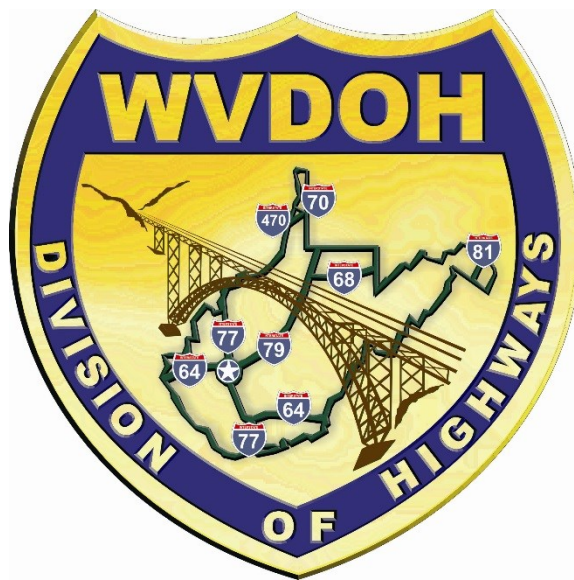


**WEST VIRGINIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS**



2017 Edition

**STANDARD SPECIFICATIONS
ROADS AND BRIDGES**

Electronic copies of this book can be obtained via the Internet at
www.Transportation.wv.gov

TAKE ME HOME, COUNTRY ROADS

Long before there was a State of West Virginia or even a Colony of Virginia, there were roads here. To a greater degree than in most other states, particularly those with flat topography, West Virginia's roads are organic in nature. Herds of bison had carved trails that were used by prehistoric natives from the Adena and *Fort Ancient* cultures, and later the different tribes that traversed the region, such as the Shawnee, Cherokee, and Iroquois. In the 17th century, Europeans arrived and began dividing up spaces that had formerly known no boundaries. As they moved westward from the Atlantic coast and into the Appalachian Mountains, they found these bison & native trails to be useful in their own migration.

Many of those same trails are still used today in the form of paved highways that evolved over the centuries. The Great Indian War & Trading Path of antiquity is now U.S. Route 219, and the famous Midland Trail is today's U.S. Route 60, stretching from the state's eastern border with Virginia to its western border with Kentucky. Where Native American hunters once pursued bison for sustenance, we now traverse the same roads to go to the grocery store, school, work, and all other activities.

As the American colonies became the United States, it was necessary to invest in the new nation's infrastructure. President Jefferson authorized the first federal highway, The National Road, to be built from Cumberland, Maryland to Wheeling. Not only did this highway bring new settlers to the Ohio Valley city, but it propagated the construction of the Wheeling Suspension Bridge in 1849, to allow the highway to extend to St. Louis. At that time it was the longest bridge in the world, and the first to extend over 1,000 feet. Still in use, it is known today as the "Father of American Bridges."

While West Virginia was a part of the Old Dominion, Virginia built The Northwestern Turnpike, now known as US50, and the Staunton-Parkersburg Turnpike, which follows present day US250/US33/WV47. As students of history know, the western portion of the state had more than its share of gripes with the mother state, especially over slavery, representation, taxation, and overall support. Hence, President Lincoln's creation of the State of West Virginia in 1863, allowed the people who inhabited the land from the mountains over to the Ohio River to be in charge of their own destiny.

The late 19th and early 20th century saw West Virginia and the rest of the nation begin to develop ideas and methodologies to improve our roadway systems. However, it wasn't until 1917, with the creation of the State Road Commission, that West Virginia began road building in earnest. America's entry into World War I and Henry Ford's mass manufacturing of affordable automobiles ramped up the need for modern highways exponentially. The voters of West Virginia realized this need, and with the passage of two Good Roads Amendments in the 1920's dirt and macadam gave way to paved roads with great alacrity.

Steady improvements were not always possible during the Depression era, as the state assumed control of all roads but generally had inadequate funds to maintain or expand the roadway system. Although, with the advent of World War II, the importance of an efficient network to

transport goods and services again came to the forefront. An influx of emergency wartime funding boosted the roadbuilding efforts in West Virginia and the conception of the Interstate System foreshadowed the era to come.

In 1950, the state began construction of the West Virginia Turnpike, which would propel the economy of not just the region, but provide a much needed link from Midwestern markets to those in the South. Later in the 1950s, President Eisenhower authorized the Interstate Highway Act, and that vast ribbon of concrete and asphalt would eventually connect West Virginia and all of the 48 contiguous states.

In the 1960's, the Appalachian Development Highway System was authorized to provide economic growth to the Appalachian states including West Virginia by building better traversable highways throughout the mountainous terrain. In the decades to follow many Appalachian Corridors were constructed across the mountain state to provide its citizens a modern transportation system. This network of highways is constructed through narrow stream valleys and over mountaintops producing amazing views and engineering accomplishments such as the iconic New River Gorge Bridge. The 1960's also encompassed the tragedy of the Silver Bridge collapse in Mason County. However, its legacy is not that of footnote wasted to history. Instead, it lead to the formation of the National Bridge Inspection Program which has served the nation hence.

Throughout subsequent generations, the State Road Commission would evolve into the Division of Highways, and become part of the Department of Transportation that oversees all forms of travel in the Mountain State. Through its concerted efforts, West Virginia's interstate system was driven to completion, and the Appalachian corridors vastly expanded and now endure with major works continuing to this day.

Thanks to the evolution of trails and paths and roads, West Virginia has a modern system of connectivity. A place once known as a barrier to the nation's growth, has become the home of the nation's 6th largest roadway system. More than 36,000 miles and over 7,000 bridges create a network that serpentine hill, hollow, ridge and vale. Comprised not only of major river crossings, interstates and expressways, but also the many small structures and rural byways woven into the landscape are of vital importance to safety, commerce and quality of life of local communities throughout the state.

Like the herds of bison that ran uninhibited in prehistory, West Virginia travelers can use these roads to celebrate our motto, *Montani Semper Liberi*: Mountaineers Are Always Free!



A Century of Transformation
1917-2017

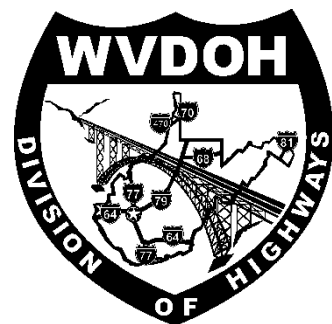


TABLE OF CONTENTS

TABLE OF CONTENTS

DIVISION 100-GENERAL PROVISIONS

Section

101	Definition of Terms
102	Bidding Requirements and Conditions
103	Award and Execution of Contract
104	Scope of Work
105	Control of Work
106	Control of Materials
107	Legal Relations and Responsibility to Public
108	Prosecution and Progress
109	Measurement and Payment
110	Miscellaneous Provisions

DIVISION 200-EARTHWORK

201	Clearing and Grubbing
202	Building Demolition, Well and Septic Tank Abandonment
203	Dismantling Structures
204	Mobilization
206	Base Course Reinforcement Geogrid
207	Excavation and Embankment
211	Borrow Excavation
212	Structure, Rock, and Wet Excavation
217	Special Rock Fill
218	Slope and Foundation Protection
219	Controlled Low-Strength Material
228	Subgrade Preparation
229	Shoulders and Ditches
240	Cleaning Culverts, Inlets and Manholes

DIVISION 300-BASES

307	Crushed Aggregate Base Course
311	Open Graded Free Draining Base Course

DIVISION 400-ASPHALT PAVEMENTS

401	Asphalt Base, Wearing, and Patching and Leveling Courses
402	Asphalt Skid Resistant Pavement
405	Surface Treatments
408	Tack Coat
410	Asphalt Base and Wearing Courses, Percent Within Limits (PWL)
412	Winter Grade Asphalt Patching Mixture
415	Milling of Asphalt Pavement Surfaces

DIVISION 500-RIGID PAVEMENT

Section

501	Portland Cement Concrete Pavement
502	Approach Slabs
503	Sealing Cracks in Concrete Pavement
504	Bituminous Underseal for Concrete Pavement
506	Concrete Pavement Repair
507	Crack and Pothole Repair
508	Diamond Grinding
510	Re-Sealing Concrete Pavement Joints
511	Dowel Bar Retrofit
512	Concrete Slab Stabilization
513	Concrete Pavement Cross Stitching
514	Roller Compacted Concrete

DIVISION 600-INCIDENTAL CONSTRUCTION

601	Structural Concrete
602	Reinforcing Steel
603	Prestressed Concrete Members
604	Pipe Culverts
605	Manholes and Inlets
606	Underdrains
607	Guardrail
608	Right-of-Way Fence
609	Sidewalks
610	Curbs, Combination Curbs and Gutters and Medians
611	Precast Concrete Traffic Dividers
612	Tunnel Liner Plate Pipe
614	Piling Walls
615	Steel Structures
616	Piling
617	Railings
618	Cast Bronze and Rolled Copper-Alloy Expansion Plates
619	Waterproofing
620	Three-Sided Reinforced Concrete Bridge/Culvert
621	Steel Grid Flooring
622	Timber Bridge Structures
623	Pneumatically Applied Mortar
624	Preformed Elastomeric Joint Sealer
625	Drilled Caisson Foundations
626	Retaining Wall Systems
631	Electrical Work
632	Horizontal Drains
633	Concrete Gutter, Invert Pipe Gutter, or Dumped Rock Gutter
634	Concrete Cribbing

Section

635	Metal Cribbing
636	Maintaining Traffic
637	Water
638	Project Markers, Right-of-Way Markers, Survey Markers, and Outlet Markers
639	Construction Surveying
640	Field Office and Storage Building
641	Mitigation Devices
642	Temporary Pollution Control
645	Reinforced Soil Slopes
651	Furnishing and Placing Topsoil
652	Seeding and Mulching
653	Vine and Ground Cover Planting
654	Tree and Shrub Planting
655	Matting for Erosion Control
656	Seedling Planting
657	Roadside Sign Supports
658	Overhead Sign Structures
659	Sign Lighting
660	Traffic Signals
661	Traffic Signs and Delineators
662	Roadway Lighting
663	Pavement Markings
664	Traffic Safety Devices
665	Plugging Gas, Oil, and Drilled Water Wells
670	Waterline Installation
675	Sanitary Sewers
679	Overlaying of Portland Cement Concrete Bridge Decks
681	Asbestos Abatement
685	Bridge Cleaning
687	Shop Painting Metal Structures
688	Field Painting of Metal Structures
689	Metalizing Steel
690	Surface Preparation and Powder Coating of New Galvanized Steel for Highway Signing and Lighting Structures

DIVISION 700-MATERIALS DETAILS

701	Hydraulic Cement
702	Fine Aggregate
703	Coarse Aggregate
704	Stone and Crushed Aggregate
705	Asphalt Materials
707	Concrete Admixtures, Curing and Coating Materials
708	Joint Materials
709	Metals
710	Wood Materials

Section

711	Paints, Coatings, Oils, and Inks
712	Guardrail and Fence
713	Metal Pipe
714	Concrete, Clay, Fiber and Plastic Pipe
715	Miscellaneous Materials
716	Embankment and Subgrade Material
717	Compaction Control of Base Course Material
718	Sewer and Waterline Material

DIVISION 100

GENERAL PROVISIONS

SECTION 101 DEFINITION OF TERMS

101.1-ABBREVIATIONS:

Whenever the following abbreviations are used in these Specifications, Plans or Contract Documents, they are to be construed the same as the respective expressions represented:

AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
AIA	American Institute of Architects
AISC	American Institute of Steel Construction, Incorporated
AISI	American Iron and Steel Institute
AMA	Automotive Manufacturer's Association
AMS	Aerospace Material Specification
ANSI	American National Standards Institute
ARA	American Railway Association
AREA	American Railway Engineering Association
AREMA	American Railway Engineering and Maintenance of Way Association
ASCE	American Society of Civil Engineers
ASD	Aluminum Standards & Data-Aluminum Association
ASLA	American Society of Landscape Architects
ASTM	American Society for Testing and Materials
ATSSA	American Traffic Safety Services Association
AWWA	American Water Works Association
AWS	American Welding Society
FHWA	Federal Highway Administration
FSS	Federal Specifications and Standards, General Services Administration
IEEE	Institute of Electronic and Electrical Engineers
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America
MIL	Military Specification
MP	Materials Procedure
NBFU	National Board of Fire Underwriters
NEC	National Electric Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
PEI-ALS	Porcelain Enamel Institute: Aluminum Standards
UL	Underwriters Laboratories
SAE	Society of Automotive Engineers
SSPC	Society for Protective Coatings
TTE-TTP	Federal Specifications and Standards

101.2-DEFINITIONS:

Access Connection-Any roadway facility by means of which vehicles enter or leave arterial highways.

Advertisements-The public announcement, as required by law, inviting bids for work to be performed, or material to be furnished.

Arterial Highway-A general term denoting a highway primarily for through traffic.

Auxiliary Lane-The portion of the roadway adjoining the traveled way for parking, speed-change or other purposes supplementary to through traffic movement.

Award-The acceptance by the Division of a bid.

Base Course-A layer or layers of specified material of designated thickness placed on a subbase or a subgrade to support a surface course or courses.

Bidder-An individual, firm, corporation, or combination thereof, acting directly or through a duly authorized representative, and prequalified according to the requirements and provisions of the Division, submitting a bid for the proposed work.

Bridge-A structure, including supports, erected over a depression or an obstruction, such as water, a highway or railway and having a track or passageway for carrying traffic or other moving loads and having a length measured along the center of roadway of more than 20 ft. (6.1 meters) between under copings of abutments or extreme ends of openings for multiple boxes.

The length of a bridge structure is the overall length measured along the line of survey stationing back to back of abutments if present, otherwise, end to end of the bridge floor, but in no case less than the total clear opening of the structure. Roadway width is the clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs.

Calendar Day-Every day shown on the calendar.

Certified Technician-A Certified Technician is an individual who has been examined by the joint Industry-Division Certification Board and deemed competent in the particular technical field for which the individual has been examined. This competency is documented by written notification and issuance of a certificate to the individual and remains in effect for a given period of time as determined by the regulations of the Board. Should any questions develop concerning the status of an individual, verification may be made through the Training section of the Personnel Division of the Division.

Change Order-A general term referring to force account work orders, supplemental agreements, and work orders of the Contract.

Channel-A natural or artificial water course.

City, Town or District-A subdivision of the county used to designate or identify the location of the proposed work.

Commissioner-West Virginia Commissioner of Highways.

Construction Limits-The physical limits of construction as described by designated lines drawn on the Plans.

Contract-The written agreement between the Division and the Contractor covering the performance of the work, the furnishing of labor, equipment and materials, and the basis of payment. The Contract includes the invitation of bids, proposal, contract form, contract bond, specifications, supplemental specifications, special provisions, plans, notice to proceed, any change orders and supplemental agreements that are required to complete the construction of the work in an acceptable manner, including authorized extensions thereof, all of which constitute one instrument.

Contract Bond-The approved form of security, executed by the Contractor and their surety, guaranteeing completion of the work and payment of all legal debts pertaining to the construction of the project.

Contract Period-The period from the specified date of commencement of work to the specified date of completion of the work, both dates inclusive, as is specified in the Contract.

Contract Time-The number of work or calendar days specified in the proposal, indicating the time allowed for the completion of the work contemplated, including authorized time extensions.

Contractor-The individual, firm or corporation, party of the second part to the Contract, acting directly or through their agents, employees, or subcontractors.

Control Of Access, Full-The condition where the right of owners or occupants of abutting land or other persons to access, light, air or view in connection with a highway is fully controlled by public authority. The authority to control access is exercised to give preference to through traffic by providing access connections with selected public roads only and by prohibiting crossings at grade or direct driveway connections.

Control Of Access, Partial-The condition where the right of owners or occupants of abutting land or other persons to access, light, air or view in connection with a highway is partially controlled by public authority. The authority to control access is exercised to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings at grade and some private driveway connections.

County-The County or Counties of West Virginia in which the work is to be done.

Culvert-Any structure not classified as a bridge which provides an opening under the roadway.

Department-West Virginia Department of Transportation.

Division-West Virginia Division of Highways

Divided Highway-A highway with separated roadways for traffic in opposite directions.

Easement-A right acquired by one party to use land belonging to another party for a specified purpose.

Embankment-The structure of soils, soils aggregate and broken rock between the embankment foundation and the subgrade.

Embankment Foundation-The material below the original ground surface whose physical characteristics affect the support of the embankment.

Employee-Any person working on behalf of the project who is under the direction of the Contractor or any subcontractor.

Engineer-The State Highway Engineer of the Division, or an authorized representative, limited by the scope of duties assigned.

Equipment-All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the work.

Estimates-The official written itemization of the value of materials in place and work performed.

Expressway-A divided arterial highway for through traffic with full or partial control of access and generally with grade separations at intersections.

Extra Work-An item of work not provided for in the contract as awarded, but found essential to the satisfactory completion of the Contract within its intended scope. See further 104.3.

Force Account Work Order-An order signed by the Engineer or an authorized representative, directing additional work to be performed, with payments based on labor, materials used, equipment cost, plus specified percentages.

Freeway-An expressway with full control of access.

Frontage Street or Road-A local street or road auxiliary to and located on the side of an arterial highway for service to abutting property and adjacent areas, and for control of access.

Highway-The entire improvement comprising the entire right-of-way. See definition for Road in Section 101.

Highway Grade Separation-Any structure carrying highway or street traffic over or under another highway or street.

Holidays-Official holidays are New Year's Day, Martin Luther King, Jr. Day, President's Day, Memorial Day, West Virginia Day, Independence Day, Labor Day, Columbus Day, Veteran's Day, Thanksgiving Day, Christmas Day, and any day in which an election (Primary or General) is held through the State and such other days as the President, Governor, or other duly constituted authority shall proclaim to be holidays. If a holiday falls on Sunday, the following Monday shall be observed in lieu thereof. If a holiday falls on a Saturday, the previous Friday shall be observed in lieu thereof.

Inspector-The Engineer's authorized representative assigned to make any or all necessary inspection of the work as further described in 105.10.

Instructions to Bidders-The notice to Contractors containing all necessary information as to provisions, requirements, date and time of submitting Proposals.

Invitation for Bids-The advertisement for bids, as required by law, inviting bids for work to be performed or material to be furnished.

Item-A specifically described unit of work for which a price is provided in the contract.

Laboratory-The testing laboratories of the Division or any other testing laboratory designated by the Division.

Lot-A lot is an isolated quantity of specified material from a single source or a measured amount of specified construction assumed to be produced by the same process.

Materials-Any substances specified for use in the construction of the project and its appurtenances.

Materials Procedure-A procedure defining standard methods or guidelines for the inspection, sampling, testing, evaluation, and documentation of the Material's Division activities relative to the quality assurance program for materials, products, and processes. Each Materials Procedure is identified by the letters MP followed by seven digits, (i.e. MP XXX.XX.XX).

Median-The portion of a divided highway separating the traveled ways for traffic in opposite directions.

Median Lane-A speed-change lane within the median to accommodate left-turning vehicles.

Multiple Deficiency-A multiple deficiency is defined as a failure to meet specified requirements involving more than one characteristic of a material within the same lot.

Notice To Proceed-Written notice to the Contractor to proceed with the contract work including, when applicable, the date of beginning of contract time.

Parking Lane-An auxiliary lane primarily for the purpose of vehicular parking.

Parkway-An arterial highway for non-commercial traffic, with full or partial control of access, and usually located within a park or a ribbon of parklike development.

Pavement Structure-The combination of subbase, base course, and surface course placed on a subgrade to support the traffic load and distribute it to the roadbed.

Plans-The approved Plans, profiles, typical cross sections, working drawings, standard drawings, and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions and details of the work to be done.

Pre-Construction Conference-A conference normally called by the District Engineer, following award and prior to start of construction, to be attended by Division officials and by the responsible officials of the Contractor and other affected parties.

Pre-Qualification Statement-The approved form or forms upon which Contractors shall furnish information as to their ability to perform work, their experience, personnel, equipment and financial condition.

Profile Grade-The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline of the roadway. Profile grade means either elevation or gradient of such trace according to the context.

Project-The specific section of the highway, together with all appurtenances and construction to be performed, under the Contract.

Project Engineer or Project Supervisor-The representative of the Engineer on a project. See further 105.9.

Proposal-The offer of a bidder, on the prescribed form, to perform the work and to furnish the labor and material at the prices quoted.

Proposal Form-The approved form on which the Division requires a bid to be prepared and submitted for the work.

Proposal Guaranty-The security furnished with a bid to guarantee that the bidder will enter into the Contract if their bid is accepted.

Railway-Highway Separation-Any structure carrying highway traffic over or under the tracks of any railway.

Ramp-A connecting roadway between two intersecting highways, usually at a highway grade separation.

Right-Of-Way-A general term denoting land, property, or interest, usually in a strip, acquired for or devoted to a highway.

Road-A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way, or needed for the maintenance of travel. See West Virginia Code, Chapter 17, Article 1, Section 3.

Roadbed-The grade portion of a highway, within top and side slopes, prepared as a foundation for the pavement structure and shoulders.

Roadside-A general term denoting the area adjoining the outer edge of the roadway. Extensive areas between the roadways of a divided highway may also be considered roadside.

Roadside Development-Those items necessary to the complete highway which provide for the preservation of landscape materials and features; the rehabilitation and protection against erosion of all areas disturbed by construction through seeding, sodding, mulching and the placing of other ground covers; such suitable planting and other improvements as may increase the effectiveness and enhance the appearance of the highway.

Roadway-The portion of the highway within limits of construction.

Seasonal Restrictions-Limitations imposed on the work which prohibit the Contractor from performing certain types of work during specific seasons of the year.

Shoulders-The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Sidewalk-That portion of the roadway primarily intended for the use of pedestrians.

Single Deficiency-A single deficiency is defined as a failure to meet specified requirements involving one characteristic of a material.

Special Provisions-Additions and revisions to the Standard and Supplemental Specifications covering conditions peculiar to an individual project.

Specialty Item-An item of work designated as "Specialty Item" in the proposal that is limited to work which requires highly specialized knowledge, craftsmanship, or equipment that is not ordinarily available in contracting organizations prequalified to bid and is usually limited to minor components of the overall Contract.

Specifications-A general term applied to all directions, provisions, and requirements pertaining to performance of the work.

State-The State of West Virginia.

Street-A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Structures-Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, foundation drains, and other features which may be encountered in the work and not otherwise classed.

Subbase-The layer or layers of specified or selected materials of designed thickness placed on a subgrade to support a base course.

Subcontractor-An individual, firm, or corporation to whom the Contractor sublets part of the Contract.

Subgrade-The upper portion of a roadbed upon which the pavement structure and shoulders are constructed.

Substantial Completion or Substantially Complete-The work on the Contract will be considered substantially complete when the Project could be opened continuously for the safe, convenient, and unimpeded use of the traveling public, or the Project has met the intention of the plans, as reasonably determined by the Engineer.

Substructure-All that part of the structure below the bearings of simple and continuous spans, skewbacks of arches and tops of footings of rigid frames, together with the backwalls, wingwalls, and wing protection railings.

Superintendent-The Contractor's authorized representative in responsible charge of the work.

Superstructure-The entire structure except the substructure.

Supplemental Agreement-A modification of the Contract covering changes in the Plans or quantities, or both, and establishing the basis of payment and time adjustment for the work necessitated by reason of the modification, requiring the signature of the Commissioner, the Contractor, and the Surety, or their authorized representatives.

Supplemental Specifications-Additions to and revisions of the Standard Specifications that are approved subsequent to issuance of the printed book. Supplemental Specifications prevail over Standard Specifications when in conflict therewith.

Surety-The corporation, partnership, or individual, other than the Contractor, executing a bond furnished by the Contractor.

Temporary Structure-A structure required for the use of traffic or other purpose while construction is in progress and not to be retained as a part of the improvement.

Titles-The titles or headings of the sections and subsections are intended for convenience of reference and shall not be considered as having any bearing on their interpretation except those titles and headings used in conjunction with the definition of terms.

Traffic Lane-The portion of the roadway for the movement of a single line of vehicles.

Traveled Way-The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Work-Work shall mean the furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all duties and obligations imposed by the contract.

Working Day-Every day shown on the calendar, exclusive of Saturdays, Sundays, and Holidays as set forth in definitions for Holidays in Section 101, on which weather and other conditions not under the control of the Contractor will permit construction operations to proceed for a minimum of five hours with normal working forces engaged in performing the controlling item or items of work.

Working Drawings-The Contractor shall submit to the Engineer all stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplemental plans or similar data for the Engineer's use.

Work Order-A written order, signed by the Engineer, requiring certain performance by the Contractor without negotiation. Such order shall not change quantities of major items beyond the twenty-five percent (25%) limitations, shall not create new items, nor make revisions to item prices.

101.3-INTERPRETATIONS:

In order to avoid cumbersome and confusing repetition of expressions in these Specifications, it is provided that whenever anything is, or is to be done, if, as, or, when, or where "contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered necessary, deemed necessary, permitted, reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected, or condemned," it shall be understood as if the expression were followed by the words "by the Engineer" or "to the Engineer".

SECTION 102

BIDDING REQUIREMENTS AND CONDITIONS

102.1-PREQUALIFICATION OF BIDDERS:

All bidders on projects let to contract by the Division shall be prequalified as provided for by rules or regulations, or both, of the Commissioner. A Certificate of Qualification will be issued by the Commissioner fixing the amount of incomplete work a Contractor may have under contract at any one time and the type of work for which the Contractor is qualified.

To obtain a Certificate of Qualification, the Contractor must file a "Contractor's Prequalification Statement" containing the information as required based on the category of work for which prequalification is being requested.

Application for qualification will be accepted by the Commissioner until 15 calendar days prior to the date set for receiving bids on projects on which the applicant may wish to submit a Proposal. Award of a certificate may be held in abeyance until such time as the Commissioner is able to verify all references and be satisfied as to the applicant's qualifications.

No Contractor will be issued a Certificate of Qualification until the Division has had adequate time to review and verify the adequacy of the information provided in the "Contractor's Prequalification Statement".

Additionally it is the Contractor's responsibility to complete any Electronic Bidding registration from the Division, and acquire all the necessary software, hardware, and networking capabilities for the Electronic Bidding process.

102.2-CONTENTS OF PROPOSAL FORMS:

The proposal forms will show the location and description of the proposed work, the approximate estimates of the various quantities of work to be performed for materials to be furnished, the amount of the proposal guaranty, the number of working days or date on which the work is to be completed, and the date, time and place of opening of proposals. The form will also include any special provisions or requirements not contained in the Standard Specifications. All documents included in the electronic proposal form are considered a part thereof and must not be detached or altered.

The Plans, Specifications, and other documents designated in the proposal form are considered a part of the proposal form whether attached or not attached.

The Proposal documents, Plans, Specifications, and other documents designated in the proposal form can be viewed and purchased on the WVDOH Bid Express Website for Electronic Bidding purposes to those authorized participants.

102.3-ISSUANCE OF PROPOSAL FORMS:

Proposal forms, will be issued to Prequalified Contractors only or to their authorized representatives, or to Contractors who have filed on a Division standard form an application for prequalification 15 calendar days prior to the date set for receiving bids on projects on which the applicant desires to bid.

The Division may at its discretion issue to a Contractor a Proposal requiring prequalification in excess of the amount allotted the Contractor provided it considers that this Contractor is particularly fitted by reason of their experience or equipment, or both, to perform work of this type involved in an amount exceeding their prequalification limits and further provided that the prospective bidder furnish the Division with a letter from a reputable Surety advising of their willingness to furnish bond to the Contractor for the project.

When more than one project is advertised, Proposals will be issued on as many projects as the Contractor requests, providing the Contractor is qualified as above for each individual project, but no contracts will be awarded exceeding the permissible limit of the Contractor's prequalification rating except as otherwise provided in 103.1.

102.4-INTERPRETATION OF APPROXIMATE ESTIMATES:

The quantities appearing in the proposal form are approximate only and are prepared for the comparison of bids. Payment to the Contractor will be made only for the work accepted, or for materials furnished in accordance with the Contract. If upon completion of the construction the actual quantities show either increase or decrease, the unit bid prices offered in the Proposal will prevail except as further provided.

102.5-EXAMINATION OF PLANS, SPECIFICATIONS, AND SITE OF WORK:

The bidder is required to examine carefully the Plans, Specifications, Supplemental Specifications, contract forms, and the site of the work contemplated. The submission of a bid shall be considered prima facie evidence that the bidder has made such examination and has judged for and satisfied themselves as to the character, quality, and quantity of work to be performed and material required to be furnished under the Contract.

102.6-PREPARATION OF PROPOSAL:

The bidders Proposal must be submitted through the Division's Bid Express Website. The bidder must furnish a unit price or a lump sum price as called for in the Proposal, in numerical figures, for each pay item listed, except that in the case of alternates, the bid may be made on only one alternate if so desired.

The Contractor or qualified and authorized agent shall use a digital signature as provided at law for the Proposal submission.

The proposal shall comply with West Virginia Contractor Licensing Act, Chapter 21, Article 11 Code of West Virginia, except that on Federal-Aid Projects a Contractor's license is not required at time of bid, but will be required before work can begin.

102.7-IRREGULAR PROPOSALS:

Proposals will be considered irregular and will be rejected for any of the following reasons:

- i. When the Proposal is on a form other than that furnished by the Division or if the form is altered. Use of a Division approved computer generated Schedule of Items shall not be considered an alteration of form or format within the meaning of these Specifications.
- ii. When there are unauthorized additions, conditional or alternate bids, or irregularities of any kind which may tend to make the Proposal incomplete, indefinite, or ambiguous as to its meaning. Also, when Division approved computer generated Schedule of Items show any alteration of format, additions or amendments not called for, errors or omissions in units of measure, or erasures.

- iii. When the bidder adds any provisions reserving the right to accept or reject an award, or to enter into a Contract pursuant to an award. This does not exclude a bid limiting the maximum gross amount of awards acceptable to any one bidder at any one bid letting, providing that any selection of awards will be made by the Division.
- iv. Failure to sign or properly execute the Proposal.
- v. Failure to indicate a proposed goal in Section C, Item 3 of the Notice contained in the Proposal, when a Division determined goal is indicated in paragraph 5 of the Special Provision for Disadvantaged Business Enterprise Utilization.
- vi. Failure to properly acknowledge receipt of amendment(s) in accordance with Section J of the notice contained in the proposal.
- vii. Failure to show the West Virginia Contractor's License Number when required in Section H of the notice contained in the proposal.

102.8-PROPOSAL GUARANTY:

No proposal will be considered unless accompanied by a digitally signed proposal guaranty bond in the form of a certified or cashier's check, or bid bond, in the amount specified in the Proposal, made payable to the West Virginia Division of Highways. Bid bonds will be accepted only if executed on the official form furnished by the Division, and any Proposal accompanied by a bond executed on a copy, duplicate, or facsimile will be rejected.

102.9-DELIVERY OF PROPOSALS:

Each Proposal shall be submitted electronically and must be received by the Bid Express website by the time designated in the proposal to proceed with the letting.

Cashier's Checks shall be submitted in an envelope and delivered prior to the date and time of letting. The Envelope and the Cashier's Check shall each contain the following Information:

Call Number	Letting Date
Project Number	Contractor's Name and Address

Envelopes shall be addressed to the West Virginia Division of Highways, Charleston, West Virginia.

102.10-WITHDRAWAL OF PROPOSALS:

Bidders may withdraw Proposals in a manner approved by the electronic bidding service provider and the Division prior to the letting.

On projects requiring prequalification, a bidder may alternatively request to withdraw its bid under the conditions and in the same manner as described for projects where Prequalification is waived provided the bidder provides written notice to the Division 2:00PM of the business day preceding the letting and the bidder receives confirmation from the Division stating the bidder will be allowed to do so.

For projects where Prequalification is waived, and after the time provided for the opening of proposals, a bidder may withdraw its bid during the course of reading of bids prior to the actual reading of bids on the project for which the bid is withdrawn only by providing a written document at the site of the letting in the following form:

"I, the undersigned, of _____, Contractor(s)
hereby acknowledge that I have this day withdrawn the sealed bid of
_____, Contractor(s) on West
Virginia Division of Highways Project No. _____."

Contractors who are found to be low bidders on a number of projects of which the total exceeds the Contractor's rating may withdraw, with the approval of the Commissioner, bids on such project or projects as will bring the remaining total to within the limit of the rating. At their discretion, the Commissioner may award contracts for the project or projects on which bids have been so withdrawn to the next lowest qualified bidder.

102.11-COMBINATION PROPOSALS:

If the Division so elects, Proposals may be issued for projects in combination or separately, so that bids may be submitted either on the combination or on separate units of the combination. The Division reserves the right to make awards on combination bids or separate bids to the best advantage of the Division. No combination bids other than those specifically set up in proposals by the Division will be considered. Separate Contracts will be written for each individual project included in the combination.

102.12-PUBLIC READING OF PROPOSALS:

Proposals will be received, decrypted, and read publicly at the time and place indicated in the notice to Contractors. Bidders, their authorized agents, and other interested parties are invited to be present.

102.13-DISQUALIFICATION OF BIDDERS:

Either of the following reasons may be considered as being sufficient for the disqualification of a bidder and the rejection of their Proposal or Proposals.

- i. More than one Proposal for the same work from an individual, firm, or corporation under the same or different name.
- ii. Evidence of collusion among bidders. Participants in such collusion will receive no recognition as bidders for any future work of the Division until any such participant shall have been reinstated as a qualified bidder.

102.14-MATERIAL GUARANTY:

The successful bidder shall furnish a complete statement of the origin, composition and manufacture of all materials to be used in the construction of the work, together with samples when required. Samples may be subjected to the tests provided for in these Specifications to determine their quality and fitness for the work.

102.15-FREE COMPETITIVE BIDDING AFFIDAVIT:

Prior to the approval of Federal-Aid Contracts, a sworn statement in the form of an affidavit shall be executed by, or on behalf of, the person, firm, association, or corporation to whom such contract is to be awarded.

The affidavit, with accompanying endorsement and acknowledgment sections, is contained in the contract Proposal.

102.16-PRE-CONSTRUCTION DATA:

Prospective bidders may review files at the West Virginia Division of Highways, Capitol Complex, Charleston, West Virginia. These files may contain additional information not included in the contract documents including, but not limited to, old plans, old shop drawings, geotechnical information, environmental documents, permit applications, permits, asbestos reports, hazardous waste reports and other data. Copies may be obtained upon request and payment of printing fees.

102.16.1-Questions Regarding Advertised Proposals: All projects advertised by the Division will require any questions to be asked using the Question and Answer feature of the electronic bidding service in accordance with any listed requirements. The various contact information required shall be filled out and completed with valid and applicable information which the Division may verify. If the contact information is unable to be verified then any questions associated with this information may not be answered.

Questions and Answers are for informational purposes only. Any posted questions or answers do not alter the terms and conditions of the advertised Contract in question. Official changes to the Contract shall only be issued by the Division through an amendment to the applicable Contract.

Potential Bidders may ask questions up until the time of the posted letting with no exceptions. However it should be noted that any questions that may necessitate a change to the Contract should be asked seven (7) days prior to the posted letting date to allow the Division to issue an amendment to modify the Contract, if necessary. Questions received three (3) working days or more in advance of a posted letting should be answered prior to the time of the posted letting. Questions received within three (3) working days of the posted time of letting may or may not be answered as time allows.

102.17-CONTRACTOR'S DRUG-FREE WORKPLACE POLICY:

Each Contractor submitting a bid must include with the bid, on a form provided by the Division, an affidavit that the Contractor implements and maintains a written drug-free workplace policy which meets the requirements of Article 1D, Chapter 21 of the Official Code of West Virginia, as amended. The successful bidder must submit a copy of its drug-free workplace policy within ten (10) days following the letting and prior to the awarding of the contract. Any successful bidder who fails to submit the policy within the specified time limit will risk forfeiture of his/her proposal guaranty bond.

The successful bidder must also insure that its subcontractors implement and maintain a written drug-free workplace policy complying with Article 1D, a copy of which must be submitted to the Division by the Contractor prior to the start of the subcontract work. The contract may be terminated if the Contractor:

1. Fails to implement its policy;
2. Fails to provide information regarding implementation of the policy at the request of the Division; or;
3. Provides to the Division false information regarding the policy.

A clearly legible copy of the written drug-free workplace policy must be kept posted in a prominent and easily accessible place at the project site by each contractor subject to the provisions of Article 1D.

Every contractor shall keep an accurate record showing the names, occupation and safety-sensitive status of all employees, in connection with the construction on the project, and showing any drug tests or alcohol tests performed and employee education and supervisor training received, which record shall be open at all reasonable hours for inspection by the Division. The Contractor must preserve these records for three years after completion and acceptance of the project.

All drug testing information specifically related to individual employee is confidential and should be treated as such by anyone authorized to review or compile program records.

SECTION 103

AWARD AND EXECUTION OF CONTRACT

103.1-CONSIDERATION OF PROPOSALS:

After the Proposals are opened and read, they will be compared on the basis of the summation of the products of the approximate quantities shown in the bid schedule by the unit bid prices. The results of such comparisons will be made immediately available to the public. In the event of discrepancy between unit bid prices and extensions, the unit bid price shall govern.

The right is reserved to reject any or all proposals, to waive technicalities or to advertise for new proposals if, in the judgment of the Commissioner, the best interests of the State will be promoted.

If Proposals for more than one project are issued to a bidder, which projects individually would be within the bidder's qualification established provided in 102.1, but a combination of more than one, considering also the work under contract and incomplete, would be in excess of their qualification, the right is reserved to consider only such Proposal or Proposals as, in the opinion of the Commissioner, are most advantageous to the Division.

Proposals containing Special Provisions for Disadvantaged Business Enterprises utilization, will be considered as follows:

- a) When the low bidder's goal submitted in Section C Item 3 - Contractor's Goal for DBE participation, of the Notice contained in the project proposal, meets or exceeds the contract DBE goals, and the Division considers the amount of the bid to be reasonable, such bidder will be the successful bidder.
- b) When the low bidder's goal submitted in Section C Item 3 - Contractor's Goal for DBE participation, of the Notice contained in the project proposal, does not meet the DBE contract goal and the Division considers the amount of the bid to be reasonable, the bid will be accepted if he or she can show that good faith efforts were made prior to the bid to meet the contract goals.
- c) When the low bidder cannot satisfy the Division that good faith efforts have been made, this bid may be rejected and the second low bid will be evaluated in the same manner. This procedure will continue, evaluating bids in the same manner, evaluating bids in ascending order, until either the contract DBE goal is attained or good faith efforts can be verified and that bid will be accepted provided the amount thereof is considered reasonable by the Division.

103.2-AWARD OF CONTRACT:

The award of Contract, if it be awarded, will be made within 30 calendar days after the opening of Proposals to the lowest responsible and prequalified bidder. The Commissioner may, with the agreement of the successful bidder, withhold award for any length of time. The successful bidder will be notified by letter, mailed to the address shown on their Proposal, that their bid has been accepted and that they have been awarded the Contract.

103.2.1-Contractor's Direct Deposit Requirements: The Contractor shall receive all payments electronically via Direct Deposit. Prior to Award of the Contract, the Contractor shall be approved and registered to accept payments through the West Virginia State Auditor's Office electronically (www.wvsao.gov).

103.3-CANCELLATION OF AWARD:

The Division reserves the right to cancel the award of any Contract at any time before the execution of the Contract documents by all parties without any liability against the Division.

103.4-RETURN OF PROPOSAL GUARANTY:

All proposal guaranties, except those of the two lowest bidders, will be returned immediately following the opening and checking of the Proposals. The retained proposal guaranty of the unsuccessful of the two lowest bidders will be returned within 10 days following the award of Contract, and that of the successful bidder will be returned after a satisfactory bond has been furnished and the Contract has been executed.

103.5-REQUIREMENT OF CONTRACT BOND:

At the time of the execution of the contract, the successful bidder shall execute and deliver to the Division a good and sufficient surety or collateral bond payable to the State of West Virginia.

The successful bidder has the option of submission of the aforementioned bond in an amount equivalent to either 102 percent or 100 percent of the contract price.

The submission of the aforementioned bond in an amount equivalent to 102 percent of the contract price by the successful bidder is the standard expectation of the Division in order to comply with the current Special Provision for Subcontractor Prompt Payment and does not necessitate the withholding of retainage by the Division from monies due on future progress voucher estimates payable under the terms of the contract. Further, the decision by a particular contractor to submit said bond in an amount equivalent to 102 percent of the contract price shall be consistent and applicable throughout the duration of the contract for which the bond is being submitted and shall be consistent and applicable to all contracts executed between the Division and that particular contractor.

If the successful bidder elects to submit the aforementioned bond in an amount equivalent to 100 percent of the contract price, it is necessary that the bidder notify the Contract Administration Division in writing prior to the submission of the bond. Submission of a bond in an amount equivalent to 100 percent of the contract price does necessitate the withholding of retainage by the Division from monies due on future progress voucher estimates payable under the terms of the contract and as set forth in 109.6. Further, the decision by a particular contractor to submit said bond in an amount equivalent to 100 percent of the contract price shall be consistent and applicable throughout the duration of the contract for which the bond is being submitted and shall be consistent and applicable to all contracts executed between the Division and that particular contractor.

As an alternate, the successful bidder may deposit with the State Treasurer cash bond, United States Treasury bonds, United States Treasury notes, United States Treasury Certificates of Indebtedness, United States Treasury bills or West Virginia Road Bonds in the amount of either 102 percent or 100 percent of the contract amount. A safe keeping receipt from a bank located in the State of West Virginia may be deposited with the State Treasurer in lieu of any of the definitive securities.

The State Treasurer shall, on a regular basis, collect all interest or income on the obligations so deposited and shall pay same, when and if collected, to the Contractor who deposited the obligations. If the deposit is in the form of coupon bonds, the State Treasurer shall deliver each coupon as it matures to the Contractor.

103.6-INSURANCE REQUIREMENTS:

The Contractor shall be required, in addition to any other form of insurance or bonds required under the terms of the Contract and Specifications, to procure and maintain during the life of the Contract the following types of insurance in the amounts set forth:

All such policies of insurance, except for Workers' Compensation, shall name the Division as an additional insured and shall be occurrence policies and the Certificate of Insurance provided to the Division shall so specify. The policies must provide coverage for all damages arising out of injury to persons or property which allegedly occurred during the life of the contract regardless of when the claim is filed subject to statute of limitations.

103.6.1-Contractor's General Liability Insurance: The Contractor shall maintain commercial general liability (CGL) coverage with limits not less than:

General Aggregate	\$2,000,000
Products/Completed Operations Aggregate	\$2,000,000
Personal & Advertising Injury	\$1,000,000
Each Occurrence *	\$1,000,000
Fire Damage	\$50,000
Medical Expense Limit	\$5,000

* Each Occurrence limit shall be \$2,000,000 when performing any operations that are subject to 107.8 – Railway-Highway Provisions.

The CGL shall be written on ISO occurrence form CG 00 01, or equivalent, and shall cover liability arising from premises-operations, independent contractors, products-completed operations, personal injury and advertising injury, and liability assumed under an insured contract. There shall be no endorsement or modification of the CGL limiting the scope of coverage for liability arising from explosion, collapse, or underground property damage whenever work involving these exposures are undertaken. The CGL policy shall include endorsements that amend the aggregate limits of insurance to be applicable to each construction project separately.

Contractor shall furnish an ACORD Form 25-S Certificate of Insurance, or its equivalent, with a 30 day notice of cancellation provisions to evidence this CGL coverage.

103.6.2-Workers' Compensation–Insurance and Employer's Liability Insurance: The contractor shall also give evidence for Workers' Compensation Insurance and Employers Liability Insurance, with a 30-day notice of cancelation. The benefits provided under the Workers' Compensation shall be benefits prescribed by West Virginia Code. The Employer's Liability policy must include coverage to protect the contractor for claims brought under Section 23-4-2(d)(2)(ii) of West Virginia Code. The limits of insurance under this section shall be as follows:

Each accident	\$1,000,000
Each disease	\$1,000,000
Each disease/employee	\$1,000,000

Evidence of this coverage can be set forth on the ACORD Form 25-S as specified in Subsection 103.6.1 or approved form and shall indicate that West Virginia statutory Workers Compensation coverage is included.

103.6.3-Automobile Insurance: The Contractor shall furnish evidence, with a 30-day notice of cancellation, to the state that it maintains an Insurance Services Office Commercial Automobile Liability insurance policy Form CA0001 or its equivalent. The policy shall include coverage for owned, non-owned, and hired vehicles.

The limits for liability insurance must be at least \$1,000,000 combined single limit. Evidence for the coverage shall be set forth on an ACORD Form 25-S Certificate of Liability Insurance.

103.6.4-Steam Boiler Insurance: In event steam boilers are used on the work, the Contractor shall furnish evidence that the Contractor carries in their own behalf standard Steam Boiler Insurance having an aggregate limit of not less than \$250,000.

The insurance specified shall be carried until all work required to be performed under the terms of the Contract is satisfactorily completed as evidenced by the formal acceptance of the State.

103.6.5-Countersignature of West Virginia Agent: The policy or policies of Insurance required must be countersigned by an Agent Licensed in West Virginia, in accordance with the applicable statute of the State of West Virginia.

All certificates of insurance used to verify the policies issued must be endorsed by an Agent Licensed in West Virginia. Such endorsement must include the printed name, street address, city, zip code and West Virginia license number of the Agent.

103.7-SPECIAL BONDS AND INSURANCE:

When the work is of such nature that special bond or insurance is required, the special requirements will be detailed and included in the Proposal for the project. This coverage could include, but not be limited to, builder's risk, installation floater, maritime exposures, environmental exposures, and professional liability.

103.8-EXECUTION OF CONTRACT:

The Contract shall be executed by the bidder to whom the Contract has been awarded, the bond executed by the principal and the sureties, and the Contract and bond returned to the Division within 20 days after the date of the notice of the award.

103.9-FAILURE TO EXECUTE CONTRACT:

Failure by the bidder to execute the Contract and file acceptable bond within 20 days after notice of award shall be just cause for the annulment of the award; and it is understood by the bidder, in the event of such an annulment of award or the Contract, that the amount of the guaranty deposited with the Proposal will be retained by the Division and deposited in the Division of Highways Fund, not as a penalty, but as liquidated damages. Award may then be made to the next lowest responsible bidder, or the work may be readvertised and constructed under contract or otherwise, as the Division may decide.

103.10-PRECONSTRUCTION CONFERENCE:

As soon as possible after the award of each Contract a preconstruction conference will be arranged by the Division. The Contractor, their superintendent, or an authorized agent shall be present at the conference and shall present the proposed schedule of work, list of proposed subcontractors, if any, and a list of suppliers from whom materials are anticipated to be purchased. The information so presented shall be on forms submitted to the Contractor with the letter of contract award. The Division will make arrangements for utility representatives to be present.

SECTION 104 SCOPE OF WORK

104.1-INTENT OF CONTRACT:

The intent of the Contract is to provide for the construction and completion in every detail of the work described. The Contractor shall furnish all labor, materials, equipment, tools, transportation, and supplies required to complete the work in accordance with the Plans, Specifications, and terms of the Contract.

Should any misunderstanding arise as to the intent or meaning of the Contract, or any discrepancy appear, the decision of the Commissioner shall be final.

104.2-ALTERATION OF PLANS OR CHARACTER OF WORK:

Under no circumstances shall alterations of Plans or the nature of the work involve work beyond the termini of the proposed construction except as may be necessary to satisfactorily complete the project.

In addition to the above, alterations in Plans or increased quantities of items may be made necessary at a time when the contract or the items involved in the operations are substantially completed, the related contractor organization demobilized, and related equipment essentially removed from the project. Under these circumstances, if it is demonstrated that the unit cost to the Contractor has increased, additional compensation may be allowed by the Engineer and the additional work performed as prescribed in 104.3 as "Extra Work."

Any adjustment in compensation because of a change(s) resulting from one or more of the conditions described above will be made in accordance with the provisions of 109.3. Any adjustment in contract time because of such change(s) will be made in accordance with the provisions of 108.6.

104.3-EXTRA WORK:

The Contractor shall perform unforeseen work for which there is no price included in the Contract, whenever it is deemed necessary or desirable in order to complete fully the work as contemplated. The work shall be performed in accordance with the Specifications and as directed, and will be paid for as provided by a written supplemental agreement on a unit price or lump sum basis. In the event the Engineer and the Contractor are unable to agree upon the terms of the supplemental agreement, the Contractor shall proceed with the work and receive payment therefore in the manner and amount prescribed in 109.4.

104.4-TEMPORARY STRUCTURES:

In contracts for bridges only, the Contractor will not be required to construct or maintain temporary structures unless the construction and maintenance of such structures are stipulated in the Contract or ordered as extra work by the Engineer. If the building of temporary structures is included in the Contract, or added by extra work order, the responsibility of the Contractor for accidents to the public or to their employees, arising from their construction or maintenance, shall extend to such structure and its roadway approaches.

104.5-MAINTENANCE OF TRAFFIC:

The Project, while undergoing improvement, shall be kept open to all traffic by the Contractor in such condition that both local and through traffic will be adequately and safely accommodated. All construction operations shall be scheduled to keep traffic delay to a minimum. The Division has adopted, and the Contractor shall follow the Standard, "Traffic Control for Street and Highway Construction and Maintenance Operations," published by the West Virginia Division of Highways.

All expenses for the following items shall be borne by the Contractor without extra compensation except when the Proposal provides for payment under 636, Maintaining Traffic:

- i. The construction and maintenance of temporary detours, temporary structures, temporary approaches, crossings and intersections with streets and roads, including the furnishing and application of aggregates for maintenance of traffic and liquid asphalt oil, calcium chloride, or water for use as dust palliative.
- ii. The furnishing of flaggers and pilot trucks and drivers.
- iii. The furnishing, erection, and maintenance of warning devices, such as signs, auxiliary barriers, channelizing devices, hazard warning lights, barricades, flares and reflective markers.

If actual field conditions are not illustrated in the Plans, engineering judgment and discretion shall be exercised to select devices that will be adaptable, but the general policies prescribed shall be adhered to. Final responsibility for the installation of adequate safety devices for the protection of the traveling public and employees, as well as for the safeguard of the work in general, shall rest with the Contractor.

During any suspension of work, the Contractor shall make passable and shall open to traffic such portions of the project and temporary roadways or portions thereof as may be agreed upon between the Contractor and the Engineer for the temporary accommodation of necessary traffic during the anticipated period of suspension. Thereafter, and until an issuance of an order for the resumption of construction operations, the maintenance of the temporary route or line of travel agreed upon will be by and at the expense of the Division. When work is resumed, the Contractor shall replace or renew any work or materials lost or damaged because of such temporary use of the project and shall remove, to the extent directed by the Engineer, any work or materials used in temporary maintenance thereof by the Division and shall complete the project in every respect as though its prosecution had been continuous and without interference. All additional work caused by such suspensions, for reasons beyond the control of the Contractor, will be paid for by the Division at contract prices or by extra work.

The Division will provide all necessary snow removal.

104.6-RIGHTS IN AND USE OF MATERIALS FOUND ON THE PROJECT:

The Contractor, with the approval of the Engineer, may use on the project such stone, gravel, sand, or other material determined suitable by the Engineer, as may be found in the excavation and will be paid both for the excavation of such materials at the corresponding contract unit price and for the pay item for which the excavated material is used. The Contractor shall replace at their own expense with other acceptable material all of that portion of the excavation material so removed and used which was needed for use in the embankments, backfills, approaches, or otherwise. No charge for the material so used will be made against the Contractor. The Contractor shall not excavate or remove any material from within the highway location which

is not within the grading limits, as indicated by the slope and grade lines, without written authorization from the Engineer.

Unless otherwise provided in the Contract, the material from any existing old structures and pipes shall become the property of the Contractor and shall be removed from the project.

104.7-FINAL CLEAN UP:

Before final acceptance is made, the Contractor shall clear the highway, waste areas, borrow pits, and all ground occupied by the Contractor during the construction, of all rubbish, excess materials, temporary structures and equipment. The Contractor shall restore in an acceptable manner all property, both public and private, which has been damaged during the prosecution of the work; and shall leave the highway or bridge site, including streams and their banks, in a neat and presentable condition in accordance with applicable laws of the State. All excavated material or falsework placed in stream channels shall be removed, and all material from around piers and abutments shall be replaced and compacted to the level of the original surface.

104.8-BRIDGE PLATE:

A bronze plate, carrying the project number, the number of the bridge, and the year of the bridge construction, will be furnished and placed by the Contractor without extra compensation. The nameplate on through steel bridges shall be placed on the end posts about eight feet (2.5 meters) vertically above the floor. On other bridges, they shall be placed in the railings as shown on the plans or as designated by the Engineer. The plate shall be a minimum of 8 inches by 10 inches (200 by 250 mm) wide, with letters and numbers of 3/4 inch (20 mm) minimum height raised 1/8 inch (3 mm) above the surface of the plate. The information on the plate shall be arranged as follows:

(Project No. on first line)	
Bridge No.	
Built	(Year of construction)

104.9-DIFFERING SITE CONDITIONS:

During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for the contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before they are disturbed and before the affected work is performed.

Upon written notification, the Engineer will investigate the conditions, and if the Engineer determines that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding loss of anticipated profits, will be made and the contract modified in writing accordingly. The Engineer will notify the Contractor of their determination whether or not an adjustment of the contract is warranted.

No contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice.

The Contractor shall promptly notify the Engineer of alleged changes to the Contract due to differing site conditions, extra work, altered work beyond the scope of the Contract, or action(s) taken by the Division that changed the Contract terms and conditions.

- A. No further work is to be performed or Contract item expense incurred with relation to the claimed change after the date the change allegedly occurred unless directed otherwise in writing or orally follow up in writing in 48 hours by the Engineer.
- B. Immediately notify the Engineer verbally of the alleged change or extra work occasioned by site conditions or actions by the Division, and in writing within five calendar days of the date the alleged change or action was noted. Thereafter, the Contractor shall provide the following information to the Engineer in writing within 15 calendar days of the written notice:
 - 1. The date of occurrence and the nature and circumstances of the occurrence that constitute a change.
 - 2. Name, title, and activity of each Division representative knowledgeable of the claimed change.
 - 3. Identify any documents and the substance of any oral communication involved in the claimed change.
 - 4. Basis for a claim of accelerated schedule performance.
 - 5. Basis for a claim that the work is not required by the Contract.
 - 6. Particular elements of Contract performance for which additional compensation may be sought under this Section including:
 - a. Pay item(s) that has been or may be affected by the claimed change.
 - b. Labor or materials, or both, that will be added, deleted, or wasted by the claimed change and what equipment will be idled or required.
 - c. Delay and disruption in the manner and sequence of performance that has been or will be caused.
 - d. Adjustments to Contract price(s), delivery schedule(s), staging, and Contract time estimated due to the claimed change.
 - e. Estimate of the time within which the Department must respond to the notice to minimize cost, delay, or disruption of performance.
- C. Following submission of the notification to the Engineer, and in the absence of directions received to the contrary from an authorized representative of the Division, the Contractor shall continue diligent prosecution of the work under the Contract to the maximum extent possible.

Within 15 calendar days after receipt of the written notice and required information, the Engineer shall respond in writing to the Contractor to:

- 1. Confirm that a change occurred and, when necessary, direct the method and manner of further performance, or
- 2. Deny that a change occurred and, when necessary, direct the method and manner of further performance, or
- 3. Advise the Contractor that adequate information has not been submitted to decide whether (1) or (2) applies, and indicate the needed information and date it is to be received by the Engineer for further review. The Division will respond to such additional information within 15 calendar days of receipt from the Contractor.

104.10-SUSPENSION OF WORK ORDERED BY THE ENGINEER:

If the performance of all or any portion of the work is suspended or delayed by the Engineer in writing for an unreasonable period of time (not originally anticipated, customary or inherent in the construction industry) and the Contractor believes that additional compensation and/or contract time is due as a result of such suspension or delay, the Contractor shall submit to the Engineer in writing a request for adjustment within seven (7) calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Engineer will evaluate the Contractor's request. If the Engineer agrees that the cost and/or time required for the performance of the contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the Engineer will make an adjustment (excluding profit) and modify the contract in writing accordingly. The Contractor will be notified of the Engineer's determination whether or not an adjustment of the contract is warranted.

No contract adjustment will be allowed unless the Contractor has submitted the request for adjustment within the time prescribed.

No contract adjustment will be allowed under this clause to the extent that performance would have been suspended or delayed by any other cause, or for which an adjustment is provided or excluded under any other term or condition of this contract.

104.11-SIGNIFICANT CHANGES IN THE CHARACTER OF WORK:

The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the project. Such changes in quantities and alterations shall not invalidate the contract nor release the surety, and the Contractor agrees to perform the work as altered.

If the alterations or changes in quantities significantly change the character of the work under the contract, whether such alterations or changes are in themselves significant changes to the character of the work or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding anticipated profit, will be made to the contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

If the alterations or changes in quantities do not significantly change the character of the work to be performed under the contract, the altered work will be paid for as provided elsewhere in the contract.

The term "significant change" shall be construed to apply only to the following circumstances:

- a) When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction; or
- b) When a major item of work, (any item having an original contract value in excess of 10 percent of the original contract amount or \$50,000 dollars), is increased in excess of 125 percent or decreased below 75 percent of the original contract quantity. Any allowance for an increase in quantity shall apply only to that portion in excess of 125 percent of original contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed.

104.12-VALUE ENGINEERING CHANGE PROPOSAL AND PRACTICAL DESIGN CHANGE PROPOSAL:

The Contractor may submit to the Engineer, in writing, Value Engineering Change Proposals (VECP) for modifying the plans, specifications or other requirements of the contract for the purpose of reducing the total cost of construction without reducing design capacity or quality of the finished product. If accepted by the Division, the cost savings difference between the original contract work being modified and the final cost of the proposed new work shall be shared between the Contractor and the Division on a fifty-fifty basis.

The Contractor may submit to the Engineer, in writing, a Practical Design Change Proposal (PDCP) for modifying the plans, specifications or other requirements of the contract for the purpose of reducing the total cost of construction. A Practical Design Change Proposal may provide a finished product with a justifiably revised scope change, as compared to the as-bid product. The PDCP may modify construction sequences, re-use existing roadway elements or underrun contract items. The PDCP shall not adversely affect safety or function of the final product. The cost savings to the Division shall be negotiated to be at least 60% of the cost difference between the original contract work being modified and the final cost of the proposed new work listed in the change order for a PDCP.

The contractor is encouraged to submit to the engineer, in writing, VECP's and PDCP's for modifying the plans, specifications or other requirements of the contract. Proposed modifications should not impair, in any manner, essential functions or characteristics of the project, including but not limited to, service life, economy of operation, ease of maintenance, and shall not impair design or safety standards, and shall not significantly delay the completion of the project.

This subsection applies to all VECPs/PDCPs initiated and developed by the Contractor and which are identified as such by the Contractor at the time of their submission to the Engineer; however, nothing shall be construed as requiring the Engineer to consider or approve a VECP/PDCP submitted hereunder.

As a minimum, the following information shall be submitted, in quadruplicate, with each VECP/PDCP along with all information additionally submitted in electronic format:

- i. A statement that this proposal is submitted as a VECP or PDCP;
- ii. A description of the difference between the existing contract requirements and the proposed change;
- iii. A statement concerning the basis for the VECP/PDCP and benefits to the Division together with an itemization of the contract items and requirements affected by the VECP/PDCP;
- iv. Separate detailed cost estimates for both the existing contract requirements and the proposed change;
- v. An itemization of plan details, design standards or specifications to be changed if the VECP/PDCP is adopted;
- vi. An estimate of the effect on collateral costs to the Division. Collateral costs are defined to be reduced costs of operation, maintenance or repair and extended useful service life; and
- vii. A statement of the time by which approval must be issued to obtain the total cost reduction during remainder of Contract, noting any effect on contract completion time or delivery schedule;

- viii. A description of any previous use or submission of the same proposal by the Contractor, including dates, job numbers, results, and/or outcome of proposal if previously submitted;
- ix. Final submittals for VECs and PDCPs shall be signed and sealed by a West Virginia Registered Professional Engineer, and that individual will become the Engineer of Record for the work described in the VEC/PCP.

It should be noted that on a case by case basis, the Contractor may be required to do presentations to the Division addressing the above issues and clarifying any additional information requested by the Division.

If approved by the Division, the Division will process the VEC/PCP in the same manner as prescribed for any other proposal which would necessitate issuance of a Contract change order. The Division may accept in whole or in part any VEC/PCP by issuing a change order which will identify the VEC/PCP on which it is based. The Division will not be liable to the Contractor for failure to accept or act upon any VEC/PCP submitted pursuant to this provision nor for any delays to the work attributable to any such proposal. The Division has the right to reject any VEC/PCP without explanation. Additionally there may be other regulatory agencies outside of the Division that may need to review the proposed VEC/PCP and have the authority to reject/accept the proposed VEC/PCP. The Division accepts no responsibility in delays or costs attributed to any such reviews by outside agencies and it is the responsibility of the Contractor to get approval from said organizations.

Until a proposal is effected by change order, the Contractor shall remain obligated to the terms and conditions of the existing contract. When an executed change order has not been issued by the date upon which the Contractor's proposal specifies that a decision should be made, or such other date as the Contractor may subsequently have specified in writing, such proposal may be deemed rejected.

The change order affecting the necessary Contract modification will establish the estimated savings agreed upon, will provide for adjustment in the Contract prices and will indicate the savings be divided between the Contractor and the Division as per the negotiated agreements. The Contractor shall absorb all costs incurred in preparing a VEC/PCP for submission to the Division. All reasonably incurred costs of reviewing and administering the VEC/PCP will be borne by the Division. The Division reserves the right to include in the change order any conditions it deems appropriate for consideration, approval and implementation of the proposal. The Contractor's share of the savings shall constitute full compensation for effecting all changes pursuant to the change order.

Acceptance of the VEC/PCP and performance of the work thereunder will not change the Contract completion date as a result of the VEC/PCP, unless specifically provided for in the change order authorizing the VEC/PCP.

The Division expressly reserves the right to adopt a VEC/PCP for general use in contracts administered by the Division when it determines the VEC/PCP is suitable for application to other contracts without obligation or compensation of any kind to the Contractor.

The Engineer shall be sole judge of the acceptability of a VEC/PCP.

When a VEC/PCP is accepted by the Division, the provisions of 104.2 pertaining to adjustment of Contract unit price due to alterations of Contract quantities will not apply to the items adjusted or deleted as a result of affecting the VEC/PCP by change order.

The cost of the revised work, as determined in the value engineering change order, will be paid on current estimates.

In addition to such payment for VECP items, the Contractor will be paid, on a Lump Sum basis by a separate item, one half of the difference of the cost of the original contract work and the final cost of the new work listed in the change order. In addition to such payment for PDCP items, the Contractor shall be paid on a Lump Sum basis by separate item the negotiated contractor portion of the savings.

For VECP, one half of contractor portion of the estimated savings will be paid to the Contractor upon approval of the change order. For PDCP, one half of the negotiated contractor portion of the estimated savings will be paid to the Contractor upon approval of the change order. The remainder of the savings due the Contractor will be paid upon completion of all items of work included in the change order. This final Lump Sum payment will be determined by the actual quantities for items paid by the unit. Final payment for other lump sum or proposal quantity items will be the change order amount, subject to 109.2.

104.13-FUNDING SOURCE IDENTIFICATION SIGNS:

104.13.1-General: Funding Source Identification Signs shall be furnished by the Contractor if the Total Contract Bid Amount of the construction exceeds \$500,000 or otherwise noted on the plans, and shall be erected during mobilization of the project. The cost of furnishing, erecting, maintaining, and removal of these signs shall be incidental to the cost of construction of the project.

104.13.2-Location: Funding Source Identification Signs shall be located as directed by the Engineer. The Contractor shall promptly remove each sign at the completion of the project for which the sign was erected.

104.13.3-Sign Content: The content of each sign and the size of letters and the size of board shall be as required by the Engineer. The funding agencies and the dollar amounts involved will be furnished to the Contractor by the Engineer.

104.13.4-Sign Construction: The materials for Funding Source Identification Signs, such as for the sign panels, their supports, and for the legend and background, are to be of a type and method of fabrication that will be consistent with the conditions and estimated period of use. Signs shall have black letters for the legend on a white background. Reflective sheeting will be permitted, but not required. Mounting, transverse location, height, and similar features for Funding Source Identification Signs shall be consistent with practices used for the installation of other informational signs either on wooden or steel U-channel supports to comply with small sign support safety practices. The sign shall be mounted as directed by the Engineer.

SECTION 105 CONTROL OF WORK

105.1-AUTHORITY OF THE ENGINEER:

The Engineer will decide all questions which may arise as to the quantity, quality, and acceptability of materials furnished and work performed, and as to the rate of progress of the work; all questions which may arise as to the interpretation of the Plans and Specifications; and all questions as to the acceptable fulfillment of the Contract on the part of the Contractor. The decision of the Engineer will be final.

The Engineer will have the authority to suspend the work wholly or in part due to the failure of the Contractor to correct conditions unsafe for the employees or the general public, for failure to carry out orders, for such periods as the Engineer may deem necessary due to unsuitable weather, for conditions considered unsuitable for the prosecution of the work, or for any other condition or reason deemed to be in the public interest. All such suspension orders will be directed to the Contractor in writing.

The Engineer is not authorized to increase the obligation of the Division to any Contract except as provided.

105.2-PLANS AND WORKING DRAWINGS:

Approved Plans will show the location, profile, typical cross section, structures, except as specified, incidental items, and a summary of all items appearing in the Proposal. Any deviations which may be required by the exigencies of the construction will be determined by the Engineer and authorized by the Engineer in writing. The Contractor shall keep one set of approved Plans available on the work at all times.

Plans will show such details as are necessary to give a comprehensive idea of the construction contemplated. Any information which may be shown on drawings regarding results obtained from test piles or borings will be a record of conditions encountered at the place where such test piles were driven or borings were made, as nearly as these conditions could be interpreted by the Engineer observing the operations. The Contractor shall interpret the data in the light of their own experience. The Contractor is not bound to accept or rely on the data shown on the drawings, but may make such additional borings and investigations, including test piles, as the Contractor may desire in order to satisfy themselves concerning the lengths of piles and the conditions governing or entering into the construction of foundations.

The Plans will show the foundation depths and dimensions on which the estimate of quantities is based. These depths and foundation dimensions, however, are subject to such variations as may be necessary to secure a foundation satisfactory to the Engineer, and the right is expressly reserved to increase or diminish the dimensions and depths of the foundations as the Engineer may determine.

The Contractor shall submit to the Engineer all stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplemental plans or similar data for the Engineers use.

Working drawings for steel and timber structures shall consist of shop detail, erection and other working plans, showing details, dimensions, sizes of material, and other information necessary for complete fabrication and erection of the work. The Division will require shop lists for structural steel to be submitted in a format as set forth by the Engineer.

Working drawings for concrete structures shall consist of such detail plans as may reasonably be required for the successful prosecution of the work and which are not included in the Plans furnished by the Engineer. These may include plans for falsework, bracing, centering and formwork, masonry layout diagrams, and diagrams for bent reinforcement.

The Contractor shall furnish the Engineer copies of the working drawing as may be required for approval and for construction purposes and upon completion of the work, reproducible, full-size tracings of the original drawings shall be delivered to the Engineer. The size of the original drawings shall be 22 inches by 36 inches (A1 metric paper), including margins, unless otherwise permitted. The working drawings submitted for approval may be reduced.

It is expressly understood that the approval by the Engineer of the Contractor's working drawing relates to the requirements for strength and general arrangement, and such approval will not relieve the Contractor from responsibility for omissions, errors in dimensions, shop fits, field connections, etc., for quantity of materials, or from any of their responsibility under the Contract for the successful completion of the work.

The Contract price shall include the cost of furnishing all working drawings, and the Contractor will be allowed no extra compensation for such drawings.

It is the Contractor's responsibility to determine the exact location of each utility in project areas where these utilities would be interrupted or damaged by performing work. In the event of damage or disruption to utilities which are active and are to remain in service, the Contractor shall immediately notify the responsible official of the organization operating the utility that is interrupted. The Contractor shall assume all costs, charges or claims connected with the interruption and repair of any utility damaged by the Contractor.

105.2.1-Shop Drawings: Shop Drawings shall be defined as those working drawings necessary for the fabrication and inspection of the work as may reasonable be required for the successful prosecution of the work and which are not included in the plans furnished by the Engineer.

Any Contractor proposed changes to the contract document shall be submitted to the Division for approval prior to certification of the shop drawings. The Division will prepare and issue all revisions to the contract plans dictated by these approved changes.

Shop drawings shall be submitted sufficiently in advance of the start of the work to allow time for distribution by the Engineer without delaying the work. Only certified copies of shop drawings that have been distributed by the Engineer shall be considered approved by the project personnel. Copies of the shop drawings which do not contain the certification stamp and have not been distributed by the Engineer and are used for construction of any part of the work shall be at the Contractor's risk.

Upon completion of the work, reproducible, full-size tracings of the original drawings shall be delivered to the Engineer. The size of the original drawings shall be 22 inches x 34 inches, including margins, unless otherwise permitted.

Shop drawings shall give full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts, such as pins, nuts, bolts, drains, reinforcing, inserts, strands, ducts, etc. Where specific orientation of parts is required, such as the rolling of plates, the direction shall be shown.

Shop drawings shall specifically identify the AASHTO material designation for all component parts.

All working drawings shall be in same unites as those used in the plans. Use of dual (Metric and U.S. Customary) units is not allowed.

Shop drawings shall give full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts.

Design camber for all members shall be shown on the shop drawings.

Any time delays encountered due to incomplete or incorrect submittals shall be the Contractor's responsibility. The time delay shall not be grounds for a claim to extend the contact completion date or a claim for costs incurred by the Contractor, his Subcontractors, or his Suppliers.

There are two methods for the approval of Shop Drawings and catalog sheets the "Division Approval Method" and the "Contractor Approval Method". The item of work shown in the shop drawing shall determine the required Approval Method. Most projects will contain items of work requiring each method. Design Directive 102 (DD-102) latest version at the time of the bid shall be used to determine which method to use for a particular item of work and where to send each required submission.

105.2.1.1-"Division Approval Method": The Contractor shall be responsible for the submission of all shop drawings and catalog sheets, and shall submit two (2) review copies as shown in DD-102. After the Division has approved the shop drawings the Contractor shall submit nine (9) copies of the shop drawings to the Engineer for verification and distribution.

The review and approval or rejection of Division approved shop drawings will normally require 14 calendar days after receipt of the drawings.

The verification and distribution of Division approved shop drawings will normally require seven (7) calendar days after receipt of the drawings.

105.2.1.2-"Contractor Approval Shop Method": The Contractor shall be responsible for the submission of al approved shop drawings and catalog sheets, and shall submit nine (9) copies of all approved shop drawings and catalog sheets to the Engineer for distribution. The Contractor's Engineer shall be responsible for the preparation, review, and approval of all shop drawings and catalog sheets.

Each page/sheet of all shop drawings submittals shall be signed by a Professional Engineer Registered in the State of West Virginia. The approving engineer's signature block shall be per the following:

"I do hereby certify that the details, materials, methods, and dimensions shown on this document meet the requirements for general arrangement and comply with the contract documents provided by the West Virginia Department of Transportation, Division of Highways for the project.

This certification by the Contractor in no way shall relieve the Manufacturer, Supplier, Fabricator or Sub-Contractor of their Full Responsibility for the product or service provided."

Name

Reg. No.

Date

Each page/sheet of all catalog sheet submittals shall be signed by a Professional Engineer Registered in the State of West Virginia. The approving engineer's signature block shall be per the following:

"I do hereby certify that this product complies with the contract documents provided by the West Virginia Department of Transportation, Division of Highways for the project.

This certification by the Contractor in no way shall relieve the Manufacturer, Supplier, Fabricator or Sub-Contractor of their Full Responsibility for the product or service provided."

_____	_____	_____
Name	Reg. No.	Date

The Contractor's authorize representative may sign and approve catalog sheets when the item on the catalog sheets is identical in every way to the item identified in the approved contract plans, If the item is not identical then the catalog sheets must be signed by a Professional Engineer Registered in the State of West Virginia as stated above. The Contractor's authorized representative must have the authority to sign legal binding contracts for the Prime Contractor. When the Contractors' authorized representative signs the certification the following approving signature block shall be used:

"I do hereby certify that this product complies with the contract documents provided by the West Virginia Department of Transportation, Division of Highways for the project and is the identical item shown in the approved plans.

This certification by the Contractor in no way shall relieve the Manufacturer, Supplier, Fabricator or Sub-Contractor of their Full Responsibility for the product or service provided."

_____	_____	_____
Name	Reg. No.	Date

All nine (9) copies of each copy of each page/sheet shall be signed by the same engineer and shall contain the same date. Each revision to individual page/sheet shall be considered a new submittal and shall require nine (9) certified copies. The Division will verify the above requirements are met prior to distribution. The Division shall return all nine (9) sets on any submittal which does not comply with the requirements of this Special Provision. The verification and distribution or rejection of Contractor approved shop drawings will normally require seven (7) calendar days after receipt of the drawings.

Additional certifications and/or slightly different wording of the above two certification may be used if approval is given by the Legal Division. This approval must be obtained prior to any submission of contractor approved shop drawings. This approval may take up to thirty (30) days to be obtained. If this approval is obtained, a copy of the approval letter must be submitted with the first submission of shop drawings for distribution.

The Division shall reserve the right to review any submission of shop drawings or catalog sheets. This review shall not delay the contractor in the construction project or delay the distribution of the approved shop drawings or catalog sheets.

105.3-CONFORMITY WITH PLANS AND SPECIFICATIONS:

All work performed and all materials furnished shall be in reasonably close conformity with the lines, grades, cross sections, dimensions and material requirements, including tolerances, shown on the Plans or indicated in the Specifications.

Should the Engineer determine the materials, or the finished product do not conform to the Specifications or the Plans, the Engineer will then make a determination if the work will be accepted and remain in place in accordance with 106.3.1 and 106.7. In this event, the Engineer will document the basis of acceptance by contract modification which will provide for an adjusted payment. All nonconforming material or construction judged to be inadequate for the use intended shall be either reworked or removed and replaced at no expense to the Division.

The adjusted payment fall into one of two categories:

- a. Within Specification Limits. For price reductions that fall within the Price Adjustment Limits of the contract specifications, there is no administrative charge for processing this type of price reduction.
- b. Outside Specification Limits. A special evaluation of the non-conformance must be made if the non-conforming material is outside of the contract specifications. Price reductions that fall outside the Price Adjustment Limits require further effort by the Department because the amount of the price reduction is not covered in contract specifications. Thus, an additional two hundred dollar, for the Division's administrative cost, must be added to each individual price adjustment.

105.4-COORDINATION OF PLANS, SPECIFICATIONS, SUPPLEMENTAL SPECIFICATIONS, AND SPECIAL PROVISIONS:

These Specifications, the Supplemental Specifications, the Plans, Special Provisions, and all Supplementary Documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete work. In case of discrepancy, calculated dimensions will govern over scaled dimensions; Supplemental Specifications will govern over Specifications; Plans will govern over Specifications and Supplemental Specifications; Special Provisions will govern over Specifications, Supplemental Specifications and Plans. When the plans provide that new work is to connect with existing structures, the Contractor must verify all dimensions with the Engineer before proceeding with the work.

The Specifications, Supplemental Specifications, and Special Provisions are in dual units. The first Primary unit is in English with the Metric unit following in parentheses “()”. The Metric values are considered replacements for the English units and they are not conversions.

The Contractor shall take no advantage of any apparent error or omission in the Plans or Specifications. In the event the Contractor discovers such an error or omission, the Contractor shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the Plans and Specifications.

105.5-COOPERATION BY CONTRACTOR:

The Contractor will be furnished one (1) complete set of plans and profile sheets, and one (1) set of Cross Sections upon request, without charge. The Contractor shall maintain on the Project at all times one complete set of Plans, Specifications, and Special Provisions.

The Contractor shall give the work the constant attention necessary to facilitate the progress thereof, and shall cooperate with the Engineer, their inspectors, other Contractors, and utilities in every way possible.

The Contractor shall have on the work at all times, as an agent, a competent superintendent capable of reading and thoroughly understanding the Plans and Specifications, and thoroughly experienced in the type of work being performed, who shall receive instructions from the Engineer or an authorized representatives. The Superintendent shall have full authority to execute orders or directions of the Engineer without delay, and to promptly supply such materials, equipment, tools, labor, and incidentals as may be required. Such superintendence shall be furnished irrespective of the amount of work sublet.

The Contractor shall furnish to the Engineer a list of addresses and telephone numbers of their personnel who may be reached in case of emergency during hours when no work is to be performed. On weekends, holidays, during suspensions of work, and during storms the Contractor shall alert certain of their personnel to stand by and shall inform the Engineer of arrangements so made.

The Contractor shall provide all reasonable facilities and furnish the Division the information, assistance and samples required by the Engineer and Inspector for proper inspecting or testing of materials and workmanship.

On some contracts it may be necessary, to insure proper coordination between the work of the Contractor and the work of various utilities, to hold a pre-construction utility meeting. The Division will arrange for the affected utilities to be present. The Contractor or their representative, authorized to make decisions for them in regard to the scheduling of the proposed work, is required to attend the meeting. A report of the pre-construction utility meeting will be prepared and distributed by the Engineer to all represented at the meeting.

105.6-COOPERATION WITH UTILITIES:

The Division will notify all utility companies, all pipe line owners, or other parties affected, and endeavor to have all necessary adjustments of the public or private utility fixtures, sewers, pipe lines, and other appurtenances within or adjacent to the limits of construction, made as soon as practicable.

Water lines, gas lines, wire lines, sewer lines, service connections, water and gas meter boxes, water and gas valve boxes, light standards, cableways, signals, and all other utility appurtenances within the limits of the proposed construction which are to be relocated or adjusted are to be moved by the owners at their expense, except as otherwise provided for in the Special Provisions or as noted on the Plans.

Should the Contractor desire temporary changes of location for their convenience of any utility appurtenances, the Contractor shall satisfy the Division that the proposed relocation does not interfere with its or other Contractors' operations or the requirements of the work and does not cause an obstruction or a hazard to traffic. The Contractor shall make their own request to the utility or other parties affected by such relocation work. Such relocation work shall be made solely at the Contractor's expense.

Any work done under or within the right-of-way of a railroad shall be under the supervision and control of the Chief Engineer, or other designated officer, of the railroad to the extent necessary in the judgment of the Chief Engineer, or other designated officer, to insure safe and uninterrupted operation of its trains and the convenient conduct of its business. Any additional conditions or requirements for doing work within the railroad right-of-way will be set forth in the Contract.

In general, it is to be understood that the Contractor has considered in their bid all of the permanent and temporary utility appurtenances in their present or relocated positions as shown on the Plans, and that no additional compensation will be made by the State for any delays,

inconvenience, or damage sustained by them due to interference from the utility appurtenances or the operation of moving them. The locations of the underground utilities shown on the Plans have been obtained by diligent field checks and searches of available records. It is believed that they are essentially correct, but the Division makes no guarantees as to their exact locations.

It is the Contractor's responsibility to determine the exact location of each utility in project areas where these utilities would be interrupted or damaged by performing work. In the event of damage or disruption to utilities which are active and are to remain in service, the Contractor shall immediately notify the responsible official of the organization operating the utility that is interrupted. The Contractor shall assume all costs, charges or claims connected with the interruption and repair of any utility damaged by the Contractor.

105.7-COOPERATION BETWEEN CONTRACTORS:

The Division reserves the right at any time to contract for and perform other or additional work on or near the work covered by the Contract.

When separate Contracts are let within the limits of any one project, each Contractor shall conduct their work so as not to interfere with or hinder the progress or completion of the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other as directed.

Each Contractor involved shall assume all liability, financial or otherwise, in connection with their Contract and shall protect and save harmless the Division from any and all damages or claims that may arise because of inconvenience, delay, or loss experienced by them because of the presence and operations of other Contractors working within the limits of the same project.

The Contractor shall arrange their work and shall place and dispose of the materials being used so as not to interfere with the operations of the other Contractors within the limits of the same project. The Contractor shall join work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

In the event the Engineer finds further coordination effort is necessary, the Engineer shall call a meeting of the Contractors involved. After the meeting has been held, the Engineer may notify the Contractors of the action required of each and the Engineer's decision shall be final.

105.8-CONSTRUCTION STAKES, LINES AND GRADES:

Except when "Construction Layout Stakes", is included in the Contract, the Engineer will set construction stakes establishing lines, slopes and continuous profile-grade, together with necessary reference stakes and bench marks. The Engineer will set sufficient right-of-way stakes to define the right-of-way limits. The Engineer will set stakes to mark centerline and establish bench marks for bridges and special structures as may be considered necessary.

The stakes and marks in the paragraph above shall constitute field control by and in accordance with which the Contractor shall establish all additional stakes and marks necessary to secure a correct layout of all the work. All stakes, except those set by the Engineer, shall be furnished by the Contractor. The Contractor shall not engage the services of any person or person in the employ of the Division for the performance of any of the Contractor's layout work.

The Contractor shall be responsible for having the finished work in reasonably close conformity with the lines, grades, elevations, and dimensions called for on the Plans or established by the Engineer. The Contractor shall be held responsible for the preservation of stakes, marks, and references, and shall have them reset at the Contractor's expense when they are damaged, lost, displaced, or removed.

105.9-AUTHORITY AND DUTIES OF THE PROJECT ENGINEER OR PROJECT SUPERVISOR:

The project Engineer or Supervisor has immediate charge of the engineering details of each construction project. The Engineer or Supervisor are responsible for the administration and satisfactory completion of the project.

The Project Engineer or Supervisor has the authority to reject defective material and to suspend any work that is being improperly performed.

The Project Engineer or Supervisor will have the authority to suspend the work wholly or in part due to the failure of the Contractor to correct conditions unsafe for the employees or the general public; for failure to carry out provisions of the Contract; for failure to carry out orders; for such periods as they may deem necessary due to unsuitable weather. All such suspension orders will be directed to the Contractor in writing. The suspension of the work for the above reasons does no relieve the Contractor of their responsibility according to 107.16.

105.10-AUTHORITY AND DUTIES OF THE INSPECTOR:

Inspectors employed by the Division will be authorized to inspect all work done and materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication or manufacture of the materials to be used. The Inspector is not authorized to alter or waive the provisions of the Contract. The Inspector is authorized to call the attention of the Contractor to any failure of the work or materials to conform to the Specifications and Contract. The Inspector is authorized to reject materials which do not meet specification requirements or suspend the portion of the work involved until any question at issue can be referred to the Project Engineer or Project Supervisor. The Inspector is not authorized to issue instructions contrary to the Plans and Specifications. The Inspector shall not act as foreman or perform other duties for the Contractor, nor interfere with the management of the work by the latter.

105.11-INSPECTION OF WORK AND MATERIALS:

All materials and each part or detail of the work shall be subject to inspection by the Engineer. The Engineer or a representative shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection. To facilitate the inspection of materials, all delivery tickets shall contain as a minimum the information required in MP 700.00.01.

At the Engineer's request, the Contractor, at any time before acceptance of the work, shall remove or uncover such portions of the finished work as may be directed. After examination, the Contractor shall restore said portions of the work to the standard required by the Specifications. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed will be paid for as extra work; but should the work so exposed or examined prove unacceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed shall be at the Contractor's expense.

Any work done or materials used without supervision or inspection by an authorized Division representative may be ordered removed and replaced at the Contractor's expense. Failure to reject any defective material or work shall not in any way prevent later rejection when such defects are discovered, nor obligate the Division to final acceptance.

When any unit of government or political subdivision or any railroad corporation is to pay a portion of the cost of the work covered by this Contract, its respective representatives shall have

the right to inspect the work. Such inspection shall in no sense make any unit of government or political subdivision or any railroad corporation a party to this Contract, and shall in no way interfere with the rights of either party hereunder.

No work shall be done at night, Saturdays, Sundays, or Holidays without documented prior approval of the Engineer.

105.12-REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK:

Except as provided in 105.3, all work which does not conform to the requirements of the Contract will be considered as unacceptable work.

Unaccepted work, whether the result of poor workmanship, use of defective materials, damage through carelessness or any other cause, found to exist prior to the final acceptance of the work, shall be removed immediately and replaced in an acceptable manner.

Unacceptable material shall be removed from the job site.

No work shall be done without lines and grades having been given or approved by the Engineer. Work done contrary to the instructions of the Engineer, work done beyond the lines shown on the Plans, or as given, except as specified, or any extra work done without authority, will be considered as unauthorized and will not be paid for under the provisions of the Contract. Work so done may be ordered removed or replaced at the Contractor's expense.

Upon failure on the part of the Contractor to comply promptly with any order of the Engineer, made under the provisions of this Subsection, the Engineer will have authority to cause unacceptable work to be remedied or removed and replaced and unauthorized work to be removed, and to deduct the costs from any monies due or to become due the Contractor.

105.13-LOAD RESTRICTIONS:

The Contractor shall comply with all legal load restrictions in the hauling of materials on public roads. A special permit will not relieve the Contractor of liability for damage which may result from the moving of equipment.

The operation of equipment of such weight or so loaded as to cause damage to structures or the roadway or to any other type of construction will not be permitted. Hauling of materials over the base course or surface course under construction shall be limited as directed. No loads will be permitted on a concrete pavement, base or structure before the expiration of the curing period. In no case shall legal load limits be exceeded unless permitted in writing. The Contractor shall be responsible for all damage done by their own equipment.

105.14-MAINTENANCE DURING CONSTRUCTION:

The Contractor shall maintain the work during construction and until the project is accepted except as otherwise provided in 105.16.1. This maintenance shall constitute continuous and effective work prosecuted day by day, with adequate equipment and forces to the end that the roadway and structures are kept in satisfactory condition at all times.

In the case of a Contract for the placing of a course upon a course or subgrade previously constructed, the Contractor shall maintain the previous course or subgrade during all construction operations.

All cost of maintenance work during construction and before the project is accepted shall be included in the unit prices bid on the various pay items, and the Contractor will not be paid an additional amount for such work except as otherwise provided in 104.5.

105.15-FAILURE TO MAINTAIN ROADWAY OR STRUCTURE:

If the Contractor, at any time, fails to comply with the provisions of 105.14, the Engineer will immediately notify the Contractor of such non-compliance. If the Contractor fails to remedy unsatisfactory maintenance within 24 hours after receipt of such notice, the Engineer may immediately proceed to maintain the project, and the entire cost of maintenance will be deducted from monies due or to become due the Contractor on their Contract.

105.16-ACCEPTANCE:

105.16.1-Partial Acceptance: If at any time during the prosecution of the project, the Contractor completes a unit or portion of the project, such as a structure, an interchange, or a section of road or pavement, the Contractor may request the Engineer to make final inspection of that unit. If the Engineer finds upon inspection that the unit has been completed in compliance with the Contract, the Engineer may accept that unit as being completed and the Contractor may be relieved of further responsibility for that unit. Such partial acceptance shall in no way void or alter any of the terms of the Contract.

105.16.2-Final Acceptance: Upon due notice from the Contractor of presumptive completion of the entire project, the Engineer will make an inspection. If all construction and other contractual requirements provided for and contemplated by the Contract is found completed to satisfaction, that inspection will constitute the final inspection. The Engineer will make the final acceptance and notify the Contractor in writing of this acceptance. Final acceptance will be the date the Contract Completion Report is fully executed by the Division.

If, however, the inspection discloses any work, in whole in part, as being unsatisfactory, the Engineer will give the Contractor the necessary instruction for correction of same in writing, and the Contractor shall immediately comply with and execute such instructions. Upon correction of the work, another inspection will be made which will constitute the final inspection provided the work has been satisfactorily completed. In such event, the Engineer will make the final acceptance and notify the Contractor in writing of this acceptance. Final acceptance will be the date the Contract Completion Report is fully executed by the Division.

105.17-CLAIMS FOR ADJUSTMENT AND DISPUTES:

If additional compensation is considered due for work or material not covered in the Contract, written notification of the intent to make a claim under Subsection 104.9, shall be given to the Engineer before beginning or continuing the affected work.

The Engineer will respond as described under Subsection 104.9 following notification. The Contractor shall provide necessary cooperation and information to the Engineer during the period of notification, review, and evaluation to provide possible resolution of the Contract question and avoid, if possible, further claim process actions.

If notification is not given, or the Contractor does not afford the Engineer proper facilities for keeping strict account of actual costs, the Contractor waives any claim for additional compensation. Notice by the Contractor, and the fact that the Engineer has kept account of the costs shall not be construed as substantiating the validity of the claim. An equitable adjustment will be made to the Contract if the claim is found to have merit.

- A. Claim submittals shall be in sufficient detail to enable the Engineer to determine the basis for entitlement and the resulting costs. The following information if available, should accompany each claim submitted:
1. Detailed factual statement of the claim providing all necessary dates locations, and items of work affected by the claim.
 2. The date actions resulting in the claim occurred or conditions resulting in the claim became evident.
 3. A copy of the "Notice of Potential Claim" Form (available from the Division), filed by the Contractor for the specific claim.
 4. The name, title, and activity of each Department employee knowledgeable.
 5. The name, title, and activity of each Contractor employee knowledgeable about the facts that gave rise to such claim.
 6. The specific provisions of the Contract that support the claim, and a statement why the provisions support the claim.
 7. The identification of any pertinent documents, and the substance of any material communications relating to the claim.
 8. A statement whether the additional compensation or extension of time is based on the provisions of the Contract or an alleged breach of Contract.
 9. If an extension of time is also sought, the specific days for which it is sought and the basis for such claim as determined by an analysis of the construction schedule.
 10. The amount of additional compensation sought and a breakdown of that amount.
- B. Required Certification of Claims. The claim submittal shall include the Contractor's written certification, under oath, attesting to the following:
1. The claim is made in good faith.
 2. Supportive data is accurate and compete to the Contractor's best knowledge and belief.
 3. The amount of the claim accurately reflects the Contractor's actual cost incurred.

In complying with this requirement, the Contractor shall use the following certification:

Under penalty of law for perjury or falsification, the undersigned
_____ (Company), hereby certifies that the claim for extra
compensation and time, if any, made herein for work on this Contract is a
true statement of the actual costs incurred and time sought, and is fully
documented and supported under the Contract between the parties this
_____ day of _____, _____.

_____(Company)

By _____

Its _____

ATTEST:

By _____

Its _____

- C. Review of Claims. All claims filed will be subject to review by the Division at any time following the claim filing, whether or not the claim is part of a suit pending in the courts of this State. The review may begin upon submission. The Contractor, Subcontractor(s), or Supplier(s) shall cooperate with the Division and shall, at a minimum, provide access to the following documents of the Contractor, Subcontractor(s), its/their subsidiaries, separate divisions and affiliates if said documents are available:
1. Daily time sheets and foreman's daily reports.
 2. Union agreements if any.
 3. Insurance, welfare, and benefits records.
 4. Payroll register.
 5. Earnings records.
 6. Payroll tax returns.
 7. Material invoices, purchases orders, and all material and supply Acquisition Contracts.
 8. Material cost distribution worksheets.
 9. Equipment records (list of company equipment, rates, etc.).
 10. Vendor rental agreements and subcontractor invoices.
 11. Subcontractor payment certificates.
 12. Canceled checks (payroll and vendors).
 13. Job cost report.
 14. Job payroll ledger.
 15. General ledger, general journal, (if used) and all subsidiary ledgers and journals together with all supporting documentation pertinent to entries made in these ledgers and journals.
 16. Cash disbursements journal.
 17. Depreciation records on all company equipment.
 18. All other documents used to develop costs for the Contractor's internal purposes in establishing the actual cost of owning and operating equipment.
 19. All documents related to the preparation of the Contractor's bid including the final calculations on which the bid was based.
 20. Worksheets used to prepare the claim, establishing the cost components for items of the claim including, but not limited to, labor, benefits and insurance, materials, equipment, subcontractors, and all documents that establish the time periods, individuals involved, the hours and the rates for the individuals.

SECTION 106 CONTROL OF MATERIALS

106.1-SOURCE OF SUPPLY AND QUALITY REQUIREMENTS:

The material used on the work shall meet all quality requirements of the Contract. To expedite the inspection and testing of materials, the Contractor shall notify the Engineer of their proposed sources of materials as required in 103.10. At the option of the Engineer, materials may be approved at the source of supply before delivery is started. If it is found after trial that sources of supply for previously approved materials do not produce specified products, the Contractor shall furnish materials from other sources at no increase in cost to the Division.

The Contractor shall provide and maintain a quality control system. This quality control system shall conform to all requirements of the Specifications.

The Contractor shall maintain equipment and qualified personnel to perform all sampling and testing to determine the magnitude of the various properties of the materials during manufacturing and placement as governed by the Specifications and shall maintain those properties within the limits of the Specifications.

The contractor shall design a quality control plan detailing the methods by which the quality program will be conducted.

The quality control plan shall be in accordance with the applicable Specifications and Material Procedure(s) for the specified item. The plan should clearly describe the methods by which the Quality Control Program will be conducted. The Quality Control Plan shall be submitted to the Engineer at the Pre-Construction Conference. The work shall not begin on the applicable item(s) until the plan has been reviewed and found to be in conformance with the contract documents and accepted by the Engineer. Items that require testing by the Contractor, but stipulate that acceptance shall be based upon written certification, do not require Quality Control Plans.

106.1.1-Domestic Aluminum, Glass, Steel and Iron in Public Works Project:

106.1.1.1-Definitions: Unless the context in which used clearly requires a different meaning, as used in this section:

"Public Works" includes roads, highways, streets, bridges, sidewalks, sewage systems, buildings, engineering and architectural works, and any other structure, facility or improvement constructed or undertaken by the Division. "Aluminum, glass, steel and iron products" means products rolled, formed, shaped, drawn, extruded, forged, cast, fabricated, or otherwise similarly processed from aluminum, glass, steel, and iron. "Domestic aluminum, glass, steel and iron products" means aluminum, glass, steel and iron products made in the United States.

Buy America requirements apply to coating. Coating is considered a manufacturing process and is interpreted to mean all processes that protect or enhance the value of a material or product to which it is applied such as epoxy coatings, galvanizing or painting.

106.1.1.2-Preference For Domestic Aluminum and Glass Products: The Division shall require that all aluminum or glass products to be supplied to purchase order or state and federal projects shall be domestic aluminum or glass products in compliance with Chapter 5, Article 19 of the West Virginia Code, unless the offered or bid price of the domestic aluminum or glass products is unreasonable or that the domestic aluminum or

glass products are not produced in sufficient quantities to meet the project requirements. The offered or bid price of domestic aluminum or glass products is not unreasonable unless it is more than 20 percent higher than the offered bid price of foreign made aluminum or glass products (including any applicable duty) if the aluminum or glass products to be supplied are produced in a "substantial labor surplus area" as determined by the United States Department of Labor, the offered or bid price of domestic aluminum or glass products is not unreasonable unless it is more than 30% higher than the offered or bid price of foreign-made aluminum or glass products (including any applicable duty). A listing of the "substantial labor surplus areas" can be obtained from the Division's Contract Administration Division. This Section does not apply to any state or federal project in an amount less than \$50,000.00.

106.1.1.3-Contract Payments; Recovery in Case of Violation of Section: The Division may not authorize or make any payments to a Contractor under a contract which contains or should contain the provision required by Section 106.1.1.2 unless such Contractor has fully complied with such Section. Prior to such payment, the Division will require the Contractor to furnish a certificate of compliance from each subcontractor and supplier. Payments made by the Division to any who did not comply with this section may be recovered by the Division.

106.1.1.4-Procedures For Use of Foreign-Made Materials: If foreign-made aluminum, glass or steel (iron) products are supplied in compliance with this Section, the Contractor shall be responsible for providing procedures acceptable to the Division for determining that specification requirements are met, including all inspections at no additional cost to the Division. The use of foreign-made products will not be reason for granting an extension of time.

106.1.1.5-Use of Domestic Steel Products: When steel or iron is used it shall be in compliance with Section 165 of the Surface Transportation Assistance Act of 1982, the applicable provisions of Title 23 CFR, Section 635.410, as amended, entitled "Buy America Requirements," and Chapter 5A, Article 3, Section 56 and Chapter 5, Article 19 of the West Virginia Code.

Pig Iron and processed, pelletized, and reduced iron ore manufactured outside of the United States may be used in the domestic manufacturing process for steel and/or iron materials used in Federal-aid highway construction projects.

The Division shall require that all steel products to be supplied to purchase order or state and federal projects shall be domestic steel products in compliance with Chapter 5A, Article 3, Section 56 of the West Virginia Code.

These provisions may not prevent the minimal use of foreign steel provided the proper approval is obtained in writing per Chapter 5A, Article 3, Section 56, Subsection (b)(1) of the West Virginia Code.

106.1.1.6-Domestic Steel Products: To be a Domestic Steel product all manufacturing processes, including application of a coating, for these materials must occur in the United States including all of its territories, continental, or insular, subject to the jurisdiction of the United States. Steel manufacturing processes shall include rolled, formed, shaped,

drawn, cast, fabricated or otherwise similarly processed, or processed by a combination of two or more such operations, from steel made by the open hearth, basic oxygen, electric furnace, Bessemer or other steel making process. Coating includes all processes that protect or enhance the value of the material to which the coating is applied.

106.2-LOCAL MATERIAL SOURCES:

106.2.1-Designated Sources: Possible sources of local materials may be designated in the contract documents. The quality of material in such deposits will be acceptable in general, but the Contractor shall determine for themselves the amount of equipment and work required to produce a material meeting the Specifications. It shall be understood that it is not feasible to ascertain from samples the limits for an entire deposit, and that variations shall be considered as usual and are to be expected. The Engineer may order procurement of material from any portion of a deposit and may reject portions of the deposit as unacceptable.

The Division may acquire and make available to the Contractor the right to take materials from the sources designated in the contract documents together with the right to use such property as may be specified, for plant site, stockpiles, and haul roads.

106.2.2-Contractor Furnished Sources: If the Contractor desires to use materials from sources other than those designated, the Contractor shall acquire the necessary rights to take materials from the sources and shall pay all costs related thereto, including any which may result from an increase in length of haul. All costs of exploring and developing such other sources shall be borne by the Contractor. The use of material from other than designated sources will not be permitted until representative samples taken by the Engineer have been approved and written authority is issued for the use thereof.

When material deposits are not designated in the Contract, the Contractor shall provide sources of material acceptable to the Engineer.

When sources of material or material deposits are provided by the Division, the Division will assume the cost of processing samples to determine the suitability of the material unless otherwise specified.

Sites from which material has been removed shall, upon completion of the work, be left in a neat and presentable condition and shall be properly drained. Unless otherwise directed by the Engineer, they shall be seeded and mulched as provided in 652 without additional compensation. Where practicable, borrow pits, gravel pits, and quarry sites shall be located so they will not be visible from the highway.

In accordance with the agreement between the Division of Highways and the Division of Environmental Protection, the Contractor cannot furnish material from borrow areas outside the right of way for any other public or private use.

106.3-SAMPLES, TESTS, CITED SPECIFICATIONS:

All materials will be inspected, tested and approved prior to incorporation into the work. Any work which incorporates materials prior to the above evaluation shall be performed at the Contractor's risk, and may subsequently be considered as unacceptable. Unless otherwise specified, the materials shall meet the applicable Standard or Interim Specifications of the American Association of State Highway and Transportation Officials, the Standard or Tentative Specifications of the American Society for Testing and Materials, or Standards adopted by other specifying agencies, with preference given in the same order in which the above agencies are listed.

The specification which is current at the time of advertisement for bids shall govern, except that, with the approval of the Engineer, subsequent revisions or adoptions may govern. All materials being used are subject to inspection, testing or rejection at any time prior to final acceptance of the completed work.

The Contractor shall be responsible for the quality of construction and materials incorporated. When called for in the Specifications, the Contractor shall perform all necessary process control inspection, sampling and testing. All materials will be approved for acceptance through the Division's acceptance procedures. The Division has the exclusive right and responsibility for determining the acceptability of the construction and materials incorporated. The Division may use the results of the Contractor's inspection, sampling and testing for acceptance purposes.

Lot or subplot sizes will normally be designated. In the event that operational conditions cause work to be interrupted, or only partially completed before the lot size designated has been achieved, the lot or subplot may be redefined by the Engineer as being either the amount of work accomplished within the day or that work partially completed combined with the next lot or subplot of work. It is the intent of these Specifications that the number of samples required to evaluate each lot or subplot will be unchanged even when the lot or subplot is redefined.

When an acceptance plan is cited, it shall be in accordance with 106.3.1.

106.3.1-Acceptance Plans:

106.3.1.1-Percent Within Tolerance: The percentage of each lot or subplot of material, product, item of construction, or completed construction within the specified tolerances will be determined by the procedures as referenced by the specification requirements. When West Virginia AP-A is referenced, it will consist of Tables 106-1 to 106-5 inclusive, published in MP 106.00.20.

106.3.1.2-Sampling of Reworked Lots or Sublots: It is the intent of these Specifications that lots or sublots of materials, products, items of construction or completed construction meet specification requirements at the time of submission. Lots or sublots generally will not be resampled unless reworked before submission. Sampling after reworking will be at the expense of the Contractor.

106.4-PLANT INSPECTION:

The Engineer may undertake the inspection of materials at the source.

In the event plant inspection is undertaken, the following conditions shall be met:

- i. The Engineer shall have the cooperation and assistance of the Contractor and the producer with whom the Contractor has contracted for materials.
- ii. The Engineer shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished.
- iii. Adequate safety measures are to be provided and maintained.

The Division reserves the right to retest all materials, which have been tested and accepted at the source of supply, after the materials have been delivered to the project and prior to incorporation into the work and to reject all materials which, when retested, do not meet the requirements of these Specifications or those established for the specific project.

106.5-STORAGE OF MATERIALS:

Materials shall be so stored as to assure the preservation of their quality and fitness for the work. Stored materials, even though approved before storage, may again be inspected prior to their use in the work. Stored materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for storage purposes and for the placing of the Contractor's plant and equipment, but any additional space required therefore must be provided by them at their expense. Private property shall not be used for storage purposes without written permission of the owner or lessee, and if requested by the Engineer, copies of such written permission shall be furnished. All storage sites shall be restored to their original condition by the Contractor at their expense. This shall not apply to the stripping and storing of topsoil, or to other materials salvaged from the work.

Care shall be exercised to protect finished concrete surfaces from being stained from storing or placing materials, including but not limited to reinforcing bars or mesh or unpainted structural steel, on same. Any such material so stored shall be adequately protected from weather. Any stains resulting from storage of materials on finished concrete surfaces shall be removed by the Contractor at their expense.

Aggregate stockpiles may be made on ground that is denuded of vegetation, hard, and well drained. If necessary, the ground shall be covered with two inch (50 mm) plank. Different kinds and sizes of aggregates shall be kept separate during transportation, handling, and storage until batched. If necessary, partitions of suitable height and strength shall be constructed between stockpiles to prevent different materials from becoming mixed. Care must be taken to prevent segregation of the coarse and fine particles of aggregates from taking place during handling or hauling. The inclusion of foreign materials will not be permitted. Aggregates placed directly on the ground shall not be removed from the stockpiles within one foot (300 mm) of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used.

106.6-HANDLING MATERIALS:

All materials shall be handled in such manner as to preserve their quality and fitness for the work. Aggregates shall be transported from the storage site to the work in tight vehicles, so constructed as to prevent loss or segregation of materials after loading and measuring, in order that there may be no inconsistencies in the quantities of materials intended for incorporation in the work as loaded and the quantities as actually received at the place of operations.

106.7-UNACCEPTABLE MATERIALS:

106.7.1-Acceptance or Rejection: Following the application of the appropriate acceptance plan, the decision of the Engineer will be final as to the acceptance, rejection, or acceptance at an adjusted price of sampled lots or sublots.

106.7.2-Disposition of Lots or Sublots: Lots or sublots not conforming to specification requirements may be reworked or removed and replaced and resubmitted for acceptance. All nonconforming lots or sublots evaluated as unsatisfactory for the use intended shall be reworked or removed and replaced and resubmitted for acceptance. When the evaluation indicates the lots or sublots may satisfactorily remain in place, acceptance will be an adjusted price as stated in the Specifications or as directed by the Engineer.

106.8-DIVISION-FURNISHED MATERIAL:

The Contractor shall furnish all materials required to complete the work, except those specified to be furnished by the Division.

Materials furnished by the Division will be delivered or made available to the Contractor at the points specified in the Contract.

The cost of handling and placing all materials after they are furnished to the Contractor shall be considered as included in the contract price for the item in connection with which they are used.

The Contractor will be held responsible for all material delivered to them, and deductions will be made from any monies due the Contractor to make good any shortages and deficiencies, from any cause whatsoever, and for any damage which may occur after such delivery, and for any demurrage charges.

106.9-SILENCE OF SPECIFICATIONS:

The apparent silence of these Specifications, Supplemental Specifications, plans and Special Provisions as to any detail, or the apparent omission from them of a detailed description concerning any point shall be regarded as meaning that only material and workmanship of acceptable quality are to be used.

SECTION 107

LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

107.1-LAWS TO BE OBSERVED:

The Contractor shall keep fully informed of all Federal and State laws, all local laws, ordinances, and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on the work, or which in any way affect the conduct of the work. The Contractor shall at all times observe and comply with all such laws, ordinances, regulations, orders and decrees; and shall protect and indemnify, defend and hold DOH harmless from any and all claims, liabilities and causes of action for any fines or penalties imposed on DOH by any state or federal agency because of violation by Contractor or any of its subcontractors and/or consultants of any state or federal law or regulation.

107.2-PERMITS, LICENSES AND TAXES:

The Contractor shall procure all permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incidental to the due and lawful prosecution of the work.

The Contractor shall provide the Division with sufficient documentation that all applicable taxes have been paid within 120 days of the project acceptance as provided for in 105.16. The Division shall have the right to revoke the Contractor's Prequalification until the Contractor provides sufficient documentation that all taxes have been paid or are the subject of a timely filed dispute currently pending in a court or other body having legal authority and jurisdiction to hear the dispute.

107.3-PATENTED DEVICES, MATERIALS, AND PROCESSES:

If the Contractor employs any design, devise, material, or process covered by letters of patent or copyright, the Contractor shall provide for such use by suitable legal agreement with the patentee or owner. The Contractor and the surety shall indemnify and save harmless the Division, and affected third party, or political subdivision from and claims for infringement by reasons of the use of any such patented design, device, material or process, or any trademark or copyright, and shall indemnify the Division for any costs, expenses, and damages which it may be obligated to pay by reason of any infringement, at any time during the prosecution or after the completion of the work.

107.4-RESTORATION OF SURFACES OPENED BY PERMIT:

The right to construct or reconstruct any utility service in the highway or street or to grant permits for same, at any time, is expressly reserved by the Division for the proper authorities of the municipality in which the work is done, and the Contractor shall not be entitled to any damages either for the digging up of the street or for any delay occasioned.

Any individual, firm, or corporation wishing to make an opening in the highway must secure a permit from the Division. The Contractor shall allow parties bearing such permits, and only those parties, to make openings in the highway. The Contractor shall, when ordered by the Engineer, make in an acceptable manner all necessary repairs due to such openings and such necessary work will be paid for as "Extra Work", or as provided in these Specifications, and will be subject to the same conditions as original work performed.

107.5-FEDERAL-AID PROVISIONS:

When the United States Government pays any portion of the cost of a project, the Federal Laws and the Rules and Regulations made pursuant to such laws must be observed by the Contractor, and the work shall be subject to the inspection of the appropriate Federal Agency.

Such inspection shall in no sense make the Federal Government a party to the Contract and will in no way interfere with the rights of either party hereunder.

107.6-SANITARY PROVISIONS:

The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of their employees as may be necessary to comply with the requirements of the State and local Boards of Health, or of other bodies or tribunals having jurisdiction. The Contractor shall not create, commit, or maintain a public nuisance.

107.7-PUBLIC CONVENIENCE AND SAFETY:

The Contractor shall at all times so conduct their work as to assure the least possible obstruction to traffic. The safety and convenience of the general public and the residents along the highway and the protection of persons and property shall be provided for by the Contractor as specified under 104.5.

The Contractor shall comply with all applicable Federal, State, and local laws governing safety, health and sanitation. The Contractor shall provide all safeguards, safety devices and protective equipment and take any other needed actions, on their own responsibility, or as the Engineer may determine, reasonable necessary to protect the life and health of employees on the job and the safety of the public and to protect property in connection with the performance of the work covered by the Contract.

The Contractor and any subcontractor shall not require any laborer or mechanic employed in performance of the Contract to work in surroundings or under working conditions which are unsanitary, hazardous, or dangerous to their health or safety, as determined under construction safety and health standards (Title 29, Code of Federal Regulations, Part 1926, formerly Part 1518, as revised from time to time). promulgated by the United States Secretary of Labor, in accordance with Section 107 of the Contract Work Hours and Safety Standards Act (83 Stat. 96).

107.7.1-Safety Plan: The Contractor shall comply with this subsection if the Total Contract Bid Amount exceeds \$2,000,000 or is otherwise noted on the plans. The contractor will provide a copy of the company comprehensive safety and health program and the name of the company safety officer at the preconstruction conference or prior to start of work. A copy of the comprehensive safety and health program for each subcontractor and the name of the company safety officer must be submitted with the request for subcontract approval. The company comprehensive safety and health program should be in accordance with ANSI A10.38-1991, "Basic Elements of an Employer Program to Provide a Safe and Healthful Work Environment" or equivalent.

A site specific safety plan covering the work of the prime contractor and all known subcontractors must be prepared and submitted at the preconstruction conference or prior to the start of work. The site specific plan must include the name of the competent person(s) responsible for safety at the project site. As additional subcontracts are negotiated the site specific safety plan for that work can be submitted with the subcontract request.

Contractor employees shall be provided hazard recognition and avoidance training. Further, newly employed workers shall be provided safety orientation training prior to being assigned any task. This training can be provided by the contractor or the contractor's representative. Likewise, training provided by other sources based on an employee's initiative or his or her affiliation with the other groups is permissible. All training should be current and up to date with appropriate refresher courses provided if previous training was not within the last three years.

All contractor safety training shall be administered or monitored by the contractor's qualified representative, known as the company safety officer. "Qualified" means one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated his or her ability to solve or resolve problems relating to the subject matter, the work or the project. Acceptable training for this individual to be considered qualified includes, but is not limited to, completion of the 30-hour OSHA 500 Trainer Course in Occupational Safety and Health Standards for the Construction Industry or its equivalent.

The Contractor or Subcontractor working on the project will conduct weekly safety "tool box" talks to discuss relevant safety issues and this meeting will be open to attendance and active participation by the on-site Division of Highways Staff.

107.8-RAILWAY-HIGHWAY PROVISIONS:

The Contractor shall comply with the following provisions when performing any operations within the existing right of way of the Railroad or when railroad protective insurance is required by the contract documents. Railroad Protective insurance shall include all of the work set forth in 107.8 with exception of the provisions of sections 107.8.7 and 107.8.8.

107.8.1-Notice of Starting Work: The Contractor shall not start any work on Railroad right of way until he has complied with the following conditions:

- (a) Give the Railroad's Chief Engineer written notice at least ten days in advance of the date he proposes to begin work on or adjacent to the Railroad right of way.
- (b) Obtain written approval from the Railroad of the Railroad Protective Insurance coverage as required herein.
- (c) Obtain written authorization from the Railroad to begin work on Railroad right of way. This authorization can be expected within two weeks after insurance has been approved.

107.8.2-Insurance: The Contractor shall secure and provide, until all work under the terms of the project is satisfactorily completed and accepted, the following types of insurance in the amounts and form as hereinafter set forth:

107.8.2.1-Contractor's Public Liability Insurance and Protective Public Liability Insurance: CGL coverage as required by Section 103.6.1 shall be written with a \$2,000,000 Each Occurrence Limit. This limit may be single limit of primary coverage or a combination of primary and excess coverage which will meet the \$2,000,000 requirement. A certificate of insurance shall be provided to the Railroad before work begins and said certificate shall provide the Railroad thirty (30) days advance written notice of cancellation or material change in insurance coverage. If any part of the work is sublet,

Commercial General Liability Insurance and evidence thereof in the same amounts as required of the Prime Contractor, shall be provided by or in behalf of the subcontractor to cover his operations on railroad right of way.

107.8.2.2-Railroad Protective Liability Insurance: With respect to the operations performed by the Contractor or subcontractors of any tier the Contractor must provide in the name of Railroad. This policy shall be written on the ISO/RIMA Form of Railroad Protective Insurance (ISO Form CG00350690) with Pollution Exclusion Amendment ISO Form CG 28311185 or their equivalents). The policy of insurance specified in this section shall be countersigned by a resident agent of the State of West Virginia in accordance with Section 103.6.5. The original of the policy shall be submitted to and approved by the Railroad before work is commenced on its right of way or within 200 feet of the nearest track or 1000 feet if blasting is required for the construction.

107.8.2.2.1-Railroad Protective Liability Insurance Limits for Non-Passenger Railway Facilities: A policy providing a limit of \$2,000,000 per occurrence for bodily injury and property damage combined. Said insurance shall be furnished with an aggregate of \$6,000,000 applying separately to each annual period.

107.8.2.2.2-Railroad Protective Liability Insurance Limits for Passenger Railway Facilities: A policy providing a limit of \$5,000,000 per occurrence for bodily injury and property damage combined. Said insurance shall be furnished with an aggregate of \$10,000,000 applying separately to each annual period.

107.8.3-Use of Grade Crossings: If the Contractor desires a temporary grade crossing of the Railroad's tracks other than that shown in the project plans; to use an existing private grade crossing; or to use an existing public grade crossing with unlicensed construction equipment, the Contractor shall make arrangements in writing with the Railroad and will be required to bear all costs, including flagging, incidental to such crossings.

107.8.4-Interference with Railroad Operations: All work to be performed by the Contractor shall be performed in a manner agreeable to the Railroad's Chief Engineer. The Contractor shall use reasonable care and diligence and cooperate with officials of the Railroad in order to avoid accidents, damages or unnecessary delay to, or interference with train movement of the Railroad.

When work within Railroad right of way is of a nature that it impedes Railroad operations such as, but not limited to, use of runaround tracks or the necessity for reduced speed, the Contractor shall schedule and conduct his operations so that such impediment is reduced to the absolute minimum.

Any cost incurred by the Railroad for repairing damages to its property or to property of its tenants, caused by or resulting from the operations of the Contractor, shall be paid directly to the Railroad by the Contractor.

The Contractor shall assume all liability for any and all damages to his work, employees, subcontractor, equipment and materials caused by Railroad traffic.

No charge or claim of the Contractor against either the Division or the Railroad will be allowed for hindrance or delay on account of train traffic, work done by Railroad, delay

incident to or necessary for safe operation and maintenance of the railroad or any delays due to compliance with these special provisions.

107.8.5-Construction Procedures: It shall be the Contractor's responsibility to arrange a schedule with the Railroad for accomplishing his work and the Railroad's or its tenants work. The Contractor in arranging a schedule shall ascertain, from the Railroad, the lead time required for assembling crews and materials and shall make due allowance therefor.

The Contractor shall submit to the Railroad's Chief Engineer, with a copy to the Division of Highways, work schedule and information regarding methods and procedures for performing work, e.g., plans and specifications for shoring and sheeting, and for protective shields covering all Railroad facilities. The Contractor shall obtain Railroad approval before commencing said work.

The Contractor shall take special precaution and care when excavating for shoring pits and footers adjacent to tracks and in driving piles to always provide adequate lateral support for the tracks and the loads which they carry, so as not to disturb the track alignment and surface and to avoid obstructing track clearances with working equipment, tools or materials.

A copy of the Contractor's blasting sequence will be provided to the railroad for their information prior to any blasting. The Contractor shall obtain specific approval of the Railroad's Chief Engineer for use of explosives on Railroad property.

All construction equipment that is parked near the track shall be effectively immobilized so that it cannot be moved by unauthorized persons.

Materials and equipment shall not be stored where they will interfere with Railroad operations, nor on the right of way of the Railroad without first having obtained written permission from the Railroad's Chief Engineer.

The Contractor will be required to maintain all ditches and drainage structures and keep them free of silt or other obstructions, to promptly repair eroded areas within Railroad right of way and to repair any other damage to the property of the Railroad or its tenants which may be the results of their operations.

Upon completion of the work, the Contractor shall remove from within the limits of the Railroad's right of way, all machinery, equipment, surplus materials, falsework, rubbish or temporary buildings which belong to the Contractor and leave said right of way in a condition satisfactory to the Railroad's Chief Engineer.

107.8.6-Track Clearances: The minimum track clearances to be adhered to by the Contractor during construction will be 15 feet (3 m) from centerline of the track or as approved by the Railroad's Chief Engineer. However, before undertaking any work within Railroad right of way or before placing any obstruction over any track, the Contractor shall:

- a) Notify the Railroad's Chief Engineer at least 72 hours in advance of work.
- b) Receive assurance from the Railroad's Chief Engineer that arrangements have been made for any flagging services necessary.
- c) Receive permission from the Railroad's Chief Engineer to proceed with the work.

107.8.7-Flagging Services: Under the terms of the agreement between the Division and the Railroad, the Railroad has sole authority to determine the need for flagging required to protect its operations.

In general, the services of Railroad flaggers will be requested when the Contractor's operations will be on or over the Railroad's right of way: (a) during the excavation, placing and removal of cofferdams, sheeting, shoring, driving of piling or placing of concrete footers adjacent to the track; (b) driving of pile bents adjacent to the track; (c) construction of the permanent structure including erection and removal of falsework, bracing or forms over or adjacent to the track; (d) transporting material or equipment across the track; (e) any operations involving direct interference with and/or coming in the close vicinity of power lines or Railroad signal and communication lines, underground cables, fuel oil facilities or pipelines which might result in fire or damage to such facilities to endanger Railroad operations or to endanger the public in the transacting of business on Railroad right of way; (f) fouling of operating clearances or reasonable probability of accidental hazard to Railroad traffic; (g) during removal of portions of existing structures immediately over or adjacent to a track; and (h) at all other times when the Railroad's Chief Engineer has determined conditions require such protection.

Flagging hours shown in the plans shall be reviewed by the Contractor and will be used as the approved flagging hours. If the Contractor feels that the hours shown in the plans are not correct, he shall submit to the Engineer, in writing within 60 days of the award of the project, his estimate for review and approval. The Department shall have 30 days to approve the revised flagging hours. Additional hours may be permitted per Section 104.9.

Additionally, all flagging charges resulting from any work done solely for the benefit of the Contractor will be deducted from the current estimate, due the Contractor.

If the Contractor works within distances that violate instructions given by the Railroad's Chief Engineer or performs work that has not been coordinated with the Railroad's Chief Engineer, a flagman may be required full time at Contractor's expense until the project has been completed.

Any work to be performed by the Contractor which requires flagging service or inspection service (watchman) shall be deferred by the Contractor until the flagging service or inspection service required by the Railroad is available at the job site.

The Contractor shall furnish to the Railroad and the Division of Highways a schedule for all work required to complete the portion of the project within Railroad right of way and arrange for a job site meeting between the Contractor, the Division of Highways, and the Railroad's Chief Engineer. A flagman may not be provided until the job site meeting has been conducted and the Contractor's work schedule provided.

The Contractor will be required to give the Railroad's Chief Engineer at least ten working days of advance written notice of his intent to begin work within Railroad right of way. Once work is begun, and is then suspended at any time for any reason, the Contractor will be required to give the Railroad's Chief Engineer at least three working days advance notice before resuming work on Railroad right of way. Such notice shall include sufficient details of the proposed work to enable the Railroad representative to determine if flagging will be required. Initially, it may take up to 30 days to obtain flagging from the Railroad. When flagging begins, the flagman is usually assigned by the Railroad to work at the project site on a continual basis until no longer needed. A flagman cannot be called for on a spot basis. If flagging becomes unnecessary and is suspended, it may again take up to 30 days to obtain a flagman from the Railroad. Due to Railroad labor agreements, it may be necessary to give five working days notice before flagging service may be discontinued and responsibility for payment stopped.

The Division of Highways will reimburse the Railroad directly for all costs incurred for flagging services by Railroad personnel, including any temporary grade crossing shown in the

project plans up to the amount of hours shown on the Division's Project plans. In the event the Division of Highways is required to reimburse the Railroad for flagging service in excess of the approved flagging hours, such excess cost will be deducted from the monthly and/or final statements of money due the Contractor.

The Railroad flagman assigned to the project will be responsible for notifying the Project Engineer upon arrival at the job site on the first working day that flagging services begin and on the last day that he performs such services. This will be required for each separate period that services are provided. The Project Engineer will document such notification in the project records. When requested, the flagman will also sign the Inspector's daily report form showing daily time spent and activity performed at the project site.

The Contractor and Division of Highways will review and sign the Railroad flagman's time sheet, attesting that the flagman was present during the time recorded. Flagman may be removed by Railroad if form is not signed. If flagman is removed, the Contractor will not be allowed to work on or re-enter the Railroad right of way until the issue is resolved.

107.8.8-Failure to Comply: In the event the Contractor violates or fails to comply with any of the requirements of these provisions:

- a) The Railroad's Chief Engineer may require that the Contractor vacate Railroad property.
- b) The Division may stop all work adjacent to the Railroad.

Any such orders shall remain in effect until the Contractor has remedied the situation to the satisfaction of the Railroad's Chief Engineer and the Division of Highways.

All costs incurred resulting from compliance with these provisions shall be incidental to the items in the contract and no separate payment shall be made.

107.9-BRIDGES OVER NAVIGABLE WATERS:

All work on navigable waters shall be so conducted that free navigation of the waterways will not be interfered with and that the existing navigable depths and vertical clearances will not be impaired except as by the U.S. Army Corps of Engineers and/or the U.S. Coast Guard.

107.10-BARRICADES AND WARNING SIGNS:

The Contractor shall provide, erect, and maintain all necessary barricades, suitable and sufficient lights, danger signals, signs, and other traffic control devices, except as provided by 104.5, and the Contractor shall take all necessary precautions for the protection of the work and safety of the public. Highways closed to traffic shall be protected by effective barricades, and obstructions shall be illuminated during hours of darkness. Suitable warning signs shall be provided to properly control and direct traffic.

The Contractor shall erect warning signs in advance of any place on the project where operations may interfere with the use of the road by traffic and at all intermediate points where the new work crosses or coincides with an existing road. Such warning signs shall be erected in accordance with the Plans furnished.

All barricades, warning signs, lights, temporary signals, and other protective devices must conform with the Standard "Traffic Control for Street and Highway Construction and Maintenance Operations," Published by the West Virginia Division of Highways, and the provisions of 715.9.

107.11-USE OF EXPLOSIVES:

When the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be responsible for any and all damage resulting from the use of explosives.

All explosives shall be stored in a secure manner, in compliance with all laws and ordinances, and all such storage places shall be clearly marked. Where no local laws or ordinances apply, storage shall be provided satisfactory to the Engineer and in general not closer than 1,000 ft. (305 meters) from the road or from any building or camping area or place of human occupancy.

The Contractor shall notify each public utility company, having structures in proximity to the site of work, of their intention to use explosives and such notice shall be given sufficiently in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury.

107.12-PROTECTION AND RESTORATION OF PROPERTY AND LANDSCAPE:

The Contractor shall be responsible for the preservation of all public and private property and shall protect carefully from disturbance or damage all land monuments and property marks until the Engineer has witnessed or otherwise referenced their location and shall not move them until directed.

The Contractor shall be responsible for all damage or injury to property of any character, during the prosecution of the work, resulting from any act, omission, neglect, or misconduct in the Contractor's manner or method of executing the work, or at any time due to defective work or materials, and this responsibility will not be released until the project shall have been completed and accepted.

When or where and direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the work, or in consequence of the nonexecution thereof by the Contractor, the Contractor shall restore, at their own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring as may be directed, or the Contractor shall make good such damage or injury in as acceptable manner.

107.13-FOREST PROTECTION:

In carrying out work within or adjacent to State or National Forests, the Contractor shall comply with all regulations of the State Fire Marshall, Division of Natural Resources, or any other authority having jurisdiction, governing the protection of forests and the carrying out of work within forests, and shall observe all sanitary laws and regulations with respect to the performance of work in forest areas. The Contractor shall keep the areas in an orderly condition, dispose of all refuse, and obtain permits for the construction and maintenance of all construction camps, stores, warehouses, residences, latrines, cesspools, septic tank, and other structures in accordance with the requirements of the Forest Supervisor.

The Contractor shall take all reasonable precaution to prevent and suppress forest fires and shall require their employees and subcontractors, both independently and at the request of forest officials, to do all reasonably within their power to prevent and suppress and to assist in preventing and suppressing forest fires and to make every possible effort to notify a forest official at the earliest possible moment of the location and extent of any fire seen by them.

107.14-RESPONSIBILITY FOR DAMAGE CLAIMS:

The Contractor shall indemnify and save harmless the Division, its officers and employees, from all suits, actions, or claims of any character brought because of any injuries or damage received or sustained by any person, persons, or property on account of the operations of the Contractor, its subcontractors and/or consultants; or on account of or in consequence of any neglect in safeguarding the work; or through use of unacceptable materials in constructing the work; or because of any act or omission, neglect, or misconduct of the Contractor its subcontractors and/or consultants; or because of any claims or amounts recovered from any infringements of patent, trademark, or copyright; or from any claims or amounts arising or recovered under the "Worker's Compensation Act," or any other law, ordinance, order, or decree; and so much of the money due the Contractor under and by virtue of their Contract as may be considered necessary by the Division for such purpose may be retained for the use of the Division or, in case no money is due, their surety may be held until such suit or suits, action or actions, claim or claims for injuries or damages as aforesaid shall have been settled and suitable evidence to that effect furnished to the Division; except that money due the Contractor will not be withheld when the Contractor produces satisfactory evidence that the Contractor is adequately protected by public liability and property damage insurance.

107.15-OPENING SECTIONS OF PROJECT TO TRAFFIC:

At the option of the Engineer, certain sections of the work may be opened for traffic. Such opening will not constitute acceptance of the work, or any part thereof, or a waiver of any provisions of the Contract; provided however, that on such portions of the project as are accepted for use of traffic, the Contractor shall not be required to assume any expense entailed in maintaining the roadway for traffic. Such expense will be borne by the Division or will be compensated for in the manner provided in 109.4. Any damage to the highway not attributable to traffic which might occur on such section, except slides, shall be repaired by the Contractor at their expense. The removal of slides shall be performed by the Contractor and payment will be in accordance with 104.3.

If the Contractor is dilatory in completing shoulders, drainage structures, or other features of the work, the Engineer may order all or a portion of the project open to traffic, but in such event the Contractor shall not be relieved of their liability and responsibility during the period the work is so opened prior to final acceptance. The Contractor shall conduct the remainder of their construction operations so as to cause the least obstruction to traffic.

107.16-CONTRACTOR'S RESPONSIBILITY FOR WORK:

Until final written acceptance of the project by the Engineer, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements, or from the nonexecution of the work. The Contractor shall rebuild, repair, restore, and make good all injuries or damages to any portion of the work occasioned by any of the above causes before final acceptance and shall bear the expense thereof except damage to the work due to unforeseeable causes beyond the control of and without the fault of or negligence of the Contractor, including but not restricted to acts of God, of the public enemy or governmental authorities.

In case of suspension of work from any cause whatever, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and to erect any necessary temporary structures, signs, or

other facilities at their expense. During such period of suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seeding, and sodding furnished under their Contract, and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

107.17-CONTRACTOR'S RESPONSIBILITY FOR UTILITY PROPERTY AND SERVICES:

At points where the Contractor's operations are adjacent to properties of railway, telegraph, telephone, and power companies, or are adjacent to other property, damage to which might result in considerable expense, loss, or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner, that duplication of rearrangement work may be reduced to a minimum, and that services rendered by those parties will not be unnecessarily interrupted.

In the event of interruption to water or utility services as a result of accidental breakage, or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with such authority in the restoration of service. If water service is interrupted, repair work shall be continuous until the service is restored. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

107.18-FURNISHING RIGHT-OF-WAY:

The Division will be responsible for securing all necessary right-of-way in advance of construction. Any exceptions will be indicated in the Contract.

107.19-PERSONAL LIABILITY OF PUBLIC OFFICIALS:

In carrying out any of the provisions of these Specifications, or in exercising and power or authority granted to them by or within the scope of the Contract, there shall be no liability upon the Commissioner, Engineer, or their authorized representatives, either personally or as officials of the State, it being understood that in all such matters they act solely as agents and representatives of the Division.

107.20-NO WAIVER OF LEGAL RIGHTS:

The Division shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefor, from showing the true amount and character of the work performed and materials furnished by the Contractor, nor from showing that any such measurement, estimate or certificate is untrue or is incorrectly made, nor that the work or materials do not in fact conform to the Contract. The Division shall not be precluded or estopped, notwithstanding and such measurement, estimate, or certificate and payment in accordance therewith, from recovering from the Contractor or sureties, or both, such damage as it may sustain by reason of their failure to comply with the terms of the Contract. Neither the acceptance by the Division or any representative of the Division, nor any payment for or acceptance of the whole or any part of the work, nor any extension of time, nor any possession taken by the Division, shall operate as a waiver

of any portion of the Contract or of any power reserved or of any right to damages. A waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach.

107.21-PROTECTION OF RIVERS, STREAMS, AND IMPOUNDMENTS:

107.21.1-Erosion and Sedimentation Control: The Contractor shall be responsible for water quality throughout the duration of construction in accordance with the National Pollutant Discharge Elimination System (NPDES) permit registration with the West Virginia Department of Environmental Protection Agency (WVDEP). The Contractor will be responsible for the following:

- i. Developing and implementing an effective erosion and sediment control plan.
- ii. Directing the construction, operation, maintenance and dismantling of temporary erosion and sediment control features.
- iii. Implementing remedial action to correct and/or repair failing erosion and sediment control features.
- iv. Implementing storm and winter shutdown procedures.
- v. Shaping the earthwork prior to the suspension of grading operations each day in a manner that will permit storm runoff with minimum erosion.
- vi. Installing, operating and maintaining erosion and sediment control features in an acceptable condition.
- vii. Cleaning out and restoring to original conditions any erosion or sediment control feature that has reached half of its capacity. For sediment basins, one half of its capacity is considered as wet volume storage.

The Contractor shall prepare a Spill Prevention, Control and Countermeasures (SPCC) plan that itemizes specific measures that will be implemented to prevent and clean up chemical and petroleum product spills that may occur during all phases of construction. Fuel storage and refueling activities, equipment maintenance activities and equipment washing will be kept at least 500 feet away from any watercourse or wetland.

Any details not shown in the plans shall be in accordance with the latest version of the West Virginia Division of Highways Erosion and Sediment Control Manual. In the event that temporary erosion and sediment control measures are necessary due to the Contractor's negligence, carelessness or failure to install permanent controls as part of the work as scheduled, such work shall be performed by the Contractor at his own expense.

In addition to the above, the Contractor shall make themselves familiar with all requirements contained within the WVDEP's General Water Pollution Control Permit, Stormwater Associated with Construction Activities Permit Number WV0115924. A copy of this permit can be found at the following internet address:

<http://www.dep.wv.gov/WWE/Programs/stormwater>

Noncompliance with permit conditions constitutes a violation of the Clean Water Act and State Code and is subject to enforcement action by the WVDEP.

At the Project's Pre-Construction Conference, the Contractor shall submit to the Department in addition to the appropriate number of Erosion and Sediment Control Plans, the Co-Applicant #1 signature page (Exhibit 1) and the Contractor's E&S Manager Contact.

The Contractor's E&S Contact shall contain the following information: the name, title, mailing address and telephone number of the person who will be responsible for the Erosion and Sediment Control plans, implementation, maintenance, etc., for the life of the NPDES registration.

Upon completion of the Pre-Construction Conference, the Department will modify the existing NPDES registration for this project to make the Contractor the number one Co-Applicant to the permit. Once this has been completed, the Contractor shall be responsible for any and all fees, violations and fines assessed against the project that is a result of the Contractor's negligence, carelessness, or failure to install permanent controls as part of the work as scheduled.

Once the project is complete, the Contractor will still bear responsibility for the NPDES registration until either a Notice of Termination (NOT) is received from the WVDEP or the Contractor has received final payment for the project. If an NOT has not been received by the time the final payment is made, the Department will modify the NPDES registration to remove the Contractor's name from the registration.

Exhibit 1 can be located online at:

<http://www.transportation.wv.gov/highways/contractadmin/specifications/107.21.1EnSExhibit1/Pages/default.aspx>

107.21.2-Pollution: The Contractor shall exercise every reasonable precaution throughout the life of the Project to prevent pollution of rivers, streams, or impoundments. Pollutions such as chemicals, fuels, lubricants, bitumen, raw sewage, products associated with bridge cleaning and painting, and other harmful wastes shall not be discharged into or alongside of rivers, streams, impoundments, or into natural or man-made channels leading thereto. The quality of the surface waters affected by construction shall meet the requirements of the West Virginia Code, Volume 8A, Chapter 22, Article 11.

The manual entitled, "West Virginia Division of Highways, Best Management Practice for Containment/Disposal of Waste Products Generated during Bridge Cleaning and Painting Activities". Latest addition, as amended is made part of the contract as a guide to follow for containment/disposal activities.

107.21.3-Basis of Payment: Except when pay items are specifically described and furnished as pay items in 642, Temporary Pollution Control, the water pollution and erosion and siltation control requirements set forth shall be at the expense of the Contractor.

107.22-PLANT PEST REGULATIONS:

The indiscriminate movement of nursery stock, hay or straw mulch, equipment and soil samples into and out of West Virginia constitutes a potential hazard to State and National Agriculture. Therefore, it shall be the responsibility of the prime Contractor to comply with all applicable State and Federal Plant Pest Regulations in the fulfillment of this contract.

Information regarding these regulations may be obtained from Plant Pest Control Division, West Virginia Department of Agriculture, Charleston, West Virginia 25305, or United States Department of Agriculture, Agriculture Research Service, Plant Pest Control Division, P.O. Box 1257, Roanoke, Virginia 24001.

107.23-AIR POLLUTION CONTROL:

The Contractor shall exercise every reasonable precaution throughout the life of the project to keep air pollution to a minimum. The Contractor shall also comply with the applicable regulations of the West Virginia Air Pollution Control Commission. During times of limited dispersion, construction operations may be suspended.

All plants in West Virginia producing bituminous concrete for the Division shall obtain a permit or certification from the West Virginia Air Pollution Control Commission.

107.24-CLEAN WATER ACT/WETLANDS:

The Contractor will comply with all aspects of Section 404 of the Clean Water Act including any and all regards to wetlands on all work associated with the project. A wetland will not be filled or disturbed on the project or any work related to the project such as a haul road, waste area, borrow pit or any other activity without a permit.

107.25-LEAD EXPOSURE IN CONSTRUCTION:

The Contractor will comply with all aspects of 29 CFR, Part 1926, Lead Exposure in Construction, by the United States Department of Labor, Occupational Safety and Health Administration.

107.26-NOTIFICATION OF ABATEMENT, DEMOLITION OR RENOVATION:

The notification for projects involving abatement, demolition, or renovation will conform to this section. The Project Engineer will have a copy of all asbestos inspection reports available at the field office. The Contractor shall provide copies of all notifications and correspondence to the Project Engineer.

107.26.1-Abatement: Abatement activities shall conform to section 681.

107.26.2-Demolition:

107.26.2.1-Asbestos Containing Materials Reported: Notifications will be in accordance with 107.26.4.

107.26.2.2-No Asbestos Containing Materials Reported: For buildings or bridges that do not contain asbestos, *only the notification form* must be submitted to the West Virginia Division of Environmental Protection (DEP) and the United States Environmental Protection Agency (EPA) at the address given in 107.26.4.

If an asbestos inspection report indicates that there is no asbestos present on a bridge scheduled for demolition or renovation, the need for a trained individual to be on site during either process is waived. However, the Contractor shall have an individual trained in accordance with the provisions as set forth in 40 CFR Part 61, Subpart M on site to observe building demolition and file a report with the Project Engineer indicating if any suspect (asbestos containing) material was encountered during demolition. A copy of the individual's current training certification must be attached to this report.

107.26.3-Renovation:

107.26.3.1-Asbestos Containing Materials Reported: For projects involving the renovation of a bridge or building, that has asbestos containing materials, the Contractor shall submit a "Notification of Abatement, Demolition or Renovation" in accordance with 107.26.4.

107.26.3.2-No Asbestos Containing Materials Reported: Structures that are being renovated and are free of asbestos, per the inspection report, do not require submittal of the "Notification of Abatement, Demolition or Renovation".

107.26.4-Notifications: In accordance with state and federal regulations, the Contractor shall submit a “Notification of Abatement, Demolition or Renovation” to the address shown below prior to the commencement of demolition of any building or bridge (regardless of the presence of asbestos). All notifications must be made a minimum of 10 working days prior to the commencement of demolition or renovation operations. Particular attention is to be made to the “Schedule” section of the form. If for any reason, demolition or renovation cannot begin on the date as submitted, the DEP, Division of Air Quality must be notified at the address below:

West Virginia Division of Environmental Protection
Division of Air Quality
601 57th Street S.E.
Charleston, West Virginia 25304
Attn: Asbestos Coordinator
Telephone: (304) 926-0499
Fax: (304) 926-0478

United States Environmental Protection Agency-Region 3
1650 Arch Street
Philadelphia, Pennsylvania 19103
Attn: Stephen Forostiak, 3WC32
Asbestos Coordinator
Telephone: (215) 814-2100
Forostiak.stephen@epa.gov

If a building or bridge contains asbestos, the notification process as outlined in Section 681, Asbestos Abatement shall be followed.

107.27-CONSTRUCTION ACCESS AND ENVIRONMENTAL PERMITS:

The Division has obtained permits for activities shown in the contract documents. The anticipated Temporary Construction Access (TCA) methods are included, if a TCA is not shown in the plans, or the permit, it has been determined that at least one TCA method exists that does not require a permit. A copy of these permits is in the contract documents.

The contractor must comply with the approved permits and exercise best environmental management practices at no additional cost to the Division.

The permits do not cover waste or borrow sites, haul roads, storage sites, staging areas or activity not shown in the contract documents or permits. These permits are to be handled in accordance with Section 107.2.

107.27.1-Temporary Construction Accesses: A Temporary Construction Access is any road, cofferdam, causeway and/or stream crossing, access fill, dike, channel retaining structure, etc. that may be required to access the work. This work shall consist of the construction of all temporary construction access required for the project and shall include, but is not limited to, all culverts, structures, excavation, rock borrow and incidental construction as required to construct the access. This work shall also include all necessary work required to maintain and remove the temporary construction access and to restore the area to its original condition. All of the work shall be in accordance with these Specifications and in reasonably close conformity with the contract documents, approved permits, or as established by the Engineer.

No payments shall be made for the Temporary Construction Access unless otherwise stated in the plans.

107.27.1.1-Changing Temporary Construction Accesses: The Contractor may elect to utilize alternate temporary construction access methods from those shown in the contract documents. If the Contractor proposes alternate temporary construction access methods, he shall obtain written approval from all affected landowners and shall provide to the Engineer all of the permit documents required to obtain additional or revised permits. The Division will submit the permit documents to the appropriate agencies for approval. Acceptance of the permit documents by the Engineer or forwarding them to the permitting agency does not guarantee or constitute approval of the permit. No work shall be performed on a permissible activity until a copy of all the appropriate approvals and permits are received by the Engineer. No time extensions or additional payments will be made for the contractor to obtain additional approvals or permits or for changes to the design of the temporary construction access.

107.27.1.2-Excavated Material: The excavated material, unless otherwise directed by the Engineer, shall be utilized for backfill or embankments. Surplus material shall be disposed in accordance with section 207.6 and in such a manner that the efficiency or appearance of the structure shall not be impaired, and the stream shall not be obstructed or excess sediment introduced into the stream.

107.27.2-Corps of Engineers Permit: If this project has been determined to involve activities, which are regulated by the Department of the Army, Corps of Engineers a permit has been included in the contract documents. These activities involve the discharge of dredge or fill materials into the Waters of the United States as regulated by Section 404 of the Clean Water Act or the obstruction or alteration of Navigable Waters of the United States regulated by Section 10 of the River and Harbor Act of 1899.

The Engineer will decide all questions that may arise as to the interpretation or violation of these conditions. The Contractor shall comply with the conditions of the Permits and the following:

1. Material will not be stockpiled in the watercourse.
2. Bilge, ballast or wash water pumped from barges or out of cofferdams will not be discharged into the watercourse without acceptable removal of solids, oils and/or toxic compounds.
3. Discharges shall be avoided during fish spawning seasons to the maximum extent practicable unless a note prohibiting such discharge is included in the construction plans.

SECTION 108 PROSECUTION AND PROGRESS

108.1-SUBLETTING OF CONTRACT:

The Contractor shall not sublet, sell, transfer, assign, or otherwise dispose of the Contract or Contracts or any portion thereof, or of their right, title, or interest, without written approval of the Engineer prior to any of the subject work being performed. The Contractor will be permitted to sublet a portion thereof but shall perform, with his/her own organization, work amounting to not less than 30 percent of the total contract cost, except that any items designated in the Contract as "specialty items" may be performed by subcontract and the cost of any such specialty items so performed by subcontract may be deducted from the total cost before computing the amount of work required to be performed by the Contractor with his/her own organization. No subcontracts, or transfer of contract, shall in any case release the Contractor of his/her liability under the Contract and Bonds.

The Contractor shall request the approval of each subcontractor, including lower-tier subcontractors. No work shall be performed by a subcontractor until the subcontractor has been approved. Each subcontract, including lower-tier subcontracts, shall be in writing and shall physically contain all of the applicable provisions, requirements, specifications, and safety plans. The Contractor may certify that a copy of all the applicable provisions, requirements, specifications, and safety plans has been provided and is physically incorporated in each subcontract including lower-tier subcontracts. Requests for approval of DBE subcontractors, however, shall also be accompanied by a copy of the proposed subcontract without the required attachments.

The Contractor shall maintain a complete subcontract file including lower-tier subcontractors at the home office, which shall be available to authorized personnel for review without notice, or at any other appropriate location as determined by the Division after a five day notice. Such file may contain a single copy of all the applicable provisions, requirements and specifications in lieu of individual subcontract files containing the applicable attachments.

108.1.1-Subletting Of Contract Materials: Roadside production of materials is construed to be the production of crushed stone, gravel, or other materials with portable or semi-portable crushing, screening, or washing plants established or re-opened in the vicinity of the work for the purpose of supplying materials to be incorporated into the work on a designated project or projects, and in all cases, unless performed by the Contractor, shall be considered as subcontracting.

The purchase of sand, gravel, crushed stone, crushed slag, batched concrete aggregates, ready mixed concrete, or any other materials produced at and furnished from established and recognized commercial plants, together with the delivery of such materials to the site of work by means of vehicles owned or operated by such plants or by recognized commercial hauling companies, shall not be considered as subcontracting under these provisions. Except as stated, all hauling of materials from roadside production sources or from railroad or water delivery points to batching plants, mixing plants, or directly to their place of use in the road, and all hauling of materials from batching plants and mixing plants to their place of use in the road, unless done by the Contractor's own equipment or by recognized hauling companies, shall be considered as subcontracting under these provisions. If batching plants or mixing plants are set up at rail or water delivery points and materials in part supplied to such plants by rail or

water transportation companies, the remaining materials required at such batching or mixing plants may be hauled to such plants without such hauling being considered as subcontracting.

108.2-NOTICE TO PROCEED:

The Notice to Proceed will stipulate the date on which it is expected the Contractor shall begin work and from which date Contract time will be charged. In the event a Notice to Proceed cannot be issued, a Conditional Notice to Proceed may be issued upon the mutual agreement of the Division and the Contractor. The Conditional Notice to Proceed will be used to allow the Contractor to begin work on a portion of the project not impacted by the issue that created the need for the Conditional Notice to Proceed.

108.3-PROSECUTION OF THE WORK:

108.3.1-General: The Contractor shall provide sufficient resources (materials, equipment, and labor, etc.) to guarantee the completion of the project in accordance with the Plans and Specifications within the time set forth in the Proposal.

The Contractor shall submit a Detailed Construction Schedule and any subsequent schedules, as required by this specification, in the form more clearly defined in section 108.3.2 with all graphic and tabular supporting documentation, hereinafter referred to as "Schedule."

Schedules will be required for all projects where the Contract Bid Amount is greater than \$2,000,000. Additionally any Project that contains an Incentive/Disincentive clause, and all Design Build projects and Public Private Partnership projects shall require a Schedule.

Unless otherwise specified, Schedules will not be required for projects on which the major portion of the work is resurfacing, landscaping, signing, lighting, installing signals, guardrail or bridge painting, or on which the Contract Bid Amount is \$2,000,000 or less.

The submitted Schedule shall include a written certification on the face of the Schedule, as well as on any diagrams and drawings, stating that the Schedule is within the contractual limits and that the submitted Schedule is the only Schedule the Contractor will use for all critical work activities, interdependent work activities, phase construction, stage construction, resource needs, transmittals for Contractor designs, drawings and other submissions, activities for subcontractors, vendors, and suppliers, and all other controlling and subsequent activities. This same written certification shall be included on all Schedule updates and revisions.

The Schedule shall show the interdependent and logical sequence of construction activities. The Schedule shall reflect that all contract time requirements are essential conditions of the Contract and shall also include allowances for seasonal weather conditions, the influence of high or low ambient temperatures, as well as any extra shifts, overtime, or additional manpower and equipment necessary to complete the critical and non-critical activities within the allotted Contract time without additional cost to the Division.

The Contractor shall provide a milestone that designates the substantial completion date of the project. Except as noted below, the substantial completion date shall equal the contract completion date. Additional activities that do not impact the project's substantial completion may be included in the Schedule subsequent to the contract completion date. However, these additional activities shall not impact the float of any preceding portion of the Schedule.

The Contractor may submit a Schedule with a Substantial Completion date earlier than the Contract Completion Date set forth in the Proposal. However, the Division will not be liable in any way for the Contractor's failure to complete the Project prior to the specified Contract Time except as when provided in Section 108.6. Any additional cost, including extended

overhead incurred between the Contractor's scheduled completion date and the Contract Completion Date set forth in the Proposal, shall be the responsibility of the Contractor.

Should the Schedule indicate an earlier completion date than the time for completion set forth in the Contract, the Schedule shall define any positive float developed between an early completion point and the Contract Completion Date as part of the overall project float. It is understood by the Contractor and the Division that positive float is a shared commodity, not for the exclusive use or benefit of either party. Either party has the full use of the positive float until it is depleted.

The Division's review of the Schedule does not represent approval of the Contractor's estimate of resources (labor, material and equipment), method of operation, or production rates.

108.3.1.1-Submission of Construction Schedules: The Contractor shall designate a competent representative, hereinafter referred to as Construction Coordinator, who shall have the decision-making authority for the Contractor to control the work in accordance with the Schedule(s) for the duration of the Contract.

With the exception of the following preliminary items: establishing the field office, setting up traffic control, and mobilizing equipment, no item of work under the contract may be pursued following the Notice to Proceed or the Conditional Notice to Proceed until a Preliminary Construction Schedule or Detailed Construction Schedule has been submitted by the Contractor and reviewed by the Engineer. The Engineer may withhold estimates until such time as a Schedule has been received and reviewed.

108.3.1.2-Preliminary Construction Schedule: Within thirty (30) calendar days of the contract award date, the Contractor may submit a sixty (60) calendar day Preliminary Construction Schedule for review by the Engineer. The Preliminary Schedule shall include a generalized project schedule for the balance of the work in summary form indicating the contract completion date. The Contractor shall maintain and submit monthly a sixty (60) calendar day Preliminary Construction Schedule until the Schedule is submitted by the Contractor and reviewed by the Engineer.

108.3.1.3-Detailed Construction Schedule (Schedule): The detailed construction Schedule shall include a report system that is maintained throughout the life of the project to measure all factors that affect the completion date. Within sixty (60) calendar days of the contract award date, the Contractor shall submit a Schedule indicating the contract completion date for review by the Engineer.

The Engineer will review the Schedule and supporting documentation for compliance with the Contract within fourteen (14) calendar days after receipt in accordance with provision 108.6.2. The Contractor shall provide the Engineer with a revised Schedule incorporating any compliance recommendations made in the Engineer's review. This schedule shall become the official Schedule and shall be used by the Contractor. The official Schedule must be completed within ninety (90) calendar days of the Contract award date. The Engineer may withhold estimate payments for any item of work under the Contract after ninety (90) calendar days until the Contractor's Schedule has been reviewed and all comments have been addressed.

108.3.1.4-Construction Schedule Requirements: The Preliminary Schedule and the official Schedule shall be submitted in electronic /digital format (.XER file) and in hard copy and shall include a legend for symbols and abbreviations used. Activities with duration times in excess of fifteen (15) working days, except for non-construction activities, shall be kept to a minimum and be subject to review by the Engineer. The Schedule shall provide a minimum of ten (10) activities or categories, hereafter referred to as "Activities," per million dollar value of the Contract and a maximum of three hundred (300) activities or as directed by the Engineer.

The Schedule shall indicate the interdependence of Activities (how the start of a given activity depends on the completion of preceding Activities) and the sequence of work (how failure to complete a given activity may restrain the start of successive activities).

The Schedule shall include the Contract completion date and any interim completion dates contained in the Contract, as well as any coordination and cooperation requirements, construction restrictions, or other requirements of the Contract.

The Schedule shall include Activities for all work required by the Contract, including Activities for subcontractors, vendors, and suppliers. In addition to construction activities, the Schedule shall include as a minimum the procurement, fabrication, and delivery of critical or special materials and equipment, as well as submission and review of all shop/work drawings, Contractor designs, and all other submissions required by the Contract.

The Activities are to be described by Contract item number, location, phase, and sequence so that the work is readily identifiable and the progress of each Activity can be measured. For Schedules requiring resource loading, the Contractor shall provide the labor and equipment involved with each Activity.

For all Schedules, each Activity will have an associated dollar amount documented on the Schedule. This Activity dollar amount will be in direct relation to the bid items and quantity of work included in the Activity. Activity duration shall be logical and consistent with the Contract documents and shall be based on realistic and available resources of the Contractor. The above requirements are applicable for all Schedules, including the official Schedules, required updates, and any revised Schedules.

Requiring the Contractor to submit Schedules allocating resources to project Activities does not imply acceptance, approval, or agreement by the Division that the Contractor's scheduled allocation of resources is sufficient to complete either the project or a scheduled activity in a scheduled time.

The Division's review and acceptance of the Schedule and progress updates does not preclude a later review of any previously submitted Schedule. If upon later review the Division discovers an issue of non-compliance with the specification or a discrepancy in the Schedule that is skewing the logic calculations and schedule results, the Division reserves the right to request a revised Schedule as per Section 108.3.5.

108.3.2-Detailed Construction Schedule (Schedule): The Schedules shall be prepared using scheduling software Primavera Project Manager P6 version 6.0 or higher. The following criteria shall apply to the development and maintenance of the Schedule:

1. All Resources shall be grouped in a Project Resource Tree. This tree structure shall have one main heading name that begins with the Project's specific 7 digit Contract ID Number followed by an underscore, followed by the Project Name.

2. Individual Resource names shall be shown as a sublevel to the main heading name. The Individual Resource names shall begin with the Project's specific 7 digit Contract ID Number followed by an underscore, followed by the Project Name. Any additional description may follow the underscore.
3. The use of Project Codes is prohibited.
4. The use of Global Activity Codes are prohibited, however, Project Activity Codes may be used. The Project Activity Code names shall begin with the Project's specific seven (7) digit Contract ID Number followed by an underscore. Any additional description may follow the underscore.
5. Global Calendars are prohibited (except as noted below in section 7). However, Project Calendars may be used. The Project Calendar names shall begin with the project's specific seven (7) digit contract number, followed by an underscore. Any additional description may follow the underscore. In addition, the Project Default Calendar shall be assigned as a Project Calendar.
6. The use of Cost Accounts is not required. However if the Contractor elects to use them, then all Cost Account names shall be grouped in a Project Cost Accounts Tree. This tree structure shall have one main heading name that begins with the project's specific 7 digit Contract ID Number followed by an underscore, followed by the Project Name.
 - a. Individual cost account names shall be shown as a sublevel to the main heading name. The individual cost account names shall begin with the Project's specific seven (7) digit Contract ID Number, followed by an underscore. Any additional description may follow the underscore.
7. The Contractor Resource Calendar shall be linked to the WVDOT Standard Calendar. The WVDOT Standard Calendar shall be assigned to each resource and shall be allowable as the only calendar for all Schedule Resources. This shall be accomplished by creating a Global Calendar named and formatted exactly as follows:
 - a. WVDOT Standard 5 Day Workweek with holidays.
 - b. The first activity on the Schedule shall be Contract letting which shall be designated as a milestone starting on the actual contract letting date.
 - c. The second activity on the Schedule shall be Project Award which shall be designated as a milestone with a 30 day lag from the Contract Letting milestone.
 - d. The third activity on the Schedule shall be Notice to Proceed which shall be designated as a milestone with a 30 day lag from the Project Award milestone (or with a 7 day lag from Project Award on projects with an Incentive/Disincentive clause).
 - e. Subsequent to the Notice to Proceed milestone, the logic and duration of remaining activities shall be developed and tied to the Substantial Completion milestone described in Section 108.3.1.
 - f. Schedule calculation will be computed by Retained Logic method.
 - g. Only contractual Constraints can be used on activities when preparing the Schedule, otherwise the use of Constraints is prohibited.
 - h. All Actual Start Dates and Actual Finish Dates shall be reasonably captured in updated schedules.
 - i. The activity costs described in Section 108.3.4 shall be incorporated into the Schedule via Resource Section. The use of Expenses for costs is prohibited

The Schedule shall be submitted on standard D size sheets (24" x 36"). The critical path shall be distinguished from other paths on the Schedule. All back-up data used to generate the Schedule shall be submitted in digital form on acceptable media that is compatible with the computer system.

The submitted Print Out of the Schedule shall include the following data for each activity in the initial submittal and in all updates and revisions:

1. Activity number, as well as preceding and following activity numbers;
2. Activity description;
3. Duration of activity, in working days;
4. All quantities in accordance with pay items;
5. Dollar value of activity;
6. Remaining duration of activity, in working days;
7. Earliest start date, by calendar date;
8. Earliest finish date, by calendar date;
9. Actual start date, by calendar date;
10. Actual finish date, by calendar date;
11. Latest start date, by calendar date;
12. Latest finish date, by calendar date;
13. Total float for activity;
14. Free float for activity;

In addition to the above, the following information and data shall be included with the submission of the digital form to the Division:

15. Number of shifts per work day, hours per shift for activity;
16. Number of work days per week for activity;
17. Major equipment and corresponding hours for activity;
18. Manpower by Trade or entity and corresponding hours for activity;
19. Activity Usage Profile Cost of Contractor's Income.

108.3.3-Schedule Resource Loading Criteria: The following criteria shall be incorporated in the development and maintenance of Schedules and Schedule updates:

108.3.3.1-Non-Resource Loaded Schedules: For projects where the Contract Bid Amount is between \$2,000,000 and \$7,500,000, the Schedule shall meet the requirements of a Schedule as described in Section 108.3.2 with the exception of Bullet 17 (Major equipment and corresponding hours for activity) and Bullet 18 (Manpower by Trade or entity and corresponding hours for activity).

108.3.3.2-Resource Loaded Schedules: Schedule resource loading will be required for all projects on which the Contract Bid Amount is equal to or exceeding \$7,500,000. Additionally all Design Build Projects and Public Private Partnerships will require Schedule resource loading regardless of the Contract Bid Amount.

The Contractor is advised that the specific details of Major Equipment (bullet #17) and Manpower (bullet #18) may be provided on a separate attachment to the Schedule. However this information must be referenced to the Schedule so that in the determination of the Engineer relevant resource evaluation can be ascertained.

108.3.4-Progress Reporting and Schedule Updating: The Contractor shall submit weekly a summary of work force by Trade including all workmen and subcontractors together with a weekly summary of all equipment used on the project. The Division shall maintain the Contractor's resource information in a confidential manner. The Contractor's certified payrolls may be a substitute for the work force summary. A Project Control Meeting shall be held monthly by the Engineer with the Contractor's Construction Coordinator to review actual progress, planned progress for the next period, and any changes since the previous update(s). Non-Resource Loaded Projects as described in 108.3.3 that require a Schedules may hold Project Control Meetings less frequently if deemed appropriate by the Regional Engineer, but not less than quarterly.

For projects where the Contract Bid Amount is greater than or equal to \$7,500,000 that require a Schedule, at least five (5) working days before the meeting, the Construction Coordinator shall provide the Engineer with a complete update of all schedule activity information included in 108.3.2. The Engineer may withhold estimate payments until the Contractor submits a Schedule update five (5) working days prior to the next Project Control meeting.

For projects that require Non-Resource Loaded Schedules as described in 108.3.3, the Construction Coordinator shall provide the Engineer with a complete update of all Schedule activity information included in 108.3.2 and 108.3.3 within five (5) working days after the end of the month. The Engineer may withhold estimate payments until the Contractor submits a Schedule update within five (5) working days after the end of the month.

The Contractor shall submit with the monthly update a narrative report which shall include, but not be limited to, a description of progress along the critical path in terms of days ahead or behind the Schedule dates, any problem areas (current and anticipated), any delaying factors and their impact, and an explanation of any corrective actions taken or proposed. The narrative report shall state any and all changes made in the Schedule since the previous update(s) and detail all activities or portions of activities, including dollar value, completed during the update period.

The original accepted Schedule shall have the sum of all activity costs equal to the Contract Bid Amount. Change Orders, Value Engineering and other required project modifications shall be incorporated into the Schedule as necessary to reflect the actual cost and scope of work being performed. Total Project costs expended and remaining should be ostensibly accurate on Schedule updates. However, the Schedule updates shall be maintained in such a way as to accurately reflect the progress of the project by the duration of remaining work.

Extension of Interim Completion Dates, the Contract Completion Date, or the revised Contract Completion Date will be governed by the provisions of 108.6.

If the Division revises work which would affect the sequence of operations or duration of time on work activities, the Contractor shall submit to the Engineer, within seven (7) calendar days after receipt of the revision, a written report in accordance with 108.6 outlining the effect on work time and cost that the revision is expected to have on the Schedule.

108.3.5-Submission of Revised Construction Schedule: The Engineer shall request the Contractor to submit a revised Schedule when any one of the following conditions is reflected by the latest Schedule:

1. A delay greater than ten (10) calendar days in the completion of any critical activity;
2. The performance of any work in a sequence or manner which varies from that represented on the Schedule;
3. The addition, deletion, or revision of activities required by Contract modification.

The revised Schedule shall indicate all the requirements described in Section 108.3.2 and shall include all additional resources (labor, material, and equipment) and modification(s) of operations necessary to meet the contract time requirements.

The Engineer will review the revised Schedule and supporting documentation for compliance with the Contract. The Contractor shall incorporate any compliance recommendations made in the Engineer's review. Should the Contractor fail to submit a revised Schedule within seven (7) calendar days of the Engineer's written request, the Engineer may withhold estimate payments for any item of work under the Contract until such Schedule is submitted.

108.4-LIMITATION OF OPERATIONS:

The Contractor shall conduct the work at all times in such manner and in such sequence as will assure the least interference with traffic. The Contractor shall have due regard to the location of detours and to the provisions for handling traffic. The Contractor shall not open up work to the prejudice or detriment of work already started, and the Engineer may require the Contractor to finish a section on which work is in progress before work is started on any additional sections if the opening of such section is essential to public convenience.

108.5-CHARACTER OF WORKERS; METHODS AND EQUIPMENT:

The Contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of work to full completion in the manner and time required by these Specifications.

All employees shall have sufficient skill and experience to perform properly the work assigned to them. Employees engaged in special work or skilled work shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

Any person who, in the opinion of the Engineer, does not perform his/her work in a proper and skillful manner or is intemperate or disorderly shall, at the request of the Engineer, be removed forthwith. Any Contractor or his/her subcontractor employing such person shall not reemploy such person on the project without the written approval of the Engineer. Should a Contractor fail to remove such a person or persons as required above or fail to furnish suitable and sufficient personnel for the proper prosecution of the work, the Engineer may suspend the work by written notice until such order is complied with.

All equipment which is proposed to be used on the work shall be of sufficient size and in such mechanical condition as to meet requirements of the work and to produce a satisfactory quality of work. Equipment used on any portion of the project shall be such that no damage to the roadway, adjacent property, or other highways will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the construction are not prescribed in the Contract, the Contractor is free to use any methods or equipment that the Contractor demonstrates will accomplish the Contract work in conformity with the requirements of the Contract.

When the Contract specifies that the construction be performed by the use of certain methods and/or equipment, such methods and/or equipment shall be used unless others are authorized by the Engineer. Should the Contractor desire to use a method or type of equipment other than specified in the Contract, the Contractor shall request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor shall be fully responsible for producing construction work in conformity with Contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet Contract requirements, the Contractor shall discontinue the use of the substitute methods or equipment and shall complete the remaining construction with the specified methods or equipment. The Contractor shall remove the deficient work and replace it with work of specified quality, or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the construction items involved nor in Contract time as a result of authorizing a change in method or equipment under these provisions.

108.6-DETERMINATION AND EXTENSION OF CONTRACT TIME:

108.6.1-General: The Division shall determine and specify in the Contract the number of working days and/or a fixed calendar date allowed for completion of the Work, hereinafter called Contract Time.

A potential working day is every day on the calendar except Saturday, Sunday and holidays as set forth in 101.2.

When the Contract Time is specified on a working day basis, the Engineer will inform the Contractor weekly, by written statement, of the number of working days charged for the preceding week, the accumulated number of working days charged against the Contract, and the number of working days remaining for completion of the Contract. The Contractor shall submit in writing to the Engineer any protest concerning the weekly statement within seven (7) calendar days after receipt of the statement. The written protest shall set forth what the Contractor considered incorrect, along with supporting information; otherwise, the statement shall be deemed to have been accepted by the Contractor as correct. The Engineer shall review any such protest and supporting information and shall render a decision either affirming or correcting the number of working days previously reported for the contested week, within fourteen (14) calendar days after receipt of the written protest.

When the Contract Time is specified on a fixed calendar date basis, it will consist of the number of calendar days counting from the effective date of the Engineer's issuance of the Notice to Proceed or Conditional Notice to Proceed to the calendar date specified for completion of the project, including all Saturdays, Sundays, holidays, and non-working days. All calendar days elapsing between the effective dates of any orders of the Engineer to suspend work and to resume work for suspensions not the fault of the Contractor shall be excluded.

The work on the Contract will be considered substantially complete when the Project could be opened continuously for the safe, convenient, and unimpeded use of the traveling public, or the Project has met the intention of the plans, as reasonably determined by the Engineer. When the Project is considered substantially complete, the Contract time charges shall be discontinued prior to final acceptance being made by the Engineer as prescribed in 105.16.

108.6.2-Extension of Contract Time: The Contractor shall be responsible for any delays caused by failing to start a work activity on the earliest date any activity can begin after its predecessors have been completed, unless the activity has float. The Contractor shall also be responsible for any delays caused by lack of continuous effort, inadequate allocation and scheduling of resources and coordination of the work, inadequate or insufficient application of resources, or inability to meet interim completion dates due to Contractor's approach to the work. Such delays shall not be considered for an extension of Interim Completion Dates, Contract Completion Date, or the Revised Contract Completion Date.

If the Contractor finds it impossible for reasons beyond his control to complete an activity or the work within the Contract time as specified or as extended according to the provisions of this Section, the Contractor shall notify the Engineer, in writing, within seven (7) calendar days of the Contractor becoming aware of the following:

- 1) a problem that develops requiring direction to the Contractor by the Engineer;
- 2) the occurrence of any delay including delays in critical path activities;
- 3) in the absence of a Schedule, delays in the controlling operation during the prosecution of Work that the Contractor believes may warrant revision of an Interim Completion date or the Contract Completion Date.

The notification shall set forth the reasons that shall justify the granting of the request, and as a minimum, identify the cause(s) for the delay, the particular critical path activity(s) or controlling operation(s) affected, the effect of any Division act or omission on each activity or operation delayed, and the significant dates that encompass the periods of delay. On projects with Schedules, the Contractor shall submit a Schedule update within seven (7) calendar days of becoming aware of the delay and another Schedule update when the Contractor indicates or the Engineer believes the delay has been resolved. In instances where controlling or critical path activities are claimed by the Contractor or determined by the Division to be delayed, the notification and Schedule update shall be considered by the Division as a request by the Contractor for a Contract time extension. If the Schedule updates relating to the delays, are not received as mentioned above, the Contractor forfeits his rights to any claims or time extensions.

In the absence of a Schedule, the controlling item will be determined from the Division's records. The Engineer will inform the Contractor weekly, by written statement, of controlling items identified for the previous week. The Contractor shall submit in writing to the Engineer any protest concerning the weekly statement within seven (7) calendar days after receipt of the statement. The written protest shall set forth what the Contractor considered incorrect, along with supporting information; otherwise, the statement shall be deemed to have been accepted by the Contractor as correct. The Engineer shall review any such protest and supporting information and shall render a decision either affirming or correcting the controlling items reported for the contested week.

If notification is not given by the Contractor within the prescribed time of the Contractor becoming aware of any delay, or if, having given notification as provided herein, the Contractor does not afford the Engineer proper facilities for keeping strict account of actual costs and loss of time, the Contractor waives any claim for additional compensation and Contract time extension. Delay costs allegedly incurred more than the allowable seven (7) days before the Contractor notifies the Engineer in accordance with this provision shall not be allowed.

If the Engineer determines that the Work was delayed because of conditions beyond the control of and without the fault or negligence of the Contractor, the Engineer may extend the time for project completion as the conditions justify.

Only delays in the activities on the critical path, or in the absence of scheduling requirements, delays in the controlling operation will be considered for a Contract time extension, provided when required, the Contractor has submitted proper notification and supporting documentation justifying the request. For projects with Schedule requirements, Time Extension reviews will be evaluated along the critical path, as determined by the project's longest path. Time Extension reviews will consider the free float and total float of all relevant activities in determining the actual project delay. The Engineer shall within fourteen (14) Calendar Days advise the Contractor in writing of the approval or rejection of the time extension request. If approved, the extended time for completion shall then be in full force and effect the same as though it were the original time for completion.

108.6.2.1-Excusable Noncompensable Delays: An excusable noncompensable delay is a delay in the critical path activity, or in the absence of a project Schedule, a delay in the controlling operation that was beyond the Contractor's control and not caused by the Contractor's fault or negligence. Consideration may be given to an adjustment in Contract time, but no consideration shall be given for additional monetary compensation. Excusable noncompensable delays include, but are not limited to:

1. Delay of Notice to Proceed or Conditional Notice to Proceed of more than thirty (30) calendar days after the contract award date for reasons beyond the control of and without the fault or negligence of the Contractor. Consideration for an adjustment of Contract time will be limited to the number of calendar days in excess of thirty (30) calendar days, counting from the Contract award date to the effective date of the Engineer's issuance of the Notice to Proceed.
2. Delay of the Notice to Proceed more than seven (7) calendar days after the contract award date for contracts with Incentive/Disincentive clauses, as long as the reasons are beyond the control of and without the fault or negligence of the Contractor. Consideration for an adjustment of Contract time will be limited to the number of calendar days in excess of seven (7) calendar days on contracts with Incentive/Disincentive clauses, counting from the Contract award date to the effective date of the Engineer's issuance of the Notice to Proceed.
3. Delays due to acts of God, labor strikes (not within the Contractor's power to settle) freight embargoes, states of national emergency, or other reasons beyond the control of the Contractor. Consideration for an adjustment of contract time shall be limited to the number of potential working days lost as determined by the Engineer.
4. Delays in obtaining materials due to extraordinary market conditions caused by industry-wide strike, natural disaster, area-wide shortage, official federal declaration that a material is critical due to national defense efforts, or for other reasons beyond the control of the Contractor. Consideration for an adjustment of contract time shall be limited to the number of potential working days lost as determined by the Engineer.

5. Delays due to adverse weather. Lost days due to adverse weather may include:
 - (1) Days with inclement weather or conditions beyond the Contractor's control that prevent the involvement of their normal working forces engaged in performing critical or controlling item(s) of work for at least sixty (60) percent of the total scheduled daily hours, and
 - (2) Days when weather conditions prevent work from beginning at the regular time and the crew is dismissed, regardless of whether or not conditions improve for the rest of the day.

An adjustment of Contract time shall not be considered for loss of time due to adverse weather:

- a. before the start of construction operations;
 - b. during periods when no on site- work on a controlling operation or critical path activity occurs;
 - c. after November 30 and before April 1 of the following year;
 - d. after the Contract completion date or the Revised Contract completion date.
6. Consideration for an adjustment of contract time shall be limited to the number of potential working days lost each month, as determined by the Engineer. Notification by the Contractor of weather related delays may be consolidated into a single request that shall be included in the narrative letter transmitting the monthly Schedule update. In addition, only weather related delays that correspond to an actual project delay will be allowable for consideration.

On projects that do not require Schedules, the request shall be received within seven (7) calendar days of the end of the month in which the weather delays occurred- If a Schedule is not required for the project, any time extensions granted by the Engineer shall be on the basis of an additional working day for each potential working day lost.

The allowable time required for the Division to take action on properly prepared submissions shall be fourteen (14) calendar days after receipt unless otherwise specified in the Contract documents.

108.6.2.2-Excusable Compensable Delays: An excusable compensable delay is a delay in the critical path activity, or in the absence of a project Schedule, a delay in the controlling operation that was caused solely by the Department. An adjustment in Contract time may be considered along with additional monetary compensation, if entitled. Excusable compensable delays include:

1. Delays in a critical path activity, or in the absence of a project Schedule, a delay in the controlling operation due to contract modifications resulting in the performance of added work, revised work, or work in greater quantities than those set forth in the Proposal except as provided in 104.11. The Division reserves the right to negotiate unit prices that include the cost for additional resources (labor, material and equipment) required to complete added work, revised work, or work in greater

quantities within the originally scheduled dates, thereby negating the need for a Contract time adjustment.

Should a substantial delay be anticipated, the Department may request the Contractor to submit his/her costs and conditions for demobilization and remobilization. The Department may pay the Contractor for demobilization/remobilization expenses in lieu of further idle equipment costs.

Consideration for adjustment of Contract time for added or revised work shall be limited to the extra time allowances as agreed on and specified in the Change Order that covers the added or revised work. Mark-up for the added or revised work will be negotiated and specified in the Change Order. The adjustment of contract time and the allowable mark-up will be full and just compensation for any and all claims that the Contractor may have regarding the added or revised work. No additional consideration will be given for Home office overhead and/or Field office overhead.

Any adjustment of Contract time for Work authorized in accordance with 104.11 that requires the performance of work in greater quantities than those specified in the Contract shall be made at the discretion of the Engineer in accordance with one of the two options below:

- a. The extra time allowances as agreed on and specified in the Change Order that covers the additional or increased work; or
 - b. The same ratio that the total cost of the added or increased work shall bear to the total contract bid amount, provided the added or increased work is judged to be a critical path activity or, in the absence of a project Schedule, a controlling operation.
2. Loss of time due to differing site conditions. Consideration for adjustment of Contract time shall be according to Section 104.9.
 3. Loss of time due to any written orders of the Engineer suspending work or delaying critical path activities on the project not the fault of the Contractor. Consideration for adjustment of Contract time shall be according to Section 104.10.
 4. Loss of time due solely to acts or omissions by the Division and not caused or contributed to by the Contractor's fault or negligence.

The allowable time required for the Division to take action on properly prepared submissions shall be fourteen (14) calendar days after receipt unless otherwise specified in the Contract documents.

Consideration for an adjustment of Contract time shall be limited to the number of potential working days lost as determined by the Engineer.

108.7-COMPLETION DATES:

108.7.1-Failure to Complete on Time and Liquidated Damages: Time is an essential element of the Contract, and it is important that the work be completed within the time specified. The cost to the Division for the administration of the Contract, including engineering, inspection, and supervision, will increase as the time required to complete the work is increased.

Therefore, for each calendar day the project is deemed not to be Substantially Complete after the Contract Time specified for completion of the work, subject to such extensions of contract time required or permitted in 108.6, the Division will assess liquidated damages against the Contractor. Daily charges will be deducted for each calendar day, as defined in 101.2, on all contracts, except daily charges will not be deducted between November 30 and April 1. The total amount of daily charges will be deducted from any monies due the Contractor, not as a penalty but as liquidated damages. Unless specified elsewhere in the Contract, the amount of the daily charge will be calculated from the table posted at the WVDOH Contract Administration's Specifications and Documents website:

<http://www.transportation.wv.gov/highways/contractadmin/specifications/Pages/LiquidDatedDamages.aspx>

on the date the project is first advertised.

108.7.2-Interim Completion Date: When an interim completion date has been specified in the Contract documents for the Contractor to complete a specific amount of work, pay item, or structure, and if the Contractor fails to meet the interim date, the Division will assess a per calendar day charge as liquidated damages, as specified elsewhere in the Contract documents until such amount of work, pay item, or structure has been completed. Extension of interim completion dates will be governed by the provisions of 108.6. The liquidated damages provided for in this subsection are in addition to those provided for elsewhere in this Section.

108.7.3-Incentive/Disincentive for Early Completion: When an Incentive/Disincentive (I/D) provision has been included in the Contract documents, Subsection 108.7.1 relating to liquidated damages remains in effect and is applicable to the total Contract time; however, there will be concurrent assessment of liquidated damages with disincentive assessments. Extension of the date(s) established for completion of work stages covered by the I/D provision and/or the Contract completion date will be governed by the provisions of 108.6.

108.8-DEFAULT AND TERMINATION OF CONTRACT:

If the Contractor:

1. Fails to begin work under the Contract within the time specified in the "Notice to Proceed"; or
2. Fails to perform the work with sufficient employees and equipment or sufficient materials to assure the prompt completion of the work; or
3. Performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable;
4. Discontinues the prosecution of the work; or
5. fails to resume work which has been discontinued within a reasonable time after notice to do so; or
6. Becomes insolvent or is declared bankrupt or commits any act of bankruptcy or insolvency; or
7. Allows any final judgment to stand against the Contractor unsatisfied for a period of ten (10) days; or
8. Makes an assignment for the benefit of creditors; or

9. For any other cause whatsoever, fails to carry out the Contract terms in an acceptable manner; the Engineer will give notice in writing to the Contractor and his/her Surety of such delay, neglect or default.

If the Contractor or Surety, within a period of ten (10) days after such notice, shall not proceed in accordance therewith, the Division will, upon written notification from the Engineer of the fact of such delay, neglect, or default and the Contractor's failure to comply with such notice, have full power and authority, without violating the Contract, to terminate the Contract. The Division may appropriate or use any or all materials and equipment on the ground as may be suitable and acceptable and may enter into an agreement with another contractor for the completion of the Contract according to the terms and provisions thereof, or use such other methods as in the opinion of the Engineer will be required for the completion of the Contract in an acceptable manner.

All cost charges incurred by the Division, together with the cost of completing the work under Contract, will be deducted from any money due or which may become due the Contractor. If such expense exceeds the sum which would have been payable under the Contract, then the Contractor and the surety shall be liable and shall pay to the Division the amount of such excess.

108.9-TERMINATION OF CONTRACT FOR CONVENIENCE OF THE STATE:

The Division may terminate the entire Contract or any portion thereof, if the Engineer determines that a termination is in the Division's interest. The Engineer will deliver to the Contractor a Notice of Termination specifying the extent of termination and the effective date.

1. **Submittals and Procedures.** After receipt of a Notice of Termination, the Contractor shall immediately proceed with the following obligations:
 - a. Stop work as specified in the notice.
 - b. Place no further subcontracts or orders for materials, services, or facilities for the terminated portion of the Contract.
 - c. Terminate all subcontracts that relate to the work terminated.
 - d. Settle all outstanding liabilities and termination settlement Proposals arising from the termination of the contract or portion thereof.
 - e. Transfer title and deliver to the Division (1) fabricated, partially fabricated, or unfabricated parts, work in process, completed work, supplies, and other material produced or acquired for the work terminated, and (2) the completed or partially completed plans, drawings, information, and other property that, if the Contract had been completed, would be required to be furnished to the Division.
 - f. Complete performance of the work not terminated.
 - g. Acceptable materials obtained by the Contractor for the Project that have not been incorporated in the work shall be inventoried in conjunction with the Engineer at a date identified by the Engineer.
 - h. Take any action necessary, or that the Engineer may direct, for the protection and preservation of the property related to the Contract that is in the possession of the Contractor and in which the Division has or may acquire an interest.
2. **Settlement Provisions.** When the Division orders termination of all or a part of the Contract effective on a certain date, completed items of work as of that date will be

paid for at the Contract bid price. Payment for partially completed work will be made either at agreed prices or under the provisions below. Items that are eliminated in their entirety by such termination shall be paid for as provided in Subsection 109.5.

- a. **Additional Costs.** Within sixty working days of the effective termination date, the Contractor shall submit a claim for additional damages or costs not covered above or elsewhere in the Contract. Such claim may include such cost items as reasonable idle equipment time, mobilization efforts, bidding and project investigative costs, overhead expenses attributable to the project terminated, legal and accounting charges involved in claim preparation, subcontractor costs not otherwise paid for, actual idle labor cost if work is stopped in advance of termination date, guaranteed payments for private land usage as part of the original Contract, and any other cost or damage for which the Contractor feels reimbursement should be made.

The Contractor and the Division may agree upon the whole or any part of the amount to be paid because of the termination. The amount may include a reasonable allowance for profit on work done. Anticipated profits will not be considered as part of any settlement. The agreed amount may not exceed the total Contract price as reduced by the amount of payments previously made, and the Contract price of work not terminated. The Contract shall be amended, and the Contractor paid the agreed amount.

- b. **Additional Cost Review.** If the Contractor and the Division fail to agree on the whole amount to be paid the Contractor because of the termination of work, the Division will pay the amounts determined as follows, but without duplication of any amounts agreed upon above:
 - i. For Contract work performed before the effective date of termination, the total (without duplication of any items) of:
 - 1) The cost of work performed;
 - 2) The cost of settling and paying termination settlement Proposals under terminated subcontracts that are properly chargeable to the termination portion of the Contract if not included in subparagraph 1 above; and
 - 3) A sum, as profit on (1) above determined by the Division to be fair and reasonable. The Division shall allow no profit under this subdivision if the Contractor's costs incurred on work performed exceed the bid item payments made.
 - ii. The reasonable costs of settlement of the work terminated, including:
 - 1) Accounting, legal, clerical, and other expenses reasonably necessary for the preparation of termination settlement proposals and support data;
 - 2) The termination and settlement of subcontracts (excluding the amounts of such settlements); and
 - 3) Storage, transportation, and other costs incurred, reasonably necessary for the preservation, protection, or disposition of the termination inventory.
 - iii. Except for normal spoilage, and to the extent that the Division expressly accepts the risk of loss, Division will exclude from the fair value, all that is destroyed, lost, stolen, or damaged so as to become undeliverable to the Division or to the buyer.

- iv. In arriving at the amount due the Contractor under this clause, there will be deducted the following:
 - 1) All unliquidated advance or other payments to the Contractor under the terminated portion of the Contract;
 - 2) Any claim that the Division has against the Contractor under the Contract; and
 - 3) The agreed price for or the proceeds from the sale of materials, supplies, or other things acquired and sold by the Contractor not recovered by or credited to the Division.

If termination is partial, the Contractor may file a Proposal with the Division for an equitable adjustment of the price(s) of the continued portion of the Contract. The Division will make any equitable adjustment agreed upon. Any Proposal for an equitable adjustment under this clause shall be requested within sixty (60) working days from the effective date of termination unless extended in writing by the Engineer.

The Division may, under the terms and conditions it prescribes, make partial payments and payments against costs incurred by the Contractor for the termination portion of the Contract, if these payments will not exceed the amount to which the Contractor is entitled.

The Contractor shall maintain and make available all project cost records to the Division for audit to the extent necessary to determine the validity and amount of each item claimed. This includes all books and other evidence bearing on the Contractor's costs and expenses under the Contract. These records and documents shall be made available to the Division at the Contractor's office, at all reasonable times, without any direct charge. If approved by the Division, photographs, microphotographs, or other authentic reproductions may be maintained instead of original records and documents.

Termination of the Contract or portion thereof shall not relieve the Contractor of contractual responsibilities of the work completed, nor shall it relieve the Surety of its obligation for and concerning any just claim arising out the work performed.

108.10-FIELD OFFICE OVERHEAD:

The Division may consider compensating the Contractor for field office overhead costs as long as the Contractor can provide documentation that the field office overhead costs are not covered by the project bid items.

108.11-HOME OFFICE OVERHEAD:

The Department shall consider payment to the Contractor for any unabsorbed or extended home office overhead costs for which payment is not previously provided for if all of the following criteria are met:

- (1) The Contractor has incurred an excusable, compensable delay that delays the Work at least forty five (45) Calendar Days beyond the Scheduled Contract Completion Date or the Revised Completion Date. These days are cumulative throughout the project.
- (2) The delay for which payment of home office overhead is sought is only due to delays defined in 108.6.2.2.

Payment will be considered for every eligible day beyond the Scheduled or Revised Contract completion date at the rate determined below up to substantial completion, as determined by the Engineer.

108.11.1-Home Office Overhead Rate: Calculate the home office overhead daily rate using the following formula:

$$(A \div B) \times C = D$$

Then

$$(D \div E) = F$$

Then

$$(F \times G) = \text{Amount Claimed}$$

Where:

- A = Contract billing amount
- B = Contractor's total billings for Contract period
- C = Contractor's total overhead for contract period
- D = overhead allocable to Contract
- E = days of performance
- F = daily contract overhead
- G = number of days of delay

Contract duration term, E, includes every Calendar Day from the execution of the Contract, unless otherwise specified by the Engineer, to the Scheduled Contract Completion Date or Revised Contract Completion Date.

When the Contractor requests home office overhead compensation for a subcontractor, use the above formula to calculate the subcontractor's daily home office overhead rate; however, in the subcontractor calculation, A is equal to the subcontractor's portion of the original contract amount as determined by the sum of all approved subcontracts issued for each individual subcontractor.

Formula items B and C are subject to verification by audit at the election of the Engineer. Any and all costs associated with the audit will be the sole responsibility of the Contractor. Information obtained through any such audit shall, if requested by the Contractor, be treated as a trade secret for purposes of exemption from disclosure under the West Virginia Freedom of Information Act.

SECTION 109 MEASUREMENT AND PAYMENT

109.1-MEASUREMENT OF QUANTITIES:

All work completed under the Contract will be measured by the Engineer according to United States standard measure.

The method of measurement and computations to be used in determining of quantities of materials furnished and of work performed under the Contract will be those methods generally recognized as conforming to good engineering practice.

Unless otherwise indicated, the requirements prescribed shall govern.

Earthwork will be computed by the average end area method, using the horizontal length measured along the centerline as the distance between sections, applying corrections for curvature where the apparent error exceeds 25 percent of the volume in any one cut. Other acceptable methods may be used.

Unless otherwise specified, longitudinal measurements for area computations will be made horizontally and no deductions will be made for individual fixtures having an area of nine square feet (one square meter) or less. Unless otherwise specified, transverse measurements for area computations will be the neat dimensions shown on the Plans or ordered in writing by the Engineer.

Structures will be measured according to neat lines shown on the Plans or as altered to fit field conditions.

All items which are measured by the linear foot (meter), such as pipe culverts, guardrail, underdrains, etc., will be measured parallel to the base or foundations upon which such structures are placed.

The term "gage" when used in connection with the measurements of plates, will mean the U.S. Standard Gage.

The galvanized sheet thicknesses to be used in the manufacture of metal cribbing, corrugated steel culvert pipe, underdrain pipe, plate pipe, pipe arches, plate pipe arches and plate arches shall be as specified in AASHTO M 36 or AASHTO M 167. The sheet thicknesses to be used in the manufacture of corrugated aluminum alloy culvert pipe, underdrain pipe, plate pipe, pipe arches, plate pipe arches and plate arches shall be as specified in AASHTO M 196 or AASHTO M 219.

The "size number" used in the measurement of wire will be as specified in AASHTO M 32 or AASHTO M 225.

The term ton will mean the short ton consisting of 2,000 lb (The term megagram is defined as a mass of 1,000 kg). All materials which are measured or proportioned by weight shall be weighed on approved scales by competent, qualified personnel. Scales for weighing shall be of either the beam type, springless-dial type or digital recorder type. All plant and truck scales and metering devices shall be inspected, approved and sealed in accordance with the requirements of the West Virginia Division of Labor, Bureau of Weights and Measures, or other appropriate agencies of the State or its political subdivisions. Poises shall be designed to be locked in any position to prevent unauthorized changes. When the beam type scales are used, provisions for a "telltale" dial shall be made for indicating to the operator that the required load in the weighing hopper is being approached. A device on the weighing beams shall clearly indicate the critical position.

Truck scales shall be provided by the producer or Contractor, except that truck scales are not required where the material is weighed at properly calibrated automatic batching plant facilities

which are equipped with digital print-out equipment. The scales shall be of sufficient size and capacity to weigh the heaviest loaded trucks that are used for delivery of the material. All truck scales shall be mounted on solid foundations which will ensure their remaining plumb and level.

A weigh person shall be provided by the producer. The weigh person shall certify that the weight of the material, as determined either by the truck scales or from the digital print-out of the weights, is correct. To signify the certification of weight the weigh person must either sign their full name on each ticket, or if the ticket printer prints the weigh person's full name they must at least initial each ticket.

Each truck shall be weighed empty prior to each load, except at automatic batch plants approved to operate without truck scales. A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification and project number. Provision shall be made for constant zero compensation and further provision shall be made so that the scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest.

In case of a breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

If material is shipped by rail, the car weight may be accepted provided the actual weight of material only will be paid for. However, car weights will not be acceptable for material to be passed through mixing plants.

Devices, used to meter or measure component or other materials in a simultaneous manner, shall be located so as to be readily accessible and visible to a single Inspector, unless otherwise directed by the Engineer.

Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to at least their water level capacity, and all loads shall be leveled when the vehicles arrive at the point of delivery.

When approved by the Engineer, material specified to be measured by the cubic yard (meter) may be weighed and these weights converted to cubic yard (meter) for payment purposes. Further, when it is impractical to measure the material by weighing, or in its original position, the material will be measured in its final position and adjusted by a volume change factor. These conversion factors will be determined by the Engineer and shall be agreed to by the Contractor before these methods of measurement are used.

When bituminous material is measured by volume, the measured volume at loading temperature shall be converted to volume at 60° F (15° C) using the temperature correction factors in 705 for asphaltic materials and 706 for tar materials, except that when volume is measured by an approved temperature compensated metering device, no further volume correction for temperature shall be required. When bituminous material is measured by weight, the actual specific gravity, API gravity, or weight per gallon (liter) of the material shall be used to convert the measured weight to volume at 60° F (15° C). The Contractor shall furnish all information necessary as determined solely by the Division to determine the amount of bituminous material actually incorporated into the project.

Net certified scale weights or weights based on certified volumes in the case of rail shipments will be used as a basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work.

When bituminous materials are shipped by truck or transport, net certified weights or volume, subject to correction for loss or foaming may be used for computing quantities.

Cement will be measured by the cwt (hundredweight = 100 lb) (kilogram). For the purpose of determining the total amount used in the mixture, one bag of cement shall be considered as weighing 0.94 cwt (42.64 kg), and one barrel of cement shall be considered as weighing 3.76 cwt (175.55 kg).

Timber will be measured by the thousand feet board measure (mfbm) (cubic meters) actually incorporated in the structure. Measurement will be based on nominal widths and thicknesses and the extreme length of each piece.

The term "lump sum" when used as an item of payment will mean complete payment for the work described in the Contract.

When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit will be construed to include all necessary fittings and accessories.

When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by gage, unit weight, section dimensions, etc., such identification will be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

109.2-SCOPE OF PAYMENT:

The Contractor shall receive and accept compensation provided for in the Contract as full payment for furnishing all materials and for performing all work under the Contract in a complete and acceptable manner and for all risk, loss, damage, or expense of whatever character arising out of the nature of the work or the prosecution thereof, subject to the provisions of 107.20.

If the "Basis of Payment" clause in the Specifications relating to any unit price in the bid schedule requires that the unit price cover and be considered compensation for certain work or material essential to the item, this work or material will not also be measured or paid for under any other pay item which may appear elsewhere in the Specifications, except as provided in 104.6.

When the Contract specifies payment of an item or a portion of an item on a plan quantity basis, the quantities for payment will be those shown on the Plans with deductions from or additions to such quantities resulting from authorized deviations from the Plans.

If the Contractor believes that a quantity which is specified for payment on a plan quantity basis is incorrect, the Contractor may request the Division in writing to check the questionable quantity. The request shall be accompanied by calculations, drawing, or other evidence indicating why the plan quantity is believed to be in error. If the plan quantity is found to be in error, payment will be made in accordance with the corrected plan quantity.

The Division reserves the right to check the quantity of an item which is specified for payment on a plan quantity basis if there is reason to believe that it is inaccurate. If the quantity is found to be in error, payment will be made in accordance with the corrected plan quantity.

Should the Division determine during construction that conditions have varied from those anticipated in design to the extent that actual measurement of a plan quantity item is warranted, the Division will make such measurement, and payment will be based in lieu of the plan quantity.

109.2.1-General Basis of Adjusted Payment:

109.2.1.1-Single Deficiency: In the case of the single characteristic deficiency, the resulting deficiency shall be used directly to determine an adjusted price.

109.2.1.2-Multiple Deficiency: In the case of a multiple deficiency, the related adjusted percentage of contract price as determined by the acceptance plan for each characteristic shall be determined and the resulting percent of contract price to be paid shall be the product of these related adjusted percentages.

109.2.2-Basis of Charges for Additional Testing: When additional acceptance testing is performed by the Division for reworked lots or sublots in accordance with 106.3.1.2, the cost of such testing will be deducted on current estimates from the amount due the Contractor by the Division. The cost of such testing will be determined in accordance with the unit costs per test as shown in Table 9-1, published in MP 109.00.20.

109.3-COMPENSATION FOR ALTERED QUANTITIES:

When the accepted quantities of work vary from the quantities in the bid schedule, the Contractor shall accept as payment in full, so far as contract items are concerned, payment at the original contract unit price for the accepted quantities of work done. No allowance except as provided in 104.2 will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting either directly from such alterations or indirectly from unbalanced allocation among the contract items of overhead expense on the part of the bidder and subsequent loss of expected reimbursements therefore or from any other cause.

Increased work involving supplemental agreements will be paid for as stipulated in such agreements. The Contractor shall furnish substantiating data required in the preparation of these agreements.

109.4-FORCE ACCOUNT WORK:

If directed by the Division, as provided for in 104.3, the Contractor shall perform extra or unforeseen work on a force account basis and shall be compensated in the following manner:

109.4.1-Labor: For all labor and for foremen and superintendence in direct charge of the specific force account operations, the Contractor or subcontractor shall receive the actual current local rate of wage, agreed to in writing before beginning work, paid for each and every hour that the labor and foremen are actually engaged in the work.

The Contractor or subcontractor shall also receive the actual costs paid to, or in behalf of, workmen by reason of subsistence and travel allowances, Worker's Compensation insurance premiums, unemployment insurance contributions, Social Security and Medicare taxes, health and welfare benefits, and pension fund benefits when such amounts are required by employment contract generally applicable to the classes of labor employed on the work. The Contractor or subcontractor shall furnish satisfactory evidence of the rate or rates and the amount paid for insurance premiums and taxes.

For overhead and profit, an amount equal to sixteen percent of the sum of the above labor costs shall also be paid to the Contractor or subcontractor.

109.4.2-Materials: For all materials used in the specific force account operation and incorporated into the project, the Contractor or subcontractor shall receive the actual cost of materials delivered including labor charges for employees of the material supplier who are required to perform an incidental amount of work in conjunction with the material furnished and freight charges paid exclusive of equipment rentals as hereinafter set forth. The Contractor or subcontractor shall furnish invoices to document actual materials costs; however, if materials used on the force account work are not specifically purchased for such work but are taken from the Contractor's or subcontractor's inventory, then in lieu of the invoices the Contractor or subcontractor shall furnish an affidavit certifying that such materials were taken from inventory, that the quantity claimed was actually used, and that the price and freight claimed represent the Contractor's or subcontractor's actual cost.

For overhead and profit, an amount equal to sixteen percent of the sum of the above materials costs shall also be paid to the Contractor or subcontractor. All materials paid for will become the property of the Division.

109.4.3-Equipment: The movement of equipment to and from the specified force account operation shall be as directed by the Engineer. All equipment must be in good operating condition to qualify for rental payment. For all Contractor or subcontractor equipment either rented or owned, the rental rates and operating costs include full compensation for major repairs, repairs due to normal wear and tear, labor and parts needed for routine daily servicing of the equipment, operating expendables such as fuel, lubricants, tires and ground engaging components, and the percentage of mechanic's wages and related maintenance vehicles chargeable to preventive and field maintenance.

Payable time periods shall not include time elapsed before the Engineer has advised the Contractor or subcontractor that the equipment is required for use in the force account or time elapsed after the Engineer has advised the Contractor or subcontractor that the equipment is no longer needed exclusive of costs for transportation, assembly and disassembly set forth in 109.4.3.4, time elapsed while equipment is broken down or time spent repairing equipment. No separate payment will be made for any type of repairs to equipment.

When equipment is rented from a rental agency which the Contractor or subcontractor owns or is part owner, the equipment shall be treated as owned equipment and rental rates determined accordingly.

109.4.3.1-Rented Equipment: For required equipment which is not owned and must be obtained by rental, the Contractor or subcontractor shall be paid the actual rental cost for the equipment for the time that the equipment is required solely for use in the force account work. The Contractor or subcontractor shall furnish invoices to document actual equipment rental costs. Estimated operating costs shall also be paid for each hour the rented equipment is actually operated in the force account work, not to exceed the estimated operating cost per hour set forth for the equipment in the current Rental Rate Blue Book for Construction Equipment published by Dataquest, Inc.

For overhead and profit, an amount equal to sixteen percent of the sum of the above costs for rented equipment shall also be paid to the Contractor or subcontractor.

109.4.3.2-Owned Equipment: For owned equipment, other than small tools costing less than \$500 each, the Contractor or subcontractor shall be paid a rental rate determined from the current Rental Rate Blue Book for Construction Equipment published by Dataquest, Inc. The hourly rate shall be determined by dividing the monthly rate set forth in the Rental Rate Blue Book by 176 with appropriate adjustments made for age and region. The hourly rate for overtime work shall be determined by dividing the monthly rate set forth in the Rental Rate Blue Book by 176 with appropriate adjustments made for age and region. The estimated operating cost per hour set forth in the Rental Rate Blue Book shall also be paid for each hour the equipment is actually operated in the force account work.

If the owned equipment is not referred to in the current Rental Rate Blue Book, the hourly rental rate will be an agreed amount not to exceed the hourly rate computed as follows: A monthly rental rate equivalent to six percent of the Contractor's or subcontractor's original acquisition cost of the equipment shall be established. The hourly rental rate shall then be determined by dividing this monthly rental rate by 176. Operating costs in such cases shall be a reasonable agreed-upon amount for each hour the equipment is actually operated in the force account work.

For overhead and profit, an amount equal to sixteen percent of the sum of the above costs for owned equipment shall also be paid to the Contractor or subcontractor.

109.4.3.3-Idle Equipment: For required equipment held on the site of force account work on an idle basis at the request of the Engineer, the Contractor or subcontractor shall be paid for such idle time at an adjusted hourly rental rate exclusive of estimated operating costs. For owned equipment, such payment shall be made at one-half (1/2) the hourly rate determined by dividing the monthly rate set forth in the Rental Rate Blue Book by 176 with appropriate adjustments made for age and region.

Payment of idle time for owned equipment on force account work shall not exceed eight (8) hours each day less the hours the equipment operates that day. Payment for idle time shall not be made on Saturday, Sunday, holidays set forth in 101.2, when equipment is operated more than eight (8) hours per day or forty (40) hours per week, when equipment is idle due to the Contractor's or subcontractor's decision not to work on potential working days or when equipment is idle due to weather.

For overhead and profit, an amount equal to sixteen percent of the sum of the above costs for idle owned equipment shall also be paid to the Contractor or subcontractor.

109.4.3.4-Miscellaneous: Transportation charges for owned or rented equipment to and from the site of the force account work shall be paid provided the equipment is obtained from the nearest approved source, the return charges do not exceed the delivery charges, haul rates do not exceed the established rates of licensed haulers, and charges are restricted to those units of equipment not already available and not on or near the project. In the case of owned equipment, the Contractor or subcontractor shall be paid idle time rates for the equipment being hauled in addition to the applicable rental rates for the hauling equipment. All costs associated with the assembly and disassembly of the equipment for transport shall also be paid. All charges by persons or firms other than the Contractor or subcontractor shall be supported by satisfactory invoices.

109.4.4-Taxes: When the work is done by the Contractor, the amount of State and municipal taxes related to the force account work required to be paid by the Contractor will be reimbursed to the Contractor. For work performed by a subcontractor, the amount of extra cost paid by both the Contractor and the subcontractor for corporate and business taxes levied by the State and municipalities due to the force account work shall be paid to the Contractor.

For overhead and profit, an amount equal to sixteen percent of the sum of the above costs for State and municipal taxes shall also be paid to the Contractor or subcontractor.

For work performed by a subcontractor, the amount of extra cost incurred by the Contractor for increased business and corporate taxes shall be computed on the gross amount of the force account work, exclusive of the increased corporate and business taxes incurred by the subcontractor.

109.4.5-Contract Bond: The cost of premiums for contract bond required by 103.5 which is extra cost and related to the force account work will be paid to the Contractor.

For overhead and profit, an amount equal to sixteen percent of the sum of the above costs for contract bond shall also be paid to the Contractor or subcontractor.

109.4.6-Insurance: The cost of premiums for Contractor's Public Liability and Property Damage Liability Insurance required by 103.6.1 and Contractor's Protective Public Liability and Property Damage Liability Insurance required by 103.6.2 which is extra cost and related to the force account work will be paid to the Contractor.

For overhead and profit, an amount equal to sixteen percent of the sum of the above costs for insurance shall also be paid to the Contractor or subcontractor.

When the force account work involves a railroad and the Contractor is required to carry Railroad's Protective Public Liability Insurance or Railroad's Protective Property Damage Liability Insurance, or both, the cost of premiums for this insurance which is extra cost and related to the force account work will be paid to the Contractor.

For overhead and profit, an amount equal to sixteen percent of the sum of the above costs for railroad insurance shall also be paid to the Contractor or subcontractor.

109.4.7-Administrative Allowance: For force account work performed by an approved subcontractor, the Contractor shall be paid an administrative allowance equal to sixteen percent of the total amount paid for all work performed by the subcontractor on the specific force account operation exclusive of additives paid for overhead and profit.

109.4.8-Records: The Contractor's representative and the Engineer shall compare records daily of the cost of work done as ordered on a force account basis, and shall indicate agreement by signature on such records.

No payment will be made for work performed on a force account basis until the Contractor has furnished the Engineer an itemized statement of the cost of such force account work detailed as follows:

- a. Name, classification, date, daily hours, total hours, wage rate, fringe benefit rate and extended amounts for each laborer and foreman.
- b. Quantities of materials, unit prices and extended amounts.
- c. Transportation of materials.

- d. Designation, dates, daily hours, total hours, rental rate/hour, operating cost/hour, and extended amount for each unit of equipment.
- e. Transportation of equipment.
- f. Rates for property damage insurance, liability insurance, bond, municipal tax, subsistence and travel allowance, Worker's Compensation insurance, unemployment insurance, Social Security and Medicare taxes.

The Contractor must also furnish satisfactory evidence of the actual cost for each of the charges listed on the itemized statement (excluding those charges for owned equipment determined from the Rental Rate Blue Book).

109.4.9-Basis of Payment: The compensation provided in 109.4.1 to 109.4.7, inclusive, shall be received by the Contractor as payment in full for extra work done on a force account basis, including all labor, materials, equipment, fuel, lubricants, maintenance of equipment, administration, overhead, use of small tools and equipment for which no rental is allowed, profit, taxes, bond costs, insurance premiums, unemployment contributions and any other expense arising from the performance of the force account work.

109.5-ELIMINATED ITEM:

Should any items contained in the proposal be found unnecessary for the proper completion of the work, the Engineer may, upon written order to the Contractor, eliminate such items from the Contract, and such action will in no way invalidate the contract. When a Contractor is notified of the elimination of items, the Contractor will be reimbursed for actual work done and all costs incurred, including mobilization of materials prior to the notification.

109.6-PARTIAL PAYMENTS:

The Engineer will make current estimates in writing, once each month on or before the date set by the Engineer at the time of starting the work, or from time to time as the work progresses, of the materials complete in place and the amount of work performed in accordance with the Contract, during the preceding month or period and the value thereof figured at the unit prices contracted. Current estimates may be prepared for payment on a semi-monthly basis at the discretion of the Engineer when the amount due the Contractor for work during the semi-monthly period exceeds \$10,000. Should there be any doubt by the Engineer as to the integrity of any part of the completed work, the estimates for that portion will not be allowed until the cause for such doubt has been removed.

As set forth in 103.5, paragraph four, if the successful bidder submits a good and sufficient surety or collateral bond payable to the State of West Virginia in an amount equivalent to 100 percent of the contract price, an amount equivalent to two percent of the whole will be deducted from the total of the amounts ascertained as payable and will be retained by the Division until the completion of the entire Contract in an acceptable manner. The balance, or an amount equivalent to 98 percent of the whole, less all previous payments, will be certified for payment.

When the work under contract has been completed and its acceptance is recommended by the Engineer, and upon written request by the Contractor accompanied by proper release by the Contractor's surety, a part of the two percent retained as outlined above, in an amount determined by the Engineer, may be released and paid the Contractor. A minimum of 0.5% (zero point five percent) of the approximate total final contract amount will be retained until payment of the final estimate.

Unless otherwise requested by the Contractor in writing, all amounts retained by the Division will be invested in the Consolidated Investment Fund of the State of West Virginia with interest accrued in the name of the Contractor. Dividends will be paid annually and a service fee as determined by the Fund will be deducted from the interest earned.

Substitution of Securities for Retainages:

- i The Contractor may, from time to time, withdraw the whole or any portion of the amount retained for payments to the Contractor, under the Contract, with the written release from Contractor's surety, pursuant to the terms of the Contract, notwithstanding the provisions above, upon depositing with the State Treasurer, United States treasury bonds, United States treasury notes, United States treasury certificates of indebtedness or United States treasury bills, or bonds or notes of the State of West Virginia. A safe keeping receipt from a bank located in the State of West Virginia may be deposited with the State Treasurer in lieu of any of the definitive securities. No amount shall be withdrawn in excess of the market value of the securities at the time of deposit or of the par value of the securities, whichever is lower.
- ii The State Treasurer shall on a regular basis, collect all interest or income on the obligations so deposited and shall pay the same, when and as collected, to the Contractor who deposited the obligations. If the deposit is in the form of coupon bonds, the State Treasurer shall deliver each coupon as it matures to the Contractor.
- iii Any amount deducted by the State, or by any public department or official thereof, pursuant to the terms of the Contract, from the retainages due the Contractor, shall be deducted, first from that portion of the retainages for which no security has been substituted then from the proceeds of any deposited security. In the latter case, the Contractor shall be entitled to receive interest, coupons or income only from those securities which remain after such amount has been deducted.
- iv Any Contractor who has substituted a security or securities for retainages and the same matures before the completion and finalling of the Contract for which the security or securities were substituted for retainages may, from time to time, substitute another security or securities for the one or ones having so matured in the same manner that the original security or securities were substituted so long as the substituted security or securities are of a kind designated in (i) above, of equal value to the matured security or securities for which it is substituted. All interest and income accruing on such substituted security or securities shall be collected and paid and the security or securities themselves shall be held, handled and delivered by the State Treasurer in the same manner, as is provided in (ii) and (iii) above, for the original security or securities deposited.

109.7-PAYMENT FOR MATERIAL ON HAND:

Partial payment may be made to the extent of the delivered costs of material to be incorporated into the work, provided the material meets the requirements of the Plans and Specifications when delivered in the vicinity of the project or at approved off-site locations. In any event, partial payment for material on hand will not exceed the bid price. Such material shall be stored in acceptable storage places, and the Contractor shall furnish evidence of payment for the delivered cost of the material within 90 days of the cut-off date of the estimate on which this material was paid.

109.8-ACCEPTANCE AND FINAL PAYMENT:

When the project has been accepted, as provided in 105.16, the Engineer will prepare the final estimate of the quantities of the various classes of work performed. Before the final payment is made, the Contractor shall execute the Statement of Acceptance on the back of the final estimate. After the Contractor executes such final estimate or if the Contractor fails or declines to execute the final estimate within 30 days after receipt, the Division will consider the estimate approved and accepted and he will be paid the entire sum found to be due after deducting all previous payments and all amounts to be retained or deducted under the provisions of the Contract. Upon written request from the Contractor received within 30 days of his receipt of the final estimate, the time for review and execution of the final estimate will be extended up to 60 additional calendar days. Should the Contractor desire to reserve the right to file a claim with the State Court of Claims for any sum or compensation not included in the final estimate, growing out of the Contract, then a Reservation of Right stipulating the nature, each item and the amount claimed shall be added at the end of the acceptance statement. This claim must be filed with the State Court of Claims within 120 days of execution of the final estimate. If any monies owed the Division are not paid within 120 days of the execution of the final estimate, the Division shall have the right to revoke the Contractor's Prequalification until the monies are paid.

All prior partial estimates and payments will be subject to correction in the final estimate and payment.

109.9-PRICE ADJUSTMENT OF FUELS:

Because of the uncertainty in estimating the cost of diesel fuel that will be used during the life of this contract, adjustment in compensation for certain contract items is provided for as follows:

Product price quotations for Fuel Oil No. 2 (diesel fuel) as published by the Oil Price Information Service (OPIS) will be utilized to establish the Contract Base Price (Cbp) as well as the Monthly Base Price (Mbp) thereafter. These prices will be the average of the individual prices for the following locations: Charleston, West Virginia; Ashland, Kentucky; Pittsburgh, Pennsylvania; Roanoke, Virginia; and Marietta, Ohio as published on the Wednesday prior to the first day of the month, with the effective date of the index being the first day of the month. If the Wednesday prior to the first day of the month falls on a holiday or the price is otherwise not published for that date, the index prices will be based on the next earliest date as published by OPIS.

The contract base price (Cbp) and the monthly base price (Mbp) may be found posted on Contract Administration's website for Fuel and Asphalt Prices at the following link: <http://www.transportation.wv.gov/highways/contractadmin/Lettings/Pages/FuelandAsphaltPrices.aspx>

Any dispute concerning the (Cbp) shall be resolved during the first voucher estimate review.

The portion of the contract unit price which reflects the cost of the specified material will be adjusted for the change in accordance with the following formula:

$$Pa = [(Mbp \div Cbp) - 1.00] \times Cbp \times C \times Q$$

Where:

- Pa = Price Adjustment
Mbp = Monthly base price at time of placement
Cbp = Contract Base Price at time of bidding
C = Cost Adjustment Factors per Unit of Contract Item Bid
as outlined in chart below
Q = 'As Constructed' Quantity

Adjustments in compensation for any period may be either plus or minus. If (Mbp) is greater than (Cbp), the adjustment will be plus. If (Cbp) is greater than (Mbp), the adjustment will be minus.

The adjustment in compensation for diesel fuel used for the listed items will be made on the separate items on the basis of the average diesel fuel requirements for processing a unit of the item as shown in the table below.

The gallons (liters) of diesel fuel for price adjustment will be determined by multiplying the usage factors listed in the table below by the amount of acceptable work performed on the separate adjustable items during an estimate period.

All adjustments will be made based on the gallons (liters) of diesel fuel indicated in the table below and no changes will be made for variations between these usage factors and the actual factors.

**TABLE OF MATERIALS TO BE ADJUSTED AND
COST ADJUSTMENT FACTORS FOR DIESEL FUEL USAGE**

		UNITS	FACTOR
Class 1:	Excavation under Sections 207 and 211	Gallons per cubic yard (Liters per cubic meter)	0.25 (1.24)
Class 2:	Crushed aggregate under Sections 307, 311, and 405	Gallons per ton** (Liters per megagram)	0.62 (2.59)
Class 3:	Bituminous concrete under Sections 401 and 402	Gallons per ton** (Liters per megagram)	1.06 (4.43)
Class 4:	Rigid concrete pavement under Sections 501 and 502	Gallons per cubic yard (Liters per cubic meter)	0.76 (3.77)

** Where the pay item for aggregate is in cubic yards (meters), conversion to tons (megagrams) for the purpose of diesel fuel price adjustment will be made on the basis that one cubic yard (meter) equals 1.75 tons (2.08 megagrams).

Any difference between the checked final quantity and the sum of quantities shown on the monthly estimates for any item will be adjusted by the following formula:

$$FA = (FCQ \div PRQ) \times EA$$

Where:

FA = Final Adjustment (dollars) for the item which increased or decreased
 FCQ = Final Checked Quantity of the item which increased or decreased
 PRQ = Total Quantity of said item previously reported on the most recent estimate
 EA = Total adjustment in dollars of said item shown on most recent estimate

The monthly base price for determining price adjustments for all work performed after the contract completion date, as revised by approved time extensions, will be the monthly base price (Mbp) at the time of the contract completion date (as extended) or at the time the work was performed, whichever is less.

The final adjustment will take into consideration any error(s) that may have been made in the computation of any prior monthly adjustments.

109.10-PRICE ADJUSTMENT OF ASPHALT BINDER:

Because of the uncertainty in estimating the cost of petroleum products that will be used during the life of this contract, adjustment in compensation for certain contract items is provided for as follows:

The contract items listed in Table 109.10.1, will be adjusted in accordance with the Division's indices for asphalt binder. The bidding index (Ib) for asphalt binder will be equal to the placement index as listed on the Contract Administrations website for Fuel and Asphalt adjustments for the Wednesday prior to the first day of the month, with the effective date of the index being the first day of the month. If the Wednesday prior to the first day of the month falls on a holiday or the price is otherwise not published for that date, the index will be based on the next earliest date as reported. The placement index (Ip) will be the price in effect on the first of the month in which the specific adjustable material was actually placed. Both the bidding index (Ib) and the placement index (Ip) will be based on the average of the posted prices of PG 64-22 asphalt binder per ton/megagram as reported from the following sources on the Wednesday prior to the first day of each calendar month:

Marathon Petroleum Company, LLC, Catlettsburg, Kentucky
 Marathon Petroleum Company, LLC, Floreffe, Pennsylvania
 Asphalt materials, Inc., Marietta, Ohio
 NuStar Asphalt Refining Company, Baltimore, Maryland
 Associated Asphalt, Martinsburg, West Virginia

If one of the sources listed above changes ownership and/or name the posted price for that terminal will continue in use as though the ownership and/or name change had not occurred.

If one of the sources used for determining either the bidding index or the placement index goes out of business, any future index will be based on the average of the remaining sources. Thus, the bidding index (Ib) could be based on the average of five sources and the placement index (Ip) on the average of four sources or vice-versa. If a source that goes out of business reopens at a later date, the placement index would once again be based on the average of five sources as indicated above.

The posted price for each source will be compared to the average of all sources. If the difference between the average and the individual price is greater than 25 % of the average, that individual source will be excluded from the calculation of the average price (Ib) or (Ip) and a new average will be calculated using the remaining sources.

Sources chosen for the index are required to report their posting to the Division no later than the Wednesday prior to the first day the month. Failure to report in a timely manner may impact source approval.

The portion of the contract unit price which reflects the cost of the specified material will be adjusted for the change in accordance with the following formula:

$$Pa = Q \cdot AC \cdot (Ip - Ib)$$

Where:

- Pa = Price Adjustment
- Ip = Price Index at time of placement
- Ib = Price Index for Bidding
- AC = Asphalt Content (see Table 109.10.1)
- Q = "As Constructed" Quantity

The price index for determining price adjustments for all work performed after the contract completion date, as revised by approved time extensions, will be determined as follows: The price index (Ip) shall be for the month in which the contract completion date (as extended) falls, or the price index for the month in which the work was performed, whichever is less.

TABLE 109.10.1-Table of Materials to be Adjusted for Price of Asphalt at the Time of Placement (English & Metric)							
Item Number	Asphalt Content (%)	Item Number	Asphalt Content (%)	Item Number	Asphalt Content (%)	Item Number	Asphalt Content (%)
--	--	401002-021	5.7%	401003-015	5.0%	402001-026	4.9%
311006-001	3.2%	401002-022	5.7%	401007-020	5.7%	402001-027	4.9%
401001-020	3.9%	401002-023	7.6%	401007-021	5.7%	402001-028	4.9%
401001-021	3.9%	401002-024	7.6%	401007-022	5.7%	402001-029	6.7%
401001-022	3.9%	401002-025	7.6%	401007-023	5.7%	402001-030	6.2%
401001-023	5.0%	401002-026	5.7%	401007-024	5.7%	402001-031	7.6%
401001-024	5.0%	401002-027	5.7%	401007-025	5.7%	402001-032	7.6%
401001-025	5.0%	401002-028	5.7%	401007-030	7.6%	402001-033	7.6%
401001-030	3.9%	401002-029	7.6%	401007-031	7.6%	402001-034	4.9%
401001-031	3.9%	401002-030	7.6%	401007-032	7.6%	402001-035	5.2%
401001-032	3.9%	401002-031	7.6%	401007-033	7.6%	402001-036	5.0%
401001-033	5.0%	402001-035	4.9%	401007-034	7.6%	402001-038	7.6%
401001-034	5.0%	402001-036	4.9%	401007-035	7.6%	402001-039	7.6%
401001-035	5.0%	402001-037	4.9%	401007-040	6.0%	402001-040	6.0%
401001-040	5.0%	401002-040	4.9%	401007-041	6.0%	402001-041	6.0%
401001-041	5.0%	401002-041	4.9%	401007-043	6.0%	402001-045	5.5%
401001-042	4.5%	401002-042	4.9%	401007-044	6.0%	402001-046	5.5%
401001-043	4.5%	401003-001	5.0%	401007-050	7.6%	402001-050	5.0%
401001-044	5.0%	401003-002	5.0%	401007-051	7.6%	402001-051	5.0%
401001-045	5.0%	401003-003	5.0%	401007-053	7.6%	402001-055	7.6%
401001-046	4.5%	401003-006	5.0%	401007-054	7.6%	402001-056	7.6%
401001-047	4.5%	401003-007	5.0%	402001-020	6.2%	402001-060	6.0%
401001-050	4.1%	401003-008	5.0%	402001-021	6.2%	402001-061	6.0%
401001-051	4.1%	401003-011	5.0%	402001-022	6.2%	402001-065	5.5%
401001-055	4.1%	401003-012	5.0%	402001-023	7.6%	402001-066	5.5%
401001-056	4.1%	401003-013	5.0%	402001-024	7.6%	402001-070	5.0%
401002-020	5.7%	401003-014	5.0%	402001-025	7.6%	402001-071	5.0%

The bidding Indexes (Ib) and the placement indexes (Ip) may be found posted on Contract Administrations website for Fuel and Asphalt Prices at the following link:

<http://www.transportation.wv.gov/highways/contractadmin/Lettings/Pages/FuelandAsphaltPrices.aspx>

The bidding index (Ib) for asphalt binder will be listed on the Contract Administrations website for Fuel and Asphalt adjustments for the Wednesday prior to the first day of the month, with the effective date of the index being the first day of the month for which the contract is let.

Any dispute concerning the bidding index shall be resolved during the first voucher estimate review.

109.11-SQUARE YARD PAVING ADJUSTMENTS:

For the purposes of Square Yard paving the value of Q the “As Constructed” Quantity in Sections 109.9 and 109.10 shall be calculated using the following formula.

Q = Quantity as per plan thickness calculated by:

$$Q=(L \times W \times 32.27) \times T$$

Where:

L = Length (mi)
W = Width (ft)
T = Plan Thickness (in)

109.12 through 109.19-BLANK

109.20-LOAD LIMIT VIOLATIONS AND WEIGH TICKETS:

The Allowable Gross Weight for any vehicle being used to haul materials on publicly maintained highways under the terms of this contract shall be as follows.

Title 23 Code of Federal Regulations, Section 658.17, establishes maximum allowable gross weight on the Interstate System. The maximum allowable gross weight on WV and US Routes will be as established in Chapter 17C, Articles 17 and 17A of the Official Code of West Virginia, as amended. The Public Service Commission, Weight Enforcement Section is responsible for the enforcement of these provisions.

A weigh ticket shall be required with each load of material from a commercial source which would normally have truck scales. This includes, but is not limited to, all asphalt paving materials and all aggregates regardless of the contract pay unit. The weigh ticket shall include gross, tare, and net weights, time and date of loading, Item Number or Description of Materials, Contract Number or Project Number, number of axles on haul unit, license number of haul unit, and signature of the weigher certifying that all information on the ticket is correct. If the weigher's name is printed by the computer on the ticket, then it only needs to be initialed by the weigher.

For material from a commercial source or a batch plant, which would not normally have truck scales, a weigh ticket documenting the tare weight, number of axles on the haul unit, license number of haul unit, date weighed, location of scales, and signature of the weigher certifying that all information on the ticket is correct, may be supplied for each haul unit as an alternate to the ticket required in the previous paragraph. The tare weight ticket shall be supplied for each contract on a yearly basis and when modifications are made to the vehicle or combination of vehicles. The weight of the material delivered shall be calculated and furnished by the vendor/supplier shipping the material to the project site or DOH facility. This includes, but is not limited to, concrete, structural steel, piling, reinforcing steel and all prepackaged material of known weight, such as cement, grout, fertilizer, lime, abrasives, etc.

If the haul unit is a combination of vehicles, the license number shall be supplied for each component. The tare weight shall be for the complete haul unit.

All weighing shall be done on scales approved and sealed by the West Virginia Division of Labor, Bureau of Weights and Measures. If the scales are moved or upon the request of the Engineer, the scales shall be reapproved and sealed. The Engineer shall be notified of any scale malfunctions. The Division of Highways may, at its option, accept inspection and sealing by out of state agencies when the material is being loaded outside West Virginia.

Any material, covered by this provision, which is delivered without the proper weigh ticket shall not be accepted by the Division of Highways.

Nothing in this provision relieves any party from compliance with the State Law on load limits or any fines which may be assessed for violation of said law.

SECTION 110 MISCELLANEOUS PROVISIONS

110.1-COMMON CARRIER RATES:

The common carrier rates and taxes which are current on the date of opening the bids shall be considered as applicable to all items subject to transportation charges there under.

If such rates or taxes are thereafter increased by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such increases, when evidenced by receipted common carrier bills, will be paid to the Contractor by the Division. All claims for such payments shall be made within sixty (60) days after final acceptance of the work.

If such rates or taxes are thereafter reduced by public authority on any materials entering into and forming a part of the Contract, an amount equal to the sum of all such decreases, when evidenced by receipted common carrier bills, will be deducted by the Division from the monies due the Contractor on the work performed under the Contract.

When deliveries of materials are performed by means other than common carriers, an increase or decrease in price will not be allowed or charged for changes in rates or methods of delivery.

110.2-MINIMUM WAGE DETERMINATIONS:

The Contractor shall comply with the requirements of the Davis-Bacon Act on all Federal-aid construction projects, as applicable.

110.3-NONDISCRIMINATION OF EMPLOYEES (GOVERNOR'S EXECUTIVE ORDER):

During the performance of this Contract for public work or for goods or services, the Contractor agrees as follows:

The Contractor and subcontractors shall provide equal employment opportunity for all qualified persons and shall not discriminate against any employee or applicant for employment because of race, creed, color, or national origin.

Contractors and subcontractors are required to give written notice to any labor union with which they have a collective bargaining or other agreement, that they have complied with the requirements of the Executive Orders by the Governor of the State of West Virginia, dated October 16, 1963, and December 15, 1965. These provisions shall be fully and effectively enforced and any breach of them will be regarded as a material breach of the Contract.

DIVISION 200

EARTHWORK

SECTION 201 CLEARING AND GRUBBING

201.1-DESCRIPTION:

This work shall consist of clearing, grubbing, removing, and disposing of all vegetation and debris within the construction limits and in other areas within the right-of-way or easement limits, as set forth in the Contract or as designated by the Engineer, including selective clearing of areas; site grading of public and private roadways, lanes, vehicular paths or any other existing man made improvements which lie between the construction and right-of-way limits; except such objects as are designated to remain or to be removed in accordance with other sections of these Specifications. This work shall also include preservation from injury or defacement of all vegetation and objects to remain.

201.2-MATERIALS:

Asphaltum base paint for tree surgery shall conform to the requirements of 715.36.

CONSTRUCTION METHODS

201.3-GENERAL:

The Engineer will designate the trees, shrubs, plants and other items to be removed or to remain. All items designated to remain shall be preserved by the Contractor. Alignment stakes, grade stakes, guard stakes, boundary markers, bench marks and tie points shall be preserved until such time as their usefulness has ceased and permission for their destruction is given by the Engineer.

201.4-CLEARING:

Areas indicated on the Plans, and borrow and waste sites furnished by the Division, shall be cleared of the obstructions described. In areas where the proposed embankment is to be 5 ft. (1.5 meters) or more in depth, measured below the subgrade, all stumps shall be cut off as close to the ground as is practicable but not to exceed 6 inches (150 mm) above the ground surface at the base of the stumps. When stumps are located in the area of the backslope rounding of cut sections, they are to be cut flush with or below the final slope line. Areas where the proposed embankment is to be less than 5 ft. (1.5 meters) shall be treated as prescribed in 201.6.

All merchantable timber and wood in the clearing area, except trees designated to remain, which has not been removed from the right-of-way prior to the date of advertising for bids shall become the property of the Contractor, unless otherwise provided.

Unsound or unsightly branches of trees and shrubs which are designated to remain, and are not specified to be removed under another item, shall be removed as directed. Branches of trees extending over the area occupied by the roadbed shall be trimmed to give a clear height of 20 ft. (6 meters) above the road and shoulder pavement surface. All trimming shall be done by skilled workers and in accordance with good tree surgery practices.

In all areas where stumps and shrubs are to remain, the surface of the ground shall not be unduly disturbed or compacted. Existing ground cover shall be preserved insofar as possible, and the area shall be left neat and clear and in a condition which is reasonably consistent with the surroundings.

All abandoned utility poles within the limits of the right-of-way shall be removed and disposed of by the Contractor. The removal shall be treated in a similar manner as the clearing and grubbing of trees. The poles to be abandoned will be marked by the Project Engineer.

201.5-SELECTIVE CLEARING AND THINNING:

In order that the trees may be properly marked in advance of thinning operations, the Contractor shall give the Engineer at least two weeks' notice prior to starting work or prior to resuming work after suspending operations. Trees or bushes not designated to remain shall be cut. In no event shall selective clearing and thinning operations begin until the Engineer has given approval.

All dead or diseased trees or shrubs, junk, trash, litter, or foreign matter of any kind shall be removed from the areas to be treated. This shall include uprooted stumps and all branches, tops, trunks, and dead wood resulting from woodcutting operations or from any other causes.

Trees and shrubs to be preserved shall be carefully pruned to remove all dead wood and diseased or injured tops or branches. In addition, in certain areas the Engineer may require the branches of designated trees to be removed to a height of 20 ft. (6 meters) above ground as directed in order to improve sight distance, provide head clearance, open vistas, or improve appearance of the tree. Complete clearing may be required in certain areas for the purpose of removing shade hazards, improving sight distances, or improving appearance. Such clearing shall be included under this Section.

The Contractor shall avoid disturbing or compacting the existing ground surface, as well as avoid damage to plant growth. The use of tractors, cranes, winches, or any other heavy equipment, operating anywhere within the area to be selectively thinned, will not be allowed unless exceptions are specifically authorized.

Any injury to trees and shrubs which are to be preserved shall be carefully repaired. Disturbed ground surface shall be restored as nearly as possible to natural condition.

All pruning and repair to live trees and shrubs shall be done by skilled workers according to approved arboricultural practice. All pruning scars and all cuts and wounds 1 inch (25 mm) in diameter or over shall be painted with an asphaltum base paint. The Engineer may permit such cuts on evergreen trees to remain unpainted. All stumps, new or old, shall be cut to a maximum height of 6 inches (150 mm) above the surrounding ground or as directed by the Engineer. Undesirable trees leaning or falling over the highway right-of-way from outside shall be cut at the property line.

201.6-GRUBBING:

In areas where embankments are to be constructed less than 5 ft. (1.5 meters) in depth, measured below the subgrade, complete grubbing of all trees, stumps, roots, bushes or hedge fences shall be accomplished.

In areas where embankments are to be constructed 5 ft. (1.5 meters) or more in depth, measured below the subgrade, stumps which have not been loosened by clearing and grubbing operations, and nonperishable solid objects, need not be grubbed or removed provided they are cut off so as not to protrude more than 6 inches (150 mm) above the original ground surface. Near the toe of embankment slopes no stump shall extend above a point 1 ft. (300 mm) beneath the embankment slope surface.

In areas not included within construction limits or selective clearing areas, all stumps shall either be grubbed or cut flush with or below the original ground line. Brush, shrubs, down timber,

rotten wood, rubbish and other objectionable objects and vegetation shall be cleared flush with the ground. Such areas will be clearly indicated on the Plans.

201.7-DISPOSAL:

All wood, trash, debris, stumps, and other foreign matter shall be removed and disposed of by the Contractor. Material may be disposed of at approved waste areas or in accordance with the provisions prescribed. Non-combustible material may be disposed of in embankments in accordance with the applicable provisions.

All burning of vegetative material shall be done in accordance with the applicable laws, ordinances, regulations, and requires an approval from the West Virginia Department of Environmental Protection, Division of Air Quality (DEP) as defined in the Code of State Rules, Title 45, Series 6. If the Contractor plans to burn during Forest Fire Season (March 1-May 31 and October 1-December 31) a permit is also required from the West Virginia Division of Forestry (No permit from the West Virginia Division of Forestry is required for burning between 4:00PM and before nightfall during Forest Fire Season). Copies of these approvals and permits are to be provided to the Engineer.

Open burning shall be extinguished prior to nightfall unless previously approved by DEP, Division of Air Quality. It is the intent of this Specification that the health, safety, comfort, and the property of persons in the vicinity are protected from the effects of such burning. Open burning of Construction/Demolition Waste as defined in Section 207.6.5 will not be allowed. The disposal of Construction/Demolition Waste Materials shall be in accordance with Section 207.6.5.

Clearing and grubbing materials (vegetative material only) shall be disposed of by chipping or burning using a pit burner/air curtain. Vegetative material may also be used in conjunction with erosion and sediment control features.

If the Contractor chooses the chipping option, vegetative material may be reduced to chips of a maximum size of 2 inch (50 mm). The chips may be disposed of in areas where erosion control is required, as a substitute for straw mulch in accordance with the applicable provisions of 642 and 652, or between slope lines and right-of-way lines in areas/locations as determined by the Engineer.

When the pit burner/air curtain method of disposing of vegetative material is utilized, the Contractor will have two options. The first being an above ground fire box. If this option is chosen, the Contractor shall follow the manufactures recommendations.

The second option is an in ground trench. If this option is chosen, the Contractor shall construct a minimum trench of 20ft (6m) in length X 10ft (3m) wide X 10ft (3m) deep with vertical walls. The air curtain shall be sufficient that post burn vegetated material will be no larger than 6 inches (150mm) in any direction. The air curtain shall have a flow of air in order to prevent continuous smoke pillars from escaping the trench.

The in ground trench is to be placed outside the roadway prism, unless otherwise approved by the Engineer. If the trenches are not to be eliminated in the subsequent excavation operation, they shall be backfilled. All backfill within the roadway prism shall be accomplished in accordance with the requirements of Section 207. Compaction of backfill outside the roadway prism shall be performed so as to obtain a minimum density equal to that of the surrounding ground.

The prevailing winds during open burning should be away from any roadway, airport, city, or occupied residence likely to be affected by the smoke to the best extent possible. Open burning of vegetative material shall not be allowed during periods of air stagnation advisories or alerts.

The Contractor will be held responsible for any damage caused by fires. The Contractor shall remove and dispose of burned material; replace trees, shrubs, fences or other objects designated or described to remain, but which have been damaged; and seed burned areas beyond construction limits; all in an acceptable manner. Upon completion of the work, nothing shall remain within the right-of-way limits, nor along the land adjacent thereto, which was deposited by the Contractor as the result of any of the operations of construction unless approved by the Engineer.

201.8-METHOD OF MEASUREMENT:

The quantity of work done, will be on a lump sum basis.

Clearing and grubbing for waste sites or borrow pits furnished by the Contractor shall be included in the bid price for Item 207001-*, "Unclassified Excavation"; Item 211001-*, "Unclassified Borrow Excavation"; Item 211002-*, "Rock Borrow Excavation"; or Item 211003-*, "Select Borrow Excavation".

The removal of trees outside of clearing and grubbing and selective clearing areas designated on the Plans shall be accomplished under the provisions of 109.4.

201.9-BASIS OF PAYMENT:

The quantities, determined as provided above, shall be paid for at the contract price bid for the item listed below, which price and payment shall be full compensation for doing all the work prescribed in a workmanlike and acceptable manner, including all labor, materials, tools, equipment, supplies, and incidentals necessary to complete the work. The lump sum bid price will be full compensation for the estimated quantities shown in the Plans. Any increase or decrease from estimated quantities will be adjusted for total compensation on a prorate basis consistent with areas that have been added or deleted.

All salvable material including merchantable timber shall become the property of the Contractor unless otherwise indicated on the Plans or in the Proposal, and any salvage expected shall be computed as a credit before arriving at the bid price for this item.

201.10-PAY ITEM:

ITEM	DESCRIPTION	UNIT
201001-*	Clearing And Grubbing	Lump Sum

* Sequence number

SECTION 202

BUILDING DEMOLITION, WELL AND SEPTIC TANK ABANDONMENT

202.1-DESCRIPTION:

This work shall consist of the demolition of buildings and the abandonment of Septic Tanks, Water Wells, Gas Wells, Oil Wells and appurtenances as are specifically designated on the Plans. It shall include rodent control, disconnecting utilities, salvaging and disposing of the resulting materials in the manner and subject to the conditions and regulations prescribed.

The Contractor shall obtain all necessary permits, bonds and licenses required for this work and must provide them to the Engineer prior to commencing the work

202.2-UTILITIES:

The Contractor shall be solely responsible for making all necessary arrangements and for performing any necessary work to the satisfaction of the utility companies and municipal departments involved in connection with the discontinuance or interruption of all public utilities or services, such as gas, water, sewage, electricity, and telephone, which may be affected by the work to be done under the demolition specified.

202.3-DISPOSAL OF MATERIALS:

Materials resulting from demolition shall be disposed of by the Contractor at a West Virginia Division of Natural Resources approved landfill. Any material that is considered hazardous material must be disposed of at an approved site.

202.4-BUILDINGS:

The demolition shall conform to the schedule of construction set up for the project.

Buildings and appurtenances shall be removed to the existing ground level, which operation shall include removal of concrete slabs or any other type of floor resting upon the ground. Basements shall be cleared of all debris, appliances, wood or metal partition walls, wood floors, etc., so that only the foundation walls and basement floor remain. The basement floors shall be shattered. If pits, trenches, holes, or basements are not to be eliminated in subsequent excavation operation, they shall be backfilled. All backfill within the roadway prism shall be accomplished in accordance with the requirements of Section 207. Compaction of backfill outside the roadway prism shall be performed so as to obtain a minimum density equal to that of the surrounding ground.

202.4.1-Rodent Control: When specified in the Contract, the following rodent control provisions shall apply.

202.4.1.1-General: The Contractor shall furnish and place suitably prepared bait containing rodenticide in and around buildings to be demolished and shall also furnish and place insecticide for control of ectoparasites. Two rodenticide treated baits differing in content and method of placement will be required within 24 hours after receipt of notification to proceed. The Contractor shall place rodenticide treated bait within the building demolition area.

If the rodent control measures are not promptly furnished by the Contractor, the Division may provide the measures as required and deduct the cost from the money due the Contractor.

202.4.1.2-Materials: The rodenticide treated bait shall consist of the following:

1. **Type I Bait**-An anticoagulant, 0.5% concentrate, such as warfarin, pival, fumarin, PMP, etc., mixed with cereals and other rodent attractants in the following proportions by weight:

One part anticoagulant to seven parts coarse yellow corn meal; five parts rolled oats; one part granulated sugar; one part corn oil.

In the event rodents do not accept this formula chopped fruit may be substituted for the rolled oats in the same proportion.

2. **Type II Bait**-Zinc phosphide, 100% concentrate (94 % minimum assay), mixed in the proportion of 1:96 (one ounce to six pounds) of ground meat or canned dog food.

All rodenticides shall be handled and mixed in the bait in accordance with the manufacturers' instructions.

3. **Insecticide**-Two percent Diazinon Dust, or five percent Malathion Dust, or ten percent Carbaryl Dust, or two to five percent Chlordane Dust.

202.4.1.3-Rodent Control Operations: Type I bait containing anticoagulant shall be placed in shallow bait containers fastened to the floor surface of buildings or in shallow containers heavy enough to prevent overturning or removal to burrows. The containers shall be protected from domestic animals and weather and shall be distinctly labeled with the word Poison and symbol thereof. The initial rate of application shall not be less than four pounds of bait per 1,000 sq. ft. (2 kg per 100 square meters) of building area.

Type II bait containing zinc phosphide shall be wrapped in paper squares approximately 4 inches by 4 inches (100 by 100 mm) in size. Bait should be placed out of reach of children or pets and should be tossed in otherwise inaccessible places. Initial rate of application shall be a minimum of 20 baits per residential building and 40 baits per commercial building.

Bait shall be placed near burrows, runways, or other areas showing rodent signs. A shallow pan containing water shall be placed in each building.

At the time the bait is set out, the Contractor shall treat all runways, burrow entrances, nests and vertical surfaces against which the rodents may brush with the insecticide dust at a rate of 2 pounds (1 kg) per residential building and 4 pounds (2 kg) per commercial building.

Location of all bait, bait containers and water containers shall be noted and bi-weekly inspection and replacement of bait and water shall be made. In the event bait is not touched for several days, the bait shall be moved to other areas in the building. Moldy, wet, caked or insect infested bait shall be replaced. Insecticide dusting shall be repeated once per month.

Baiting and insecticide dusting shall continue until all buildings and rubble are removed from the building demolition area.

A sign shall be posted at the front and rear of each building treated for rodent control. The sign shall be a minimum size of 30 inches by 30 inches (750 by 750 mm) with red lettering and poison symbols on a contrasting background.

Wording of the sign shall be as follows:

**THIS BUILDING
TREATED
FOR RODENT CONTROL
POISON
NO ADMITTANCE**

Minimum size lettering of the word POISON and symbols thereof shall be 6 inches (150 mm). All other lettering shall be a minimum of 4 inches (100 mm). The sign shall be made of weather resistant materials such as plastic or exterior plywood and shall be securely fastened to the building.

Where buildings to be demolished have had exterior poison warning signs placed upon them during the Division's phase of the rodent control program, the signs remaining on the buildings to be demolished will serve as adequate warning and the signing requirement of this Section is waived.

Exterior poison warning signs previously placed by the Division shall, upon demolition of the buildings, remain Division property and shall be stored on the project for removal by the Division.

Dead rodents shall be removed from the building demolition area daily and shall be buried at a minimum depth of 2 ft. (600 mm). The disposal area shall be provided by the Contractor and shall be subject to approval by the Engineer.

202.4.2-Insurance Requirements: In addition to the insurance required of the Contractor on all Division Contracts, the Contractor is required to maintain Liability Insurance for this work in the amounts and form as set forth below for the duration of the work:

Public Liability	\$1,000,000
Products Liability	\$1,000,000
Owner Liability	\$1,000,000

The above insurance shall be purchased by the Contractor on behalf of the Division from a company authorized to do business in the State of West Virginia.

202.5-WELLS:

The Contractor shall plug the well prior to starting any other construction in the vicinity of the well.

202.5.1-Materials: Materials for plugging water wells shall meet the requirements of Division 700 as follows:

MATERIAL	SUBSECTION
Bentonite	715.45
** Concrete	601

** Class D with or without air entrainment at the option of the Contractor.

202.5.2-Gas and Oil Wells: The well shall be plugged using bentonite and cement as provided for by law, and the work shall be accomplished by a qualified service company meeting the approval of the Department of Environmental Protection office of Oil and Gas. All work pertaining to plugging the well must be performed under the supervision of the representative of the DEP office of Oil and Gas. The Contractor shall notify the Project Engineer and the DEP office of Oil and Gas at least 14 days in advance of the date on which the Contractor intends to begin work.

The Division will make available upon request copies of regulation Title 35 Series 4 and Article 6, Chapter 22 of the Gas and Oil Laws. The Contractor shall obtain a permit from DEP office of Oil and Gas and must follow all procedures prescribed in the permit.

202.5.3-Water Wells: The Contractor shall plug all drilled water wells within the right-of-way limits prior to starting any other work in the vicinity of the wells. The well casing shall be pulled as much as practical and then filled from the bottom to the top with bentonite, concrete or a mixture of concrete and 5% bentonite to the ground surface. This operation shall be continuous.

The Contractor shall obtain a permit to abandon a water well from the County Sanitarian or State Health Department and must follow all procedures prescribed in the permit.

202.6-SEPTIC TANKS:

A septic tank that serves a building that is being demolished shall be abandoned as follows:

The contents of the septic tank shall be removed by a licensed septic tank cleaner and the tank removed and disposed of at an approved landfill. The excavation made to remove the tank shall be backfilled with material free of sod, trash, organic substances and muck. The backfill shall be compacted as outlined in 202.4.

202.7-METHOD OF MEASUREMENT:

The unit of measurement will be lump sum value as determined for each building to be demolished and removed, each water well abandonment, each septic tank abandonment, each gas well abandonment, or each oil well abandonment.

202.8 through 202.9-BLANK

202.10-BASIS OF PAYMENT:

The Building Demolition shall constitute full compensation for performing all of the requirements of this item, including furnishing all material, labor, tools, equipment, supplies, rodent control and incidentals thereto. Salvageable materials shall become the property of the Contractor, unless otherwise indicated on the Plans or in the Proposal.

The water wells, gas wells, oil wells, or septic tanks abandoned as provided above will be paid for at the contract price per each and shall be full compensation for performing all of the requirements of the item, including furnishing all material, labor, tools, equipment, supplies, permits, and incidentals thereto.

202.11-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
202001-*	Building Demolition Number, “x” / ”y”	Lump Sum
202002-*	Water Well Abandonment Number, “x” / ”y”	Lump Sum
202003-*	Septic Tank Abandonment Number, “x” / ”y”	Lump Sum
202004-*	Gas Well Abandonment Number, “x” / ”y”	Lump Sum
202005-*	Oil Well Abandonment Number, “x” / ”y”	Lump Sum

* Sequence number

x = parcel number

y = building, well, or septic tank number

SECTION 203 DISMANTLING STRUCTURES

203.1-DESCRIPTION:

This work shall consist of dismantling such structure or structures specifically designated on the Plans for removal, match marking, handling and storage if called for, or disposal if required.

The Contractor is responsible for determining the current condition of the structure (s) and shall use methods and procedures for dismantling the structures in a safe and efficient manner.

Bridge inspection reports are available for informational purposes and may be viewed at the following location:

West Virginia Division of Highways
1900 Kanawha Boulevard East
Building 5, Room A-350,
Maintenance Division
Charleston, West Virginia 25305

The work shall also include the preparation of a demolition/dismantling plan by the contractor. The plan shall be prepared and sealed by a Professional Engineer registered in the State of West Virginia, experienced in structural analysis of bridges.

The plan shall include a complete structural analysis for all phases of the demolition/dismantling with due regard to the existing condition of the structure at the time the work is performed. Additionally, the analysis shall show that the structure meets the design criteria of the latest edition, including all Interims, of the *AASHTO Standard Specifications for Highway Bridges*, or the *AASHTO LRFD Bridge Design Specifications* during all phases of demolition/dismantling. The design loads shall match those applied to the structure by the contractor's "means and methods" of demolition/dismantling.

The demolition/dismantling plan shall be provided to the Division's Project Supervisor at least seven calendar days prior to the beginning of any demolition/dismantling work. Receipt of the demolition/dismantling plan does not constitute review or approval or relieve the Contractor of his/her responsibility to satisfactorily demolish/dismantle the structure specified.

203.2-MATERIALS:

Not specified.

203.3-CONSTRUCTION METHODS:

The work shall include dismantling and storing, or disposing of designated structures by such methods as specified on the Plans. If the old structure is remain the property of the Division, it shall be carefully dismantled without unnecessary damage, the parts match marked, and carefully stored or erected as required by the Plans or as directed by the Engineer.

Unless otherwise noted in the plans, all material removed shall become the property of the contractor and shall be removed. Disposal, if required, shall be accomplished in accordance with the provisions of 201. The final ground around dismantled structures shall conform to the final grading plan or shall be graded to drain as directed by the Engineer. The bridge may contain lead base paint and the Contractor shall provide protection for their Workers as per the requirements of 29 CFR 1926.62.

203.4-METHOD OF MEASUREMENT:

"Dismantling Structures" will be measured as a complete unit and shall include the complete execution of the work of dismantling, handling, storing, or removing all of the structures so designated.

203.5-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract lump sum price bid for this item, which price and payment shall be full compensation for completing the item, including removal and disposition of all falsework, debris and refuse resulting from the work, leaving the premises in good condition.

The cost of preparation and transmittal of the demolition/dismantling plan shall be included in the lump sum bid for Item 203001-.*.

203.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
203001-*	Dismantling Structure	Lump Sum

* Sequence number

SECTION 204 MOBILIZATION

204.1-DESCRIPTION:

This work shall consist of the performance of construction preparatory operations, including the movement of personnel and equipment to the project site and for the establishment of the Contractor's offices, buildings and other facilities necessary to begin work on a substantial phase of the contract. The bid for mobilization shall be a lump sum. When Item 204001-*, "Mobilization", is not included as a separate bid item it is specifically understood that the cost of mobilization will be included in the unit bid price for each individual item.

204.2-MATERIALS:

Not specified.

204.3-CONSTRUCTION METHODS:

Not Specified.

204.4-METHOD OF MEASUREMENT:

The method of measurement will be a lump sum.

204.5-BASIS OF PAYMENT:

Partial payments will be made as the work progresses in accordance with the following schedule.

- i. 2.5% of the original contract amount or 50% of the amount bid for mobilization, whichever is less, will be released to the Contractor as the first estimate payable, not less than 15 days after the start of work at the project site.
- ii. 2.5% of the original contract amount or the remaining 50% of the amount bid for mobilization, whichever is less, shall be released with the estimate payable 30 days after the first estimate.

Upon completion of all work on the project, payment of any amount bid for mobilization in excess of 5% of the original contract amount will be released.

Nothing herein shall be construed to limit or preclude partial payments otherwise provided for by the contract.

No deduction will be made, nor will any increase be made, in the lump sum mobilization item amount regardless of decreases or increases in the final total contract amount or for any other cause.

204.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
204001-*	Mobilization	Lump Sum

* Sequence number

SECTION 205-BLANK

SECTION 206

BASE COURSE REINFORCEMENT GEOGRID

206.1-DESCRIPTION:

This work shall consist of furnishing, testing and installing base reinforcement geogrid elements in accordance with these specifications and in reasonable close conformity with the lines, grades and dimensions shown on the plans or established by the Engineer. Design details for base reinforcement geogrid such as geogrid type, base aggregate minimum thickness, asphalt thickness and associated details shall be shown on the plans.

206.2-REFERENCE DOCUMENTS:

ASTM Standards:

D1388	Flexural Rigidity
D4355	Practice of Sampling of Geosynthetics for Testing
D4595	Test Method of Tensile Properties of Geotextiles by the Wide Width Strip Method

Corps of Engineers:

COE	CW02215 Percent open area

Geosynthetic Research Institute:

GG1	Standard Test Method for Geogrid Rib Tensile Strength
GG2	Standard Test Method for Geogrid Junction Strength

206.3 - GEOGRID MATERIAL:

206.3.1-General: The Contractor shall be responsible for obtaining the geogrid reinforcement materials and associated components that meet all requirements of the Specification.

Geogrid reinforcement elements shall consist of a regular network of integrally connected longitudinal and transverse polymer tensile elements with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil, aggregate or other material.

206.3.2 - Certification of Materials and Submittals:

206.3.2.1-Specification Compliance Certification: Prior to construction the Contractor shall submit to the Engineer the Manufacturer's certification that the geogrid has been evaluated in full compliance with this Specification. The Contractor's submittal package shall include; but not be limited to; the Manufacturer's written certification that all resin used to produce the geogrid is virgin and classified as polypropylene or high molecular weight polyester.

206.3.2.2-Fitness for Use: The Manufacturer of the base reinforcement geogrid shall supply written certification that the resin and additives used in manufacture of the geogrid (including coating materials, if applicable) and that the Manufactured geogrid product has been evaluated in accordance with this specification and is durable in a soil environment. Certification shall be notarized and signed by an officer of the manufacturing company.

206.3.3-Base Course Reinforcement Geogrid: The geogrid shall be a biaxial geogrid and shall have aperture geometry and rib and junction cross-sections sufficient to permit significant mechanical interlock with the material being reinforced. The geogrid shall have high flexural rigidity and high tensile strength at ribs and junctions of the grid structure. The geogrid shall maintain its reinforcement and interlock capabilities under repeated dynamic loads while in service and shall also be resistant to ultraviolet degradation, to damage under normal construction practices, and to all forms of biological or chemical degradation normally encountered in the material being reinforced.

The geogrid shall also conform in all respects to the property requirements outlined below:

PROPERTY	TEST METHOD	UNITS	TYPE I	TYPE 2
Interlock				
Aperture Size ¹	I.D. Calipered ²			
MD		in	1.0 (nom)	1.0 (nom)
CMD		in	1.3 (nom)	1.3 (nom)
Open Area	COE Methold ³	%	70 (min)	70 (min)
Thickness	ASTM D1777-64			
Ribs		in	0.03 (nom)	0.05 (nom)
Junctions		in	0.11 (nom)	0.16 (nom)
Secant Aperture Stability Modulus @20 cm-kg	Grid Aperture Test Univ. of Alaska, Fairbanks ⁴	cm-kg/deg	3.2	6.5
Reinforcement				
Flexural Rigidity	ASTM D1388-64 ⁵	mg-cm	250,000 (min)	750,000 (min)
True Initial Modulus	GRI GG1-87 ⁶	lb/ft	15,000 (min)	32,000 (min)
Tensile Strength @ 2% strain	ASTM D4595 ⁷	lb/ft	280 (min)	410 (min)
Tensile Strength @ 5% strain	ASTM D4595 ⁷	lb/ft	580 (min)	810 (min)
Junction Strength	GRI GG2-87 ⁸	lb/ft	765 (min)	1080 (min)

*All values listed are RV's (Minimum Average Roll Values.)

Notes:

1. MD dimension is along roll length, CMD dimension is across roll width.
2. Maximum inside dimension is each principal direction measured by calipers.
3. Percent open area measured without magnification by Corps of Engineers method as specified in CW 02215 Civil Works Construction Guide, November 1977.
4. Grid Aperture Stability Test developed by Dr. T. Kinney at the University of Alaska, Fairbanks.
5. ASTM D1388-64 modified to account for wide specimen testing.
6. True resistance to elongation when initially subjected to a load measured via GRI-GG1 without deforming test materials under load before measuring such resistance or employing "secant" or "offset" tangent methods of measurement so as to overstate tensile properties.
7. True tensile strength at indicated strain levels measured via GRI-GG1 without deforming test materials under load before measuring their tensile strength so as to overstate tensile properties.
8. Geogrid junction strength as measured by Geosynthetic Research Institute test method GG2-87 "Geogrid Junction Strength".

206.3.4-Alternate Material: Alternate geogrid materials will be considered. However, the material properties of the geogrid must be evaluated based on testing the total structure and not based on simply adding the values of the individual components/layers together. Also, no preloading or strain “offset” is permitted when reporting True Initial Modulus values as outlined in the table found in section 3.3 *Base Course Reinforcement Geogrid*. Such materials must be pre-approved in writing by the Engineer prior to bid date. Alternate material packages must be submitted to the Engineer a minimum of 15 days prior to bid date. Submittal packages must include the following as a minimum:

1. Full-scale laboratory testing and in-ground testing of pavement structures reinforced with the specific geogrid which quantifies the structural contribution of the geogrid to the pavement structure. The increase in the structural layer coefficient of the base course must meet or exceed that of the design geogrid.
2. Independent certified test results stating that the alternate geogrid has a secant aperture stability modulus at 20 cm-kg, when tested in accordance with the “Grid Aperture Stability by In-Plane Rotation” test of 3.2 or greater for Type 1 and 6.5 or greater for Type 2.
3. A list of 5 comparable projects, in terms of size and applications, in the United States, where the results of the specific alternate geogrid’s use can be verified after a minimum of one year of service life.
4. A sample of the geogrid and certified specification sheets.
5. Recommended installation instructions.

The burden of proof that the alternate material is equal to the specified material is the responsibility of the alternate geogrid material supplier. The Engineer will be the sole judge of the adequacy of the proposed alternate geogrid.

206.4-MANUFACTURING QUALITY CONTROL:

Conformance testing shall be performed as part of the manufacturing process. If the Manufacturer has an established quality control program, then documentation describing the program shall be submitted to the Engineer for review. As a minimum, the Manufacturer shall conduct quality control testing as outlined below:

Test	Test Procedure	Testing Frequency (SF)
Flexural Rigidity	ASTM D1388	100,000 (9 290 m ²)
Tensile Modulus	GRI GG1	100,000 (9 290 m ²)
Junction Strength	GRI GG2	100,000 (9 290 m ²)

The Manufacturer shall perform these tests. Samples not satisfying the specifications shall result in the rejection of the applicable rolls at no cost to the owner. At the Manufacturer’s discretion and expense, additional testing of individual rolls may be performed to more closely identify the noncomplying rolls and/or to qualify individual rolls.

The Manufacturer shall certify the quality of the rolls of geosynthetic reinforcement. As a minimum, the Manufacturer shall provide quality control certificates for each batch of resin and each shift’s production. These quality control certificates shall be signed by an office of the Manufacturer and supplied to the Engineer at least fourteen (14) days prior to installation of the base reinforcement geogrid.

The quality control certificate shall include:

1. Roll numbers and identification.
2. Sampling procedures.
3. Result of quality control tests, including a description of test methods used.

206.5-TRANSPORTATION, HANDLING AND STORAGE:

The Contractor shall check the geogrid upon delivery to ensure that the proper material has been received. During all periods of shipment and storage, the geogrid shall be protected from temperatures greater than 140° F (60° C) and all deleterious materials that might otherwise become affixed to the geogrid and adversely affect its performance. Follow Manufacturer's recommendations in regards to protection from direct sunlight.

All tears, cracks, punctures or flaws to the base reinforcement geogrid coating, if applicable, shall be repaired by placing a suitable patch over the defective area as approved by the Engineer. If the substrate of a coated geogrid is exposed at roll ends or as a result of cuts, cracks, punctures or flaws, the exposed area shall be sealed with a coating solution identical to the original coating. The coating solution shall be applied by dip coating or spread coating with an applicator. The area shall be thoroughly clean and dry, and working temperatures shall not be below 32° F (0° C). All exposed substrate or repair patches shall be treated in the same manner.

206.6-CONSTRUCTION:

A qualified and experienced representative of the geogrid manufacturer or its supplier shall be on site, for a minimum of one day at the start of installation, to assist the Contractor and the Engineer in the proper construction/installation techniques. Thereafter, the representative shall be available on an as needed basis, as requested by the Engineer, during the construction of the remainder of the project.

A quality assurance program shall be conducted by the owner's representative verifying that the product supplied to the jobsite meets the design requirements. Independent testing of field samples shall be conducted at the frequencies outlined below.

Property	Method	Frequency (Sy)
Flexural Rigidity	ASTM D1388	150,000 (13 935 m ²)
Tensile	GR1 GG1	150,000 (13,935 m ²)
Junction Strength	GR1 GG2	150,000 (13,935 m ²)

Foundation soil shall be excavated to the lines and grades as shown on the drawings or as directed by the Engineer.

Geogrid shall be laid at the proper elevation and orientation as shown on the construction drawing or as directed by the Engineer. Correct orientation (roll direction) of the geogrid shall be verified by the Contractor. Geogrid may be temporarily secured in-place with staples, pins, sand bags or backfill as required by fill properties, fill placement procedures, or weather conditions, or as directed by the Engineer.

Base course aggregate material shall be placed in lifts and compacted as directed under Section 307. Base course aggregate shall be placed, spread and compacted in such a manner that minimizes the development of wrinkles in and/or movement of the geogrid. Tracked construction equipment shall not be operated directly upon the geogrid. A minimum fill thickness of 4 inches (100 mm) is required prior to operation of tracked vehicles over the geogrid. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the

geogrid. Rubber tired equipment may pass over the geogrid reinforcement at slow speeds, less than 10 mph (16 km/h). Sudden braking and sharp turning shall be avoided.

Any geogrid damaged during installation shall be replaced by the Contractor at no additional cost to the Division.

206.7-MEASUREMENT/PAYMENT:

Measurement of geogrid reinforcement is on a square yard (meter) basis and will be computed on the total area of geogrid shown on the construction drawings.

The quantity of geogrid, acceptably placed, measured as noted above, will be paid for at the contract unit price per square yard which shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete these items of work.

206.8-PAY ITEM:

ITEM	DESCRIPTION	UNIT
206002-*	Base Reinforcement Geogrid, Type "type"	Square Yard (Meter)

* Sequence number

SECTION 207 EXCAVATION AND EMBANKMENT

207.1-DESCRIPTION:

This work shall consist of excavation for the roadway and channel changes including the removal and hauling of all material, of whatever character encountered, not being removed under some other item; preparing areas upon which embankments are to be placed, and constructing embankments with excavated material; disposing of unsuitable and surplus material; preparing the subgrade; finishing shoulders, slopes, ditches and drains; constructing benches and removing slides as may be required by the Plans or as directed by the Engineer; all in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses and cross sections shown on the Plans or established by the Engineer.

The compaction of embankments and subgrades will be accepted in accordance with these Specifications and the applicable requirements of 105, 106, and 109.

207.2-MATERIALS:

Materials shall meet the requirements specified in 715.11 and 716.

207.2.1-Quality Control Testing: Quality control of the embankment and subgrade material is the responsibility of the Contractor as specified in 106.1.

The Contractor shall maintain necessary equipment and qualified personnel to perform all sampling and testing necessary to determine the magnitude of the various properties of the material governed by the Specifications and shall maintain these properties within the limits of the Specifications.

The Contractor shall notify the Engineer prior to construction of the test strip data for all compaction testing on the forms as set forth in MP 700.00.24 and maintain records of the necessary equipment used to compact the material in accordance with 716.3.2.3. Completed test data forms shall be provided to the Engineer at or immediately after the time of testing.

The Contractor shall submit a quality control plan detailing the methods by which the quality control program will be conducted. This plan, prepared in accordance with the guidelines set forth in the appropriate portions of MP 307.00.50 and MP 717.04.21, shall be submitted to the Engineer at the preconstruction conference. The work shall not begin until the plan is reviewed for conformance with the contract documents.

207.2.2-Sampling and Testing: Frequency of sampling and testing shall be in accordance with the contractor's quality control plan. The minimum sampling and testing frequencies for gradation shall be as indicated in Attachment 1 of MP 307.00.50. The material shall be sampled in accordance with MP 700.00.06. The minimum sampling and testing frequency for compaction will be in accordance with MP 717.04.21.

207.2.2.1-Compaction: Compaction of embankment and subgrade shall meet the requirements set forth in 207 and 716.

207.2.2.2-Gradation: Acceptance for gradation shall be on the basis of test results on consecutive random samples from a lot. A lot shall be considered the quantity of material represented by an average test value, not to exceed five sublots. Generally at the beginning

of the project, the average shall be started on the second sample in accordance with MP 300.00.51. A subplot is the quantity of material represented by a single gradation test. In the case where only one sample is taken, this subplot shall be considered the lot. When the average, or when the most recent three consecutive individual test values fall outside the limits specified in 716.1 and 716.1.1.2, the lot of material represented will be considered nonconforming to the extent that the last of its sublots is nonconforming. When this occurs, the last subplot shall have its price adjusted in accordance with Table 207.16.1. In the case where the average is nonconforming and the last subplot contained is conforming, then there would be no price adjustment. In no event, however, shall a subplot of material have its price adjusted more than once, and the first adjustment, which is determined, shall apply.

207.2.2.3-Degree of Nonconformance: When a subplot of material is to have its price adjusted, the percentage point difference between the nonconforming test value and the specification limit shall be determined for each sieve size determined to be nonconforming, and this value shall be multiplied by its appropriate multiplication factor as set forth in Table 207.2.2.3 to determine the degree of nonconformance of that sieve.

TABLE 207.2.2.3

Nonconforming Sieve Size	Multiplication Factor
3 in. (75 mm)	1.0
No. 200 (75 μ m)	1.0

The total measure of nonconformance of an individual subplot is the sum of all nonconformance of an individual sieve sizes of that subplot.

When the total degree of nonconformance has been established and it is 12.0 or less, the material will be paid for at an adjusted contract price as specified in Table 207.16.1.

When the degree of nonconformance is greater than 12.0, the nonconforming subplot shall be resolved on an individual basis, requiring a special investigation by the Engineer to determine the appropriate course of action to be followed. Pending resolution of the matter, additional lifts of select material for backfill shall not be placed over the nonconforming material

CONSTRUCTION METHODS

207.3-ROADWAY EXCAVATION:

207.3.1-Slopes: Slope lines shall conform to the lines and grades shown on the Plans or established by the Engineer within the following tolerances: For all slopes back of the ditch line a construction tolerance of plus or minus 1 ft. (300 mm), measured in a horizontal plane, will be permitted. No change will be permitted in the width, grade or dimensions of the roadway ditch due to the tolerance. The slope may be varied only by permission of the Engineer. Slopes shall be trimmed neatly to present a uniform surface, free from hollows or protrusions and loose or overhanging rocks. Slopes shall not be undercut. The tops of all slopes, except where the material is of solid rock, shall be rounded as shown on the Plans.

The Contractor shall take precautions by benching or other methods, as directed by the Engineer, to prevent slides and slipouts.

In all roadway cuts, including areas where ledges of rock or hard shale, boulders, coal or other solid formations are encountered at or near subgrade elevation, the excavation shall be carried to a minimum depth of 6 inches (150 mm) below the surface of the subgrade for the full cross section width of the roadway between the ditches. The surface of all areas excavated below subgrade elevation shall be graded in such a manner that undrained pockets are eliminated before placing subgrade material. Excavation to the 6 inches (150 mm) limit will be paid for at the contract unit price bid for "Unclassified Excavation". Excavation made below this 6 inches (150 mm) limit will not be paid for.

207.3.2-Use of Explosives: The provisions of 107.11 will be enforced. The Contractor shall not employ any method of blasting which will result in breakage beyond the slope line, or which is dangerous to the public or destructive to property. Excessive blasting or "over-shooting" will not be tolerated. Any material outside the authorized cross section which becomes shattered or loosened by blasting shall be removed without compensation if so ordered by the Engineer.

207.3.3-Rock Excavation:

207.3.3.1-Presplitting Technique: When explosives are used in excavation, the presplit technique shall be used except for fill bench construction and where slopes flatter than 1 to 1 are designed. This involves a single row of holes drilled along the neat excavation line and the blasting charge fired before any adjoining main excavation area is blasted. Depending on the type of rock, the drill holes for the presplitting shall be on centers from 2 ft. to 5 ft. (0.6 to 1.5 meters) as determined by field demonstration.

The holes to be loaded for presplitting shall be string loaded as recommended by the manufacturer of the explosives. The presplitting may be accomplished during the primary blast by delaying the primary holes so the presplitting holes will fire ahead of them. The end result is intended to yield a minimum of breakage outside the neat line of the plan cross sections. The Contractor shall make available upon request a record of the spacing and the amount and type of explosives used in the presplit operation.

207.3.4-Archeological and Historical Findings: Should the Contractor's excavation operations encounter remains of prehistoric people's dwelling sites or artifacts of historical or archeological significance, the operation in that locality shall be temporarily discontinued. The Engineer will contact appropriate authorities to determine the disposition thereof. When directed by the Engineer, the Contractor shall excavate the site in such manner as to preserve the artifacts encountered and shall remove them for delivery to the custody of the proper State authorities. Such excavation will be considered and paid for as defined by 104.3.

207.4-BENCHES:

Benches to be constructed either above or below the profile grade shall conform to the dimensions shown on the Plans or as directed by the Engineer. Necessary drainage shall be placed as directed before backfilling. The Contractor shall arrange benching operations to allow sufficient time for the Engineer to complete all cross sections before placing embankment material.

207.5-DITCHES:

Ditches, drains, channels, and stream changes, including inlet and outlet ditches for culverts, shall be constructed where shown on the Plans or as directed by the Engineer. Diversion ditches, where specified, shall be cut beyond the rounded edges of slopes. Ditch slopes shall be rounded and trimmed neatly to line, and flow lines shall be trimmed of irregularities in the grade which might cause surface water pockets.

207.6-DISPOSAL OF MATERIAL:

207.6.1-Suitable Material: All suitable material excavated as above provided shall be used for forming embankments for the roadways, connecting roads, ramps and approaches; for constructing subgrade and shoulders; around structures and buildings; or for any other purpose necessary for the completion of the project as shown on the Plans or directed by the Engineer.

Random material, hard shale and rock, as defined in 716, are suitable for use in embankments. Within soil groups, preference shall be given to the more granular soils which have greater dry weights, greater percentages of coarse and fine aggregate, and lower liquid limits.

Where the quantity of suitable material for certain work is limited, such material shall be reserved for the purpose as directed by the Engineer. Should the Contractor fail to reserve such available material when so directed, replacement shall be made by the Contractor at no additional cost to the Division.

207.6.2-Unsuitable Material: Materials which cannot be satisfactorily placed and compacted to a stable and durable condition may be designated as unsuitable by the Engineer. Sod, trash, organic substances, and muck are considered unfit for use in embankments.

Soil to be excavated, or being excavated, that contains excessive moisture shall also be considered unsuitable for use in embankments. However, the Contractor may at their option dry the material and use it in the construction of embankments. Aeration, or other drying method, shall be at the expense of the Contractor. If the Contractor elects to waste rather than dry, suitable replacement material, if needed to complete embankments or otherwise fulfill the intent of the Plans, shall be furnished and placed by the Contractor at their expense. Any material borrowed to obtain necessary replacement material shall be accomplished in accordance with the provisions of 211.

207.6.3-Waste: The Contractor shall locate and furnish all sites for disposal of any waste and surplus material. The Contractor will have the option to waste within the WVDOH right-of-way limits (R/W) or on private property located outside the right-of-way limits. If the Contractor chooses to waste within the R/W, and the proposed waste site becomes a structural component of the roadway template, it shall be treated as a roadway embankment in accordance with Section 207.7. The following procedure is to be followed before any waste will be allowed:

207.6.3.1-Waste within WVDOH Right-Of-Way Limits: The Contractor shall submit copies of a site plan for any waste to be placed within the R/W as per Section 105.2.1.2 and each page/sheet of all submittals shall be signed by a professional Engineer Registered in the State of West Virginia. The approving Engineer's signature block shall be as per section 105.2.1.2 for shop drawing submittals.

The plan for the site shall include, but not be limited to:

1. The location and approximate boundaries of the waste site;
2. Topographical features including existing and final ground slopes, drainage structures, etc;
3. Streams, storm water features, roads, access to properties, utilities, etc;
4. An erosion and sediment control plan utilizing the best management practices consistent with all phases of operation of the waste site;
5. Restoration or cover vegetation plan of the site;
6. If the waste site requires the modification of an existing US Army Corps of Engineers permit, the Contractor shall provide the necessary revised permit drawings to show the proposed changes to the DOH in order to modify the existing 404 permit and to obtain a 401 Water Quality Certification if necessary. A minimum of 2 months may be required to get approval.
7. If the Contractor proposes to dispose of any Construction/Demolition Waste Material within the waste site, the criteria as set forth in subsection 207.6.5- Construction/Demolition Waste Material must be followed and a copy of the notification sent to the West Virginia Department of Environmental Protection.

If the Contractor has unsuitable waste material and they choose to waste within the R/W, the waste site shall not be a structural component of the roadway and must follow the guidelines as outlined above. The waste site shall have equipment compaction.

The following will not be allowed for waste sites within the R/W:

1. Steepening of slopes (without a geotechnical analysis);
2. Placement above roadway grade (without a geotechnical analysis);
3. Fill within the 100 year floodplain.

Upon receipt of the Contractor's complete waste site submission, the Engineer shall follow the guidelines as set forth in the latest edition of the Erosion and Sediment Control Manual for review and acceptance by the Division. The Contractor may be required to revise the site plan prior to acceptance by the Division. The Contractor's waste site plan must be approved as per section 105.2.1.2 and the West Virginia Department of Environmental Protection before any waste material can be placed in the site.

The DOH will bear the cost of all features associated with the waste site except for necessary revisions to drainage structures (ie. lengthening of culverts, etc.).

Upon completion of work, all waste sites shall be neatly trimmed and drained and all debris and spoil disposed of in accordance with the approved plan. No material shall be wasted at places other than those approved, except as provided, nor shall any material be wasted above established grades of any road unless authorized by the Engineer in writing. Slopes shall be trimmed neatly to present a uniform surface, free from hollows or protrusions and loose or overhanging rocks. The Contractor shall take precautions by benching or other methods to prevent slides and slip outs. Waste areas shall be graded by the Contractor then fertilized, seeded and mulched in accordance with the applicable Specifications and will be paid for in accordance with the pay items within the contract.

For waste sites not to exceed 300 cy (230 m³) and within the R/W, the Contractor shall prepare a plan to include erosion and sedimentation control features to be approved by the District Environmental Coordinator. No plan will be approved if it is within a floodplain.

For these waste sites, the Contractor shall comply with existing laws and/or regulations and save the State harmless from any claims for damages which may result from the waste.

The Contractor shall minimize pollution or sedimentation of rivers, streams, lakes, ponds, and other bodies of water while conducting all wasting operations.

207.6.3.2-Waste outside of WVDOH Right-Of-Way Limits: For waste sites outside the R/W, the Contractor and/or property owner shall bear all costs and responsibilities associated with erosion and sediment control, stability, permitting, mitigation, etc. Appropriate Traffic Control items within the Project Limits will be paid accordingly. The Contractor and/or property owner shall comply with existing laws and/or regulations and save the State harmless from any claims for damages which may result from the waste.

The Contractor shall minimize pollution or sedimentation of rivers, streams, lakes, ponds, and other bodies of water while conducting all wasting operations.

207.6.4-Conduit: Conduit designated to be re-laid shall be removed with care and stored where it can be protected from damage until reused. The Contractor shall replace sections lost from storage, damaged by negligence, or used in an improper manner.

207.6.5-Construction/Demolition Waste Material: The Code of State Rules for the West Virginia Department of Environmental Protection Title 33 Series 1 Section 2.38 defines "Construction/Demolition Waste" as waste building materials, packaging, and grubbing waste, resulting from construction, remodeling, repair and demolition operations on houses, commercial and industrial buildings, including, but not limited to, wood, plaster, bricks, blocks and concrete, and other masonry materials, but does not include asbestos-containing materials, household furnishings, burnt debris, material containing lead-based paint, pressure-treated wood, contaminated solid waste, yard waste or waste tires, and other items listed in subdivision 5.4.a of the Title 33, Series 1, in the Code of State Rules.

The Code of State Rules for the West Virginia Department of Environmental Protection Title 33 Series 1 Section 3.16.e.2.C. provides a One-Half Acre Exemption for Division of Highways Projects. The Division of Highways or its contractors working on highway construction that dispose of construction/demolition waste material, which, for the purpose of this paragraph, includes Category I Nonfriable Roofing, are exempt from the permitting requirements of the rule, provided that the disposal area does not exceed one-half acre, does not fill natural wetlands, adheres to best management practices for construction, maintains cover over the material, and the parties are obligated by contract to comply with all disposal provisions specified by the West Virginia Division of Highways Standard Specifications, Roads and Bridges, including Supplemental Specifications published by the Division of Highways (Standard Specifications). This exemption does not apply to multiple one-half acre sites on the same parcel of land, or to disposal of material not generated by the highway project. Eligibility for this exemption requires the Division of Highways or its contractors provide the Secretary for the West Virginia Department of Environmental Protection with seven (7) days' notice prior to disposal and a copy of the landowner agreement. Eligibility also requires proper management of the site by the Division of Highways.

Hazardous Waste disposal shall be conducted in accordance with State and Federal Laws and Regulations. Hazardous Waste shall be taken to an EPA approved Hazardous Waste Disposal facility.

The legitimate beneficial reuse of clean bituminous (asphaltic) concrete, Portland cement concrete and other clean masonry substances for the purpose of fill, riprap, road surfacing or road base material is exempt from the West Virginia Department of Environmental Protection permitting requirements of the rule, provided that any such fill will not be placed in natural wetlands, adheres to the best management practices for construction and maintains cover over the material when used as a structural component of a fill, and provided further that bituminous (asphaltic) concrete may not be used for riprap material.

For the purpose of the above paragraph, "clean" will be defined as uncontaminated bituminous (asphaltic) concrete, Portland cement concrete, or masonry material that does not have protruding metal prior to its reuse. In cases where Portland cement concrete is used as riprap and that concrete contains metal, the Secretary of the West Virginia Department of Environmental Protection will decide on a case-by-case basis whether this reuse is eligible for an exemption under this rule.

Concrete, stone, brick, and other masonry materials which have been broken into pieces not exceeding 2 ft. (600 mm) in any dimension may be permitted in embankments but not within 2 ft. (600 mm) of the subgrade 1 ½ ft. (450 mm) of the top of the side slopes. Material such as wood, steel, and broken concrete matted together by steel reinforcement will not be permitted in any portion of the embankment. All voids shall be completely filled with suitable material and compacted to the density specified in 207.

Portland cement concrete and bituminous (asphaltic) concrete removed from a project may be used as fill in a waste site provided the placement is in accordance with Section 207.7.3.2.3-Rock. All Portland cement concrete and bituminous (asphaltic) concrete in the waste site shall be covered with a minimum of 2 ft. (600 mm) of soil. The fill area of Portland cement concrete and bituminous (asphaltic) concrete shall not be within 300 feet (91m) of a wetland, a perennial stream, or within the 100-year floodplain.

The Contractor shall take all precautions for the stability of slopes in any waste site containing Construction/Demolition waste by benching or other methods to prevent slides and slip outs. It may be necessary to compact the Construction/Demolition waste to ensure stability. Construction/Demolition waste materials shall not be burned. Construction/Demolition waste materials which do not qualify for the Exemptions in the Code of State Rules for the West Virginia Department of Environmental Protection Title 33 Series 1 must be recycled or disposed of in a DEP approved landfill.

The Contractor shall not allow any temporary disposal sites on the right-of-way to remain after construction is completed and must dispose of all Construction/Demolition waste in accordance with this section.

207.7-FORMING AND COMPACTING EMBANKMENT:

Slope lines for all embankments shall conform to the lines shown on the Plans or established by the Engineer, except that a construction tolerance of plus or minus 1 ft. (300 mm), measured in a horizontal plane, will be permitted, except further that the roadbed width due to the tolerance shall not be less than plan width. The slopes may be varied only by permission of the Engineer. Slopes shall be trimmed to present a neat and uniform surface, free from hollows or protrusions. The tops of all slopes shall be rounded as shown on the Plans.

207.7.1-Preparation: When fills are 5 ft. (1.5 meters) or less in depth, the top soil and sod shall be stripped to the depth specified by the Engineer, and the top 8 inches (200 mm) of the

embankment foundation shall be scarified and compacted to the density requirements specified.

If the required density is unobtainable due to excessive moisture, organic substances, or other causes, the Contractor may be required, as directed by the Engineer, to remove and waste the in-place material to a depth prescribed by the Engineer before starting embankment; or to place an initial layer of rock, hard shale, or granular material, thickness to be prescribed by the Engineer; or both.

When embankments of less than 3 ft. (1 meter) in depth are to be placed upon old concrete pavements or pavements with concrete base, the pavements or base shall be removed and disposed of unless otherwise directed by the Engineer. When embankments of 3 ft. (1 meter) or more in depth are to be placed on old concrete pavements, the pavements shall be broken up in pieces not to exceed one square foot (90000 square mm) and may be left under the new embankments, unless otherwise directed by the Engineer. When embankments are to be placed upon other than rigid types of pavement, the pavements, shall first be scarified to their full depth and recompact.

All existing slopes, other than rock, against which embankments are to be placed shall be plowed or deeply scarified so as to allow blending of the in-place material with the embankment material. When specified in the Contract or directed by the Engineer, the slopes shall be benches before the embankment is placed.

Prior to the commencement of excavation and embankment, when called for in the Contract, top soil shall be salvaged and stockpiled at the locations designated by the Engineer. Construction and payment procedures shall be in accordance with 651.

207.7.2-Materials for Formation and Compaction of Embankments: Embankment materials, test methods and the Contractor's quality control requirements shall conform to be applicable provisions of 716.

207.7.3-Placing Embankment:

207.7.3.1-General: No embankment shall be placed on frozen material. During the process of excavation and embankment construction, the roadway shall be maintained in such a condition that it will be well drained at all times. Depositing and compacting embankment in layers shall be started at the lowest point of the fill below grade, at the bottom of ravines, and at the foot of slopes on side hills. Unconsolidated soil or random material, unless removed under other provisions of the Specifications, shall be removed as directed by the Engineer, replaced and compacted as specified before placing embankment thereon. The layers shall be constructed approximately parallel with finished grade. Each layer, before starting the next, shall be leveled and smoothed by means of power driven graders, dozers or other suitable equipment with adequate weight, capacity and power to do the work. Layers shall be extended across the entire fill at the level of deposition unless otherwise authorized by the Engineer. Each layer, before starting the next, shall be compacted.

Materials to be used in any area of an embankment shall be free from stumps and spongy or frozen soil. The amount of organic material shall be no greater than that specified in the applicable provisions of 716.

Soil having organic material greater than that specified in 716 shall be disposed of as directed in 207.6.3. Embankments at bridge abutments shall be free of rock in the area

where piles are to be driven, unless otherwise specified. Where rock is required for the entire embankment at bridge abutments, the piles will require predrilling. Predrilling may be required for other embankments where the depth, density of material, or negative skin friction require it. When embankment is being formed around structures, the material shall be deposited on both sides of the structure in approximately level layers and in accordance with 212.10.

The plan and sequence of operations shall make use of all the rock obtained from the excavation or borrow in accordance with the following provisions.

Rock occurring in the excavation shall be placed to form the base for embankments, to form select embankment layers, to form drainage systems, to form the outer edges of embankments under construction or to widen previously constructed embankments. In all rock slopes, the large rocks shall be placed at the outer face and the smaller rocks and spalls near the center. The rock shall not be dumped in place but shall be distributed and placed the full width of the lift being formed by blading or dozing in a manner to assure proper placement in the final position in the embankment. The larger rock shall be well distributed and the voids, pockets, and bridging reduced to insure minimum deformation and still permit drainage where required. When there is insufficient material, other than rock, encountered in the excavation to permit the other material being properly compacted in layers, the other material will be reserved to be placed as directed by the Engineer. Material that is too wet to be properly compacted shall not be used to fill the voids of previously placed rock. Random material that meets moisture requirements may be blended with rock and shall be placed in the embankment in lift thickness as prescribed.

To the extent that it is available and needed, sufficient suitable material shall be reserved from the unclassified excavation for use in filling voids in the top of the rock fill.

Where rock is placed on an embankment of other material, the top of the other material shall be sloped from the center to the sides at a rate of approximately four percent.

207.7.3.2-Lift Thickness: The Contractor shall record material type and the lift thickness for all types of embankment.

When embankments are to be constructed across low swampy grounds which will not support the weight of trucks or hauling equipment, the lower part of the fill may be constructed by dumping successive vehicle loads of rock, hard shale or granular material in a uniformly distributed layer. The thickness of a layer shall not be greater than that necessary to support the vehicle placing subsequent layers, after which the remainder of the embankment shall be constructed in layers and compacted as specified.

In places inaccessible to a roller, such as adjacent to culverts, retaining walls and other structures, the fill material shall be placed in 4 inches (150 mm) compacted layers, uniformly compacted with approved tampers.

207.7.3.2.1-Random Material (Soil, Granular Material and Soft Shale): Random material as defined in 716 shall be placed in embankments in successive layers not to exceed 6 inches (150 mm) in thickness after compaction.

207.7.3.2.2-Hard Shale: This material is defined in the applicable provisions of 716. When suitable random material is to be mixed with hard shale, this mixture shall be placed in the embankment in lift thicknesses prescribed. Mixtures which contain 66 percent or

more of suitable random material shall be placed in lifts not to exceed 6 inches (150 mm) in thickness after compaction. Mixtures which contain 35 to 65 percent (by visual inspection) of suitable random material shall be placed in lifts not to exceed 12 inches (300 mm) before compaction. Mixtures which contain from zero to 35 percent (by visual inspection) of suitable random material shall be placed in lifts not to exceed 24 inches (600 mm). The lift thickness shall be as thin as the excavated material will permit.

207.7.3.2.3-Rock: This material, as defined in 716, shall be placed in the embankment in layers of thickness as prescribed.

Mixtures which contain 66 percent or more (by visual inspection) of suitable random material shall be placed in lifts not to exceed 6 inches (150 mm) after compaction. Mixtures which contain 35 to 65 percent (by visual inspection) of suitable random material shall be placed in lifts not to exceed 12 in (300 mm) before compaction. Mixtures which contain zero to 35 percent (by visual inspection) of suitable random material shall be placed in lifts not to exceed 36 in (900 mm). The lift thickness shall be as thin as the excavated material will permit.

Rock lifts that are designated as Select Embankment shall contain no more than 15 percent of other suitable embankment material (by visual inspection). The dominant rock size shall be 6 inches, (150 mm) and greater. During excavation and handling, the Contractor shall avoid contaminating the Select Embankment with other embankment materials. Rock for Select Embankment shall be reserved from the excavation up to the plan quantity required. If Select Embankment from the excavation is wasted prior to meeting the plan quantities, the Contractor shall be responsible, and bear the expense, for replacing the material wasted up to the plan quantity. Rock lifts in embankment shall be placed in approximately level layers of uniform thickness. The size of the rock lifts shall not exceed 36 inches (900 mm). The rock shall not be greater in any dimension than 36 inches (900 mm).

When rock is used as a lining for drainage channels, it shall be placed to the thickness called for on the plans or cross sections. The dimensions of the rock may be as large as the thickness of the blanket will permit.

207.7.4-Compaction of Embankments: Embankment material consisting of random material and hard shale as described in 716, which does not contain sufficient moisture to be compacted to the requirements specified, shall receive applications of water necessary for compaction. Water shall be applied with suitable sprinkling devices and shall be thoroughly incorporated into the material which is to be compacted. Embankment and subgrade materials which contain excess moisture shall be dried, prior to or during compaction, as necessary to obtain satisfactory compaction.

Layers of soil shall be moistened or dried to the tolerance specified in 716.3.1 at the time compactive effort is applied. Water shall be added to or excess moisture removed from soils by the use of plows, discs, or other methods.

Each layer of embankment shall be uniformly compacted to the applicable requirements specified in 716.

Hard shale shall be broken down in placing by manipulating with tractors, bulldozers, power graders, rollers, or other approved devices until voids between particles are substantially

filled. This material shall be compacted and shall be at a moisture content that will provide proper compaction.

Rock shall be placed as required under 207.7.3 and compacted, using the equipment specified in 207.7.5, to the satisfaction of the Engineer.

207.7.5-Compaction Equipment: Sufficient leveling and compacting equipment shall be provided to do the work of leveling and compacting without delay after the material has been deposited. When the equipment is inadequate for the rate of depositing, the rate of excavation and placement of fill shall be reduced to a rate not to exceed the capacity of the leveling and compacting equipment, with particular attention to the loss of moisture during the delay. When two or more fills are being constructed and are so isolated from one another that one roller cannot compact the fills satisfactorily, additional rollers shall be provided as ordered by the Engineer.

Vibratory compactors, grid, paddle-foot, or vibratory rollers, or other compacting equipment approved by the Engineer, shall be used for fills constructed of materials which are predominately rock or hard shale.

Approved pneumatic or power driven backfill tampers shall be used in areas inaccessible to rollers.

Three-wheel rollers shall weigh not less than 10 tons (9 Mg). They shall be of sturdy construction and especially designed for heavy work. They shall be in good mechanical condition and have sufficient power to travel over rough surfaces and steep grades.

Pneumatic tired rollers shall operate on two axles in such manner that the rear group of tires will not follow in the tracks of the forward group. They shall be mounted on a rigid frame and have a loading platform or body suitable for ballast loading. The pneumatic tired rollers, under working conditions, shall have a minimum rolling width of 60 inches (1.5 meters) and shall give a minimum compression of 325 lb. per inch (2.24 KN/mm) of width of tire tread.

Single axle pneumatic rollers of an approved type may be used, providing the requirements as to width and compression per inch (mm) of width of tire tread are met.

Tamping rollers shall consist of metal rollers, drums, or shells surmounted by metal studs with self-cleaning tamping feet. The cross sectional area and spacing of tamping feet and the weight of the roller shall be such that the compaction or density for the particular material shall be obtained as specified. Each tamping roller shall consist of at least two sections not rigidly joined.

Grid rollers shall consist of drums at least 5 ft. (1.5 meters) in diameter whose cylindrical faces present the appearance of an open woven bar mesh. Each drum shall be at least 2-1/2 ft. (750 mm) long and they shall be independently mounted close together on the same axle. The complete roller, when operating without ballast, shall weigh not less than six tons or 200 lb. per in (5.4 Mg or 1.38 KN/mm) of length of roller drum.

Arrangements shall be provided for adding ballast, as directed by the Engineer, to such an extent that the total weight of the unit can be increased to at least 15 tons and 500 lb. per inch (13.5 Mg and 3.45 KN/mm) of length of roller drum. Grid rollers shall make at least three complete coverages of each layer or until the required density is obtained.

The use of trucks, carryalls, scrapers, tractors, tractor wagons, or other haulage equipment shall not be considered in lieu of compacting equipment prescribed, but the traffic of such hauling equipment shall be distributed over the fill in such a manner as to make use of the compaction afforded as an addition to compaction by rolling or vibrating.

207.8-FINISHING EARTH ROADS:

When no pavement or surfacing is included in the Contract, the roadway shall be finished as a graded earth road. The roadway, shoulders, and superelevated curves shall be constructed simultaneously to the required cross section and grade. Unsatisfactory or unsuitable material shall be removed and replaced as specified in 207.9. The entire surface shall be brought to a smooth condition by repeated use of an approved power grader and continuously maintained in a condition suitable for traffic until final completion and acceptance of the work. When grading work is being done simultaneously on more than one section of a Contract, an approved grader shall be furnished on each section if so required by the Engineer.

207.9-SUBGRADE:

The subgrade shall be constructed in accordance with these Specifications, in substantial conformity with lines, grades, and cross sections shown on the Plans or established by the Engineer.

The subgrade shall be 6 inches (150 mm) compacted thickness for all embankment and excavation sections and shall be constructed out of suitable material free of particles larger than 3 inches (75 mm) and consisting of granular material, conforming to the requirements of 716.1.1.2, that can be satisfactorily compacted to a stable condition. The tolerance set forth in section 207.9.1 shall apply. Excavation made below this 6 inches (150 mm) limit in cut sections will not be paid for, except, when unsuitable material is removed as specified below, payment will be made for removal to an additional depth of 12 inches (300 mm) of this unsuitable material with the actual locations and depth of removal established by or acceptable to the Engineer.

The subgrade layer or layers shall be moistened or dried to a uniform moisture content suitable for maximum compaction and brought to a firm unyielding condition by compaction. The subgrade shall be uniformly compacted to the applicable requirements specified in 716.

The surface of the subgrade shall be maintained in such condition that it will drain at all times.

When trenching is done for narrow base widening, ditches of an adequate depth shall be constructed across the shoulders at sufficient intervals to permit a free outlet of water. Equipment or vehicles shall not be allowed to travel in a single track and form ruts in the subgrade. Any ruts or irregularities formed in the subgrade shall be scarified and recompacted.

When the construction of a base, pavement, or surface is included in the Contract, or is so provided on the Plans, the profile grade of the subgrade shall be such that the specified thickness of the base course, pavement and surface will be obtained within limits of final surface grade. Any grade revision necessitated shall be called to the attention of the Engineer.

When unsuitable material is encountered at the subgrade elevation, it shall be removed to a depth of 12 inches (300 mm) and replaced with suitable material.

When so designated, engineering fabric for subgrade stabilization, conforming to 715.11, shall be installed over the area which shall be relatively smooth, free of sharp protrusion, depressions or debris. The fabric shall be placed with the machine direction of the fabric parallel with the alignment and shall be relatively smooth and free from creases. The joining of fabrics shall be accomplished by sewing (either in the field by portable sewing machine or during manufacture of the fabric) as outlined in 715.11.3 or shall be installed so any splice joints have a minimum overlap of 3 ft. (900 mm) or as directed by the Engineer.

Once the fabric is placed, cover material shall be brought to the working face, dumped and spread with equipment exerting the minimum ground pressure possible. Construction equipment

shall not operate directly on the fabric. A minimum of 6 inches (150 mm) of cover material shall be maintained between the construction equipment and the fabric.

Compaction shall be accomplished by conventional methods after the cover material is spread. Sheepsfoot rollers will not be permitted.

The completed subgrade shall present a uniform appearance and shall be checked for conformity to the lines, grades, and dimensions shown on the Plans.

When the Plans require engineering fabric for subsurface drainage or separation, the material shall conform to 715.11 and be placed as fabric for stabilization except the fabric may be joined by overlapping so the splice joints have a two foot (600 mm) minimum overlap. Construction equipment is permitted on the fabric provided all damage is repaired as specified in 715.11.3. When the fabric is placed in structure backfill applications, such as bridge abutments, the orientation of the fabric will be directed by the Engineer.

207.9.1-Tolerance: The completed surface shall not vary more than ½ inch (13 mm) above or below plan grade. Deviations shall be corrected by scarifying, adding additional approved aggregate if necessary, and recompacting.

The subbase course shall be checked for proper thickness after final compaction. The Contractor shall refill all test holes with approved material and adequately recompact the material.

Any deficiency in total thickness of the subbase in excess of 1 inch (25mm) shall be corrected.

207.10-SHOULDERS:

Before any base or pavement may be placed upon the subgrade, the shoulders along and adjacent thereto shall be built to the dimensions shown on the cross section. In order to provide adequate side support for macadam or other stone types of base or surface, shoulders shall be constructed full width, substantially to line and grade and to the depth of the course being constructed, and compacted with at least a 10 ton (9 Mg) roller, and then trimmed to the required line. When concrete base or pavement is being constructed, or where the shoulders are to be built of stabilized material, these requirements may be waived by the Engineer.

Upon completion of the base, pavement, or surfacing, the shoulders shall be finally shaped, dressed, and compacted to conform to the dimensions shown on the Plans. No stone exceeding 3 inches (75 mm) in maximum dimension will be permitted within 3 inches (75 mm) of the surface. The outer edge of the shoulder shall be trimmed to a neat line parallel with the centerline of the roadway, and the entire surface rolled to within 12 inches (300 mm) of the outside edge, refilling and rerolling any depressions that develop. Ditches and back slopes shall be finally cleaned and trimmed to line upon completion of the shoulder work.

The in-place density of shoulders shall be as specified for the subgrade in 716.

207.11-DRAINAGE:

When grading, subgrading, constructing shoulders, or placing base or pavement is suspended because of unsuitable weather or any other reason, suitable provisions shall be made to drain the grade, subgrade or shoulders by means of the construction of adequate side ditches and drains. The ditches and drains shall be kept open and maintained during the period of suspension, including the removal of slides. Upon failure of the Contractor to construct and maintain the temporary drains prior to the acceptance of the work, the Engineer may cause such work to be done by others, and the cost will be deducted from moneys due the Contractor.

Upon completion of the subgrade or shoulders and before any base or pavement is placed, subgrade drains or weeps shall be placed as shown on the Plans or as directed by the Engineer in accordance with 606.

207.12-TEMPORARY SURCHARGE:

When shown on the Plans or directed by the Engineer, a temporary surcharge composed of suitable compacted material from the "Unclassified Excavation" or "Unclassified Borrow Excavation" shall be placed after completion of the embankment to the elevations of the base of the subgrade. The temporary surcharge shall be placed in accordance with location limits and elevations shown on the Plans or as directed by the Engineer. Surcharge material shall be placed in accordance with the provisions of 207.7. The first 5 ft. (1.5 meters) of the surcharge shall be compacted as specified for embankment in the applicable provisions of 716. The remaining surcharge shall be compacted as specified above except that the target percentage of dry density shall be 90 percent.

The surcharge shall be maintained for the period indicated on the Plans or directed by the Engineer.

207.13-PROTECTION OF CURTAIN WALLS:

All bridges which will be used for permissible haulage, but which do not have the approach slabs constructed, shall have the pavement notch of the curtain walls built up to final grade by the use of timber to eliminate the possibility of damage to the curtain walls.

207.14-SLIDES AND SLIPOUTS:

Material outside the planned roadway or ditch slopes which, in the opinion of the Engineer, is unstable and constitutes a potential slide area, material from slides which has come into the roadway or ditch, and material which has slipped out of new or old embankments shall be excavated to designated lines or slopes either by benching or in such manner as directed by the Engineer. Such material shall be used in the construction of the embankments and in flattening of slopes, or disposed of as directed by the Engineer.

Erosion, regardless of amount or extent, caused by the action of the elements and which results in damage to the work or materials shall in no case be considered a slide or slipout.

207.15-METHOD OF MEASUREMENT:

The quantity of work done will be measured in cubic yards (cubic meters) for Item 207001-*, "Unclassified Excavation", which shall be the material actually moved and disposed as herein prescribed, measured in its original position and determined from the cross sections by the method of average end areas. The quantity of unclassified excavation for payment will be the number of cubic yards (meters) as further described. The quantities shall be computed using the cross section areas shown on the Plans with deductions from or additions to such cross section areas in accordance with 109.2 and authorized deviations. The quantity for payment will be to plan lines for material excavated in accordance with the construction tolerance set forth in 207.3.1 except as provided. In no case where the tolerance line has not been reached will the quantity for payment exceed the quantity actually excavated; unless otherwise authorized, the Contractor will be required to continue or resume excavation until within tolerance rather than receive payment for a lesser (out-of-tolerance) excavated quantity.

No material removed beyond the slope lines or below the grade line shown on the Plans, except as provided in 207.3.4 and 207.9, will be included for payment unless authorized in writing by the Engineer. Slides and material removed from beyond the slope lines, not attributable to carelessness, overshooting, or unsuitable construction methods on the part of the Contractor, will be included only when so authorized.

Excavation below grade, including undercutting, as shown on the Plans or as directed by the Engineer; ditches to divert water from the slopes of cuts; inlet and outlet ditches for drainage structures; other ditches as authorized by the Engineer; removal of topsoil, sod, old pavement, boulders, walls, and other unsuitable material within the areas upon which the embankment is to be placed; benching; and all other excavation authorized but not shown by the cross sections, will be measured separately and included for payment.

Where stone base or concrete pavements have been scarified or broken but not removed, or slopes other than rock upon which embankments are to be made are plowed or scarified and the loose soil has been manipulated and compacted but not removed, such work and all the work of placing and compacting all embankments, widenings or waste pits, placing and consolidating rockfills, will be considered as a necessary part of manipulation, the cost of which is included in the price bid per cubic yard (meter) for "Unclassified Excavation".

Payment for placing of temporary surcharge will be included in the contract unit price for "Unclassified Excavation" or "Unclassified Borrow Excavation", as the case may be. Removal of temporary surcharge will be paid at the contract unit price for "Unclassified Excavation".

The removal and disposal of slide and slipout material in accordance with 207.14 will be paid for at the contract price for "Unclassified Excavation", unless the Engineer, prior to the removal of such material, orders the slide or slipout material to be removed and disposed of as "Extra Work", or the Contractor, prior to performing any such work, requests in writing that the removal and disposal of any such slide or slipout material be paid for as "Extra Work", and the Engineer approves.

The cost of any work outside the limits of the slide necessary to make slide or slipout areas accessible to normal excavation equipment will be paid for as "Extra Work".

The above provisions shall not be so construed as to relieve the Contractor from the duty of maintaining all slopes true and smooth.

The quantity of subgrade work done under this item will be the number of cubic yards (meters) of "Subgrade" established in the Proposal, subject to adjustment as provided for in 104.2 and 109.2. Any additional work beyond the scope of the original Plans but authorized by the Engineer will be measured in cubic yards (meters), compacted in place, and paid for at the unit bid price for subgrade, subject to the provisions of 104.2.

The quantity of subgrade work done under Item 207002-* will be the number of cubic yards (meters) measured and compacted in place, subject to adjustment as provided for in 104.2 and 109.2. Any additional work beyond the scope of the original Plans but authorized by the Engineer will be measured in cubic yards (meters), compacted in place, and paid for at the unit bid price for subgrade.

Measurement and payment for subgrade drains will be in accordance with the provisions of 606.

207.16-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for these items, which prices and payments shall be full compensation for doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

The cost of unclassified excavation including the hauling of all material, any reserving and rehandling of unclassified excavation material, embankment construction including compaction, furnishing and applying water as an aid to embankment compaction, and the cost of furnishing additional waste sites, grading, fertilizing, and seeding and mulching of all waste sites, shall be included in the unit price bid for "Unclassified Excavation".

The cost of furnishing all materials, including furnishing and applying water necessary as an aid to subgrade compaction, shall be included in the unit price bid for "Subgrade".

207.16.1-Price Adjustment: Subgrade material not conforming with the gradation requirements as described in 207.2.2.3 will be paid for at the adjusted contract price base on the degree of nonconformance as specified in Table 207.16.1

TABLE 207.16.1

Adjustment of Contract Price for Gradation not Within Specifications	
Degree of Nonconformance	Percent of Contract Price to be Reduced
1.0 to 3.0	2
3.1 to 5.0	4
5.1 to 8.0	7
8.1 to 12.0	11
Greater than 12	*

* The Division will make a special evaluation of the material and determine the appropriate action.

207.17-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
207001-*	Unclassified Excavation	Cubic Yard (Meter)
207002-*	Subgrade	Cubic Yard (Meter)
207032-*	Fabric For Subsurface Drainage	Square Yard (Meter)
207033-*	Fabric For Subgrade Stabilization	Square Yard (Meter)
207034-*	Fabric For Separation	Square Yard (Meter)

* Sequence number

SECTION 208 THROUGH SECTION 210-BLANK

SECTION 211 BORROW EXCAVATION

211.1-DESCRIPTION:

This work shall consist of furnishing, excavating, transporting, placing, compacting, and furnishing material required to complete the roadway and embankments;

211.2-MATERIALS:

211.2.1-Unclassified Borrow Excavation: Materials shall be obtained which are suitable for the particular purpose for which unclassified borrow excavation is authorized.

211.2.2-Rock Borrow Excavation: Material shall meet the requirements specified for Rock in 207.7.3.2.3.

211.2.3-Select Borrow Excavation: Material shall consist of a granular material as defined in 716.1.1.2 unless otherwise specified in the Contract.

211.2.4-Impervious Core: Materials shall meet the requirements specified in Section 211.3.3.

CONSTRUCTION METHODS

211.3-GENERAL:

The Contractor shall locate and furnish all borrow sites to obtain materials in the amounts directed, by the methods and subject to the same provisions as prescribed in 207 except as modified or amended within. Borrow excavation should not be obtained or placed until after all available roadway excavation has been utilized in the embankments and there is no likelihood of slip or excess material. The Contractor will have the option to borrow within the WVDOH right-of-way limits (R/W) or on private property located outside the R/W. If the Contractor chooses to borrow within the R/W, the following procedure must be adhered to before any borrow will be allowed:

211.3.1-Borrow within WVDOH R/W Limits: The Contractor shall submit copies of a site plan for any borrow within the R/W and each page/sheet of all submittals shall be signed by a professional Engineer Registered in the State of West Virginia. The submittals and the approving Engineers' signature block shall be as per Section 105.2.1.2 for shop drawing submittals.

The plan for the site shall include, but not be limited to:

1. The location and approximate boundaries of the borrow site, including any adjacent landowner property information;
2. Topographical features including existing and final ground slopes, drainage structures, etc.;
3. Storm water features, roads, access to properties, utilities, etc.;
4. An erosion and sediment control plan utilizing the best management practices consistent with all phases of operation of the borrow site;
5. Restoration or cover vegetation plan of the site;

6. If the borrow site requires the modification of an existing US Army Corps of Engineers permit, the Contractor shall provide the necessary revised permit drawings to show the proposed changes to the DOH in order to modify the existing 404 permit and to obtain a 401 Water Quality Certification if necessary. A minimum of 2 months may be required to get approval.

Steepening of slopes will not be allowed for borrow sites within the R/W without a geotechnical analysis.

Upon receipt of the Contractor's complete borrow site submission, the Engineer shall follow the guidelines as set forth in the latest edition of the Erosion and Sediment Control Manual for review and acceptance by the Division. The Contractor may be required to revise the site plan prior to acceptance by the Division. The Contractor's borrow site plan must be approved as per section 105.2.1.2 and the West Virginia Department of Environmental Protection before any borrow material can be obtained from the site.

The DOH will bear the cost of all features associated with the borrow site except for necessary revisions to drainage structures (i.e. lengthening of culverts, etc.).

Upon completion of work, all borrow sites shall be neatly trimmed and drained and all debris and spoil disposed of in accordance with the approved plan. No material shall be borrowed from places other than those approved, except as provided. Slopes shall be trimmed neatly to present a uniform surface, free from hollows or protrusions and loose or overhanging rocks. The Contractor shall take precautions by benching or other methods to prevent slides and slip outs. Borrow areas shall be graded by the Contractor then fertilized, seeded and mulched in accordance with the applicable Specifications and will be paid for in accordance with the pay items within the contract.

The Contractor shall minimize pollution or sedimentation of rivers, streams, lakes, ponds, and other bodies of water while conducting borrow operations.

211.3.2-Borrow outside of WVDOH R/W Limits: For borrow sites outside the R/W, the Contractor and/or property owner shall bear all costs and responsibilities associated with the site. Appropriate Traffic Control items within the Project Limits will be paid accordingly. The Contractor and/or property owner shall comply with existing laws and/or regulations to include approval from the State Historic Preservation Officer and save the State harmless from any claims for damages which may result from the borrow.

The Contractor shall minimize pollution or sedimentation of rivers, streams, lakes, ponds, and other bodies of water while conducting borrow operations.

Borrow pits shall not be excavated below the level of the natural drainage for the area, and the drainage ditches required to keep the pit free from standing water during the progress of the work and upon completion and shall be constructed without extra compensation.

211.3.3-Imperious Core: Imperious cores shall be constructed for all sediment dams built of rock, gravel, and pervious soils.

The impervious core shall have a minimum dimensions as set forth in Item 5, par. 20.3.4.3.1 *Erosion and Sediment Control Manual*, West Virginia Division of Highways, latest edition.

When a key is necessary for the sediment dam, the impervious core shall be made an integral part of the key. When the impervious core is not constructed of soil, the core shall be anchored into the key by trenching for a minimum depth of 2 feet (610 mm).

The impervious core may be constructed using one of the following methods:

- a) **Soil Impervious Core:** Soil impervious cores may be shaped to facilitate placement and compaction. The coefficient of permeability of the soil used for the impervious core must be 10^{-4} cm per sec or less. A key, a minimum of 4 feet (1.2 m) in depth, must be constructed into the original ground. The compaction of the impervious core shall be as in accordance with Section 716.3.
- b) **Concrete Impervious Core:** When concrete is used for the impervious core, Class B Concrete shall be used. The requirements of Section 601, Structural Concrete shall control the mixture and placement of the concrete. The Engineer may waive the testing of the Class B Concrete if the concrete is from an approved plant.
- c) **HDPE or LLDPE Impervious Core:** When the impervious core is constructed of High Density Polyethylene (HDPE) or Low Linear Density Polyethylene (LLDPE), the liner shall be manufactured to be suitable for buried conditions and may be either smooth or textured. The Contractor shall obtain recommendations from a liner manufacturer for the material best suited for impervious cores, handling, storage, and construction procedures. The manufacturer of the liner shall furnish the Engineer a Letter of Certification stating the liner is suitable for the intended use.
- d) **Other Methods for an Impervious Core:** The Contractor may design and use other methods of preventing the seepage of water from the wet area. The Engineer must approve the design of the alternative method.

When the impervious core is not constructed used the Soil Impervious Core method the Contractor shall submit a plan containing construction details and materials to be used for the impervious core(s) for the approval of the Engineer prior to the start of work and the purchase of any materials. This submittal will be part of the temporary and permanent pollution control schedules and methods required by Section 642.3-Preconstruction Conference, Construction Methods, Section 642, Temporary Pollution Control, of the *West Virginia Division of Highways Standard Specifications Roads and Bridges*, latest edition.

211.4-UNCLASSIFIED BORROW EXCAVATION:

Unclassified borrow excavation shall consist of material, as prescribed, incorporated into embankments, backfill, shoulders, or any other type of work shown on the Plans or designated by the Engineer. The method of placement, compaction and density shall be in accordance with the applicable requirements of 207.7.

211.5-ROCK BORROW EXCAVATION:

Rock borrow excavation shall consist of materials, as prescribed, incorporated into embankments in accordance with the provisions of 207.7 covering the construction of rock fills.

Stones used for scour protection shall be in accordance with section 218.4.1.

211.6-SELECT BORROW EXCAVATION:

Select borrow excavation shall consist of material as prescribed, incorporated into embankments, backfills, shoulders, or any other type of work shown on the Plans or designated by the Engineer. The method of placement, compaction and density shall be in accordance with the applicable requirements for granular material as prescribed under 207.7.

211.7-METHOD OF MEASUREMENT:

211.7.1-Cubic Yard (Meter) Measurement: The quantity of work done will be measured in cubic yards (cubic meters) actually obtained and incorporated in the work, determined in its original position from cross sections by the average end areas.

The method of measurement may also be calculated as 80 percent of the truck load volume of each truck used to haul the material. The measurement of the load will be taken inside each bed and will include length, width and average height to the top of the load. However, the measurement will exclude the hoist housing. When Rock Borrow is obtained from a commercial source payment may be per cubic yard by converting 1.65 tons (2 Mg) to equal 1 cubic yard (cubic meter).

If the borrow is obtained in such quantity or in such manner that a waste of unclassified excavation, slips, or excess material is caused, the amounts of such waste shall be deducted from the borrow volume. In determining the amount of material to be developed due to unauthorized placement of borrow material or unclassified excavation material in the embankments, the quantity outside the construction tolerance will be measured and deducted from borrow on a yard-to-yard (meter to meter) basis without adjustment due to shrinkage or swelling.

211.7.2-Ton (Megagram) Measurement: The quantity of work done will be measured in tons (megagrams) actually obtained and incorporated in the work, determined by the total of the weights shown on receipted railroad freight bills when materials are shipped by rail, by actual measured displacement of barges certified by the Producer when water shipments are made, providing materials delivered by the aforementioned methods are not stockpiled or stored; or determined by the Contractor from the total of weigh slips for each vehicle load weighed on an approved truck scale, and certified by the Contractor to be correct.

The Producer or Contractor shall provide truck scales. The scales shall be of sufficient size and capacity to weigh the heaviest loaded trucks that are used for delivery of the material.

All truck scales shall be mounted on solid foundations, which will insure their retaining plumb and level. All truck scales shall be inspected and sealed by the West Virginia Department of Labor, Bureau of Weights and Measures, or other appropriate agencies of the State or its political subdivisions. The Department may, at its option, accept inspection and sealing by out of state agencies when the material is weighed outside West Virginia.

A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification and project number. Provision shall be made for constant zero compensation and further provision shall be made so the scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest. In case of a breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

A weighman shall be provided by the Producer/Supplier. The weighman shall certify that the weight of the material, as determined either by the scales or from the digital printout of the weights, is correct.

Each truck shall be weighed empty prior to each load.

211.7.3-Square Foot (Meter) Measurement: The measurement of the Impervious Core will be by the square foot (meter) of core placed and accepted by the Engineer. The area of

measurement shall be calculated from the surface of a vertical plane through the centerline of the impervious core.

211.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for these items, which unit prices and payments shall be full compensation for doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work. There will be no additional compensation for furnishing, grading, fertilizing, seeding and mulching of borrow pits.

211.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
211001-*	Unclassified Borrow Excavation	Cubic Yard (Meter)
211002-*	Rock Borrow Excavation	Cubic Yard (Meter)
211003-*	Select Borrow Excavation	Cubic Yard (Meter)
211007-*	Unclassified Borrow Excavation	Ton (Megagrams)
211008-*	Rock Borrow Excavation	Ton (Megagram)
211009-*	Select Borrow Excavation	Ton (Megagram)
211017-*	Impervious Core	Square Foot (Meter)

* Sequence number

SECTION 212

STRUCTURE, ROCK, AND WET EXCAVATION

212.1-DESCRIPTION:

This work shall consist of the excavation and backfill or disposal of all materials required to be removed for the construction of retaining walls, box culverts, catch basins, drop inlets, manholes, bridge foundations, and other structures for which excavation is not otherwise provided; the removal of all old structures, including abutments, piers and wingwalls, unless otherwise specified or directed; in accordance with these Specifications and in reasonably close conformity with the lines, grades and typical cross sections shown on the Plans or established by the Engineer. It shall include pumping, draining, sheeting, and constructing cribs and cofferdams if necessary.

212.2-MATERIALS:

Select material for backfilling shall be crushed stone, gravel, slag, or any combination thereof meeting the requirements of 703. The grading shall be such that 100 percent of the material passes the 2 inch (50 mm) sieve and 0 to 5 percent passes the No. 16 (1.18 mm) sieve. Any of the standard coarse aggregate sizes from AASHTO No 4 through AASHTO No. 8, as shown in Table 703.4, would comply with the above gradation requirement.

Controlled low strength material shall meet the requirements of 219.

Quality Control of select material for backfilling is the responsibility of the Contractor as specified in 106.1.

Engineering fabric shall be fabric for subsurface drainage or separation meeting 715.11.

212.2.1-Quality Control Testing: Quality control of the select material for backfill is the responsibility of the Contractor as specified in 106.1.

The Contractor shall maintain necessary equipment and qualified personnel to perform all sampling and testing necessary to determine the magnitude of the various properties of the material governed by the Specifications and shall maintain these properties within the limits of the Specifications.

The Contractor shall submit a quality control plan detailing the methods by which the quality control program will be conducted. This plan, prepared in accordance with the guidelines set forth in the appropriate portions of MP 307.00.50 and MP 717.04.21, shall be submitted to the Engineer at the preconstruction conference. The work shall not begin until the plan is reviewed for conformance with the contract documents.

212.2.2-Acceptance Testing: Quality control sampling and testing performed by the Contractor shall be used by the Division for acceptance

212.2.3-Sampling and Testing: Frequency of sampling and testing shall be in accordance with the Contractor's quality control plan. The minimum sampling and testing frequencies for gradation shall be as indicated in Attachment 1 of MP 307.00.50. The material shall be sampled in accordance with MP 700.00.06. The minimum sampling and testing frequency for compaction will be in accordance with MP 700.00.24.

212.2.4-Acceptance Procedure: Material conforming to the specification requirements will be accepted at full contract price. Material failing to comply with the quality requirements of Table 704.6.2B shall not be incorporated into the work.

Acceptance of the material for compaction and for gradation shall be in accordance with 212.2.1.

212.2.5-Acceptance Plan:

212.2.5.1-Compaction: Compaction of random material and select backfill material shall meet 212.10.

212.2.5.2-Gradation: Acceptance for gradation shall be on the basis of test results on consecutive random samples from a lot. A lot shall be considered the quantity of material represented by an average test value, not to exceed five sublots. Generally at the beginning of the project, the average shall be started on the second sample in accordance with MP 300.00.51. A subplot is the quantity of material represented by a single gradation test. In the case where only one sample is taken, this subplot shall be considered the lot. When the average, or when the most recent three consecutive individual test values fall outside the limits specified in 212.2, the lot of material represented will be considered nonconforming to the extent that the last of its sublots is nonconforming. When this occurs, the last subplot shall have its price adjusted in accordance with Table 212.12.1. In the case where the average is nonconforming and the last subplot contained is conforming, then there would be no price adjustment. In no event, however, shall a subplot of material have its price adjusted more than once, and the first adjustment, which is determined, shall apply.

212.2.5.3-Degree of Nonconformance: When a subplot of material is to have its price adjusted, the percentage point difference between the nonconforming test value and the specification limit shall be determined for each sieve size determined to be nonconforming, and this value shall be multiplied by its appropriate multiplication factor as set forth in Table 212.2.5.3 to determine the degree of nonconformance of that sieve.

TABLE 212.2.5.3

Nonconforming Sieve Size	Multiplication Factor
2 in. (50 mm)	1.0
No. 16	1.0

The total measure of nonconformance of an individual subplot is the sum of all nonconformance of an individual sieve sizes of that subplot.

When the total degree of nonconformance has been established and it is 12.0 or less, the material will be paid for at an adjusted contract price as specified in Table 212.12.1.

When the degree of nonconformance is greater than 12.0, the nonconforming subplot shall be resolved on an individual basis, requiring a special investigation by the Engineer to determine the appropriate course of action to be followed. Pending resolution of the matter, additional lifts of select material for backfill shall not be placed over the nonconforming material.

CONSTRUCTION METHODS

212.3-GENERAL:

The foundation pits shall be excavated according to the outlines of footings as shown on the Plans and shall be of sufficient size to permit the placing of the full width and length of the footing. The Engineer may order, in writing, such changes in dimensions or footing elevations as may be necessary to secure a satisfactory foundation.

Structural excavation for pipe culverts and underdrains shall be accomplished in accordance with the sections covering pipe culverts and underdrains.

All foundation excavation adjacent to the tracks of any railroad shall be shored, braced and supported as required by the railroad company or the Engineer, and the Contractor will be held responsible for securing such information and complying. Plans for this shoring, bracing, and supporting shall be submitted to and shall meet with the approval of the Chief Engineer of the railway company before starting excavation. Bracing, shoring, and supporting excavation at structures other than railroad tracks shall meet with the approval of the Engineer.

212.4-DISPOSAL OF MATERIAL:

The excavated material, unless otherwise directed by the Engineer, shall be utilized for backfill or embankments. Surplus material shall be disposed of in such a manner that the efficiency or appearance of the structure shall not be impaired, and the stream not muddied or obstructed.

212.5-COFFERDAMS:

The term cofferdam designates any barrier system that provides a dry, watertight as practicable, area for excavation, inspection or placing concrete. Subject to other requirements in these Specifications, a cofferdam may be constructed of materials including sheet piling, wood, sand bags, earth embankment, etc. or a combination of any of these.

Cofferdams shall, in general, be carried well below the bottom of the footings and shall be well braced and as watertight as practicable. The interior dimensions of cofferdams shall be sufficient to give adequate clearance for the construction of forms and to permit pumping from outside of the forms. When sandy or porous material is encountered in the foundation which renders it impracticable to dewater the excavation before placing masonry, the bottom may be sealed with concrete placed by the tremie method, after which the remainder of the work shall be carried on in the dry.

No bracing of any kind shall be left in cofferdams in such a way as to extend in to the substructure masonry without the written permission of the Engineer.

Cofferdams shall be removed by the Contractor upon completion of the substructure.

212.6-PUMPING:

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the passage of water through fresh concrete. No pumping will be permitted during the placing of concrete, or for a period of at least 24 hours, unless it is done with a suitable pump separated from the concrete by a water-tight wall.

212.7-INSPECTION:

After an excavation is completed, the Contractor shall notify the Engineer, and no footing, pipe, or other structure shall be placed until the Engineer has approved the depth of excavation,

the character of foundation material encountered, and has obtained the necessary foundation measurements.

212.8-PREPARATION OF FOUNDATIONS:

Rock or other hard foundation material shall be free from all loose material, cleaned and cut to a firm surface, stepped or serrated as directed by the Engineer. All seams shall be cleaned and filled with concrete, mortar, or grout. Excavation in rock shall be made to the neat lines of the footing as nearly as practicable and the concrete placed against the rock without forming.

When masonry is to rest on an excavated surface other than rock, special care shall be taken not to disturb the bearing surface, and the final removal of foundation material shall not be made until just before masonry is to be placed.

212.9-DRAINAGE:

Adequate drainage for the backs of retaining walls, abutments and wing walls shall be provided by outlet tile or pipe drains extending through the walls at the ground line or as indicated on the Plans. In case the outlet end of these drains is below the ground line or would be covered by fill material, the drains shall connect to pipe outlets or be extended to the toe of the slope of the fill. When drain pipes are not called for or indicated on the Plans for these drains, the drains shall be constructed to a minimum sectional area of 24 by 24 inches (600 by 600 mm) and shall consist of sand, crushed stone, or gravel. Excavation and backfilling shall conform to the requirements of this Specification.

When underdrains with pipe are shown or indicated on the Plans and there are bid items for the same, they shall conform to the applicable requirements of 606.

The back of retaining walls, abutments and wing walls shall have porous drains, 1 ft. (300 mm) thick or as shown on the Plans, placed on the back side of the walls and abutments for the entire length and height of the same, beginning at the elevation of the outlet drains.

212.10-BACKFILLING:

Backfill material shall be suitable random material, controlled low strength material or select backfill material. Random material shall be free from particles larger than 3 inches (75 mm), frozen lumps, wood, or other extraneous material. Unless otherwise specified in the plans, any of the types of controlled low strength material may be used and shall be an alternative to random material at the contractor's option. Select backfill material shall be in accordance with 212. Controlled low strength material shall be in accordance with 219.

All spaces excavated and not occupied by abutments, piers, or other structures shall be backfilled to the surface of the surrounding ground. All backfill, except controlled low strength material, shall be thoroughly compacted by rolling or tamping as prescribed below and the top surface neatly graded.

Random material and select backfill material behind and around abutments, wingwalls, piers, bents, pedestals and all other structures, including those inaccessible to a roller, shall be compacted in layers not to exceed 4 inches (100 mm) after compaction. Controlled low strength material shall be placed according to 219.

The quality control and acceptance of controlled low strength material shall be in accordance with 219.

The quality control and acceptance for compaction of random material shall be in accordance with applicable sections of 207 and 716. Five density tests shall be performed for quality control. The target percentage of dry density shall be 95%.

Special precautions shall be taken to prevent any wedging action against the masonry and the slope bounding the excavation for abutments and walls. Such condition shall be prevented by stepping or serrating to destroy wedge action. Jetting of fill behind retaining walls, abutments, and wing walls will not be permitted. Backfill over and around abutments, culverts, arches, and columns shall be brought up uniformly to avoid bending or distortional stresses in the structures, shall be made as soon as practicable after forms are removed, and shall be sloped to drain. The 4 inch (100 mm) layer requirement and compaction for backfill in water will be waived. The testing of backfill compaction, at piers or other structures, which will not become part of an embankment or highway pavement or shoulder area will be waived.

Select backfill material shall be placed behind abutments, wingwalls, retaining walls, and box culverts to the dimensions shown on the Plans. The material shall be placed in horizontal layers not to exceed 4 inches (100 mm) compacted. The quality control testing and acceptance for the select backfill material shall be in accordance with applicable sections of 207 and 716.

A lot shall normally consist of the quantity of backfill material required to fill behind and around abutments, wingwalls, piers, bents, pedestals and all other structures as approved by the Engineer.

The select backfill materials shall be tested according to MP 700.00.24. Five density tests shall be performed for quality control. The target percentage of dry density shall be 95%.

In all areas where select backfill will contact random material, engineering fabric shall be placed in accordance with the last paragraph of 207.9.

212.11-METHOD OF MEASUREMENT:

The quantity of work done for Item 212001-*, "Structure Excavation", Item 212002-*, "Wet Excavation", Item 212003-*, "Rock Excavation" and Item 212005-*, "Select Material for Backfilling", will be the number of cubic yards (meters) measured. Any additional work beyond the scope of the Plans, authorized by the Engineer, will be measured in cubic yards (meters) for the excavated material removed or Select Backfill in place and paid for in accordance with the Subsection and 109.2. Measurement for "Structure Excavation" and "Wet Excavation" will be limited to the volume bounded by vertical planes 18 in. (450 mm) outside the neat line of footings and parallel thereto; "Rock Excavation" will be limited to the volume bounded by the neat lines of the footings.

When an increase in depth of foundation has been ordered by the Engineer, the excavation for the first 5 ft. (1.5 meters) or fraction thereof below the elevation shown on the Plans will be paid at the unit bid price. The Engineer may require the Contractor to make excavation to a depth greater than 5 ft. (1.5 meters) below Plan elevation in accordance with 104.3.

All excavation performed under this section will be classified as "Structure Excavation", except as stated. When the Plans specify "Rock Excavation", all material encountered in the excavation requiring blasting for its removal and all boulders greater the 1/2 cu. yd. (0.4 cubic meters) in volume will be considered as "Rock Excavation" and be paid for as such. When a quantity of "Wet Excavation" is shown on the Plans, and a normal pool elevation is indicated, excavation below the normal pool elevation, except that classified as "Rock Excavation", will be considered "Wet Excavation" and will be measured below normal pool elevation from the stream bed to the bottom of the footings.

The cost of bracing, shoring and supporting excavation adjacent to railroad tracks and other structures shall be included in the unit price bid for "Structure Excavation", "Wet Excavation", or "Rock Excavation".

Structural excavation for old structures requiring removal will be limited to the outside dimensions of the structure.

Excavation for the drains specified in 212.9 will be paid as Item 212001-*, "Structure Excavation", and the cost of backfilling drains with sand, crushed stone or gravel shall be included in the price bid for "Structure Excavation".

Clearing of right-of-way within the construction limits of piers, abutments, retaining walls, etc., and backfilling to the level of the original ground will be included in unit prices bid for "Structure Excavation", except that select material for backfilling will be paid for under Item 212005-*. If backfill above original ground is required, material for the backfill will be measured and paid for as prescribed under 207 or 211.

The measurement and payment for engineering fabric will be included in the unit price bid for "Select Material for Backfilling".

Item 212004-* "Cofferdams", will be measured and paid for each unit complete in place, including their removal, and shall include all labor, materials, and equipment incidental to the construction, pumping and removal. Progress payments, determined by the Engineer, may be made.

212.12-BASIS OF PAYMENT:

The quantities, measured as provided above, will be paid for at the contract unit price bid for these items, which prices and payments shall be full compensation for furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work, and also including cost of cofferdams and their removal, except when a separate bid item is provided for Item 212004-*, "Cofferdams".

212.12.1-Price Adjustment: Select material for backfill not conforming with the gradation requirements as described in 212.2.5.3 will be paid for at the adjusted contract price base on the degree of nonconformance as specified in Table 212.12.1.

TABLE 212.12.1

Adjustment of Contract Price for Gradation not Within Specifications	
Degree of Nonconformance	Percent of Contract Price to be Reduced
1.0 to 3.0	2
3.1 to 5.0	4
5.1 to 8.0	7
8.1 to 12.0	11
Greater than 12	*

* The Division will make a special evaluation of the material and determine the appropriate action.

212.13-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
212001-*	Structure Excavation	Cubic Yard (Meter)
212002-*	Wet Excavation	Cubic Yard (Meter)
212003-*	Rock Excavation	Cubic Yard (Meter)
212004-*	Cofferdam	Each
212005-*	Select Material For Backfilling	Cubic Yard (Meter)

* Sequence number

SECTION 213 THROUGH SECTION 216-BLANK

SECTION 217 SPECIAL ROCK FILL

217.1-DESCRIPTION:

This work shall consist of furnishing and placing at the foot of embankments, inside or outside the neat line, where called for on the Plans or as directed by the Engineer, durable rock in accordance with the Specifications and in reasonably close conformity to the lines, grades, dimension and sections shown on the Plans

217.2-MATERIALS:

The rock for special rock fill shall meet the requirements specified in 704.5.

217.3-CONSTRUCTION METHODS:

Where possible, the material shall be handled as ordinary rock embankment as prescribed in 207.7.3; however, if the location for the special rock fill is not accessible to ordinary placing, the material may be placed by other methods.

Foundation trenches and other necessary excavations shall be excavated by the Contractor, in accordance with the applicable provision of 212, and approved by the Engineer before the placing of the special rock fill is begun. Unless otherwise shown on the Plans or directed by the Engineer, the rock fill shall extend approximately 2 ft. (600 mm) below the bed of the stream.

217.4-METHOD OF MEASUREMENT:

The quantity of work done will be measured in cubic yards (meters) of "Special Rock Fill", complete in place and accepted, determined by the method of average end areas.

217.5-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for this item, which price and payment shall be full compensation for furnishing all the material and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, and incidentals necessary to complete the work.

217.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
217001-*	Special Rock Fill	Cubic Yard (Meter)

* Sequence number

SECTION 218 SLOPE AND FOUNDATION PROTECTION

218.1-DESCRIPTION:

This work shall consist of the construction of revetments of stone or concrete, with or without engineering fabric, to prevent erosion of slopes or banks, or to protect foundations, at places indicated on the Plans or where designated by the Engineer, all in accordance with these Specifications and in reasonable close conformity with the lines, grades, dimension, and cross sections shown on the Plans.

218.2-MATERIALS:

Materials shall meet the requirements specified in the following Sub-sections of Division 700:

MATERIALS	SUBSECTION
Cement for Grout	701.1 or 701.3
Engineering Fabric for Erosion Control	715.11
Gabions	715.23
Reinforcement	709.3, 709.4
Sand for Grout	702.1.1 through 702.1.5 and 702.6, or 702.2
Shot Rock	704.8
Stone for Gabions	704.3
Stone for Riprap	704.2

The stone for crushed rock slope protection shall meet the requirements of 704.6, Class 7, except 704.6.3. Acceptance for Gradation of Class 7 aggregate shall be by visual inspection; a written explanation of the manufacturing process shall be provided if requested by the Engineer. Class 7 from a non-approved source, shall not exceed a weighted loss of 30 percent when subjected to five cycles of the Sodium Sulfate Soundness Test, will be acceptable.

An alternate to this gradation shall be AASHTO size No. 1. Certified test data from the producer showing the AASHTO No. 1 material meets the gradation requirements of 703.4.

Stone for foundation protection shall conform to the requirements of riprap stone, except for size and shape.

CONSTRUCTION METHODS

218.3-SLOPE PROTECTION:

218.3.1-General: The slopes to be revetted shall reasonably conform to the lines, grades, dimensions, and cross sections as shown on the Plans, unless otherwise directed.

The placing of riprap or grouted riprap shall start in a trench, the invert of which is parallel to and 2 ft. (600 mm) below the toe of the slope, and the trench shall be 2 ft. (600 mm) in width. The construction shall progress from the invert of the trench up the slope to conform to the requirements specified.

Slope protection with crushed rock, concrete slabs, or precast concrete blocks shall start at a concrete bottom sill, shall be included within side sills, and shall progress upward to the berm

in front of the abutment. The design and dimensions of the sills shall be as shown on the Plans. The area of the sills shall be considered a part of the area of the slope protection. The concrete sills may be precast or cast-in-place and shall be placed in a trench excavated to receive them. Concrete used in the sills shall meet the requirements specified in 218.3.6.2.

Construction equipment shall not operate directly on engineering fabric. The fabric shall be protected from detrimental contamination by surface runoff. Any fabric so contaminated shall be removed and replaced with uncontaminated fabric.

Weep holes shall be provided as directed by the Engineer when grouted riprap, concrete slab, or concrete block slope protection is specified.

218.3.2-Riprap: Riprap shall be composed of stones having the dimensions specified, each stone being firmly bedded on the slope in such a manner that it abuts against other stones to form a layer, the interstices of which are filled with suitably sized spalls. The dimensions of each stone in a plane parallel to the plane of the slope shall be not less than 3 inches by 12 inches (75 by 300 mm) Unless otherwise specified, the longer dimension shall be placed horizontally. The surface of each stone shall not vary more than 3 inches (75 mm) from the specified surface plane. Abutting stones shall have depths not different by more than 1-1/2 inches (40 mm). The average depth of the stone placed in the riprap shall be not less than the specified depth of the riprap. The first row of stone shall be firmly bedded on the invert of the trench so as to form a firm foundation, and the construction shall progress up the slope by fitting additional and abutting stones with well broken joints and in such a manner that the most compact mass of riprap is developed.

218.3.3-Grouted Riprap: Grouted riprap shall be as defined in 218.3.2 with the interstices filled with spalls and grouted with cement grout. The grout filler shall be composed of a mixture of one part Portland cement and three parts sand, mixed with water to produce a workable consistency. The amount of water shall be that designated by the Engineer. The stone shall be thoroughly wet immediately before grout is applied. As soon as the grout is deposited on the surface, it shall be thoroughly worked into the joints. The stones shall then be brushed so that their top surfaces are exposed.

Grouted riprap shall be cured in accordance with any of the methods specified in 501.15, with a blanket of earth kept wet for 72 hours, or by sprinkling with a fine spray of water every two hours during the day-light hours for a period of three days.

218.3.4-Gabions: Gabions, consisting of galvanized wire mesh baskets filled with rocks, shall conform to these Specifications and the dimensions shown on the Plans.

Assembling of the gabion units and their filling with rock shall be carried out as directed by the Engineer. The visible faces of the baskets shall be hand placed to insure an attractive appearance, and the core of the baskets may be filled by mechanical equipment.

218.3.5-Crushed Rock Slope Protection: The thickness of crushed rock slope protection shall be as indicated on the Plans. The rock shall be raked in place to obtain a reasonably smooth and continuous surface conforming to the thickness and slope lines indicated on the Plans.

218.3.6-Concrete Slope Protection:

218.3.6.1-General: Concrete slope protection may be by cast-in-place concrete slab or precast concrete blocks; only one method shall be used at any one bridge.

218.3.6.2-Cast-in-Place Concrete Slab: Concrete slabs shall be not less than 6 inches (150 mm) thick, shall be reinforced with Type B Fabric, and shall conform to the applicable provisions of 501, unless otherwise indicated. Transit mix concrete will be permitted. A wood float finish will be acceptable. Construction joints shall be provided at intervals of 10 ft. (3 meters) in both directions. Class B Concrete, meeting the requirements of 601 may be used in lieu of the concrete provided above.

218.3.6.3-Precast Concrete Blocks: Precast concrete blocks shall conform to the applicable provisions of 601 and shall be made of Class B concrete, reinforced with Type B fabric. The blocks shall be 3 by 1- ft. and 4 in (1000 by 500 by 100 mm) thick. The longer dimension shall be placed on a horizontal plane. The blocks shall be firmly embedded against the slope and against adjoining blocks, with the ends in contact. The finished surface shall present an even, tight surface, reasonably true to line, grade, and section.

218.3.7-Engineering Fabric:

218.3.7.1-Fabric Placement: The area in which the fabric is to be installed shall be prepared in a relatively smooth state, free of sharp protrusions, depressions and debris. The machine direction of the fabric shall generally be placed parallel with the direction of major water flow, i.e., parallel to the stream or as authorized by the Engineer. The fabric shall be placed in a relatively loose and unstretched condition such that the fabric and underlying material deforms slightly under riprap weight when placed. Fastener pins shall be placed to prevent displacement of the fabric.

The fabric shall be field sewn as described in 715.11.3 or overlapped. When the overlapping technique is used, an overlap of 3 ft. (900 mm) shall be maintained so the upgrade fabric shall always be lapped over the downgrade fabric.

218.3.7.2-Cover Material Placement: Extreme care shall be exercised in placing cover material over the fabric, especially when riprap is used. Under no circumstances shall heavy angular stone, such as riprap, be dropped on the fabric from more than 1 ft. (300 mm) in height. A cushioning layer of sand or gravel may be placed between the fabric and riprap, providing this material does not inhibit free drainage of the slope.

All cover material shall be placed from downslope to upslope in such a manner as to prevent slippage of the cover material off the fabric.

218.4-FOUNDATION PROTECTION:

The area around piers, abutments or other foundations shall be excavated to a depth and width indicated on the Plans, or as otherwise directed.

Stone for foundation protection shall be largely equidimensional, angular, and generally ranging in size between one cubic foot (300 cubic millimeters) and one cubic yard (meter). The stone need not be placed, but may be dumped from trucks or bulldozed in place. The stone shall be placed where indicated on the Plans or as directed by the Engineer.

218.4.1-Scour Protection: Stones used for scour protection shall be well graded throughout the thickness as determined by Engineer via visual inspection. Stones smaller than the specified lowest gradation as specified in the plans are not allowed in an amount exceeding 20% by weight. Material quality shall be satisfactory to Engineer. The use of shale is not permitted.

218.5-METHOD OF MEASUREMENT:

Except for "Shot Rock" which will be measured in tons (Mg), the quantity of work done under Slope Protection will be measured in cubic yards (meters) of "Riprap", "Grouted Riprap", or "Gabions", and in square yards (meters) of "Crushed Rock Slope Protection", "Concrete Slope Protection" or "Fabric for Erosion Control", excluding overlaps.

The number of tons (Mg) of "Shot Rock" shall be determined by the total of the weights shown on receipted railroad freight bills when materials are shipped by rail; by actual measured displacement of barges certified by the producer when water shipments are made, providing materials delivered by the methods are not stockpiled or stored; or determined by the Contractor from the total of weigh slips for each vehicle load weighed on an approved truck scale, and certified by the Contractor to be correct.

Truck scales shall be provided by the producer or Contractor. The scales shall be of sufficient size and capacity to weigh the heaviest loaded trucks that are used for delivery of the material.

All truck scales shall be mounted on solid foundations which will insure their remaining plumb and level. All truck scales shall be inspected and sealed by the West Virginia Division of Labor, Bureau of Weights and Measures, or other appropriate agencies of the State or its political subdivisions. The Division may, at its option, accept inspection and sealing by out of state agencies when the material is weighed outside West Virginia.

A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification and project number. Provisions shall be made for constant zero compensation and further provision shall be made so that the scales may not be manually manipulated during the printing process.

The system shall be interlocked so as to allow printing only when the scale has come to rest. In case of a breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

Each truck shall be weighed empty prior to each load.

A weigh person shall be provided by the producer. The weigh person shall certify that the weight of the material, as determined either by the truck scales or from the digital printout of the weights, is correct.

Area dimensions will be based on slope measurement; concrete sills will be included in the area measurement for crushed rock or concrete slope protection. Volumes may be determined by verified plan dimensions or from measurements of the completed work, as authorized by the Engineer. The quantity of work done under "Foundation Protection" will be measured in cubic yards (meters), actually produced and incorporated in the work, determined in its original position from cross sections by the method of average end areas, unless otherwise authorized by the Engineer.

218.6-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for these items, which prices and payments shall be full compensation for excavating and preparing the embankment or slope, footing and sill trench; furnishing all the materials, including steel reinforcement; and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

218.7-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
218001-*	Riprap	Cubic Yard (Meter)
218002-*	Grouted Riprap	Cubic Yard (Meter)
218003-*	Gabion	Cubic Yard (Meter)
218004-*	“thickness” Crushed Rock Slope Protection	Square Yard (Meter)
218005-*	Concrete Slope Protection	Square Yard (Meter)
218006-*	Foundation Protection	Cubic Yard (Meter)
218007-*	Fabric For Erosion Control	Square Yard (Meter)
218008-*	Shot Rock	Ton (Megagram)

* Sequence number

SECTION 219 CONTROLLED LOW-STRENGTH MATERIAL

219.1-DESCRIPTION:

A Controlled Low Strength Material (CLSM) is a non-compacted, cementitious material used primarily as a backfill in lieu of a compacted material.

This work shall consist of furnishing and placing CLSM as a backfill material in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses and cross sections shown on the Plans or established by the Engineer.

219.2-MATERIALS:

Materials shall meet the requirements specified in the following Subsections of Section 700.

MATERIAL	SUBSECTION								
Admixtures	707								
Aggregate									
Bottom Ash	703.3.3 (except with the following gradation and a maximum loss on ignition of 12%):								
	<table> <tr> <th>Sieve Size</th><th>Percent Passing by Weight:</th></tr> <tr> <td>3/4 inch (19 mm)</td><td>95%</td></tr> <tr> <td>3/8 inch (9.5 mm)</td><td>85-100%</td></tr> <tr> <td>#100 (150 µm)</td><td>0-25%</td></tr> </table>	Sieve Size	Percent Passing by Weight:	3/4 inch (19 mm)	95%	3/8 inch (9.5 mm)	85-100%	#100 (150 µm)	0-25%
Sieve Size	Percent Passing by Weight:								
3/4 inch (19 mm)	95%								
3/8 inch (9.5 mm)	85-100%								
#100 (150 µm)	0-25%								
Fine Aggregate	702.1.1–702.1.5 with the following gradation:								
	<table> <tr> <th>Sieve Size</th><th>Percent Passing by Weight:</th></tr> <tr> <td>3/8 inch (9.5 mm)</td><td>100%</td></tr> <tr> <td>#200 (150 µm)</td><td>0-10%</td></tr> </table>	Sieve Size	Percent Passing by Weight:	3/8 inch (9.5 mm)	100%	#200 (150 µm)	0-10%		
Sieve Size	Percent Passing by Weight:								
3/8 inch (9.5 mm)	100%								
#200 (150 µm)	0-10%								
Flyash	707.4.1 (except with a maximum loss on ignition of 12%)								
Portland Cement	701.1 or 701.3								
Water	715.7								

219.3-PROPERTIES:

<u>Type</u>	<u>28 Day Compressive Strength</u>
A	50 psi min./150 psi max. (345 kPa min./1035 kPa max.)
B	50 psi min. (345 kPa)
C	1000 psi min. (6900 kPa)

pH: 5.0-13.0

Flow: Minimum spread of 6 inches (152 mm)

219.4-CONSTRUCTION METHODS:

219.4.1-Proportioning: Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportions of materials, including admixtures, to be used which will result in a workable, CLSM mixture having the desired properties.

A mix design shall be required for each type of CLSM to be used in the work. The mix design shall be accompanied by a statement giving the source of materials and certified test data demonstrating the adequacy of the mix design.

The results of the mix design testing shall include a listing of the components used in the mix, the results of unconfined compressive strength tests, pH, and flow.

The unconfined compressive strength test specimens for mix design approval shall consist of two sets (3 cylinders per set) of standard 6 inch (152 mm) by 12 inch (304 mm) cylinders. Both sets of cylinders shall be molded, cured, and tested at an age of 28 days in accordance with ASTM D4832. Both sets of cylinders shall meet the strength requirements specified in section 219.3.

The mix shall have a consistency that will allow the material to fill all voids during placement without vibration or other consolidation methods.

219.4.2-Testing: Material shall be sampled in accordance with ASTM D5971. Flow tests shall be conducted in accordance with ASTM D6103. Compressive strength tests shall be conducted in accordance with ASTM D4832.

The Contractor shall determine the flow, and shall mold one set (3 cylinders) of standard 6 inch (152 mm) by 12 inch (304 mm) compressive strength specimens for every 100 cubic yards (75 cubic meters), or fraction thereof, of material that is placed. These cylinders shall be cured and tested in accordance with ASTM D4832 except that they shall be stored at the construction site in the storage container until the fourteenth day after preparation. After the fourteenth day, they shall be transported to the site of the curing environment, specified in ASTM D4832, where they will be cured for the remainder of the 28 day period. The average compressive strength at 28 days shall meet the strength requirements listed in section 219.3. Material not meeting the minimum compressive strength at 28 days shall be removed at the Contractor's expense. The Division shall evaluate Type A material that exceeds the maximum compressive strength.

Report all test results, in written form, to the Engineer within 24 hours after completion of each test.

Contractor's Quality Control: Quality control of the CLSM is the responsibility of the Contractor. The Contractor shall maintain equipment and certified Portland cement concrete inspector(s) who shall maintain equipment and direct all field inspection, sampling and testing necessary to determine the magnitude of the various properties of the CLSM governed by the Specifications and shall maintain these properties within the limits of this Specification. A Quality Control Plan prepared according to MP 601.03.50 shall be submitted to the Engineer at the pre-construction conference.

Acceptance Testing: Acceptance sampling and testing of CLSM is the responsibility of the Division.

Quality control sampling and testing performed by the Contractor may be used by the Division for acceptance.

219.4.3-Equipment and Tools: Equipment shall be according to 601.5.

219.4.4-Site Preparation: The Contractor shall provide the necessary barriers to confine the CLSM. Pipe culverts and any other items to be backfilled that could move or float during backfilling, shall be secured by the Contractor to prevent movement.

219.4.5-Mixing: The mixing shall be in accordance with 601.7 except that CLSM shall be delivered in a truck mixer. Mixing and delivery is also permitted using volumetric batching and mixing equipment in accordance with AASHTO M241. Volumetric mixers shall be properly calibrated and shall sufficiently mix the materials to produce a uniform product. The limitation on the total number of drum revolutions is waived. Sufficient drum revolutions shall be used just prior to discharge to insure a homogeneous slurry.

219.4.6-Placement: The drop height for the CLSM shall be limited to the minimum necessary by using chutes or other devices.

CLSM shall be brought up evenly by moving the discharge points or by spreading the backfill manually. For backfilling around pipes, the backfill shall be placed evenly on both sides of the trench to avoid overstressing the pipe.

The lift thickness shall be limited to that shown on the plans or as directed by the Engineer to avoid overstressing the pipe, forms, structures or to avoid floating the pipe. Prior to placement of successive lifts, the CLSM shall be allowed to cure until it is self-supporting.

CLSM shall not be finished between lifts. The top of a lift shall be cleaned, if necessary, to insure bonding with the next lift.

219.5-PAY ITEM:

ITEM	DESCRIPTION	UNIT
219001-*	Controlled Low Strength Material, Type "type"	Cubic Yard (Meter)

* Sequence number

SECTION 220 THROUGH SECTION 227-BLANK

SECTION 228

SUBGRADE PREPARATION

228.1-DESCRIPTION:

This work shall consist of preparing the subgrade for the placing of base or subbase in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions and cross section shown on the Plans.

This item is intended to be used for any project or portion thereof where the Contract is for paving without grading.

228.2-MATERIALS:

Not specified.

228.3-CONSTRUCTION METHODS:

All work shall be performed in accordance with the applicable provisions of 207 and 211.

Subgrade preparation shall include the entire width of the subgrade. Excavation material shall be used to bring eroded areas to the plan cross section. If sufficient material is not obtained from the subgrade preparation, additional suitable material shall be obtained by the Contractor.

228.4-METHOD OF MEASUREMENT:

The quantity of work done will be measured in square yards (meters) of "Subgrade Preparation" as determined from lines and dimensions shown on the Plans.

When borrow is necessary to complete the subgrade preparation item, it will be measured and paid for under the provisions of 211.

228.5-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price for the item listed below, which price and payment shall be full compensation for doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, and incidentals necessary to complete the work.

228.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
228001-*	Subgrade Preparation	Square Yard (Meter)

* Sequence number

SECTION 229

SHOULDERS AND DITCHES

229.1-DESCRIPTION:

This work shall consist of trimming, sloping, shaping, grading, subgrading, scarifying, and compacting existing shoulders and ditches including inlets and outlets to pipe culverts, and constructing new shoulders and ditches where necessary, in accordance with these Specifications and in reasonably close conformity with the lines, grades, and cross sections shown on the Plans or established by the Engineer.

229.2-MATERIALS:

Not Specified.

CONSTRUCTION METHODS

229.3-SHOULDERS:

Shoulders shall be formed and compacted as soon as possible after the surfacing item is completed, or as directed by the Engineer, to the grade and cross section shown on the Plans. Needed material shall be furnished by the Contractor.

The character and operation of the equipment shall be such that the pavement will not be damaged. Pavement damage by these operations shall be repaired, or removed and replaced by the Contractor to the satisfaction of the Engineer, without extra compensation. Upon evidence of such damage, the Engineer may require the discontinuance of the methods used and the work to be done by other methods. The final dressing shall be by hand methods if so required. Shoulders shall be constructed of suitable material obtained on the project or of selected material as designated on the Plans. Surplus or unsuitable material shall be removed and disposed of as directed, which shall include shaping shoulders under existing guardrail to edge of the fill.

The entire shoulder area shall be uniformly compacted by rollers, mechanical tampers, or hand methods, and finally dressed to true section.

229.4-DITCHES:

Existing ditches shall be trimmed, sloped, and cleaned, and inlets and outlets to existing structures opened and shaped to a uniform grade as directed by the Engineer.

229.5-METHOD OF MEASUREMENT:

The quantity of work done will be the number of linear miles (kilometers), or portion thereof measured. Any additional work beyond the scope of the original Plans but authorized by the Engineer will be measured in linear miles (kilometers) and paid at the unit bid price for this item.

229.6-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for this item, which price and payment shall be full compensation for doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, material, and incidentals necessary to complete the work.

Stabilizing material when specified on the Plans will be measured and paid for separately.

229.7-PAY ITEM:

ITEM	DESCRIPTION	UNIT
229001-*	Shoulders And Ditches	Mile (Kilometer)

* Sequence number

SECTION 230 THROUGH SECTION 239-BLANK

SECTION 240

CLEANING CULVERTS, INLETS AND MANHOLES

240.1-DESCRIPTION:

This work shall consist of complete removal of obstructions and thorough cleaning of trash, dirt and other debris from culverts, and their appurtenant structures; e.g., inlets, manholes, etc.; when appropriate or so designated, in a manner determined by the Contractor and acceptable to the Engineer.

240.2-MATERIALS:

Not Specified.

240.3-CONSTRUCTION METHODS:

Methods employed and equipment utilized by the Contractor for cleaning culverts and their appurtenant structures; e.g., inlets, manholes, etc.; shall be acceptable to the Engineer.

Cleaning procedures employed shall insure that the removal and disposal of obstructions, trash, and debris be accomplished such that the existing structure being cleaned is not damaged and deposition on, or damage to, adjacent and downstream property will be avoided. Likewise, the cleaning methods shall minimize as much as practicable, pollution and sedimentation of receiving streams, rivers, or other bodies of water and clogging of, or damage to, downstream drainage structures.

240.4-METHOD OF MEASUREMENT:

"Cleaning Culverts" will be measured by the linear foot (meter) of each size of culvert cleaned, the measurement being considered along the centerline of each culvert. The lengths for branch connections, tees, wyes and elbows will be considered along their centerlines and those values included in the total lengths of the appropriate culvert. Measured values for culverts with sloped or skewed ends will be the length along the invert. The portion of culverts extending through to the inside face of headwalls, wingwalls, manholes, inlets, boxes or other structures shall be included in the measurement.

"Cleaning Inlets" and "Cleaning Manholes" will be measured by the unit and will be the number of such structures that are actually cleaned.

240.5-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items below, which prices and payments shall be full compensation for doing the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

Payment for any maintenance of traffic necessary in connection with the work shall be included in the appropriate 636 items of the specifications.

240.6-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
240001-*	Clean Culvert	Linear Foot (Meter)
240002-*	Clean Inlet	Each
240003-*	Clean Manhole	Each

* Sequence number

DIVISION 300

BASES

SECTION 301 THROUGH SECTION 306-BLANK

SECTION 307 CRUSHED AGGREGATE BASE COURSE

307.1-DESCRIPTION:

This work shall consist of furnishing, spreading, and compacting one or more courses of crushed aggregate on a prepared surface in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer.

307.2-MATERIALS:

The crushed aggregate base course shall be composed of materials meeting the requirements of 704.6 for the class shown on the Plans except that 704.6.3 shall not apply.

307.2.1-Quality Control Testing: Quality control of the crushed aggregate base course is the responsibility of the Contractor as specified in 106.1.

The Contractor shall maintain necessary equipment and qualified personnel to perform all sampling and testing necessary to determine the magnitude of the various properties of the material governed by the Specifications and shall maintain these properties within the limits of the Specifications.

The Contractor shall submit a quality control plan detailing the methods by which the quality control program will be conducted. This plan, prepared in accordance with the guidelines set forth in the appropriate portions of MP 307.00.50 and MP 717.04.21, shall be submitted to the Engineer at the preconstruction conference. The work shall not begin until the plan is reviewed for conformance with the contract documents.

307.2.2-Acceptance Testing: Acceptance sampling and testing of crushed aggregate base course is the responsibility of the Division, except for furnishing the necessary materials. Quality control sampling and testing performed by the Contractor may be used by the Division for acceptance.

307.2.3-Sampling and Testing: Frequency of sampling and testing shall be in accordance with the Contractor's quality control plan. The minimum frequencies shall be as indicated in applicable portions of MP 307.00.50. Crushed aggregate shall be sampled in accordance with MP 700.00.06, Aggregate Sampling Procedures.

307.2.4-Acceptance Procedure: Material conforming to the specification requirements will be accepted at full contract price. Material failing to comply with the quality requirements of Table 704.6.2B shall not be incorporated into the work.

Acceptance of crushed aggregate base course for compaction and for gradation shall be in accordance with appropriate portions of 307.2.4.1.

307.2.4.1-Acceptance Plan:

307.2.4.1.1-For Compaction: Acceptance for compaction shall be on a lot by lot basis. A lot shall consist of a single layer of not more than 2,000 linear ft. (600 meters) per width being placed. A lot shall be divided into five approximately equal sized sublots. One nuclear moisture and density measurement in accordance with applicable portions of 717 shall be made at a random location within each of the five sublots. The random locations shall be determined in accordance with MP 712.21.26. If the result of five density tests on a lot indicates that at least 80 percent of the material, in accordance with 106.3.1 (West Virginia AP-A), has been compacted to the specified target percentage of dry density, the lot will be accepted. If less than 80 percent has been compacted to the specified target percentage of dry density, no additional material shall be placed on that layer until it has been reworked to meet the specified requirements. Reworking and retesting shall be at the expense of the Contractor. When the Division performs the testing in the evaluation of reworked lots, the testing will be at the expense of the Contractor at the unit cost specified in 109.2.2.

Compaction of shoulder aggregate on resurfacing projects adjacent to asphalt or concrete pavement shall be based on visual inspection to assure that the surface of the shoulder has been compacted to the level of the finished pavement surface.

Compaction of Class 7 aggregate shall be based on visual inspection to assure that the aggregate particles are arranged in a stable manner.

307.2.4.1.2-For Gradation: Acceptance for gradation shall be on the basis of test results on consecutive random samples from a lot. A lot shall be considered the quantity of material represented by an average test value, not to exceed five sublots. Generally at the beginning of the project, the average shall be started on the second sample in accordance with MP 300.00.51. A subplot is the quantity of material represented by a single gradation test. In the case where only one sample is taken, this subplot shall be considered the lot. The material shall be sampled and tested in accordance with 307.2.3. The gradation test results shall be plotted on a control chart in accordance with MP 300.00.51. When the average, or when the most recent three consecutive individual test values fall outside the limits of Table 704.6.2A the lot of material represented will be considered nonconforming to the extent that the last of its sublots is nonconforming. When this occurs, the last subplot shall have its price adjusted in accordance with Table 307.9.1. In the case where the average is nonconforming and the last subplot contained is conforming, then there would be no price adjustment. In no event shall a subplot of material have its price adjusted more than once, the first adjustment shall apply.

Acceptance for Gradation of Class 7 aggregate shall be by visual inspection; a written explanation of the manufacturing process shall be provided if requested by the Engineer. Class 7 from a non-approved source, shall not exceed a weighted loss of 30 percent when subjected to five cycles of the Sodium Sulfate Soundness Test, will be acceptable.

307.2.4.2-Degree of Nonconformance: When a subplot of material is to have its price adjusted, the percentage point difference between the nonconforming test value and the specification limit shall be determined for each sieve size determined to be nonconforming, and this value shall be multiplied by its appropriate multiplication factor as set forth in Table 307.2.4.2 to determine the degree of nonconformance on that sieve.

TABLE 307.2.4.2

Nonconforming Sieve Size	Multiplication Factor
2 in. (50 mm)	1.0
1 ½ in. (37.5 mm)	1.0
¾ in. (19 mm)	1.0
No. 4 (4.75 mm)	1.0
No. 40 (425 µm)	1.5
No. 100 (150 µm)	2.0
No. 200 (75 µm)	2.5

The total measure of nonconformance of an individual subplot is the sum of all nonconformances on the various sieve sizes of that subplot.

When the total degree of nonconformance has been established and it is 12.0 or less, the material will be paid for at an adjusted contract price as specified in Table 307.9.1.

When the degree of nonconformance is greater than 12.0, the nonconforming subplot shall be resolved on an individual basis, requiring a special investigation by the Engineer to determine the appropriate course of action to be followed. Pending resolution of the matter, additional lifts of base or pavement shall not be placed over the nonconforming material.

307.2.5-Reclaimed Asphalt Pavement: Reclaimed Asphalt Pavement (RAP) may be substituted for Class 10 Shoulder Stone material on roadways where edge line pavement markings exist or are installed. Materials testing will be waived, however the Top Size gradation shall not exceed 1 ½ inches (37 mm) or the maximum shoulder placement thickness as defined on the Plans (whichever is less). Approval shall be by visual inspection by the Engineer.

Payment for RAP shoulder material substitution shall be at the same unit bid price for Shoulder Stone Material in the Contract documents.

CONSTRUCTION METHODS

307.3-EQUIPMENT:

Any machine, combination of machines, or equipment which will handle the material without undue segregation and produce the completed base course meeting these Specifications for handling, spreading, moistening, mixing and compacting may be used when approved by the Engineer.

307.4-PLACING:

Prior to the placing of any base course material on the subgrade, the subgrade shall meet the applicable requirements of 207.9 or 228. The profile grade of the subgrade shall be such that the specified thickness of the base course may be obtained. No base shall be placed when the subgrade is frozen or when it is sufficiently wet that its surface can be marred by construction equipment.

The base course shall be placed and shaped on the prepared surface in layers to achieve the compacted thickness shown on the Plans. When more than one layer is required, each layer shall be shaped and compacted to the required density before the succeeding layer is placed. Each layer

shall be kept at least 500 ft. (150 meters) ahead of the succeeding layer. Tailgating will not be permitted. If power graders are used for spreading, the material shall be placed in windrows and uniformly and thoroughly mixed prior to final spreading and compaction.

On resurfacing projects the existing shoulders shall be scarified to a depth of 2 inches (50 mm) or as shown on the Plans. Subgrade soil or ditch soil shall not be mixed with the loosened material. The loosened material shall then be broken and reshaped to form a uniform grade and cross section.

Aggregate for shoulders on resurfacing projects shall be spread over the prepared surface to a width as specified in the Plans and to a depth sufficient to bring the uncompacted surface to a height of at least 1 inch (25 mm) above the finished pavement edge elevation. For compacted shoulder thicknesses exceeding 3 inches (75 mm), the differential from the pavement edge elevation must be increased to assure that the loose aggregate thickness is approximately equal to 1-1/3 times the compacted thickness. The loose aggregate is then to be shaped to proper grade and cross section maintaining the height differential.

307.5-COMPACTING:

Each layer shall be compacted. The moisture content shall be maintained at a level sufficient to facilitate compaction. Required density and testing shall be in accordance with the provisions of the appropriate portions of 717. The surface of each layer shall be maintained during the compaction operations in such a manner that a uniform texture is produced and the aggregates firmly keyed. The surface of the top layer of the base course shall be carefully trued by blading if necessary.

Shoulder aggregate adjacent to concrete or asphalt pavement shall be compacted by pneumatic tire rollers when the drum roller is wider than the shoulder width or as directed by the engineer.

307.6-TOLERANCE:

307.6.1 Surface Tolerance: The completed surface shall not vary more than 3/8 inch (10 mm) above or below Plan grade, nor more than 3/8 inch (10 mm) from a straightedge 10 ft. (3 m) long applied parallel to the centerline of the pavement. Deviations shall be corrected by scarifying, adding additional approved aggregate if necessary, reshaping, and recompacting.

Shoulder surfaces on resurfacing projects adjacent to concrete or asphalt pavement do not need to be checked with a straightedge.

307.6.2-Thickness Tolerance: The base course shall be checked for proper thickness after final compaction. The Contractor shall refill all test holes with approved base course material and adequately recompact the material.

Any deficiency in total thickness of the base course in excess of 1/2 in. (13 mm) shall be corrected.

307.7-MAINTENANCE:

The surface of the completed base shall be protected against the loss of fine material by the addition of moisture when necessary, and it shall be maintained in a satisfactory and smooth condition until such time that it is surfaced or finally accepted.

307.8-METHOD OF MEASUREMENT:

307.8.1 Cubic Yard (Meter) Measurement: The quantity of work done will be the number of cubic yards (meters) measured in place. Any additional work beyond the scope of the original Plans but authorized by the Engineer will be measured in cubic yards (meters) in place and paid for at the unit bid price for this item, subject to the provisions of 104.2 and 109.2.

Base course constructed outside the lines, dimensions, and cross sections shown on the Plans or designated will not be measured for payment.

307.8.2-Ton (Mg) Measurement: The quantity of work done will be the number of tons (Mg) of material complete in place and accepted.

The number of tons (Mg) shall be determined by the total of the weights shown on receipted railroad freight bills when materials are shipped by rail; by actual measured displacement of barges certified by the producer when water shipments are made, providing materials delivered by the methods are not stockpiled or stored; or determined by the Contractor from the total of weigh slips for each vehicle load weighed on an approved standard scale or from digital printout slips from an automatic batching plant, and certified by the Contractor to be correct.

Truck scales shall be provided by the producer or Contractor, except that truck scales are not required where the material is weighed at properly calibrated automatic batching plant facilities which are equipped with digital print-out equipment. The scales shall be of sufficient size and capacity to weigh the heaviest loaded trucks that are used for delivery of the material.

All truck scales shall be mounted on solid foundations, which will insure their remaining plumb and level. All truck scales shall be inspected and sealed by the West Virginia Division of Labor, Bureau of Weights and Measures, or other appropriate agencies of the State or its political subdivisions. The Division may, at its option, accept inspection and sealing by out of state agencies when the material is weighed outside West Virginia.

The producer shall provide a weigh person. The weigh person shall certify that the weight of the material, as determined either by the truck scales or from the digital printout of the weights, is correct.

Each truck shall be weighed empty prior to each load, except at automatic batch plants approved to operate without truck scales. A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification and project number. Provision shall be made for constant zero compensation and further provision shall be made so that the scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest.

In case of a breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

When reconditioning surface with aggregate is specified it shall include the cost of all surface reconditioning work.

307.9 BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which price and payment shall be full compensation for furnishing all the materials including water for compaction, scarification and manipulation of existing surface, and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

307.9.1-Price Adjustment: Aggregates not conforming with the gradation requirements as described in 307.2.4.1 will be paid for at the adjusted contract price based on the degree of nonconformance as specified in Table 307.9.1.

TABLE 307.9.1

Adjustment of Contract Price for Gradation not Within Specifications	
Degree of Nonconformance	Percent of Contract Price to be Reduced
1.0 to 3.0	2
3.1 to 5.0	4
5.1 to 8.0	7
8.1 to 12.0	11
Greater than 12	*

* The Division will make a special evaluation of the material and determine the appropriate action.

307.10 PAY ITEMS:

ITEM	DESCRIPTION	UNIT
307001-*	Aggregate Base Course, Class "class"	Cubic Yard (Meter)
307005-*	Aggregate Base Course, "aggregate type", Class "class"	Ton (Megagram)

* Sequence number

"aggregate type" shall be either stone and gravel, slag or steel slag

"class" From Table 704.6 2 A and B

SECTION 308 THROUGH SECTION 310-BLANK

SECTION 311

OPEN GRADED FREE DRAINING BASE COURSE

311.1-DESCRIPTION:

This work shall consist of constructing a base course of coarse stabilized aggregate spread and compacted on a prepared surface in accordance with these specifications and in reasonably close conformance with the lines, grades, thickness, and typical cross sections as shown on the Plans or as established by the Engineer. It is the intent to allow the Contractor a choice between asphalt stabilizer and Portland cement stabilizer.

311.2-MATERIALS:

Depending on the alternative chosen, (asphalt or Portland cement) the materials shall conform to the requirements of the following subsections of Division 700.

MATERIAL	SUBSECTION	UNIT
Aggregate*	703.1, 703.2, 703.3, 703.4	AASHTO 57, 67, 357, or 467
Curing Material***	707.10	
Performance Graded Binders**	705.5	Standard grade for area
Portland cement***	701.1	Type 1
Water***	715.7	

* If river gravel is used, the crushed particle requirement shall be 100% two face fracture.

** Asphalt stabilized applications only.

*** Portland cement applications only.

CONSTRUCTION METHODS

311.3-GENERAL:

General requirements shall comply with the applicable portion of 401.3 of the Specifications.

311.4-COMPOSITION OF OPTIONAL STABILIZING MIXTURES:

If the asphalt stabilized alternative is used, the asphalt cement shall be confined to 2.0%, plus or minus 0.5% by weight of the mix if Blast Furnace Slag is used the asphalt cement may be increased.

If the Portland cement stabilized alternative is chosen, the cement shall be Type 1 and shall have a minimum cement content of 150 ± 5 pounds per cubic yard (90 ± 2 kg per cubic meter). This base course shall be capable of withstanding construction operations without showing any detrimental effects.

311.5-TESTING:

311.5.1-Quality Control Testing: Quality control is the responsibility of the Contractor as specified in 106.1.

The contractor shall design a quality control plan detailing the methods by which the quality program will be conducted. The Contractor shall conduct one test daily to determine mix properties in accordance with 311.4. Frequency will be one test per day. Acceptance for

gradation will be in accordance with section 703.6. If gravel is used for the coarse aggregate a crushed particle analysis, in accordance with Section 311.2 will be conducted before placement and every 10,000-ton (9000-mg) thereafter. Unless otherwise specified compaction testing shall be waived.

311.5.2-Acceptance Testing: Acceptance sampling and testing of aggregates is the responsibility of the Division, except for furnishing the necessary materials. The Division may use quality control sampling and testing performed by the Contractor for Acceptance.

311.6-WEATHER AND SEASONAL LIMITATIONS:

Weather and seasonal limitations shall be in accordance with 401.8 for asphalt applications. Portland cement base shall not be mixed or placed while the temperature of the course on which the material is to be placed is below 40° F (4° C). When conditions indicate that the temperature of the in-place material may fall to less than 35° F (2° C) within 24 hours, adequate means satisfactory to the Engineer shall be provided for the protection of the work. In no instance shall the mix be placed on frozen subgrade.

311.7-EQUIPMENT:

Depending on the alternative used, equipment shall meet the applicable requirements of 401.9 or 501.5 – whichever is appropriate.

311.8-PREPARATION AND BATCHING OF MATERIALS:

All aggregate shall be dried until it has no surface moisture and not more than 0.5 percent of absorbed moisture. Mixing temperature of aggregate shall be as directed and shall range between 225° - 300° F (107° -149° C).

Bituminous material shall be heated in melting kettles or tanks designed to secure even heating of the mass. Heating temperatures shall be as directed and shall range between 250° - 275° F (120° - 135° C).

The temperature of the mix shall be within the range of 200° - 250° F (95° - 120° C).

Preparation of materials for Portland cement applications shall conform to the requirements of 501.7.

311.9-MIXING AND TRANSPORTING REQUIREMENTS:

The materials used in asphaltic mixes shall be mixed in an asphalt concrete mixing plant that has been inspected and approved by the Division. Transportation of such mixes shall be in accordance with 401.09.7 of the Specifications.

The materials used in Portland cement mixes may be mixed at a central mix plant, in a transit mix truck or a pugmill type mixer. Regardless of which type of equipment is used, the mixing time shall be a minimum of two minutes once all component materials are batched.

311.10-PLACING, SPREADING, AND/OR COMPACTING:

Placement of the stabilized material shall be by acceptable spreading equipment to the appropriate line, grade and thickness. Acceptable equipment includes asphalt pavers for asphalt stabilized bases and spreader boxes, self-propelled spreaders or conventional concrete placing equipment for Portland cement stabilized bases.

A four to ten ton (3.6 to 9.1 Mg) steel wheel tandem roller shall be used to compact the asphalt stabilized free draining base material. The number of roller passes shall be two or three unless otherwise directed. In the case of the asphalt stabilized aggregate, the mat temperature, at the time of initial rolling, shall be between 150° and 175° F (65 and 80° C) unless otherwise directed. In the case of the asphalt stabilized aggregate, the purpose of the rolling is to compact the base sufficiently to support the weight of the equipment that will place the next layer or pavement. The compacted base is to be porous so that water will drain through it. The base is not to be compacted to the point that it is not free draining or that the aggregate is crushed.

311.11-CURING:

No curing is required for Portland cement stabilized based.

311.12-TOLERANCE:

Thickness tolerance shall meet the requirements of 307.6.2.

311.13-MAINTENANCE:

The Contractor shall maintain the base course porous and free from being contaminated or clogged by deleterious material, transported and deposited by construction equipment, traffic, etc., until the next layer of the pavement is placed. The Contractor shall also maintain the final surface of the base course true to specified line, grade and cross section until such time that the pavement is placed.

311.14-METHOD OF MEASUREMENT:

The quantity of work done will be the number of cubic yards (meters) measured in place. Any additional work beyond the scope of the original plans but authorized by the Engineer will be measured in place and paid at the unit bid price, subject to the provisions of 104.2 and 109.2.

Base course constructed outside the lines, dimensions and cross sections shown on the Plans or designated will not be measured for payment.

311.15-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item below, which price and payment shall constitute full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including labor, tools, equipment, supplies, and incidentals necessary to complete the work.

311.16-PAY ITEM:

ITEM	DESCRIPTION	UNIT
311006-*	Open Graded Free Draining Base Course	Cubic Yard (Meter)

* Sequence number

DIVISION 400

ASPHALT PAVEMENTS

SECTION 401 ASPHALT BASE, WEARING, AND PATCHING AND LEVELING COURSES

401.1-DESCRIPTION:

This work shall consist of constructing one or more courses of hot-mix asphalt (HMA) or warm-mix asphalt (WMA), mixed mechanically in a plant, composed of aggregate and asphalt material designed in accordance with either the Marshall or Superpave Design System as specified in the contract documents, on a prepared foundation in accordance with these specifications and in reasonable close conformity with the lines, grades, weights or thicknesses, and cross sections shown on the Plans or established by the Engineer.

The unit of measurement for HMA or WMA will be by the ton (megagram), square yard (square meter) or cubic yard (cubic meter).

The work will be accepted in accordance with these Specifications and the applicable requirements of Sections 105, 106, and 109.

401.2-MATERIALS:

The materials shall conform to the following requirements:

MATERIAL	SUBSECTION	PG BINDER GRADE
Coarse Aggregate	703.1 thru 703.3 ^{Note 1} and ^{Note 3} (See MP 401.02.28 for exceptions and additions required for Superpave Items.)	PG 70-22 ^{Note 2} shall be used on projects specified with over 20 million ESALs.
Fine Aggregate	702.3 (See MP 401.02.28 for additions required for Superpave Items)	Any deviation from the above criteria will be specified in contract documents.
Mineral Filler	702.4	
Performance Graded Binders	705.5	Standard grade shall be a PG 64-22.

Note 1 The total shale, coal and other lightweight deleterious material and friable particles shall not exceed 3%.

Note 2 PG 64-22 Binder may be used in asphalt placed below the top two lifts. Scratch course and patching-and-leveling are not identified as lifts

Note 3 When slag is specified in the contract, the coarse aggregate shall be slag which meets the requirements of 703.3, except as amended in this subsection

CONSTRUCTION METHODS

401.3-GENERAL:

Construction methods to be used in performing the work shall be submitted to the Engineer for review prior to the start of work. This review may require modification of the proposed methods to provide the desired end product. All equipment, tools, machinery, and plant shall be maintained in a satisfactory working condition.

401.4-COMPOSITION OF MIXTURES:

401.4.1-General: The aggregate for use in the designated mixture shall consist of a mixture of aggregate (coarse, fine, reclaimed asphalt pavement (RAP) if desired, or mixture thereof) and mineral filler if required. It shall be the responsibility of the Contractor to determine the percentage of RAP to be used in the mix. The amount and grade of virgin PG Binder to be used in the RAP designs shall be determined in accordance with Materials Procedure (MP) 401.02.24.

401.4.2-Job Mix Formula: Job Mix Formula (JMF) is the specification for a single mix produced at a single plant. This mix may be specific to a single project or be used on multiple projects if the basic design criteria (design compaction level and PG Binder grade) are the same.

The Contractor shall submit a proposed JMF for each combination of aggregate and asphalt material for each type of HMA to be produced. Depending on the design type, the JMF gradations shall be within the tolerances set forth in either Table 401.4.2A or Table 401.4.2B. Marshall mix designs shall be developed in accordance with MP 401.02.22. Superpave mix designs shall be developed in accordance with MP 401.02.28.

Each proposed JMF must be documented on the Division Form T400 or T400SP and the entire JMF package shall be forwarded for review to the District Materials Engineer/Supervisor. The T400/T400SP and JMF package shall then be transmitted to the Materials Control, Soils and Testing Division for final review. If the JMF requires revision, it will be returned to the designer through the District. The T400/T400SP Form shall contain the following information:

- i. Identification of the source and type of materials used in the design.
- ii. The aggregate blend percentages and the percentage for each sieve fraction of aggregate considered the desirable target for that fraction.
- iii. The percentage of asphalt binder representing the optimum asphalt content for the JMF submitted, which is to be considered the desirable target percentage.
- iv. The temperature of the completed mixture at the plant which shall be within $\pm 25^{\circ}$ F ($\pm 14^{\circ}$ C) of the median mix temperature established by the temperature-viscosity chart or as recommended by the asphalt supplier.
- v. The ratio (calculated to the nearest one-tenth percent) of the Fines to Asphalt (FA). For Marshall mixes the ratio is defined as the percentage of aggregate passing the No. 200 (75 μ m) sieve, divided by the percentage of asphalt content calculated at the percentage optimum asphalt content of the design. For Superpave mixes the ratio is defined as the percentage of aggregate passing the 75 μ m (No. 200) sieve, divided by the percentage of effective asphalt content calculated at the percentage optimum asphalt content of the design.

TABLE 401.4.2A
Design Aggregate Gradation Requirements for Marshall Mix Designs

Type of Mix	Base-I	Base-II (Patch & Level)	Wearing IV	Wearing-I (Scratch-I)	Wearing-III (Scratch-III)
Sieve Size	Nominal Maximum Size				
	1 ½ in (37.5 mm)	¾ in (19 mm)	¾ in (19 mm)	3/8 in (9.5 mm)	No. 4 (4.75 mm)
2 in (50 mm)	100	—	—	—	—
1 ½ in (37.5 mm)	90-100	—	—	—	—
1 in (25 mm)	90 max	100	100	—	—
¾ in (19 mm)	—	90-100	90-100	—	—
½ in (12.5 mm)	—	90 max	90 max	100	—
3/8 in (9.5 mm)	—	—	—	85-100	100
No. 4 (4.75 mm)	—	—	47 min	80 max	90-100
No. 8 (2.36 mm)	15-36	20-50	20-50	30-55	90 max
No. 16 (1.18 mm)	—	—	—	—	40-65
No. 30 (600 µm)	—	—	—	—	—
No. 50 (300 µm)	—	—	—	—	—
No. 200 (75 µm)	1-6	2-8	2-8	2-9	3-11

TABLE 401.4.2B
Design Aggregate Gradation Requirements for Superpave Mix Designs

Type of Mix	37.5	25	19 ^{Note 1} (Patch & Level)	12.5	9.5 (Scratch)	4.75 (Scratch)
Standard Sieve Size	Nominal Maximum Size					
	37.5 mm (1 ½ inch)	25 mm (1 inch)	19 mm (¾ inch)	12.5 mm (½ inch)	9.5 mm (⅜ inch)	4.75 (No. 4)
50 mm (2")	100	—	—	—	—	—
37.5 mm (1½")	90-100	100	—	—	—	—
25 mm (1")	90 max	90-100	100	—	—	—
19 mm (¾")	—	90 max	90-100	100	—	—
12.5 mm (½")	—	—	90 max	90-100	100	100
9.5 mm (⅜")	—	—	—	90 max	90-100	95-100
4.75 mm (No.4)	—	—	—	—	90 max	90-100
2.36 mm (No.8)	15-41	19-45	23- 49	28-58	32-67	
1.18 mm (No.16)	—	—	—	—	—	30-60
600 µm (No.30)	—	—	—	—	—	—
300 µm (No. 50)	—	—	—	—	—	—
75 µm (No.200)	0-6	1-7	2-8	2-10	2-10	6-12

Note 1 When a 19 mm mix is specified for use as a heavy duty surface mix, it shall be designed as a fine graded mix with the additional requirement of a minimum of 47% passing the 4.75 mm (No.4) screen.

If it becomes necessary to change aggregate sources, a new mix design shall be developed and submitted for approval. When using neat (unmodified) PG Binders, the binder source may be changed without requiring a new mix design, but the binder grade must always remain the same for each design. If a source change results in the use of an additive- enhanced modified binder of the same grade, a new mix design will be required.

If a modified binder source is changed or if the modification process is changed, a new mix design shall be developed and submitted for approval. A source change to a new location with the original manufacturer/supplier and the original modification process will not require a new mix design.

At no time shall different grades of PG Binders be mixed together in the same storage tank. When it is necessary to switch to a new binder grade the tank shall be drawn down as far as possible, normally to the top of heating coils, before refilling with the new binder. The new binder shall be circulated thoroughly before restarting production.

401.4.2.1-Warm Mix Asphalt: When the Division allows an approved HMA design to be produced as warm-mix asphalt (WMA) using the water injection system, the temperature of the completed mixture at the plant may be lowered to an established range that has previously been determined through trial production. The allowable temperature range specified on the approved T400 mix design form shall be adjusted accordingly when producing WMA. In addition, all references to the minimum compaction temperatures in Sections 401.10.3 and 401.10.4 of this specification and in MP 401.05.20, Compaction Testing of HMA Pavements, may be waived if it can be established that additional density can be obtained at lower temperatures without damaging the pavement. Intermingling of WMA and HMA on the same course should be avoided. If circumstances result in the need for intermingling, it must be approved by the Engineer. Upon approval, the location where intermingling occurs on the project shall be clearly defined and documented by the Contractor and submitted to the Engineer. Also, if the intermingling occurs on a project where the density of the pavement is being controlled by the rollerpass compaction method, then a new test section shall be established on the new material beginning at the point where the WMA and HMA meet. All testing requirements established for HMA mix designs and quality assurance/quality control testing shall also apply to WMA.

401.5-TESTING:

401.5.1-Test Methods:

MP 700.00.06	Aggregate Sampling Procedures
AASHTO T168	Sampling Hot-Mix Asphalt
AASHTO T11	Materials Finer than No. 200 (75 µm) Sieve in Mineral Aggregates by Washing
AASHTO T27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T30	Mechanical Analysis of Extracted Aggregate
AASHTO T164	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
AASHTO T308	Asphalt Content of HMA by the Ignition Method (Test Method A)
AASHTO T245	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D5581	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (For Base-I Marshall designs only)
AASHTO T166	Bulk Specific Gravity of Compacted Bituminous Mixtures
AASHTO T209	Maximum Specific Gravity of Bituminous Paving Mixtures
AASHTO T312	Determining the Density of HMA Specimens by Means of the Superpave Gyratory Compactor

401.6-CONTRACTORS QUALITY CONTROL:

401.6.1-Quality Control Testing: Quality control of bituminous asphalt is the responsibility of the Contractor. The Contractor shall maintain equipment and qualified personnel including at least one certified Asphalt Plant Technician at each plant. The technician shall be in charge of all plant quality control activities such as mix proportioning and adjustment and all sampling and testing activities necessary to maintain the various properties of asphalt within the limits of the specification.

The Contractor shall maintain necessary equipment and qualified personnel including at least one certified Asphalt Field and Compaction Technician at each project during paving operations. Additionally, a certified Asphalt Field and Compaction Technician with certification to perform nuclear density testing of asphalt pavements shall perform all testing necessary to assure compaction of the asphalt meets specification requirements. Compaction Technicians may serve as Asphalt Field and Compaction Technicians for asphalt compaction testing until December 31, 2017.

The Contractor, shall design a workable Quality Control Plan, detailing the type and frequency of sampling and testing deemed necessary to measure and control the magnitude of the various properties of the asphalt governed by these specifications. This plan, prepared in accordance with MP 401.03.50 shall be submitted to the Engineer for review prior to production of material under this specification.

401.6.2-Job Mix Formula (JMF) Field Verification: For each JMF, a mix design field verification shall be conducted during the first days of plant production. For Marshall designs, the verification shall be in accordance with the guidelines established in MP 401.02.27. For Superpave, designs it shall be in accordance with MP 401.02.29. The field verification is for the purpose of demonstrating that the JMF can be produced within the specified tolerances set forth in the MP. If the mix cannot be produce within these requirements, a new mix design will be required.

401.6.3-Quality Control Testing Requirements: After the JMF design field verification has been successfully completed, sampling frequency and test requirements for quality control shall be as set forth in MP 401.02.27 for Marshall designs and MP 401.02.29 for Superpave designs. If the Division determines that a mix cannot be consistently produced within the tolerance limits of the specified design properties, approval of the mix may be revoked and the contractor will be required to provide a new mix design.

401.7-ACCEPTANCE TESTING:

401.7.1-Acceptance Testing of HMA: Acceptance testing of asphalt is the responsibility of the Division. For Superpave mixes, the acceptance sampling and testing requirements for the mixture shall be as set forth in MP 401.02.29.

401.7.2-Surface Tolerance: It is the intent of these specifications that projects with a total new pavement thickness of 3 inches (75 mm) or more and minimum length of two lots (1100 ft. (340 m)) shall be constructed to provide a smooth riding surface. The smoothness of the riding surface will be determined by the Engineer using an inertial profilometer or Mays Ride Meter. The smoothness testing shall be accomplished within 30 days after the project is substantially complete. On urban projects with numerous side streets where traffic must cross through the paving operation, the Engineer shall determine if it is practical to evaluate the pavement for smoothness.

The pavement will be divided into sampling Lots of one-tenth (0.1) lane-mile (0.16 km) each. Each Lot shall exhibit a smoothness measurement, expressed in inches per mile (millimeters per kilometer) equal to or less than that shown in the appropriate Table 401.7.2E or 401.7.2M. When a Lot is represented by a smoothness number greater than that shown in Tables 401.7.2E or 401.7.2M, the unit price shall be adjusted as in 401.13.2.

TABLE 401.7.2E

Total New Pavement Thickness	Smoothness
3 inches to 4 inches	81 inches per mile or less
4 inches or greater	65 inches per mile or less

TABLE 401.7.2M

Total New Pavement Thickness	Smoothness
75 mm to 100 mm	1 250 mm/km or less
100 mm or greater	1 000 mm/km or less

When compaction is completed on the course, it shall present a uniform surface, true line and grade, conforming to the cross section shown on the Plans. When tested with a straightedge of approximately 10 feet (3 meters) in length and a template of the specified dimensions, the finished base course shall not show a deviation greater than ¼ inch (6 mm) and the finished wearing course shall not show a deviation from the required surface greater than 3/16 inch (5 mm).

The Contractor shall provide the straightedge and template for checking the surfaces and an employee to use them under the direction of the Engineer. Any irregularity of the surface exceeding the limits specified shall be corrected. Depressions which develop after the initial rolling shall be corrected by loosening the mixture and adding new material. High places shall be corrected by removing excess material.

Areas of completed courses found to be defective shall be removed and replaced with approved mixtures laid in accordance with these specifications, and no additional compensation will be allowed for materials used or work involved in replacing defective areas.

401.7.3-Compaction: Acceptance testing for compaction shall be performed in accordance with either the Lot-by-Lot method described in Section 401.7.3.1 or the rollerpass procedure described in MP 401.05.20, based the following criteria:

Roadway Type	Compaction Method
Interstate and Expressways	Lot By Lot
APD Routes	Lot By Lot
NHS Routes	Lot By Lot
All other routes and roadways	Determined by Table 401.7.3.A

Patching-and-leveling and scratch courses shall not be included in determining the total new pavement thickness. When asphalt is placed in areas that require a non-uniform thickness or is tapered to a thin edge, the method of acceptance testing shall be determined by the Engineer. Acceptance testing is not required on areas in which a full-size roller is restricted from properly compacting the mat. These areas shall be compacted to the satisfaction of the Engineer.

TABLE 401.7.3A
Mainline Compaction Methods

Traffic Type	Total New Pavement Thickness	Marshall Lift Thickness	Superpave Lift Thickness	Compaction Method Note 1, Note 2
Heavy ≥ 3 million ESALs	≥ 2.5 inches (63 mm)	≥ 1.5 inch (37.5 mm)	≥ 1.5 inch (37.5 mm)	Lot-by-Lot
		< 1.5 inch (37.5 mm)	< 1.5 inch (37.5 mm)	Rollerpass
	< 2.5 inches (63 mm)	> 1.5 inch (37.5 mm)	> 1.5 inch (37.5 mm)	Lot-by-Lot
		≤ 1.5 inch (37.5 mm)	≤ 1.5 inch (37.5 mm)	Rollerpass
Medium < 3 million ESALs	≥ 3.0 inches (75 mm)	> 1.5 inch (37.5 mm)	> 1.5 inch (37.5 mm)	Lot-by-Lot
		≤ 1.5 inch (37.5 mm)	≤ 1.5 inch (37.5 mm)	Rollerpass
	< 3.0 inches (75 mm)	All lifts	All lifts	Rollerpass

Note 1 Any lift that is placed at a thickness of less than two times the nominal maximum aggregate size, as specified in either Table 401.4.2A or Table 401.4.2B, shall be compacted using the rollerpass method.

Note 2 Any asphalt that has been specified with a higher than standard grade PG Binder (i.e. PG 70-22, PG 76-22, etc.) shall be compacted using the Lot by Lot method in accordance with Section 10.0 of MP 401.05.20.

TABLE 401.7.3B
Other Compaction Situations

Procedure	Construction Situation	Compaction Method
Shoulders	New Construction	Lot-by-Lot
	Overlay Projects	Rollerpass
Shoulders with Rolled-In Rumble Strips	Surface Course Only	See Section 401.7.3.2
Trench Paving	All	Rollerpass or Satisfaction of the Engineer
Pavement Widening	All	Rollerpass or Satisfaction of the Engineer
Pavement Repairs	All	Rollerpass or Satisfaction of the Engineer

401.7.3.1-Lot-by-Lot Testing: Randomly located nuclear density tests will be performed in accordance with the Lot-by-Lot test procedure described in MP 401.05.20. The pavement shall be divided into Lots not exceeding 1000 feet (300 meters) of paving lane. A randomly located density test shall be conducted in each Lot. The density shall be within the range of 92 to 96% of the maximum density of the approved mix design or the maximum density established under Section 401.6.2, Job Mix Formula Verification. If the

density is outside the range, an additional five tests shall be conducted for the Lot and the average of these five tests used to judge acceptance of the Lot in accordance with Table 401.13.3.

401.7.3.2-Shoulders with Rolled-In Rumble Strips: On both new construction and overlay projects, the compaction requirement for the surface course of the shoulder shall be in accordance with the rollerpass procedure described in MP 401.05.20. However, the number of roller passes may be reduced in the area of the rolled-in rumble strip to allow for the proper placement of the rumble strip.

401.7.4-Thickness: When a uniform thickness of three inches (75 mm) or more is specified, excluding resurfacing, cores shall be taken to verify the thickness of the compacted pavement.

Cores will be taken by the Division at random locations. The sampling frequency shall be approximately five cores per 2,000 feet (600 meters) of two-lane construction, except that the sampling frequency shall normally be limited to a minimum of five and a maximum of 50 cores per project. The Division may elect to waive coring for short projects of less than 1,000 feet (300 meters) in length or for projects where a paving mat of uniform thickness cannot be expected (for example: tapered paving mats or pavement widening projects). The Division may also elect to take additional cores when needed to resolve problems related to pavement thickness.

The thickness shall be considered acceptable if one or both of the following criteria are met:

- (a) The average thickness equals or exceeds the specified thickness.
- (b) The average thickness is less than the specified thickness, but the difference is not statistically significant at the 95% confidence level. (Standard one tail “t” test at 0.05 significance).

The calculated ‘t’ value shall be less than or equal to the standard ‘t’ value at the 95% confidence level. The method for calculating Criteria ‘B’, shall be as follows:

$$t \leq t_{95}$$

Where:

t_{95} = value from standard “t” table for 95% confidence level

$$t = \frac{x_s - \bar{x}}{s} \sqrt{n-1}$$

x_s = specified thickness

$\bar{x}$ = average thickness

n = number of samples

$$s = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$$

x = individual core thickness

If the average thickness is less than specified and is determined to be significant as determined by criteria 'B', the Division shall decide on a course of action as described in Section 401.13.4.

401.8-WEATHER RESTRICTIONS:

Bituminous asphalt shall only be placed when the surface is dry and when weather conditions are such that proper handling, finishing, and compaction can be accomplished. In no case however, shall asphalt be placed when the surface temperature is below the minimum established in Table 401.8.

TABLE 401.8

Course Thickness	Minimum Surface Temperature
3 inches (75 mm) and over	35 °F (2 °C) ^{Note 1}
1.5 to 2.9 inches (38 to 74 mm)	40 °F (4 °C)
Less than 1.5 inches (38 mm)	50 °F (10 °C)

Note 1 In lieu of 35 °F (2 °C), a minimum air temperature of 40 °F (4 °C) shall be used when paving directly on an aggregate base, subbase, or subgrade.

In addition to the above surface temperature requirements, no wearing courses shall be placed when the air temperature is less than 40° F (4° C).

401.8.1-Cold Weather Paving: When the air temperature falls below 50° F (10° C) or the surface temperature falls below 60° F (15° C) the provisions for cold weather paving shall apply.

Paving shall be performed so that the transverse joints in adjacent lanes shall be no more than 50 feet (15 meters) apart at the end of each day's paving operations.

The surface temperature shall be taken a minimum of once every hour and shall be taken in all shaded areas. The temperature requirements as listed in Table 401.8 shall apply.

It shall be the Contractor's responsibility to monitor the declining surface temperature to insure that material delivery from the plant be terminated so as to allow that all material can be placed prior to the surface temperature falling below the surface temperatures listed in Table 401.8.

The temperature of the delivered material and the mat temperature at the time final density is obtained shall be taken for every truck load. These temperatures shall be in accordance with Section 401.10.3 for delivered material and 401.10.4 for the mat temperature at the time final density is obtained.

401.9-EQUIPMENT:

401.9.1-Plants: All plants in West Virginia producing asphalt for the Division shall provide documented evidence of compliance with current requirements of the West Virginia Air Pollution Control Commission.

All plants which are not in West Virginia but producing asphalt for the West Virginia Division of Highways shall provide documented evidence of compliance with current requirements of the laws and regulations of the State in which they are producing, applicable to air pollution. All plants shall meet the general requirements set forth in AASHTO M156 unless it can be demonstrated to the satisfaction of the Engineer that a consistent quality mix can be produced with modifications to any of these requirements.

401.9.2-Dust Collector: An efficient dust collecting system shall be provided to prevent the loss of fine material. The material collected may be returned to the mixture at a uniform rate or discarded.

401.9.3-Truck Scales: Truck scales shall be provided at each Plant, except that truck scales are not required at properly calibrated automatic batching plant facilities which are equipped with digital printout equipment, and which load the trucks directly from the mixer or the weigh hopper in a surge or storage bin.

A person designated as a weigher shall be provided by the producer. The weigher shall certify that the weight of the asphalt, as determined either by the truck scales or from the digital printout of the batch weights, is correct.

Each truck shall be weighed empty prior to each load, except at automatic batch plants approved to operate without truck scales.

All truck scales shall be mounted on solid foundations which will insure them remaining plumb and level.

Approval and sealing of scales shall be conducted at the frequency determined by the West Virginia Division of Labor, Bureau of Weights and Measures, and when the plant is moved, or upon the request of the Engineer. The Engineer shall be notified of any scale malfunctions when material is being furnished to Division of Highways projects. The Division may, at its option, accept inspection and sealing by out-of-state agencies when the mixing plant is located outside West Virginia.

A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification, and project number. Provision shall be made for constant zero compensation and further provision shall be made so that the scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest. In case of breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

The scales shall be of sufficient size and capacity to weigh the loaded trucks that are used for delivery of asphalt from the plant.

401.9.4-Test Weights: As part of its standard equipment, each plant which proportions aggregate by weight shall provide a minimum of ten 50-pound (22.68 kg) test weights for the purpose of maintaining the continued accuracy of its weighing equipment.

Plants which proportion asphalt material by weight shall furnish, in addition to the above, one five pound (2.268 kg) test weight.

401.9.5-Surge and Storage Bins: During the normal daily operation of the plant, asphalt may be stored in a surge or storage bin for a maximum of 12 hours, provided the bin has received prior evaluation and acceptance through the District plant inspection. The resulting temperature of the material at time of placement and compaction shall be sufficient to comply with 401.10.3 and 401.10.4

Longer silo storage times, up to 24 hours, may be permitted for dense graded asphalt if the storage silo is insulated and/or heated to assure that the proper mix temperature is maintained. The gates at the bottom of the storage silo shall be adequately heated and sealed when the asphalt is held for the extended period of time. An inert gas system may be used to purge the

silo of oxygen to prevent oxidation of the asphalt. The asphalt delivered from the storage silo shall meet all of the specification requirements.

When asphalt is stored for the extended time period, it shall not be used until the temperature has been checked and the asphalt has been visually inspected for hardening of the mix and stripping of the asphalt from the aggregate. Approval of the extended storage time may be revoked if it is determined through inspection and/or testing that the extended storage is having a detrimental effect on the asphalt.

Loading of trucks through the storage bin will only be permitted when a minimum 25-ton (23-Mg) buffer of material is being maintained or an amount as recommended by the bin manufacturer, means shall be provided for loading the trucks directly from the mixer when the storage bin is not in operation.

401.9.6-Inspection of Equipment and Plant Operations: The Engineer shall have access to the plant to assure the adequacy of the equipment in use, to inspect the conditions and operation of the plant, to verify weights, to verify the proportion and character of materials, and to determine if specified temperatures are being maintained in the preparation of the mixture.

401.9.7-Trucks for Transporting Mixture: The inside surfaces of trucks shall be thinly coated with a soapy water or a mixture with not more than ten percent lubricating oil. The use of diesel fuel, kerosene, or similar solvent-based products which can dissolve the asphalt film from the aggregate particles will not be permitted. Any commercial release agent which can be certified as harmless to the mix may be used; however, the Division reserves the right to restrict any release agent that is shown to cause problems during placement of the mix. In the case of mixtures composed of PG Binders which contain polymer modification, truck surfaces should be coated with a release agent recommended by the binder supplier. All excess coating material shall be removed from the truck bed prior to loading the asphalt.

All truck beds shall be insulated with approved material. No trucks shall be used which cause segregation of the materials, which show large oil leaks, or which cause undue delays in delivery of material. All trucks shall be provided with a waterproof cover and a hole in the body for the purpose of conveniently checking the temperature of the load. Covers shall be suspended slightly above the mixture, shall extend over the sides of the truck, and shall be securely fastened to eliminate air infiltration and to prevent water from coming in contact with the mixture.

401.9.8-Laboratory: A testing facility or laboratory, as described below, shall be provided within reasonable proximity of the asphalt plant. Plant operations must be visible from within the laboratory.

The laboratory shall be of sufficient size to hold all laboratory test equipment and supplies with adequate floor space to allow the technicians to test samples in an efficient manner. The laboratory shall be furnished and maintained with adequate ventilation, heat, light, water, sink and drainage, electrical or gas outlets, or both, work table, shelves, and supply cabinets.

The laboratory shall be supplied with the equipment and materials listed below and these shall be maintained to meet the applicable requirements of AASHTO or ASTM:

- i. Hot plate, gas or electric.
- ii. Large ovens (as needed for heating and drying samples), gas or electric.
- iii. Unit weight container, ½ cubic foot (0.014 cubic meter). Required for slag only.
- iv. Balances of sufficient capacity and accuracy for conducting specified tests and plant calibration.
- v. Thermometers: dial type, liquid-in-glass, and digital as required for conducting standard test procedures and monitoring mix temperatures. Digital thermometers shall be equipped with an appropriate sturdy probe that can be pushed into a sample of hot asphalt to check the temperature of the mix.
- vi. Standard Gilson shaker or equivalent, with screens.
- vii. Ro-Tap shaker or equivalent, with 8 and/or 12 inch (200 and/or 300 mm) diameter screens.
- viii. Sample splitters for fine and coarse aggregates.
- ix. Miscellaneous items (including sample splitting trowels, scoops, square point shovel, aggregate sample pans, heat resistant gloves, measuring rules, brushes, flashlight, timing devices, and glassware as needed).
- x. Expendable supplies necessary for performance of tests.
- xi. Equipment for determining the maximum specific gravity of asphalt mixtures as specified in AASHTO T209.
- xii. Equipment for determining the in-place density of asphalt mixtures meeting the requirements of MP 401.05.20.
- xiii. Non-contact infrared thermometer accurate to $\pm 2^{\circ}\text{F}$ ($\pm 1^{\circ}\text{C}$).
- xiv. Equipment for determining the bulk specific gravity of HMA using saturated surface dry specimens complying with AASHTO T166.
- xv. Marshall equipment necessary to comply with AASHTO T245 and ASTM D5581, including a calibrated automatic testing apparatus having recording capabilities and compaction hammers. (Marshall designs only)
- xvi. Asphalt content ignition oven with built-in scale and printer meeting the requirements of AASHTO T308, Test Method A. (Optional for Marshall designs – Mandatory for Superpave designs)
- xvii. Calibrated Gyratory compactor meeting requirement of AASHTO T312 with computer (including software for data acquisition and test calculations) and primer. Compactor must be calibrated to the internal angle in accordance with AASHTO TP71 with annual verification (Superpave designs only).

401.9.9-Asphalt Paving Equipment: Asphalt paving equipment shall be self-contained and of sufficient size, power and stability to receive, distribute and strike-off the asphalt mixture at rates and widths commensurate with the typical sections and other details shown on the plans. The paver shall be provided with an activated screed or strike-off assembly equipped to be heated. Approval of the paver by the Engineer will be based on the demonstrated capability of the equipment to place the mixture to the required cross-section, profile and alignment in an acceptable, finished condition ready for compaction.

The paver shall be equipped with means of preventing the segregation of the coarse aggregate particles when moving the mixture from the paver hopper to the paver augers. It shall also be capable of pushing a sufficient amount of the mixture under the auger gearbox to prevent streaking or tearing of the mat. Some paver models may require the installation of a manufacturer retrofit kit or equipment modification to accomplish this.

Specialized equipment or hand methods approved by the Engineer may be employed to spread the asphalt mixture where the use of standard full scale paver is impractical due to the size or irregularity of the area to be paved.

Pavers shall be equipped with mechanical or automatic grade and slope controls. The use of automatic grade and slope controls with a traveling straight edge shall be required only when specified on the Plans or in the Proposal. Both the grade and slope controls shall be in working order at all times. In the event of failure of the automatic controls, the Contractor will be permitted to finish the day's work using manual controls but will not be allowed to resume work the following day until the grade and slope controls are in proper working order.

401.9.10-Compaction Equipment: Compaction may be performed by self-propelled steel-wheeled, pneumatic-tired and/or vibratory rollers. Hand-held rollers or vibrating plates may be used in small inaccessible areas if approved by the Engineer. Prior to use on any project, the roller shall be inspected to see that it is in good mechanical condition. The total weight, weight per inch of width (steel-wheeled), and average ground contact pressure (pneumatic-tired) shall be documented.

401.10-PAVING OPERATIONS:

401.10.1-Cleaning and Sweeping: Immediately prior to the arrival of the paving mixture, the existing base or surface shall be thoroughly cleaned by the use of tools and equipment as may be required to remove all mud, dirt, dust, and other caked or loose material foreign to the type of treatment or surface being placed. The cleaning shall be done to a minimum width of one foot on each side beyond the width of the surface being placed.

401.10.2-Patching and Leveling and Scratch Courses:

401.10.2.1-Patching and Leveling: A tack coat shall be applied to the existing pavement prior to placing patching and leveling.

Patching and leveling shall be placed at various locations throughout the project to remove irregularities in the existing pavement such as dips, or to raise the outside edge of the existing pavement to provide a uniform template prior to placing a base or wearing course. Patching and leveling shall not be placed as a continuous layer or course over the full width and length of the project.

Compaction of patching and leveling shall be performed with three-wheel (steel) or pneumatic-tire rollers.

401.10.2.2-Scratch Course: A tack coat shall be applied to the existing pavement prior to placing a scratch course.

The scratch course shall be placed to the limits designated on the plans. Scratch course shall be placed with a paving machine. The paving machine screed shall be set to drag on the high areas of the existing pavement, only depositing material in ruts and other depressions.

The wearing course, or at least one lift of base course, should be placed over the scratch course prior to maintaining traffic in the lane where the scratch course has been placed. All repairs to a scratch course due to traffic damage shall be at the contractor's expense.

Compaction of a scratch course shall be performed with a three-wheel (steel) or pneumatic-tire roller.

401.10.3-Spreading and Finishing: Before spreading any material, the contact surfaces of curbs, gutters, manholes, and of adjacent Portland cement concrete pavement edges shall be painted or sealed with asphalt material. Exact edge of pavement, except on concrete, shall be established by a string or chalk line for a distance of not less than 500 feet ahead of the spreading operation.

For mixes produced with neat (non-modified) asphalts (which may include PG 70-22, PG 64-22, PG 64-28, and PG 58-28) the temperature of the mixture at the time of placement shall be within the temperature requirements of the JMF. The JMF temperature range shall be within the master temperature range of 250° and 338° F (121° and 170° C) unless otherwise specified by the asphalt supplier. The mix temperature shall be monitored by inserting a dial type thermometer into the mix through the hole in the truck bed.

The temperature of the completed mix, when measured at the plant, shall be within the tolerance as established by the JMF. The first load which demonstrates temperatures outside of that range shall be accepted, provided that the temperature is still within the master temperature range. No additional loads of material shall be run out until necessary steps are taken to reestablish the temperature of the mix within the plant tolerance. When measured at the project site, the temperature of the mix shall be within the tolerance established by the JMF. The first truck load of material which demonstrates temperatures outside of that range or any trucks in transit at that time shall be accepted provided temperatures are within the master temperature range. Any truckload of material which exceeds the master temperature range may be rejected by the Engineer. However, the plant shall immediately be notified that no additional loads of material are to be dispatched until necessary action is taken to reestablish temperature within JMF specification limits.

When the surface temperature falls to within 10° F (6° C) of the weather restrictions of Table 401.8, the mix temperature may be increased up to a maximum of 338° F (170° C) unless otherwise specified by the asphalt supplier. The temperature of each truckload of material shall be monitored for compliance. Any truckload of material which exceeds this maximum temperature may be rejected by the Engineer.

Mixes produced with asphalts that contain modifiers for high or low temperature performance enhancement shall meet the temperature requirements recommended by the asphalt supplier, which will be referenced on the JMF.

401.10.4-Rolling Procedure: Shoulders, ramps, and similar areas shall be compacted in the same method as the mainline.

During rolling, roller wheels shall be kept moist with only enough water to avoid picking up material. Fuel oil on roller wheels or pneumatic tires is not allowed. Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver.

If rolling causes material displacement, the affected area shall be loosened at once with lutes or rakes and restored to its original grade with loose material before being re-rolled. Heavy equipment, including rollers, should not be permitted to stand on the finished surface before it has thoroughly cooled or set.

Mat temperature shall be measured using a non-contact infrared thermometer. The required density shall be obtained prior to the mat temperature reaching 175° F (80° C). The Contractor shall be allowed to lower this temperature to 165° F (74° C) if they can demonstrate during the first day of placement of each lift on each project that additional densification can be achieved without causing any pavement distress.

401.10.5-Joints: The longitudinal joint in any layer shall offset that in the layer immediately below by approximately six inches; however, the joint in the top layer shall be at the centerline of the pavement if the roadway comprises two lanes of the width, or at lane lines if the roadway is more than two lanes in width. The transverse joint in any layer shall offset that in the layer immediately below by approximately six feet.

All transverse joints between existing and new pavement shall be “heeled-in” to the existing surface at the beginning and at the end of the project and at all other locations where the new pavement terminates against an existing pavement. Transverse joints between one day's production and the next shall be carefully constructed and shall be formed by cutting back into the existing section to expose the full depth of the course. All joints shall be squared up to the full vertical depth of the course to be placed, and a tack coat of asphalt material shall be applied. Joints adjacent to curbs, gutters, or adjoining pavement shall be formed by transporting back sufficient hot material to fill any space left uncovered by the paver.

The longitudinal joint between adjacent mats shall be set up to a sufficient height to receive the full compactive effort from the rollers and shall be tacked prior to placing adjacent material.

Transverse joints shall be checked for smoothness with a ten foot straight edge provided by the Contractor. All surface irregularities shall be corrected prior to proceeding with paving operations.

401.11-PROTECTION OF PAVEMENT AND TRAFFIC CONTROL:

The Contractor shall be responsible for the protection of asphalt surfaces from damage by their equipment and personnel. When the construction of asphalt surfaces is undertaken on projects under public traffic and the road surface is 16 feet wide or greater and the ADT is 400 or greater, the Contractor shall place no passing signs, Interim pavement markings, and Temporary pavement markings to delineate the edge line, centerline, and/or lane line of the roadway as required herein and in the project plans. The provision of Section 636: Maintaining Traffic shall apply.

401.12-METHOD OF MEASUREMENT:

Asphalt concrete will be measured by the ton (Mg), or square yard (square meter). For projects paid by the ton, the quantity will be determined by the Contractor from the total weigh slips for each vehicle load weighed upon an approved standard scale or from digital printout slips from an automatic batching plant, and certified by the Contractor as correct. For projects paid by the square yard, the quantity will be determined by the Plan Quantity as provided for in the proposal unless otherwise directed by the Engineer.

Any patching or leveling mixture placed on a subbase or base course constructed in the same Contract with the asphalt items shall be at the expense of the Contractor. No additional compensation will be allowed for the material or any work incidental to its placement.

401.13-BASIS OF PAYMENT:

The quantities determine as provided above, will be paid for at the contract unit price for the items listed below, which prices and payment shall be full compensation for furnishing all the materials and doing all the work herein prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, field laboratory, supplies, and incidentals necessary to complete the work.

The conditioning, cleaning, and sweeping of the existing base or underlying surface shall be considered as part of the construction of the appropriate items listed in 401.14, and no additional compensation will be allowed for "Cleaning and Sweeping".

There will be no additional compensation for tack coat material used for minor (spot) areas to be patched and leveled; the cost of this tack coat material will be included in the unit bid price for the "patching and leveling" Item.

There will be no additional compensation for Interim Pavement Markings.

401.13.1-When a Lot of Superpave asphalt material is found not in compliance with the tolerance requirements of MP 401.02.29, it shall be subject to a price adjustment in accordance with the criteria established in this MP.

401.13.2-When a Lot of asphalt pavement is represented by a smoothness value larger than that shown in Tables 401.7.2E or 401.7.2M, the unit price of the Lot (surface course only) shall be determined as follows:

<u>ENGLISH VERSION:</u>	
Reduced Unit Price	= Unit Bid Price X [(127.86 – As)/100]
Where A	= 0.429 when specified smoothness is 65 in/mi
Where A	= 0.341 when specified smoothness is 81 in/mi
Where s	= Smoothness value measured as per 401.7.2

<u>METRIC VERSION:</u>	
Reduced Unit Price	= Unit Bid Price X [(127 – As)/100]
Where A	= 0.0274 when specified smoothness is 1 000mm/km
Where A	= 0.0218 when specified smoothness is 1 250 mm/km
Where s	= smoothness value measured as per 401.7.2

When the measured smoothness value exceeds the specified value by 50% or more, the Lot so measured shall be corrected, at the Contractor's expense, to comply with Tables 401.7.2E or Table 401.7.2M.

401.13.3-When a Lot of asphalt pavement does not meet the density requirements of 401.7.3, the Price shall be adjusted as follows:

FORMULA-1: Projects requiring only mat density testing:

$$\text{Lot Price Adjustment (Mat only)} = (\text{unit price}) \times (\text{Lot quantity}) \times (\text{mat density price adjustment \% from Table 401.13.3A})$$

TABLE 401.13.3A

Adjustment of Contract Price for Pavement Density not Within Tolerance of Density	
Percent of Density	Percent of Contract Price to be Paid
Greater than 96 %	Note 1
95% to 96%	102
92% to 94%	100
91%	98
90%	96
89%	92
88%	88
Less than 88%	Note 2

Note 1 Mat density slightly above 96% is normally only a problem if it leads to asphalt flushing on the surface of the mat or rutting due to an unstable mix. The Division will make a special evaluation of the material and determine the appropriate action

Note 2 When the density is less than 92%, the mat will be more susceptible to accelerated deterioration and a decrease in the expected service life of the pavement. For price adjustments on mat densities less than 88%, the percent of Contract Bid Price will be decreased by 10% per percentage of mat density less than 88%, unless a Special evaluation performed by the Division determines a more appropriate action.

401.13.4-When a Lot of asphalt pavement is determined to be statistically non-conforming in accordance with criteria ‘B’ of Section 401.7.4, the Division will review the plans and project records to determine if there is an acceptable explanation for this deficiency. If it is determined that a deficiency does exist, one of the following adjustments may be used. If the deficiency is less than $\frac{3}{4}$ inch (19 mm), the Division may choose to accept the material at a price equal to the bid price times the ratio of the average thickness divided by the specified thickness. If the deficiency is $\frac{3}{4}$ inch (19 mm) or greater, the Division may require that an additional lift of material [specified to the nearest $\frac{1}{4}$ inch (6 mm) of the deficiency] be placed at the Contractor’s expense. Retesting of the overlay will be at the expense of the Contractor in accordance with MP 109.00.20.

401.14-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
401001-*	“design method” Asphalt Base Course, “aggregate type”, Type “mix type”	Ton (Megagram)
401002-*	“design method” Asphalt Wearing Course, “aggregate type”, Type “mix type”	Ton (Megagram)
401003-*	“design method” Asphalt Patching And Leveling Course, “aggregate type	Ton (Megagram)
401007-*	“design method” Asphalt Scratch Course, “aggregate type”, Type ‘mixed type”	Ton (Megagram)

* Sequence number

“design method” shall be either Marshall or Superpave

“aggregate type” shall be either stone and gravel or slag

“mix type” from Table 401.4.2A or 401.4.2B

SECTION 402

ASPHALT SKID RESISTANT PAVEMENT

402.1-DESCRIPTION:

This work shall consist of constructing a Hot-Mix Asphalt (HMA) and Warm-Mix (WMA) Skid Resistant Wearing Coarse or a Superpave (HMA or WMA) Skid Resistant Wearing Coarse in accordance with the requirements of the Section 401 Asphalt Specification with the following exceptions and additions:

402.2-MATERIALS:

The coarse aggregate shall consist of gravel, slag, or other acceptable polish resistant aggregate, or combinations thereof, meeting the requirement of Subsections 703.1 through 703.3, except as amended in this subsection.

When stone or gravel is specified in the contract, the coarse aggregate shall consist of gravel or other acceptable polish resistant aggregate, or combination thereof meeting the requirements of 703.1 through 703.3, except as amended in this subsection. When slag is specified in the contract, the coarse aggregate shall be slag which meets the requirements of 703.3, except as amended in this subsection.

Acceptable dolomite may be used alone or as a part of a coarse aggregate blend on roadways with a projected ESAL value of less than 3,000,000. On roadways with a projected ESAL value of 3,000,000 or greater, acceptable dolomite may be used only as a part of the coarse aggregate blend and shall not exceed 50% of that blend.

The total of shale (determined by MP 703.00.27), coal and other lightweight deleterious material (determined by ASTM C123) and friable particles (determined by MP 703.01.20) shall not exceed three percent.

402.2.1-Marshall Mix Designs: For Marshall mix designs, the coarse aggregate or blends thereof shall have a minimum of 80 percent two-face fracture, and, except for those carbonate rocks which may be designated as acceptable polish resistant aggregate, the portion obtained on the No. 4 (4.75 mm) sieve shall contain no more than 15 percent carbonate particles.

The total thin and elongated pieces, when tested as per MP 703.00.25, shall not exceed five percent.

402.2.2-Superpave Mix Designs: For Superpave mix designs, the coarse aggregate or blends thereof shall have a minimum angularity requirement as specified in MP 401.02.28, Table 401.02.28C and, except for those carbonate rocks which may be designated as acceptable polish resistant aggregate, the portion obtained on the No. 4 (4.75 mm) sieve shall contain no more than 15 percent carbonate particles.

Flat and elongated particles shall be tested in accordance with ASTM D4791 and the procedure modification referenced in AASHTO MP2. The total flat and elongated particles, measured at a 5:1 ratio, shall not exceed ten percent by weight for all pavements where the estimated traffic level is greater than or equal to 0.3 million ESALs.

402.3-FINE AGGREGATE:

402.3.1-Marshall Mix Designs: Fine aggregate shall meet the requirements of 702.3.

402.3.2-Superpave Mix Designs: Fine aggregate shall meet the requirements of 702.3 along with the addition of the fine aggregate angularity and sand equivalent requirements noted in MP 401.02.28, Table 401.02.28C.

402.4-MIXING:

The skid resistant paving mix shall be type designated on the plans.

402.5-PAY ITEM:

Method of measurement and basis of payment will be in accordance with the applicable sections of Section 401.

ITEM	DESCRIPTION	UNIT
402001-*	“design method” Asphalt Skid Resistant Pavement, “aggregate type”, Type “mix type”	Ton (Megagram)

- * Sequence number
- “design method” shall be either Marshall or Superpave
- “aggregate type” shall be either stone and gravel or slag
- “mix type” from Table 401.4.2A or 401.4.2B

SECTION 403 THROUGH SECTION 404-BLANK

SECTION 405 SURFACE TREATMENTS

405.1-DESCRIPTION:

This work shall consist of the construction of a wearing course, composed of bituminous material and aggregate, in one or more applications upon the completed and accepted base course or existing surface, in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and cross sections shown on the Plans or established by the Engineer.

The type of surface treatment will be indicated on the Plans. The contractor may select the emulsion grade from the table below. The District may specify the use of a polymer modified emulsion.

The contractor shall notify the engineer a minimum of two weeks prior to starting any surface treatment operation.

405.2-MATERIALS:

The materials shall conform to the requirements of the following Subsections of Division 700:

MATERIALS	SUBSECTION	KIND OR GRADATION
Cationic Emulsified Asphalt ²	705.11	CMS-2 or CRS-2 Grades
Coarse Aggregate ¹	703.1-4	57, 67, 8 or 9
Asphalt Emulsion	705.4	RS-2, MS-2, HFMS-2, or HFRS-2 Grades
Polymer Modified Cationic Emulsified Asphalt	705.12	CRS-2P

¹In addition to meeting the gradation requirements specified in Table 703.4 the aggregates shall have a maximum of 2.0% passing the #200 (75µm) sieve as determined by AASHTO T-11 and T-27. The aggregates shall be crushed with a minimum of 80% two face fracture.

²May be used with aggregate other than gravel only if the aggregate asphalt combination meets the requirements of ASTM D1664 for the dry aggregate coating test.

405.2.1-Quality Control Testing: Quality control is the responsibility of the Contractor as specified in 106.1.

The contractor shall design a quality control plan in accordance with applicable section of MP307.00.50, excluding the attached page, detailing the methods by which the quality control program will be conducted. Samples will be obtained at a minimum frequency of one sample per day of aggregate placement.

405.2.2-Acceptance Testing: Acceptance sampling and testing of aggregates is the responsibility of the Division, except for furnishing the necessary materials. Quality control sampling and testing performed by the Contractor may be used by the Division for Acceptance.

405.2.3-Acceptance for the Grading of Coarse Aggregate: Acceptance for gradation shall be on the basis of test results on consecutive random samples from a lot. A lot shall be considered the quantity of material represented by an average test value, not to exceed five

sublots. Generally at the beginning of the project, the average shall be started on the second sample in accordance with MP 300.00.51. A subplot is the quantity of material represented by a single gradation test. In the case where only one sample is taken, this subplot shall be considered the lot. The material shall be sampled and tested in accordance with the applicable specification. The gradation test results shall be plotted on a control chart in accordance with MP 300.00.51. When the average, or when the most recent three consecutive individual test values fall outside the limits of Table 703.4 the lot of material represented will be considered nonconforming to the extent that the last of its sublots is nonconforming. When this occurs, the last subplot shall have its price adjusted in accordance with Table 405.2.3.2. In the case where the average is nonconforming and the last subplot contained is conforming, then there would be no price adjustment. In no event, however, shall a subplot of material have its price adjusted more than once, and the first adjustment, which is determined, shall apply.

405.2.3.1-Degree of Nonconformance: When a subplot of material is to have its price adjusted, the percentage point difference between the nonconforming test value and the specification limit shall be determined for each sieve size determined to be nonconforming and this value shall be multiplied by its appropriate multiplication factor as set forth in Table 405.2.3.1 to determine the degree of nonconformance on that sieve.

TABLE 405.2.3.1

Nonconforming Sieve Size	Multiplication Factor
4 in. (100mm) to No. 16(1.18mm)	1.0
No. 40 (4.25µm) to No. 50 (300µm)	1.5
No. 100 (150µm)	2.0
No. 200 (75µm)	3.0

The total measure of nonconformance of an individual subplot is the sum of all nonconformances on the various sieve sizes of that subplot. When the total degree of nonconformance has been established and it is 12.0 or less, the material will be paid for at an adjusted contract price as specified in Table 405.2.3.2. When the degree of nonconformance is greater than 12.0, the nonconforming subplot shall be resolved on an individual basis, requiring a special investigation by the Engineer to determine the appropriate course of action to be followed.

If the degree of nonconformance exceeds 8.0 then the contractor shall cease operations and review and/or revise the quality control plan and/or procedure to become in compliance with these specifications.

405.2.3.2-Price Adjustment: Aggregates not conforming with the gradation requirements will be paid for at the adjusted contract price based on the degree of nonconformance as specified in Table 405.2.3.2.

TABLE 405.2.3.2

Adjustment of Contract Price for Gradation not Within Specifications	
Degree of Nonconformance	Percent of Contract Price to be Reduced
1.1 to 3.0	2
3.1 to 5.0	4
5.1 to 8.0	7
8.1 to 12.0	11
Greater than 12	*

- * The Division will make a special evaluation of the material and determine the appropriate action. Pending resolution of the matter, additional lifts of base or pavement shall not be placed over the nonconforming material.

CONSTRUCTION METHODS

405.3-WEATHER RESTRICTIONS:

Surface treatment shall be constructed only when the condition of the base, subbase or existing surface is satisfactory to the Engineer, when the temperature of the material being overlaid is 50° F (10° C) or above, and when other weather conditions are satisfactory for construction. The temperature may be waived but only when approved by the Engineer. No surface treatment shall be performed between October 1 and May 1.

Surface treatment operations shall be suspended immediately when rain begins or when the project engineer determines that a rain event is imminent.

405.4-EQUIPMENT:

Equipment shall include equipment for heating bituminous material, a self-powered bituminous material pressure distributor, an aggregate spreader, and compaction equipment. Equipment shall also include scrapers, hand brooms, shovels, and other items as may be necessary to thoroughly clean the base or surface.

Equipment for heating bituminous material shall consist of a retort coil so designed that steam will not be introduced into the material and shall not degradate the emulsion.

The distributor shall be so designed, equipped, maintained and operated that bituminous material at even heat may be applied uniformly on variable widths of surface up to 15 ft. (4.6 m) at readily determined and controlled rates from 0.05 to 2.0 gal. per sq. yd (0.22 to 9.3 liters m²) with uniform pressure and with an allowable variation from any specified rate not to exceed 0.02 gal. per sq. yd (0.09 liter m²). The distributor shall also have a cab-metering system, which will automatically adjust the flow of the bituminous material as the speed of the truck changes and allow the operator to adjust the rate of application from the cab of the truck.

Distributor equipment shall include a tachometer, pressure gages, and accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically. A manifold connection shall be provided and hand spraying equipment shall be available to cover areas and patches inaccessible to the distributor.

The spreader for cover grades of coarse aggregates shall be self-propelled. It shall be a mechanical revolving cylinder type or mechanical roller hopper spreader that can be so adjusted

to spread accurately the required amounts of materials per square yard. The spreader for other grades of coarse aggregate shall be a self-propelled mechanical stone spreader capable of laying a uniform surface.

Compaction equipment shall be a pneumatic-tired roller conforming to the requirements of Section 401.9.10.

405.5-PREPARING AND REPAIRING EXISTING SURFACE:

This operation shall be performed as prescribed in 401.

405.6-CLEANING AND SWEEPING:

Immediately before starting construction, the existing surface shall be swept and thoroughly cleaned by the use of tools or machinery as may be required to remove all mud, dirt, dust, and other caked or loose material foreign to the type of surface to be placed. Cleaning shall be done to a minimum width of one foot on each side beyond the width of the surface to be placed excluding the shoulder.

When the new surface is to be placed on an untreated aggregate surface, the sweeping shall continue until embedded larger aggregate is exposed to a depth of approximately $\frac{1}{4}$ in (6 mm). When the new surface is being compacted and finished, the Contractor shall maintain a neat edge of the surface treatment. Materials collected in the cleaning operation shall be removed and disposed of as directed.

405.7-APPLICATION OF BITUMINOUS MATERIAL:

This operation shall be performed as prescribed in 401, except as modified. The bituminous material shall be applied to the prepared surface at the rate specified in 405.12.

Except when required to maintain traffic, surface treatment operations shall be done upon the full width of the section.

Only Type-C or Type-D surface treatment shall be used on new bases.

405.8-APPLICATION OF AGGREGATE:

Immediately following each application of bituminous material, aggregate at the rate or rates called for in 405.12 shall be spread with the spreader in such a manner that the entire area being treated is uniformly covered. Equipment shall be operated so that bituminous material will be covered with aggregate before equipment passes over the area that was tacked with bituminous material. Additional aggregate shall be spread if necessary, and hand spreading shall be done to cover areas inaccessible to the spreading equipment. When directed by the Engineer, the aggregate shall be dried or moistened as required in order to obtain a near Surface Saturated Dry condition.

405.9-BROOMING AND ROLLING:

Immediately following spreading of each layer of aggregate, the entire surface of the aggregate shall be rolled until the aggregate is keyed into the bitumen. Any area that tends to ravel shall be repaired and rerolled. Rolling shall be parallel to the centerline and shall begin at the edges of the treatment and progress toward the center; on superelevated curves, rolling shall begin at the low edge of the curve and continue the entire width of the treatment, each trip uniformly overlapping the preceding trip.

Rolling shall cease before the aggregate is crushed to any appreciable extent. Rollers shall be the type and weight specified in 405.4. The number of rollers shall be sufficient to obtain

compaction to the satisfaction of the Engineer. Water, to prevent adhesion of the bituminous material to the roller wheels, shall not be used in excessive amounts. The use of fuel oil, paraffin oil, and kerosene on rollers or other equipment, for the purpose of preventing material from picking up or sticking, is prohibited.

405.10-JOINTS:

The longitudinal construction joints between adjacent lanes shall be kept clean of material foreign to the type of surface being treated. The joints shall be constructed without overlaps or gaps between the materials.

The transverse joint at the end of successive sections or lanes shall be covered with paper to prevent overlapping of the bituminous material. Following its use, the paper shall be removed and disposed of satisfactorily.

405.11-PROTECTION OF PAVEMENT AND TRAFFIC CONTROL:

The Contractor shall be responsible for the protection of the surface against damage by their equipment and personnel. Traffic shall not be permitted on any part of the work under construction until the treatment has cured sufficiently to prevent raveling or pickup under traffic. The applicable provisions of 636 shall apply for regulating traffic.

405.12-SEQUENCE OF OPERATIONS AND QUANTITIES OF MATERIALS:

The quantities and kinds of materials to be used and the sequence of applications and operations for the various treatments shall be as follows. The quantities shown are the rates per square yard (meter).

Maximum quantities of bituminous material shall be used only when the old surface is open or porous. For blast furnace slag aggregate, 91 percent of the aggregate quantities shown shall be used and the quantity of bituminous material shall be increased to a maximum of 10 percent.

The rates of aggregate and bituminous material may be adjusted by the engineer. When in the opinion of the engineer adequate coverage is not being obtained.

405.12.1-Type A-Light Seal:

- i. Clean and sweep.
- ii. Apply 0.15 to 0.25 gal. (0.7 to 0.9 liters) of bituminous material.
- iii. Spread immediately 8 to 10 lb. (4.4 to 5.5 kg) of #9 aggregate.
- iv. Roll immediately.

405.12.2-Type B-Single Surface Treatment:

- i. Clean and sweep.
- ii. Apply 0.25 to 0.40 gal. (0.9 to 1.6 liters) of bituminous material.
- iii. Spread immediately 15 to 25 lb. (8.3 to 13.5 kg) of #8 aggregate (#9 aggregate if directed by the Engineer).
- iv. Roll immediately.

405.12.3-Type C-Double Surface Treatment:

- i. Clean and sweep.
- ii. Apply 0.25 to 0.40 gal. (0.9 to 1.6 liters) of bituminous material.

- iii. Spread immediately 25 to 35 lb. (13.5 to 19 kg) of #8 aggregate (#57 or #67 aggregate if directed by the Engineer).
- iv. Roll tightly.
- v. Apply 0.25 to 0.35 gal. (0.9 to 1.5 liters) of bituminous material.
- vi. Spread immediately 10 to 20 lb. (5.5 to 11 kg) of #8 aggregate (#9, #57 or #67 aggregate if directed by the Engineer).
- vii. Alternately roll.

405.12.4-Type D-Triple Surface Treatment:

- i. Clean and sweep.
- ii. Apply 0.30 to 0.50 gal. (1.0 to 1.8 liters) of bituminous material.
- iii. Spread immediately 25 to 45 lb. (13.5 to 20.4 kg) of #8 aggregate (#57 or #67 aggregate if directed by the Engineer).
- iv. Roll tightly.
- v. Apply 0.30 to 0.50 gal. (1.0 to 1.8 liters) of bituminous material.
- vi. Spread immediately 25 to 35 lb. (13.5 to 19 kg) of #8 aggregate (#57 or #67 aggregate if directed by the Engineer).
- vii. Roll tightly.
- viii. Apply 0.25 to 0.35 gal. (0.9 to 1.5 liters) of bituminous material.
- ix. Spread immediately 10 to 20 lb. (5.5 to 11 kg) of #8 aggregate (#9 or #57 aggregate if directed by the Engineer).
- x. Alternately roll.

405.13-METHOD OF MEASUREMENT:

No materials shall be removed from the Project for any purpose until the operation has been completed and the quantities of materials incorporated into the operations have been determined, except when authorized by the Engineer.

The quantities of work done will be measured as follows:

The quantity of "Surface Treatment Aggregate" & "Patching & Leveling Aggregate" shall be measured by the ton (megagram) of material complete in place and accepted.

The number of tons (megagrams) of "Surface Treatment Aggregate" & "Patching & Leveling Aggregate" shall be determined by the total of the weights shown on receipted railroad freight bills with materials are shipped by rail; by actual measured displacement of barges certified by the producer when water shipments are made, providing materials delivered by the methods are not stockpiled or stored; or determined by the Contractor from the total and weigh slips for each vehicle load weighed on an approved standard scale or from digital printout slips from an automatic batching plant, and certified by the Contractor to be correct.

Truck scales shall be provided by the producer or Contractor, except that truck scales are not required where the material is weighed at properly calibrated automatic batching plant facilities which are equipped with digital print-out equipment. The scales shall be of sufficient size and capacity to weigh the heaviest loaded trucks that are used for delivery of the material.

All truck scales shall be mounted on solid foundations which will insure their remaining plumb and level. All truck scales shall be inspected and sealed by the West Virginia Division of Labor, Bureau of Weights and Measures, or other appropriate agencies of the State or its political subdivisions. The Division may, at its option, accept inspection and sealing by out of state agencies when the material is weighed outside West Virginia.

A weigh person shall be provided by the producer. The weigh person shall certify that the weight of the material, as determined either by the truck scales or from the digital printout of the weights, is correct.

Each truck shall be weighed empty prior to each load, except at automatic batch plants approved to operate without truck scales.

A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification and project number. Provision shall be made for constant zero compensation and further provision shall be made so that the scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest. In case of a breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

The weight of all surface moisture in the aggregate will be deducted from the pay quantity.

The quantity of "Bituminous Material" shall be the number of gallons (liters) incorporated into the completed work, which volume will be measured as prescribed in 109.1.

Where a surface treatment is placed upon a base constructed as an item in the same contract, the conditioning and cleaning and sweeping of the base shall be considered as a part of the construction of the base and no additional compensation will be allowed for "Cleaning and Sweeping".

The Quantity of "Surface Treatment" when specified to be paid by the square yard shall be measured by the total length of the area the surface treatment is applied times the average applied width of the treated area.

When items for maintaining traffic are included in the Contract, they will be measured and paid as provided in 636.

405.14-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

The Quantity of "Surface Treatment" when specified to be paid by the square yard shall include the cleaning and sweeping, aggregate and all labor and equipment required to perform the operation

405.15-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
405001-*	Surface Treatment Aggregate, **	Ton (Megagram)
405002-*	Patching And Leveling Aggregate, **	Ton (Megagram)
405003-*	Asphalt Material	Gallon (Liter)
405004-*	Cleaning And Sweeping	Square Yards (Meters)
405005-*	Surface Treatment, Type "type"	Square Yards (Meters)

* Sequence number

** Type of Aggregate

"type" from section 405.12

SECTION 406 THROUGH SECTION 407-BLANK

SECTION 408 TACK COAT

408.1-DESCRIPTION:

This work shall consist of preparing and treating an existing hot-mix asphalt or concrete surface with asphalt material in accordance with these Specifications and in reasonably close conformity with the lines shown on the Plans or established by the Engineer.

408.2-MATERIALS:

Materials shall conform to the requirements of the following Subsection of Division 700:

MATERIALS	SUBSECTION	TYPE
Asphalt Emulsion	705.4	SS or RS Grades
Cationic Emulsified Asphalt	705.11	CSS or CRS Grades

408.2.1-Quality Control: Quality control is the responsibility of the Contractor as specified in 106.1.

Quality control shall consist of calibrating the distributor to the proper application rate, verifying the volume and temperature measuring devices, and when performed, assuring that the proper dilution rate is maintained.

408.2.1.1-Acceptance Testing: Approval of asphalt emulsions used for tack coat material will be handled by the Materials Control, Soils and Testing (MCS&T) Division. MCS&T maintains a list of all approved asphalt emulsion sources and grades. The local District Materials Section can provide a copy of the latest list. The list is also posted on the MCS&T web page under the heading Approved Source/Product Listing. The use of non-approved material without prior testing by MCS&T may result in nonpayment of the item.

CONSTRUCTION METHODS

408.3-WEATHER RESTRICTION:

Tack coat shall be applied only when the weather and existing surface are satisfactory to the Engineer and when the temperature of the surface is 40°F (4°C) or above. When the surface temperature is less than 50°F (10°C), care must be exercised to assure that the tack coat “breaks”
(Note 1) prior to the application of the hot-mix asphalt.

Note 1: Tack coat “break” is the process in which water separates from the asphalt emulsion and the color of the tack coat begins to change from brown to black. The time required for breaking will depend on the type and grade of the emulsion, the application rate, the temperature of the existing pavement surface, and environmental conditions. Tack coat “set” refers to the final stage of the process when water has completely evaporated from the emulsion leaving a thin film of asphalt binder on the pavement. The rate of set depends on the same conditions that control the rate of break of the emulsion.

408.4-EQUIPMENT:

Equipment shall include a power broom and power blower, a broom drag, equipment for heating asphalt material, and a self-powered asphalt material pressure distributor. Equipment shall also include scrapers, hand brooms, shovels, and other equipment as may be necessary to thoroughly clean the base or surface. Equipment for heating asphalt material to the required temperature shall consist of a retort coil so designed that steam will not be introduced into the material and shall not degrade the emulsion.

The distributor shall be so designed, equipped, maintained and operated that asphalt material at even heat may be applied uniformly on variable widths of surface up to 15 ft. (4.6 m) at readily determined and controlled rates from 0.05 to 2.0 gal/sy (0.2 to 0.9 liters/m²) with uniform pressure and with an allowable variation from any specified rate not to exceed 0.02 gal/sy (0.09 liter/m²). The distributor shall also have a cab-metering system that will automatically adjust the flow of the asphalt material as the speed of the truck changes and allow the operator to adjust the rate of application from the cab of the truck.

Distributor equipment shall include a tachometer, pressure gages, and accurate volume measuring devices or a calibrated tank, and a thermometer for measuring temperatures of tank contents. Distributors shall be equipped with a power unit for the pump, and full circulation spray bars adjustable laterally and vertically. A manifold connection shall be provided and hand-spraying equipment shall be available to cover areas and patches inaccessible to the distributor.

408.5-PREPARING AND REPAIRING BASE OR EXISTING SURFACES:

No tack coat shall be applied until breaks, holes, depressions, and other irregularities in the base or existing surface have been repaired and cured sufficiently to permit the tack coat to be placed in a uniform application.

Patching and leveling material shall be plant mixed. Hand patching will be permitted where necessary.

408.6-CLEANING AND SWEEPING:

Immediately before starting construction, the existing surface shall be swept and thoroughly cleaned by the use of tools or machinery as may be required to remove all mud, dirt, dust, and other caked or loose material foreign to the type of surface to be placed. Cleaning shall be done to a minimum width of one foot on each side beyond the width of the surface to be placed excluding the shoulder.

408.7-APPLICATION OF ASPHALT MATERIAL:

Except when required to maintain traffic, the work shall be done on the full width of the section.

After the base or surface has been cleaned, when called for, and is in a dry condition, the asphalt material shall be applied by means of a pressure distributor. The spray bar shall be raised to a sufficient height so as to uniformly and completely coat the entire surface. The rate of application of asphalt material shall be as recommended in 408.11, or as determined by the Engineer. Application temperatures of the asphalt material shall be within the range specified in Subsection 705 for the particular material being used. With the exception of SS and CSS grades, all emulsion grades used for tack coat shall be applied without dilution. Anionic asphalt emulsion grades SS-1 and SS-1h, and cationic emulsion grades CSS-1 and CSS-1h, may be diluted at a 1:1 ratio by addition water to the emulsion.

The tack coat shall not precede the placement of the subsequent HMA course to such an extent that the treated surface will be damaged during the interim. No patching and leveling or surface courses of any type shall be applied to the tacked surface until the asphalt material is thoroughly “set” (see Note 1 in Section 408.3). Tack coat shall not be applied over newly placed patching and leveling courses. However, to facilitate construction, minor (spot) areas that have been tacked, patched and leveled may be retacked and the quantity so used will be included for payment as part of the normal tack coat operation. The intent of the two preceding sentences, in conjunction with the next to the last paragraph of 401.13, is (1) to provide one tack coat application on the existing surface, although two applications, one over one under, for minor (spot) patching and leveling area, are permitted as indicated above, and (2) to limit payment for such operations to one application of the tack coat upon the existing surface for the entire project.

The surfaces of sidewalks, curbs, other structures, and trees adjacent to the area being treated shall be protected in such a manner as to prevent their being spattered or marred. Material used for such protection shall be removed and disposed of in a satisfactory manner. The distributor shall not be cleaned or discharged within the right-of-way, into borrow pits, or so as to pollute or block water courses.

408.8-APPLICATION OF COVER AGGREGATE:

Any tack coat material applied in excess of the requirements shall be removed or covered with a blotter course of dry sand or stone chips as directed by the Engineer.

408.9-JOINTS:

Longitudinal joints shall be treated using an application rate that will thoroughly coat the vertical face without excessive runoff

408.10-PROTECTION OF THE PAVEMENT AND TRAFFIC CONTROL:

The Contractor shall be responsible for the protection of the surface against damage by their equipment and personnel. Traffic shall not be permitted on any part of the work under construction until the treatment has cured sufficiently to prevent raveling or picking up under traffic. The applicable provisions of 636 shall apply for regulating traffic.

408.11-QUANTITIES OF MATERIALS:

The application rates referenced in Table 408.11 shall be used as guide to assure the proper amount of asphalt is distributed over the pavement surface under various pavement conditions. The undiluted application rate refers to the unmodified emulsion that meets all standard specifications of the specified grade. When an SS or CSS grade emulsion is diluted with water at the allowable 1:1 ratio the residual asphalt content (the amount of asphalt remaining on the pavement surface after all water has evaporated from the emulsion) will be cut in half. Therefore the distribution rate must be doubled in order to obtain the same residual asphalt application as the undiluted emulsion.

Unless otherwise specified on the Plans, the recommended application rates for undiluted and diluted asphalt tack coat shall be as specified in Table 408.11. These rates are provided for guidance and may be adjusted as directed by the Engineer to assure a uniform application that covers the entire pavement, and to assure that excessive asphalt does not cause a slippage plane between two pavement courses.

TABLE 408.11

Condition of Existing Pavement	Application Rate (gal/sy) / (L/m ²) (Note 2)	
	Undiluted	Diluted (1:1) (Note 3)
New HMA (Note 4)	0.04 – 0.05 / (0.18 – 0.23)	0.08 – 0.10 / (0.36 – 0.45)
Oxidized HMA	0.07 – 0.10 / (0.32 – 0.45)	0.13 – 0.20 / (0.59 – 0.90)
Milled Surface	0.10 – 0.13 / (0.45 – 0.49)	0.20 – 0.27 / (0.90 – 1.22)
PC Concrete	0.07 – 0.10 / (0.32 – 0.45)	0.13 – 0.20 / (0.59 – 0.90)

Note 2: Application rates are for slow setting emulsions grades (SS and CSS) that contain approximately 60% asphalt material. Rapid setting emulsion grades may contain slightly higher or lower asphalt contents, but can usually be applied within the same application range.

Note 3: Dilution rate only applies to SS and CSS grades.

Note 4: Tack coat is normally not needed over a layer of new HMA that has been placed within the last few days, as long as the underlying new layer has not become dirty under traffic or from windblown dust.

408.12-METHOD OF MEASUREMENT:

No materials shall be removed from the Project for any purpose until the operation has been completed and the quantities of materials incorporated into the operations have been determined, except when authorized by the Engineer.

The quantity of “Asphalt Material” for tack coat shall be the number of gallons (liters), prior to dilution, incorporated into the completed work. Any applicable dilution rates, shall be supplied to the Engineer by the Contractor on the material delivery ticket.

Dry sand or stone chips used as a blotter course due to excessive use of tack coat shall be considered incidental to the work.

When items for maintaining traffic are included in the Contract, they will be measured and paid as provided in Section 636.

408.13-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, included all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

408.14-PAY ITEM:

ITEM	DESCRIPTION	UNIT
408002-*	Asphalt Material	Gallon (Liter)

*Sequence number

SECTION 409-BLANK

SECTION 410 ASPHALT BASE AND WEARING COURSES, PERCENT WITHIN LIMITS (PWL)

410.1-DESCRIPTION:

410.1.1-General: The Contractor shall note that this Section is to be used for Square Yard Paving operations; however the proposal and / or plans may contain 401 and 402 items to be paid and measured by the Ton (TN). Instances where those items occur they shall be constructed and measured in accordance with the applicable sections of the West Virginia Division of Highways Standard Specifications Roads and Bridges, current edition, and the Supplemental Specifications current when the contract is let.

Additionally the following Materials Procedures (MP) for Square Yard Paving may be obtained by contacting the Materials Control, Soil and Testing (MCS&T) Division:

- a. MP 401.02.31 QC & Acceptance
- b. MP 401.07.20 Sampling Loose Asphalt Pavement Mixtures
- c. MP 401.07.21 Sampling Compacted Asphalt
- d. MP 401.07.22 Thickness of Asphalt Concrete Using Cores
- e. MP 401.07.23 Bond Strength
- f. MP 401.07.24 Pavement Macrotexture
- g. MP 401.07.25 Evaluation of Asphalt Pavements
- h. MP 401.13.50 Determination of PWL

410.1.2-PWL Paving Description: This work shall consist of constructing one or more courses of asphalt, mixed mechanically in a plant, composed of aggregate and asphalt material designed in accordance with either the Marshall or Superpave Design System as specified in the contract documents, on a prepared foundation in accordance with these specifications and in reasonable close conformity with the lines, grades, weights or thicknesses, and cross sections shown on the Plans or established by the Engineer.

The unit of measurement for asphalt will be by the ton (megagram), square yard (square meter), or cubic yard (cubic meter).

The work will be accepted in accordance with these Specifications and the applicable requirements of Sections 105, 106, and 109.

410.2-MATERIALS:

The materials shall conform to the following requirements:

MATERIAL	SUBSECTION	PG BINDER GRADE
Coarse Aggregate	703.1 thru 703.3 ^{Note 1 & Note 3} (See MP 401.02.28 for exceptions and additions required for Superpave Items.)	For the top two lifts PG 70-22 ^{Note 2} shall be used on projects specified ≥ 20 million ESALs.
Fine Aggregate	702.3 (See MP 401.02.28 for additions required for Superpave Items)	Any deviation from the above criteria will be specified in contract documents.
Mineral Filler	702.4	
Performance Graded Binders	705.5	Standard grade shall be a PG 64-22.

Note 1 The total shale, coal and other lightweight deleterious material and friable particles shall not exceed 3%.

Note 2 PG 64-22 Binder may be used in asphalt mixtures placed below the top two lifts.

Note 3 When slag is specified in the contract, the coarse aggregate shall be slag which meets the requirements of 703.3, except as amended in this subsection.

CONSTRUCTION METHODS

410.3-GENERAL:

Construction methods to be used in performing the work shall be submitted to the Engineer for review prior to the start of work. This review may require modification of the proposed methods to provide the desired end product. All equipment, tools, machinery, and plant shall be maintained in a satisfactory working condition.

410.4-COMPOSITION OF MIXTURES:

410.4.1-General: The aggregate for use in the designated mixture shall consist of a mixture of aggregate (coarse, fine, reclaimed asphalt pavement (RAP) if desired, or mixture thereof) and mineral filler if required. It shall be the responsibility of the Contractor to determine the percentage of RAP to be used in the mix. The amount and grade of virgin PG Binder to be used in the RAP designs shall be determined in accordance with Materials Procedure (MP) 401.02.24 and MP 401.02.28.

410.4.2-Job Mix Formula: Job Mix Formula (JMF) is the specification for a single mix produced at a single plant. This mix may be specific to a single project or be used on multiple projects if the basic design criteria (design compaction level and PG Binder grade) are the same.

The Contractor shall submit a proposed JMF for each combination of aggregate and asphalt material for each asphalt mixture to be produced. Depending on the design type, the JMF gradations shall be within the tolerances set forth in either Table 410.4.2A or Table 410.4.2B. Marshall mix designs shall be developed in accordance with MP 401.02.22. Superpave mix designs shall be developed in accordance with MP 401.02.28.

Each proposed JMF must be documented on the Division Form T400 or T400SP and the entire JMF package shall be forwarded for review to the District Materials Engineer/Supervisor. After the District reviews the T400/T400SP and JMF package shall then be transmitted to the Materials Control, Soils and Testing Division for final review. If the JMF

requires revision, it will be returned to the designer through the District. The T400/T400SP Form shall contain the following information:

- i. Identification of the source and type of materials used in the design.
- ii. The aggregate blend percentages and the percentage for each sieve fraction of aggregate considered the desirable target for that fraction.
- iii. The percentage of virgin asphalt binder to be blended with RAP and the total asphalt binder representing the optimum asphalt content for the JMF submitted, which is to be considered the desirable target percentage.
- iv. The temperature of the completed mixture at the plant which shall be within $\pm 25^{\circ}$ F ($\pm 14^{\circ}$ C) of the median mix temperature established by the temperature-viscosity chart or as recommended by the asphalt supplier.
- v. The ratio (calculated to the nearest one-tenth percent) of the Fines to Asphalt (FA). For Marshall mixes the ratio is defined as the percentage of aggregate passing the No. 200 (75 μ m) sieve, divided by the percentage of asphalt content calculated at the percentage optimum asphalt content of the design. For Superpave mixes the ratio is defined as the percentage of aggregate passing the 75 μ m (No. 200) sieve, divided by the percentage of effective asphalt content calculated at the percentage optimum asphalt content of the design.

TABLE 410.4.2A
Design Aggregate Gradation Requirements for Marshall Mix Designs

Type of Mix	Base-I	Base-II (Patch & Level)	Wearing IV	Wearing-I (Scratch-I)	Wearing-III (Scratch-III)
Sieve Size	Nominal Maximum Size				
	1 ½ in (37.5 mm)	¾ in (19 mm)	¾ in (19 mm)	3/8 in (9.5 mm)	No. 4 (4.75 mm)
2 in (50 mm)	100	—	—	—	—
1 ½ in (37.5 mm)	90-100	—	—	—	—
1 in (25 mm)	90 max	100	100	—	—
¾ in (19 mm)	—	90-100	90-100	—	—
½ in (12.5 mm)	—	90 max	90 max	100	—
3/8 in (9.5 mm)	—	—	—	85-100	100
No. 4 (4.75 mm)	—	—	47 min	80 max	90-100
No. 8 (2.36 mm)	15-36	20-50	20-50	30-55	90 max
No. 16 (1.18 mm)	—	—	—	—	40-65
No. 30 (600 μ m)	—	—	—	—	—
No. 50 (300 μ m)	—	—	—	—	—
No. 200 (75 μ m)	1-6	2-8	2-8	2-9	3-11

TABLE 410.4.2B
Design Aggregate Gradation Requirements for Superpave Mix Designs

Type of Mix	37.5	25	19 ^{Note 1} (Patch & Level)	12.5	9.5 (Scratch)	4.75 (Scratch)
Standard Sieve Size	Nominal Maximum Size					
	37.5 mm (1 ½ inch)	25 mm (1 inch)	19 mm (¾ inch)	12.5 mm (½ inch)	9.5 mm (⅜ inch)	4.75 (No. 4)
50 mm (2")	100	—	—	—	—	—
37.5 mm (1½")	90-100	100	—	—	—	—
25 mm (1")	90 max	90-100	100	—	—	—
19 mm (¾")	—	90 max	90-100	100	—	—
12.5 mm (½")	—	—	90 max	90-100	100	100
9.5 mm (⅜")	—	—	—	90 max	90-100	95-100
4.75 mm (No.4)	—	—	—	—	90 max	90-100
2.36 mm (No.8)	15-41	19-45	23- 49	28-58	32-67	
1.18 mm (No.16)	—	—	—	—	—	30-60
600 µm (No.30)	—	—	—	—	—	—
300 µm (No. 50)	—	—	—	—	—	—
75 µm (No.200)	0-6	1-7	2-8	2-10	2-10	6-12

Note 1 When a 19 mm mix is specified for use as a heavy duty surface mix, it shall be designed as a fine graded mix with the additional requirement of a minimum of 47% passing the 4.75 mm (No.4) screen.

If it becomes necessary to change aggregate sources, a new mix design shall be developed and submitted for approval. When using neat (unmodified) PG Binders, the binder grade must always remain the same for each design, however the binder source may be changed without requiring a new mix design given that the replacement binder is provided from an approved source. If a source change results in the use of an additive enhanced modified binder of the same grade, a new mix design will be required.

If a modified binder source is changed or if the modification process is changed, a new mix design shall be developed and submitted for approval. A source change to a new location with the original manufacturer/supplier and the original modification process will not require a new mix design.

At no time shall different grades of PG Binders be mixed together in the same storage tank. When it is necessary to switch to a new binder grade the tank shall be drawn down as far as possible, normally to the top of heating coils, before refilling with the new binder. The new binder shall be circulated thoroughly before restarting production.

410.4.2.1-Warm Mix Asphalt: When the Contractor chooses to use an approved asphalt design to be produced as warm-mix asphalt (WMA) using the water injection system, the temperature of the completed mixture at the plant may be lowered to an established range that has previously been determined through trial production. The allowable temperature range specified on the approved T400 mix design form shall be adjusted accordingly when producing WMA. In addition, all references to the minimum compaction temperatures in Sections 410.10.3 and 410.10.4 of this specification, may be waived if it can be established that additional density can be obtained at lower temperatures without damaging the pavement. All testing requirements established for Hot Mix Asphalt mix designs and quality assurance/quality control testing shall also apply to WMA.

410.5-TESTING:

410.5.1-Test Methods:

MP 700.00.06	Aggregate Sampling Procedures
AASHTO T168	Sampling Hot-Mix Asphalt
AASHTO T11	Materials Finer than No. 200 (75 µm) Sieve in Mineral Aggregates by Washing
AASHTO T27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T30	Mechanical Analysis of Extracted Aggregate
AASHTO T164	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
AASHTO T308	Asphalt Content of HMA by the Ignition Method (Test Method A)
AASHTO T245	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D5581	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (For Base-I Marshall designs only)
AASHTO T166	Bulk Specific Gravity of Compacted Bituminous Mixtures
AASHTO T209	Maximum Specific Gravity of Bituminous Paving Mixtures
AASHTO T312	Determining the Density of HMA Specimens by Means of the Superpave Gyratory Compactor
AASHTO T331	Bulk Specific Gravity and Density of Compacted HMA Using Automatic Vacuum Sealing Method
ASTM D7227	Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus
MP 401.02.31	Quality Control and Acceptance of Asphaltic Mixtures
MP 401.07.20	Sampling Loose Asphaltic Mixtures in the Field
MP 401.07.21	Sampling Compacted Asphaltic Mixtures in the Field
MP 401.07.22	Measuring Thickness of Asphalt Pavement using Drilled Cores
MP 401.07.23	Measuring Bond Strength of Cored Specimens
MP 401.07.24	Measuring Asphaltic Pavement Macrotexture
MP 401.07.25	Evaluation of Pavement with Substandard Properties
MP 401.13.50	Determination of Percent Within Limits

410.6-CONTRACTORS QUALITY CONTROL:

410.6.1-Quality Control Testing: Quality control of the asphalt pavement is the responsibility of the Contractor. The Contractor shall maintain equipment and qualified personnel including at least one certified Asphalt Plant Technician at each plant. The technician shall be in charge of all plant quality control activities such as mix proportioning and adjustment and all sampling and testing activities necessary to maintain the various properties of asphalt within the limits of the specification.

The Contractor shall maintain necessary equipment and qualified personnel including at least one certified Asphalt Field and Compaction Technician at each project during paving operations. Additionally, a certified Asphalt Field and Compaction Technician with certification to perform nuclear density testing of asphalt pavements shall perform all testing necessary to assure compaction of the asphalt meets specification requirements. Compaction Technicians may serve as Asphalt Field and Compaction Technicians for asphalt compaction testing until December 31, 2017.

410.6.2-Job Mix Formula Field Verification: For each JMF, a mix design field verification shall be conducted during the first days of plant production. For Marshall and Superpave designs, the verification shall be in accordance with the guidelines established in MP 401.02.31. The field verification is for the purpose of demonstrating that the JMF can be produced within the specified tolerances set forth in the MP 401.02.31. If the mix cannot be produce within these requirements, a new mix design will be required.

410.6.3-Quality Control Testing Requirements: After the JMF design field verification has been successfully completed, sampling frequency and test requirements for quality control shall be as set forth in MP 401.02.31 for Marshall and Superpave designs. If the Division determines that a mix cannot be consistently produced within the tolerance limits of the specified design properties, approval of the mix may be revoked and the contractor will be required to provide a new mix design.

410.7-ACCEPTANCE TESTING:

410.7.1-Acceptance Testing of Asphalt: Material from the paving of the traveled lanes and shoulders will be accepted in the field on a lot by lot basis. Lots will be established cumulatively and will be specific for each JMF. Each lot consists of five equal sublots (n=5). A completed subplot will have cores obtained for Pavement Density, and Bond Strength and a Loose Mixture sample for gradation and asphalt content. Samples for mat density and bond strength shall also be used to measure lift thickness prior to any preparation for density or bond strength. All field samples shall be obtained from locations determined as per MP 401.07.20 and MP 401.07.21.

A normal lot size is 2,500 tons with five, 500 ton sublots (n=5), unless operational conditions or project size dictate otherwise. If operational conditions or project size dictate, readjustment of the lot will be made as specified in Table 410.7.1. Breakdowns or stoppages of short periods due to such causes as weather or equipment failure will not be considered as reason to adjust the lot size. The original lot will be continued when work resumes after stoppages of less than 5 days. If a lot is terminated due to a stoppage of 5 days or more, adjust the lot size and number of sublots as specified in Table 410.7.1.

TABLE 410.7.1

Re-adjustment of Lot Size and Associated Number of Sublots Remaining Quantity Following Last Full Lot	Action
Less than 500 tons without a combination of one mixture acceptance sample and one density core	Quantity combined with the previous lot, (n=5)
Less than 500 tons with a combination of one mixture acceptance sample and one density core	One new subplot defined and quantity combined with the previous lot, (n=6)
500 tons to less than 1,000 tons without a combination of two mixture acceptance samples and two density cores	One new subplot defined and quantity combined with the previous lot, (n=6)
500 tons to less than 1,000 tons with a combination of two mixture acceptance samples and two density cores	Two new sublots defined and quantity combined with the previous lot, (n=7)
1,000 tons to less than 1,500 tons without a combination of three mixture acceptance samples and three density cores	Two new sublots defined and quantity combined with the previous lot, (n=7)
1,000 tons to less than 1,500 tons with a combination of three mixture acceptance samples and three density cores	New lot defined, (n=3)
1,500 tons to less than 2,000 tons without a combination of four mixture acceptance samples and four density cores	New lot defined, (n=3)
1,500 tons to less than 2,000 tons with a combination of four mixture acceptance samples and four density cores	New lot defined, (n=4)
2,000 tons to less than 2,500 tons without a combination of five mixture acceptance samples and five density cores	New lot defined, (n=4)
2,000 tons to less than 2,500 tons with a combination of five mixture acceptance samples and five density cores	New lot defined, (n=5)

Immediately after each sample is taken, it shall be identified by labeling or otherwise with the following information:

- 1) Contract ID
- 2) State Project Number
- 3) Sample Type (density, bond, loose, etc.)
- 4) Pavement Course (surface, base)
- 5) Lot Number
- 6) Sublot Number
- 7) Date
- 8) Sampled By

A sample labeling standard is shown in MP 401.07.20 Sampling of Loose Asphaltic Pavement Mixtures and MP 401.07.21. Upon fully identifying, marking or labeling, and securing, samples shall be transported to the District Materials Laboratory for testing unless otherwise indicated in the proposal.

410.7.1.1-Mixture Acceptance Samples. The Inspector will select sample locations in each subplot according to MP 401.07.20 Sampling of Loose Asphaltic Pavement Mixtures. The Inspector or in the presence of the Inspector, one loose mixture sample shall be obtained for each subplot. This sample is to be taken directly from the uncompacted mixture and immediately processed in accordance with the MP.

410.7.1.2-Compaction: Compaction testing for mat density shall be performed for all traveled lanes, ramps and shoulders. Work will be evaluated based on an Upper Specification Limit (USL) of 97.0 and a Lower Specification Limit (LSL) of 91.5 for all mats within travel lanes. Acceptance of mat density shall be in accordance with 410.13.3.

Maximum density values that are supplied by the asphalt producer shall be verified by the District Materials staff by determining the theoretical maximum specific gravity in accordance with AASHTO T209 Theoretical Maximum Specific Gravity (Gmm). This verification of Gmm shall be conducted once per lot for all mixes, or one in each five reported values from the asphalt producer. This Gmm value must be within 0.024 of the asphalt producer's daily average. Any deviation of greater shall warrant special evaluation.

Joint density testing is required. The joint density shall be evaluated based on a Lower Specification Limit (LSL) of 89% of a maximum density established by averaging the maximum densities for the paved mats adjacent to the constructed longitudinal joint. The joint density requirement shall only apply to the surface lift of the pavement structure. Lots for joint density shall also be established cumulatively and laid out as per the applicable provisions within MP 401.07.21.

A normal lot size for evaluation of joint density is 10,000 linear feet of constructed joint with five, 2000 feet long sublots unless operational conditions or project size dictate otherwise. Lots for joint density determined to be 4000 feet in length or less shall be incorporated into the previous full lot and two samples shall be taken and the lot be evaluated with seven samples (n=7). Lots for joint density that are greater than 4000 feet in length shall have samples taken representative of each 2000 foot long subplot or portion thereof.

Acceptance for joint density shall be as per 410.13.4.

Patching-and-leveling and scratch courses shall not be included in determining the total new pavement thickness to be tested for compaction. When asphalt is placed in areas that require a non-uniform thickness or is tapered to a thin edge, the method of acceptance testing shall be determined by the Engineer. Acceptance testing is not required on areas in which a full-size roller is restricted from compacting the mat properly. These areas shall be compacted to the satisfaction of the Engineer.

410.7.1.3-Shoulders and Ramps: As per MP 401.07.21, shoulders and ramp areas that are constructed simultaneously with the mainline are not included in the sampling plan. However, these simultaneously constructed shoulder and ramp areas shall be included in the lot of the adjacent mainline for the purposes of penalty and bonus calculations for compaction and mixture properties.

Shoulders that are constructed independently of the mainline shall be tested as per MP 401.07.21. However, compaction penalty calculations for these independently constructed shoulders shall not apply.

410.7.1.4-Thickness: Thickness testing shall be performed on all traveled lanes and shoulders.

Cores obtained for mat density and bond strength will both be measured for thickness as per MP 410.07.22 Measurement for Thickness of Asphalt Pavement Using Drilled Cores, prior to those subsequent analyses. The core measurements which represent the thickness of the sampling units shall be analyzed to determine the average value of the pavement thickness. Pavement Thickness (T), shall include all of the pavement layers as specified excluding any patch and level course and scratch courses. This value will be used to determine the degree of compliance with the provisions and to develop certain factors to be used in the derivation of equitable deductions as set forth in Section 410.13.5, in the event the provisions of this Specification are not met.

410.7.1.5-Bond Strength: Bond testing shall be performed on all traveled lanes and shoulders. Additionally, Bond Tests will be performed for all surface layers beginning with the Existing Pavement layer and then all intermediate pavement layers called for in the Proposal and Plans. However if a scratch course is called for in the plans, then a bond test will be performed at the scratch course layer and the first new surface pavement layer, not between the existing pavement layer and the scratch course layer.

Core bond strength shall exceed a minimum of 100 psi when tested in accordance to MP 410.07.23 Guide to Determining Interface Bond Shear Strength. If all samples obtained within a lot exceed the minimum requirement, there will be no adjustment for pay. If any of the specimens result in strength below the required amount, the values shall then be evaluated for payment as per 410.13.50 Guide to Statistical Analysis of Material Using Quality Level Analysis-Percent within Limits. For the purpose of relieving large standard deviations from abnormally strong samples, any sample with a strength exceeding 150 psi will be evaluated as 150 psi instead of the actual strength. The actual strength should still be recorded as such on the reporting form.

410.7.2-Surface Tolerance: Shall be in accordance with Section 720 on the finished mat.

410.7.3-Pattern Segregation: Pattern segregation is continuous or repeated areas of non-uniform distribution of coarse and fine aggregate particles in the finished mat. The Division will address pattern segregation as follows:

410.7.3.1-Evaluating Pattern Segregation: If the Engineer observes pattern segregation that may result in defective pavement, then:

- i. The Inspector will notify the Contractor of the observed pattern segregation.
- ii. The Contractor may continue to work at their own risk while they immediately and continually adjusts the operation to eliminate the pattern segregation from future work.

- iii. As a minimum and in the presence of the Engineer and the Contractor's Representative, Division personnel shall determine the average depth of pavement surface macrotexture according to MP 401.07.24 in areas with the pattern segregation and in areas with non-segregated pavement. The pattern segregation is unacceptable if the difference in average pavement texture depth between the non-segregated and segregated areas exceeds the following:
 - a) For 9.5 mm or Wearing I mixes – 0.012 inch (0.305 mm)
 - b) For 12.5 mm mixes – 0.016 inch (0.406 mm)
- iv. The Engineer will determine if the pavement is defective as specified in Section 410.7.3.3.

410.7.3.2-Test Section: If the macrotexture tests identify unacceptable pattern segregation, then:

- i. Immediately suspend placing the asphalt course. Evaluate the cause of pattern segregation according to the Paving Operation QC Plan. Provide proposed corrective actions to the Engineer and do not resume placing the asphalt course until after the Engineer reviews the proposed corrective actions and authorizes paving to continue.
- ii. Determine if the pattern segregation resulted in defective pavement as specified in Section 410.7.3.3.
- iii. After the Engineer allows paving to resume, place a test section not to exceed 200 tons. If the corrective actions do not eliminate observed pattern segregation, the Department will suspend paving, even if it is before the Contractor places the entire test section. Propose additional corrective actions, and construct another test section. Resume normal paving operations after constructing an entire test section without pattern segregation as determined by the Engineer.

410.7.3.3-Defective Pavement: At locations selected by the Engineer and with the Engineer present, drill three 6-inch diameter cores from the area of pattern segregation and three cores from the pavement representing a non-segregated area. Do not compress, bend, or distort samples during cutting and handling and immediately provide the cores to the Inspector. The Inspector will transport cores to the producer's laboratory. With the Engineer present, test the cores at the plant for density, asphalt content, and gradation. Additional cores and/or additional testing as per MP 401.07.24 Measuring Pavement Macrotexture Depth can be used to further evaluate the pavement.

An area of pattern segregation contains defective pavement if:

- a) the summation of absolute deviations from any two sieves is 20% or more from the JMF
- b) the core density is defective, the mixture is defective in asphalt content
- c) or the mixture is defective for percent passing the 75 μ m (No. 200) sieve.

The core density is defective, or the cores are defective for asphalt content or gradation of the 75 μ m (No. 200) sieve if the PWL is less than 55 as determined in accordance with MP 401.13.50 and based on three samples (n=3). Remove and replace the full width of the affected lane and a minimum of 5 feet beyond each end of the area with unacceptable pattern segregation. Construct replacement pavement conforming to the appropriate surface tolerances.

410.7.4-Flushing: Provide a mix that will not flush. Flushing is continuous or repeated areas of excessive asphalt on the pavement surface. The Division may recognize flushing until the Division approves the project through final inspection. The Division will address flushing as follows:

410.7.4.1-Evaluating Flushing: When the Engineer observes flushing, then:

- i. The Engineer will immediately notify the Contractor of the observed flushing.
- ii. The Contractor may continue work at its own risk while it immediately and continually adjusts the operation to eliminate flushing from future work.
- iii. In the presence of the Engineer, determine the average depth of pavement surface macrotexture according to MP 401.07.24 in areas of suspected flushing. If the average texture depth is less than or equal to 0.006 inches (0.152 mm), then the pavement will be considered to be flushed and is defective.

410.7.4.2-Test Section: If the macrotexture tests identify flushing, then:

- i. Immediately suspend placing the paving course. Evaluate the cause of flushing according to the Paving Operation QC Plan and as directed. Provide proposed corrective actions to the Engineer and do not resume placing the paving course until after the Engineer reviews the proposed corrective actions and authorizes paving to continue.
- ii. Remove and replace the defective wearing course at no cost to the Division for the full width of the affected lane and a minimum of 5 feet beyond each end of the area of defective wearing course. Construct replacement wearing course conforming to the appropriate surface tolerances.
- iii. After the Engineer allows paving to resume, place a test section not to exceed 200TN. If the corrective actions do not eliminate observed flushing, the Division will suspend paving even if it is before the Contractor places the entire test section. Propose additional corrective actions and construct another test section. Resume normal paving operations after constructing an entire test section without flushing as determined by the Engineer.

410.8-BLANK

410.9-EQUIPMENT:

410.9.1-Plants: All plants shall meet the general requirements set forth in AASHTO M156 unless it can be demonstrated to the satisfaction of the Engineer that a consistent quality mix can be produced with modifications to any of these requirements.

All plants in West Virginia producing asphalt for the Division shall provide documented evidence of compliance with current requirements of the West Virginia Air Pollution Control Commission.

All plants which are not in West Virginia but producing asphalt for the West Virginia Division of Highways shall provide documented evidence of compliance with current requirements of the laws and regulations of the State in which they are producing, applicable to air pollution.

410.9.2-Dust Collector: An efficient dust collecting system shall be provided to prevent the loss of fine material. The material collected may be returned to the mixture at a uniform rate or discarded.

410.9.3-Truck Scales: Truck scales shall be provided at each Plant, except that truck scales are not required at properly calibrated automatic batching plant facilities which are equipped with digital printout equipment, and which load the trucks directly from the mixer or the weigh hopper in a surge or storage silo.

A person designated as a weigher shall be provided by the producer. The weigher shall certify that the weight of the asphalt, as determined either by the truck scales or from the digital printout of the batch weights, is correct.

Each truck shall be weighed empty prior to each load, except at automatic batch plants approved to operate without truck scales.

All truck scales shall be mounted on solid foundations which will insure them remaining plumb and level.

Approval and sealing of scales shall be conducted at the frequency determined by the West Virginia Division of Labor, Bureau of Weights and Measures, and when the plant is moved, or upon the request of the Engineer. The Engineer shall be notified of any scale malfunctions when material is being furnished to Division of Highways projects. The Division may, at its option, accept inspection and sealing by out-of-state agencies when the mixing plant is located outside West Virginia.

A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification, and project number. Provision shall be made for constant zero compensation and further provision shall be made so that the scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest. In case of breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

The scales shall be of sufficient size and capacity to weigh the loaded trucks that are used for delivery of asphalt from the plant.

410.9.4-Test Weights: As part of its standard equipment, each plant which proportions aggregate by weight shall provide a minimum of ten 50-pound (22.68 kg) test weights for the purpose of verifying the continued accuracy of its weighing equipment.

Plants which proportion asphalt material by weight shall furnish, in addition to the above, one five pound (2.268 kg) test weight.

410.9.5-Surge and Storage Silos: During the normal daily operation of the plant, asphalt may be stored in a surge or storage silo for a maximum of 12 hours, provided the silo has received prior evaluation and acceptance through the District plant inspection. The resulting temperature of the material at time of placement and compaction shall be sufficient to comply with 410.10.3 and 410.10.4

Longer silo storage times, up to 24 hours, may be permitted for dense graded asphalt if the storage silo is insulated and/or heated to assure that the proper mix temperature is maintained. The gates at the bottom of the storage silo shall be adequately heated and sealed when the asphalt is held for the extended period of time. When asphalt is stored for the extended time

period, it shall not be used until the temperature has been checked and the asphalt has been visually inspected for hardening of the mix and stripping of the asphalt from the aggregate. Approval of the extended storage time may be revoked if it is determined through inspection and/or testing that the extended storage is having a detrimental effect on the asphalt.

410.9.6-Inspection of Equipment and Plant Operations: The Engineer shall have access to the plant to assure the adequacy of the equipment in use, to inspect the conditions and operation of the plant, to verify weights, to verify the proportion and character of materials, and to determine if specified temperatures are being maintained in the preparation of the mixture.

410.9.7-Trucks for Transporting Mixture: The use of diesel fuel, kerosene, or similar solvent-based products which can dissolve the asphalt film from the aggregate particles will not be permitted for use as a release agent. Any commercial release agent which is certified as harmless to the mix may be used; however, the Division reserves the right to restrict any release agent that is shown to cause problems during placement of the mix. All excess release agent shall be removed from the truck bed prior to loading the asphalt.

All truck beds shall be insulated with approved material. No trucks shall be used which cause segregation of the materials, which show large oil leaks, or which cause undue delays in delivery of material. All trucks shall be provided with a waterproof cover and a hole in the body for the purpose of conveniently checking the temperature of the load. Covers shall be suspended slightly above the mixture, shall extend over the sides of the truck, and shall be securely fastened to eliminate air infiltration and to prevent water from coming in contact with the mixture.

410.9.8-Laboratory: A testing facility or laboratory, as described below, shall be provided within reasonable proximity of the asphalt plant. Plant operations must be visible from within the laboratory.

The laboratory shall be of sufficient size to hold all laboratory test equipment and supplies with adequate floor space to allow the technicians to test samples in an efficient manner. The laboratory shall be furnished and maintained with adequate ventilation, heat, light, water, sink and drainage, electrical or gas outlets, or both, work table, shelves, and supply cabinets.

The laboratory shall be supplied with the equipment and materials listed below and these shall be maintained to meet the applicable requirements of AASHTO or ASTM:

- i. Hot plate, gas or electric.
- ii. Large ovens (as needed for heating and drying samples), gas or electric.
- iii. Unit weight container, $\frac{1}{2}$ cubic foot (0.014 cubic meter). Required for slag only.
- iv. Balances of sufficient capacity and accuracy for conducting specified tests and plant calibration.
- v. Thermometers: dial type, liquid-in-glass, and digital as required for conducting standard test procedures and monitoring mix temperatures. Digital thermometers shall be equipped with an appropriate sturdy probe that can be pushed into a sample of hot asphalt to check the temperature of the mix.
- vi. Ro-Tap Sieve shaker or equivalent, with 8 and/or 12 inch (200 and/or 300 mm) diameter screens.
- vii. Sample splitters for fine and coarse aggregates.

- viii. Miscellaneous items (including sample splitting trowels, scoops, square point shovel, aggregate sample pans, heat resistant gloves, measuring rules, brushes, flashlight, timing devices, and glassware as needed).
- ix. Expendable supplies necessary for performance of tests.
- x. Equipment for determining the maximum specific gravity of asphalt mixtures as specified in AASHTO T209.
- xi. Non-contact infrared thermometer accurate to $\pm 2^{\circ}\text{ F}$ ($\pm 1^{\circ}\text{ C}$).
- xii. Equipment for determining the bulk specific gravity of asphalt mixtures using saturated surface dry specimens complying with AASHTO T166.
- xiii. Marshall equipment necessary to comply with AASHTO T245 and ASTM D5581, including a calibrated automatic testing apparatus having recording capabilities and compaction hammers. (Marshall designs only)
- xiv. Asphalt content ignition oven with built-in scale and printer meeting the requirements of AASHTO T308, Test Method A.
- xv. Calibrated Gyratory compactor meeting requirement of AASHTO T312 with computer (including software for data acquisition and test calculations) and printer. Compactor must be calibrated to the internal angle in accordance with AASHTO TP71 with annual verification (Superpave designs only).

410.9.9-Asphalt Paving Equipment: Asphalt paving equipment shall be self-contained and of sufficient size, power and stability to receive, distribute and strike-off the asphalt mixture at rates and widths commensurate with the typical sections and other details shown on the plans. The paver shall be provided with an activated screed or strike-off assembly equipped to be heated. Approval of the paver by the Engineer will be based on the demonstrated capability of the equipment to place the mixture to the required cross-section, profile and alignment in an acceptable, finished condition ready for compaction.

The paver shall be equipped with means of preventing the segregation of the coarse aggregate particles when moving the mixture from the paver hopper to the paver augers. It shall also be capable of pushing a sufficient amount of the mixture under the auger gearbox to prevent streaking or tearing of the mat. Some paver models may require the installation of a manufacturer retrofit kit or equipment modification to accomplish this.

Specialized equipment or hand methods approved by the Engineer may be employed to spread the asphalt mixture where the use of standard full scale paver is impractical due to the size or irregularity of the area to be paved.

Pavers shall be equipped with mechanical or automatic grade and slope controls. The use of automatic grade and slope controls with a traveling straight edge shall be required only when specified on the Plans or in the Proposal. Both the grade and slope controls shall be in working order at all times. In the event of failure of the automatic controls, the Contractor will be permitted to finish the day's work using manual controls but will not be allowed to resume work the following day until the grade and slope controls are in proper working order.

410.9.10-Compaction Equipment: Compaction may be performed by self-propelled steel-wheeled, pneumatic-tired and/or vibratory rollers. Hand-held rollers or vibrating plates may be used in small inaccessible areas if approved by the Engineer. Prior to use on any project, the roller shall be inspected to see that it is in good mechanical condition. The total weight, weight per inch of width (steel-wheeled), and average ground contact pressure (pneumatic-tired) shall be documented.

410.10-PAVING OPERATIONS:

410.10.1-Spreading and Finishing: Before spreading any material, the contact surfaces of curbs, gutters, manholes, and of adjacent Portland cement concrete pavement edges shall be painted or sealed with asphalt material. Exact edge of pavement, except on concrete, shall be established by a string or chalk line for a distance of not less than 500 feet ahead of the spreading operation. For projects where the existing pavement was milled prior to the placement of new asphalt, the edge of pavement shall be the edge of milled section.

For mixes produced with neat (non-modified) asphalts (which may include PG 70-22, PG 64-22, PG 64-28, and PG 58-28) the temperature of the mixture at the time of placement shall be within the temperature requirements of the JMF. The JMF temperature range shall be the liquid asphalt supplier's specified mixing temperature $\pm 45^{\circ}\text{F}$ ($\pm 25^{\circ}\text{C}$) with a maximum mixing temperature of 338°F (170°C). Additional allowances will be made for water injection processes with a minimum mixing temperature of 220°F (105°C).

The mix temperature shall be monitored by inserting a thermometer into the mix through the hole in the truck bed.

The temperature of the completed mix, when measured at the plant, shall be within the tolerance as established by the JMF. The first load which demonstrates temperatures outside of that range shall be accepted, provided that the temperature is still within the master temperature range. No additional loads of material shall be run out until necessary steps are taken to reestablish the temperature of the mix within the plant tolerance. When measured at the project site, the temperature of the mix shall be within the tolerance established by the JMF. The first truck load of material which demonstrates temperatures outside of that range or any trucks in transit at that time shall be accepted provided temperatures are within the master temperature range. Any truckload of material which exceeds the master temperature range may be rejected by the Engineer. However, the plant shall immediately be notified that no additional loads of material are to be dispatched until necessary action is taken to reestablish temperature within JMF specification limits.

When the surface temperature falls to within 10°F (6°C) of the weather restrictions of Table 410.8, the mix temperature may be increased up to a maximum of 338°F (170°C) unless otherwise specified by the asphalt supplier. The temperature of each truckload of material shall be monitored for compliance. Any truckload of material which exceeds this maximum temperature may be rejected by the Engineer.

Mixes produced with asphalts that contain modifiers for high or low temperature performance enhancement shall meet the temperature requirements recommended by the asphalt supplier, as determined using the mid-point of the mixing temperature range shown on the asphalt temperature-viscosity charts and allowing for $\pm 25^{\circ}\text{F}$ (14°C).

410.11-PROTECTION OF PAVEMENT AND TRAFFIC CONTROL:

The Contractor shall be responsible for the protection of asphalt surfaces from damage by their equipment and personnel. When the construction of asphalt surfaces is undertaken on projects under public traffic and the road surface is 16 feet wide or greater and the ADT is 400 or greater, the Contractor shall place no passing signs, Interim pavement markings, and Temporary pavement markings to delineate the edge line, centerline, and/or lane line of the roadway as required herein and in the project plans. The provision of Section 336: Maintaining Traffic shall apply.

Interim markings are described as markings applied to freshly resurfaced roadways between lifts and after placement of the final lift prior to opening the portion of the roadway being resurfaced to traffic. These markings are intended to provide the minimum amount of delineation required for safe navigation of the roadway, and are to be succeeded by Temporary markings within a three (3) to fourteen (14) day period, based on the type of roadway and AADT, as specified herein. Interim and Temporary markings shall conform to the requirements of Section 663: Pavement Markings.

410.12-METHOD OF MEASUREMENT:

Asphalt will be measured by the Square Yard (SY). The quantity will be determined by the Plan Quantity as provided for in the proposal unless otherwise directed by the Engineer.

Any patching or leveling mixture placed on a subbase or base course constructed in the same Contract with the asphalt items shall be at the expense of the Contractor. No additional compensation will be allowed for the material or any work incidental to its placement unless otherwise approved by the Engineer.

410.13-BASIS OF PAYMENT:

The quantities determine as provided above, will be paid for at the contract unit price for the items listed below, which prices and payment shall be full compensation for furnishing all the materials and doing all the work herein prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, field laboratory, supplies, tack coat, and incidentals necessary to complete the work and provide the performance criteria specified.

There will be no additional compensation for Interim Pavement Markings.

410.13.1-When a Lot of asphalt material is found not in compliance with the tolerance requirements for asphalt content and gradation as shown in MP 401.02.31, it shall be subject to a price adjustment in accordance with the criteria for Determination of Percent Within Limits established in MP 401.13.50 and pay factors in Table 410.13.3.1.

410.13.2-BLANK

410.13.3-The unit price for each Lot of asphalt pavement Mat shall be adjusted as follows in Table 410.13.3.1 in accordance with MP 401.13.50.

TABLE 410.13.3.1

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96-100 ^{Note 1}	102 ^{Note 1}
90-95	100
75-89	[(0.5)PWL]+55
55-74 ^{Note 2}	[(1.4)PWL]-12

Note 1 Payment of 102% for mat density shall be subject to additional requirement of the average compaction for the lot being evaluated to be a minimum of 93% density.

Note 2 Material with a PWL less than 55 is considered defective, and will be considered for removal and replacement of the lot. If only one lot characteristic has a percent within limits less than 55, the Engineer, may allow the Contractor to leave the defective lot in place. The decision to remove and replace the subject lot shall include evaluation of all lot characteristics for pay and surface characteristics as per guidelines set forth in MP 401.07.25. If the material is left in place, the Department will pay for the defective lot at a value not to exceed 50% of the contract unit price of asphalt per square yard. (ie Contract unit price = \$10 sy → \$5 sy max)

410.13.3.1-Price Adjustment: The Division will compute the percent of the contract unit price paid as follows:

$$\text{Lot Payment} = \text{CP} (2\text{PD} + \text{PB} + \text{PA}) / 400$$

Where:

CP = Contract unit price per lot (unit price times lot quantity)

PD = Payment Factor Percentage for mat density

PB = Payment Factor Percentage for asphalt content.

PA = Payment Factor Percentage for percent passing the 75 µm (No. 200) sieve

Shoulders and ramps shall be included in penalty calculations for mixture and compaction, unless they are constructed independently where the density requirements shall be waived. When compaction requirements are waived, PD will be minimum of 100.

410.13.4-Joint Density Adjustments: Joint Density PWL calculations shall be in accordance with MP 401.13.50. Joint Density bonus adjustments will be calculated for joint lots with a PWL greater than or equal to 80. Joint Density negative adjustments will be calculated for joint list with a PWL less than or equal to 60. Price adjustments shall be calculated using the formulas below. There will be no adjustment for joint lots who's PWL falls between 60 and 80.

Bonus adjustment calculated as follows:

$$\$T = \frac{\text{PWL}-80}{20} \times 4,000$$

Negative adjustment calculated as follows:

$$\$T = \frac{60-\text{PWL}}{60} \times 12,500$$

Adjustments calculated for lots less than or greater than 10,000 feet in length shall be prorated directly proportional to the amount of length less than or greater than 10,000 feet.

410.13.5-Thickness Adjustments: No payment will be made for pavement areas deficient in thickness by more than 35% T.

Pavement which is deficient in thickness by more than 50% T is considered to be inadequate to perform satisfactorily and shall be removed and replaced at no added cost to the Division.

The balance of the item, the portion of the item not treated in the manner set forth above, will be treated in the manner set forth in 410.13.5.1 below.

410.13.5.1- Price Adjustments for Thickness - When all individual measurements meet or exceed the specified thickness, there will be no adjustment for payment. If any individual values or when the average value of the pavement thickness per lot is less than the specified total thickness, the quantity of pavement represented by this average thickness will be paid by a direct calculation as defined as follows:

$$\text{Price Adjustment \%} = \left(\frac{t}{T} \right) \times 100$$

Where:

T = Total Plan Thickness

t = avg. lot thickness + 0.04 in.

This value is then applied to the unit price for the asphalt place in the lot, this adjustment shall remain separate from the PWL adjustments for AC, Gradation, Density, etc.

410.13.6-Bond Strength:

410.13.6.1-Tack Coats: Any tack coats applied by the contractor shall be applied in accordance with section 408. It is the intent of the Sections 410.13.6, 410.13.6.1 and Section 408.7 to provide one tack coat application on the existing surface including any milled surfaces.

However, any new intermediate asphalt layers installed shall receive an additional tack coat when such layers have been used for maintaining traffic for two or more weeks prior to placement of any final or intermediate layers. If the contractor chooses not to tack any intermediate layers as described above, then the Bond Strength Pay adjustment factor described in section 410.13.6.2 shall apply.

410.13.6.2-Bond Strength Calculations: If no tack coat is applied in accordance with Section 408, then the following price adjustment will be applied for Bond Strength.

When a lot of Asphalt does not meet the Bond Strength requirements as specified in Section 410.7.1.4, the price shall be adjusted as follows:

Negative adjustment calculated as follows:

$$\$T = \frac{70 - \text{PWL}}{70} \times 40,000$$

410.13.7-Lot Payment Calculations: The pay factors that are calculated with in the specification are to be applied in the following way:

410.13.7.1-PWL Factors: The calculated total PWL for a given lot is applied to the bid unit price for the asphalt mixture in the lot. Once the unit price has been adjusted the quantities can be calculated to arrive at the payment for the lot.

410.13.7.2-Thickness Adjustment: There is no adjustment for thickness greater than the thickness that is specified in the plans. If there is a Price Adjustment (Section 410.13.5) for thickness this factor (percentage) is applied to the contract bid unit price times the quantity in the lot to arrive at a dollar amount penalty. This penalty is applied to the overall payment for the lot.

410.13.7.3-Joint Density Adjustment: If it is determined in Section 410.13.4 of this specification that a Joint Density Adjustment is warranted the dollar amount determined in the formulas of Section 410.13.4 shall be applied to the overall payment for the lot.

410.13.7.4-Bond Strength Adjustment: If it is determined that a Bond Strength Adjustment is warranted by Section 410.7.1.4 of this specification the formulas in Section 410.13.6.2 shall be used to calculate the adjustment. This adjustment shall be applied to the overall payment for the lot.

410.14-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
410001-*	“design method” Asphalt Base Course, Type “mix type”	Square Yard (Meter)
410002-*	“design method” Asphalt Wear Course, Type “mix type”	Square Yard (Meter)
410007-*	“design method” Asphalt Skid Pavement, Type “mix type”	Square Yard (Meter)

- * Sequence number
“design method” shall be either Marshall or Superpave
“mix type” from Table 401.4.2A or 401.4.2B

SECTION 411-BLANK

SECTION 412 WINTER GRADE ASPHALT PATCHING MIXTURE

412.1-DESCRIPTION:

This work shall consist of preparing a mixture of aggregate and bituminous material suitable for stockpiling and remaining workable for a period of six months.

412.2-MATERIALS:

412.2.1-Bituminous Material: The material shall conform to the requirements of 705.1, Winter Grade Cut-Back Asphalt.

412.2.2-Aggregate: The aggregate shall consist of crushed stone, crushed gravel, or slag, meeting the requirements of 703.1, 703.2 and 703.3 respectively, and sand meeting the requirements of 702.3. The gradation of the final mixture shall be as follows:

<u>Sieve Sizes</u>	<u>Percent Passing</u>
1/2 in.(12.5 mm)	100
3/8 inch(9.5 mm)	85-100
# 4 (4.75 mm)	25-65
# 8 (2.36 mm)	10-20
# 100 (150 µm)	0-5

CONSTRUCTION METHODS

412.3-MIXING PROPORTIONS:

Samples of bituminous materials and aggregates intended to be used shall be furnished the Division who will advise the mixture proportions to be used.

412.4-PREPARATION OF MIX:

The asphaltic binder shall be heated to 150° to 175° F (66 to 79° C), care being taken to prevent local overheating. The aggregate and bituminous material shall be measured separately and accurately to the proportions in which they are to be mixed. After the aggregate and binder have been combined, they shall be thoroughly mixed until all particles of the aggregate are coated. At no time shall the finished mixture be at a temperature greater than 150° F (66° C).

The constituents shall be combined in such proportions as to produce a mixture conforming to the following composition by weight:

	<u>Limestone or Gravel Percent</u>	<u>Slag Percent</u>
Total Mineral Aggregate	94.0-95.0	92.5-94.0
Winter Grade Cut Back Asphalt	5.0-6.0	6.0-7.5

When the correct percentage of bituminous material is established for a given aggregate, this quantity shall not vary more than minus 0.1 percent or plus 0.3 percent.

412.5-METHOD OF MEASUREMENT:

The quantities of work done will be measured in tons (megagrams) of "Winter Grade Bituminous Patching Mixture", F.O.B. vendor's plant or stockpile, or the Division's stockpile as designated.

The number of tons (megagrams) of "Winter Grade Bituminous Patching Mixture" shall be determined by the total of the weights shown on receipted railroad freight bills when materials are shipped by rail; by actual measured displacement of barges certified by the producer when water shipments are made, providing materials delivered by the methods are not stockpiled or stored; or determined by the Contractor from the total of weigh slips for each vehicle load weighed on an approved standard scale or from digital printout slips from an automatic batching plant, and certified by the Contractor to be correct.

Truck scales shall be provided by the producer or Contractor, except that truck scales are not required where the material is weighed at properly calibrated automatic batching plant facilities which are equipped with digital print-out equipment. The scales shall be of sufficient size and capacity to weigh the heaviest loaded trucks that are used for delivery of the material.

All truck scales shall be mounted on solid foundations which will insure their remaining plumb and level. All truck scales shall be inspected and sealed by the West Virginia Division of Labor, Bureau of Weights and Measures, or other appropriate agencies of the State or its political subdivisions. The Division may, at its option, accept inspection and sealing by out of state agencies when the material is weighed outside West Virginia.

A weigh person shall be provided by the producer. The weigh person shall certify that the weight of the material, as determined either by the truck scales or from the digital printout of the weights, is correct.

Each truck shall be weighed empty prior to each load, except at automatic batch plants approved to operate without truck scales. A digital recorder shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification and project number. Provision shall be made for constant zero compensation and further provision shall be made so that the scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest. In case of a breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

412.6-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item listed below, which price and payment shall be full compensation for furnishing and handling all the materials incorporated in the mixture.

412.7-PAY ITEM:

ITEM	DESCRIPTION	UNIT
412001-*	Winter Grade Bituminous Patching Mixture, **	Ton (Megagram)

* Sequence number

** Type of Aggregate

SECTION 413 THROUGH SECTION 414-BLANK

SECTION 415

MILLING OF ASPHALT PAVEMENT SURFACES

415.1-DESCRIPTION:

This item shall govern for the milling of existing and/or new asphalt pavement at locations shown on the plans or as directed by the engineer in accordance with the requirements herein and MP 401.07.24. The work shall provide a skid resistant surface that meets smoothness requirements and provides a constant cross slope, or be used as surface preparation prior to placement of a final surface course.

415.1.1-Standard Milling: Item 415005-* shall be used as the default milling of asphalt pavements. It should be used when the Division plans to remove existing asphalt pavement in preparation for an asphalt overlay or other process. This method of removal is most common and possesses a minor level of profile and slope control, or as otherwise shown in the plans.

415.1.2-Fine Milling: Item 415006-* shall be used when the Division intends to overlay the milled surface with a thin lift asphalt course, or as otherwise shown in the plans. This removal method shall be considered a detailed surface preparation, therefore requiring a high level of profile and slope control, or as otherwise shown in the plans.

415.1.3-Micromilling: Item 415007-* shall be used for in an effort to recover skid resistance on existing pavement or smoothness correction, bump and/or grade corrections on existing or newly paved surfaces where called for in the plans. This removal method shall be considered specialized and is not intended to be used when standard overlays are to be used.

415.2-CONSTRUCTION:

415.2.1-General: The plans will designate the area of pavement surfaces to be milled. Milling of roadway shoulders will not be required unless indicated on the plans or required to provide drainage.

415.2.2-Equipment: The equipment for removing the existing pavement shall be a power operated planing machine or grinder. The equipment shall be capable of accurately establishing profile grades along each edge of the machine within plus or minus 1/4 inch (6 mm) by referencing from the existing pavement and able to maintain accurate depth of cut and cross-slope.

The machine shall have a control system providing for uniformly varying the depth of cut while the machine is in motion to prevent cutting of or damage to drainage works, manholes or other appurtenances within the paved area.

At the end of each working day, all equipment shall be removed to a location where it does not present a hazard to traffic, the pavement shall be cleaned by sweeping or flushing.

415.2.3-Milling Residue: The Contractor shall establish a positive and immediate means for removal of milling residue. The machine shall have adequate loading equipment to remove solid residue from the surface and discharge them into a truck or as directed. Residue shall not be permitted to flow across lanes used by the traveling public or into gutters or drainage facilities.

415.2.4-Millings: The removed pavement material shall become the property of the Contractor.

Excess waste material resulting from the operation shall be removed and disposed of in a manner approved by the Engineer.

415.2.5-Milled Surface Opened to Traffic: If the ground area is opened to traffic the following shall apply;

- 1) Any transverse vertical face shall be sloped so as not to present a hazard to traffic;
- 2) Any longitudinal vertical face shall not exceed 2 inches (50 mm);
- 3) The pavement surface shall be cleaned by sweeping or flushing.

415.2.6-Cross Slope: Milling will be accomplished in a manner that eliminates crack or joint faults while providing positive lateral drainage by maintaining a constant cross-slope between grinding extremities in each lane. Auxiliary or ramp lane grinding shall transition as required from the mainline edge to provide positive drainage and an acceptable riding surface.

The operation shall result in pavement that conforms to the typical cross-section and the requirements specified for the final surface finish. However, it is the intention of this specification that the faulting at joints and cracks be eliminated and the overall riding characteristics be restored within the limits specified. To accomplish the smoothness required, milling may not be required on 100 percent of the pavement surface. If directed by the Engineer, any spalling or dislodged unsound pavement due to milling shall be corrected by the Contractor via section 109.4.

415.2.7-Surface Finish: The milling process shall produce a smooth riding pavement surface that is true to the established line, grade and cross section with the milled area consisting of a longitudinal corduroy-type texture. The milling operation shall be capable of efficiently and accurately establishing profile grades along each edge of the machine within the tolerance listed below:

415005-*	Standard Milling	1/4 inch (6 mm)
415006-*	Fine Milling	1/8 inch (3 mm)
415007-*	Micromilling	1/8 inch (3mm)

Transverse joints and cracks shall be made flush with adjacent surfaces. Transverse joints and cracks shall be visually inspected to ensure that adjacent surfaces are in the same plane. Alignment of adjacent sides of the joints or cracks shall be within 1/8 inch (3 mm) of each other to be considered flush.

The transverse slope of the pavement shall be uniform to a degree that no depressions of misalignment of slope greater 1/4 inch (6 mm) in 12 ft. (3.65 m) are present when tested with a straightedge placed perpendicular to the centerline. Straightedge requirements do not apply outside of the milled area. The peaks of the ridges shall be approximately 1/8 inch (3 mm) higher than the grooves.

The finished, milled pavement surface shall be evaluated using MP 401.07.24 except that the volume of glass beads to be used for each test shall be 200 ml (12in³), and only one such test shall be required at each individual test location. The measured diameter for each test shall be equal to or greater than the values shown below:

415005-*	Standard Milling	NA
415006-*	Fine Milling	9" Dia.
415007-*	Micromilling	12" Dia.

Testing shall be performed as soon as practical behind the milling operation in order to not allow gaps to occur between sections being milled and sections being evaluated. Three tests shall be performed within the first 3,000 square yards of milling, and then at a minimum frequency of one test for every 7,500 square yards of milled surface thereafter. If the minimum diameter is not maintained, cease operations until necessary adjustments to the equipment and/or the process are made to meet this requirement. Do not resume milling operations until the Engineer is satisfied with the corrective actions.

Upon resuming operations after any adjustments are made, the first 3,000 square yards shall be evaluated as stated above. Additionally, if the equipment is replaced for any reason, or if mobilization back to the project site occurs at a later date for any reason, the first 3,000 square yards shall be evaluated as stated above.

The Engineer may reduce the testing frequency provided that a uniform texture is consistently maintained meeting the requirements shown above.

415.3-METHOD OF MEASUREMENT:

Pavement milling will be measured by the square yard (square meter) of pavement milled and accepted. The quantity of pavement milling will be determined by multiplying the width specified on the plans by the total length of the finished pavement surface.

415.4-BASIS OF PAYMENT:

The contract price per square yard (square meter) for Standard, Fine Milling, or Micromilling shall be full compensation for furnishing all labor, materials, tool, equipment and incidentals and for doing all work involved in milling the existing pavement, removing residue, cleaning the pavement, and testing per MP 401.07.24 in accordance with these specifications and as shown on the plans.

415.5-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
415005-*	Standard Milling	Square Yard (Meter)
415006-*	Fine Milling	Square Yard (Meter)
415007-*	Micromilling	Square Yard (Meter)

* Sequence number

DIVISION 500

RIGID PAVEMENT

SECTION 501 PORTLAND CEMENT CONCRETE PAVEMENT

501.1-DESCRIPTION:

This work shall consist of a pavement or an unbonded overlay pavement composed of Portland cement concrete, with or without reinforcement as shown on the Plans, constructed on a prepared subgrade, base course, or existing pavement in accordance with these Specifications and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the Plans or established by the Engineer.

Pozzolanic materials (fly ash, ground granulated blast furnace slag and microsilica) conforming to the provisions of these specifications may be used as an additive to portland Cement Concrete Pavement at the Contractor's option. These additives are not permitted when a blended hydraulic cement is used.

A water reducing admixture may be used at the Contractor's option. A water reducing admixture shall not be used in conjunction with a water reducing retarder.

501.2-MATERIALS:

Materials shall meet the requirements of Division 700, as follows:

MATERIAL	SUBSECTION
Air Entraining Admixture	707.1
Coarse Aggregate	703.1-4
Coated Dowel Bars	709.15
Curing Materials	707.6-707.10
Fine Aggregate*	702.1
Joint Tie Bolt Assembly	709.7
Low Modulus Silicone Joint Sealant; Back-Up Material	708.4
Pavement Reinforcement	709.4, 709.6
Performed Elastomeric Joint Seals; Lubricant-Adhesive	708.2
Portland Cement	701.1, 701.3
Pozzolanic Additives	707.4
Preformed Expansion Joint Filler	708.1.1 (Type 1), 708.1.2
Tie Bars	709.1
Water	715.7
Water Reducer	707.3

* The use of limestone will not be permitted.

Shipping and Storage of Cement: Cement shall be shipped from pretested and approved bins at the mill or other terminal locations. Cement stored by the Contractor for a period longer than 90 days shall be retested before being used in the work. Cement failing to meet any of the specified requirements at any time prior to incorporation into the work will be rejected and removed from the work. Cements of different types shall be stored separately.

Shipping and Storage of Pozzolanic Additives: Pozzolanic additives shall be shipped from only those sources approved by the Division. Bulk Pozzolanic additives shall be stored at

the job site in weatherproof bins. Pozzolanic additives from different sources or from different lots at the same source shall be stored separately.

501.2.1-Recycled Pavement for use as Coarse Aggregate for Concrete:

501.2.1.1-The existing portland cement concrete pavement may be removed and crushed, when called for on the Plans. If asphaltic concrete resurfacing is present, the asphaltic concrete shall be removed before the portland cement concrete is crushed.

501.2.1.2-Any existing reinforcing steel encountered shall be removed from the existing pavement prior to or during the crushing operation and shall be disposed of by the Contractor.

501.2.1.3-The Contractor shall remove the pavement in a manner which excludes subgrade and base material to the maximum extent practical.

501.2.1.4-The pavement material shall be crushed to pass the 1½ in. (37.5 mm) sieve. Processing equipment shall include a No. 4 (4.75 mm) screen and excessive fines in the crushed material shall be controlled by removal of fines passing the No. 4 (4.75 mm) screen.

501.2.1.5-Any excess material removed during processing shall be disposed of by the Contractor.

CONSTRUCTION METHODS

501.3-PROPORTIONING:

Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportions of materials, including admixtures, to be used which will result in a workable concrete having the properties enumerated below, including those of Table 501.3.1. The mix design, prepared in accordance with MP 711.03.23, shall include a statement giving the source of materials and certified test data from a Division approved laboratory demonstrating the adequacy of the mix design. The Contractor shall notify the Engineer of any change in the source of materials or the addition of admixtures during the process of the work since such change may necessitate a new mix design. The Contractor shall also state the $\bar{A}$ value of the combined grading of the coarse aggregate, fine aggregate, and cement used in the mix design.

The combined grading of the coarse aggregate, fine aggregate, and cement used in the pavement concrete shall conform to the design mix $\bar{A}$ plus or minus the tolerance specified in the following table for the coarse aggregate size used:

Coarse Aggregate Size No.	Design Mix $\bar{A}$ Tolerance
357 or 467	±0.35
57 or 67	±0.25

$\bar{A}$ is the values of total solids (coarse aggregate, fine aggregate and cement). The grading of the total solids shall be determined by the Contractor at least once each production day. Should the moving average of any five consecutive grading test results of the total solids have an $\bar{A}$ outside the specified mix design tolerance limits, production shall be discontinued until appropriate corrections are made. Corrections shall be made either in the proportions of the concrete (the mix design), the gradation of the aggregates, or the storage and loading of the aggregate, as the Contractor may elect.

TABLE 501.3.1 {ENGLISH}

Minimum 28-Day Design Strength	Minimum Cement Factor	Maximum Water Content	Standard Size of Coarse Aggregate
psi	Bags per cu. yd.	Gal. per cu. yd. of concrete	Number
3,000 Compressive or 500 Flexural*	6**	33	357, 467 57 or 67

TABLE 501.3.1 {METRIC}

Minimum 28-Day Design Strength	Minimum Cement Factor	Maximum Water Content	Standard Size of Coarse Aggregate
Mpa	kg per cu. meter	Liters per cu. m. of concrete	Number
20.7 Compressive or 3.5 Flexural*	335 kg**	163.4	357, 467 57 or 67

* Flexural strength when tested by the third point method.

** An equal volume of a Pozzolanic additive may be substituted for portland cement up to the following maximum amount. Only one Pozzolanic additive is permitted in a mix design.

<u>MATERIAL</u>	<u>QUANTITY</u>
Fly Ash	1 bag
Ground Granulated Blast Furnace Slag	3 bags
Microsilica	1/2 bag

MP 711.03.26 shall be used to control the cement factor in pavement concrete if the Contractor has a suitable means of verifying the minimum 28-day design strength, and providing a copy of the plan for verifying the strength is submitted to the Engineer. When MP 711.03.26 is used to control the cement factor in portland cement concrete pavements, then column two in Table 501.3.1 will be considered to contain a target cement factor instead of a minimum cement factor.

The amount of entrained air in freshly mixed concrete shall be 7 percent plus or minus 2-½ percent.

Concrete shall have the consistency which will allow proper placement and consolidation in the required position. The optimum consistency shall be as indicated in Table 501.3.2.

TABLE 501.3.2 CONSISTENCY

Type	Optimum Consistency Inches (mm) Of Slump
(a) For pavements when concrete is permitted to be placed using a slip form paver, where a low slump is required to maintain the prescribed geometry.	*1 in. (25 mm)
(b) For pavements supplied by travel mixers of central mixers where the concrete is struck off and consolidated entirely by mechanical equipment.	**2 in. (50 mm)
(c) For pavements and approaches supplied by travel, central or transit mixtures where the concrete is struck off and consolidated partially by hand labor.	**2 ½ in. (65 mm)

* The consistency shall be that which will allow a proper placement and consolidation of the concrete, and will permit the prescribed geometry to be maintained. The concrete will be rejected when the consistency exceeds 2 inches (50 mm).

** If the consistency exceeds the optimum plus $\frac{3}{4}$ in. (20 mm), the Contractor shall take immediate steps to reduce the slump of succeeding loads by making necessary adjustments in the mixture. The Contractor will be allowed a reasonable time for the trucks already on the road for a central mix or transit mix operation. Failure to comply will be cause for rejection of the concrete. If the consistency exceeds the optimum plus 2 inches (50 mm), the concrete will be rejected.

The approved mix design shall be subject to modification under the following conditions:

After the start of the first concreting operation and immediately after the specified consistency and entrained air have been established, three unit weight determinations shall be made from different batches and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be adjusted as required to correct the actual yield to correspond to the theoretical.

During the progress of the work, the actual yield may be verified; and, if the yield based on a single unit weight determination should differ from the theoretical more than plus or minus two percent, two additional unit weight determinations shall be made from different batches and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be determined from the average unit weight, and the design mix shall again be adjusted as required to correct the actual yield to correspond to the theoretical.

In addition to the design mix adjustments specified above to correct for yield, other adjustments in the design mix proportions shall be made as necessary to maintain a plastic, workable mix with suitable finishing characteristics.

No change in the sources of material shall be made without prior approval of the Engineer.

Methods for determining the properties enumerated above shall be in accordance with 501.4.

501.4-TESTING:**501.4.1-Test Methods:**

Slump of Hydraulic Cement Concrete	AASHTO T 119
Air Content of Freshly Mixed Concrete by the Pressure Method	AASHTO T 152
Air Content of Freshly Mixed Concrete by the Volumetric Method	AASHTO T 196
Unit Weight and Yield of Concrete	AASHTO T121
Making and Curing Concrete Test Specimens in the Field	AASHTO T 23 with MP 601.04.20
Flexural Strength of Concrete	AASHTO T 97
Obtaining and Testing Drilled Cores and Sawed Beams of Concrete	AASHTO T 24
Measuring Length of Drilled Concrete Cores	AASHTO T 148
Non-Destructive Thickness Determination of Pavements Using Magnetic Imaging Tomography Technology	MP 700.10.01
Total Evaporable Moisture Content of Aggregate by Drying	AASHTO T 255
Sampling Fresh Concrete	AASHTO R 60
Sieve Analysis of Fine and Coarse Aggregates	AASHTO T 27
Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing	AASHTO T 11
Determination of Free Moisture in Fine Aggregate Using a "Speedy Moisture Tester"	MP 702.00.20
Aggregate Sampling Procedures	MP 700.00.06
Standard Method for Determination of $\bar{A}$ of the Total Solids in Portland Cement Concrete	MP 601.03.51

501.4.2-Contractor's Quality Control: Quality control of the portland cement concrete is the responsibility of the Contractor as designed in MP 601.03.50. The Contractor shall maintain equipment and qualified personnel, including at least one certified portland cement concrete technician who shall direct all field inspection, sampling and testing necessary to determine the magnitude of the various properties of concrete governed by the Specifications and shall maintain these properties within the limits of this Specification. The Contractor's personnel who conducts the field sampling and testing shall be a certified portland cement concrete inspector. The quality control plan designated by MP 601.03.50 shall be submitted to the Engineer at the preconstruction conference.

Work shall not begin until the Contractor's Quality Control Plan, in accordance with MP 601.03.50, is reviewed for conformance with the contract documents.

Two separate concrete samples shall be taken, from the finished concrete surface behind the concrete paving operation, at the beginning of first day's paving operation. These concrete samples shall be tested for air content. The results from these two samples shall be compared to air content test results from samples taken ahead of the paving operation. These values shall then be used by the Contractor to determine the amount by which the air content of the concrete is being reduced due to paving operations. If the air content behind the paving operation is

found to be below the specified level, the Contractor shall make adjustments in the concrete mix to allow for this loss of air content, and retest. The Contractor shall fill the voids in the plastic concrete created by obtaining these samples and shall finish the plastic concrete surface to match the adjacent concrete surface.

501.4.3-Acceptance Testing: Acceptance sampling and testing of portland cement concrete is the responsibility of the Division, except for furnishing of necessary materials.

Strength, as used in this Specification, is only one indicator of the durability of the portland cement concrete. Evaluation of a pavement may include evaluation of the freeze-thaw durability, including scaling characteristics, abrasion resistance, density, and such other factors as the Division deems appropriate to the pavement.

Quality control sampling and testing performed by the Contractor may be used by the Division for acceptance.

501.4.4-Testing for Opening Pavement to Traffic: A minimum of three sets of three concrete specimens (beams or cylinders) each shall be made for each day's paving operation. The three sets of specimens shall be treated in the following manner to determine when the pavement represented may be put into service under the provisions of 501.18, except that said determination and the action permitted shall in no way affect the treatment of concrete as specified in 501.21.1 and 501.14.

In lieu of the cylinders outlined in the previous paragraph, the Contractor may use the Maturity Method for the estimation of concrete strength, as outlined in MP 601.04.21, for determining when the pavement may be opened to traffic.

One specimen from each of the three sets shall be tested at age four days and the results averaged to establish the test value. If the test value complies with the Specification, the portion of pavement which is aged four days may be put into service.

In the event Specification compliance has not been verified at age four days, one specimen from each of the three sets shall be tested at age six days and the results averaged to establish the test value. If the test value complies with the specifications the portion of pavement which is aged six days may be put into service.

In the event Specification compliance has not been verified at age six days, one specimen of the remaining specimen from each of the three set shall be tested at age eight days and the results averaged to establish the test value. If the test value complies with the Specification, the portion of pavement that has aged eight days may be put into service.

In the event the test value determined at age eight days does not comply with the Specification, the test values determined at ages four, six, and eight days may be plotted on a graph and a line drawn through the points in such a manner as to establish the age-strength relationship. The line may be projected to age 28 days, and if the projection indicates specification design strength compliance prior to age 28 days, then the pavement may be put into service at the age at which specification compliance is indicated.

When high early strength cement is used, the first test value may be established at age three days and all succeeding values established at 24 hour intervals.

501.4.5-Compressive Strength Tests for Acceptance: The compressive strength of concrete will be determined by testing concrete cylinders. Concrete cylinders shall be fabricated at the frequency specified in MP 601.03.50. A compressive strength test shall

consist of three test specimens. Either 6" x 12" (150 mm x 300 mm) or 4" x 8" (100 mm x 200 mm) cylinders are permitted, provided the requirements of MP 711.03.23 are met. The size of cylinders which the Contractor intends to use on each project shall be listed in the Contractor's Quality Control Plan. The test shall be the average of three test specimens, except that if one specimen shows manifest evidence of improper sampling, molding, or testing, it shall be discarded and the remaining two strengths averaged. Should more than one specimen representing a given test show definite defects due to improper sampling, molding, or testing, the entire test shall be discarded.

The maximum acceptable range of compressive strengths within a set of three cylinders is 9.5%. This range is found by multiplying 9.5% times the average compressive strength of the three cylinders. If this acceptable range is exceeded, the cylinder that varies the most from the average shall be discarded, and the remaining two cylinders shall be evaluated as outlined in the following paragraph.

The maximum acceptable range of compressive strengths within a set of two cylinders is 8.0%. This range is found by multiplying 8.0% times the average compressive strength of the two cylinders. If this acceptable range is exceeded, the entire test shall be discarded. Under no circumstances shall a compressive strength test consist of less than the average of two specimens.

Compressive strength tests shall conform to the requirements of Table 501.3.1. Statistical analysis may indicate a percentage of production to be below nominal minimum design strength. Concrete represented by compressive strengths below the nominal design strength of Table 501.3.1 may be removed and replaced by the Contractor. If the Contractor elects to leave the material in place, it will be evaluated as to adequacy for the use intended. All concrete evaluated as unsatisfactory for the use intended shall be removed and replaced or otherwise corrected by and at the expense of the Contractor as required in 105.3. When an evaluation indicates that the work may satisfactorily remain in place, a statistical analysis will be made of the material. If this statistical analysis indicates at least 93 percent of the material may be expected to have compressive strengths equal to or greater than that shown in Table 501.3.1, and 99.87 percent of the material may be expected to have compressive strengths at least one standard deviation above forty percent of the design strength ($0.4f'_c + \sigma$), the work will be accepted as substantially complying with the specification requirements. If this statistical analysis indicates that less than 93 percent of the material may be expected to have compressive strengths equal to or greater than that shown in Table 501.3.1 or less than 99.87 percent of the material may be expected to have compressive strengths at least one standard deviation above forty percent of the design strength ($0.4f'_c + \sigma$), the Engineer will provide for an appropriate adjustment under the provisions of 601.15.

Whenever possible, the Division's statistical analysis will be based on a minimum of 10 cylinder test results. These results may be from the concrete item being placed, the same class of concrete on the project, or the same class of concrete from the producer. All of the cylinder test results used in this evaluation, however, must be from the same mix design.

501.5-EQUIPMENT AND TOOLS:

Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be

examined. Any equipment not maintained in satisfactory working order, or which is proved inadequate, shall be improved or new equipment substituted, as directed by the Engineer.

501.5.1-Field Laboratory: Portland cement concrete shall be supplied by a plant which has been certified by the Division as meeting all requirements of the governing Specifications and as having the facilities necessary to ascertain and control the quality of the product in accordance therewith.

A testing facility or laboratory, as described below, shall be provided within reasonable proximity of the concrete batch patch.

The laboratory shall have inside dimensions which provide a minimum working area of 26 ft. (8 meters) in length by 6 ft. (2 meters) in width (examples which would generally meet this requirement are a building with inside dimensions of 12 by 13 ft. (3.5 by 4 meters), or a trailer with dimensions of 8 by 30 ft. (2.5 by 9 meters)). The laboratory shall be furnished and maintained with adequate ventilation, heat, light, water, sinks and drainage, electrical or gas outlets, or both, work table, shelves, and supply cabinets.

The laboratory shall be supplied with the equipment and materials listed below and shall be maintained in such a condition that the equipment will meet the applicable requirement of ASTM or AASHTO.

- i. Hot plate, gas or electric.
- ii. Large oven, gas or electric.
- iii. Pressure air meter or volumetric air meter (Rollameter).
- iv. Slump cone and rod.
- v. Unit weight container, $\frac{1}{2}$ cu. ft. (0.014 m³)
- vi. Solution balance, 20 kg. capacity, one gram increments.
- vii. Balance, minimum capacity 1,000 g., 0.1 g. increments.
- viii. Platform scale, 100 kg. capacity, 10 g. increments.
- ix. Thermometer, armored type.
- x. Standard Gilson shaker or equivalent, with screens.
- xi. Ro-Tap shaker or equivalent, with 8-inch (200 mm) round screens.
- xii. Wire basket and container for weighing aggregates under water.
- xiii. Sample splitters for fine and coarse aggregates.
- xiv. Equipment for determining specific gravity of sand.
- xv. Miscellaneous items (including rubber hammer, mason's trowels, approximate dimensions 4 in. and 8 in. (100 mm and 200 mm), square point shovel, small and large sugar scoops, heavy galvanized pail approximate 14 qt. (13 liter) capacity, aggregate sample pans, brushes, flashlight, glassware, steel straightedge approximate dimensions 18 by 2 in. (450 by 50 mm)), and such expendable supplies as are necessary for the tests to be made.
- xvi. "Speedy Moisture Tester", 20 g. or 26 g. capacity.

501.5.2-Batching Plant Equipment:

501.5.2.1-General: The batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a separate bin, hopper, and scale for cement shall be included. The weighing hopper shall be properly sealed and vented to preclude dusting during operation. If fly ash is used in the concrete, a separate bin shall be included.

501.5.2.2-Bins and Hoppers: Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

501.5.2.3-Scales: The scales for weighing aggregates and cement shall conform to the requirements of 109.1.

Scales shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 50 pound (22.68 kg) test weights for frequent testing of all scales.

Batching plants equipped to proportion aggregates and bulk cement by means of automatic weighing devices may be used.

501.5.2.4-Water Measuring Equipment: Unless the water is weighed, the water measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

501.5.2.5-Admixture Dispenser: A positive, automatic mechanical method shall be used for adding admixtures in solution.

501.5.3-Mixers and Hauling Equipment:

501.5.3.1-General: Mixers at the site of construction or at central point, truck mixers, and hauling equipment shall conform to the requirements specified. Each mixer shall have attached in a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

501.5.3.2-Mixers: Mixing shall be in a mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period. The mixer shall be equipped with a timing device which will automatically lock the discharge level when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired.

The mixers shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 3/4 in. (20 mm) or more. The Contractor shall (1) have available at the job site a copy of the manufacturer's design showing dimensions and arrangements of blades in reference to original height and depth, or (2) provide permanent marks on blades to show points of 3/4 in. (20 mm) wear from new conditions. (Holes of 1/4 in. (6 mm) diameter near each end and at a midpoint of each blade are recommended.)

501.5.3.3-Truck Mixers and Truck Agitators: Truck mixers used for mixing and hauling concrete, and truck agitators used for hauling central-mixed concrete, shall conform to the requirements of AASHTO M 157.

501.5.3.4-Nonagitator Trucks: Bodies of nonagitator hauling equipment for concrete shall be smooth, mortar tight, metal (non-aluminum) containers and shall be capable of discharging the concrete at a satisfactorily controlled rate without segregation. The concrete shall be discharged from the bottom of the container. If discharge of concrete is accomplished by tilting the body, the surface of the load shall be retarded by a suitable baffle. Covers shall be provided when needed for protection.

501.5.4-Finishing Machine: The finishing machine shall be designed and operated to strike off, consolidate, and obtain a smooth finish. The top of the forms, if used, shall be kept free from accumulation by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true.

501.5.5-Vibrators: For full width vibration of concrete paving slabs, vibrators may be either the surface pan type or the internal type with either immersed tube or multiple spuds. They may be attached to the spreader or the finishing machine, or may be mounted on a separate carriage. They shall not come in contact with the joint, load transfer devices, subgrade, or side forms. The frequency of the surface vibrators shall not be less than 3,500 impulses per minute, and the frequency of the internal type shall not be less than 5,000 impulses per minute for tube vibrators and shall be between 5,000 and 10,000 impulses per minute for spud vibrators.

When spud type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute.

Other types of vibrators may be used when shown they perform the function intended.

501.5.6-Concrete Saw: When sawing joints is elected or specified, the Contractor shall provide sawing equipment, adequate in number of units and power to complete the sawing to the required dimensions and at the required rate for preventing uncontrolled cracking. A standby saw and ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and continuously during concrete pavement.

501.5.7-Forms: Straight side forms shall be of adequate design to support the paving train and to provide the proper pavement section without horizontal joints. Flexible or curved forms of proper radius shall be used for curves of 200-feet (60 meter) radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure setting and shall have an attachment provision for forming the keyed joint between lanes. When in place they shall withstand, without visible springing or settlement, the impact and vibration of consolidating and finishing equipment. Forms with battered top surfaces, and bent, twisted, or broken forms shall be removed from the job. The top face of the forms shall not vary from a true plane more than 5/8 in. (3 mm) in 10 ft. (3 mm in 3 meters), and the upstanding leg shall not vary more than 1/4 in. (6 mm) from a plane normal to the subgrade. The forms shall contain provisions for locking the ends of abutting form sections together tightly, and for secure setting.

501.5.8-Edging Tools: Edging tools shall have $\frac{1}{4}$ in. (6 mm) radius for all edges except outside edges, which shall have a $\frac{3}{4}$ in. (20 mm) radius.

501.6-PREPARATION OF GRADE, SETTING FORMS, AND CONDITIONING OF SUBGRADE OR BASE:

501.6.1-Preparation of Grade: After the roadbed has been graded and compacted, as provided in 207 or 228, the grade shall be trimmed approximately to correct elevation, extending the work at least 2 ft. beyond each edge of the proposed concrete pavement to provide support for the fixed-forms or the slip-form paver tracks.

501.6.2-Setting Forms:

501.6.2.1-Base Support: The foundation under the forms shall be hard and true to grade so that the form, when set, will be firmly in contact for its whole length and at the specified grade. Any grade which at the form line is found below established grade shall be filled to grade with granular material, in lifts of $\frac{1}{2}$ in. (13 mm) or less for a distance of 18 in. (450 mm) on each side of the base of the form, and thoroughly compacted. Imperfections or variations above grade shall be corrected by tamping or by cutting as necessary.

501.6.2.2-Form Setting: Forms shall be set sufficiently in advance of the point where concrete is being placed. After the forms have been set to correct grade, the grade shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. Form sections shall be tightly locked, free from play or movement in any direction. The forms shall not deviate from true line by more than $\frac{1}{4}$ in. (6 mm) at any point. Excessive settlement or springing of forms under the finishing machine will not be tolerated. Forms shall be cleaned and oiled prior to the placing of concrete.

501.6.2.3-Grade and Alignment: The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor prior to placing the concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

501.6.3-Conditioning of Subgrade or Base: The base shall be brought to the proper cross section and plan grade within the tolerances specified for the final course underlying the pavement. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed. The grade shall be constructed sufficiently in advance of the paver to prevent delays.

Unless waterproof subgrade or base course cover material is specified, the subgrade or base course shall be uniformly moist when the concrete is placed.

501.6.3.1-Conditioning of Surfaces Receiving an Unbonded Concrete Overlay: If required, the bond breaker/leveling course for unbonded concrete overlays shall be constructed as shown on the Plans.

Construct any specified hot-mix asphalt base, bond breaker, or patching and leveling course in accordance with Section 401. Remove all loose materials from the existing pavement prior to placing the asphalt.

If required on the Plans, mill the surface before concrete placement in accordance with Section 415. After milling, tight blade the surface to remove ridges and loose material. Prior to placement of the overlay, the milled surface shall be swept clean. The Engineer shall be notified if milling operations expose underlying concrete pavement. All areas where the underlying concrete pavement is exposed shall be repaired, regardless of size. The Contractor shall first determine, in the presence of the Engineer, if the remaining asphalt surrounding the area of exposed concrete is sound. This asphalt shall be considered sound if it cannot be easily removed by prying it loose with a shovel. If it can be easily removed in such a manner, the Contractor shall continue to remove all such unsound asphalt until sound asphalt is encountered. If the asphalt surrounding the exposed concrete area is less than 2 inches (50 mm) thick, greater than 50 square feet (4.6 square meters) or are wider than 6 feet (1.8 meters) in the transverse direction, spray exposed concrete with tack coat meeting the requirements of Section 408 and cover with engineering fabric meeting the requirements of Section 715.11.8. If the asphalt surrounding the exposed concrete area is 2 inches (50 mm) or more in thickness, repair the exposed concrete area with an asphalt patch of the same thickness as the surrounding asphalt with either a Base-II or 19 mm mix in accordance with Section 401.

501.7-HANDLING, MEASURING, AND BATCHING MATERIALS:

The batch plant site, layout, equipment and provisions for transporting material shall be such as to assure a continuous supply of material to the work.

Stockpiles shall meet the requirements of 106.5. Aggregates shall be handled, hauled, and stored in such a manner which will minimize segregation, avoid contamination, and secure a uniform grading of the material within the specified gradation band. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining a sufficient time to eliminate excess water. Aggregates which have dried below a saturated surface-dry condition shall be wet down the night previous to their use, and sprinkled during the day to obtain saturated surface-dry condition.

The fine aggregate and each size of coarse aggregate shall be separately weighed into hoppers in the respective amounts approved by the Engineer for the job mix. Cement shall be measured by weight. Separate scales and hoppers shall be used for weighing the cement, with a device to indicate positively the complete discharge of the batch of cement. Bulk fly ash shall be stored in weatherproof bins. Batching shall be so conducted as to result in weights within a tolerance of one percent for cement and two percent for aggregates.

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not over one percent.

All admixtures shall be measured into the mixer with an accuracy of plus or minus three percent. Admixtures shall be introduced into the mix simultaneously with the mixing water. When more than one type of admixture is used they shall be introduced into the mix separately.

When cement or pozzolanic additives are being added in bag form, under no circumstances shall the packaging material be allowed to enter into the mix.

Handling, measuring, and batching of materials for volumetric batching and continuous mixing shall, in addition to the preceding requirements, conform to the applicable requirements specified in AASHTO M 241.

501.8-MIXING CONCRETE:

Concrete may be mixed at the site or a central mix plant, or it may be produced by volumetric batching and continuous mixing as designated in AASHTO M 241. When permitted in the Contract, concrete may be mixed in a truck-mixer.

Ready-mixed concrete shall be mixed and delivered in accordance with the requirements of AASHTO M 157 paragraphs 10 and 11, or AASHTO M 241 paragraphs 7 and 8, except as otherwise specified.

The required minimum mixing time for an individual mixer may be specified as that which, as shown by tests made at the Contractor's expense, will result in satisfactory mixing. Performance tests and the acceptable ranges in test results within each batch from the three different samples are given in Table 501.8. The mixing time shall not be less than 75 seconds. Where mixer performance tests are not made, minimum mixing time shall be 60 seconds plus 15 additional seconds for each cubic yard (meter) of concrete being batched in excess of one cubic yard (meter).

The mixer shall be operated at a drum speed recommended by the manufacturer. Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his expense. The mixer shall not be operated in excess of its nominal capacity as shown on the manufacturer's rating plate.

The mixing of concrete shall continue for the required mixing time after all ingredients, except water and admixture if added with water, are in the mixing compartment of the mixer before any part of the batch is released. The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the flow of materials into the drum.

The time elapsing from the time water is added to the mix until the concrete is deposited in place at the site of the work shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor shall it exceed 60 minutes when hauled in transit-mix trucks or truck agitators.

The addition of water after the completion of the initial mixing operation will not be permitted, except that when concrete is delivered in transit-mix trucks additional water may be added to the batch materials and additional mixing (minimum of 20 revolutions at mixing speed) performed to modify the consistency to meet the specified requirements, provided all these operations are performed within 45 minutes after the initial mixing operation and provided the maximum number of revolutions at mixing speed is not exceeded. Concrete that is not within the specified consistency limits at the time of placement shall not be used.

No concrete shall be mixed, placed or finished when the natural light is insufficient unless an adequate artificial lighting system is used.

TABLE 501.8

PERFORMANCE TESTS AND ACCEPTABLE RANGES FOR CENTRAL MIXED CONCRETE	
*Test Criteria	**Permissible Ranges Within Batch From Three Samples
	Plant
Slump, in inches (mm)	2.25 (60 mm)
Air content, percent by volume of concrete sample.	2.0
Weight per cu. ft. of plastic concrete, in lbs.	4.0 (64.8 mm)
Coarse aggregate retained on No. 4 sieve expressed as a percent of three-sample average weight retained	11.0

* Tests to be made in accordance with applicable AASHTO or ASTM Methods.

** Each property measured shall not exceed the permissible range in more than one out of seven batches

NOTE: Mixer performance data shall be based on three concrete samples per test batch, taken at the mixer during discharge from approximately 1/6th, 1/2 and 5/6th points of the batch discharge.

Determination of coarse aggregate uniformity within the batch where concrete ingredients are batched from separate stockpiles of more than one size of coarse aggregate shall be made using sieves of appropriate size to identify the quantity of coarse aggregate coming from each of the separate stockpiles.

A minimum of seven production batches of concrete shall be tested for the proposed minimum mixing time unless the Engineer determines, on the basis of prior tests on concrete produced with the equipment and materials to be used, that a different number of batches is adequate for the purpose. When any change occurs in size of the batch, the operating process, conditions affecting mixing or hauling, the ingredients of the concrete, or other conditions which will affect the quality of the concrete incorporated in the pavement, an additional seven production batches of concrete shall be tested.

501.9-PLACING CONCRETE:

The concrete shall be deposited on the grade in such manner as to require as little rehandling as possible. Unless transit-mix trucks, agitators, or other hauling equipment units are equipped with means for discharge of concrete without segregation, the concrete shall be unloaded into a spreading device and mechanically spread on the grade in such manner as to prevent segregation of the materials. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Necessary hand spreading shall be done with shovels, not rakes. Workers shall not be allowed to walk in the fresh concrete with boots or shoes coated with earth or foreign substances.

The pavement shall be constructed by placing two longitudinal traffic lanes full width in one operation unless otherwise indicated in the Contract. Lane-at-a-time construction will be permitted in variable width sections or other sections designated by the Engineer.

When the Contract permits lane-at-a-time construction and concrete is to be placed adjoining a previously constructed lane of pavement and mechanical equipment other than finishing equipment will be operated upon the existing lane, that lane shall first meet the requirements of 501.18. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after three days.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket onto a joint assembly unless the bucket is well centered on the joint assembly.

When using a slip-form paver, or combination of pavers, they shall be designed to spread, consolidate, screed and float-finish the freshly placed concrete in one complete pass of the paving train in such manner that a minimum of hand finishing will be necessary to provide a dense and homogenous pavement in conformance with the Plans and Specifications. The equipment shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Such vibration shall be accomplished with vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface of the concrete. No appreciable edge slumping of the in-place concrete will be allowed, and, if necessary, forms shall be trailed behind the paver to prevent slumping. If training forms are used, they shall be rigidly supported laterally.

Slip-form pavers shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering and spreading concrete shall be so coordinated as to provide uniform progress. If, for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

Placement to essential full width is required when slip-form paving methods are used. However, the Engineer may permit lane-at-a-time placement on variable width, small, or otherwise restricted sections using standard forming methods detailed elsewhere in these Specifications.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the equipment mounted vibrators be operated when the equipment is not moving in the forward direction. All equipment mounted vibrators shall be stopped, either manually or automatically, when the equipment stops its forward progress.

Should any concrete materials fall on, or be worked into, the surface of a completed slab, they shall be immediately removed.

When placing an unbonded concrete overlay, place the concrete when the base temperature is below 115° F (46° C). Reduce the temperature by spraying a fine water fog on the base. Ensure water does not pond in front of the plastic concrete. The application of white curing compound or a lime slurry shall be permitted as temperature control measures when waterproof bases are encountered. Concrete shall not be placed if frost exists in the base or if the base temperature is below 35° F (2° C).

When placing unbonded concrete overlays, concrete should be placed on the grade to the nominal thickness shown on the Plans. Any deviations for profile adjustments, and/or cross section adjustments, should be above the nominal thickness. When adjustments are necessary for grade or yield improvement, the thickness shall not, in any case, be less than the minimum thickness shown on the Plans.

501.10-STRIKE-OFF OF CONCRETE AND PLACEMENT OF REINFORCEMENT:

Following placing, the concrete shall be struck off to conform to the cross section shown on the Plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the Plans. When reinforced concrete pavement is placed in two layers, the entire width of the bottom layer shall be struck off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its

final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after when the top layer of the concrete shall be placed, struck off, and screeded. All portions of the bottom layer which have been placed more than 30 minutes without being covered by the top layer shall be replaced at the Contractor's expense. When reinforced concrete pavement is placed in one layer, the reinforcement may be positioned in advance of concrete placement, or it may be placed in the plastic concrete, after spreading, by mechanical or vibratory means. When reinforcement is specified, it shall be placed in the center portion of the pavement. Variation in the depth of reinforcement is permitted, but the minimum concrete cover shall be one-third of the plan depth of the pavement.

Reinforcement shall be as designated on the Plans and shall be free from dirt, oil, paint, grease, and loose rust which could impair bond of the steel with the concrete.

501.11-JOINTS:

Joints shall be constructed of the type and dimensions and at the locations shown on the approved Joint Layout Plan(s). The Contractor shall submit for approval a Joint Layout Plan for all intersections on the project in general accordance with the following: "Street Jointing Criteria: Ten Rules Of Practice" as suggested by the Portland Cement Association (PCA), Skokie, Illinois; the American Concrete Pavement Association's Intersection Joint Layout Guidelines; the latest issue of the West Virginia Division Of Highways' Standard and Supplemental Specifications; the West Virginia Division Of Highways' "Standard Details Book Volume 1 – Drainage, Guardrail, Pavement, Fence, and Markers" hereinafter referred to as "Standard Details Volume 1"; or as directed by the Engineer.

The "Street Jointing Criteria: Ten Rules of Practice" suggested by the PCA are paraphrased and revised for the West Virginia Division of Highways' needs as follows:

- i Joints are used in concrete pavement to aid construction and to minimize random cracking. Avoid odd-shaped areas of pavement.
- ii Space longitudinal joints not to exceed 12.0 ft. (3.8 m). The contractor shall decide on the type of longitudinal joint as shown on Standard Detail Sheet PVT1 of "Standard Details Volume 1" needed depending on the type of construction. Type D joints will be used for full-width construction. Type D joints with a projecting tie bar for the following lane/shoulder pour are acceptable. Type E joints without the key are acceptable for lane-at-a-time construction. Type F joints are not acceptable at any location on the project.
- iii Space transverse joints at regular intervals of 15.0 ft. (4.6 m) or less.
- iv Thinner slabs tend to crack at closer intervals than do thicker slabs. Long narrow slabs tend to crack more than square ones.
- v All contraction and expansion joints must be continuous through any Combination Concrete Curb and Gutter or Integral Concrete Curb (Standard Sheet PVT6, Sheet 1 of 2 of Standard Details Volume 1). See Standard Specification Section 610.3.4.
- vi Longitudinal construction joints should be butt-type joints with tie bars (Types D or E joints based on construction method) as shown on Standard Detail Sheet PVT1 of Standard Details Volume 1. The purpose of these tie bars is to hold adjacent slabs in vertical alignment. The normal backfill behind any integral curb or curb and gutter constrains the slabs and holds them together. With separate curb and gutter built on fill, use Type E Joints as shown on Standard Detail Sheet PVT1 of Standard Details Volume 1.

- vii Offsets at radius points should be at least 2.0 ft. (0.60 m) in width. Angles of less than 60° shall be avoided.
- viii Make minor adjustments in joint locations to meet all structures projecting through, into or against the pavement. Minor adjustments should not make any joint spacing greater than that specified in ii. and iii. in this list.
- ix (Deleted)
- x Manhole and inlet frames, as well as any other metal structure projecting through, into or against the pavement shall be isolated in accordance with 501.11.6.

The Contractor shall submit a Joint Layout Plan for each intersection on the Project to the Engineer for approval a minimum of 10 working days before ordering materials. No work on or ordering of materials for the intersections shall be performed until the Engineer has approved the Joint Layout Plan(s). These Submittals are not required to be signed and sealed by a Registered Professional Engineer.

501.11.1-Longitudinal Joints: Deformed steel tie bars (Type D joint) or tie bolt assemblies (Type E joint) shall be placed perpendicular to the longitudinal joints. They shall be placed by suitable mechanical equipment or rigidly secured by suitable supports to prevent displacement. Tie bars shall be epoxy coated and free of grease, oils, dirt, paint or other foreign materials, and shall not be enclosed in tubes or sleeves.

All longitudinal joints shall be sawed normal to the surface of the pavement with a suitable concrete saw. Construction of longitudinal joints shall be in accordance with the appropriate requirements, as follows:

- i When the longitudinal joint separates adjacent pavement lanes or slabs that are poured at the same time (full-width construction: Type D joint), sawing of longitudinal joints shall be performed between 4 and 24 hours after the pavement is placed and before any equipment and vehicles are allowed on the pavement. The saw cut shall be to a minimum depth of one-third of the plan depth of pavement; the width shall be 1/8 in. (3 mm), with a tolerance of plus or minus 1/16 in. (2 mm).
- ii When the longitudinal joint separates adjacent pavement lanes or slabs that are poured separately (lane-at-a-time construction: Type D or E joint), the longitudinal joint shall be sawed. The saw cut shall be to a depth of 1 in. (25 mm), plus 1/4 in. (6 mm); the width shall be 1/8 in. (3 mm) plus or minus 1/16 in. (2 mm).

501.11.2-Transverse Expansion Joints (Type B or Type C joint): The expansion joint filler shall be one piece, continuous from form to form, shaped to the subgrade and to the cross section of concrete. The filler shall be depressed 1/2 in. (13 mm) below the surface of the pavement.

The expansion joint filler shall be held in a vertical position. Finished joints shall not deviate more than 1/4 in. (6 mm) in the horizontal alignment from a straight line at right angles to the centerline of the pavement. No plugs of concrete will be permitted anywhere within the expansion space.

501.11.3-Transverse Contraction Joints: Transverse contraction (Type A) joints shall consist of planes of weakness created by sawing or forming grooves, normal to the grade, in the surface of the pavement as shown on the approved Joint Layout Plan(s). These contraction

joint grooves shall be centered, within 1 in. (25 mm) of the mid-length of the dowels, over the coated dowel bars specified.

Unless otherwise specified or authorized, all transverse contraction joint grooves shall be constructed as described, resulting in the dimensions detailed on the approved Joint Layout Plan(s) and at the spacing and locations shown on the Plans.

As soon as feasible after placing the concrete, the contraction joints shall be sawed to the dimensions shown on the approved Joint Layout Plan(s). Sawing of joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excess raveling, usually 4 to 24 hours. All joints shall be sawed before uncontrolled shrinkage cracking takes place, but no later than 24 hours after placement of concrete. If necessary, sawing operations shall be continuous, through day and night, regardless of weather conditions. In general, all joints should be sawed in sequence. The sawing of any joint shall be omitted if cracking occurs at or near the joint location prior to the time of sawing. Sawing of a joint shall be discontinued when a crack develops ahead of the saw. If extreme conditions exist which make it impractical to prevent erratic cracking by early sawing, the contraction joints shall be formed in the plastic concrete.

All joint repair work shall be done at the Contractor's expense and to the satisfaction of the Engineer.

When formed joints are permitted, they shall be effected by an approved mechanically operated device to the dimensions specified and while the concrete is still in the plastic state.

Random cracking at transverse contraction joints, as described in 501.11.7, shall be sealed with silicone sealant.

501.11.4-Transverse Construction Joints: Transverse construction joints shall be installed when there is an interruption of more than 30 minutes in the concreting operations. No construction joint shall be installed within 10 ft. (3 meters) of an expansion or contraction joint. If sufficient concrete has not been placed to form a slab at least 10 ft. (3 meters) long, the excess concrete back to the last proceeding joint shall be removed.

Construction joints shall be constructed in a manner similar to transverse contraction joints utilizing a Type A joint. The groove shall have the same dimensions as for transverse contraction joints.

501.11.5-Coated Dowel Bars: Coated dowel bars (load transfer reinforcement) shall be used across all transverse Type A joints as shown on the approved Joint Layout Plan(s). Dowels shall be located at mid-depth of the pavement with a tolerance of placement within plus or minus 1 in. (25 mm) of the lateral and vertical positions shown on the approved Joint Layout Plan(s). Dowels shall be aligned parallel to the centerline and surface of the pavement with a tolerance for such alignments within plus or minus 0.6 inches (15 mm) per dowel.

Dowels shall be held in position in the pavement by means of metal supports that remain in the pavement, except as noted. The combination of dowel bars and all the various components of the metal supports at a joint is commonly referred to as the dowel bar assembly or load transfer unit. Welding of dowels to the supports, to achieve a fixed end condition, shall be performed in accordance with the details shown on the approved Joint Layout Plan(s). For dowel assemblies at contraction and construction joints, welding of dowels to any member of the supports will not be permitted within the middle one-third of the dowel's length. The longitudinal misalignment of one end of a dowel assembly with respect to the other end in

achieving a perpendicular alignment with the centerline of the pavement (longitudinal side shift) shall not exceed 2 inches (50 mm) when 18 inch (450 mm) long dowel bars are used. Acceptance of a type of dowel assembly by the Division in no way relieves the Contractor of their responsibility for furnishing, as part of the assembly, coated dowel bars that meet the requirements of 709.15, nor does it relieve the Contractor of the Contractor's responsibility for placing and maintaining the assembly in its proper position and alignment during paving operations.

The mechanical implanting method of placing dowel bars is permitted if the Contractor can show, by the method outlined below or other approved methods, that the dowel bars can be placed within the required tolerance with no adverse effects to the finished concrete pavement. Prior to, or on the first day of the paving operation, the Contractor shall use non-destructive testing methods, such as the MIT Scan-2 technique, approved by the Engineer, to confirm dowel placement and alignment.

Dowel bars shall be placed to within plus or minus 1 inch (25 mm) of the depth shown on the plans, and parallel to the traffic lane centerline and top of roadway surface within a tolerance of 0.6 inches (15 mm) per 18 inches (450 mm) of dowel bar length.

Suspend paving operations if dowels are installed improperly and dowel alignment does not meet the specified tolerances. Paving operations shall not be resumed until the Contractor demonstrates to the Engineer that the problem has been corrected.

For coated dowel bar types that require a bond breaker, the bond breaking material, prequalified for use with that particular type coating, shall be carefully applied over the entire length of the bar just prior to placement of concrete unless an approved bond breaker lubricant has been applied in the shop.

The free end of expansion joint dowels utilized in a Type B joint shall be provided with a close fitting metal cap or sleeve equipped with a stop to prevent closing during paving operations. A clearance of 1 in. (25 mm) shall be maintained between the closed end of the cap and the end of the dowel to accommodate future movement of the concrete slab.

501.11.6-Expansion Joints around Structures: Expansion joints shall be formed by placing pre-molded expansion joint material about all structures and features projecting through, into or against the pavement. Unless otherwise indicated, such joints shall be ½ in. (13 mm) in width.

501.11.7-Random Cracks: Random cracks falling within 3 inches (75 mm) of the center of the transverse contraction joint's dowel bars shall be sawed for the full width, widening and deepening the crack to the dimensions of sawing for transverse contraction joints.

If any random or uncontrolled crack occurs outside 3 inches (75 mm) from a doweled joint, the entire pavement within the lane where such crack occurs shall be removed for the entire 15ft panel between joints. The dowel assembly or bars, as the case may be, shall be replaced with a new dowel assembly with drilling. The new joint over the dowel assembly shall be initially formed by the use of a removable insert or by sawing. The tie bars shall be replaced with a Modified Type E joint. The above described work shall be done at no additional cost to the Division.

501.11.8-Transverse Joints in Concrete Shoulders: Dowel bars are not required in paved shoulders except where turning traffic may use the shoulders as a lane.

501.12-FINAL STRIKE-OFF, CONSOLIDATION AND FINISHING:

501.12.1-Sequence: The sequence of operations shall be strike-off and consolidation, floating and removal of laitance, straight-edging, and final surface finish.

Any addition of water to the surface of the concrete to assist in the finishing operations will not be permitted. When conditions are such that unusually rapid drying is occurring, an atomized mist may be used to prevent the rapid evaporation of water from the concrete surface during the final finishing.

501.12.2-Finishing at Joints: The concrete adjacent to joints shall be consolidated or firmly placed without voids or segregation against the joint material, under and around all load transfer devices, joint assemblies, and other features designed to extend into the pavement. Concrete adjacent to the joints shall be mechanically vibrated as required in 501.9.

The operation of the finishing machine over the joints shall not cause segregation of concrete and damage to or misalignment of joints.

501.12.3-Machine Finishing: The concrete shall be distributed as soon as placed. It shall immediately be struck off and screeded by the finishing machine.

Vibrators for full width vibration of concrete paving slab shall meet the requirements of 501.5.5. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms, at structures, and throughout the pavement, the Contractor will be required to furnish equipment and methods which will produce pavement conforming to the Specifications.

501.12.4-Hand Finishing and Consolidation: Hand finishing will not be permitted except under the following conditions:

In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade.

Areas of narrow widths or irregular dimensions, where operation of mechanical equipment is impractical, may be finished by hand.

Concrete, as soon as placed, shall be struck off and screeded. A portable screed shall be used.

If reinforcement is used, a second screed shall be provided for striking off the bottom layer of concrete.

The surface screed shall be at least 2 ft. longer than the maximum width of slab to be struck off. It shall be sufficiently rigid to retain its shape under all working conditions, and constructed either of metal or of other suitable material shod with metal.

Consolidation shall be attained by the use of suitable vibrator or other equipment.

In operation the screed shall be moved forward on the forms in the direction the work is progressing, using a combined longitudinal and transverse shearing motion, so manipulated that neither end is raised from the side forms during the striking process. This shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

501.12.5-Floating: After the concrete has been struck off and consolidated, it shall be further smoothed, trued, and consolidated by means of a mechanical longitudinal float, except when waived by the Engineer.

If necessary, following one of the methods of floating described, long-handled floats may be used to smooth and fill in open textured areas in the pavement. Care shall be taken not to work the crown out of the pavement during the operation.

501.12.5.1-Mechanical Method: The mechanical longitudinal float shall be maintained in proper working order. At the beginning of each day's operation the float shall be checked and adjusted to the design crown of the pavement. A small amount of mortar shall be carried ahead of the float at all times. The forward speed shall be adjusted so that succeeding strokes of the float shall overlap on each transverse trip. The float shall pass over each area of pavement sufficient number of times until the surface shows no variation from straightedge requirements, but excessive operation over a given area will not be permitted. All excess water, laitance, or other foreign material shall be wasted over the side forms on each pass.

Pipe float devices may be used for longitudinal floating when slipform paving.

501.12.5.2-Alternative Mechanical Method: As an alternate to the above method, the Contractor may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by at least four visible wheels riding on, and constantly in contact with, the side forms.

501.12.5.3-Hand Method: The hand-operated longitudinal float shall be not less than 12 ft. in length and 6 inches (150 mm) in width, properly stiffened to prevent flexibility and warping. The float shall be operated from foot bridges resting on the side forms and spanning but not touching the concrete. The float shall be worked with a sawing motion, while held in a floating position parallel to the road centerline and passing gradually from one side of the pavement to the other. Movement ahead along the centerline of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water, laitance, and other foreign material shall be wasted over the side forms on each pass.

501.12.6-Straightedge Checking and Surface Correction: After the floating has been completed and the excess water removed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 10-foot straightedge. The Contractor shall furnish and use a 10 foot straightedge swung from handles at least 3 foot longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the road centerline and the whole area gone over from one side of the slab to the other as necessary. Advance along the road shall be in successive stages of not more than one-half the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meet the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and the slab conforms to the required grade and cross section.

501.12.7-Final Finish: The surface of the mainline pavement, acceleration and deceleration lanes, ramps, and all traveled ways shall be given a final groove finish. The tool

used shall produce a groove that it approximately 3/32 in. (2 mm) wide. The depth of the groove shall be 1/8 in. (3 mm) to 3/16 in. (5 mm) and spaced approximately 1/2 in. (13 mm) center to center. The grooves shall be formed in a direction transverse to the centerline of the roadway. Adjacent strokes to establish the texture shall abut one another without appreciable overlap. Texturing shall be performed when the concrete surface is of such plasticity as to prevent excessive raveling (concrete too dry) or to prevent mortar from flowing back into the grooves (concrete too wet). All texturing shall be accomplished with a single pass of the tool.

501.12.8-Edging at Forms and Joints: Before the concrete has taken its initial set, the edges of the pavement along each side of the slab and on each side of all formed joints, except joints initially formed that will be later widened by second-step sawing, shall be rounded. A 3/4 in. (20 mm) radius edging tool shall be used for rounding outside edges and a 1/4 in. (6 mm) radius tool for other edges. A well-defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting the tool during use. Any tool marks shall be eliminated by brooming the surface without disturbing the radius. All concrete on top of the joint filler shall be removed.

All joints shall be checked with a straightedge before the concrete has set and all necessary corrections made if one side is higher than the other or if they are higher or lower than the adjacent slabs.

501.12.9-Station Numbers: The Contractor shall impress station numbers into the pavement before it takes its final set. The complete station number is to be marked each 100 ft. (20 meters). Where equalities in alignment occur, they shall be marked in the pavement in the same manner as they are shown on the Plans. The numerals shall be 3 to 4 inches (75 to 100 mm) in height and 1/4 in. (6 mm) in depth. The station numbers shall be placed parallel to the transverse joints, approximately 12 to 24 inches (300 to 600 mm) from the outside edge of the pavement. Station numbers shall be placed along the right edge of a two-lane highway, readable in the direction of increasing stations. On multi-lane highways, numbers shall be placed along the outside edge of the two outside lanes of the roadway, readable in the direction of travel.

501.12.10-Protection Against Rain: In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the Contractor shall have available at all times materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of metal forms or wood planks having a nominal thickness of not less than 2 inches (50 mm) and nominal width of not less than the thickness of the pavement at its edge for protection of the pavement edges, and covering material such as burlap or cotton mats, curing paper, or plastic sheeting for protection of the surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin placing forms against the sides of the pavement and covering the surface of the unhardened concrete with the protective covering.

501.13-SURFACE TESTS:

The smoothness of the riding surface will be determined by the engineer using an inertial Profilometer or Mays Ride Meter calibrated to an inertial Profilometer. The smoothness testing will generally be accomplished within 30 days after the project is complete.

501.13.1-Sampling Units: The pavement will be divided into sampling Lots of 0.1 lane mile (0.16 lane kilometer) each. Each Lot shall exhibit a smoothness measurement, expressed in inches per mile (millimeters per kilometer).

501.13.2-Smoothness Requirement: Each sampling unit shall exhibit a smoothness equal to or less than 65 inches per mile (1000 millimeters per kilometer). Sampling units exhibiting smoothness values greater than 65 inches per mile (1000 millimeters per kilometer) shall be paid for at an adjusted price as follows:

$$\begin{aligned}\text{Revised Unit Price} &= \text{UBP} - \left[\left(1.00 - \frac{127.86 - 0.429S}{100} \right) (0.18 \text{ UBP}) \right] \text{ English} \\ &= \text{UBP} - \left[\left(1.00 - \frac{127.86 - 0.028S}{100} \right) (0.18 \text{ UBP}) \right] \text{ Metric}\end{aligned}$$

Where:

UBP = Unit Bid Price
S = Smoothness in inches per mile (millimeters per kilometer).

When the measured smoothness value exceeds the specified value by 50 percent or more, the Lot shall be corrected to comply with these specifications.

501.13.3-Grinding Requirements: When the pavement requires corrective action as noted above, the diamond grinding operations shall be in accordance with section 508, except that the final pavement smoothness requirements shall be in accordance with section 501.

501.14-CURING:

Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured in accordance with one of the methods described.

In all cases in which curing requires the use of water, the curing shall have prior right to the use of all water supplies. Failure to provide sufficient curing materials of whatever kind the Contractor may elect to use will be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

Concrete placed in cold weather, as defined in 501.21, shall be cured a minimum of seven calendar days or when the Contractor provides suitable means for documenting the maturity (degree-hours) of the concrete, based on slab surface temperature, the curing period may be terminated when the curing has been maintained for a minimum of 7,000 degree hours.

During the curing period the surface temperature of the concrete shall not be allowed to fall below freezing. The Contractor shall be responsible for the quality of the concrete placed or cured, or both, during cold weather. Any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

Polyethylene coated burlap and white polyethylene sheeting will be permitted as a curing application only on areas where intimate contact with the concrete surface can be obtained and maintained.

501.14.1-Burlap Mats: The surface of the pavement shall be entirely covered with the mats. The mats shall be of such length that they will extend at least twice the thickness of the pavement beyond the edges of the slab. The mat shall be placed so that the entire surface and both edges of the slab are completely covered. Before placing, the mats shall be thoroughly saturated with water. The mats shall be weighted down so as to remain in intimate contact with the surface covered and shall be maintained fully wetted and in position for 72 hours after the concrete has been placed, unless otherwise specified.

501.14.2-Waterproof Paper: The top surface and sides of the pavement shall be entirely covered with waterproof paper. The units shall be lapped at least 18 in. (450 mm). The paper shall be weighted down so as to remain in intimate contact with the surface. Each unit as laid shall extend at least twice the thickness of the pavement beyond the edges of the slab. Paper not manufactured in sizes providing this width shall be securely sewed or cemented together, the joints being securely sealed in such a manner that they do not open up during curing. The surface shall be thoroughly wetted before placing the paper. Curing shall continue for 72 hours after the concrete is placed, unless otherwise specified.

501.14.3-Straw Curing: When this type of curing is used, the pavement shall be cured initially with burlap or cotton mats, as specified above, until after final set of the concrete or, in any case, for 12 hours after placing the concrete. As soon as the mats are removed, the surface and sides of the pavement shall be thoroughly wetted and covered with at least 8 inches (200 mm) of straw or hay, thickness to be measured after wetting. The straw or hay shall be kept thoroughly saturated with water for 72 hours after placing the concrete. If the straw or hay becomes displaced during the curing period, it shall be replaced to the original depth and saturated. Upon removal, the covering shall be disposed of in such a manner as to leave the right-of-way in a neat condition. The straw or hay shall not be burned on, or adjacent to, the pavement.

501.14.4-White Pigmented Impervious Membrane: The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing operation and before initial set has taken place, or, if the pavement is initially cured with burlap or cotton mats, it may be applied upon removal of the mats. The curing compound shall not be applied during rainfall.

Curing compound shall be applied under pressure by mechanical sprayers. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. The rate of application of the curing compound shall be as follows:

1. Pavement with Burlap Drag Finish-One Gallon Per Maximum of 150 sq. ft. (0.27 liters per square meter)
2. Pavement Requiring Groove Finish-One Gallon Per Maximum of 125 sq. ft. (0.33 liters per square meter)

For unbonded concrete overlays, the curing compound application rates noted below shall be doubled.

At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application the compound shall be continuously agitated. Hand spraying of odd widths or shapes and surfaces exposed by

removal of forms will be permitted. Curing compound shall not be applied to the inside faces of joints to be sealed.

Should the film become damaged from any cause within the required curing period (72 hours after placement of concrete, unless otherwise specified), the damaged portions shall be immediately repaired with additional compound.

Upon removal of the side forms, the sides of the exposed slabs shall be protected immediately with a curing treatment equal to that provided for the surface.

501.14.5-White Polyethylene Sheeting or Polyethylene Coated Burlap: The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting or polyethylene coated burlap. Units shall be lapped at least 18 in. (450 mm). The covering shall be weighed down so as to remain in intimate contact with the surface covered. The covering shall extend at least twice the thickness of the pavement beyond the edges of the slab. The covering shall be maintained in place at least 72 hours after the concrete is placed, unless otherwise specified.

501.15-REMOVING FORMS:

Forms shall not be removed until at least 12 hours after placement of the concrete. Forms shall be removed carefully so as to avoid damage to the slab. As soon as the side forms have been removed, minor honeycombed areas shall be filled with mortar composed of one part cement to two parts fine sand and cured as outlined in one of the methods indicated above. Major honeycombed areas shall be removed and replaced. All areas or sections so removed shall be not less than 10-feet in length nor less than the full width of the traffic lane involved. Any remaining portion of the slab adjacent to the joints that is less than 10-feet in length shall also be removed and replaced. Slabs shall be cut by sawing full depth for removal.

501.16-SEALING JOINTS:

All transverse contraction and construction joints to be sealed shall have the preformed elastomeric seal installed or shall be filled with silicone sealer before the pavement is opened to traffic, including construction traffic, and as soon after completion of curing as is feasible.

All longitudinal joints shall be sealed with silicone sealant.

Cleaning and sealing of all joints is not required unless shown in the Plans.

501.16.1-Silicone Sealant: Following forming, initial sawing and final or second-step sawing operations, the joints shall have been cleaned in accordance with 501.11.8. In preparation for sealing, all joints that have become contaminated since those forming or sawing operations shall be cleaned by wire brushing, sandblasting, or a high pressure water blast or by a combination of these methods.

Just prior to installing the back-up material, the joints shall be blown out with compressed air at a pressure of at least 90 psi (620 kPa) to remove all dust, loose particles and debris. Air compressors used for this purpose shall be equipped with traps capable of removing moisture and oil from the compressed air. A joint shall not be sealed until it is thoroughly clean and dry.

When recommended by the manufacturer, the vertical surfaces of joints shall be fully wetted by a primer. The primer and application, including all safety precautions, shall be as per the manufacturer's recommendations. The primer shall be allowed to dry tack-free prior to installation of the backer rod.

The back-up material shall be installed in the joint at the required depth. The silicone sealant shall then be applied from inside the joint in a manner which causes it to wet the joint faces and to reasonable close conformity with the required dimensions.

Immediately following placement of the sealant and before a skin forms, the sealant shall be tooled to force it against the joint faces and to provide a slightly concave surface with a depth of approximately $\frac{1}{4}$ inch (6 mm) (at the center of the joint) below the pavement surface.

Any unreasonable deviation from the required joint or sealant dimensions will be just cause for rejection of the joint until satisfactory corrective measures are taken by the Contractor at no additional cost to the Division.

Any failure of the joint material in either adhesion or cohesion will be cause for rejection of the joint, and the joint shall be repaired to the Engineer's satisfaction by the Contractor at no additional cost to the Division.

Silicone sealant shall never be applied to frozen, dirty, wet, or damp concrete or during inclement weather conditions. Silicone sealant shall not be placed in the joints without the approval of the Engineer when the temperature at the surface of the concrete is less than 40° F (5° C).

501.16.2-Performed Elastomeric Seal: The dimensional requirements shall be as specified on the Plans. Joints shall be clean and dry at the time the elastomeric seal is installed. Just prior to installation of the seal, the lubricant-adhesive shall be applied to the joint faces or the sides of the seal, or both, to facilitate installation of the seal and to help secure the seal in place in the joint. The lubricant-adhesive shall be applied in such a manner as to cover both sides of the seal over the full area in contact with the joint faces. Any lubricant-adhesive that gets on top of the seal shall be immediately removed. Seals shall be installed in a substantially full compressed condition with the vertical axis of the seal parallel to the joint faces. Seals shall be installed in the joints to the depth shown on the Plans using suitable machines or tools that will not twist, curl, nick, notch, or otherwise damage the seal and that will insert the seal in such a manner that elongation of the seal shall not exceed five percent. The in place seals shall be one-piece construction, without field or factory splices, for the full length of the joint. Any seal that is damaged during installation shall be removed and replaced with a new, undamaged seal. Any seal that is improperly installed or positioned in the joint or that shows more than five percent elongated following installation shall be removed and properly reinstalled or replaced.

501.17-PROTECTION OF PAVEMENT:

The Contractor shall protect the pavement and its appurtenances against both public traffic and the traffic caused by their own employees and agents. This protection shall include watchmen to direct traffic, and the erection and maintenance of warning signs, lights, barricades, pavement bridges, crossovers, etc. The above shall be arranged so as not to interfere with public traffic on any lane intended to be kept open.

All damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced, as the Engineer may direct.

501.18-OPENING PAVEMENT TO TRAFFIC:

If approved by the Engineer, the Contractor may open the pavement to traffic prior to 28 days after placement of concrete, provided tests conducted in accordance with 501.4.4 indicate the

pavement has attained the 28-day design strength. If the Contractor wishes to open pavement to traffic prior to age 28 days, then all provisions for making test specimens and conducting and reporting the tests shall be handled by the Contractor at their expense. However, the Engineer may require that the pavement not be opened to traffic for a period of 28 days or longer, after placement of concrete, if conditions make it advisable to extend this time.

501.19-TOLERANCE IN PAVEMENT THICKNESS:

It is the intent of these Specifications that the pavement shall be constructed in substantial conformity with the specified thickness. Paving operations shall be directed toward obtaining an average and uniform thickness equal to or greater than the specified thickness.

For the purpose of establishing an adjusted unit price for pavement areas deficient in thickness, the thickness characteristics will be determined in accordance with the criteria specified.

501.19.1-Sampling Units and Sampling Requirements: The pavement thickness characteristics will be determined from an analysis of measurements made by non-destructive methods in accordance with MP 700.10.01. These measurements will be made by the Division with a frequency of one measurement from each sampling unit as defined. If the accuracy of a result from the non-destructive method is questioned by the Engineer, then a core shall be taken from the location at which the non-destructive measurement was taken. The subject core thickness shall then be used to verify the measurement from the non-destructive method, and if a difference of more than $\frac{1}{4}$ inch (6 mm) between the two measurements exists, the core measurement shall be used for acceptance purposes, instead of the non-destructive method measurement.

501.19.1.1-Highway Proper: The total length of paving lane in linear feet in the highway proper shall be divided by 500 to determine the largest whole number which shall be the number of sampling units in the highway proper. The width of the sampling unit shall be the width of the paving lane, and the length of the sampling unit shall be determined by dividing the total length of paving lane in linear feet in the highway proper by the number of sampling units determined in the manner set forth. When paving lane width exceeds 24 ft. (7.2 meters), the Division may establish shorter sampling units.

When the number as determined above is less than 10, the total length of the paving lane in linear feet shall be divided into 10 equal sampling units.

501.19.1.2-Auxiliary Features: Intersections, entrances, exits, crossovers, ramps, etc., may be considered individually or collectively so as to form sampling units most nearly the length previously established in the highway proper.

501.19.2-Deficient Thickness (Detection and Delineation): One thickness measurement will be taken, by the method outlined in MP 700.10.01, from each sampling unit. That thickness measurement shall represent the thickness of the pavement in that unit.

When a sampling unit is represented by a measurement which is less than the specified pavement thickness (T) minus 7.8%T ($T - 7.8\%T = 0.922T$), the sampling unit will be evaluated as set forth in 501.19.2.1.

501.19.2.1-When a thickness measurement, which represents a sampling unit, has a value of 0.922T or less, the area of deficient thickness in that sampling unit will be delineated by taking exploratory cores at approximately 20 ft. (6 m) intervals, parallel to the centerline, in each direction from the measurement taken in 501.19.2, until a core is obtained, in both directions, which is greater than 0.922T in thickness (length). Areas thus defined shall be removed and replaced at no additional cost to the Division. These exploratory cores will not be used in the analysis of the remainder of the unit. The balance of the sampling unit will be treated as a separate sampling unit.

One additional core will be obtained from another random location in that sampling unit and shall represent the thickness of the remainder of that sampling unit. The thickness of the sampling unit represented by this core, when greater than 0.922T, will be included in the measurements specified in 501.23.1.1.

501.19.3-Refilling of Cores: As soon as directions are issued by the Engineer, the Contractor shall refill and properly cure all test holes at no additional cost to the Division.

501.20-PAVEMENT WIDENING:

When called for on the Plans or directed by the Engineer to widen an existing pavement by means of strips of portland cement concrete, on one or both sides, the construction methods and materials shall be as specified for regular portland cement concrete pavement, except as modified.

- i. Compaction of the fine grade may be by means of an approved special roller capable of exerting a compressive force of not less than 100 lb. per in. (1.8 kg per mm) of width and as further prescribed in 207.9.
- ii. Forms may be of steel or wood. They shall be secured as required by the Engineer.

501.21-ADVERSE WEATHER CONDITIONS:

501.21.1-Cold Weather Concreting: When the component materials are not artificially heated and the temperature of the plastic concrete becomes less than 55° F (13° C), the provisions for cold weather concreting shall apply. The concrete shall have a temperature of at least 50° F (10° C) but not more than 85° F (30° C). This temperature shall be maintained by heating the water or aggregate, or both, as necessary. Heating methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The equipment shall be capable of heating materials uniformly. Aggregates or water shall not be heated to a temperature exceeding 150° F (65° C). Stockpiled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire. Binned aggregates may be heated by steam-coil or water-coil heating. The use of live steam on or through binned aggregates will not be permitted.

If the Contractor is placing concrete or plans to place concrete during cold weather conditions, the Contractor shall advise the Division of their plans for curing and protecting the concrete. The Division may, at any time, require the Contractor to provide additional protection to cause the provisions of this Specification to be met. When concrete is being placed and the air temperature is expected to fall below 35° F (2° C), a sufficient supply of suitable blanketing material shall be provided. Any time the air temperature is expected to reach the freezing point during the day of placement or the following night, the material so provided shall be spread over the pavement to a sufficient thickness to prevent freezing of the

concrete. The material shall be covered or otherwise secured to insure that it will remain in place for the duration of the curing period.

No concrete shall be placed on a frozen subgrade. Materials containing frost or lumps of frozen material shall not be used.

501.21.2-Hot Weather Concreting: The Contractor will be required to state, at the pre-construction conference, their plan of action when the temperature of plastic concrete reaches 90° F (32° C).

When a shaded thermometer in the vicinity of the production plant reaches 85° F (30° C), thermometer readings of the temperature of the plastic concrete shall be taken at least once per hour.

When the temperature of the plastic concrete reaches 85° F (30° C), the elapsed time between the introduction of the mixing water to the cement-aggregates and discharge of the mix shall not exceed 45 minutes. At this temperature or above, particular attention shall be paid to the Specification provisions concerning the sprinkling and wetting of subgrade and forms, the maintenance of coarse aggregate stock in saturated surface-dry condition, and the prompt start of concrete curing operations.

When the temperature of the plastic concrete reaches 90° F (32° C), immediate steps shall be taken to cool either mixing water or aggregates, or both, in order to maintain a plastic concrete temperature of 90° F (32° C), or less. Crushed or flaked ice may be used to cool the mixing water. Crushed or flaked ice may also be introduced into the mixing drum when the concrete is batched and mixed in a truck mixer. The ice will be considered as part of the mix water in the mix proportions. The mixing operation shall not be considered complete until all ice in the drum has melted.

In no event shall concrete be placed when its temperature in the plastic state, at the completion of mixing, exceeds 90° F (32° C).

501.22-METHOD OF MEASUREMENT:

The quantity of concrete pavement to be paid for will be the number of square yards (meters) complete in place and accepted. The width for measurement will be the width of the pavement shown on the typical cross section of the Plans and additional widening where called for or as otherwise directed in writing by the Engineer. The length will be measured on the surface along the centerline of each roadway ramp.

When Item 501009-* is specified in the project plans, the quantity of concrete overlay placement to be paid for will be the number of square yards (meters) complete in place and accepted. The width for measurement will be the width of the pavement or overlay shown on the typical cross section of the Plans and additional widening where called for or as otherwise directed in writing by the Engineer. The length will be measured on the surface along the centerline of each roadway and each roadway ramp.

When Item 501011-* is specified in the project plans the quantity of concrete used in concrete overlays to be paid for will be the number of cubic yards (meters) in place and accepted. The Engineer will measure the volume of concrete used in concrete overlays using the Contractor's certified batch tickets or other approved documentation.

Bridge approach expansion joints will be measured separately and shall be the actual number of joints constructed, complete in place and accepted.

In contracts where only widening is called for, the square yards (meters) of pavement widening will be determined from the length of strips, measured along the edges and upon the surface, times the width as measured at regular intervals, plus the area of any widening on curves, turnouts or intersections authorized and measured separately.

No extra payment will be made for removing and crushing the existing pavement for use as coarse aggregate for concrete.

501.23-BASIS OF PAYMENT:

501.23.1-General: The quantities, determined as provided above, will be paid for at the contract unit prices less adjustments referred to below, which shall constitute full compensation for furnishing and preparing of all materials, including reinforcing steel, transverse and longitudinal joints, expansion joint filler, elastomeric joint seals, silicone sealant, epoxy mortar for joint repair work, polyethylene tape, rope or rod joint back-up material, lubricant-adhesive for elastomeric seals, and dowels or load transfer devices as are required in the Plans; construction of any bond breaker/leveling course, milling existing surface; placing, finishing and curing concrete; and all labor, equipment, tools, field laboratory, supplies and incidentals necessary to complete the work.

501.23.1.1-The core measurements which represent the thickness of the sampling units shall be analyzed to determine the average value of the pavement thickness. This value will be used to determine the degree of compliance with the provisions set forth in 501.19 and to develop certain factors to be used in the derivation of equitable deductions as set forth in 501.23.1.2 and 501.23.1.3, in the event the provisions of this Specification are not met.

No payment will be made for pavement areas deficient in thickness by more than $7.8\%T$, the area being defined in the manner set forth in 501.19.2. Pavement which is deficient in thickness by more than 0.7 inches (18 mm) and is considered by the Engineer to be inadequate to perform satisfactorily shall be removed and replaced at no added cost to the Division. The balance of the item, the portion of the item not treated in the manner set forth above, will be treated in the manner set forth in 501.23.1.2 or 501.23.1.3.

501.23.1.2-When the average value of the pavement thickness is equal to or greater than the specified thickness, the quantity of pavement represented by this average thickness will be paid at the contract unit price.

501.23.1.3-When the average value of the pavement thickness is less than the specified thickness, the fraction of pavement having a thickness greater than $0.922T$ will be paid for at a unit price as set forth in the following schedule, and no payment will be made for the remainder of the pavement being considered.

SCHEDULE OF UNIT PRICES	
Average Value of Pavement Thickness	Unit Price as Percent of Contract Unit Price
0.01 to 0.10 inches (0.25 to 2.66 mm) Less Than Specified Thickness	98.0
0.11 to 0.20 inches (2.67 to 5.20 mm) Less Than Specified Thickness	96.0
0.21 to 0.30 inches (5.21 to 7.74 mm) Less Than Specified Thickness	94.0
0.31 to 0.40 inches (7.75 to 10.28 mm) Less Than Specified Thickness	92.2
0.41 to 0.50 inches (10.29 to 12.82 mm) Less Than Specified Thickness	90.3
0.51 to 0.60 inches (12.83 to 15.36 mm) Less Than Specified Thickness	88.4
0.61 to 0.70 inches (15.37 to 17.78 mm) Less Than Specified Thickness	86.5
More than 0.70 inches (17.78 mm) Less Than Specified Thickness	0.0

501.24-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
501001-*	"thickness" Reinforced Portland Cement Concrete Pavement	Square Yard (Meter)
501002-*	"thickness" Reinforced High-Early-Strength Portland Cement Concrete Pavement	Square Yard (Meter)
501003-*	"thickness" Reinforced Portland Cement Concrete Pavement Widening	Square Yard (Meter)
501004-*	"thickness" Reinforced High-Early Strength Portland Cement Concrete Pavement Widening	Square Yard (Meter)
501005-*	"thickness" Non-Reinforced Portland Cement Concrete Pavement	Square Yard (Meter)
501006-*	"thickness" Non-Reinforced High-Early-Strength Portland Cement Concrete Pavement	Square Yard (Meter)
501007-*	"thickness" Non-Reinforced Portland Cement Concrete Pavement Widening	Square Yard (Meter)
501008-*	"thickness" Non-Reinforced High-Early-Strength Portland Cement Concrete Pavement Widening	Square Yard (Meter)
501009-*	"thickness" Unbonded Portland Cement Concrete Overlay	Square Yard (Meter)
501010-*	Bridge Approach Expansion Joint	Each
501011-*	Unbonded Portland Cement Concrete Overlay	Cubic Yard (Meter)

* Sequence number
"thickness" in inches

SECTION 502 APPROACH SLABS

502.1-DESCRIPTION:

This work shall consist of reinforced Portland cement concrete approach slabs for bridges, constructed on the completed and accepted subgrade, subbase or other base course, in accordance with these Specifications and in reasonably close conformity with the lines, grades and dimensions specified on the Plans or established by the Engineer.

502.2-MATERIALS:

Materials for this work shall conform to the requirements for materials in 501 except as modified.

Class B concrete, under the provisions of 601, may be used in lieu of the concrete in 501, in which case materials and batching requirements for this work shall conform to the requirements for 601.

Compressive strength tests for acceptance of concrete shall be conducted in accordance with 601.4.4.

Reinforcing steel shall conform to the requirements prescribed in 602.

CONSTRUCTION METHODS

Construction methods and equipment used for this work shall conform to the requirements prescribed for construction methods and equipment in 501, except as modified.

502.3-FORMS:

Side forms may be of steel or wood. Forms shall not be removed for at least 24 hours after the concrete is placed.

502.4-PLACING:

The subgrade or base shall be thoroughly moistened immediately prior to placing the concrete. The concrete shall not be placed until the forms and reinforcing steel have been checked. The method and sequence of placing concrete shall be approved by the Engineer.

Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms.

502.5-JOINTS:

Approach slabs shall have longitudinal joints in line with the longitudinal joints of the adjacent pavement. Longitudinal joints shall be sawed to a minimum depth of one-fourth of the plan depth of the slab plus $\frac{1}{4}$ in. (6 mm); the width shall be $\frac{1}{4}$ in. (6 mm), with a tolerance of plus or minus $\frac{1}{16}$ in. (2 mm). Sawing shall be performed within five days after the slab is placed and prior to opening to construction traffic. Joints shall be sealed in accordance with the requirements of 501.17 and 503.

502.6-CURBS:

The safety curbs shall be constructed using the same type of concrete as for the approach slab and shall be in accordance with the Plans. The finish of the curb shall be in accordance with 610.

502.7-METHOD OF MEASUREMENT:

The quantity of work done will be measured in square yards (meters) of "Portland Cement Concrete Approach Slab" complete in place and accepted; the area will be measured to the extremity of the concrete.

502.8-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item below, which price and payment shall be full compensation for furnishing all materials including reinforcing steel, such transverse and longitudinal joints, joint filler, dowels and curbs, and all labor equipment, tools and incidentals necessary to complete the work.

502.9-PAY ITEM:

ITEM	DESCRIPTION	UNIT
502001-*	"thickness" Portland Cement Concrete Approach Slab	Square Yard (Meter)

* Sequence number
"thickness" in inches

SECTION 503

SEALING CRACKS IN CONCRETE PAVEMENT

503.1-DESCRIPTION:

This work shall consist of the cleaning and sealing of cracks in concrete pavement in the manner and subject to the conditions and regulation prescribed.

503.2-MATERIALS:

The sealant shall be in accordance with section 708.3.

The joint back-up material shall be in accordance with section 708.4.2, shall meet the requirements of the Sealant Manufacturer, and shall be appropriate for outdoor applications.

CONSTRUCTION METHODS

Old filler and foreign material in the cracks shall be removed. The cracks shall then be sealed as prescribed. Other means and/or methods recommended by the Sealant Manufacturer and approved by the Engineer may be used.

503.3-BLANK

503.4-PREPARATION OF MATERIAL BEFORE USE:

Before charging the compound into the melting unit, the unit shall be free from all foreign material. If the type of heater to be used requires that the sealing material as shipped, be cut into smaller pieces before melting, the method used is subject to approval by the Engineer.

The heating kettle used for melting sealing materials shall be of the indirect heating or double boiler type, using oil as the heat transfer medium. It shall have a thermostatically controlled heat source, a built-in automatic agitator, and thermometers installed to indicate both the temperature of the melted sealing material and that of the oil bath. Other methods of indirect heating approved by the Engineer may be used. A positive means of controlling the temperature of the heat transfer medium at all points in the system shall be incorporated in the heater. Sealing material shall be uniformly heated until the pouring temperature recommended by the Sealant Manufacturer is reached. Should the maximum recommended pouring temperature be exceeded, the material will be rejected. The material shall be poured as soon as possible after the pouring temperature is reached. Only sufficient material for the day's operation shall be heated each day. Other means and/or methods recommended by the Sealant Manufacturer and approved by the Engineer may be used.

503.5-PREPARATION OF JOINTS FOR SEALING:

Cracks should be widened with a crack saw to a minimum width of ½" (16 mm) and to a depth necessary to provide a 1:1 width to depth ratio including room for the backer rod. The cracks shall be thoroughly cleaned of all loose scale, dirt, dust, other foreign matter, old sealant and loosely stuck particles of mortar and aggregate, so that dry, sound, and clean surfaces result. The use of any tool which results in damage to the pavement is prohibited. Just prior to the actual sealing operation, the crack shall be thoroughly blown out with an air jet having sufficient volume and pressure to remove any loose material left by the cleaning operation. After the final cleaning, the back-up material shall be inserted into the crack in accordance with the Manufacturer's recommendations to provide the correct shape factor for the sealant.

503.6-EQUIPMENT FOR APPLYING SEALER:

The equipment used for the placing of sealing material in the cracks may consist of conventional hand pouring pots, individual mechanical pouring kettles mounted on wheels with a pouring shoe, or heating units from which material may be discharged into the joint through the use of flexible lines and suitable shoes. Any heat, which it may be necessary to apply to sealing material after it leaves the main heating unit, shall be applied by indirect and controlled methods as specified in 503.4. No direct heat will be permitted on the pouring unit in order to meet field controls set forth below. Any method of placing sealing material, which results in compliance with the following requirements, will be satisfactory.

503.7-PLACEMENT REQUIREMENTS:

After insertion of the back-up material and prior to becoming contaminated, the crack shall be sealed in accordance with the Sealant Manufacturer's recommendations. At the time of sealing, the crack faces shall be dry and dust free. The sealant shall be introduced into the crack in a continuous uniform operation to properly fill and seal the crack from the bottom upward in order to avoid trapping any air bubbles. The crack shall be sealed to within 1/8 to 1/4 inch (3 to 6 mm) below the pavement surface. Traffic shall not be allowed on the sealed joint for the minimum time recommended by the Sealant Manufacturer after placement, unless otherwise approved by the Engineer.

Sealant shall never be applied to frozen, dirty, wet, or damp concrete or during inclement weather conditions. Sealant shall not be placed in the cracks unless the temperature of the pavement is 40° F (4° C) or higher unless approved by the Engineer.

503.8-METHOD OF MEASUREMENT:

The quantity of work done will be measured in linear feet (meters) of "Sealing Cracks", when the item below is included in the contract.

503.9-BASIS OF PAYMENT:

The quantity of work, as described above, will be paid for at the contract unit price bid for the item below, which price and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in an acceptable manner, including all the labor, tools, equipment, supplies, and incidental items necessary to complete the work.

503.10-PAY ITEM:

ITEM	DESCRIPTION	UNIT
503001-*	Sealing Cracks in Concrete Pavement	Linear Foot (Meter)

* Sequence number

SECTION 504

BITUMINOUS UNDERSEAL FOR CONCRETE PAVEMENT

504.1-DESCRIPTION:

This work shall consist of drilling holes in portland cement concrete pavement at the locations shown on the Plans or where directed by the Engineer, pumping bituminous material through the holes, and sealing the holes with cement grout.

504.2-MATERIALS:

The materials shall meet the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Asphalt Cement	705.6
Fine Aggregate*	702.1
Portland Cement	701.1 & 701.3
Water	715.7

* The use of limestone sand will not be permitted.

Grout for sealing holes shall consist of one part Portland cement and three parts fine aggregate, mixed to the consistency directed by the Engineer.

CONSTRUCTION METHODS

504.3-GENERAL:

Holes of 1-1/2 in. (40 mm) diameter shall be drilled through the concrete pavement at the locations shown on the Plans or as directed by the Engineer. Bituminous material shall then be pumped through the holes and under the pavement by means of an approved type of pump.

Equipment for pumping shall be capable of developing a pressure of 80 lb. per sq. in. (550 kPa), the exact working pressure to be determined by the Engineer.

Prior to pumping, the surface of the concrete pavement around the previously drilled holes shall be thoroughly sprinkled with water or shall be covered with sand, earth or other suitable material in order to prevent any bitumen that may be spilled on the pavement from adhering to the surface. The nozzle shall then be inserted in the hole, driven to a snug fit, and pumping operations begun. Bituminous material shall be pumped through the holes and under the pavement until the voids under the pavement are completely filled, or the concrete pavement has been raised to the grade of existing adjacent pavement or to such grade as directed by the Engineer. At the first indication of an undesirable movement of the slab or a blowout, pumping shall immediately be discontinued. The connecting device placed in the drilled hole shall not be removed from the hole until the bitumen has cooled sufficiently to prevent backflow. At the time the bituminous material is pumped under the pavement, it shall have a temperature of not less than 400° F (205° C). The Contractor shall provide all necessary facilities for determining the temperature of the bituminous material in all heating equipment and distributors.

After completion of the pumping in each hole, all bituminous material shall be cleaned from the pavement surface and the drilled hole shall be filled with grout to an elevation flush with the pavement surface.

After the completion of subsealing operations, the pavement surface shall be left in a clean and neat condition satisfactory to the Engineer.

The bituminous material shall not be applied on a frozen subgrade, nor when the atmospheric temperature is below 40° F (5° C) and is falling, with the further provision that it shall be placed only when general weather conditions, in the opinion of the Engineer, are suitable.

504.4-METHOD OF MEASUREMENT:

The quantity of work done will be measured in gallons (liters) of "Bituminous Underseal Material" and in "Drilling Holes in Concrete Pavement" determined as follows: The quantity of "Bituminous Underseal Material" shall be the number of gallons (liters) incorporated in the completed and accepted work, which volume will be measured as prescribed in 109.1. The quantity of "Drilling Holes in Concrete Pavement" shall be the actual counted number of holes drilled and satisfactorily filled.

504.5-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials, including grout, and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

504.6-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
504001-*	Bituminous Underseal Material	Gallon (Liter)
504002-*	Drilling Holes In Concrete Pavement	Each

* Sequence number

SECTION 505-BLANK

SECTION 506

CONCRETE PAVEMENT REPAIR

506.1-DESCRIPTION:

This work consists of the removal and replacement of deteriorated concrete pavement and patches, and replacing subbase material where required, at locations as shown on plans or as specified by the Engineer.

The following is a description of each patch type:

i. **Jointed Concrete Pavement Patch, Type I:**

Patching shall consist of full depth, full lane width concrete pavement repairs equal to or greater than 6 feet (1.8 meters) in length. Type I patches shall be constructed in accordance with the Concrete Repair Details in the plans.

ii. **Jointed Concrete Pavement Patch, Type II:**

Patching shall consist of partial depth concrete pavement repairs that extend a minimum of 2 inches (50mm) and no deeper than one-half the slab thickness at cracks or no more than one-third the slab thickness at doweled joints. Type II patches shall be constructed in accordance with the Concrete Repair Details in the plans.

iii. **Jointed Concrete Pavement Patch, Type III:**

Patching shall consist of a repair along the edge of a transverse crack or joint that extends from the bottom of a partial depth repair (Type II) to potentially the full depth of the slab, and isolated within 12" of either the longitudinal joint or pavement edge. Type III patches shall be constructed in accordance with the Concrete Repair Details in the plans.

506.2-MATERIALS:

Materials shall meet the requirements of section 501 or 601, and as follows:

MATERIAL	SECTION OR SUBSECTION
Accelerating Admixtures	707.13
Curing Materials	707.6-707.10
Epoxy-Coated Dowel Bars	709.15
Joint Sealer	708.3, 708.4
Portland Cement Concrete	501 or 601
Subbase	307
Tie Bars and Hook Bolts	709.1

An approved epoxy grout shall be used to firmly anchor dowel bars in 30 minutes.

Cement meeting the requirements of ASTM C150, Type III may be used in the concrete mixes for concrete pavement repair.

506.3-PROPORTIONING:

Portland cement concrete for patching concrete pavement shall meet the requirements of Section 501, or Class B or Modified Class B as specified in Section 601, except that it shall be shown by compressive strength tests that the concrete mix shall attain 2,000 psi (13.8 Mpa) prior to the time at which the pavement will be opened to traffic, and an AASHTO number 8 coarse aggregate shall be required in Type II repairs with a depth of 3 inches (75 mm) or less.

Type III repairs may be placed simultaneously with Type II repairs. When constructed in this manner, the same concrete mix shall be used in both repair types.

Prior to the start of work, the Contractor shall submit the mix proportions and recent compressive strength test data for the specified age at which the concrete is to be opened to traffic.

506.4-TESTING:

All testing shall be in accordance with section 501. The Contractor shall fabricate a minimum of nine compressive strength cylinders for each 24 hour period of operation. Six of these nine field cured cylinders shall be field cured in a temperature and moisture condition as close as possible to that of the concrete in the repair area. When the average strength of three of these cylinders, representing the concrete placed, indicate that the concrete has attained the required strength for opening to traffic, that concrete may be put into service. These cylinders shall represent concrete produced from the batch from which they were fabricated and, if applicable, concrete from previous batches also. These cylinders will not represent any concrete which was placed after the time that they were fabricated. Three of the nine cylinders shall receive standard curing and shall be tested at 28 days to verify that the required strength at that age has been achieved.

In lieu of six field cured cylinders required above, the Contractor may use the Maturity Method for the Estimation of concrete strength, as outlined in MP 601.04.21 for determining when the pavement may be opened to traffic.

506.5-EQUIPMENT AND TOOLS:

Equipment and tools shall be in accordance with section 501 unless noted otherwise. Saw cutting equipment shall be capable of sawing neat vertical faces along the patch boundaries. The use of a carbide-toothed wheel saw shall not be permitted for sawing the patch boundaries. A carbide-tipped wheel saw may be used for additional saw cuts provided that a minimum 3-inch (75 mm) clearance from the sawed boundary is maintained.

506.6-CONSTRUCTION METHODS:

506.6.1-Removal of Existing Pavement: Designated defective pavement shall be removed full depth, and undisturbed portions of the existing pavement adjacent to the area to be patched shall be left with straight vertical sides.

The existing pavement to be removed shall be sawed full depth along the transverse and longitudinal boundaries, including the lane and shoulder/lane joints as shown on the plans or as directed by the Engineer. Additional saw cuts inside the patch boundaries will be permitted to facilitate the concrete removal operation.

Concrete sawn full depth to be removed shall be lifted out by means of chains, lift-pins, or other approved devices. The breaking of concrete in-place shall not be permitted. During the removal operations, utmost care shall be exercised to minimize disturbance and damage to the base material, and the adjacent pavement and shoulder.

506.6.2-Conditioning Existing Subbase: Prior to placing concrete in the repair area, any subbase material that is disturbed below the desired level of cleanout shall be removed and the patch area compacted to the satisfaction of the Engineer. Unsuitable subbase material, concrete, reinforcing steel, and any other debris shall become property of the Contractor and shall be legally disposed. The Contractor shall replace the removed subbase material with

concrete integral to pavement replacement up to a maximum 1-inch (25 mm) depth. In the event that soft areas are encountered in the subbase or subgrade, or if more than 1-inch (25 mm) of subbase material is removed, replacement of subbase and subgrade shall be in accordance with Section 307, testing shall be waived. When subbase or subgrade material is replaced, it shall be brought to grade and compacted to the satisfaction of the Engineer.

506.6.3-Placing Concrete: Unless behind permanent closures or unless otherwise approved by the Engineer, all excavated areas shall be patched the same day that they are excavated. The excavated area shall be thoroughly cleaned of loose material and debris and moistened prior to the placement of concrete.

Existing pavements shall not be removed if such removal will result in concrete being placed when the ambient air temperature is below 32° F, unless approved by the Engineer. Concrete for partial depth repairs shall not be placed when the ambient temperature is below 40° F. The concrete temperature at the time of placement shall not be less than 70° F and not more than 95° F, unless approved by the Engineer.

Concrete shall be deposited in the excavated area, and the free fall shall not be more than 3 feet (1 m). If the concrete does not fall into its final position in the patch, it shall be moved by means of shovels; raking is prohibited. The concrete shall be worked with tampers, spades, or other tools to completely fill the patch area. Maximum effort will be used to ensure that the area beneath the existing concrete pavement is completely filled. Internal vibration shall be used.

Following the placing of the concrete, the surface will be struck off to a finished grade and floated to a smooth finish. Finishing of the plastic concrete shall conform to the requirements of Section 501.12 of the Specifications, except that the final concrete surface shall be textured similar to that of the adjoining pavement.

506.6.4-Straightedge Checking and Surface Correction: During finishing operations, deviations in adjacent lanes which are also to be repaired shall not be transferred to the new construction. The Contractor shall furnish and use straightedges to check the surface tolerance. For patches 10 feet (3 m) or more in length, a 10 foot (3 m) straightedge shall be used. Shorter straightedges shall be used for patches less than 10 feet (3 m) in length.

The minimum length straightedge shall be 6 feet (1.8 m). Section 501.12.6 shall govern except that the shorter straightedges shall be used for shorter patches.

506.6.5-Curing: Immediately after straight edging and texturing, the concrete shall be cured in accordance with Section 501.14. Where early opening to traffic is required, insulation mats or blankets may be used over the repairs during curing in order to accelerate strength gain.

506.6.6-Sealing Joints: When patching two lanes simultaneously, the longitudinal joint shall be reestablished by sawing. Joint sealing shall be done in accordance with Section 510.

506.6.7-Repair of Adjacent Shoulders: Within 24 hours after completion of a patch area, any adjacent shoulders damaged during pavement repair operations shall be reconstructed in accordance with the requirements of the applicable section of the specifications to match the finished shoulder grade and to the satisfaction of the Engineer. In the event traffic is to be

permitted on the patch area prior to reconstruction of the shoulder, the Contractor shall first make such temporary repair to the shoulder as is necessary to avoid any hazardous condition.

506.6.8-Specific Construction Methods: Construction methods specific to each repair type are noted in the following sections.

506.6.8.1-Type I Repairs: Where the existing joint dowel assembly is to be removed, the existing concrete shall be saw cut full depth and removed a minimum of 1 foot (300 mm) on either side of existing transverse joints. Minimum length of removal shall be 6 feet (1.8 m) in accordance with that shown in the WVDOH Concrete Repair Details.

Oversawing into the adjacent slabs or shoulder shall be kept to the minimum amount necessary to ensure that full depth cuts in the corners have been achieved. All oversawing shall be cleaned and filled with an approved epoxy material.

Any areas damaged during concrete sawing and removal operations shall be repaired to the satisfaction of the Engineer by extending the patch boundary or repairing spalls at the Contractor's expense. Spalls greater than ¼ inch (6 mm) wide and 2 inches (50 mm) long and more than ½ inch (13 mm) deep below the pavement surface shall be repaired using an approved epoxy mortar. The patch boundary shall be extended by re-sawing the limits of the patch beyond the spalled area when spalls greater than 1 inch (25 mm) wide and 12 inches (300 mm) long and more than ½ inch (13 mm) deep below the pavement surface are created by the pavement removal operation.

A bond breaking material, approved by the Engineer, shall be placed at the longitudinal joint for Type I patches as shown in WVDOH Concrete Repair Details. Acceptable bond-breaking materials include white pigmented curing compound, roofing felt, and tar paper.

Where dowels are required, holes slightly larger than the diameter of the dowels shall be drilled 9 inches (225 mm) into the face of the existing slab starting 6 - 12 inches (150 – 300 mm) from either edge and then on 12 inch (300 mm) centers. The number of dowels per joint shall be as shown in the WVDOH Concrete Repair Details. The holes shall be located at a depth as shown in the WVDOH Concrete Repair Details. The dowels shall be carefully aligned (within ¼ inch (6 mm)) with the direction of the pavement and parallel to the plane of the surface. An approved quick setting, non-shrinking mortar or an approved high viscosity epoxy shall be used to anchor the dowels in the holes. The holes shall be completely filled around the dowels so as to minimize vertical movement of the dowels and ensure that the dowels are permanently fastened to the existing concrete. The epoxy or grout is to be put into the hole in sufficient quantity so that when the bar is inserted, the material completely fills the annular space around the dowel. The holes shall be filled from the back to the front with epoxy or grout prior to insertion of the dowel. Dipping of the dowels into epoxy or grout prior to insertion into the holes is not permitted. A grout retention ring shall be used as shown in the WVDOH Concrete Repair Details.

The surface edges of all patches shall be tooled, formed and/or sawed, and cleaned to result in a properly dimensioned reservoir for sealant. All transverse and longitudinal joints at pavement repair locations shall be sealed in accordance with manufacturer's recommendations unless otherwise approved by the Engineer.

506.6.8.2-Type II Repairs: Full lane-width partial depth repairs at transverse joints and cracks and at longitudinal joints 12 feet or more in length shall be a minimum of 18 inches (450 mm) wide, with the vertical face of the repair being no less than 6 inches (150 mm) from the crack or the joint. Partial depth repairs shall be sawed a minimum depth of 2 inches (50 mm) around the perimeter of the patch area to provide a vertical face at the edges unless removal is to be performed with milling operations. Acceptable milling operations shall provide neat vertical faces and be approved by the Engineer. Concrete within the patching area shall be broken out with a pneumatic hammer not heavier than a 35-pound class or by other methods approved by the Engineer. Edge spalls greater than ¼ inch (6 mm) wide and 2 inches (50 mm) long and more than ½ inch (50 mm) deep below the pavement surface shall be repaired using an approved epoxy mortar. The patch boundary shall be extended by re-sawing the limits of the patch beyond the spalled area when spalls greater than 1 inch (25 mm) wide and 12 inches (300 mm) long and more than ½ inch (13 mm) deep below the pavement surface are created by the pavement removal operation.

The area of failure shall be removed by equipment that will not damage the adjacent sound pavement. The exposed faces of the concrete shall be free of loose particles, oil, dust, and other contaminants before placement of patch material. Immediately prior to placement of the concrete patch, all exposed concrete faces within the patched area shall be cleaned by sandblasting, then airblasting, then coated with an approved epoxy bonding compound per the manufacturer's recommendations. All residues shall be removed just prior to placement of the concrete bonding agent.

Any crack or joint within the limits of, or adjacent to, the partial depth repair shall be re-established by forming with an acceptable material in order to follow the crack or joint alignment. The method and material used to re-establish the crack or joint shall be approved by the Engineer. However, at joint repairs, sawcutting through the full-depth of the repair area may be used to fully re-establish the joint being repaired. Additionally, the Contractor shall saw and seal existing joints and cracks, involving partial depth repairs, in accordance with Section 510.

506.6.8.3-Type III Repairs: "Turned Down Edge" repairs at transverse joints and cracks shall extend no more than 12 inches (300 mm) into the slab from the edge of pavement whether at the outside or along an interior longitudinal joint. Concrete within the patching area shall be broken out with a pneumatic hammer not heavier than a 35-pound class or by other methods approved by the Engineer. The area of failure shall be removed by equipment that will not damage the adjacent sound pavement.

Number 4 tie bars, 10 inches (250 mm) in length, shall be inserted into the exposed vertical faces within the repair area. One bar shall be placed per one-foot (300 mm) of exposed face, or fraction thereof, on each side of the transverse crack or joint. The bar(s) shall be inserted at mid-depth of the slab, allowing for five inches (125 mm) of length to extend into the area to be repaired. The hole(s) for placement of the tie bar(s) into the exposed vertical face of the slab shall be slightly larger than the diameter of the bar and shall be drilled at an angle in order to allow for drill clearance. Additionally, a minimum clearance of one inch shall be maintained around the hole for placement of concrete. The holes shall be filled from the back to the front with epoxy or grout prior to insertion of the bar. Dipping of the bars into epoxy or grout prior to insertion into the hole is not permitted.

The bar should be bent prior to insertion into the grouted hole such that the exposed portion of the bar within the area being repaired shall be parallel with the pavement surface. No bars shall be placed in a manner that would interfere with free movement of the joint or crack being repaired and re-established.

The exposed faces of the concrete shall be free of loose particles, oil, dust, and other contaminants before placement of patch material. Immediately prior to placement of the concrete patch, all exposed concrete faces within the patched area shall be cleaned by sandblasting, then airblasting, then coated with an approved epoxy bonding compound per the manufacturer's recommendations. All residues shall be removed just prior to placement of the concrete bonding agent.

Any crack or joint within the limits of, or adjacent to, the repair shall be re-established by forming with an acceptable material in order to follow the crack or joint alignment. However, at joint repairs, sawcutting through the full-depth of the repair area may be used to fully re-establish the joint being repaired. The method and material used to re-establish the crack or joint shall be approved by the Engineer. Additionally, the Contractor shall saw and seal existing joints and cracks, involving partial depth repairs, in accordance with Section 510.

506.7-RIDE ACCEPTANCE:

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 10 foot (3 m) straightedge. The straightedge shall be placed in successive positions parallel to the road centerline, matching existing wheel paths. Areas showing deviations (either high or low) of more than $\frac{1}{4}$ inch (6 mm) in 10 feet (3 m) shall be marked and corrected down with approved grinding equipment to an elevation where the surface deviations will not be more than $\frac{1}{4}$ inch in 10 feet (3 m). All joint sealing operations shall be performed after any grinding operations.

In the event that the deviation cannot be corrected to $\frac{1}{4}$ inch (6 mm) or less (either high or low) in 10 feet (3 m), the areas shall be removed and replaced at the discretion of the Engineer and at the Contractor's expense. All areas or sections so removed shall not be less than 6 feet (1.8 m) in length or less than full width of the traffic lane involved. Any remaining portion of the slab adjacent to the joints that is less than 6 feet (1.8 m) in length shall also be removed and replaced. Where concrete repairs are made that are to be overlaid, the smoothness criteria is waived for the concrete repair.

506.8-METHOD OF MEASUREMENT:

The quantity of concrete pavement repair to be paid for will be the number of square yards (meters) complete in place and accepted for all Type I and Type II repairs.

For Type III repairs, each location complete in place and accepted will be paid for.

506.9-BASIS OF PAYMENT:

The quantity of concrete pavement repair, determined as provided above, will be paid for at the contract unit price and shall constitute full compensation for the furnishing, hauling, and placing of all materials, saw cutting pavement to the required depth, the removal and disposal of old concrete, preparing of sublayer, furnishing and installing steel dowels, furnishing and installing reinforcing steel as specified, furnishing, placing, finishing, and curing the concrete, cleaning and sealing joints, patch area protection, and for all other materials, labor, tools, equipment, and incidentals necessary to complete the item.

506.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
506001-003	Concrete Pavement Repair, Type I, “thickness”	Square Yard (Meter)
506001-004	Concrete Pavement Repair, Type II	Square Yard (Meter)
506001-005	Concrete Pavement Repair, Type III	Each
506003-*	Replace Existing Aggregate Base Course	Ton (Megagram)

- * Sequence number
“thickness” shall be in inches

SECTION 507

CRACK AND POTHOLE REPAIR

507.1-DESCRIPTION:

This work shall consist of repairing an existing concrete pavement surface prior to resurfacing with hot-laid asphalt concrete in accordance with these specifications.

507.2-MATERIALS:

The materials shall conform to the requirements of the following sections.

MATERIAL	SECTION
Fine Aggregate	702.3
Hot-Mix Asphalt Base Course	401
Performance Graded Binder	705.5
Tack Coat	408

507.3-CONSTRUCTION METHODS:

All cracks in excess of 1 in. (25 mm), but less than 3 inches (75 mm) in width, shall be thoroughly cleaned of all dirt, debris, loose or other foreign or unstable material and filled with a mixture of sand and asphalt. The asphalt content shall be 5 to 10%. Asphalt mixture shall be applied at a temperature range of 250° to 325° F (120° C to 162° C).

All cracks in excess of 3 inches (75 mm) and all potholes greater than 1 in. (25 mm) in depth, shall be thoroughly cleaned of all dirt, debris, loose or other foreign or unstable material. After cleaning, the cracks and potholes are to be tacked, in accordance with Section 408 of the Specifications, and filled with asphalt concrete base course material in accordance with 401 or as approved by the Engineer.

Prior to resurfacing, all cracks and potholes are to have the same finished grade as the adjacent surfaces.

507.4-METHOD OF MEASUREMENT:

The quantity of work done for crack and pothole repair will be measured by the actual number of tons (megagrams) of material used for crack and pothole repair and shall include cleaning, tack material, asphalt, sand, asphalt concrete base course complete in place and accepted.

507.5-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the item listed below, which price and payment shall be full compensation for furnishing all the materials, and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

507.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
507002-*	Crack And Pothole Repair	Ton (Megagram)

* Sequence number

SECTION 508 DIAMOND GRINDING

508.1-DESCRIPTION:

This work consists of diamond grinding portland cement concrete pavement and roadway surfaces of structures to provide good riding characteristics, a surface texture and proper drainage.

508.2-EQUIPMENT:

Grinding shall be done utilizing diamond blades mounted on a self-propelled machine designed for grinding and texturing pavement. The equipment shall have a minimum weight, including the grinding head, of 35,000 lbs (15,875 kg) and of a size that will grind a strip at least 3 feet (1 meter) wide. Grinding equipment that causes raveling, aggregate fractures, spalls, or disturbance to the transverse or longitudinal joints shall not be permitted. The equipment shall have a positive means of vacuuming the grinding residue from the pavement surface and will leave the pavement in a clean condition.

508.3-CONSTRUCTION:

The construction operation shall be scheduled and proceed in a manner that produces a neat, uniform, finished surface. Auxiliary or ramp lane grinding shall transition from the edge of the mainline as required to provide drainage and an acceptable riding surface. Pavement repair, if required, shall be completed prior to any grinding. Joint resealing shall be completed subsequent to all diamond grinding operations.

Grinding shall be accomplished in a manner that eliminates joint or crack faults and provides lateral drainage by maintaining a constant cross slope between grinding extremities in each lane. The cross slope of the pavement shall be as shown on the plans and shall have no depressions or misalignment of slope greater than 1/4 inch (6 mm) in 12 feet (3.7 meters) when measured with a 12-foot (3.7 meter) straightedge placed perpendicular to the centerline. Areas of deviation shall be reground. Straightedge requirements will not apply across longitudinal joints or outside the ground area. Areas that display a ridge in excess of 1/4 inch (6 mm) at the pavement shoulder interface shall be diamond ground a minimum width of 2 feet (0.6 meters) on to the shoulder and paid for at the Contractor's bid price.

Grinding shall begin and end at lines normal to the pavement centerline at the project limits. No unground surface area between passes will be permitted.

508.4-FINAL SURFACE FINISH:

The grinding process shall produce a pavement surface which is true to grade and uniform in appearance with a longitudinal line-type texture. The line-type texture shall contain corrugations, parallel to the outside pavement edge, which present a narrow ridge corduroy type appearance. The peaks of the ridges shall be 1/8 inch $\pm$ 1/16 inch (3 mm $\pm$ 1.5 mm) higher than the bottoms of the groove with evenly spaced ridges having a width that measures within the ranges listed in the table below:

TABLE 508.4

Type of aggregate used in the pavement	Limestone	Gravel
Blade segment thickness minimum	0.120 inch (3.0 mm)	0.120 inch (3.0 mm)
Blade segment thickness maximum	0.130 inch (3.3 mm)	0.130 inch (3.3 mm)
Land area between grooves*	0.090 to 0.120 inch (2.3 to 3.0 mm)	0.080 to 0.110 inch (2.0 to 2.8 mm)

* Based on an average of a minimum of five measurements per lane mile (1600 meters) of pavement ground.

It shall be the Contractor's responsibility to select the number of grooves per foot (meter) to be used to produce the previously described surface finish for each aggregate type that may be present in the concrete surface on the project. The engineer may require removal of unbroken fins at the contractor's expense. At a minimum, 95% of the pavement surface shall be textured. Depressed pavement areas due to subsidence or other localized causes will be excluded from this requirement when approved by the engineer.

508.5-SLURRY REMOVAL:

All residue from the pavement surface shall become the responsibility of the Contractor and shall be removed and disposed of legally in a manner and at a location which satisfies environmental regulations.

Solid residue shall be removed from the pavement surface before any residue is blown by traffic action or wind. Residue shall not be permitted to encroach on open lanes. The residue shall not enter into gutters or closed drainage systems. Erosion control items that help prevent slurry discharge into drains and culverts (etc.) may be necessary to ensure that uncontrolled slurry releases are prevented.

508.6-SMOOTHNESS REQUIREMENTS:

An initial profile index of representative portions of the pavement will be available through the Engineer upon written request. After the contract is awarded, the initial profile index will be available from the Engineer. This information represents a summary of conditions found to exist at the time the survey was made. If this IRI testing is conducted more than 180 calendar days prior to the scheduled beginning of the work, the Engineer or Contractor may request new IRI testing. This information is provided to give the Contractor an idea of the condition of the pavement in regard to smoothness when bidding on this work. The Contractor assumes the risk of error if the information is used for any purpose other than the intended purpose. Prior to performing any grinding work, the Contractor shall provide a profile trace utilizing light weight profiler (LWP) equipment approved by the Engineer. This profile trace will be used to identify the required smoothness for the project. Each segment of the finished ground surface shall have a final profile index of:

- i. For speeds greater than 45 mph (70 kph) - 80 in/mile (1.26 m/km) IRI or a minimum 30 percent improvement.
- ii. For speeds 45 mph (70 kph) or less and pavements that do not warrant the increased level of smoothness -135 in/mile (2.13 m/km) IRI or a minimum 30 percent improvement.

The profile trace shall be run in both wheel paths and averaged for acceptance. The Engineer may test for smoothness and bumps near the center line and at other spot locations where compliance is questionable. Additional grinding may be required.

The finished ground surface shall not include any bumps exceeding 0.3 inch in 25 feet (7.5 mm in 8 m). Depressed pavement areas due to subsidence or other localized causes and areas where the maximum cut at mid panel or a fault restricts further grinding, will be excluded from testing when approved by the Engineer.

508.7-METHOD OF MEASUREMENT:

Grinding of pavement will be measured by the square yard (meter). The square yards (meters) measured will be the final textured surface area regardless of the number of passes required to achieve acceptable results. Minor areas of untextured pavement within the designated areas to be textured will be included in the measurement.

508.8-BASIS OF PAYMENT:

Grinding will be paid for at the contract unit price per square yard (meter). Payment shall be full compensation for all labor, equipment, material, and incidentals to complete this work, including hauling and disposal of grinding residue.

508.9-SMOOTHNESS:

Smoothness of the riding surface shall be determined by the Engineer using an inertial profiler. Smoothness incentives based on the International Roughness Index (IRI) shall be as follows:

TABLE 508.9-ENGLISH

Posted Speeds $\leq$ 45 mph		Posted Speeds $>$ 45 mph	
Final IRI (inches/mile)	Incentive (\$ per 0.1 mile section)	Final IRI (inches/mile)	Incentive (\$ per 0.1 mile section)
0.00 - 70.00	\$450.00	0.00 - 50.00	\$450.00
70.01 - 100.00	$-11 * (IRI) + 1220.00$	50.01 - 65.00	$-22 * (IRI) + 1550.00$
100.01 - 135.00	\$0.00	65.01 - 80.00	\$0.00

TABLE 508.9-METRIC

Posted Speeds $\leq$ 70 km/h		Posted Speeds $>$ 70 km/h	
Final IRI (meters/km)	Incentive (\$ per 0.1 km section)	Final IRI (meters/km)	Incentive (\$ per 0.1 km section)
0.0000 - 1.1048	\$450.00	0.0000 - 0.7892	\$450.00
1.1050 - 1.5784	$-950 * (IRI) + 1499.56$	0.7893 - 1.0259	$-1899.54 * (IRI) + 1949.12$
1.5785 - 2.1308	\$0.00	1.0261 - 1.2627	\$0.00

508.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
508001-*	Slurry Removal	Lump Sum
508002-*	Erosion Control Items For Prevention Of Slurry Release	Lump Sum
508003-*	Final Textured Surface Area Of Diamond Ground Pavement	Square Yard (Meter)

* Sequence number

SECTION 509-BLANK

SECTION 510

RE-SEALING CONCRETE PAVEMENT JOINTS

510.1-DESCRIPTION:

This work includes all labor, equipment, and material required to remove existing sealers, clean the joint, and seal the joint with a sealant meeting the requirements of section 510.2. The location of the joints to be sealed shall be as shown in the plans or as directed by the Engineer.

510.2-MATERIALS:

The joint sealant shall be in accordance with either section 708.3 or 708.4.

The joint back-up material shall be in accordance with section 708.4.2, shall meet the requirements of the Sealant Manufacturer, and shall be appropriate for outdoor applications.

510.3-CONSTRUCTION METHODS:

510.3.1-Joint Preparation: All spalls along the joint which are directed by the Engineer to be repaired, shall be repaired as specified in section 506 for partial depth repair. The spalls shall be repaired prior to resealing the joint. Existing joint sealer or sealant shall be removed from the joint groove as designated by the Engineer.

Where re-sealing in an area of previously installed sealant, a fresh sawcut shall be made to provide a clean face for the new sealant to bond. The new sawcut shall provide a joint groove of adequate width and depth to provide a width to depth ratio (shape factor), including joint back-up material, of 1:1 for hot-poured sealant and 2:1 for silicone sealant. Any damage done to newly placed sealant by re-sawing operations shall be repaired to the satisfaction of the Engineer. The longitudinal joints shall be sawed prior to resealing the intersecting transverse joints.

Immediately following the final sawing operation, both vertical faces of the joint shall be completely free of dirt and dust; leaving a clean dry, newly exposed concrete surface. Joints shall be cleaned by sandblasting each vertical face with the nozzle held at an angle to the joint face and within 1 or 2 inches (25 to 50 mm) of the pavement. Sandblasting shall be done to a depth at which the sealant and backer rod are to be installed.

Just prior to installing the back-up material, the joints shall be blown out with compressed air at a pressure of at least 90 psi (620 kPa) to remove all dust, loose particles, and debris. Air compressors used for this purpose shall be equipped with traps capable of removing moisture and oil from the compressed air. A joint shall not be sealed until it is thoroughly clean and dry.

After the final cleaning, the back-up material shall be inserted into the joint groove in accordance with the Manufacturer's recommendations to provide the correct shape factor for the sealant being used.

510.3.2-Joint Sealing: After insertion of the back-up material and prior to becoming contaminated, the joint groove shall be sealed in accordance with the Sealant Manufacturer's recommendations. At the time of sealing, the joint groove faces shall be dry and dust free. The sealant shall be pumped into the joint groove in a continuous uniform operation to properly fill and seal the joint groove from the bottom upward in order to avoid trapping any air bubbles. Tooling of the sealant, in order to force the sealant against the joint faces and provide a slightly concave surface with a depth of approximately ¼ in. (6 mm) (at the center of the joint) below

the pavement surface, is required unless otherwise directed by the sealant manufacturer. When not tooled, the joint groove shall be sealed flush to within 1/8 to 1/4 inch (3 to 6 mm) below the pavement surface. Traffic shall not be allowed on the sealed joint for the minimum time recommended by the Sealant Manufacturer after tooling or placement, unless otherwise approved by the Engineer.

Sealant shall never be applied to frozen, dirty, wet, or damp concrete or during inclement weather conditions. Sealant shall not be placed in the joints unless the temperature of the pavement is 40° F (4° C) or higher unless approved by the Engineer.

510.4-METHOD OF MEASUREMENT:

The quantity of re-sealing concrete pavement joints to be paid for will be the number of linear foot (meters) complete in place and accepted.

510.5-BASIS OF PAYMENT:

Re-sealing concrete pavement joints will be paid for at the contract unit price per linear foot (meter). Payment shall be full compensation for all labor, equipment, material, and incidentals required to remove all existing sealers or sealants, clean the joint groove, install the back-up material, and seal the joint with sealant.

510.6-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
510001-*	Re-Sealing Transverse Concrete Pavement Joints	Linear Foot (Meter)
510002-*	Re-Sealing Longitudinal Concrete Pavement Joints	Linear Foot (Meter)

* Sequence number

SECTION 511 DOWEL BAR RETROFIT

511.1-DESCRIPTION:

Dowel bar retrofit consists of installing epoxy-coated, round steel dowels into existing concrete pavement across transverse joints and/or cracks. Slots are cut using diamond-tipped saw blades, the existing concrete is removed, the dowels are placed in the slots across the joints or cracks, and the slots are backfilled.

511.2-MATERIALS:

Materials shall meet the requirements of the following Sections:

MATERIAL	SECTION OR SUBSECTION
Bond Breaker	511.2.1 or 707.9
Caulking Filler	511.2.1
Dowel Bar Support Chairs	511.2.1
Epoxy-Coated Dowel Bars	709.15
Expansion Caps	511.2.1
Foam Core Insert	511.2.1
Non-Shrink Concrete Backfill Material	ASTM C 928 and 511.2.1

511.2.1-Material Requirements:

Bond Breaker: Acceptable bond-breaking compounds include white pigmented curing compound or other approved bond breaker materials. Apply bond breaker coating on all surfaces of the dowel bar, either at the manufacturing facility before shipment, or on-site. Do not apply bond breaker while the dowel bars are in place within the pavement section.

Dowel Bar End Caps (Expansion Caps): Use tight-fitting, commercial quality end caps made of a non-metallic, non-organic material that allow for ¼ inch (6 mm) of movement at each end of the dowel bar.

Dowel Bar Support Chairs: Use chair devices for supporting the dowel bars that conform to the epoxy-coated steel requirements of ASTM A884/A884M, or are fabricated from commercial quality, nonmetallic, non-organic material. Dowel bar chairs are used to firmly hold the dowels centered in the slots during backfill operations.

Design the dowel bar chairs to hold the bar a minimum of ½ inch (13 mm) above the bottom of the slot while the backfill material is placed and consolidated.

Foam Core Insert: Use a foam core insert to re-establish the joint or crack. The insert shall consist of rigid styrofoam material or closed cell foam, faced with poster board or plastic material. The foam core insert (joint/crack re-former) allows each side of the slot to expand and contract. Ensure that the insert extends up to the bottom of the existing joint sealant reservoir.

Caulking Filler: Acceptable silicone caulking filler used for sealing the existing transverse joint or crack at the bottom and sides of the slot includes any commercial silicone caulk designed as a concrete sealant that is compatible with the patch material being used. Caulking filler is used to prevent backfill material from flowing into the joint or crack.

Non-Shrink Concrete Backfill Material – Use concrete backfill material tested as Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs in accordance with ASTM C 928. Only use material that: (1) provides a compressive strength of 3000 psi (21 MPa) prior to the time anticipated for opening to traffic; (2) has a calculated minimum durability factor of 90 percent at the end of 300 freeze-thaw cycles per ASTM C 666; and (3) has a total chloride ion content less than 0.75 lb/yd³ (450 g/m³). Provide certified material test results, for this material, from an approved independent testing laboratory to the Engineer at least 30 calendar days prior to any placement operations. A manufacturer's representative shall be on-site at the beginning of the backfill operation.

511.2.2-Material Submittal Requirements: Submit samples of the following materials to the Engineer for approval prior to the installation of the following items:

- Dowel Bar End Caps
- Dowel Bar Support Chairs
- Foam Core Insert
- Caulking Filler

Submit the material samples at least 30 calendar days prior to use or at the pre-construction conference, whichever occurs first.

511.3-CONSTRUCTION METHODS:

Install dowel bars in the existing portland cement concrete pavement at locations as shown in the plans. When retrofitting existing doweled joints, the Contractor shall be responsible for locating any existing dowel bars. The location of the retrofit dowel slots shall be adjusted so that the retrofit slots are mid-way between pairs of existing dowels. The Contractor shall use non-destructive testing methods, such as the MIT Scan-2 technique, as approved by the Engineer, to confirm the locations of any existing dowels.

511.3.1-Saw Cutting: Make two saw cuts in the pavement to outline the longitudinal sides of each dowel bar slot. These saw cuts shall be parallel to each other and shall create a slot which is $2\frac{1}{2} \pm \frac{1}{8}$ inches (63 ± 3 mm) wide. Saw to a depth and length that allows the center of the dowel to be placed at mid-depth in the pavement slab. The slots shall be sawed so that half the length of each dowel bar is located on either side of the transverse joint and/or crack. Saw slots parallel to each other and to the centerline of the roadway with a maximum tolerance of $\frac{1}{4}$ inch (6 mm) per 12 inches (300 mm) of dowel bar length. Use saws equipped with gang mounted diamond blades capable of cutting a minimum of three or four slots simultaneously in each wheel path. Skewed joints or cracks may require slots longer than the length specified in the plans.

Pick up and remove water and residue from the pavement surface immediately by means of a vacuum attachment on the sawing machine. This material shall become property of the Contractor and shall be disposed of in accordance with all applicable local, state, and federal regulations.

For smaller projects, a slot sawing machine might not be feasible. The Engineer may approve the use of walk-behind saws for slot cutting when the project contains less than 100 retrofit bars. The Contractor shall take additional steps to ensure proper slot alignment and spacing when using walk-behind saws for creating the slots.

511.3.2-Concrete Removal: Use maximum weight 30 lb (14 kg) jackhammers to remove the concrete remaining between the saw cuts. If the concrete removal operations cause damage to the pavement that is to remain, discontinue concrete removal operations and only resume after taking corrective measures. Repair or replace pavement damaged during concrete removal operations at no additional expense to the owner and to the satisfaction of the Engineer.

During concrete removal operations, use appropriate equipment as necessary to produce a flat, level surface within the slot, so the backfill flows and consolidates under the dowel bars. Dispose of any debris generated during concrete removal operations outside the right-of-way in accordance with Section 207.

Installation of retrofit dowels, with dowel bars and placement of backfill must be completed prior to reopening the lane to public traffic.

511.3.3-Slot Cleaning and Preparation: Sandblast all exposed surfaces in the dowel bar slot to remove saw slurry and debris such that clean aggregate is exposed. After sandblasting, clean the slot by blowing with moisture-free, oil-free compressed air having a minimum pressure of 150 psi (1 MPa) to remove any dust, residue, or debris left in the slot.

511.3.4-Sealing Joints and Cracks in Slot: Seal the existing transverse contraction joint and/or all cracks at the bottom and the sides of the dowel bar slot with an approved caulking filler to prevent any of the backfill material from entering these areas. Prior to sealing, ensure that surfaces receiving the caulking filler are clean and free of moisture. Do not extend the caulking filler beyond 3/8 inch (9.5 mm) of each side of the existing joint or crack.

511.3.5-Placing Dowel assembly in slot: Use good construction practices to prevent contamination of the cleaned slot before or while placing dowel assemblies to limit the potential of bonding loss with the backfill material.

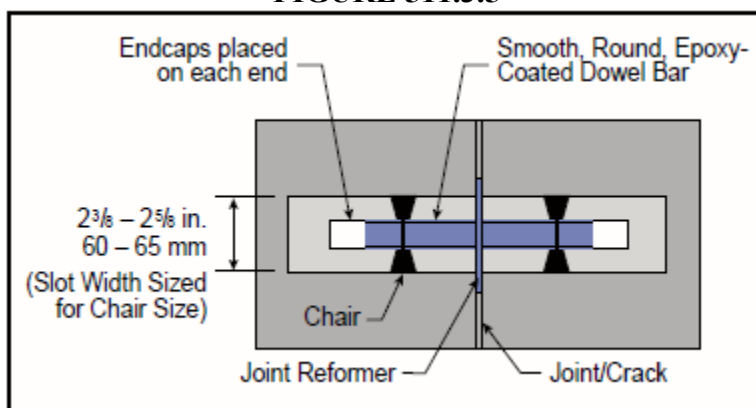
Refer to Figure 511.3.5 as a guide for dowel bar placement in the slot.

Dowel bar end caps shall be installed on the end of each dowel bar, and an approved bond breaker material shall be applied to each dowel bar prior to placement of the bar in the slot.

Place the dowel bars in the slots to within 5% tolerance of the depth shown on the plans, and parallel to the traffic lane centerline and top of roadway surface within a tolerance of 1/4 inch (6 mm) per 12 inches (300 mm) of dowel bar length. Center dowels at the transverse joint or crack, such that approximately one-half of the dowel extends into each adjacent panel. Cease and adjust operations if the chairs do not hold dowel bars securely in place during placement of the backfill material.

Place a foam core insert at the middle of the dowel bar and 2 inches (50 mm) below the surface of pavement. Place the insert so it covers the existing transverse joint or crack and is capable of remaining in a vertical position, tight to all edges during backfill placement operations. Re-establish the joint or crack above the foam core insert within 4 hours of backfill placement by means of sawing when the backfill material has hardened sufficiently.

FIGURE 511.3.5



511.3.6-Mixing and Placing Backfill Material: Mix backfill material in accordance with the manufacturer's instructions and the specifications. Refer to manufacturer's information on handling, mixing, and placing backfill material.

Take extreme care regarding backfill material mix proportions, water cement ratio, and the condition of the mixing equipment. Improper mix proportioning and/or inefficient mixing apparatus can result in premature deterioration of the backfill material. When using auger type mixing equipment, take steps to keep the auger flights free from material buildup, causing inefficient mixing operations.

Fill each dowel bar slot with backfill material after placement of the caulking filler, the dowel bar, expansion caps, support chairs, and the foam core insert. Ensure that the foam core inserts remain upright and over the existing joint or crack during the backfill process. Vibrate the backfill material with a small hand held vibrator capable of thoroughly consolidating the backfill material into the slot around the dowel bars and support chairs.

Place backfill while fresh, and before the backfill has taken an initial set. Do not re-temper the backfill with water. Discard unacceptable backfill material outside the right-of-way in accordance with Section 207.

Overfill, by approximately 1/8 inch (3 mm), the slot and finish the surface of the filled slot level with the existing concrete. It is acceptable to leave the slot slightly overfilled if diamond grinding is to be employed. Cure backfill material in accordance with the backfill manufacturer's recommendations. Apply curing compound within 60 seconds after placing the backfill material.

511.3.6.1-Testing: Fabricate a minimum of six compressive strength specimens in accordance with AASHTO T 23 for each day of backfill placement. The compressive strength of an average of three of these specimens shall represent the compressive strength of all backfill material placed after the batch from which the previous compressive strength specimens were fabricated through the batch from which these specimens were fabricated.

511.3.7-Diamond Grinding: Diamond grinding shall conform to the requirements of Section 508 if the pavement section is to be diamond ground following the dowel retrofit operations. Diamond grind dowel bar retrofitted joints after the backfill material has cured properly in the dowel bar slots and has achieved a compressive strength of at least 3000 psi (21 Mpa). Diamond grinding must be completed within 14 calendar days of the installation of

the project's final dowel bar. Diamond grind the entire width of the pavement lane, from longitudinal joint to longitudinal joint.

511.3.8-Sealing Joints and Cracks: If specified, widen the transverse joints or cracks by diamond saw cutting after completion of the retrofit dowel installation if diamond grinding is not employed, or after the grinding has been completed. This work shall be done and paid for in accordance with Section 510 of the Specifications.

511.4-OPENING TO TRAFFIC:

Unless otherwise permitted in writing by the Engineer, do not permit traffic on dowel retrofitted pavement until the backfill attains a compressive strength of 3000 psi (21 MPa) or greater as verified by specimens fabricated and tested in accordance with Section 511.3.6.1.

511.5-DOWEL BAR ALIGNMENT ASSURANCE:

The Contractor shall use one of the two methods below to assure dowel bar alignment.

511.5.1-Coring: The Contractor may use diamond coring to confirm dowel placement and to randomly check dowel positioning. Check each day's retrofitting within two calendar days by performing one test for every 600 dowels placed. One test consists of drilling two cores, one on each end of a dowel bar to expose both ends and allow measurement for proper alignment. Identify the concrete cores with a location description immediately after coring and submit to the Engineer for inspection. Core the holes by a method that will not shatter or damage the concrete adjacent to the holes. Use a minimum diameter of 4 inch (100 mm) cores.

Clean and fill the core holes in the concrete pavement using the same requirements for the backfill materials as specified earlier in this document. Finish the core hole backfill material after placement to match the adjacent pavement surface. The backfill shall not evidence any depressions or surplus material above the level surface of the existing pavement.

If tests indicate dowel bars are aligned incorrectly or backfill material is improperly placed, the Engineer shall select the number and location of any additional coring tests to determine the severity.

Suspend dowel retrofitting operations if: (1) dowels are installed improperly and (2) dowel alignment does not meet the specified tolerances. Do not allow dowel retrofitting operations to resume until the Contractor demonstrates to the Engineer that the problem has been corrected. Replace any individual dowel bar retrofit not functioning or damaged.

511.5.2-Non-Destructive Testing: The Contractor may use non-destructive testing methods, such as the MIT Scan-2 technique, approved by the Engineer, to confirm dowel placement and alignment.

Check each day's retrofitting operation the next calendar day by testing 10% of the joints completed on the first day of operation and 5% of the joints completed each day thereafter.

Suspend dowel bar retrofitting operations if dowels are installed improperly and/or dowel alignment does not meet the specified tolerances. Do not allow dowel retrofitting operations to resume until the Contractor demonstrates to the Engineer that the problem has been corrected. Replace any individual dowel bar retrofit not functioning or damaged.

511.6-TEST SECTION:

In the presence of the Engineer, construct a test section that consists of slot sawing, concrete removal, and placement of dowel bars and backfill material at a location directed by the Engineer prior to the start of major operations. A test section shall be one lane wide and of a length which contains three joints and/or cracks to be retrofitted. This test section may consist of a section of existing concrete which is not within the limits of the project.

Take six full depth cores (one at each end of two dowel bars and one at the midpoint of two additional dowels), at least 4 inches (200 mm) in diameter as directed by the Engineer at least twenty-four hours after the completion of the retrofit test section. These cores shall be used to determine the completeness of the slot removal, dowel bar installation, and backfill placement operations. Begin production operations upon approval from the Engineer.

If the test section does not conform to the plans and specifications, construct additional test sections at the direction of the Engineer to demonstrate ability to install the retrofit dowels in a fashion that meets the requirements of the plans and specifications.

If a Contractor can provide evidence that they have sufficient experience with this type of work, based on experience with previous projects, then this test section requirement may be waived by the Engineer.

511.7-METHOD OF MEASUREMENT:

Dowel bar retrofit is measured by each dowel bar installed and accepted.

511.8-BASIS OF PAYMENT:

The contract unit price paid for each dowel bar includes full compensation for all material removal and for furnishing and placing all the materials and doing the work herein prescribed in an acceptable manner including all labor, tools, equipment, supplies, and incidentals necessary to complete the dowel bar retrofit. This also includes the cost of each dowel bar assembly installed in the construction of the dowel retrofit test section and the cost of dowel bar placement alignment assurance.

511.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
511001-*	Installation Of Dowel Bar	Each
511002-*	Installation Of Dowel Bar At Existing Doweled Joint	Each

* Sequence number

SECTION 512

CONCRETE SLAB STABILIZATION

512.1-DESCRIPTION:

This item of work shall consist of drilling holes in Portland cement concrete pavement as directed, pumping a portland cement/fly ash grout through the holes to fill voids under the pavement, and filling the drilled holes with mortar.

512.2-MATERIALS:

Materials shall meet the requirements of the following Sections:

MATERIAL	SECTION OR SUBSECTION
Accelerating Admixtures	707.13, 707.14
Curing Compound	707.9
Fine Aggregate	702.1
Fly Ash	707.4.1
Portland Cement	701.1, 701.3
Water-Reducing Admixtures	707.3

512.3-PROPORTIONING:

512.3.1-Mix Design Requirements: The subsealing grout mix shall be as follows:

94 pounds (42.6 kg) of portland cement (minimum)

210 pounds (95.3 kg) of fly ash

Water-reducing admixture dosed at the Manufacturer's recommended dosage rate
for the cementitious material content listed above

Water to achieve required fluidity

If ambient temperatures are below 55 °F (13 °C), an accelerating admixture shall be used.

Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportions of materials, including admixtures, to be used which will result in a workable subsealing grout mixture having the desired properties. Submittals shall include tests of the grout by an approved laboratory showing 1-day, 3-day, and 7-day compressive strengths and flow cone efflux time. An approved laboratory is defined as a laboratory which is regularly inspected by the Cement and Concrete Reference Laboratory. The 7-day strength shall not be less than 400 psi (2.8 Mpa) as measured by ASTM C 109. The subsealing grout efflux time shall be measured by ASTM C 939 (Flow Cone Method) and shall be between 16 and 25 seconds.

512.4-EQUIPMENT:

The grout plant shall consist of a positive displacement cement injection pump and mixing equipment that is capable of providing a thoroughly mixed and homogenous mixture.

Rock drills or other devices capable of drilling the grout injection holes through the pavement and base material will be permitted. The rock drill shall not be heavier than 60 pounds (27 kg), and the downfeed pressure whether by hand or mechanical means shall not damage the bottom portion of the slab.

The Contractor shall supply equipment capable of detecting the lift of the pavement near the hole being grouted. These devices shall make lift measurements from a stable reference point and shall be of a design satisfactory to the Engineer.

The Contractor shall also furnish all necessary hoses, valves, valve manifolds, positive cut-off, bypass provisions, pressure gauges with gauge protectors, expanding packers or hose for positive seal, and any other equipment necessary to control pressure and volume during grout injection.

512.5-CONSTRUCTION METHODS:

512.5.1-Drilling Holes: The hole pattern for joints or transverse cracks shall require one hole in the approach panel or slab 1.5 feet (0.5 m) from the fissure and 6 feet (2 m) from the centerline, and two holes in the slab on the panel on the opposite side of the fissure. This side of the fissure shall be noted as the leave panel. Of these two leave panel holes, one hole shall be 3 feet (1 m) from the fissure and 3 feet (1 m) from the pavement edge, and the other hole shall be 3 feet (1 m) from the fissure and 3 feet (1 m) from the centerline.

When full depth repairs were made under previous contracts, the hole pattern for grouting shall be two approach panel holes and two leave panel holes, 1.5 feet (0.5 m) from the full depth repair and 3 feet (1 m) from the pavement edge and centerline, respectively. Full depth repairs made under this contract shall not be grouted.

Grout holes shall not be larger than 2.5 inches (63 mm) in diameter. Holes shall be drilled to a depth sufficient to penetrate through any stabilized base, but they shall not penetrate into a granular subbase more than 1 to 2 inches (25 to 50 mm). Holes may be washed or blown out, if necessary, to obtain thorough distribution of the injected grout.

512.5.2-Subsealing: The Contractor shall grout one hole at a time using an expanding rubber packer or hose on the nozzle connected to the discharge of the grout pump. When grout appears at any longitudinal or transverse crack or adjacent holes, or when the lift monitoring device indicates slab movement of 3/16 inch (5 mm), grouting shall be stopped. Immediately, after the nozzle is removed, the grout hole shall be temporarily sealed with a round tapered plug constructed from wood or another suitable material as approved by the Engineer. The plug shall remain in place until the grout in the hole is not disturbed by adjacent grouting.

Pavement which has been raised in excess of ¼ inch (6 mm) shall be deemed unacceptable. No payment for any subsealing material at the subject location shall be made when this tolerance is exceeded.

Grout holes shall be filled full-depth and flush with the surface of the pavement with a stiff mortar consisting of one part portland cement to three parts of fine aggregate. The surface shall be troweled and painted with curing compound.

Grout subsealing shall not be performed when ambient temperatures are below 40 °F (4 C). In addition, subsealing operations shall not be performed if the subgrade or base course material is frozen.

Mixed grout held in the mixer or injection pump for more than one hour after mixing shall not be used.

In the event the Engineer determines that continued grout injection at any specific location is no longer practical, he may direct the Contractor to cease grout injection at that location.

512.5.3-Testing: The Contractor shall determine the grout efflux time in accordance with ASTM C 939. The Contractor shall furnish the flow cone for this test. The Contractor shall perform a minimum of three tests per day, in the presence of the Engineer. More tests shall be performed if deemed necessary by the Engineer. The subsealing grout efflux time shall be between 16 and 25 seconds. Adjustments to the grout mixture will be made during the subsealing operation to meet flow requirements.

512.6-OPENING TO TRAFFIC:

No traffic will be permitted on the grouted slabs for at least 3 hours after grouting, unless otherwise approved by the Engineer.

512.7-METHOD OF MEASUREMENT:

The quantity of work performed for concrete slab stabilization shall be measured by the number of holes drilled and filled with grout. This work shall include drilling and filling holes with grout; full compensation for furnishing all labor, materials, tools, equipment and incidentals; and, for doing all work involved in grout subsealing of existing concrete pavement, in place, complete and accepted.

The quantity of grout for subsealing of concrete slabs shall be measured by the number of pounds (kg) of portland cement used in the work, complete in-place and accepted.

512.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit bid price for all of the items listed below. The price and payment shall be full compensation for furnishing and placing all the materials and doing the work herein prescribed in an acceptable manner including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

512.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
512001-*	Holes Drilled For Concrete Slab Stabilization	Each
512002-*	Grout Used For Subsealing Of Slabs	Tons (Megagram)

* Sequence number

SECTION 513 CONCRETE PAVEMENT CROSS STITCHING

513.1-DESCRIPTION:

Concrete pavement cross stitching consists of drilling holes and anchoring deformed reinforcing bars diagonally across longitudinal cracks.

513.2-MATERIALS:

Materials shall meet the requirements of the following Subsections of Division 700:

MATERIAL	SUBSECTION
Deformed Steel Reinforcing Bars	709.1

513.2.1-Material Requirements:

Deformed Steel Reinforcing Bars shall be Grade 60.

Anchoring Material and Dispensing Equipment - Use a pourable, two component, 100% solids structural epoxy which is approved by the Engineer. It shall be dispensed either from:

- i. Side-by-side cartridges by manual or pneumatically powered injection guns.
- ii. Through a static nozzle that homogeneously mixes the material without any hand mixing first.

513.3-EQUIPMENT AND TOOLS:

513.3.1-Drills: Use a hydraulic drill with tungsten carbide bits. Control the forward and reverse travel of the drills by mechanically applied pressure. Mount the drill on a suitable piece of equipment such that it is quickly transported and positioned. Rest and reference the drill rig frame on and to the pavement surface such that the drilled holes are cylindrical and repeatable in terms of position and alignment on the surface being drilled. Hand-held drills are not permitted.

513.4-CONSTRUCTION METHODS:

513.4.1-Drilling Holes: Drill the end holes in a slab 18 – 20 inches (450 - 500 mm) from the transverse joints. Drill interior slab holes at a maximum of 12 inch (300 mm) spacing.

Drill such that the:

- i. Holes are oriented at a 30° angle to the pavement surface.
- ii. Hole centerlines are perpendicular to the crack at each location being drilled.
- iii. Adjacent holes are drilled in opposite directions across the crack.
- iv. Longitudinal centers of drilled holes are at the crack.
- v. Hole diameters are in accordance with the anchoring material Manufacturer's written recommendations. Those recommendations shall be submitted to the Engineer prior to the start of construction.
- vi. Hole bottoms are no more than 1 inch (25 mm) from the slab bottom.

Repair cracks that result from drilling with a full depth repair as approved by the Engineer.

513.4.2-Cleaning Holes: Clean the drilled holes in accordance with the anchoring material Manufacturer's written recommendations. Those recommendations shall be submitted to the Engineer prior to the start of construction. As a minimum, clean holes with oil-free and moisture-free compressed air. The Engineer will check the compressed air stream purity with a clean white cloth. The compressor must deliver air at a minimum pressure of 120 ft³ (3.4 m³) per minute and develop a minimum nozzle pressure of 90 psi (0.62 Mpa). Insert the nozzle the full depth of the hole, to the back of the hole, to force out all dust and debris. Also, clean any chipped areas at the surface resulting from drilling holes at an angle. Repair chipped area with the anchoring material.

513.4.3-Deformed Bar Installation: Unless otherwise specified by the Engineer, use 0.75 inch (19 mm) diameter bars of sufficient length such that, when anchored, the top of the bar is 1.75 – 2 inches (45 – 50 mm) below the pavement surface and the center of the bar is at the crack.

When using new cartridges of anchoring material, ensure the initial material exiting the nozzle appears uniformly mixed. If it is not uniformly mixed, waste the material until uniformly mixed material extrudes.

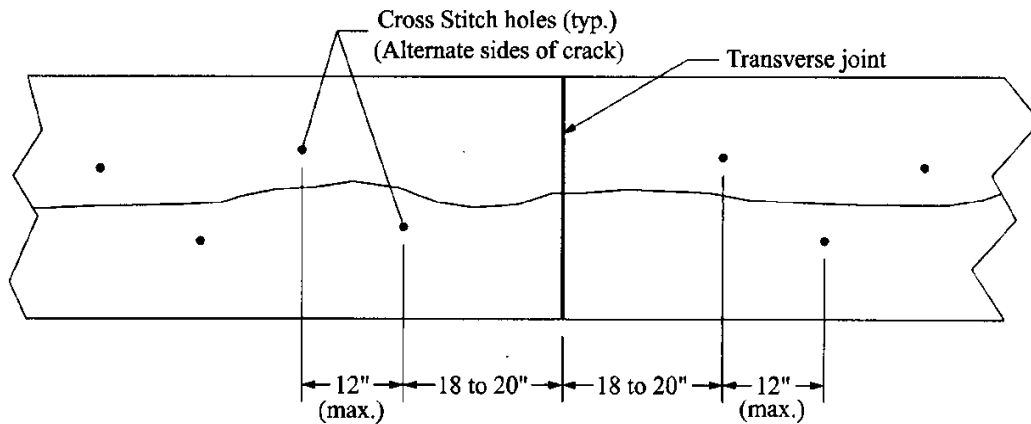
Place the anchoring material in the back of the hole using a nozzle or wand of sufficient length. Insert the bar such that the anchoring material is evenly distributed around the bar and slightly extrudes out the hole as the bar is inserted. Trowel the anchoring material smooth to the pavement surface, filling any chipped areas.

TABLE 513.4

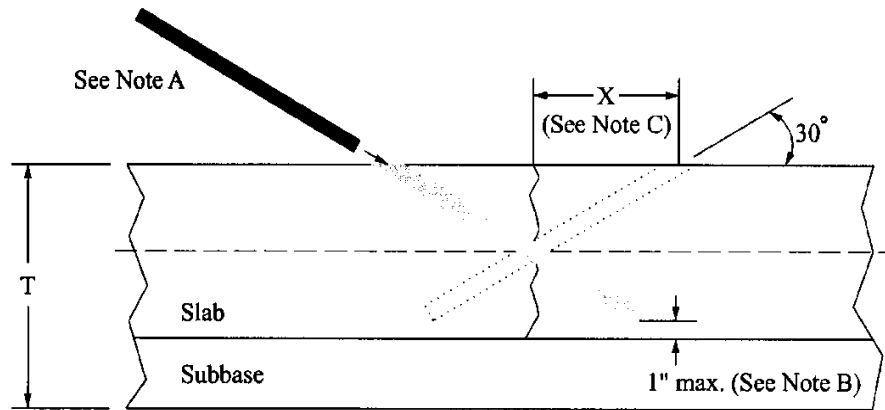
Slab thickness (T), in. (mm)	8 (200)	9 (225)	10 (250)	11 (275)	12 (300)
Distance (X) from crack to centerline of hole, in. (mm)	6.9 (175)	7.8 (198)	8.7 (220)	9.5 (241)	10.4 (264)
Length of bar, in. (mm)	9 (230)	11 (280)	13 (330)	15 (380)	17 (430)

Typical Cross Stitching Repair Details

TOP VIEW



CROSS-SECTIONAL VIEW



Note A: Epoxy deformed bar into hole. Lengths shown in Table 513.4 provide 1.75 - 2 inches (45 - 50 mm) cover at surface and assume drilling per Note B

Note B: Do not drill hole completely through slab. Stop drilling 1 inch (25 mm) from bottom of slab so epoxy will not run out of the bottom while backfilling

Note C: Distance from crack to centerline of bar will vary depending on slab thickness. See Table 513.4 for recommended bar lengths.

513.5-OPENING TO TRAFFIC:

No traffic will be permitted on the cross-stitched pavement until the anchoring material can be expected, as shown by test data supplied by the anchoring material Manufacturer from an Independent Approved Laboratory, to have a compressive strength of at least 2,000 psi (14 Mpa), unless otherwise approved by the Engineer.

513.6-METHOD OF MEASUREMENT:

Concrete pavement cross stitching is measured by each deformed bar installed and accepted.

513.7-BASIS OF PAYMENT:

The contract unit price paid for each deformed bar includes full compensation for furnishing and placing all the materials and the cost of all labor, tools, equipment, supplies, and incidentals necessary to complete the work in an acceptable manner. No payment will be made for items required by the Engineer to repair damage to the adjacent pavement incurred during drilling.

513.8-PAY ITEM:

ITEM	DESCRIPTION	UNIT
513001-*	Installation Of Deformed Bar	Each

* Sequence number

SECTION 514 ROLLER COMPACTED CONCRETE

514.1-DESCRIPTION:

Roller Compacted Concrete (RCC) consists of aggregate, Portland cement and possibly other supplementary cementitious materials (fly ash, slag), and water. RCC is proportioned, mixed, placed, compacted, and cured in accordance with these specifications. Ensure that the RCC conforms to the lines, grades, thickness, and typical cross section shown in the plans or otherwise established by the WVDOH. When used as base course, it shall be constructed as shown in the plans.

514.2-MATERIALS:

Materials shall conform to the requirements of the following Subsection of Division 700:

MATERIAL	SUBSECTION
Coarse Aggregate	703.1-4
Curing Materials	707.6-707.10
Fine Aggregate ^{Note 1}	702.1
Portland Cement	701.1, 701.3
Pozzolanic Additives	707.4
Water	715.7
Water Reducing and Retarding Admixtures	707.2

Note 1 The use of limestone as fine aggregate will not be permitted

Shipping and storage of Cement and Pozzolanic Additives: Cement and pozzolanic additives shall be shipped and stored as outlined in Section 501.2.

514.2.1-Material Requirements:

Aggregates: Use no aggregate where the plasticity index of the aggregate exceeds 5. Aggregates may be a blend of fine and coarse aggregates. Use well-graded aggregate without gradation gaps and conforming to the following gradation:

Sieve Size	% Passing by Weight
1 inch	100
¾ inch	95-100
½ inch	70-90
3/8 inch	60-85
#4	40-60
#16	20-40
#100	3-15
#200	0-8

Prior to the start of each day's production, the Contractor shall perform a gradation test on the material to be used that day in order to verify that the aggregate gradation meets the above requirements. If the results of this test show that the aggregate gradation does not meet the

above requirements, the Contractor shall immediately notify the Engineer and shall not begin production that day unless approved to do so by the Engineer. The Contractor shall then take immediate action to correct any gradation not meeting the above requirements, regardless of whether or not production is allowed. All gradation test results shall be submitted to the Engineer within 72 (seventy-two) hours.

514.3-PROPORTIONING:

514.3.1-RCC Mix Design Requirements: At least 45 days prior to the start of construction, the Contractor shall submit to the Engineer for approval the proportion of materials to be used which will result in a workable RCC mix. No more than 25%, by mass, of the cementitious material content of the RCC mix shall be pozzolanic materials. The Engineer will review these proportions within 14 (fourteen) Calendar Days.

Laboratory density tests, in accordance with AASHTO T180 (Method D), shall be performed during development of the mix design in order to determine the maximum laboratory density and optimum moisture content for the RCC mix. The material proportions used to achieve the maximum laboratory density and the optimum moisture content shall be the material proportions used in the approved mix design and during construction. Compressive strength tests, as outlined in Section 514.3.2 shall be conducted on at least two separate batches of RCC developed from these material proportions. The mix design results shall be reported on the attachments for MP 711.03.23. The maximum laboratory density and optimum moisture content shall be reported and included on the mix design submittal also.

The mix design shall be accompanied by a document listing the source of materials and certified test data from a Division approved laboratory demonstrating the adequacy of the mix design. The Contractor shall notify the Engineer of any change in the source of materials or the addition of admixtures during the progress of work, since such change may necessitate a new mix design.

514.3.2-Design Compressive Strength: A mix design shall be used which demonstrates a minimum compressive strength of 4500 psi within 28 days. Compressive strength specimens shall be prepared in accordance with ASTM C1435 and tested in accordance with AASHTO T22. At least three sets of three cylinders shall be produced, with one set being tested at 3 days, one set being tested at 7 days, and the other at 28 days. The compressive strength at a particular age shall be determined as the average of the three specimens. If one individual result is much lower or much higher than the other two due to defects in the specimen as outlined in section 601.4.4, that value shall be discarded.

514.3.3-Design Moisture Content: A test for moisture content, in accordance with ASTM C566, shall be performed on each of the RCC batches produced in Section 514.3.1, from which compressive strength specimens were fabricated. The average moisture content shall be considered the target evaporable moisture content of the RCC mix, and shall be used for quality control purposes as outlined in Section 514.4.2.1.

514.3.4-Test Section: If the mix design appears satisfactory to the Engineer, the Contractor shall prepare and test a trial batch mixture and representative test section at least 100 ft. (30 m) in length and 10 ft (3 m) in width to verify that the design criteria for strength and density are met. The criteria for strength and lift thickness shall be verified by the Contractor by taking three cores

at random locations and testing them in accordance with AASHTO T24. The minimum required compressive strength for each of these cores is 3,500 psi (24 Mpa), measured at an age no later than 28 days, or within 10 percent of either the 3 or 7-day mix design strength, as determined in Section 514.3.2. Density testing, as outlined in Section 514.4.2.3 shall be performed on this Test Section also. The minimum required density for this testing is 98 percent of the maximum laboratory density.

Perform batch mixture preparation and testing in the presence of representatives of the Engineer. Construction, using RCC, shall not begin until an approved mix design has been obtained.

The Test Section shall be located in a location approved by the Engineer. If permitted by the Engineer, it is acceptable to place and leave the Test Section in place as part of the completed pavement if it meets all of the above required testing and acceptance criteria. If the Test Section is placed in an area which is to be paved with RCC, and it does not meet all of the above acceptance criteria, it shall be removed at the Contractor's expense.

514.4-TESTING:

514.4.1-Test Methods:

Standard Practice for Molding Roller-Compacted Concrete in Cylinder Molds Using a Vibrating Hammer	ASTM C1435
Compressive Strength of Cylindrical Concrete Specimens	AASHTO T22
Making and Curing of Concrete Specimens	AASHTO T23
Obtaining and Testing Drilled Core Specimens	AASHTO T24
Measuring Length of Drilled Concrete Cores	AASHTO T148
Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying	ASTM C566
Moisture-Density Relations of Soils using a 4.54 kg (10 lb.) Rammer and a 457 mm (18 inches) Drop	AASHTO T180

514.4.2-Contractor's Quality Control:

514.4.2.1-RCC Moisture Content: The Contractor shall perform moisture content tests in accordance with ASTM C566 on the initial batch of RCC produced each day and then once again if the ambient temperature reaches 85 °F (30 °C) or greater, as recorded in the vicinity of the concrete production facility.

514.4.2.2-Testing for Opening Pavement to Traffic: A minimum of three sets of compressive strength specimens shall be made for each day's paving operation. These compressive strength specimens shall be fabricated in accordance with ASTM C1435, and under the direct observation of the Engineer. A set of specimens consists of three cylinders. Field cure the specimens in accordance with AASHTO T23. Test one cylinder from each set of these cylinders for compressive strength in accordance with AASHTO T22 at each of the following ages under the direct observation of the Engineer: 3 days, 5 days, and 7 days. The compressive strength of each set of cylinders shall be the average of the three specimens except that if one specimen shows evidence of improper sampling, molding, or testing, it shall be discarded and the remaining two strengths averaged. Should more than one specimen representing a given test show definite defects due to improper sampling, molding, or testing, the entire test shall be discarded.

The Contractor's personnel who fabricate the compressive strength specimens shall provide evidence, prior to the start of construction and to the satisfaction of the Engineer, that they are proficient in the specified test methods.

RCC pavement at an age of 3, 5, or 7 days may be put into service if the average compressive strength test result of the set of cylinders at the corresponding age is at least 3,000 psi (21 Mpa).

The results of the 3 and 7 day quality control compressive strength tests shall also be compared to the compressive strength results obtained in Section 514.3.2. If the compressive strength of these quality control specimens is less than 90% of the compressive strength results obtained in Section 514.3.2, the Contractor shall investigate the potential causes of the low strengths and report to the Engineer within 24 hours. If the compressive strength of these quality control specimens is less than 80% of the compressive strength results obtained in Section 514.3.2, and the compressive strength is also less than 3,500 psi immediately stop production and notify the Engineer. Do not resume production until the cause of the discrepancy has been determined to the satisfaction of the Engineer.

If the average strength of any of these sets of quality control cylinders, representing a single day's production, is equal to or greater than 4,000 psi (28 Mpa), then the Contractor is not required to test any of the remaining quality control cylinders representing that day's production.

514.4.2.3-Density Testing: Field density tests for quality control shall be performed by the contractor as soon as possible, but no later than 30 minutes after the completion of the rolling. The in-place density and moisture content shall be determined using a properly maintained nuclear moisture-density gauge in accordance with the applicable provisions of MP 717.04.21. All testing shall be performed in direct transmission mode. Only wet density is used for evaluation.

The testing shall be performed at a frequency not to exceed one test for every 1,000 yd² placed. The required minimum density is 98 percent of the maximum laboratory density obtained according to AASHTO T 180 (Method D), as determined in Section 514.3.1. The gauge will be calibrated for moisture content at the beginning of the work and at any time during the work. Any lot of RCC which was properly placed and compacted, but not meeting the density requirements based on the initial testing, can be further evaluated by obtaining five additional randomly located density tests within the lot in question. If the average of these five additional tests meets the required minimum density, the lot shall be considered acceptable.

If the lot has been determined to not meet the specified minimum density requirements, it may be cored and tested by the Division in addition to any coring performed for acceptance as per Section 514.4.3.1. If the tested area achieves 3,500 psi (24 Mpa), it will be paid at the full unit price. If the tested area indicates strength less than 3500 psi but greater than 3150 psi, payment will be made as set forth in Table 514.4.2.3.

TABLE 514.4.2.3

Compressive Strength (psi)	Price Reduction (percent of unit bid price)
3300-3499	5
3150-3299	15

If the cores indicate strengths less than 3150 psi at 28 days or longer, the Engineer will evaluate the results and may reject the affected area and require removal and replacement or elect to pay at a reduced rate.

514.4.3-Acceptance Testing:

514.4.3.1-Compressive Strength Tests for Acceptance: The compressive strength for acceptance of RCC will be determined by testing cores. The RCC shall be at least 28 days old before the cores are obtained. One 4-inch (100 mm) diameter core shall be obtained, by the Division, for every 1,500 yd² (1,250 m²) or fraction thereof of RCC placed and represent that area for acceptance purposes. These cores shall be tested by the Division for compressive strength. The minimum required compressive strength of these cores is 3,500 psi (24 Mpa).

The Contractor shall repair the core holes using concrete meeting the requirements of Section 501 and shall rod and neatly strike off the repair material.

Areas of RCC represented by any cores not meeting the minimum compressive strength requirements shall be handled in accordance with Section 105.12. Such areas that are allowed to remain in place shall be paid for at a reduced unit bid price as outlined in Section 601.15.2, with the Design Strength being 3,500 psi (24 Mpa).

Additionally, as outlined in Section 514.4.2.3, cores may also need to be obtained to determine the compressive strength of any areas which are found to not meet the specified density requirements. It should be noted that lot sizes for density testing (1,000 yd²) and compressive strength acceptance testing (1,500 yd²) are different, and will overlap throughout the project. However, only one price adjustment shall be applied to any area not meeting the specification requirements. If any lot, or portion of a lot, is determined to have compressive strengths below 3,500 psi (24 Mpa) as outlined in Section 514.4.2.3 and is also found to be deficient in strength as outlined in Section 514.4.3.1, the price adjustment to be applied to that lot, or portion of that lot, shall be the greater of either the price adjustments calculated accordingly.

514.4.3.2-Thickness Tests for Acceptance: The cores obtained in Section 514.4.3.1 shall be measured for thickness, in accordance with AASHTO T148, prior to being tested for compressive strength.

If the thickness of any core is found to be less than the specified design thickness, then an evaluation of the area represented by that core shall be performed by the Engineer in accordance with Section 105.12. If the Engineer allows that area of deficient thickness to remain in place, then that area shall be paid for at a reduced unit bid price as outlined in Table 514.4.3.2.

TABLE 514.4.3.2

Average Value of Pavement Thickness as Represented by Acceptance Core	Unit Price as Percent of Contract Unit Price
0.1 to 1.0% Less than Specified Thickness	98.0%
1.1 to 2.0 % Less than Specified Thickness	96.0%
2.1 to 3.0% Less than Specified Thickness	94.0%
3.1 to 4.0% Less than Specified Thickness	92.2%
4.1 to 5.0% Less than Specified Thickness	90.3%
5.1 to 6.0% Less than Specified Thickness	88.4%
6.1 to 7.0% Less than Specified Thickness	86.5%
More than 7.0% Less than Specified Thickness, with a maximum of 0.70 inches (18 mm) Less than Specified Thickness	Remove and Replace

514.5-EQUIPMENT AND TOOLS:

Construct roller compacted concrete with any combination of equipment that will produce a completed pavement meeting the requirements for mixing, transporting, placing, compacting, finishing, and curing as provided in this specification.

514.5.1-Field Laboratory: RCC shall be supplied by a plant which has been certified by the Division as meeting all requirements of the governing Specifications and as having the facilities necessary to ascertain and control the quality of the product in accordance therewith. A testing facility or laboratory, meeting the requirements of Section 501.5.1 shall be provided by the Contractor.

514.5.2-Mixing Plant:

514.5.2.1-General: Unless approved measures are taken to delay the setting time of the RCC, the mixing plant shall be located within a thirty-minute haul time from the point of RCC placement. Use only plants capable of producing an RCC pavement mixture in the proportions defined by the final approved mix design and within the specified tolerances. The capacity of the plant must be sufficient to produce a uniform mixture at a rate compatible with the placement equipment. The estimated production rate of the Plant shall be noted in the Contractor's Quality Control plan. If the plant is unable to produce material at a rate adequate to prevent unnecessary cold joints and frequent paver stoppages, the Engineer may halt production until such time that a plant of appropriate capacity is used. The plant shall be inspected and approved by WVDOH District Materials Personnel prior to production of material under these specifications.

514.5.2.2-Pugmill Plant: Use only pugmill plants of the central plant type with a twin-shaft pugmill mixer, capable of batch or continuous mixing, equipped with synchronized metering devices and feeders to maintain the correct proportions of aggregate, cement, pozzolan, and water. These plants shall meet the requirements of AASHTO M156. Other pugmill plant requirements are as follows:

514.5.2.2.1-Aggregate Storage: If previously blended aggregate is furnished, storage may be in a stockpile from which it is fed directly to a conveyor feeding the mixer. If

aggregate is furnished in two size groups, follow proper stockpiling techniques in accordance with section 501.7 to ensure aggregate separation.

514.5.2.2.2-Aggregate Feed Rate: Use aggregate bins with a feed rate controlled by a variable speed belt, or an operable gate calibrated to accurately deliver any specified quantity of material. If two aggregate size stockpile sources are used, the feed rate from each bin must be readily adjustable to change aggregate proportions, when required. Feed rate controls must maintain the established proportions of aggregate from each stockpile bin when the combined aggregate delivery is increased or decreased.

514.5.2.2.3-Plant Scales: Plant scales, if utilized, for any weigh box or hopper must comply with Section 601.5.2.3.

514.5.2.2.4-Cement and Pozzolan Material Storage: Supply separate and independent storage silos for Portland cement and pozzolan. At plants with two or more silos in which different types of cement or cementitious materials are stored, ensure that each silo has a sign at each fill inlet to reduce the potential for loading errors. Make the sign from a durable material, with minimum two-inch high by 1/4-inch wide letters that are raised, indented, or cut. Ensure that the sign clearly identifies the material that is in the silo and may be easily read even when completely coated with dust.

514.5.2.2.5-Portland Cement and Pozzolan: If using Portland cement and pozzolan (such as fly ash or slag), employ blending equipment acceptable to the WVDOH and demonstrate, with a testing plan, the ability to successfully produce a uniform blended material meeting the mix design requirements. Perform testing on at least a daily basis to ensure both uniformity and proper quantities.

514.5.2.2.6-Cement and Pozzolan Feed Unit: Provide a satisfactory means of dispensing Portland cement and pozzolan, volumetrically or by weight, to ensure a uniform and accurate quantity of cementitious material enters the mixer.

514.5.2.2.7-Water Control Unit: Use a water control unit capable of measuring the required amount of water for the approved mix by weight or volume. Ensure that the unit is equipped with an accurate metering device. Vary the amount of water to be used only with the approval of the Engineer.

514.5.2.2.8-Gob Hopper: For continuous operating pugmills, provide a gob hopper attached to the end of the final discharge belt to temporarily hold the RCC discharge in order to allow the plant to operate continuously.

514.5.2.3-Rotary Drum Mixer: Shall meet the requirements of Section 501.5.3 and shall provide a rotary drum batch mixer capable of producing a homogeneous mixture, uniform in color, and having all coarse aggregate coated with mortar. Equip the mixer with batching equipment to meet the following requirements:

514.5.2.3.1-Weighing Equipment: Measure the amounts of cement, pozzolan, and aggregate entering into each batch of RCC by direct weighing equipment. Use only weighing equipment that is readily adjustable in order to compensate for the moisture content of the aggregate or to change the proportionate batch weights. Include a visible dial or equally suitable device that will accurately register the scale load from zero to full capacity. The cement and pozzolan may be weighed separately or cumulatively in the same hopper on the same scale, provided the cement is weighed first.

514.5.2.3.2-Weigh Hoppers: Use only bulk cement and pozzolan weigh hoppers that are equipped with vibrators to operate automatically and continuously while weighing hoppers are being dumped. Ensure that the weigh hopper has sufficient capacity to hold not less than 10 percent in excess of the cementitious material required for one batch.

514.5.2.3.3-Water Metering: Measure the amount of water entering each batch of RCC by weight or volume. Use only equipment capable of measuring the water to within a tolerance of plus or minus one percent and equipped with an accurate gauge or dial measuring device. Vary the amount of water to be used only with the approval of the Engineer. During batching, admit water to the mixer only through the water measuring device and then only at the time of charging.

514.5.2.3.4-Mixing Time: Use only drum mixers equipped with an accurate clock or timing device, capable of being locked, for visibly indicating the time of mixing after all the materials, including the water, are in the mixer.

514.5.2.3.5-Recharging: Discharge all material in the drum before recharging. Ensure that the volume of mixed material per batch does not exceed the manufacturer's rated capacity of the mixer.

514.5.3-Paver: Place RCC with a high-density asphalt-type paver subject to approval by the Engineer. Use only pavers equipped with compacting devices capable of producing an RCC pavement with a minimum of 90 percent of the maximum density in accordance with AASHTO T 180, Method D prior to any additional compaction. Ensure that the paver is of suitable weight and stability to spread and finish the RCC material, without segregation, to the required thickness, smoothness, surface texture, cross-section, and grade.

514.5.4-Compactors: Use self-propelled steel drum vibratory rollers having a minimum static weight of 10 tons (9.1 Mg) for primary compaction. For final compaction, use either a steel drum roller, operated in a static mode, or a rubber-tired roller of equal or greater weight. Only use walk-behind vibratory rollers or plate tampers for compacting areas inaccessible to large rollers.

514.5.5-Haul Trucks: Use trucks for hauling the RCC material from the plant to the paver with covers available to protect the material from inclement weather and excessive evaporation. To ensure adequate and continuous supply of RCC material to the paver, have a sufficient number of trucks. If the number of trucks is inadequate to prevent frequent starts and stops of the paver, cease production until additional trucks are obtained.

514.5.6-Water Trucks: Keep at least one water truck, or other similar equipment, on-site and available for use throughout the paving and curing process. Equip such equipment with a spreader pipe containing fog spray nozzles capable of evenly applying a fine spray of water to the surface of the RCC without damaging the final surface.

514.5.7-Inspection of Equipment: Before start-up, the Contractor's equipment will be carefully inspected. Should any of the equipment fail to operate properly, cease work until the deficiencies are corrected.

514.5.8-Access for Inspection and Calibration: Provide the Engineer or WVDOH District Materials Inspector access at all times for any plant, equipment, or machinery to be used in order to check calibration, scales, controls, or operating adjustments.

514.6-PREPARATION OF GRADE AND CONDITIONING OF SUBGRADE OR BASE:

Before the RCC processing begins, prepare the subgrade in accordance with Section 228 of the WVDOH Standard Specifications.

514.7-HANDLING, MEASURING, AND BATCHING MATERIALS:

Handling, measuring, and batching of materials shall be in accordance with Section 501.7, except that volumetric batching shall not be permitted.

514.8-MIXING RCC:

514.8.1-Mixing Process: Use the same mixture for the entire project unless otherwise stated in the project documents. If, during production, the source of Portland cement, pozzolan, or aggregates is changed, then suspend production and submit a new mix design to the Engineer for approval. Do not exceed the manufacturer's rated capacity for dry concrete mixtures in the mixing chamber. Keep the sides of the mixer and mixer blades free of hardened RCC or other buildups. Routinely check mixer blades for wear and replace if wear is sufficient to cause inadequate mixing.

514.8.2-Mixing Time: Use a mixing time adequate to ensure a thorough and complete mixing of all materials. Do not allow the mixing time, after all materials including water are in the mixer, to be less than 1½ minutes for one cubic yard (0.76 cubic meter) and 20 seconds for each additional cubic yard (0.76 cubic meter).

514.8.2.1-Mixing Time for Truck Mixers: When truck mixers are used to mix RCC, the mixer capacity shall be limited to 5 cubic yards (3.8 cubic meters) per batch and mixing time shall be a minimum of 3 minutes. If the condition of the blades in the drum of any truck mixer, used for mixing RCC, is such that the adequacy of mixing after 3 minutes is questionable, or if there is any other reason to question the adequacy of the mixing, uniformity testing, in accordance with AASHTO M157, for mass per cubic foot (meter) and coarse aggregate content, shall be performed on that truck prior to using it during production. If that truck mixer cannot produce a uniform RCC mix after 3 minutes of mixing, then the required mixing time shall be increased to the mixing time which is shown to produce a uniform mix.

514.8.3-Plant Calibration: Prior to commencement of RCC production, carry out a complete and comprehensive calibration of the plant in accordance with Section 501.5.2. Provide all scales, containers, and other items necessary to complete the calibration. After completion of the initial calibration, calibrate the plant periodically as directed by the Engineer. Plants listed on WVDOT approved list at the time of RCC production are exempt from this requirement, although the WVDOT reserves the right to require additional calibration if variation in mixture quantities are suspected.

514.8.4-Daily Reports: Supply daily plant records of production and quantities of materials used that day to the Engineer. These records may be used as a check on plant calibration.

514.8.5-Transportation: Transport the RCC pavement material from the plant to the areas to be paved in dump trucks equipped with retractable protective covers for protection from rain or excessive evaporation. Ensure that the trucks are dumped clean with no buildup or hanging of RCC material in the corners. Have the dump trucks deposit the RCC material directly into the hopper of the paver or into a secondary material distribution system that deposits the material into the paver hopper. Dump truck delivery must be timed and scheduled so that RCC material is spread and compacted within the specified time limits.

514.9-PLACING RCC:

514.9.1-Subbase Condition: Prior to RCC placement, ensure that the surface of the subbase is clean and free of foreign material, ponded water, and frost. Ensure that the subbase is uniformly moist at the time of RCC placement. If sprinkling of water is required to remoisten certain areas, ensure that the method of sprinkling will not form mud or pools of freestanding water. Correct soft or yielding subbase areas prior to placement of RCC as specified in Section 6.1 above.

514.9.2-Adverse Weather Conditions:

514.9.2.1-Cold Weather Precautions: Employ cold weather precautions as detailed in Section 601.9.1 of the Standard Specifications.

Stop placement operations when the air temperature falls below 40°F (4.5°C) and is declining. Start operations only if the air temperature rises above 35°F (1.7°C) and is elevating.

If the air temperature is expected to fall below 40°F (4.5°C) at some time during construction, and if the Contractor plans to place RCC during that time, the Contractor shall advise the Division of his plans for cold weather curing and protecting the RCC. The Division may, at any time, require the Contractor to provide additional protection to cause the provisions of this specification to be met.

514.9.2.2-Hot Weather Precautions: Employ hot weather precautions as detailed in Section 601.9.2 of the Standard Specification. During periods of hot weather or windy conditions, take special precautions to minimize moisture loss due to evaporation. Cooling of aggregate stockpiles by shading or the use of a fine mist may be required. Protective covers may be required on dump trucks. Keep the surface of the newly placed RCC pavement continuously moist.

The Engineer may decrease the allowable time, specified in Section 514.10.1, between mixing and the completion of compaction when the ambient temperature exceeds 90°F (32°C) or during windy conditions.

In no event shall RCC be placed when its temperature at any time after the completion of mixing exceeds 90°F (32°C).

514.9.2.3-Rain Limitations: Conduct no placement of RCC pavement during rain conditions sufficient to be detrimental to the finished product. Placement may continue during light rain or mists provided the surface of the RCC pavement is not eroded or damaged in any way. Use dump truck covers during these periods. The WVDOH may terminate paving at any time when, in the WVDOH judgment, the rain is detrimental to the finished product.

514.9.3-Paver Requirements: Place all RCC with an approved paver as specified in Section 514.5.3, and also meeting the requirements of this Section.

514.9.3.1-Filling the Paver: Do not allow the quantity of RCC material in the paver to approach empty between loads. Maintain the material above the auger at all times during paving.

514.9.3.2-Stopping the Paver: Ensure that the paver proceeds in a steady, continuous operation with minimal starts and stops, except to begin a new lane. Maximum paver speed during laydown is 10 feet (3 m) per minute. Higher paver speeds may be allowed at the discretion of the WVDOH if the higher speeds may be obtained without distress to the final product or cause additional starts and stops.

514.9.3.3-Surface Condition: Ensure that the surface of the RCC pavement is smooth, uniform, and continuous without excessive tears, ridges, or aggregate segregation once it leaves the paver.

514.9.4-Inaccessible Areas: Pave all areas inaccessible to either roller or paver with cast-in-place concrete meeting the requirements of Section 501.

514.9.5-Adjacent Lane Pavement: Place adjacent paving lanes within 60 minutes. If more than 60 minutes elapses between placement of adjacent lanes, the vertical joint must be considered a cold joint and prepared in accordance with Section 514.11. At the discretion of the Engineer, this time may be increased or decreased depending on ambient conditions of temperature, wind, and humidity. Multiple pavers may be used in tandem to reduce the occurrence of cold joints.

514.9.6-Hand Spreading: Broadcasting or fanning the RCC material across areas being compacted is not permissible. Such additions of materials may only be done immediately behind the paver and before any compaction has taken place. Any segregated coarse aggregate shall be removed from the surface before rolling.

514.9.7-Segregation: If segregation occurs in the RCC during paving operations, placement shall cease until the cause is determined and corrected to the satisfaction of the

Engineer. If the segregation is judged by the Engineer to be severe, remove and replace the segregated area at no additional cost to the Department.

514.10-COMPACTION:

514.9.1-Time to Compaction Start: Ensure that compaction begins with the placement process and is completed within 60 minutes of the start of the mixing at the plant. The time may be increased or decreased at the discretion of the WVDOH depending on ambient conditions of temperature and humidity. Do not permit delays in rolling unless approved by the Engineer. Plan operations and supply sufficient equipment to ensure that these criteria are met.

514.10.2-Rolling: Determine the sequence and number of passes by vibratory and non-vibratory rollers to obtain the specified density and surface finish. Only operate rollers in the vibratory mode while in motion. Rubber-tire rollers may be used for final compaction. Use additional rollers if specific density requirements are not obtained or if placing operations get ahead of the rolling operations.

514.10.3-Rolling Longitudinal and Transverse Joints: Do not operate the roller within 2 feet of the edge of a freshly placed lane until the adjacent lane is placed. Then, roll both edges of the two lanes together within the allowable time. If a cold joint is planned, then roll the complete lane and follow cold joint procedures as specified in Section 514.11.

514.10.4-Inaccessible Areas: Compact areas inaccessible to large rollers using walk-behind rollers or hand tampers. Cast-in-place, meeting the requirements of Section 501, may be used in these areas as a replacement for RCC.

514.11-JOINTS:

514.11.1-Fresh Vertical Joints: A joint is considered a fresh joint when an adjacent RCC lane is placed within 60 minutes of placing the previous lane or as specified by the Engineer based on ambient conditions. Fresh joints do not require special treatment.

514.11.2-Cold Vertical Joints: Any planned or unplanned construction joints that do not qualify as fresh joints are considered cold joints. Prior to placing fresh RCC mixture against a compacted cold vertical joint, thoroughly clean the cold joint of loose or foreign material. Wet the vertical joint face and maintain it in a moist condition immediately prior to placement of the adjacent lane.

514.11.2.1-Sawing Cold Vertical Joints: For uncompacted surfaces or slopes more than 15 degrees from the vertical, cut the joint vertically for the full depth. Within 2 hours of final compaction, the edge of a cold joint may be cut with approved mechanical equipment. For edges cut after 2 hours, sawcut to the full depth of the pavement. Demonstrate any modification or substitution of the sawcutting procedure to the WVDOH for approval prior to use. In no case allow cutting of the edge to cause raveling or tearing of the surface. Moisten the cut edge immediately prior to placement of the adjacent lane.

514.11.3-RCC Pavement Joints at Structures: Line structures such as manholes, valves, or concrete curb and gutter with joint filler as defined in Section 708 of the Standard Specifications.

514.11.4-Control Joints: Construct transverse contraction joints in the RCC pavement by sawing. At the option of the Contractor, soft-cut or green-cut saws may be utilized as soon as possible behind the rolling operation and set to manufacturer's recommendations. Conventional cut saws must be used as soon as the sawing operation will not result in raveling or other damage to the RCC pavement, but not more than 18 hours after RCC placement. Cut all joints to 1/4 the depth of the RCC pavement to a single saw blade width. Joints should be spaced at intervals not to exceed 24 times the nominal pavement thickness unless otherwise indicated on the Plans or directed by the WVDOH. (For example, for an 8-inch RCC pavement, cut joints at 16-foot intervals.).

In areas where RCC is placed adjacent to existing concrete pavement, such as in shoulder areas, the Contractor shall adjust the joint spacing to align with the joints in the existing adjacent concrete pavement. In these areas, in order to work out a joint spacing which aligns with the joints in the existing pavement, the joints in the RCC may be spaced at intervals up to 24 times the nominal RCC pavement thickness, plus 10 percent of that distance. (For example, for an 8-inch RCC pavement, cut joints at a maximum spacing of 17.6-foot intervals).

514.12-FINISHING:

Ensure that the finished surface of the RCC pavement, when tested with a 10-foot straightedge or crown surface template, does not vary from the straightedge or template by more than 1/4 inch at any one point and shall be within 5/8 inch of the specified finished grade. When surface irregularities are outside these tolerances, or other smoothness requirements specified in the plans, diamond-grind the surface to meet the tolerance at no additional cost to the WVDOH.

514.13-CURING:

Immediately after final rolling and compaction testing, keep the surface of the RCC pavement continuously moist until an approved curing compound, a suitable prime coat, or a layer of asphalt concrete is applied or for 72 hours after placement, whichever comes first.

Until the RCC has achieved the required strength for opening to traffic, the surface temperature of the RCC shall not be allowed to fall below freezing. The Contractor shall be responsible for the quality of the RCC placed and cured during cold weather. Any RCC injured by frost action shall be removed and replaced at the Contractor's expense.

514.13.1-Water Cure: Apply water cure by water trucks equipped with fog spray nozzles, soaking hoses, sprinkling system, or other means such that a uniform moist condition on the surface of the RCC is ensured. Apply this moisture in a manner that will not erode or damage the surface of the finished RCC pavement.

514.13.2-Curing Compound: Do not use curing compounds when the RCC material is to be promptly covered with asphalt. Apply curing compound as indicated in Section 707.9 of the Standard Specifications, except that the minimum rate of curing compound application is 11 square yards per gallon (2.5 m²/L) unless a higher rate is specified by the curing compound manufacturer.

514.14-OPENING TO TRAFFIC:

Protect the RCC from vehicular traffic during the curing period. Do not place vehicular traffic, except for curing equipment or sawcutting equipment, on the RCC pavement until the RCC material achieves a minimum compressive strength of 3,000 psi (21 Mpa) as demonstrated in Section 514.4.2.2.

514.15-MAINTENANCE:

Maintain the RCC pavement in good condition until all work is completed and accepted. Perform such maintenance at no additional cost to the Engineer.

514.16-METHOD OF MEASUREMENT:

The quantity of RCC placement to be paid for will be the number of square yards (meters) complete in place and accepted. The width for measurement will be the width of the pavement or overlay shown on the typical cross section of the Plans and additional widening where called for or as otherwise directed in writing by the Engineer. The length will be measured on the surface along the centerline of the roadway or roadway ramp. Construction of control joints will not be measured separately and no direct payment will be made for this work.

514.17-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices less adjustments referred to below and shall constitute full compensation for furnishing and preparing of all materials, equipment, tools, labor, and incidentals necessary to satisfactorily complete the work.

514.17.1-Thickness: Any sampling units found to be deficient in thickness, and which are allowed to remain in place by the Engineer, shall be paid for at a reduced Contract Unit Bid Price as outlined in Table 514.4.3.2. No compensation will be allowed for the materials or labor involved in the removal of defective material.

514.17.2-Strength: Determination of RCC strength shall be in accordance with Section 514.4.3.1. Any sampling units found to be deficient in strength, and which are allowed to remain in place by the Engineer, shall be paid for at a reduced Contract Unit Bid Price as outlined in Section 514.4.3.1. No compensation will be allowed for the materials or labor involved in the removal of defective material.

514.17.3-Density: Determination of RCC density shall be in accordance with Section 514.4.2.3. Any sampling units found to be deficient in density, shall be handled in accordance with Sections 514.4.2.3 and 514.4.3.1.

514.18-PAY ITEM:

ITEM	DESCRIPTION	UNIT
514001-*	"thickness" Roller Compacted Concrete	Square Yard (Meter)

* Sequence number

DIVISION 600

INCIDENTAL CONSTRUCTION

SECTION 601 STRUCTURAL CONCRETE

601.1-DESCRIPTION:

This work shall consist of furnishing and placing portland cement concrete for structures, and incidental construction, in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions as shown on the Plans or established by the Engineer.

All concrete shall be air-entrained.

Classes of concrete shall be used as indicated below unless noted otherwise on the Plans:

Class A concrete shall be used in railing, cribbing, precast shapes, for filler, and in steel grid floors.

Class K concrete shall be used in all sidewalks, parapets, decks, and median barriers when they are a part of the bridge superstructure.

Class B concrete shall be used in all beams and girders, roadway sidewalks, columns, hammerhead piers, arch rings including ties and spandrel walls, rigid frames, box culverts, heavily reinforced abutments, retaining walls, footings, pedestals and other areas not specifically designated as to class of concrete.

Class C concrete shall be used in massive footings and pedestals, massive pier shafts, gravity walls and, in general, for non-reinforced or lightly reinforced concrete.

Class D concrete shall be used as unformed and non-reinforced concrete for backfilling of any excavated pockets or voids on which footings are to be located.

Class H concrete shall be used for bridge decks and other bridge elements when designated in the plans.

Class DC concrete shall be used in drilled caisson foundations.

If the Contractor so elects, the Engineer may permit the use of a higher class concrete than the particular class designated for the work, in which event the higher class concrete shall meet the Specifications applicable without additional compensation. If the contractor uses a higher class concrete, and the strength specimens do not meet the minimum strength requirement of that higher class concrete, no penalty will be applied, provided that the strength specimens exceed the minimum strength requirement of the concrete that was originally designated for the work.

When called for on the Plans, an admixture of water-reducing retarder shall be added to all concrete so specified. A retarder may be used in other concrete at the Contractor's option.

The work will be accepted in accordance with these Specifications and the applicable requirements of 105, 106, and 109.

All classes of concrete shall be designated as *modified* when using increased design strengths.

All classes of concrete shall be designated as *architectural* when using additional formwork as shown in Section 601.8.10.

A hydration control stabilizing admixture may be used at the Contractor's option provided that the conditions in section 601.7 are met.

601.2-MATERIALS:

Materials shall meet the requirements specified in the following Sections or Subsections of Division 700:

Class H Concrete Requirements: The total concrete constituents shall contribute less than 0.10% water soluble chloride ion by weight of cement. The Contractor shall use only one brand and/or source for any concrete constituent. The Contractor shall obtain a written statement from the manufacturer of the microsilica admixture that confirms the compatibility of the material combination and the sequence in which they are combined. The written statement, along with the results of all required tests, shall be furnished to the Engineer prior to the pre-pour meeting.

MATERIAL	SECTION OR SUBSECTION
Accelerating Admixtures	707.13
Air-Entraining Admixtures	707.1
Boiled Linseed Oil	711.2
Coarse Aggregate	703
Curing Materials	707.6-707.10
Epoxy Resin Protective Coating	707.11
Fine Aggregate**	702.1
Hydration Control Stabilizing Admixtures	707.15
Joint Filler (Substructure)****	708.1.2
Joint Filler (Superstructure)*****	708.1.1
Petroleum Spirits (Mineral Spirits)	711.5
Portland Cement*	701.1, 701.3
Pozzolanic Additives***	707.4
Specific Performance Admixtures	707.17
Water	715.7
Water Reducer	707.3
Water-Reducing, Accelerating Admixtures	707.14
Water-Reducing, Set-Retarding Admixtures	707.2

- * It is normally intended that the product of only one mill or of any one brand or type of Portland cement be used on any one structure.
- ** Only siliceous sand shall be used as fine aggregate in bridge deck wearing surfaces.
- *** The use of a Pozzolanic additives will not be permitted when a blended hydraulic cement is used. Unless otherwise permitted by the Engineer, only one source of a Pozzolanic additive shall be used in any one structure.
- **** Joint filler for vertical joints in the substructure shall be in accordance with Section 708.1.2.
- ***** Preformed joint filler for vertical joints in the superstructure shall be sponge rubber in accordance with Section 708.1.1.

Shipping and Storage of Cement: Cement shall be shipped from pretested and approved bins at the mill or distribution terminals. Cement stored by the Contractor for a period longer than 90 days shall be retested before being used in the work. Cement failing to meet any of the specified requirements at any time prior to incorporation into the work will be rejected and shall be removed from the work. Cements of different brands, types, or from different mills shall be stored separately.

Shipping and Storage of Pozzolanic Additives: Pozzolanic additives shall be shipped from only those sources approved by the Division. Bulk Pozzolanic additives shall be stored at

the job site in weatherproof bins. Pozzolanic additives from different sources or from different lots at the same source shall be stored separately.

CONSTRUCTION METHODS

601.3-PROPORTIONING:

The proportions for any concrete designated as *modified* shall be submitted by the Contractor to the Engineer for approval. The Design 28-Day Compressive Strength shall be as shown in the plans. The contractor's mix design shall utilize Table 601.3.1, except the Target Cement Factor may be revised to obtain the modified strength.

Class H concrete shall consist of a homogeneous mixture of cement, fine aggregate, coarse aggregate, microsilica admixture, fly ash or ground granulated blast furnace slag, chemical admixtures, and water.

Establishment of mixture proportions shall be coordinated with the manufacturer of the microsilica admixture.

Design mixture testing for Class H concrete shall be in accordance with MP 711.03.23 and shall include air content, slump, compressive strength, and rapid chloride permeability tests. For establishment of mixture proportions, rapid chloride permeability tests shall be made on representative samples prepared and tested in accordance with AASHTO T277. The rapid chloride permeability test specimens shall be tested at an age of 90 days (or at any time prior to 90 days), and the results of this test shall not exceed 750 coulombs. Specimens shall be moist cured for 56 days prior to the start of specimen preparation unless specimens are to be tested prior to 56 days, in which case the specimens shall be moist cured until the time of test. The 28-day compressive strength of the test mix that satisfies the 750 coulomb threshold shall be used as the basis for acceptance of Class H concrete per Section 601.4.5. The cost of all test mix requirements shall be considered incidental to the cost of Class H concrete.

For establishment of mixture proportions, as an alternative to the curing methods for rapid chloride permeability testing outlined in the previous paragraph, specimens may be moist cured for 7 days in accordance with ASTM C 192, then cured for 21 days in lime-saturated water at 100.0 ± 3.5 °F (38.0 ± 2.0 °C), then tested at an age of 28 days. This method of curing shall be noted as the accelerated RCPT curing method.

601.3.1-Mix Design Requirements: Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportion of materials, including admixtures, to be used which will result in a workable concrete having the applicable properties enumerated below, including those of Table 601.3.1A. A mix design prepared in accordance with MP 711.03.23, shall be required for each class of concrete to be used in the work. The mix design shall be accompanied by a statement giving the source of materials and certified test data from a Division approved laboratory demonstrating the adequacy of the mix design. The Contractor shall notify the Engineer of any change in the source of materials or the addition of admixtures during the progress of the work, since such change may necessitate a new mix design. The Contractor shall also state the $\bar{A}$ value of the fine aggregate and the $\bar{A}$ value of the combined grading of the coarse aggregate, fine aggregate, and cement used in the mix design. Each mix design shall remain approved for a period of three years from the date of approval, after which the mix design may be re-approved for an additional time period. The guidelines for this re-approval process are set forth in MP 711.03.23.

Approved Hydration Control Stabilizing Admixtures, as defined in Section 707.15, which are designed to stop the hydration of cement in a concrete mix, enabling an extension to the allowable discharge time from a truck mixer as outlined in Section 601.7, may be added to an existing approved concrete mix design in accordance with the procedures outlined in MP 711.03.23.

TABLE 601.3.1A {ENGLISH}

Class of concrete	Design 28 Day Compressive Strength	Target Cement Factor	Maximum Water Content	Standard Size of Coarse Aggregate***	Entrained Air
	Pounds per Square inch	lbs./c.y. *	lb. of water / lb. of cement **	Number	Percent
A	3500	682	0.51	7, 78, or 8	7½
K	4000	658	0.44	57, 67	7
B	3000	564	0.49	57, 67	7
C	2500	494	0.58	57, 67	6
D	2000	400	0.62	57, 67	5½
H	4000	658	0.40	57, 67	6½
DC	4500	705	0.44	7, 78, 8	6

TABLE 601.3.1A {METRIC}

Class of concrete	Design 28 Day Compressive Strength	Target Cement Factor	Maximum Water Content	Standard Size of Coarse Aggregate***	Entrained Air
	Mpa	Kg per cu. m. *	L/Kg of cement **	Number	Percent
A	24	404	0.51	7, 78, or 8	7½
K	28	390	0.44	57, 67	7
B	21	335	0.49	57, 67	7
C	17	295	0.58	57, 67	6
D	14	235	0.62	57, 67	5½
H	28	390	0.40	57, 67	6½
DC	31	418	0.44	7, 78, or 8	6

* An equal volume of a pozzolanic additive may be substituted for Portland cement up to the maximum amount in Table 601.3.1B. Only one pozzolanic additive is permitted in a mix design, except for Class H concrete. The target cement factor of Class H concrete shall consist of Option 1 or Option 2 from Table 601.3.1C. The Contractor may choose either option.

** When using a pozzolanic additive, volumes of these materials shall be considered as cement for purposes of establishing maximum water content.

*** A number 67 coarse aggregate may be used in Class DC concrete, provided the Engineer approves the use of that size aggregate for the specific project on which it is to be used. That approval will depend on the minimum spacing of the reinforcing steel in the drilled caisson.

TABLE 601.3.1B

Material	Class Of Concrete	Quantity
Fly Ash	B, C, D	0.48 ft ³ (0.014 m ³)
	A, K	0.60 ft ³ (0.017 m ³)
	DC	0.72 ft ³ (0.020 m ³)
Ground Granulated Furnace Slag	A, B, K	1.43 ft ³ (0.040 m ³)
	C, D	0.96 ft ³ (0.027 m ³)
	DC	1.79 ft ³ (0.051 m ³)
Microsilica	All Classes	0.24 ft ³ (0.007 m ³)

TABLE 601.3.1C

Option	Cement	Fly Ash	Ground Granulated Furnace Slag	Microsilica
1	2.39 ft ³ (0.068 m ³)	0.84 ft ³ (0.024 m ³)		30 lbs. (13.6 kg)
2	2.15 ft ³ (0.061 m ³)		1.08 ft ³ (0.031 m ³)	30 lbs. (13.6 kg)

MP 711.03.26 shall be used to control the cement factor in all classes of concrete except Class H.

601.3.2-Field Tolerances and Adjustments:

601.3.2.1-Consistency: Concrete shall have the consistency which will allow proper placement and consolidation in the required position. Every attempt shall be made to obtain a uniform consistency. The optimum consistency for various types of highway structures shall be as indicated in Table 601.3.2. Concrete for any “Slump Test” shall be deposited in a manner and location that excludes the effects of vibrations caused by traffic and concrete placement operations.

An approved Type F or Type G admixture may be used to increase the consistency and improve the workability of the concrete as long as the requirements of section 707.2.2.1 or section 707.3.2.1 are met. When an admixture is used for this purpose, it may be referred to as a superplasticizer.

No more than a total of two additions of a superplasticizer shall be permitted in any one batch of concrete. If a superplasticizer is used at the batch plant, then only one field addition is permitted. The total quantity of the superplasticizer shall not exceed the manufacturer’s recommended dosage rate.

Upon addition of a superplasticizer at the job site, the mixing drum shall be turned for a minimum of 60 revolutions or 5 minutes at mixing speed to establish a workable mixture of uniform composition and consistency. If a second job site addition of superplasticizer is used; the mixing drum shall be turned a minimum of 30 additional revolutions at mixing speed. All additions and mixing of the superplasticizer shall be completed before placement of the concrete is started. The total number of revolutions shall not exceed 300, and the concrete shall be discharged within the time limits in section 601.7. The slump of Class H concrete shall not exceed 7 inches (175 mm) under any circumstances.

When a superplasticizer is used, the optimum consistency target value may be increased by 4 inches (100 mm), but under no circumstances shall the slump exceed 8 inches (200 mm).

Acceptance tests for consistency (slump), air content, compressive strength, etc. shall be made after all additions and mixing of the superplasticizer. Slump tests shall be performed on every batch of concrete to which superplasticizer is added (one test before and one test after the addition of superplasticizer).

The Contractor shall obtain a written statement from the manufacturer of the superplasticizer stating:

- i. The manufacturer is satisfied with the compatibility of the combination of materials and the sequence in which they are combined.
- ii. The recommended maximum admixture dosage rate.
- iii. Immediately after mixing, the air content and slump shall be measured by a certified Portland Cement Concrete Inspector.

This written statement from the admixture manufacturer shall be made available to project personnel before any superplasticizer is added at the job site.

TABLE 601.3.2 CONSISTENCY

TYPE	*Optimum Consistency Inches of Slump (mm of slump)
i. For structures which have exposed, inclined surfaces such as concrete gutters, cast in place concrete slope protection, etc., requiring low slump concrete to allow proper placement and consolidation and the maintenance of the prescribed geometry; those structures which are placed by slip form construction methods where a low slump is required to maintain the prescribed geometry; and mass nonreinforced concrete.	1 inch (25 mm)
ii. For reinforced concrete structures which are sufficiently massive and generally have sufficient clearances to allow the access of workers into the immediate area of concrete placement, such as bridge piers, column and abutment footings; piers, large columns, and other similar type structures into which workers may enter for the purpose of placing and consolidating the concrete.	2 inches (50 mm)
iii. a. For reinforced concrete structures which are not easily accessible for spading and vibrating and offer a fair degree of difficulty in the placement and consolidation of the concrete, such as pier caps and abutments, beams and girders, box culverts, miscellaneous structure footings and other slab type structures, wall or vertical sections 8 inches (200 mm) or greater in width with one line of reinforcement or 12 inches (300 mm) or greater in width with two lines of reinforcement. b. For bridge decks	3 inches (75 mm) 2 ½ inches (62 mm)
iv. For structures which are inaccessible to workers and generally offer a considerable degree of difficulty in the placement and consolidation of the concrete, such as long slender columns and thin-walled 3 ½ sections less than 8 inches (200 mm) thickness.	3 ½ inches (87 mm)
v. For structures which present peculiar conditions under which concreting must be done, such as structural steel encasement; other special structures which contain small openings through which the concrete must pass; tremie concrete which must be placed and consolidated into all spaces without mechanical disturbances; and other special structures which would require high consistency concrete for proper placement and consolidation.	**

* If the consistency exceeds the target value plus one inch (25 mm), the Contractor shall take immediate steps to reduce the slump of succeeding loads by making necessary adjustments in the mixture. The Contractor will be allowed a reasonable time for the trucks already on the road for a central mix or truck mix operation. Failure to comply will be cause for rejection of the concrete. If the consistency exceeds the target value plus 1 ¾ inches (445 mm), the concrete will be rejected.

** The optimum consistency shall be that consistency which will allow a proper placement and consolidation of the concrete into all spaces.

601.3.2.2-Air Content: The target value of the entrained air at the point of placement shall be as shown in Table 601.3.1A. If the entrained air does not conform with the target value within plus or minus 2.5 percentage points, the Contractor shall take immediate steps to adjust the air content of succeeding loads by making necessary adjustments in the mixture. The air content shall be measured on loads already batched and enroute, as well as the first load to which any adjustments were made in batching procedures. If the air content exceeds the target value plus 3.0 percentage points the concrete shall be rejected. When the concrete is delivered in a truck mixer and the air content is less than the target value minus 2.5 percentage points the concrete shall be rejected, or the Contractor may use additional air entraining agent in an amount that is intended to achieve the target value specified. The addition is permitted under the conditions listed below.

The target of the entrained air content of Class H concrete at the time of placement shall be as shown in Table 601.3.1A. If the entrained air does not conform with the target value within plus or minus 1.5 percentage points, the Contractor shall take immediate steps to adjust the air content of succeeding loads by making necessary adjustments in the mixture. If the entrained air content of Class H concrete does not conform to the target value plus 2.0 percentage points, the concrete shall be rejected. When Class H concrete is delivered in a truck mixer and the air content is less than the target value minus 2.0 percentage points, the concrete shall be rejected or the Contractor may use additional air-entraining agent in an amount that is intended to achieve the target value specified. The addition is permitted under the conditions listed below.

- i. The air entraining agent is the same as used in the approved mix design and is thoroughly mixed with a minimum of 2 gallons (7.57 liter) of water. The solution will be directed to the front of the mixer.
- ii. The mixer is turned a minimum of 30 revolutions, at mixing speed, or the number of revolutions established in tests to comply with uniformity requirements, whichever is more.

Immediately after mixing, the air content and slump shall be measured by a certified inspector or technician.

An air adjustment may be attempted twice per truck. If after the second addition the specified air content is not achieved, the concrete shall be rejected. These procedures do not alter the limits placed on time to discharge, the total revolutions of the mixing drum, or the specified slump.

601.3.2.3-Yield: The approved mix design shall be subject to modification under the conditions prescribed.

After the start of the first concreting operation and immediately after the specified consistency and entrained air have been established, three unit weight determinations shall be made from different batches and the average of the three determinations shall be considered the unit weight of the concrete. The actual yield shall be determined from the average unit weight. The design mix shall be adjusted as required to correct the actual yield to correspond to the theoretical.

During the progress of the work, the actual yield shall be verified at the frequency noted in MP 601.03.50; and, if the yield, based on a single unit weight determination, should differ from the theoretical yield by more than plus or minus two percent, two additional unit weight determinations shall be made, and the average of the three determinations shall

be considered the unit weight of the concrete. The actual yield shall be determined from that average unit weight, and the design mix shall be adjusted as required to correct the actual yield to correspond to the theoretical yield.

In addition to the mix design adjustments specified above to correct for yield, other adjustments in the design mix proportions shall be made as necessary to maintain a plastic, workable mix with suitable finishing characteristics.

No change in the brands or sources of material shall be made without prior approval of the Engineer. Methods for determining the properties enumerated above shall be in accordance with 601.4.

601.3.2.4-Total Solids $\bar{A}$: The combined grading of the coarse aggregate, fine aggregate, and cement used in the structural concrete shall conform to the design mix $\bar{A}$ plus or minus the tolerance specified in the following table for the coarse aggregate size used.

TABLE 601.3.2.4-Total Solids $\bar{A}$

Coarse Aggregate Size Number	Design Mix $\bar{A}$ Tolerance
3 or 4	± 0.35
57 or 67	± 0.25
7, 78 or 8	± 0.15

$\bar{A}$ is the value obtained by grading of the total solids (coarse aggregate, fine aggregate, and cement). The $\bar{A}$ shall be determined by the Contractor (in accordance with MP 601.03.51) at least once for every 50 cubic yards (37.5 cubic meters) of concrete that are produced from the same mix design. However, not more than one $\bar{A}$ test (for each mix design) shall be required per calendar day as long as not more than 400 cubic yards (305 cubic meters) of concrete are produced in a single day from the same mix design. In situations when more than 400 cubic yards (305 cubic meters) of concrete are produced in a single day from the same mix design, two $\bar{A}$ tests shall be required (one in the AM and one in the PM) for that mix design.

During any calendar week (Sunday through Saturday) in which concrete is being produced, a minimum of one $\bar{A}$ test shall be required (for each mix design from which concrete is being produced). This $\bar{A}$ test shall be conducted on the first day of production of that calendar week. For days on which concrete is being produced, but no $\bar{A}$ test is required, laboratory number 1392885 shall be used for $\bar{A}$ test documentation purposes.

Should the moving average of any five consecutive grading tests of the total solids have an $\bar{A}$ outside the specified mix design tolerance limits, production shall be discontinued until appropriate corrections are made. Corrections shall be made either in the proportions of the concrete (the mix design), the gradation of the aggregates, or the storage and loading of the aggregate, as the Contractor may elect.

When the small quantity work condition applies, the $\bar{A}$ required after 50 cubic yards (37.5 cubic meters) of concrete production shall be performed on the day that the 50 cubic yard quantity is achieved. All concrete produced on that day (the day that the 50 cubic yard quantity is achieved) shall be represented by the previous $\bar{A}$. The $\bar{A}$ conducted on the day that the 50 cubic yard quantity is achieved shall represent the next 50 cubic yards of concrete produced, beginning with the concrete produced on the next day of production.

When, in a concrete mix, gradations tests show that the percentage of material which passes the No. 200 (75 μm) sieve, exceeds the amount permitted in Sections 702.1.2 and 703.4, and provided the Engineer permits the material to remain in place and the Contractor elects to leave the material in place, then a penalty shall be applied in the manner outlined in the following paragraph.

It shall be determined which material (coarse aggregate, fine aggregate, or both) caused the total material finer than the No. 200 (75 μm) sieve to exceed the specification limits as determined in Sections 702.1.2 and 703.4. The mass of the material(s) in the concrete mix (M_{ca} , M_{fa} , or both, as defined in MP 601.03.51), which caused the total material finer than the No. 200 (75 μm) sieve to exceed the specification limits shall be divided by M_t (as defined in MP 601.03.51). The resulting number shall be multiplied by the unit price of the concrete, as billed by the Concrete Supplier and by the quantity of non-specification concrete placed. That value shall be the penalty applied for the use of the material which did not meet the specification requirements.

601.4-TESTING:

601.4.1-Sampling and Testing Methods:

Sampling fresh concrete	AASHTO R 60
Sampling aggregate	MP 700.00.06
Sieve analysis of fine and coarse aggregates	AASHTO T 27 and T 11
Slump of portland cement concrete	AASHTO T 119 ^{Note 1}
Air content of freshly mixed concrete	AASHTO T 152 AASHTO T 196
Unit weight/Yield of concrete	AASHTO T 121
Making and curing concrete compressive specimens	AASHTO T 23 With MP 601.04.20
Compressive strength of cylindrical concrete specimens	AASHTO T 22
Total moisture content of aggregate by drying	AASHTO T 255
Predicting potential strength of portland cement concrete	MP 711.03.31
Determination of $\bar{A}$ of total solids in concrete	MP 601.03.51
Determination of free moisture in fine aggregate using 20 gram or 26 gram A "Speedy Moisture Tester"	MP 702.00.20
Rapid Chloride Permeability Test	AASHTO T 277

Note 1 When testing concrete produced by volumetric batching and continuous mixing, the consistency testing shall be delayed for approximately three to five minutes after mixing.

601.4.2-Contractor's Quality Control: Quality control of the structural concrete is the responsibility of the Contractor as designated in MP 601.03.50. The Contractor shall maintain equipment and qualified personnel, including at least one certified Portland cement concrete technician who shall direct all field inspection, sampling and testing necessary to determine the magnitude of the various properties of concrete governed by the Specifications and shall maintain these properties within the limits of this Specification. The Contractor's personnel who conducts the field sampling and testing shall be a certified Portland Cement Concrete Inspector. The quality control plan designated in MP 601.03.50 shall be submitted to the Engineer at the preconstruction conference. Work shall not begin until the plan is reviewed for conformance with the contract documents.

The Contractor shall provide a copy of the quality control test results to the Supplier of the concrete which was tested within 48 hours of the completion of the test.

601.4.3-Acceptance Testing: Acceptance sampling and testing of Portland cement concrete is the responsibility of the Division, except for furnishing of necessary materials.

Quality control sampling and testing performed by the Contractor may be utilized by the Division for acceptance.

Strength as used in this specification, is only one indicator of the durability of the Portland cement concrete. Evaluation of structural concrete may include evaluation of the freeze-thaw durability, scaling characteristics, abrasion resistance, density and such other factors the Division deems appropriate.

601.4.4-Compressive Strength Tests for Acceptance: A strength test shall consist of three test specimens. Either 6" x 12" (150 mm x 300 mm) cylinders or 4" x 8" (100 mm x 200 mm) cylinders are permitted, provided the requirements of MP 711.03.23 are met. The size of the cylinders which the Contractor intends to use on each project shall be listed in the Contractor's Quality Control Plan. The test shall be the average of the three specimens, except that if one specimen shows manifest evidence of improper sampling, molding, or testing, it shall be discarded and the remaining two strengths averaged. Should more than one specimen representing a given test show definite defects due to improper sampling, molding, or testing, the entire test shall be discarded.

The maximum acceptable range of compressive strengths within a set of three cylinders is 9.5%. This range is found by multiplying 9.5% times the average compressive strength of the three cylinders. If this acceptable range is exceeded, the cylinder that varies the most from the average shall be discarded, and the remaining two cylinders shall be evaluated as outlined in the following paragraph.

The maximum acceptable range of compressive strengths within a set of two cylinders is 8.0%. This range is found by multiplying 8.0% times the average compressive strength of the two cylinders. If this acceptable range is exceeded, the entire test shall be discarded. Under no circumstances shall a compressive strength test consist of less than the average of two specimens.

Compressive strength tests shall conform to the requirements of Table 601.3.1. Statistical analysis may indicate a percentage of production to be below nominal minimum design strength. Concrete represented by compressive strengths below the nominal minimum design strength of Table 601.3.1 may be removed and replaced by the Contractor. If the Contractor elects to leave the material in place, it will be evaluated as to adequacy for the use intended.

All concrete evaluated as unsatisfactory for the use intended shall be removed and replaced or otherwise corrected by and at the expense of the Contractor as required in 105.3. When an evaluation indicates that the work may satisfactorily remain in place, a statistical analysis will be made of the material. If this statistical analysis indicates at least 93 percent of the material may be expected to have compressive strengths equal to or greater than that shown in Table 601.3.1 and 99.87 percent of the material may be expected to have compressive strengths at least one standard deviation above forty percent of the design strength ($0.4f'_c + \sigma$), the work will be accepted as substantially complying with the specification requirements. If this statistical analysis indicates that less than 93 percent of the material may be expected to have compressive strengths equal to or greater than that shown in Table 601.3.1 or less than 99.87 percent of the material may be expected to have compressive strengths at least one standard deviation above forty percent of the design strength ($0.4f'_c + \sigma$), the Engineer will provide for an appropriate adjustment under the provisions of 601.15.

Whenever possible, the Division's statistical analysis will be based on a minimum of 10 cylinder test results. These results may be from the concrete item being placed, the same class of concrete on the project, or the same class of concrete from the producer. All of the cylinder test results used in this evaluation, however, must be from the same mix design.

601.4.5-Tests for Permeability Acceptance of Class H Concrete: The Contractor shall be required to compare the compressive strength test results obtained in Section 601.4.4, for Class H concrete, to the compressive strength of the approved test mix per Section 601.3.

The Contractor shall also be required to fabricate six rapid chloride permeability test specimens in accordance with AASHTO T277 every time that a set of compressive strength specimens for Class H concrete is fabricated. Chloride Permeability of the in-place concrete shall be considered acceptable if the 28-day compressive strengths obtained in Section 601.4.4 are greater than eighty percent of the 28-day compressive strength of the approved test mix. Concrete represented by compressive strengths below eighty percent of the 28-day compressive strength of the approved test mix may be removed and replaced by the Contractor. If the Contractor elects to leave the material in place, it will be evaluated as to adequacy for the use intended. All concrete evaluated as unsatisfactory for the use intended shall be removed and replaced or otherwise corrected by and at the expense of the Contractor as required in Section 105.3.

The Contractor shall also be required to fabricate six rapid chloride permeability test specimens in accordance with AASHTO T277 every time that a set of compressive strength specimens is fabricated. These test specimens shall be moist cured until as close to the time of test as possible. If the 28-day compressive strength of the in-place concrete (obtained in Section 601.4.4) is less than or equal to eighty percent of the compressive strength of the approved test mix, these rapid chloride permeability test specimens shall be tested in accordance with AASHTO T277, otherwise testing of these specimens is not required. When testing of these specimens is required, two test specimens shall be tested at each of the following ages: 35, 56, and 90 days. These test results shall be used by the Engineer as the basis for evaluation as to the adequacy of the material for the use intended.

601.5-EQUIPMENT AND TOOLS:

601.5.1-Field Laboratory: Field laboratory provisions shall conform to the requirements prescribed in 501.5.1.

601.5.2-Batching Plant and Equipment:

601.5.2.1-General: The batching plant shall include bins, weigh hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a separate bin, weight hopper, and scale for cement shall be included. The cement weight hopper shall be properly sealed to preclude dusting during operation and shall be properly vented to prevent a build-up in pressure. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will not lodge in it nor leak from it. When fly ash is used in the concrete a separate bin shall be included.

601.5.2.2-Bins: Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.

601.5.2.3-Scales: The scales for weighing aggregates and cement shall conform to the requirements in 109.1.

Scales shall be inspected and sealed as often as may be deemed necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 50 lb. (20 kg) weights for testing scales.

601.5.2.4-Automatic Weighing Devices: Batching plants equipped to proportion aggregates and bulk cement by means of automatic weighing devices of an approved type may be used.

601.5.2.5-Water Measuring Equipment: Water shall be measured by volume or by weight. The device for the measurement of the water shall be readily adjustable and, under all operating conditions, shall have an accuracy within one percent of the quantity of water required for the batch.

601.5.2.6-Admixture Dispenser: A positive, automatic method shall be used for adding each admixture in solution.

601.5.2.7-Aggregate Sampling: Provisions shall be made to allow a rapid sampling of the aggregates as they pass from the storage bin to the weigh hopper or as they pass from the storage bin into the conveyor feed.

601.5.3-Mixers and Agitators: Site and central mixers, truck mixers, truck agitators, and non-agitator trucks shall conform to the requirements of AASHTO M 157, except as modified.

Volumetric mixers shall conform to the requirements of AASHTO M 241, except as modified.

Central mixers shall be equipped with a device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, providing that each batch is mixed for the specified time period.

All mixers shall be cleaned at suitable intervals. The pickup and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down $\frac{3}{4}$ inch (20 mm) or

more. The Contractor shall either have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or provide permanent marks on blades to show points of $\frac{3}{4}$ inch (20 mm) wear from new conditions. Holes of $\frac{1}{4}$ inch (6 mm) diameter near each end and at midpoint of each blade are recommended).

601.5.4-Recording Thermometer: The Contractor shall supply a continuous recording thermometer capable of recording temperatures in the 30-150° F (1 – 66 °C) range. It shall likewise provide a recording capability over a 24-hour continuous period, minimum. The Contractor shall provide any ancillary equipment, supplies and labor necessary for calibration of this equipment.

601.6-HANDLING, MEASURING, AND BATCHING OF MATERIALS:

Handling, measuring, and batching of materials for ready-mix concrete shall conform to the requirements specified in 501.7. Handling, measuring, and batching of materials for volumetric batching and continuous mixing shall conform to the applicable requirements specified in 501.7 and AASHTO M 241.

When microsilica densified powder is used, the densified powder shall be weighed using an approved cement scale or standard 25 lb. (11.3 kg) or 50 lb. (22.6 kg) full bags may be substituted. Batching tolerance for the cement plus densified powder shall be 1.0%.

Batching and mixing recommendations for bulk and bagged densified microsilica (silica fume) are provided in the Silica Fume User's Manual which is available through the Silica Fume Association (Report Number FHWA-IF-05-016).

These recommendations include procedures to be used when the Ready-Mix Supplier desires to add microsilica, which is supplied in repulpable bags, into the mix. If these recommendations are followed, and the Ready-Mix Supplier can satisfactorily demonstrate to the Engineer, by means of testing and wet-sieving a trial batch (see section 7.3.6 of the Silica Fume User's Manual), that there are no fragments of the packaging material remaining in the mix, then the restriction in section 501.7, concerning the addition of the pozzolan packaging material, may be waived.

The above referenced testing and wet-sieving of the trial batch shall be done on a plant-by-plant and mix-by-mix basis. When truck-mixed concrete is used, the truck which demonstrates the greatest degree of variability in the uniformity requirements, as specified in AASHTO M 157, shall be the truck which is used to produce the trial batch for testing and wet-sieving purposes. If the Ready-Mix Supplier intends to use this approach, it shall be addressed in the Plant portion of the Quality Control Plan.

601.7-MIXING:

Concrete may be central-mixed, truck-mixed, or shrink-mixed as defined in AASHTO M 157 and will be designated as ready-mixed concrete. The production of ready-mixed concrete shall meet the applicable requirements of AASHTO M 157, paragraphs ten and eleven, except as otherwise specified.

Concrete for incidental construction items may be made by volumetric batching and continuous mixing as designated in ASTM C 685, except as otherwise specified. Concrete produced by this method will not be permitted in bridge, box culvert, pavement, or retaining wall construction.

When a truck mixer or agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within one and one-half hours

after the addition of the cement to the aggregates. Each batch of the concrete delivered at the job site shall be accompanied by a batch ticket (Form HL 411A) bearing complete batching information. In adverse weather or under other conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85° F (30° C) or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed one hour. When a truck mixer is used for the complete mixing of the concrete, the mixing operation shall begin within one hour after the cement has been added to the aggregate.

When placing concrete at remote locations, due to excessive haul time to the site of work from the closest approved batch plant, and when discharge of the concrete within the time limits specified in the previous paragraph is not possible, or in other circumstances when approved by the Engineer, a concrete mix that includes a hydration control stabilizing admixture may be used to extend the allowable concrete discharge time. The subject concrete mix containing this admixture must be approved in accordance with section 601.3.1, and the hydration control stabilizing admixture must be approved in accordance with section 707.15. When conditions are such that a hydration control stabilizing admixture is used, the allowable time between the introduction of the cement to the aggregates and discharge of the concrete shall be increased to three hours. The limit of 300 maximum revolutions (pertaining to truck mixers or agitators) specified in AASHTO M 157 may be waived when hydration control stabilizing admixtures are used, provided that no additional water is added prior to discharge of the concrete. A single batch of concrete containing a hydration control stabilizing admixture may not be discharged on more than one project

The addition of water after completion of initial mixing will not be permitted, except that when concrete is delivered in truck mixers, additional water may be added to adjust to a specified consistency. In this event, a minimum of 20 additional revolutions of the truck mixer drum at mixing speed shall be required before discharge of any concrete; the maximum allowable time between the addition of the cement to the aggregates and the discharge of the batch shall not be exceeded. Concrete that is not within the specified consistency limits at the time of placement shall not be used.

Shrink-mixed concrete is a ready-mixed concrete which is initially and partially mixed in a central mix plant and lastly mixed to completion in a truck mixer while in transit to or after arrival at the job site. Shrink-mixed concrete will be allowed for use in the work if specified in the Contract.

601.8-FORMS:

601.8.1-General: Forms shall be of wood, metal or other approved material and shall be mortar tight and sufficiently rigid to prevent distortion due to pressure of the concrete and other loads incidental to the construction operations including vibration. Wood forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber.

All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads without appreciable settlement or deformation. Suitable jacks, wedges or other approved devices shall be used to maintain the forms at correct elevation and to permit lowering the centers gradually and uniformly without injury to the structure.

Deck slab overhang forms shall be supported from the bottom flange of fascia girders or stringers. The Contractor shall submit forming plans and supporting calculations for the overhang to the Engineer for approval prior to erecting the formwork.

A "Telltale" or other approved type of indicator shall be attached to the forms and arranged in such a manner that any settlement or movement in the forms or falsework is indicated. Forms shall be filleted and chamfered as shown on the Plans and shall be given a bevel or draft in the case of all projections to assure easy removal.

All field welding shall be performed by a certified welder. Welding of form ties and supports to the beam will not be permitted. Welding of screed rail supports will not be permitted in the top flange in tension zone.

601.8.2-Form Lumber: Form lumber for all exposed concrete surfaces shall be dressed at least on one side and two edges.

601.8.3-Metal Ties: Metal ties or anchorages within the forms shall be constructed to permit their removal to a depth of at least 1 inch (25 mm) from the face without injury to the concrete. Only rods shall be used for internal ties. The cavities shall be filled with cement mortar and the surface left sound, smooth, even, and uniform in color.

601.8.4-Cleanouts: Where the bottom of the form is inaccessible, the lower form area shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

601.8.5-Surface Treatment: Forms shall be treated with oil in such manner as to prevent contamination of reinforcing steel. Oil which will adhere to or discolor the concrete shall not be used.

601.8.6-Metal Forms: The metal used for the forms shall be of such thickness that the forms will remain true to shape. All bolts and rivet heads shall be countersunk. Clamps, pins, and other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Metal forms shall be kept free of rust, grease, or other foreign matter.

601.8.7-Removal of Forms and Construction of Superimposed Elements: The forms for any portion of the structure shall not be removed until the concrete is strong enough to prevent damage. Methods of form removal likely to cause overstressing of the concrete shall not be used.

The minimum requirements for removal of forms or supports and the construction of superimposed elements shall be as specified in Table 601.8.7.

In lieu of field cured cylinders for the determination of compressive strength required for removal and construction of superimposed elements, the Contractor may use the Maturity Method for the estimation of concrete strength as outlined in MP 601.04.21.

TABLE 601.8.7

Requirements for Removal of Forms and Construction of Superimposed Elements		
Structural Element	Removal of Forms	Placing Concrete In Superimposed Elements
	Compressive Strength-psi (Mpa)	Compressive Strength-psi (Mpa)
Bridge Decks	2000 (14.0)	3000 (21)
Columns	2000 (14.0)	2000 (14.0)
Walls & Beams	2000 (14.0)	2000 (14.0)
Footings	500 (3.5)	2000 (14.0)
Components Supported By Falsework	3000 (21)	3000 (21)
Parapets	2000 (14.0) (See 601.11)	-----

601.8.8-Slip Forming: Slip forming and related methods of placing concrete may be used. At the Contractor's option, parapet wall joints and median barrier on the bridge may be sawed in lieu of formed open joints and the joints shall be spaced as shown on the Plans and shall be $1/4$ inch $\pm$ $1/16$ inch (6 mm $\pm$ 1.6 mm) wide. Joints shall be sawed full width from the top of the wall to the upper break point in the wall. From the upper break point to the bottom of the wall a 2 inches (50 mm) minimum depth saw cut shall be made along the face and back of the wall. Joints shall be sealed in accordance with Section 501.16.1. The face of the back-up material shall be $1/2$ inch (13 mm) minimum from the concrete surface.

Initial sawing of joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excess raveling, usually 4 to 24 hours. All joints shall be initially sawed before uncontrolled shrinkage cracking takes place, but no later than 24 hours after placement of concrete.

601.8.9-Stay-in-Place Fabricated Metal Forms for Concrete Bridge Decks: All concrete bridge decks shall be constructed with a stay-in-place fabricated metal forming system per the requirements shown in this specification unless otherwise noted in the plans.

601.8.9.1-General: Stay-in-place fabricated metal forms for concrete deck slabs of bridges shall be used on all interior bays of beams. For overhangs and where longitudinal expansion joints are located between stringers removable forms shall be used. The design and material of the forms, in the judgment of the Engineer, shall be such as to give an expected maintenance free service life equal to the service life of the concrete slab. The stay-in-place fabricated metal forms shall be crimped at each end.

Unless otherwise specified in the plans, the weight of stay-in-place fabricated metal forms plus concrete in the form flutes used in the design is 15 psf (74 N/m²). The contractor shall submit revised computations if the proposed forming system is heavier than 15 psf (74 N/m²). The cost of the revised computations shall be at no additional cost to the Division.

601.8.9.2-Material: Stay-in-place fabricated metal forms for concrete decks slabs and exposed material for supports shall be zinc-coated (galvanized) steel sheet conforming to ASTM A-653, Designation SS, Grades 33 (230) through 80 (550), with a G165 Coating

Designation. The stay-in-place fabricated metal forms shall be designed on the basis of dead load of the forms, reinforcement, and the plastic concrete plus 50 psf (2400 N/m²) for construction loads. Unit working stresses shall be in accordance with the AASHTO LRFD Bridge Design Specifications for construction loads and the unit stress in the steel sheet shall be not more than 0.725 of the specified minimum yield strength of the material furnished but not to exceed 36,000 psi (250 Mpa). Maximum deflection under weight of plastic concrete, reinforcement and form shall not exceed 1/180 of the form span or ½" (13 mm), whichever is less. Maximum deflection under 60 psf (2900 N/m²) of live loads shall not exceed 1/360 of the form span or ¼" (6 mm), whichever is less. The form span for design and deflection shall be the clear distance between the flanges of the supporting beams less 2" (50 mm), measured parallel to the form flutes.

All stay-in-place fabricated metal forms shall have a minimum thickness of 22 gage.

Physical design properties shall be computed in accordance with requirements of American Iron and Steel Institute Specification for the Design of Cold-Formed Steel Structural members, latest published edition.

All reinforcing bars in the bottom layer of the deck slab reinforcement shall have a minimum concrete cover of 1" (25 mm). The distance from the top of the slab to the bottom layer of deck slab reinforcement shall not be less than that shown on the plans.

601.8.9.3-Installation: All forms shall be installed in accordance with detailed fabrication plans submitted to the Engineer for approval. The fabrication plans shall clearly indicate locations where the forms are supported by steel beam flanges.

Form sheets shall not be permitted to rest directly on the top of the stringer or floor beam flanges. Sheets shall be securely fastened to form supports and shall have a minimum bearing length of 1" (25 mm) at each end. Form supports shall be placed in direct contact with the flange of stringer or floor beam. All attachments shall be made by bolts, clips, or other approved means. Welding of form supports to flanges shall not be permitted.

Any exposed form metal where the galvanized coating has been damaged shall be thoroughly cleaned and wire brushed, and then painted with two coats of zinc-rich primer, conforming to Subsection 711.21, to the satisfaction of the Engineer.

Transverse construction joints shall be located at the bottom of a flute and ¼" (6 mm) weep holes shall be provided in the field at 12" (300 mm) ± 3" (75 mm) on center along the line of the joint.

601.8.9.4-Placement of Concrete: Concrete shall be placed in accordance with the contract specifications. The entire form shall be filled with deck concrete. No filler material shall be permitted. Particular emphasis should be placed on proper vibration of the concrete to avoid honeycomb and voids, especially at construction joints, expansion joints, flutes, and ends of form sheets.

The use of covered flutes or fillers of any kind in the flutes of the stay-in-place fabricated metal forms is not permitted.

Prior to placement of concrete, the Contractor shall submit to the Engineer for approval Concrete Volume to Stay in Place Form Adjustment Factor (SIP_{adj}). The SIP_{adj} shall be the equivalent ratio of the concrete volume in the form flutes to Square Yard of Stay-In-Place Form Area.

601.8.9.5-Inspection: The Contractor's method of construction shall be carefully observed during all phases of the construction of the bridge deck. These methods include installation of the Stay-in-place fabricated metal forms; location and fastening of the reinforcement; composition of concrete, placement and vibration; and finishing of the bridge deck.

Unless waived by the Engineer, the Contractor shall remove at least one section of the forms at a location and time selected by the Engineer for each concrete placement in each approved pour sequence. This should be done as soon after placing the concrete as practicable in order to provide visual evidence that the concrete mix and the Contractor's procedures are obtaining the desired results. An additional section shall be removed each time the concrete mix or the contractor's procedures are changed, unless waived by the Engineer.

After the deck concrete has been in place for a minimum of two days, the concrete shall be tested for soundness and bonding of the forms by sounding on the forms with a hammer at least 50 percent of the area of at least 25 percent of the individual form panels, as selected by the Engineer on a random basis. If areas of doubtful soundness are disclosed by this procedure, the Contractor will be required to remove the forms from such areas for visual inspection.

At locations where sections of the forms are removed, the Contractor will not be required to replace the forms, but the adjacent metal forms and supports shall be repaired to present a neat appearance and assure their satisfactory retention. As soon as the form is removed, the concrete surfaces will be examined for cavities, honeycombing and other defects. If irregularities are found, and in the opinion of the Engineer these irregularities do not justify rejection of the work, the concrete shall be given a Class 1, Ordinary Surface Finish in accordance with the contract specifications and shall be repaired as the Engineer may direct. If the concrete where the form is removed is unsatisfactory, additional forms shall be removed, as necessary, to inspect and repair the slab, and the Contractor's methods of construction shall be modified as required to obtain satisfactory concrete in the slabs.

The amount of sounding and form removal may be moderated, at the Engineer's discretion, after a substantial amount of slab has been constructed and inspected if the Contractor's methods of construction and the results of the inspections as outlined above indicate that sound concrete is being obtained throughout the slabs.

The Contractor shall provide all facilities required for the safe and convenient conduct of the Engineer's inspection procedures.

601.8.9.6-Forming System Changes: The contractor shall not utilize a removable forming system without the submittal of the following information:

1. Revised camber tables based on actual forming system.
2. Revised dead load deflection tables based on actual forming system.

These revised drawings must be stamped by a West Virginia Professional Engineer and approved by the Engineer prior to commencing forming. No change in unit prices, or contract completion date will be permitted for the use of a removable forming system.

601.8.10-Architectural Formwork:

601.8.10.1-General: This work includes additional requirements for the forming of cast-in-place structural concrete designated as *architectural*. The scope of this work is as indicated and as detailed on the drawings.

601.8.10.2-Submittals: The following shall be submitted to the Engineer for his review:

- A. Product data and installation instructions for manufactured form systems, form liners, release agents, ties, and accessories. The release agent manufacturer shall certify that the products supplied comply with regulations controlling the use of volatile organic compounds (VOC's).
- B. Shop drawings for fabrication and erection. These drawings shall show all items that visually affect the exposed concrete, including, but not limited to, general form construction, jointing, specially formed joints or reveals, and patterns of placement. The Engineer's review will be for general architectural applications and features only. Formwork design for structural stability and sufficiency is the Contractor's responsibility and shall not be submitted for the Engineer's review.
- C. Mockup or Sample Panels. The Contractor shall submit a mockup or sample panel of their respective material indicating texture, finish, and pattern in accordance with Section 601.8.10.3.A. This Mockup or Sample Panel shall have a minimum front surface area of 15 ft² (1.2 m²).

601.8.10.3-Quality Assurance:

- A. The Contractor shall construct a mockup or sample panel using the proposed formwork and facing materials in order to demonstrate the required finishes and textures. Actual construction of *architectural* concrete shall not proceed until the Engineer has accepted the sample units.
- B. Before placing concrete, the Contractor shall check lines and levels of erected formwork, and shall make corrections and adjustments to ensure:
 - 1) proper size and location of concrete members
 - 2) stability of the forming systems
- C. During concrete placement, the Contractor shall check formwork and related supports to ensure the forms are not displaced and that completed work will be within specified tolerances.

601.8.10.4-Materials:**601.8.10.4.1-Form Materials:**

- A. Forms for Exposed-Finish Concrete: Unless otherwise indicated, construct formwork for exposed concrete surfaces with plywood, metal, metal-framed plywood-faced or other paneled materials to provide as-cast surfaces. Furnish in largest sizes to minimize number of joints and to conform to joint system shown on drawings. Provide form materials with sufficient thickness to withstand pressure of placed concrete without bow or deflection beyond allowable tolerances.

- 1) Use overlaid plywood, APA grade trademarked "High Density Overlay (HDO)."
 - 2) Use plywood, APA grade trademarked "B-B Plyform Class 1."
- B. Forms for Textured Finish Concrete: Provide special forming materials to produce surfaces with face design, texture, arrangement, and configuration as shown on drawings or as required to match Engineer's control sample. Provide solid backing and form supports to ensure stable textured form liners.
- C. Form Coating: Provide a commercial formula release agent that will not bond with, stain, or adversely affect concrete. Provide material that will not impair subsequent treatment of concrete surfaces requiring bond or adhesion, nor impede wetting surfaces to be cured with water or a curing compound.

601.8.10.4.2-Formwork Design: Design formwork for easy removal without impact, shock, or damage to the concrete and adjacent materials.

601.8.10.5-Construction Methods:

601.8.10.5.1-Form Construction:

- A. General: Construct forms to sizes, shapes, lines, and dimensions shown, and as required to obtain accurate alignment, location, level, and plumb work in finished structures. Provide for openings, offsets, keyways, recesses, chamfers, blocking, screeds, bulkheads, and other as required.
- B. Fabricate forms to prevent cement paste from leaking while placing concrete and for easy removal without hammering or prying against exposed concrete surfaces. Provide crush plates where stripping might damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete. Solidly butt joints and provide backup material at joints to prevent leakage and fins. Assemble forms so that they may be easily removed without damaging exposed concrete surfaces
- C. Provide temporary form openings where inaccessible formwork interior can be cleaned and inspected before placing concrete. Place temporary form openings as inconspicuously as possible, consistent with project requirements.
- D. When drilling forms used for exposed concrete, drill from the contact face to the outside to suit the ties used and to prevent leakage of concrete mortar. Do not splinter the forms by driving ties through improperly prepared holes.
- E. Unless otherwise shown in the plans,
 - 1) provide sharp, clean corners at intersecting planes with no visible edges or offsets.
 - 2) provide accurately formed chamfered corners using $\frac{3}{4}$ x $\frac{3}{4}$ inch (19 x 19 mm) strips, surfaced to produce uniformly straight lines and tight edge joints.

601.8.10.5.2-Form Coatings:

- A. General: Coat form contact surfaces with form-release agent before placing reinforcement. Do not allow excess material to accumulate in forms or to come into contact with reinforcement or surfaces that will be bonded to fresh concrete. Apply coating according to manufacturer's instructions.

- B. Coat steel forms with non-staining, rust-preventative release agent, or otherwise protect from rusting. Rust-stained steel formwork is not acceptable.

601.8.10.5.3-Reusing Forms: Split, frayed, delaminated, or otherwise damaged form-facing materials are not acceptable. Clean and apply a new form-release agent to concrete contact surfaces.

601.9-ADVERSE WEATHER CONDITIONS:

601.9.1-Cold Weather Concreting: The plastic concrete shall have a temperature of at least 50° F (10° C) but not more than 85° F (30° C) at the time of placing. When the plastic concrete has a temperature of less than 55° F (13° C), the provisions for cold weather concreting shall apply. Maintenance of at least the minimum temperature shall be accomplished by heating the water or the aggregates, or both, as necessary. Heating methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. Heating equipment shall be capable of heating the materials to achieve the specified temperature of the plastic concrete. The temperature of the aggregates or water shall not exceed 150° F (65° C) at the time the cement is added to the mixture. Materials containing frost or lumps of frozen materials shall not be used.

If the Contractor is placing concrete or plans to place concrete during cold weather conditions, the Contractor shall advise the Division of his plans for curing and protecting the concrete. The Division may at any time, require the Contractor to provide additional protection to cause the provisions of this specification to be met.

Stockpiled aggregate may be heated by the use of dry heat or steam. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire.

Binned aggregates may be heated by steam-coil or water-coil heating. The use of live steam on or through binned aggregate will not be permitted.

The use of calcium chloride to hasten the initial set of structural concrete will not be permitted.

Insulated forms may be used for protecting and curing concrete. There will be no additional cost to the Division for the use of insulated forms.

Class H or Class K Concrete Cold Weather Provisions: Cold weather periods shall be defined as those periods when temperatures above 50° F (10° C) do not occur for more than half of any 24 hour duration. The temperature of the surface on which the concrete is to be placed shall not be less than 45° F (7° C) immediately prior to placement of the concrete. During the cold weather periods, as defined above, the temperature of the concrete immediately after placement shall be between 55 and 75° F (13 and 24° C).

601.9.2-Hot Weather Concreting: The Contractor will be required to state, at the pre-construction conference, his plan of action when the temperature of plastic concrete reaches 90° F (32° C).

When a free air, shaded thermometer in the vicinity of the concrete production plant reaches 85° F (30° C), thermometer readings of the temperature of the plastic concrete shall be taken at least hourly.

When the temperature of the plastic concrete reaches 85° F (30° C), the elapsed time between the introduction of the mixing water to the cement-aggregates and discharge of the

mix shall not exceed 1 hour. At this temperature or above, particular attention shall be paid to the Specification provisions concerning the sprinkling and wetting of surfaces not oil-treated, the maintenance of coarse aggregate stock in saturated surface-dry condition, and the prompt start of concrete curing operations.

When the temperature of the plastic concrete reaches 90° F (32° C), immediate steps shall be taken to cool either mixing water or aggregates, or both, in order to maintain a plastic concrete temperature of 90° F (32° C) or less. Crushed or flaked ice may be used to cool the mixing water. Crushed or flaked ice may also be introduced into the mixing drum when the concrete is batched and mixed in a truck mixer. The ice will be considered as part of the mix water in the mix proportions. The mixing operation shall not be considered complete until all ice in the drum has melted.

In no event shall concrete be placed when its temperature in the plastic state at the completion of mixing exceeds 90° F (32° C).

Bridge Decks: The Contractor's plan of action for all bridge deck concreting operations shall contain provisions designed to minimize the probability that any bridge deck concrete will be placed when the ambient temperature is greater than 85° F (30° C).

601.10-PLACING CONCRETE:

601.10.1-General: Concrete shall not be placed until forms and reinforcing steel have been inspected and approved. The forms shall be cleaned of all debris immediately prior to placing concrete, and surfaces not oil treated shall be wetted. The method and sequence of placing concrete will be subject to approval by the Engineer. Concrete shall be placed so that no segregation will occur and no displacement of reinforcement will be caused. Concrete shall be placed in the forms as nearly as practical in its final position in order to avoid rehandling, and an approximately horizontal surface of the plastic concrete shall be maintained. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement. Concrete shall not be placed until all laitance which may have formed on concrete previously placed, or any loose deleterious material on reinforcing bars, has been removed.

601.10.1.1-Pre-Pour Meeting: On projects for which the concrete is being used in bridge construction, the Contractor shall schedule a meeting prior to the start of the concrete work. The Engineer, Construction Manager, Prime Contractor, Concrete Contractor, Concrete Finisher, Concrete Supplier, and the Individual or Agency that will perform the quality control testing of the concrete shall attend. Topics of discussion shall include concrete mixture proportions, batching, transporting, handling, placing, finishing, curing, and on-site quality control testing requirements.

601.10.1.2-Concrete Placement Limitations: Immediately prior to, and during, placement of Class H concrete, if the evaporation rate exceeds 0.10 lb./sq. ft. per hour (0.5 kg/sq. m per hour) (see Figure 1), the Contractor shall make provisions (i.e. wind breaks, fogging, etc.) to reduce the rate prior to placing concrete. These provisions shall be maintained during the placement of the concrete. If the evaporation rate obtained from Figure 1 is close enough to the maximum allowable value of 0.10 lb./sq. ft. per hour (0.5 kg/sq. m per hour) that there may be a discrepancy in the exact numerical value, the following equation shall be used to obtain a more accurate value.

$$E = [T_c^{2.5} - (r \times T_a^{2.5})] [1 + 0.4V] \times 10^{-6}$$

Where:

E = evaporation rate, lb/ft²/h
T_c = concrete temperature, °F
T_a = air temperature, °F
r = (relative humidity %) / 100
V = wind velocity, mph

Example:

Air Temperature = 65 °F
Relative Humidity = 45%
Concrete Temperature = 60 °F
Wind Velocity = 20 mph

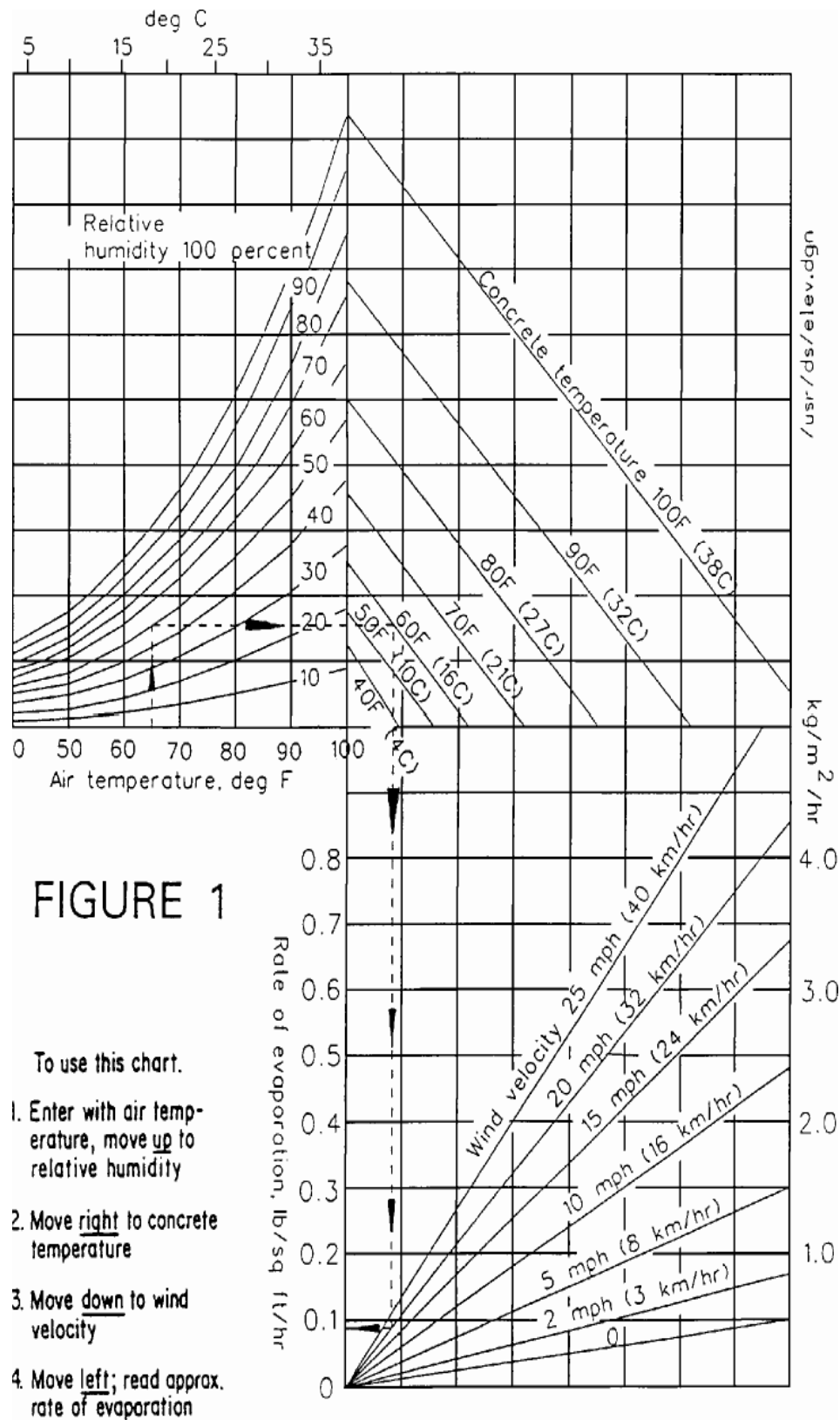
Result Using Figure 1:

Evaporation Rate ≈ 0.11 lb/ ft²/h

Result Using Formula:

$$\begin{aligned} E &= [T_c^{2.5} - (r \times T_a^{2.5})] [1 + 0.4V] \times 10^{-6} \\ E &= [60^{2.5} - (0.45 \times 65^{2.5})] [1 + (0.4 \times 20)] \times 10^{-6} \\ E &= [27885 - 15328] [1 + 8] \times 10^{-6} \\ E &= 12557 \times 9 \times 10^{-6} \\ E &= 0.11 \text{ lb/ ft}^2/\text{h} \end{aligned}$$

601.10.1.3-Concrete Placement at Night: If placement of any concrete is to be made at night, a plan which provides adequate lighting for the work area shall be submitted at least 14 days before concrete is placed for the Engineer's approval.



601.10.2-Chutes and Troughs: Concrete shall not be dropped in the forms a greater distance than 5 feet (1.5 meters) without the use of closed chutes or pipes. When chutes or troughs are used under steep slope conditions, they shall be equipped with baffle boards or shall be used in short lengths to reverse the direction of movement. All chutes, troughs or pipes shall be kept clean and free of hardened concrete by flushing with water after each run. Flushing water shall be discharged outside the forms. Aluminum chutes, troughs or pipes shall not be used.

601.10.3-Vibrating: Concrete shall be compacted by the operation of approved mechanical vibrators within the concrete. When required, vibrating shall be supplemented by hand spading to assure proper compaction, to force all coarse aggregate from the surface, and to bring mortar against the forms to produce a smooth finish. Vibrators shall be manipulated in such a manner that concrete is worked around reinforcement and imbedded features and into angles of the form. Vibration shall be of sufficient duration to accomplish compaction but shall not be prolonged to the point where segregation occurs. Vibration shall not be used to cause concrete to flow from point to point within forms. The frequency of the vibrators shall meet the requirements of Section 501.5.5.

601.10.4-Placing Concrete Bridge Decks: Concrete for bridge decks shall be placed and finished with mechanical equipment unless waived by the Engineer. The Contractor shall furnish the Engineer information as to the weight of the proposed machine, the volume of concrete to be placed per hour, and the operating procedure to be followed.

Where beam support screeds are used and the distance between the support and gutter line is in excess of 1 foot (300 mm), the Contractor shall use devices to control the grade of the gutter line during the deck finishing operations.

601.10.4.1-Fogging Equipment: When Class H concrete is used, fogging equipment shall be available for use in accordance with these specifications. The fogging nozzles shall produce an atomized mist. Fogging nozzles shall incorporate compressed air to create the mist. Hand held or hand operated equipment shall be permitted when the Contractor has demonstrated that his operator has been trained in its use.

601.10.4.2-Placement: The following requirements shall apply during placement of the Bridge Deck concrete:

- a. So that the use of hand tools will be kept to a minimum, concrete shall be deposited as nearly as possible to its final position. Internal vibrators shall not be used for moving concrete into position.
- b. A pencil type vibrator shall be used along all construction joints to further consolidate the concrete to prevent voids.
- c. The new concrete shall be placed slightly above final grade. It shall then be struck-off, screeded, and finished to final grade.
- d. The finished surface, before texturing, shall be uniformly smooth, dense and even. Variations in pavement surface in excess of 1/8 inch (3 mm) above, or below, the proper finished elevation, or surface irregularities of more than 1/8 inch (3 mm) in 10 feet (3 m), will not be accepted.

- e. A construction dam, or bulkhead, shall be installed in case of a delay in the placement operations exceeding 30 minutes duration. During any delays of 30 minutes or less, the placement shall be protected from drying with several layers of wet burlap. If the concrete placement is stopped, or delayed, for 90 minutes or more, further placement shall be discontinued and may be resumed only after the concrete has cured. This restriction does not prohibit continuation of the placement provided a gap is left in the placement. This gap shall be sufficient in length to allow the finishing machine to clear the previously placed concrete.
- f. Adequate precautions shall be taken to protect freshly placed concrete from rainfall. All placement operations shall stop when it starts to rain. The Engineer may order removal and replacement of material damaged by rainfall.
- g. The addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted.

601.10.5-Depositing Concrete Under Water: Concrete shall not be placed until all laitance which may have formed on concrete previously placed has been removed. Still water shall be maintained at the point of deposit. While depositing foundation concrete, pumping shall be discontinued if it results in a flow of water inside the forms. All concrete deposited under water shall have the minimum cement content increased at least 10 percent.

Concrete deposited under water shall be carefully placed in a compact mass in its final position by means of a tremie, a closed bottom dump bucket, or other approved method and shall not be disturbed after being deposited.

601.11-FINISHING CONCRETE SURFACES:

The surface of the concrete shall be finished immediately after form removal.

The exposed surfaces of bridge parapets, wingwalls, headwalls and vertical edge of the bridge deck shall be given a Class 2, Rubbed Finish, or a Class 1, Ordinary Surface Finish supplemented with wood float rubbing. When the Class 1, Ordinary Finish is used, the forms shall be removed as early as practical, not to exceed six hours (in lieu of 601.8.7) after placing, and the finish completed including rubbing with a wood float and water. The rubbing shall produce a nonplastered, smooth textured and uniform color surface. Other concrete surfaces except bridge decks shall be given a Class 1, Ordinary Finish.

Unless otherwise shown in the plans, all concrete designated as *architectural* shall receive a Class 1, Ordinary Surface Finish, as defined in Section 601.11.1.

601.11.1-Class 1, Ordinary Surface Finish: Immediately following the removal of the forms, all fins and irregular projections shall be removed from all surfaces except those which are not to be exposed or are not to be waterproofed. On all surfaces the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned, saturated with water, and carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the class of concrete being finished. Mortar used in pointing shall be not more than 30 minutes old. The mortar patches shall be cured as specified in 601.12. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with clean and true edges.

The resulting surfaces shall be true and uniform. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be rubbed as specified for Class 2, Rubbed Finish.

601.11.2-Class 2, Rubbed Finish: After removal of forms, the rubbing shall be started as soon as the condition of the concrete will permit. The concrete shall be thoroughly saturated with water immediately prior to rubbing and shall be kept saturated throughout the rubbing operation.

Sufficient time shall have elapsed before wetting down to allow the mortar used in pointing to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand in the same proportion as the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled, and a uniform surface obtained. The paste produced by this rubbing shall be left in place. After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until all the paste produced by the first rubbing operation has been removed from the face of the concrete except from depressions and defects which have been filled with the paste. The surface of the concrete after rubbing shall have a non-plastered, smooth texture and a uniform color.

After the final rubbing is completed and the surface has dried, the surface shall be rubbed with burlap to remove loose powder.

The resulting surfaces shall be free from all unsound patches, paste, powder, and objectional marks.

601.11.3-Class 6, Float Finish: This finish, for horizontal surfaces, shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating tool of wood, canvas or cork. Before the finish has set, the surface cement film shall be removed with a fine brush in order to have a fine grained, smooth but sanded texture.

601.11.4-Finishing Concrete Bridge Decks: Any addition of water to the surface of the concrete to assist in the finishing operations will not be permitted. When conditions are such that unusually rapid drying is occurring, an atomized mist may be used to prevent the rapid evaporation of water from the concrete surface during the final finishing.

601.11.4.1-Class K Bridge Decks: After striking off, consolidating, and floating have been completed, both while the concrete is still plastic, the surface shall be checked for trueness with a straightedge. The Contractor shall furnish an accurate scraping type straightedge with a minimum length of 10 feet (3.048 meters) and swung from a handle at least 3 feet (1 meter) longer than one-half the width of the slab.

The straightedge shall be held in successive positions parallel to the road centerline and in contact with the roadway surface and operated from side to side until the surface is within the permissible tolerance provided. Advance along the roadway shall be in successive stages of not more than one-half of the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck-off,

consolidated, and refloated. High areas shall be cut down and refloated. The straightedge testing and reflecting shall continue until the surface is found to be free from observable departures from the straightedge and the slab has the required grade and contour.

Upon completion of the above operations, the surface shall be smoothed with a lute or smoothing float, 4 to 6 feet (1.2 to 1.8 meters) in length, after which the surfaces shall be tested with an accurate straightedge. This checking straightedge shall be 10 feet (3.048) meters long and shall be held in a position parallel to the centerline of the roadway. The advance of this straightedge along the slab shall be in successive stages of not more than one-half of its length. When tested with this straightedge, the finished surface shall be free from observable departures from the straightedge.

Upon completion of the above operations, the surface of the concrete shall be given a groove finish while the concrete is still plastic. The tool used shall produce a groove that is approximately 3/32 inch (2 mm) wide. The depth of this groove shall be 1/8 inch (3 mm) to 3/16 inch (5 mm) and spaced approximately 1/2 inch (13 mm) center to center. The grooves shall be formed in a direction that is transverse to the centerline of the roadway or parallel to the skew. On any one bridge the direction of the grooves shall be consistent. Adjacent strokes to establish the texture shall abut one another without appreciable overlap. Texturing shall be performed when the concrete surface is of such plasticity as to prevent excessive raveling (concrete too dry) or to prevent mortar from flowing back into the grooves (concrete too wet). All texturing shall be accomplished with a single pass of the tool. To facilitate drainage, the 12 inches (300 mm) immediately adjacent to the curbline shall be left untextured.

Instead of forming the grooves into the plastic concrete by tining, as specified in the previous paragraph, the Contractor may sawcut the grooves into the hardened concrete bridge deck as specified in Section 601.11.4.4. All sawcutting shall be performed before any sealing operations required in Section 601.13.1. No additional payment will be made for constructing this type of bridge deck surface.

601.11.4.2-Class H Bridge Decks: The surface of the Class H concrete shall be uniformly smooth, dense and even. The surface shall then be given a suitable texture with an approved burlap drag.

The Contractor shall texture in a transverse or longitudinal direction. Once begun, the direction of texturing shall not change. All texturing shall be performed prior to the beginning of curing operations. Only one pass of the drag over the finished area will be permitted. Texturing shall be in strict accordance with the time requirements of 601.12.4 for applying wet burlap.

If texturing is done in the transverse direction, the Contractor shall texture by hand methods as soon as practicable after finishing machine passage, without any additional finishing operations between the machine passage and texturing operations.

If texturing is done in the longitudinal direction, the burlap drag shall be a seamless strip and shall be attached to the work bridge such that the surface of the concrete is textured as soon as practicable after finishing machine passage, without any additional finishing operations between the machine passage and texturing operations. Small areas, inaccessible to the attached drag, may be textured by hand methods.

The finishing movement and resulting progress of the burlap drag shall be done in a manner so as to prevent ridges or gouges from forming in the concrete surface. The drag

shall be weighted and the contact area changed as required to produce a texture acceptable to the Engineer. The drag shall be cleaned as required; to remove all hardened concrete particles and shall be replaced after each day's operation.

Texture resulting from the drag shall stop within one foot (305 mm) of curbs or parapets.

Any hand finishing operations shall be kept to a minimum for Class H bridge decks.

601.11.4.3-Straightedge Testing of Hardened Bridge Decks: When finishing has been completed and the concrete has hardened sufficiently, the surface shall be given a further test for trueness with a rolling straightedge. Areas showing high spots of more than 1/8 inch (3 mm) shall be marked by the Engineer and, only when directed by the Engineer, such areas shall be ground with an approved grinding tool, utilizing carborundum stones or industrial diamond wheels; grinding shall be done to an elevation where the area or spot will not show a surface deviation in excess of 1/8 inch (3 mm) when tested with the 10 feet (3.048 meter) rolling straightedge, except that the maximum depth of grinding shall not exceed 1/4 inch (6 mm). The ground areas shall be treated as directed by the Engineer. Where the initial deviation from the straightedge is 1/2 inch (13 mm) or more, the Contractor will be required to remove and replace the complete pour in which the areas not meeting the required tolerance are located.

After grinding, all areas either high or low, not meeting the requirements of 1/8 inch (3 mm) tolerance will be measured and disposition of these areas will be as set forth in 601.15.2.

601.11.4.4-Class H Concrete Finished Deck Grooving: After completion of water curing the concrete and after corrective grinding, but before opening the bridge to traffic, saw longitudinal or transverse grooves in accordance with the following applicable subsection.

601.11.4.4.1-Transverse Grooving: After corrective grinding and before opening to traffic, grooves shall be cut into the concrete using a mechanical saw. These grooves shall be 0.10 inch (3 mm) wide and 0.25 inch (6 mm) deep. Groove spacing shall be 1.5 inches (38 mm) center to center. No later than one week prior to grooving operations, the Contractor shall provide the Engineer with two accurate, easily readable gauges with which to verify groove dimensions. Groove depth and spacing tolerances are limited to $\pm 1/16$ inch (± 2 mm). Groove width tolerances are +0.02 (+0.5 mm) inch and -0.0 inch (-0 mm). The grooves shall be cut in a direction that is transverse to the centerline of the roadway or parallel to the skew. On any one bridge the direction of the grooves shall be consistent. Grooves shall be cut continuously across the deck to within one foot (305 mm) of gutter lines or drainage structures. Grooves shall also be continuous across the full width of the deck surface including construction joints. Grooves shall terminate within 1 inch (25 mm) of any exposed metal component or elastomeric concrete of an expansion joint. When the deck is skewed and the contractor is using gang blades to saw the grooves, the maximum distance (measured perpendicular to the centerline of the expansion joint) from the last groove termination in the pass to the expansion joint shall be 1 foot - 8 inches (508 mm). Radial grooving shall be performed in increments limited to 12 feet (3.7 m) of bridge length.

601.11.4.4.2-Longitudinal Grooving: Use diamond blades mounted on a multi-blade arbor on self-propelled machines that were built for grooving of concrete surfaces. The groove machines shall have depth control devices that detect variations in the pavement surface and adjust the cutting head height to maintain the specified depth of the groove. The grooving machines shall have devices to control alignment. Do not use flailing or impact type grooving equipment. More than one size grooving machine may be required in order to saw the grooves as specified.

Provide an experienced technician to supervise the location, alignment, layout, dimension, and grooving of the surface.

Saw grooves parallel to the bridge centerline in a continuous pattern across the surface. Begin and end sawing 9 to 12 inches (220 to 300 mm) from any device in place in a bridge deck, such as scuppers or expansion joints. Stop sawing a minimum of 2 inches (50 mm) to a maximum of 24 inches (600 mm) from skewed expansion joints. Maintain a clearance of a minimum of 2 inches (50 mm) and a maximum of 4 inches (100 mm) from the grooves to longitudinal joints in the deck. Maintain a minimum clearance of 9 inches (220 mm) to a maximum of 30 inches (750 mm) clearance between the grooves and the curb or parapet toe. However, at no point shall un-grooved portions of deck extend beyond edge line and into the temporary or permanent travelled lanes. Saw grooves in a uniform pattern spaced at 3/4 inch minus 1/4 inch or plus 0 inches (19 mm minus 6 mm or plus 0 mm). Saw grooves 0.15 inches (4 mm) deep and 0.10 inches (3 mm) wide. Groove tolerances for depth are +0.0625 inches (2 mm) and minus 0 inches (0 mm). Groove tolerances for width are +0.02 inches (0.5 mm) and minus 0 inches (0 mm).

For staged, or phased bridge deck work, saw the grooves parallel to the final, permanent bridge centerline. If the different stages or phases of the bridge deck work occur within one construction season, any stage opened to traffic shall receive an interim coarse broom finish during placement, then saw the longitudinal grooves after the final stage. The interim broom finish will not be allowed as a surface texture when opened to traffic over a winter season. Saw longitudinal grooves in the deck prior to opening to traffic for a winter season.

For bridge decks that widen from one end to the other, saw the longitudinal grooves parallel to the centerline of the roadway. On the side of the bridge that widens, saw the longitudinal grooves to follow the edge line. Saw longitudinal grooves in the gore areas, avoiding the overlapping of grooves.

At the beginning of each work shift, furnish a full complement of grooving blades with each saw that are capable of cutting grooves of the specified width, depth, and spacing.

If during the work, a single grooving blade on a machine becomes incapable of cutting a groove, continue work for the remainder of the work shift. The Contractor is not required to cut the groove omitted because of the failed blade. Should two or more grooving blades on a machine become incapable of cutting grooves, cease operating the machine until it is repaired.

Continuously remove all slurry and remaining residue from the grooving operation and leave the deck surface in a clean condition. Prevent residue from grooving operations from flowing across shoulders or across lanes occupied by public traffic or from flowing into gutters or other drainage facilities. Remove solid residue before the residue is blown by passing traffic or by wind.

Provide water as necessary to saw grooves according to this subsection.

601.12-CURING AND PROTECTING CONCRETE:

601.12.1-Curing Under Normal Conditions: All concrete shall be protected by one or more of the curing materials, meeting the requirements of 601.2, as soon as possible after placement to prevent loss of moisture from the surface. Burlap and water curing shall be used on all bridge decks.

Concrete surfaces shall be kept completely and continuously moist. Curing shall be continued for a period of at least 7 days. This curing period may be reduced if the contractor presents evidence that the in place concrete has attained 70% of the specified strength for the class of concrete under cure. Under no circumstances, shall the period of cure be less than 3 days. The reduced curing period option is not applicable to Class H or Class K concrete. The contractor shall not be permitted to add additional cement to the target cement factor in the approved mix design in order to obtain high-early strength and/or reduce curing time. Surfaces may have coverings temporally removed for finishing, but the covering shall be restored as soon as possible.

Membrane forming curing compounds may be used providing they do not conflict with other requirements of these Specifications. If membrane forming curing compound is used, all surfaces shall be given the required finish prior to application of the curing compound with the concrete protected by some other method before finishing.

Curing compound shall be applied at a minimum rate of one gallon of liquid coating per 300 square feet (13.6 liters of liquid coating per 100 m²) of concrete surface for each application. The curing compound shall be continuously agitated during use. All concrete cured by this method shall receive two applications of the curing compound. The first coat shall be applied immediately after acceptance of the concrete finish. If the surface is dry, the concrete shall be saturated with water and the curing compound applied as soon as the surface film of water disappears. The second application shall be made after the first application has set. Placement in more than two coats may be required to prevent streaking.

During the curing period, any coating marred or otherwise disturbed shall be given an additional coating. Should the surface coating be subjected continuously to injury, another method of cure shall be immediately substituted. If the use of an impervious compound results in a streaky or blotched appearance, the method shall be stopped and water curing applied until the cause of the defective appearance is corrected.

Curing Temperature is the air temperature at the concrete surface, or the air temperature between the concrete surface and its protective covering.

601.12.2-Curing Under Cold Weather Conditions: When the air temperature is expected to fall below 30° F (-1° C), the Contractor shall provide suitable measures to maintain the concrete surface temperature between 50° F (10° C) and 90° F (32° C).

Calendar days on which the surface temperature of the concrete falls below 50° F (10° C) shall not be considered days of curing. In no event shall the temperature of the concrete be allowed to fall below 35° F (2° C) before the specified curing is completed. The Contractor shall be responsible for the quality and strengths of the concrete placed or cured, or both, during the cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

When protection is removed from the structure after the specified curing is complete, the temperature of the concrete shall not be permitted to fall at a greater rate than 20° F (11° C) per 24 hour period.

Class H or Class K Concrete Provisions: The surface temperature of the concrete shall be maintained between 55 and 75° F (13 and 24° C) for 72 continuous curing hours immediately after placement. After this 72 hour period, a minimum concrete surface temperature of at least 50° F (10° C) shall be maintained for an additional 96 continuous curing hours.

If it is expected that the surface temperature of the concrete will drop below 50° F (10° C) during the 168 hour curing period, then the surface shall be enclosed and external heat shall be provided in accordance with the provisions of this section. Once external heat provisions are required, they shall remain on the surface until curing is complete, regardless of the ambient air temperature. Enclosures for heat retention shall be properly vented to prevent surface disintegration from carbon dioxide gas.

Continuous wetting shall be replaced by wetting at regular intervals if, in the opinion of the Engineer, expected air temperatures could result in freezing of run-off water.

601.12.3-Protection of Finished Surfaces: All exposed finished surfaces of concrete shall be protected to prevent rust stains, paint splotches, scars or other blemishes tending to disfigure or discolor the finished surface. Where reinforcing steel bars or other steel inserts are left exposed for extended periods or over the winter, they shall be given a coat of neat cement paste to prevent rust staining. Water runoff from concrete curing operations shall be deflected away from the steel girders and shall not drain onto the substructure concrete after contacting the weathering steel.

Any stains or other blemishes shall be corrected by the Contractor.

601.12.4-Curing Class H Concrete: It is the nature of Class H concrete material to quickly form a plastic film at the surface upon drying. This film is to be protected from drying and cracking by prompt covering with wet burlap. Regardless of the type of concrete placed, the use of membrane curing compounds will not be allowed. Floor drains shall be immediately unplugged to permit the deck to drain.

The concrete surface shall be completely covered with clean, wet burlap. The burlap shall be thoroughly saturated over its entire area, but shall be drained of excess water before application. Burlap shall be lapped a minimum of one foot (305 mm) and shall lay flat. Failure to apply wet burlap within 30 minutes after discharge of the concrete from the truck and within 10 minutes of the completion of finishing operations shall be cause for rejection of the work as determined by the Engineer. Care shall be exercised to ensure that the burlap is well drained. Burlap shall be continuously wet for a period of seven days by means of automatic intermittent sprinkling or a continuous wetting system.

601.12.5-Protecting Concrete Decks: Construction equipment with an axle load greater than 20,000 lbs (20 kips) shall not be permitted on bridge deck. Construction equipment or loads that are not required to complete the slab, parapets, railing overlay, or other appurtenances shall not be allowed on the bridge deck.

601.13-PROTECTIVE SURFACE TREATMENT:

601.13.1-Silane Treatment for Bridge Superstructure: After the concrete has achieved a minimum of 80% of the design strength, a silane protective treatment as specified shall be applied to the entire top surface of bridge decks, approach slabs when they are included in the Contract, concrete bridge medians, top and curb face of bridge sidewalks, and the inside faces of parapets. When approach slabs are specified to be overlaid with asphalt, the silane treatment is not required.

The application of this silane protective surface treatment is not required for elements constructed from Class H concrete.

The surface to receive the treatment shall be dry for at least 48 hours before treatment and shall be free from sand, surface dust and dirt, oil, grease, chemical films, and other contaminants prior to application of the silane. Immediately before application, the entire surface shall be air blown to remove any loose dust. The surface, air, and material temperatures shall be between 40 and 100° F during application, and temperatures above 40° F, without precipitation, must be forecast for the twelve hours following application. Any coating damaged by rain or moisture shall be corrected by an additional application.

The surface treatment shall consist of one of the silane sealers listed on the Division's Approved Product List of Concrete Sealers.

The surface treatment, including application rate, shall be applied in accordance with the requirements listed above and the Manufacturer's recommendations.

Metal hand rails shall be protected from spray by shielding or masking.

The Contractor shall prohibit all pedestrian and vehicular traffic on the structure during the drying period of the protective coating.

601.13.1.1-Silane Treatment for Bridge Substructure: Before placing any steel superstructure members on the concrete substructure units, the Contractor shall coat all exposed areas of the abutment, tops, sides, and all faces of pier caps and pier stems to the ground or water line elevation with an approved silane based concrete sealer except for projects where concrete protective or other coatings are specified. Preparation of surfaces, application rates, and methods shall be as recommended by the silane manufacturer.

Upon completion of all superstructure concrete curing operations, the Contractor shall remove all stains from substructure units using proprietary chemical stain removers and/or mild acid etching. Abrasive blast cleaning shall be used to supplement the other cleaning methods to completely remove all stains if the stained areas are severe or extensive. All cleaning methods shall be subject to approval of the Engineer.

Re-coat all areas where stains were removed, regardless of the cleaning method used, with an approved silane based concrete sealer as specified above.

601.13.2-Epoxy Resin Protective Coating: The top surface of abutment bridge seats, including drainage areas, and the adjacent bottom 6 inches (150 mm) of the backwall and the top surface of pier caps which are located beneath expansion devices shall receive an epoxy resin protective coating. The area immediately beneath the bearing masonry plates may be omitted at the Contractor's option.

Concrete surfaces to be coated shall be sound, dry and free of all laitance and curing materials. The coating shall not be applied until the concrete has attained the age recommended by the manufacturer.

When required by the Engineer in the field, concrete surfaces shall be cleaned of all oil, grease and other potential bond inhibiting matter by acid etching with a 10 percent to 15 percent muriatic acid solution. The acid solution shall be spread and allowed to react until bubbling has subsided, approximately three to five minutes. The surface shall then be thoroughly flushed with clear water and allowed to dry. Where, in the opinion of the Engineer, acid etching is insufficient to clean the concrete, then sandblasting or an approved method of mechanical abrading shall be required.

The exact indicated amounts of the base polymer and the reacting system, as recommended by the manufacturer, shall be measured into mixing container and mixed thoroughly with a low-speed paddle-type mixer. After mixing, the material shall stand for an induction period of one hour before application.

Following the one hour induction period, the mixed protective coating may be applied by brush, roller or spray. When applied by roller, a first quality, long nap roller is recommended for rough surfaces, and a short nap roller for smooth surfaces. If applied by spray, an externally atomized spray gun is recommended. If thinning is necessary for spray application, thinner shall be of the type and amount recommended by the coating manufacturer.

Two coats of mixed material shall be applied in thin, uniform coats of approximately 2 to 3 mil (50 μm to 75 μm) dry film thickness each (4-5 mils wet thickness (100-125 μm wet thickness)). The second coat shall be applied approximately 24 hours after the application of the first coat. One gallon of the system will cover approximately 275 square feet of smooth concrete, first coat; a second coat will cover approximately 400 square feet. One liter of the system will cover approximately 6.75 m^2 of smooth concrete, first coat; a second coat will cover approximately 10 m^2 .

In all cases application shall be made at temperatures recommended by the manufacturer.

601.13.3-Concrete Protective Coating: This section shall apply only when the pay item for concrete protective coating is included in the plans.

601.13.3.1-Concrete Surface Preparation: After the Engineer has inspected and accepted the concrete surfaces of bridges and median barriers as having a satisfactory ordinary surface finish, clean the concrete surfaces specified hereinafter of all dust, rust, foreign matter, and form oil, and apply a Department approved protective coating finish. Coat the following surfaces, including all beveled edges:

- 1) Bridge Abutments and Wingwalls – Every exposed surface above a point six inches below ground or fill line. Exclude where epoxy coating is applied.
- 2) Bridge Pier Caps – The tops (including exposed surfaces of pads, pedestals, and keys), sides and ends. Do not apply the coating to bearing areas. Exclude where epoxy coating is applied.
- 3) Bridge Superstructure – The tops, inside and outside faces, and ends of all barrier walls, parapets, curbs, and points that will be exposed. Do not apply the coating to the riding surface of the bridge deck.
- 4) Exposed Surfaces of Substructure and the Superstructure – all surfaces identified in 1), 2), and 3) above and the underneath surfaces of slab overhangs that are outside of exterior girders and the exterior side and bottom of exterior beams or girders, the interior windows of barriers, and all exposed surfaces of piers and abutments. Extend the masonry coating from a point six inches below ground line to the top of the exposed surface.

Thoroughly clean all surfaces to receive a protective coating and keep them free of oil, form oil, grease, dust, dirt, mud, curing compound, release agents, loose patching mortar, or any other substance that may prevent bonding. Before applying the protective coating material, fill all air holes flush with the surface with the protective coating material or an approved mortar to provide a uniform surface.

Check all surfaces to receive a protective coating for the presence of dust by wiping a dark cloth across the surface of the concrete. If a white powder can be seen on the dark cloth, clean the concrete by wire brushing, grinding, or water blasting and then allow it to thoroughly dry before applying the masonry coating. The Engineer will recheck the surface for the presence of dust after cleaning.

Check all surfaces to receive a protective coating for the presence of oily conditions by sprinkling or fogging water on the surface of the concrete. If the water stands in droplets without spreading out immediately, this indicates the surface is contaminated with an oily substance, and the Engineer will require cleaning using a detergent and water followed by thorough rinsing with water. The Engineer will recheck the surface for the presence of oil conditions after cleaning.

Thoroughly dry all surfaces to receive a protective coating before applying the coating, unless the coating manufacturer specifically recommends the surface to be wet. The Department's List of Approved Materials contains each manufacturer's recommendations. The Engineer will not consider surfaces to be dry unless an absorbent paper pressed tightly against the surface does not show any trace of moisture.

Suspend coating application any time the ambient temperature or the temperature of the concrete does not comply with the coating manufacturer's recommendations.

Prior to application of the materials, furnish the Engineer with copies of the coating material manufacturer's brochures or booklets. Apply protective coating materials in strict conformity with the manufacturer's written instructions and apply the material at a uniform rate of at least $50 \pm 10 \text{ ft}^2/\text{gal}$ ($1.75 \pm 0.35 \text{ m}^2/\text{L}$).

Satisfactorily repair or remove any portions of the coating that are not clean, uniform in color, texture, thickness, tightly bonded, or that are damaged before final acceptance of the project and replace them with an acceptable finish and coating.

Provide a neat uniform appearance, and prevent the coating from being dripped, sprayed, or otherwise deposited upon concrete and surfaces not designated to receive the coating. Remove any objectionable deposits or material and repair the surfaces to the Engineer's satisfaction.

601.13.3.2-Concrete Protective Coating Materials:

Description: This section covers requirements for materials to be used as surface finishes for designated surfaces of cement concrete structures. The protective coatings must hide form marks, patches, and other minor irregularities and prevent deterioration, spalling, and other damage to the concrete due to the action of the weather and deicing chemicals.

Approval: Select masonry coatings from the Department's List of Approved Materials. Use a material that is readily recognizable by its name, trademark, container, or other feature. Conform to the Department's testing criteria to be placed on or remain on the Department's List of Approved Materials.

For initial approval submit representative samples, color chip(s), and duplicate copies of certified test reports to the Division of Materials for review and approval. An independent testing laboratory acceptable to the Department shall perform the tests described herein on representative samples of the material. Tests listed herein are the minimum testing requirements to be met. When requested in writing, the Engineer may accept materials based on conformance to the same type of test but differing on minor procedural points. Attach copies of test procedures which differ from those stated herein. In addition to the material, provide brochures or booklets containing detailed instructions and explanatory remarks about surface preparation, application procedures, and other pertinent operations.

- A. Freeze-Thaw Test. Cast and cure 3 concrete specimens no less than 4 by 6 by 6 inches (100 by 150 by 150 mm). Moist cure specimens for 14 days and then dry in room air at 60° to 80° F (15° to 27° C) for 24 hours before applying protective coating. Ensure that there is no excessive oil on specimen forms. Coat sides of specimens (brush permitted) according to the manufacturer's directions at a rate of 50± 10ft²/gal (1.75± 0.35 m²/L) and cure at room temperature for 48 hours, after which:
 - 1) Immerse in water at room temperature 60° to 80° F (15° to 27° C) for 3 hours and remove.
 - 2) Place in cold storage at 5° F (-15° C) for one hour and remove.
 - 3) Thaw at room temperature, 60° to 80° F (15° to 27° C) for one hour.
 - 4) Repeat steps 1), 2) and 3) to complete a total of 50 cycles. At the end of 50 cycles of the Freeze/Thaw Test, ensure that the coated specimens show no visible defects.
- B. Accelerated Weathering. Test according to ASTM D 822. Apply at an application rate of 50± 10 ft²/gal (1.75± 0.35 m²/L). Test for 335 hours in the Atlas Type XW Sunshine Arc Weatherometer or for 500 hours in an Atlas Type DMC Enclosed Violet Carbon Arc Weatherometer or equivalent. Perform the test in 120 minute cycles consisting of 102 minutes of light and 18 minutes of light and demineralized water. At the end of the exposure test, ensure that there is no checking, cracking, or loss in film integrity, and no other film defects. Ensure that the coating shows no more than very slight color change.
- C. Salt Spray Resistance. Apply the masonry coating to concrete at a rate of 50± 10ft²/gal (1.75± 0.35 m²/L), and test the coating according to ASTM B 117. Expose the coating to a 5 percent sodium (salt) solution for 300 hours, and maintain it at 194° ± 4° F (90± 2° C) during the period of exposure. Ensure that it shows no loss of adhesion or deterioration at the end of the 300 hours.
- D. Fungus Growth Resistance. Ensure that like protective coatings passes a fungus resistance test as described by federal specifications TT-P-29. After a minimum incubation period of 21 days, ensure that no growth is exhibited on the coatings.

601.13.3-Concrete Protective Coatings: In order for a concrete protective coating to be placed on the approved list, it must be one which will hide form marks, patches, and other minor irregularities and which will prevent deterioration, spalling, and other damage to the concrete due to the action of the weather and deicing chemicals. The material shall be one that is readily recognizable by its name, trademark, container, or other feature. The material shall

be one which is accompanied by brochures or booklets containing detailed instructions and explanatory remarks about surface preparations, application procedures, and other pertinent operations. Additionally, materials to be placed on or remain on the approved listing will be required to meet testing criteria established by the Materials Control, Soil and Testing Division to ensure their durability. These tests shall include: (1) resistance to freezing and thawing; (2) resistance to accelerated weathering, (3) resistance to salt spray and; (4) resistance to fungus attack.

See list of approved products.

601.14-METHOD OF MEASUREMENT:

The quantity of work done for Classes A, B, C, D, H, K, and M concrete will be measured in cubic yards (meters), complete in place and accepted as determined by the dimensions on the Plans or Contract Documents, subject to adjustments provided for in Sections 104.2 and 109.2.

The quantity of work done for Class H and Class K concrete will be measured in cubic yards (meters), complete in place and accepted, as measured from one end of the bridge to the other, fascia to fascia, and from the top of the forms to the finished elevation of the proposed deck surface. The volume of concrete required to fill the flutes of stay-in-place forms shall be calculated by taking the Contractor's approved *SIP_{adj}* factor and multiplying by the square yardage of SIP area minus beam widths, expansion dam widths, etc. as applicable.

No deductions will be made for the volume occupied by pipe less than 8 inches (200 mm) in diameter, nor for reinforcing steel, anchors, conduits, weep holes or piling, or other small inserts.

The cost of copper, copper-nickel alloy or other type of flashing, expansion joint filler, preformed joint filler, concrete bearing pads, drain pipes for weep drains through abutments, wings and walls or bridge floors, unless otherwise specified, shall be included in the unit prices bid for the several classes of concrete.

All costs associated with the revised mix design and proportions shall be in the unit price bid for the class of concrete designated as *modified*.

All costs associated with architectural formwork shall be in the unit price bid for the class of concrete designated as *architectural*. No deductions will be made for the volume occupied by the architectural formwork.

The quantity of work done under line items 603.13.3 will include preparation and application of concrete protective coating to all exposed surfaces of special bridge railing, outside face of exterior prestressed girders, exposed portion of abutments, wingwalls and piers. The area to be coated will be measured on a square foot (square meter) basis.

601.15-BASIS OF PAYMENT:

601.15.1-General: The quantities, determined as provided above, will be paid for at the contract unit prices bid or at the adjusted percent of contract price as specified for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, joint filler, field laboratory, supplies and incidentals necessary to complete the work.

The cost of stay-in-place fabricated metal forms and all work associated therewith shall be included in the unit price bid for concrete placed as the bridge deck. The amount of concrete required to fill the form flutes is included in the plan quantity of the concrete bridge deck material, and shall be paid for per Section 601 of the Specifications.

The quantities determined as provided above, complete in place, will be paid under item 601019-* concrete protective coatings on a square foot (square meter) basis.

No additional payment will be allowed for concreting under adverse weather conditions nor when the use of a higher class concrete than that specified is permitted.

601.15.2-Price Adjustments: The Contractor will be assessed an equitable deduction of twenty-five dollars (\$25.00) per square foot. (two-hundred-seventy dollars (\$270.00) per square meter) for areas of bridge decks not meeting the specified 1/8 in (3mm) tolerance and not specified to be removed nor directed to be ground, and for any areas that have been ground but do not meet the specified tolerance. Deviations will be tested with a 10ft (3.048 meter) rolling straightedge.

Concrete found not in compliance with the requirements of 601.4.4 for compressive strength will be paid for at a reduced contract price in accordance with the following formula:

$$\text{Percent Reduction} = \frac{f'_c - X}{0.6f'_c - \sigma}$$

Where:

- f'_c = Design Strength, psi (MPa)
- X = Observed strength, psi (MPa)
- σ = Standard Deviation

The percent reduction shall be applied to the subplot with the low strength.

601.16-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
601001-*	Class A Concrete	Cubic Yard (Meter)
601002-*	Class B Concrete	Cubic Yard (Meter)
601003-*	Class K Concrete	Cubic Yard (Meter)
601003-*	Class K Concrete, Architectural	Cubic Yard (Meter)
601005-*	Class C Concrete	Cubic Yard (Meter)
601006-*	Class D Concrete	Cubic Yard (Meter)
601009-*	Class H Concrete	Cubic Yard (Meter)
601019-*	Concrete Protective Coating	Square Foot (Meter)
601025-002	Modified Concrete, Class A	Cubic Yard (Meter)
601025-003	Modified Concrete, Class B	Cubic Yard (Meter)
601025-005	Modified Concrete, Class C	Cubic Yard (Meter)
601025-006	Modified Concrete, Class D	Cubic Yard (Meter)
601025-007	Modified Concrete, Class H	Cubic Yard (Meter)
601025-008	Modified Concrete, Class K	Cubic Yard (Meter)
601026-002	Modified Architectural Concrete, Class B	Cubic Yard (Meter)
601026-003	Modified Architectural Concrete, Class H	Cubic Yard (Meter)
601026-004	Modified Architectural Concrete, Class K	Cubic Yard (Meter)

* Sequence number

SECTION 602 REINFORCING STEEL

602.1-DESCRIPTION:

This work shall consist of furnishing and placing epoxy coated or uncoated reinforcing steel or corrosion resistant reinforcement in accordance with these Specifications and in reasonably close conformity with the Plans.

602.2-MATERIALS:

Reinforcing steel bars and fabric reinforcement shall meet the requirements of 709.1 and 709.4 respectively, except rail-steel shall not be used in bridge decks or parapets.

Epoxy coated reinforcing steel bars shall meet the requirements of 709.1.2, except rail-steel shall not be used in bridge decks and parapets.

Corrosion resistant reinforcing steel bars shall meet the requirements of AASHTO MP18 with minimum yield level of 100,000 psi. The degree of corrosion resistance for reinforcement shall be specified in the plans.

CONSTRUCTION METHODS

602.3-ORDER LISTS:

All order lists and bending diagrams shall be furnished by the Contractor. If requested by the Engineer, order lists and bending diagrams shall be submitted for approval. Approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams.

602.4-PROTECTION OF MATERIALS:

Steel reinforcement shall be stored above the well-drained surface of the ground upon platforms, skids, or other supports and shall be protected from mechanical injury. Reinforcement shall be free from injurious defects such as cracks and laminations. Any loose scale, loose rust, dirt, paint, grease, oil or other foreign materials present on the reinforcement shall be removed by wire brushing, sand blasting or other approved methods before the placement of concrete.

Reinforcing steel which will be exposed over the winter shall be protected, within one week after the placing of the initial concrete, with a brush coat of neat cement, mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before the placing of the adjacent pour.

602.5-BENDING OF REINFORCING BARS:

Unless otherwise permitted, all reinforcing bars shall be cold bent in the shop. Bars partially embedded in concrete shall not be field bent except when shown on the Plans or permitted by the Engineer. Only competent men shall be employed for cutting and bending, and proper appliances shall be provided for the work.

Bending shall be in accordance with the Manual of Standard Practice for Detailing, Reinforced Concrete Structures, ACI 315, latest revision. Rail-steel bars shall not be field bent or straightened.

Unless otherwise specified in the plans, bending of all corrosion-resistant reinforcing bars shall be per requirements of with the latest edition of the AASHTO LRFD Bridge Design Specifications.

602.6-PLACING AND FASTENING:

602.6.1-General: All reinforcing steel shall be accurately placed and, during the placing of concrete, firmly held by supports in the position shown on the Plans. Reinforcing bars shall be securely fastened together. Bars shall be tied at all intersections except where spacing is less than 1 foot (300 mm) in each direction, in which case alternate intersections shall be tied. Distance from the forms shall be maintained by means of stays, blocks, ties, hangers, chairs, or other approved supports. Blocks for holding reinforcement from contact with forms shall be precast mortar blocks of approved shape and dimension; the use of pebbles, broken stone, metal pipe or wooden blocks will not be permitted. Reinforcement in any member will be inspected and approved before any concrete is placed.

The clear distance between the reinforcing steel and the face of the concrete unless otherwise shown in the plans shall be:

Top of deck slab:	2.5"
Bottom of deck slab:	1.0"
Bottom of footings:	3.0"
All other locations:	2.0"

602.6.2-Epoxy Coated Bars: Epoxy coated bars shall be placed on plastic coated wire supports. Supports shall be installed in a manner to prevent planes of weakness in the hardened concrete. The reinforcing steel shall be held in place by use of plastic or plastic coated tie wires especially fabricated for this purpose.

Any visible damage to the epoxy coating of the reinforcing steel that occurs during shipment, storage and installation of the steel shall be repaired. The patching Supplier shall furnish patching material to the project with the first shipment of epoxy coated steel. The patching material shall be prequalified as required for the coating material and shall be either identified on the container as meeting the requirements of AASHTO M284, Annex A or shall be accompanied by a Certificate of compliance. Patching of damaged areas shall be performed in accordance with the patching material manufacturer's recommendations.

In the event it is anticipated that the epoxy bars will be stored on the project site, and/or placed in final position without the concrete cover for a period of 90 days or more, then the bars shall be stored in a temporary shed or covered with plastic to prevent damage to the epoxy coating due to ultra-violet rays or other atmospheric conditions. Any temporary storage means used, shall provide adequate ventilation to the bars to prevent the build-up of moisture on the bar surface.

602.7-BAR SPLICES:

602.7.1-Lapping: All reinforcement shall be furnished in full lengths as indicated on the Plans. No splicing of bars, except where shown on the Plans, will be permitted without the written approval of the Engineer. Lapped splices shall be well distributed or located at points of low tensile stress. The bars shall be rigidly clamped or wired at all splices in a manner approved by the Engineer. Minimum lengths of lap splices unless otherwise noted shall be:

Bar Designation	Min. Lap Splice (Ft)
#4 Bar	1'-9"
#5 Bar	2'-2"
#6 Bar	2'-9"
#7 Bar	3'-9"
#8 Bar	4'-11"
#9 Bar	6'-2"
#10 Bar	7'-10"
#11 Bar	9'-7"

For epoxy coated bars, the minimum lap splice length shall be increased by 50 percent at locations where concrete cover is less than 3 bar diameters and 20 percent at all other locations.

Lapped splices for corrosion-resistant rebar shall be in accordance with the latest edition of the AASHTO LRFD Bridge Design Specifications.

602.7.2-Welding: Splicing by welding of reinforcement will be permitted only if detailed on the Plans or if authorized by the Engineer in writing. Welding shall comply with the current specifications of the American Welding Society, D 1.4, and the weld shall develop an ultimate strength equal to or greater than that of the bars connected. Welding of corrosion resistant reinforcement is not permitted.

602.7.3-Mechanical Splice Connectors: Mechanical splice connectors shall develop in tension or compression at least 125 percent of the specified yield strength of the bar.

602.8-FABRIC REINFORCEMENT:

Mesh sheets or uncoated reinforcing steel, except steel mesh, will be measured by the pound (kg), based on Plan lengths and numbers of bars, using the unit weights in Table 602.9. The quantity for payment will be the number of pounds (kg) calculated and placed as shown on the Plans or directed, complete in place and accepted, subject to adjustment as provided for in 104.2 and 109.2.

602.9-METHOD OF MEASUREMENT:

Epoxy coated or uncoated reinforcing steel, except steel mesh, will be measured by the pound (kg), based on Plan lengths and numbers of bars, using the unit weights in Table 602.9. The quantity for payment will be the number of pounds (kg) calculated and placed as shown on the Plans or directed, complete in place and accepted, subject to adjustment as provided for in 104.2 and 109.2.

TABLE 602.9

Bar Designation	Weight Per Lin. Ft. in Lb. (<u>Mass</u> kg per meter)	Bar Designation	Weight Per Lin Ft. in Lb. (<u>Mass</u> kg per meter)
# 3 (10)	0.376 (.560)	# 9 (29)	3.400 (5.060)
# 4 (13)	0.668 (.994)	# 10 (32)	4.303 (6.404)
# 5 (16)	1.043 (1.552)	# 11 (36)	5.313 (7.907)
# 6 (19)	1.502 (2.235)	# 14S (43)	7.650 (11.38)
# 7 (22)	2.044 (3.042)	# 18S (57)	13.600 (20.24)
# 8 (25)	2.670 (3.973)		

602.10-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which price and payment shall be full compensation for furnishing, fabricating, transporting, storing and placing epoxy coated or uncoated reinforcing steel; and the furnishing of all other materials and doing all the work described in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

602.11-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
602001-*	Reinforcing Steel Bar	Pound (Kilogram)
602002-*	Epoxy Coated Reinforcing Steel Bar	Pound (Kilogram)
602003-*	Corrosion Resistant Reinforcing Steel Bar	Pound (kilogram)

* Sequence number

SECTION 603 PRESTRESSED CONCRETE MEMBERS

603.1-DESCRIPTION:

This work consists of the construction of precast/prestressed concrete members, pretensioned in accordance with these specifications and in conformity with the plan details and notes. This work shall include manufacturing, inspection, handling, storing, transporting and erecting of structural members of precast/prestressed concrete, and, when specified, shall also include precast concrete members which do not contain pretensioning steel components.

Concrete floors, curbs, parapets, curtain walls, and diaphragms shall be cast in place on the project unless otherwise provided for on the plans. When the above elements are specified as precast members, they shall be manufactured in accordance with this specification.

603.2-MATERIALS:

Materials shall meet the requirements specified in the following Sections/Subsections:

Precast/Prestressed Concrete Materials	Sections/Subsections
+Admixtures:	
Air Entraining Admixtures	707.1
Retarding Admixtures	707.2
Water Reducing Admixtures	707.3
**Pozzolonic Additives	707.4
Specific Performance Admixtures	707.17
Cement	ASTM C150, 701.3
Coarse Aggregates*	703.1, 703.2, & 703.3
Concrete Sealant	707.12
Elastomeric Bearing Pads	715.14
Fine Aggregates #	702.1
Hot-Poured Elastic Type Concrete Joint Sealer	708.3
Mixing Water	715.7
Preformed Expansion Joint Filler	708.1
Prestressing Steel	709.2
Reinforcing Steel	709.1
Shear-Key Grout	715.5
Steel Bolts and Nuts	709.23
Welded Wire Fabric	709.4

When the top surface of a prestressed member is designed as the bridge wearing surface

* The maximum size of coarse aggregate shall not exceed the minimum horizontal or vertical clear spacing between pretensioned or reinforcing steel elements divided by 1.33. Lightweight aggregates shall not be used unless their use is permitted by the Engineer in writing.

For Class S-P concrete, a blend of two AASHTO gradations of coarse aggregates can be used. The maximum aggregate size permitted is ¾ inches (19 mm). A coarse aggregate gradation using a #67 aggregate is allowed only if 100% of the material passes the ¾ inch (19 mm) sieve

** The use of a pozzolonic additive is not permitted when a blended hydraulic cement is used. For Class S-P concrete, a combination of up to two pozzolonic additives is permitted, as shown in Table 603.6.3.1. The maximum percent of total cementitious materials permitted in Class S-P concrete mix designs is shown in Table 603.6.3.1.

+ Calcium chloride or any admixture containing chloride ion in excess of 0.1 percent by weight shall not be used in prestressed concrete members.

603.2.1-Inspection and Testing: A representative of the Engineer shall have free entry at all times, while the work on the Contract is being performed, to all parts of the manufacturer's works which concern the manufacture of the materials ordered. The manufacturer shall afford the representative of the Engineer, without charge, all reasonable facilities to satisfy themselves that the material is being furnished in accordance with these specifications.

603.3-PLANT REQUIREMENTS AND APPROVAL:

603.3.1-Plant Approval: All fabricators of prestressed concrete members shall be certified in the appropriate Group and Category in accordance with the Precast/Prestressed Concrete Institute (PCI) Plant Certification Program. Fabricators shall be certified in Group B3 or B4 for manufacture of prestressed straight strand bridge members. For prestressed draped strand bridge members, the fabricator shall be certified in Group B4. The Engineer or his authorized representative shall approve all plants manufacturing prestressed and precast reinforced concrete bridge members before manufacture of the members may be started. Requests for such approvals shall be submitted to the Engineer at least three weeks prior to the date of manufacture of the members. Requests shall include details of the plant facilities, materials, and the production methods the manufacturer intends to use.

The manufacturer shall have an established quality control program in effective operation at the plant. This program shall be submitted to the Engineer for approval at least 30 days prior to the start of the production.

If a contractor/fabricator is found to consistently deviate from PCI guidelines, the contractor/fabricator will be required to use independent laboratory quality control testing and inspection until it can be shown that conformity with PCI guidelines has been reestablished. The laboratory used is subject to the approval by the Engineer. The cost of the independent laboratory is to be borne by the contractor/fabricator.

603.3.2-Supervision: The contractor/fabricator shall provide a PCI Level II certified technician, skilled in the use of the system of prestressing to be used, who shall supervise the work and give the Engineer or his representative such assistance as may be considered necessary.

603.3.3-Equipment and Tools:

603.3.3.1-General: All equipment, tools and machinery used in the work shall be adequate for the purpose for which it is to be used and shall be maintained in a satisfactory working condition. The use of portable pretensioning beds for the manufacture of prestressed concrete members is not acceptable.

The contractor/fabricator shall provide all other equipment and tools necessary for the construction and the prestressing.

603.3.3.2-Equipment: The jacks shall be equipped with instruments for monitoring the hydraulic pressure. Electronic pressure transducers with digital indicators may be used. All pressure gauges or electronic pressure indicators shall indicate the load directly to one (1) percent of the maximum gauge or sensor/indicator capacity or (2) two percent of the maximum load applied, whichever is smaller.

Each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force. The calibration of the jack and

gauge shall be done while the jack is in the identical configuration as will be used on the site, e.g., same length hydraulic lines. An independent laboratory shall furnish certified calibration charts with each jack and gauge used in the work. Certified calibration of each ram shall be made prior to the start of stressing operations and every six (6) months thereafter, or as requested by the Engineer. Any repair of the rams, such as replacing seals, changing length of hydraulic lines, changing type of pump or using gauges which have not been calibrated with the ram, shall be cause for recalibration of the jack and gauge with a load cell. No extra compensation will be allowed for the initial or subsequent ram calibrations.

603.3.3.3-Forms and Casting Beds: Forms and casting beds shall be subject to the approval of the Engineer. Unless otherwise approved, only metal forms on concrete founded casting beds shall be used. The forms and casting beds shall be well constructed, carefully aligned, substantial and firm, securely braced and fastened together, sufficiently tight to prevent leakage of mortar and strong enough to withstand the action of mechanical vibrators. The forms shall be constructed to permit movement of the members without damage during release of the prestressing force or movement caused by thermal expansion during curing. The casting beds and all form work will be approved before any concrete is placed, but such approval shall not relieve the contractor/fabricator of responsibility for the results obtained.

603.4-WORKING DRAWINGS:

603.4.1-General: The contractor/fabricator shall expressly understand that the Engineer's approval of the working drawings submitted by the contractor/fabricator covers the requirements for "strength and detail," and that the Engineer assumes no responsibility for errors in dimensions.

Working drawings must be approved prior to performance of the work involved and such approval shall not relieve the contractor/fabricator of any responsibility under the contract for the successful completion of the work.

All working drawings shall be in English units. Use of dual (metric and English) units is not allowed.

603.4.2-Shop Drawings: The contractor/fabricator shall submit copies of the detailed shop drawings to the Engineer for approval. Shop drawings shall be submitted sufficiently in advance of the start of the work to allow time for review by the Engineer and corrections by the contractor/fabricator without delaying the work. The size of the original drawings shall be 22 inches x 34 inches (559 mm x 864 mm) including margins, unless otherwise permitted. The shop drawings submitted for approval may be reduced.

Shop drawings for concrete structures shall give full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts. Design camber for all members shall be shown on the shop drawings.

603.4.3-Erection Drawings: The contractor shall submit drawings illustrating fully their proposed method of erection. The drawings shall show details of all falsework bents, bracing, guys, dead-men, lifting devices, and attachments to the bridge members: sequence of erection, location of cranes and barges, crane capacities, location of lifting points on the bridge

members, and weights of the members. The plan and drawings shall be complete in detail for all anticipated phases and conditions during erection. Design calculations, sealed by a Registered Professional Engineer, shall be submitted by the contractor/fabricator to the Engineer for approval which will demonstrate that allowable stresses for falsework and concrete members being erected are not exceeded and that member capacities and final geometry shall be correct.

When the designated concrete deck overhang exceeds 30 inches (760 mm) , the erection drawings submitted by the contractor/fabricator shall include complete details of the forming and bracing for the overhang and shall transmit the concrete deck dead load to an area of the beam or stringer which will prevent distortion. All forming and bracing procedures are subject to approval of the Engineer.

603.5-REINFORCEMENT:

All reinforcing bars and welded wire fabric shall meet all requirements of Section 602 and shall be free of frost, loose rust, grease, dirt, oil, paint, mill scale, corrosion or other deleterious substances. Any steel which cannot be satisfactorily cleaned shall not be used.

When splicing is required, all reinforcing bars shall be lapped for a length of at least 30 bar diameters.

Reinforcing bars, welded wire fabric and other embedded fixtures shall be accurately placed as indicated on the Plans and shall be maintained in their correct position during the manufacture of the unit. Reinforcement shall not be held in position by tack welding.

The minimum concrete cover for reinforcing steel shall be as follows, unless otherwise shown on the Plans:

Main Reinforcement.....	1½ inches (40 mm)
Slab Reinforcement, top of slab	1½ inches (40 mm)
Slab Reinforcement, bottom of slab	1 inch (25 mm)
Stirrups and Ties.....	1 inch (25 mm)

The longitudinal or main wires of welded wire fabric shall be placed transverse to the longitudinal axis of the unit. Laps of welded wire fabric shall be a minimum of 6 inches (150 mm) unless otherwise approved by the Engineer.

603.6-CONCRETE:

603.6.1-General: The composition, proportioning, and mixing of concrete shall be such so as to produce a homogeneous concrete mixture of a quality that will conform to the test and design requirements specified and as noted on the Plans. Concrete for all prestressed members shall have a minimum compressive strength as may be specified on the plans or in the special provisions. Materials used to form voids in the members shall be fabricated from form material acceptable to the Engineer or from cardboard, which has been treated with a waterproofing agent. Any void made from more than one piece of material shall be glued and banded to prevent separation during concreting operations. Any evidence of separation will be cause for rejection. All concrete materials including admixtures shall meet requirements specified in subsection 603.2 and/or as indicated in the plans.

603.6.1.1-Class S-P Concrete: Class S-P concrete shall be self-consolidating concrete for precast/prestressed applications and may be used for the fabrication of prestressed

concrete box beams. If Class S-P concrete is to be used in the fabrication of prestressed concrete I-Beams or Bulb Tee Beams, additional testing, as outlined in Section 603.6.1.1.1, shall be required. Class S-P concrete shall meet the requirements of this Section.

Class S-P concrete shall consist of a homogeneous, flowable mixture of cement, fine aggregate, coarse aggregate, chemical admixtures and water. Class S-P concrete may also contain fly ash, ground granulated blast furnace slag, and silica fume. The mixture proportions shall be such that the Class S-P concrete will resist segregation, bleeding, and the generation of foam during placement, and will need no external compaction or vibration, unless the mix is qualified as outlined in Section 603.6.1.1.1. While the properties of fresh SCC differ significantly from that of conventional fresh concrete, the quality in terms of strength, durability, and performance of the hardened SCC shall be equal to or better than that of a similar specified conventional concrete mix. Establishment of the mixture proportions shall be coordinated with the manufacturer of the admixtures which will be used in the Class S-P concrete.

SCC exhibits self-leveling capabilities. Creating a successful SCC mix requires combining ingredients to achieve a highly-flowable product that also has the capability to resist dynamic segregation and foaming during placement while resisting static segregation and bleeding once in place. SCC mix designs are often achieved using high-range water reducing (HRWR) admixtures, and by carefully selecting a proper aggregate gradation, incorporating high volumes of powder in the mix, through the use of viscosity-modifying admixtures (VMAs), or a combination of the previously mentioned.

For Class S-P concrete, a combination of admixtures which may be used includes water-reducing admixtures, air-entraining agents, water-reducing and retarding admixtures, VMAs, shrinkage-reducing admixtures (SRAs), and other specific performance admixtures, provided they are on the WVDOH approved list of admixtures. These admixtures used shall all come from the same manufacturer, and measures should be taken to ensure that no adverse reactions occur. Also, for Class S-P concrete, it is permitted to use a combination of up to two AASHTO gradations of coarse aggregate to obtain an optimal combination of strength, self-consolidating ability, and passing ability. Likewise, a combination of up to two pozzolanic additives may be used in combination with Portland cement for Class S-P concrete in order to achieve ideal characteristics for the mix.

603.6.1.1.1-Pre-Qualification of Class S-P Concrete Construction Methods: If Class S-P is to be used in the fabrication of prestressed concrete I-Beams or Bulb Tee Beams, or if vibration is to be used during fabrication, the Class S-P concrete mix and proposed method of construction must be pre-qualified prior to fabrication.

A full-size test member, at least 10 feet (3 m) in length shall be constructed with the Class S-P concrete mix which will be used during fabrication. The full-size test member shall represent the “worst-case” member which the Fabricator shall be allowed to fabricate, using Class S-P concrete. This “worst-case” member shall consist of the tallest I-beam or Bulb Tee shape and shall contain the maximum amount of prestressing strand and reinforcing steel which would be encountered in such a member. The type and maximum duration of vibration, which will be used during fabrication, shall also be used during construction of this test member. All other aspects of construction of this test member, including the free fall height of concrete above the beam, shall be identical to those which will be used during fabrication of members during production.

After the completion of curing of this test member, three 4-inch (100 mm) diameter cores shall be taken from the member at mid-length. One core shall be taken from the top flange of the member, one core shall be taken from the web of the member at mid-height, and one core shall be taken from the bottom flange or bulb of the member. A point count, in accordance with MP 700.03.50 or other equivalent test method approved by the Engineer, shall be performed on each of these cores in order to determine if segregation is occurring due to the vibration.

If the results of the point counts show that the percentages of coarse aggregate, fine aggregate, air content, and paste vary by more than 15% between any of these three cores, that type of member shall not be permitted to be constructed with Class S-P concrete.

If, at some time after the above mentioned “worst-case” test member is fabricated and tested, the Fabricator needs to fabricate a member larger than this “worst-case” member (which would now be a new “worst-case” member), the Engineer shall determine, based on the test results from the previous “worst-case” member, whether or not the testing required in this section will again be required for this new “worst-case” member. If the test results from the previous “worst-case” member are within an acceptable margin below the allowable test criteria, and if the new “worst-case” member is not significantly larger than the previous “worst-case” member, then the Engineer may allow this new “worst-case” member to be constructed with Class S-P concrete without additional pre-qualification testing required in this section.

603.6.2-Mix Design: Concrete mixtures must be established initially by methods in accordance with ACI 318, Chapter 5. Class S-P concrete mixtures shall be developed in accordance with MP 711.03.23 and the requirements of this Section, not the ACI methods. Mixes may be designed either by a commercial laboratory or by PCI certified concrete plant personnel. Prior to adoption of a mix design as a plant standard, it shall be field tested by use of the production plant batching and mixing equipment, construction methods, and curing to be used in production of the members. The use of a previous mix design can be approved for a project if sufficient test data (30 or more tests) are available from the past year for evaluation (ACI 301, Chapter 3, method).

All design mixes shall be developed using the type of cement, the type and gradation of aggregates, and admixtures proposed for use in plant mixes. The mix design shall also include either compressive strength tests or a penetration resistance test (in accordance with ASTM C 403) that verify the amount of time it takes to achieve a compressive strength of 500 psi (3.5 Mpa). The Engineer shall approve the mix design. When any of these variables are changed, or after a three-year time period, the mix shall be re-evaluated and submitted to the Engineer for approval.

603.6.2.1-Class S-P Concrete Mix Design Testing: To ensure repeatability of production, two batches of concrete with the same mix proportions shall be created for mix qualification testing. The results of this testing shall be submitted to the Division for approval at least 45 days prior to the use of the mix in construction.

The two trial batches at the target cement factor plus one bag (see Section 3.3 of MP 711.03.23), are not required for Class S-P concrete mixes.

Batching equipment and curing procedures for test specimens fabricated from these test batches should be as close as possible to the techniques that will be used by the Fabricator

during production. The minimum batch size for these trial batches shall be 2.0 yd³ (1.53 m³), or the largest possible batch when using the mixer that will be used for production, if approved by the Division.

The fresh properties measured at the proposed time of casting for each trial batch shall include air content, consistency, Visual Stability Index (VSI), T₅₀, J-Ring Value, Unit Weight, Yield, Rapid Assessment of Static Segregation Resistance, and Segregation Resistance. Target values and their tolerances for the fresh properties of the trial batches shall conform to the requirements in the following table:

TABLE 603.6.2.1A

Fresh Property	Mix Design Batch Acceptance Criteria
Air Content	***Target minus 0.5% ≤ Air Content ≤ ***Target plus 1.5%
Slump Flow (ASTM C1611)	Target ≤ Spread ≤ Target plus 1.5 inches (38 mm) 2 seconds ≤ T ₅₀ ≤ 7 seconds Visual Stability Index ≤ 1.0
Passing Ability (ASTM C1621)	J-Ring Value ≤ 1 inch (25 mm)
Rapid Assessment of Static Segregation Resistance (ASTM C1712)	Penetration Depth (PD) ≤ 0.5 inch (13 mm)
Segregations Resistance (ASTM C1610)	Segregation ≤ 12%
Unit Weight and Yield	± 2% of Theoretical

*** The target air content of Class S-P concrete shall be determined in accordance with Table 603.6.2.1B

TABLE 603.6.2.1B

Nominal Maximum Aggregate Size in the Class S-P Mix	Target Air Content of Class S-P Concrete
3/8 inch (9.5 mm)	7.5%
1/2 inch (12.5 mm)	7.0%
3/4 inch (19 mm)	6.0%

After the properties of the trial batches of fresh concrete have been established to be within the specification limits in Table 603.6.2.1A, specimens will be cast for compressive strength, modulus of elasticity, creep, length change (total shrinkage), rapid chloride permeability and freeze-thaw testing. Casting of all Class S-P specimens to be used for hardened property testing shall be done in one lift without rodding. Compressive strength testing shall be conducted on both trial batches, but modulus of elasticity, creep, length change (total shrinkage), rapid chloride permeability and freeze-thaw testing is only required on one of the trial batches.

If steam curing is to be used during the production, the same curing procedure (time, temperature, etc.) shall be used on all of the above test specimens except for the shrinkage specimens. After discontinuation of steam curing, all specimens shall be cured as noted in the footnotes in the table below.

Target values and their tolerances for the hardened properties of the trial batches shall conform to the requirements in Table 603.6.2.1C:

TABLE 603.6.2.1C

Hardened Property Test	Total # Specimens	Specimen Size	Age at Testing	Magnitude of Loading	Approval Condition
Compressive Strength (AASHTO T22)	7	4"x8" (100x200 mm) or 6"x12" (150 x 300 mm) cylinders	1 @ 24 ± 2 hrs. 1 @ 3days ± 2 hrs. 1 @ 7days ± 2 hrs. 1 @ 14days ± 2 hrs. 3 @ 28days ± 4 hrs.	Load Until Failure	per Design
Modulus of Elasticity ^b (ASTM C469)	7	6"x12" (150 x 300 mm) cylinders	1 @ 3days ± 2 hrs. 1 @ 7days ± 2 hrs. 1 @ 14days ± 2 hrs. 3 @ 28days ± 4 hrs.	40% of compressive strength (obtained above)	$\geq 57,000\sqrt{f'_c}$ ^a
Creep ^b (ASTM C512)	8 total (3 loaded, 3 remain unloaded, 2 tested for compressive strength)	6"x12" (150 x 300 mm) cylinders	72 ± 2 hours at age of initial loading	40% of compressive strength at time of loading	Creep Coefficient ^c ≤ 1.19 at 90 days ^a
Length Change (ASTM C157)	3	3"x3"x11" (75 x 75 x 275 mm) prisms	56 days	28-day cure per ASTM C157 then Air Storage for 28-days	≤ 0.0002 at 28 days of Air Storage ^a
Rapid Chloride ^b Permeability (AASHTO T277)	3	4"x2" (100 x 50 mm) disc specimen	56 days or 28 days	60.0 ± 0.1 V	≤ 1500 coulombs (56 days) or ≤ 2000 coulombs (28 days)
Freeze-Thaw Resistance (ASTM C666-Procedure A) ^b	3	3"x4"x16" (75 x 100 x 400 mm) prisms	28 day cure prior to testing	300 cycles (0°F to 40°F)	Durability Factor ≥ 80

- If the values obtained from testing the Class S-P mix do not meet the specified values in Table 603.6.2.1C, then the Fabricator's Engineer may submit calculations for prestress losses, camber, and long term deflections to the Division for review in accordance with Section 105.2.1.1, the Division Approval Method for shop drawings. If the Fabricator's calculations show that the values exceeding the specified values in Table 603.6.2.1C will not adversely affect the prestress losses, camber, and long term deflections, and the Division approves these calculations, then the Class S-P mix in question may be used to fabricate prestressed bridge members.
- After the discontinuation of steam curing, test specimens shall be removed from the molds within 23.5 ± 0.5 hours and moist cured in the laboratory at a temperature between 73.5 ± 3.5 °F (23.0 ± 2.0 °C) until the time of test. Freeze-Thaw Resistance testing shall begin when the specimens are at an age of 28 days.
- The Creep Coefficient shall be defined as the Creep Strain at 90 days divided by the Initial Elastic Strain at the Time of Initial Loading. The Initial Elastic Strain shall be determined within 2 minutes after the application of the initial load.

In addition to the hardened property tests above, at least one trial batch shall be subjected to the prestressing strand bond strength testing as outlined in MP 603.06.20. The Class S-P mix in question must pass this test.

Although a concrete mix may meet the necessary strength requirements and exhibit acceptable fresh properties at the time of initial testing, the Engineer can require a re-design of the mix based on other criteria, such as insufficient retention of the slump flow for the mix, excessive foam buildup, etc. The slump flow of the mix must be retained, within the limits specified in Table 603.6.4.1, throughout the duration of the concrete placement. The submittal for a proposed mix design shall include completed copies of Attachments 1S-P, 2S-P and 3S-P of MP 711.03.23. All pertinent information supporting these attachments and pertaining to the information in them should also be submitted.

603.6.3-Proportioning of Normal (Non-SCC) Concrete: Materials shall be proportioned by weight, unless otherwise authorized by the Engineer. The concrete shall contain the minimum water-to-cementitious materials (w/c) ratio required to obtain satisfactory workability and the specified minimum strength, but in no case shall this (w/c) ratio exceed 0.44, including the free water in the aggregate and/or admixtures. The minimum cement factor shall be 658 lbs. per cubic yard (390 kg per cubic meter). Concrete for all members shall be air-entrained with a target air content of seven percent. A working tolerance of plus or minus two percentage points will be allowed. When the ambient temperature is 90 °F (32°C) or higher, a mix using a retarding admixture shall be used. Slump shall not exceed 8 inches (200 mm) with the use of high range water reducers.

603.6.3.1-Proportioning of Class S-P Concrete: The water-to-cementitious materials (w/c) ratio for Class S-P concrete shall fall within a range of 0.32 to 0.40. A water-to-cementitious materials (w/c) ratio less than 0.32 may be used if approved by the Engineer. The minimum cementitious material factor for Class S-P concrete shall be 658 lbs. per cubic yard (390 kg per cubic meter). Unless otherwise approved by the Engineer, the maximum cementitious material factor for Class S-P concrete shall be 799 lbs. per cubic yard (474 kg per cubic meter).

Concrete for members cast with Class S-P concrete shall be air-entrained with a target air content as shown in Table 603.6.2.1B. A working tolerance of plus or minus 1.5 percentage points will be allowed during fabrication. Material proportions should be selected to ensure an optimal combination of fresh and hardened properties.

A standard Class S-P concrete shall be designed to have a slump flow of 25 ± 2 inches (635 ± 50 mm) in diameter. This 25 inch (635 mm) slump flow diameter will be referred to as the target value for mix qualification and site approval. The contractor may request that the Engineer approve a different target slump, which must be less than 25 inches (635 mm). If approved, this requested value will be used as the target value for mix qualification and the approval of batches during production.

TABLE 603.6.3.1

Cementitious Materials	Maximum Percent of Total Cementitious Materials in Class S-P Concrete by Mass
Class F Fly Ash	25
Ground Granulated Blast Furnace Slag	50
Microsilica	10
Total of Class F Fly Ash and Silica Fume	35
Total of Ground Granulated Blast Furnace Slag and Silica Fume	50

NOTE:

Class F Fly Ash shall constitute no more than 25 percent of the total weight of cementitious materials.

Microsilica shall constitute no more than 10 percent of the total weight of cementitious materials.

603.6.4-Sampling and Test Methods:

Sampling Freshly Mixed Concrete	AASHTO T 141
Slump of Hydraulic-Cement Concrete	AASHTO T 119
Unit Weight and Yield of Concrete	AASHTO T 121
Air Content of Freshly Mixed Concrete	AASHTO T 152 or AASHTO T 196
Making and Curing Concrete Test Specimens in the Field	AASHTO T 23
Compressive Strength of Cylindrical Concrete Specimens	AASHTO T 22
Temperature of Concrete	ASTM C 1064
Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression	ASTM C469
Fabricating Test Specimens with Self-Consolidating Concrete	ASTM C 1758
Slump-Flow of Self-Consolidating Concrete	ASTM C 1611
Passing Ability of Self-Consolidating Concrete using J-Ring	ASTM C 1621
Rapid Assessment of Static Segregation Resistance of Self-Consolidating Concrete Using Penetration Test	ASTM C 1712
Static Segregation of Self-Consolidating Concrete using Column Technique	ASTM C 1610
Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration	AASHTO T 277
Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing	ASTM C 666
Standard Test Method for Creep of Concrete in Compression	ASTM C 512
Length Change (Drying Shrinkage) of Hardened Concrete	ASTM C 157
Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete	ASTM C457
Standard Method of Microscopical Determination of Air-Void Content	MP 700.03.50

Cylinders shall be manipulated and cured by methods identical to those used in curing the concrete members.

Slump, Temperature, and Air Content tests shall be conducted on the first batch of concrete each day and every time that cylinders are fabricated. Slump, Temperature, and

Air Content tests shall also be conducted whenever Quality Control Personnel or the Inspector see a variation in the mix.

Unit Weight and Yield tests shall be conducted on the first batch of concrete each day and thereafter, as deemed necessary by Quality Control or Quality Assurance Personnel.

The Fabricator's Quality Control Personnel shall maintain records of the beam number(s) into which each batch of concrete is placed.

603.6.4.1-Acceptance Testing of Class S-P Concrete: During production, each batch of Class S-P concrete shall be tested to determine the air content, slump-flow, passing ability using the J-Ring, rapid segregation resistance, and temperature. Unit Weight and Yield tests shall be conducted on the first batch of concrete each day and thereafter, as deemed necessary by the Quality Control or Quality Assurance Personnel. The fresh concrete properties shall meet performance criteria as shown in Table 603.6.4.1.

TABLE 603.6.4.1

Fresh Property	Production Acceptance Criteria
Air Content (ASTM C173)	Target $\pm 1.5\%$
Consistency (ASTM C1611)	Target Spread ± 2.0 inches (50 mm) 2 seconds $\leq$ Measured $T_{50} \leq 7$ seconds Visual Stability Index ≤ 1.0
Passing Ability (ASTM C1621)	J-Ring Value ≤ 1.5 inch (38 mm)
Rapid Segregation Resistance (ASTM C1712)	Penetration Depth (PD) ≤ 0.5 inch (13 mm)
Temperature	$< 90^{\circ}\text{F}$ (32°C)
Unit Weight and Yield	$\pm 2.0\%$ of Theoretical

603.6.5-Strength of Concrete: Each strength test (i.e. strand release and 28-day) shall consist of the average strength of a minimum of two compressive strength test cylinders fabricated from a single randomly selected batch of concrete, as it is being placed in the forms.

A minimum of one set of cylinders shall be fabricated (at random) for each member cast in a form, with a maximum of one set of cylinders per batch of concrete. These cylinders, molded during fabrication, shall be the same size specimens as were used in the approved mix design.

Any member, for which the average concrete compressive strength at 28-days is less than the 28-day design compressive strength value, may be rejected at the option of the Contractor. If the Contractor elects to use such a member, it will be evaluated as to its adequacy for the use intended. Any member evaluated as unsatisfactory will be rejected by the Division, and the Contractor shall fabricate another member to replace the one which was evaluated as unsatisfactory. When the evaluation indicates that the member will be satisfactory for its intended use, the Engineer will provide for an appropriate price adjustment under the provisions of 603.14.2.1.

Whenever the compressive strength of a member at 28-days is less than the 28-day design compressive strength value, the subject member may still be accepted without a price adjustment if the compressive strength at any time prior to shipment (up to a maximum of 56-days from the date of fabrication) exceeds the 28-day design compressive strength value. The Division shall not be responsible for any project delays incurred due to the delayed strength

attainment, and time extensions under Section 108 of the Specifications are not applicable to this scenario.

603.6.6-Batching and Mixing: Concrete batching plants and their operation shall be in conformance with ASTM C 94, “Specifications for Ready-Mix Concrete”. Concrete batch plants shall be capable of producing concrete of the quality required and they shall be adequately equipped and properly operated. Concrete supplied to the plant by an outside batch plant shall meet the same requirements of batch plant facilities. Evidence of conformance will be certification of the outside plant by the National Ready-Mix Concrete Association (NRMCA).

Fine and coarse aggregates and cement shall be measured by weight. Water and liquid admixture may be measured by either weight or volume. Measurement of the various components of concrete, and measuring equipment shall be in accordance with ASTM C 94.

Concrete shall be mixed by one of the following methods:

1. Central mixed concrete-concrete mixed in a central stationary mixer and delivered to the casting area by appropriate methods.
2. Shrink mixed concrete-concrete that is partially mixed in a stationery mixer, then mixed completely and delivered to the casting site in a truck mixer.
3. Truck mixed concrete-concrete that is completely mixed in a truck mixer as it is delivered to the casting site.

Mixing times shall be established by uniformity tests in accordance with procedures in ASTM C 94.

Class S-P concrete shall be batched at the site of fabrication of the prestressed members. For Class S-P concrete, all wash water must be completely discharged from the mixing drum prior to addition of any materials for the subsequent batch. When using Class S-P concrete, under no circumstances shall water be used to adjust the consistency of the mix. If it is necessary to adjust the Class S-P concrete’s consistency, this shall be done through the addition of chemical admixtures only, and adequate mixing after the adjustment, must occur before any Class S-P concrete is discharged into the formwork. Two compressive strength specimens, from this adjusted batch, shall be fabricated and tested. Also, the concrete tests required in Table 603.6.4.1, with the exception of the unit weight and yield tests, shall be performed on this adjusted batch. These results must meet the requirements shown in Table 603.6.4.1.

603.6.7-Placing Concrete: Suitable means shall be used for placing concrete without segregation. The concrete mixture shall not be dropped from a distance of more than 4 feet (1.2 meters), relative to the top of the form or the reinforcement. Special care shall be taken to deposit the concrete in its final position in each part of the form. Working of flowing concrete along the forms from the point of deposit will not be permitted. Care must be taken to work the concrete under and around the prestressing strands and reinforcement. The plastic concrete shall be consolidated in place by either external or internal vibration, or both when necessary. The vibrators shall be of a type and design approved by the Engineer, and the size of the vibrating head will be governed by the spacing of the prestressing cables and reinforcement. Vibrators may be used only to consolidate the concrete after it has been properly placed.

Internal vibrators shall be operated vertically and shall be slowly pushed into and pulled out of the concrete and shall not be held in one spot long enough to cause segregation. Concrete segregated by the vibrator shall be removed and discarded. Partially hardened layers of concrete shall not be penetrated or disturbed by the vibrator. Transmission of vibration into prestressing cable or reinforcement embedded in partially hardened concrete by the vibrating equipment will not be permitted.

The plans for delivery and placement of Class S-P concrete to the casting beds should ensure that construction of the entire member is completed during the workable period of the concrete established in MP 711.03.23, such that no vibration of the concrete is necessary at any point during construction. If vibration is to be used at any time during fabrication, the Class S-P concrete mix and the method of construction must be pre-qualified as outlined in Section 603.6.1.1.1. Batching, transportation and delivery of the Class S-P shall be planned by the manufacturer such that there is a reasonably continuous feed into the formwork and, therefore, at no time shall there be a large pause or delay in the casting process which causes the fresh concrete properties to exceed the limits set forth in Table 603.6.4.1.

603.6.8-Cold Weather Production: In addition to the requirements of Subsection 601.9.1, the following requirements shall apply to outdoor casting operations. When ambient temperatures below 40° F (4°C) are anticipated, the following shall be used as necessary to keep the temperature of concrete within the prescribed limits:

1. Minimum concrete temperature shall be 50° F (10°C) after placement.
2. Concrete shall not be placed on cold forms, steel, or appurtenances. When the temperature of these facilities are below 40° F (4°C), steam heat or other means shall be provided to maintain the temperature to at least 50° F (10°C) unless concrete is delivered above 60° F (15°C) and no frost, snow or ice is present in the form.
3. Placing concrete under covers or in suitable enclosures.
4. Use of heated mixing water.
5. Avoidance of the use of frozen aggregate or aggregate containing frost, snow or ice.
6. Use of insulated forms.

603.6.9-Hot Weather Production: In addition to the requirements of Subsection 601.9.2, the following requirements shall apply to outdoor casting operations:

When the ambient temperature is above 100° F (38°C), or other adverse weather conditions are present, it is recognized that plastic shrinkage of concrete, or loss of strength below specification requirements, or both may occur. If such conditions do occur, the following procedures or combination of procedures shall be used as necessary to correct these deficiencies:

1. Water fog spraying of forms, prior to placement of concrete. Forms exposed to direct sunlight can be misted for cooling prior to placement of concrete.
2. Shaded storage for aggregates.
3. Burying, insulating or shading water supply facilities.
4. Sprinkling or fog spraying of aggregates.
5. Use of shaved or crushed ice for a portion of the mixing water. Only so much ice shall be used as will be entirely melted at the completion of the mixing period.

6. Use of cold water in batching. Water can be chilled and stored in an insulated tank or pulled from a source if temperatures are low enough to aid mix temperature reduction.
7. Application of wet burlap or mats or fog spraying as soon as the water sheen disappears from the concrete. This is especially important for hot, windy, exposed locations.
8. Use of white pigmented curing compound for its heat-reflective properties except on composite surfaces.
9. Use of self-retarding admixtures.
10. Avoidance of the use of cement with temperatures over 170° F (77°C).
11. Shading of product surface during and after casting to avoid heat buildup in direct sunlight.

Concreting operations shall be discontinued when concrete temperatures exceed 100° F (38°C) at the time of placing.

603.7-PRESTRESSING:

603.7.1-Protection of Prestressing Steel: All prestressing steel shall be protected against physical damage and rust at all times during storage and manufacturing. Prestressing steel shall also be free of deleterious material such as grease, oil, wax, or paint, except where called for on the plans. Prestressing steel that has sustained physical damage at any time shall be rejected. The use of prestressing reinforcement having kinks, bends, nicks, or other defects will not be permitted. The development of pitting, other than slight rusting shall be cause for rejection.

Prestressing steel shall be packaged in containers or shipping forms for the protection of the strand against physical damage and corrosion during shipping and storage. A corrosion inhibitor which prevents rust or other results of corrosion shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete.

The shipping package or form shall be clearly marked with a statement that the package contains high strength prestressing steel, and the type of corrosion inhibitor used, including the date packaged.

All anchorages, end fittings, couplers, and exposed strands, which will not be encased in concrete or grout in the completed work, shall be permanently protected against corrosion.

If an anti-bonding agent is used on the forms to facilitate member removal, every precaution shall be taken to protect the prestressing strands against any ° of coating by the anti-bonding agent.

603.7.2-Storing of Prestressing Steel: Prestressing steel shall be stored in a protected area which includes a roof (and sides if necessary) to keep moisture off the strand. In addition the cover must have a floor or at least the strand must be placed on supports to keep it out of mud and water until it is to be used. It shall not be removed from its protective packaging until immediately prior to installation in the forms and placement of concrete. Openings in the packaging shall be resealed as necessary to protect the unused steel. While exposed, the steel shall be protected to prevent corrosion.

603.7.3-Placement of Prestressing Steel: Prestressing shall be accurately installed in the forms and held in place by the stressing jack or temporary anchors and, when tendons are to be draped, by hold-down devices. The hold down devices used at all points of change in slope of tendon trajectory shall be of a low-friction type.

603.7.4-Safety Measures: Effective safety measures shall be taken to prevent injuries to personnel due to the breakage of strands or failure of anchorage devices during the tensioning operations. The protection provided shall be adequate and shall permit the inspector to perform his normal duties. When the safety precautions, in the opinion of the Engineer, are inadequate the contractor will revise the procedures or equipment to the satisfaction of the Engineer. The inspector will abide by the safety rules established by the producer.

603.7.5-Stressing Requirements:

603.7.5.1-General: The provisions set forth in this section refer to the application and measurement of stresses to prestressed concrete members manufactured by the process of pretensioning. Prestressing forces shall not be transferred to any member nor shall end anchors be released before the concrete has attained a minimum compressive strength as specified on the plans or in the special provisions as determined by tests of standard cylinders cured identically as the member.

An initial force shall be applied to each strand such as to develop a load of approximately 10% of the final prestressing load as shown on the plans. A record shall be maintained of the jacking force and elongations thereby. Several prestressed members may be cast in one continuous line and stressed at one time.

Forms shall be removed and members detensioned immediately after steam curing or heat curing is discontinued while the concrete is still warm and moist. The elements shall be cut or released in an order such that lateral eccentricity of prestress forces will be a minimum.

603.7.5.2-Tensioning of Strands: In all methods of tensioning, stress induced in the strands shall be determined by monitoring applied force and independently by measurement of elongation. Applied force may be monitored by direct measurement using a pressure gauge piped into the hydraulic pump and jack system. The elongation measurements shall agree with their computed theoretical values within a tolerance of $\pm 5\%$. If discrepancies are in excess of 5% between the calculated forces, determined by elongation measurement and gauge reading, the tensioning operation shall be suspended and the source of error determined, evaluated, and corrected by qualified personnel before proceeding.

Calculations for elongation and gauge readings must include appropriate allowances for friction in the jacking system, strand seating, movement of bulkheads, bed shortening if under load, thermal corrections, and any other compensation for the setup.

603.7.5.3-Methods of Stress Measurement: Methods of measurement of the stressing force consist of pressure gauges to measure force from the pressure applied to hydraulic jacks or any other method approved by the Engineer.

603.7.5.4-Gauging Systems: Hydraulic gauges shall conform to the provisions set forth in Section 603.3.3. All gauges measuring the stressing load shall be graduated so they can be read within a tolerance of $\pm 2\%$.

Tensioning methods employing hydraulic gauges shall have appropriate bypass valve snubbers and fittings so that the gauge pointer will not fluctuate but will remain steady until the jacking load is released.

603.7.5.5-Control of Jacking Force: Pressure bypass valves may be used for stopping the jack at the required load or for manually stopping the load with the valve. The accuracy of setting of automatic cutoff valves shall be verified by running to the desired cutoff load whenever there is reason to suspect improper results, and at a minimum, at the beginning of the operation each day.

603.7.5.6-Wire Failure in Strands: Failure of wires in a pretensioning strand is acceptable provided the total area of wire failure is not more than 2% of the total area of strands in a member, and providing the breakage is not symptomatic of a more extensive distress condition. Failure of any individual wire prior to placing concrete will require replacement of the strand.

603.7.5.7-Calibration Records for Jacking Equipment: All jacking and load measuring equipment shall be calibrated as specified in Section 603.3.3. Calibration records should show the following data.

1. Date of calibration.
2. Agency, laboratory or registered Professional Engineer (PE) supervising the calibration.
3. Method of calibration; i.e. proving ring, load cell, testing machine, etc., and its calibration reference.
4. The full range of calibration with gauge readings indicated against actual load.

Calibration records for all tensioning systems being used shall be available for preparing theoretical tensioning values. Personnel involved in preparing tensioning calculations shall have a copy of these records for reference.

603.7.6-Pretensioning and Strand Debonding: Pretensioning shall conform to the provisions set forth in Article 2.2, "Pretensioning" of the latest edition of the PCI Quality Control Manual MNL-116.

Plastic sheathing shall be used for strand debonding and shall be approved by the Engineer prior to use. Items such as animal fat, reactive greases, or PVC pipes shall not be used. Any other material shall be approved by the Engineer prior to use.

603.7.7-Detensioning: Detensioning shall conform to the provisions set forth in Article 2.3, "Detensioning" of the latest edition of the PCI Quality Control Manual MNL-116.

603.7.8-Concrete Cover: Minimum concrete cover for prestressing steel shall be 1 ½ inches (40 mm) unless otherwise shown on the plans.

603.8-CURING:

603.8.1 General: Careful attention shall be given to the proper curing of concrete. Prior to placing of concrete, the contractor shall submit the proposed curing methods and procedures to the Engineer for approval. Elevated temperature curing facilities shall be tested prior to approval. Approved equipment and materials for curing shall be available for use prior to casting.

Inadequate curing facilities or lack of attention to the proper curing of concrete shall be sufficient cause for the Engineer to stop all concrete placement until approved curing is provided. Inadequate curing may be cause for rejection of the member. All test cylinders shall be cured in the same environment as the precast/prestressed concrete members.

Curing shall be commenced prior to the formation of surface shrinkage cracks. The curing mats, sheets, or blankets shall be carefully placed in contact with the concrete member to avoid damage to the freshly finished concrete.

The following curing requirements shall apply for precast/prestressed members. Any other special method of curing shall meet with the approval of the Engineer. Concrete shall not be exposed to temperatures below freezing until the specified minimum strength as shown in plan notes has been attained.

All concrete shall be cured by water curing, accelerated temperature curing, or any other method approved by the Engineer.

603.8.2-Water Curing: All exposed surfaces of the concrete shall be kept wet continuously for the required curing time. The water used for curing shall meet the requirements of 603.2. Water curing shall be permitted as follows:

603.8.2.1-Wet Mat Method: For water curing by the mat method, cotton mats, polyethylene sheeting, or polyethylene burlap blankets may be used. The mats, sheets or blankets shall be adequately anchored and weighted to provide continuous contact with all concrete surfaces. Any concrete surfaces which cannot be cured by contact shall be enclosed by mats, adequately anchored, so that outside air cannot enter the enclosure. Sufficient moisture shall be provided inside the enclosure to keep all of the surfaces of the concrete wet for the required curing time, but in no case less than 36 hours.

603.8.2.2-Saturated Cover Curing: The member, covered as specified for the initial phase of curing, shall be maintained on the casting bed in an approved enclosure designed and equipped to insure complete saturation of the covering. The temperature within the enclosure and that of the covering material shall be maintained to provide a uniform curing temperature at the surface of the member, within the limits of 80 °F to 130 °F (27°C) to (54°C), until the specified strength is attained, but in no case less than 36 hours. The covering shall be kept thoroughly saturated throughout the entire curing period and the temperature of the water used shall be controlled uniformly to maintain the selected curing temperature of the surface of the member.

603.8.2.3-Water Spray Curing: The member, covered as specified for the initial phase of curing, shall be maintained in the casting bed in an approved enclosure. When the concrete is sufficiently hardened to resist damage, the covering shall be removed and the exposed surfaces of the unit shall be subjected to a continuous fine spray of water. The

temperature within the enclosure and that of the water used shall be controlled to provide a uniform curing temperature at the surface of the member, within the limits of 80°F and 130°F (27°C) to (54°C) until the specified member strength is attained, but in no case less than 36 hours.

603.8.3-Accelerated Curing: Accelerated curing of the concrete shall be done by low pressure steam curing, or radiant heat curing. Transfer of stress shall be accomplished immediately after the heat curing has been discontinued. Accelerated curing shall be applied at a controlled rate following initial set of the concrete as per ASTM C403. Accelerated curing shall be done under suitable enclosures which minimize all heat losses and maintain uniform cure conditions within the enclosed area. Members must be maintained wet during accelerated curing time.

If accelerated curing is used, the contractor/fabricator shall furnish recording thermometers showing the time-temperature relationship of the concrete throughout the entire curing period. Recording thermometers shall be kept in proper calibration and recalibrated at least annually.

603.8.3.1-Low-Pressure Steam Curing: Low-pressure steam curing shall be done under a suitable enclosure to contain the live steam and minimize moisture and heat losses. The concrete shall be allowed to attain its initial set before application of the live steam.

Application of live steam shall not be directed on the concrete or forms such as to cause localized high temperatures. During the initial application of live steam, the concrete temperature shall be raised at an average rate not exceeding 80°F (27°C)/per hour, until the curing temperature is reached. The maximum sustained concrete temperature during the curing cycle shall not exceed 160°F (70°C). The maximum temperature shall be held until the concrete has reached the required release strength. The maximum peak concrete temperature during the curing cycle shall be 190°F (88°C). The concrete temperature shall be maintained uniformly throughout the extremities of the prestressed member. At the end of curing, the concrete temperature shall be reduced at an average rate not exceeding 50°F (10°C)/per hour.

603.8.3.2-Radiant Heat Curing: Radiant heat may be applied by means of pipes circulating steam, hot oil or hot water, or by electric heating elements. Radiant heat curing shall be done under a suitable enclosure to contain the heat, and moisture loss shall be minimized by covering all exposed concrete surfaces with a plastic sheeting or by applying an approved liquid membrane curing compound to all exposed concrete surfaces. The heat application shall be maintained to create a uniform concrete temperature throughout the extremities of the member.

After the waiting period prior to application of the heat, the concrete temperature shall increase at an average rate not exceeding 80°F (27°C)/per hour until the curing temperature is reached. The maximum sustained concrete temperature within the curing cycle shall not exceed 160°F (70°C). The maximum temperature shall be held until the concrete has reached the required release strength as shown in plan notes. The maximum peak concrete temperature during the curing cycle shall be 190°F (88°C). The maximum cooling rate from sustained concrete curing temperature shall be 50°F (10°C)/per hour.

603.9-FINISHING:

To assure the production of well-formed matching members, all surfaces of the concrete shall be finished, shall be true and even, and shall be free from rough, open, or honeycombed areas, depressions or projections. The edges shall be finished or chamfered, or both. Care shall be exercised in removing forms to avoid spalling or otherwise damaging the concrete.

Top surfaces of prestressed members shall be screeded or rough floated to bring mortar to the surface and cover all aggregate. The top surface of members that will receive cast-in-place concrete on the project site shall be finished as noted on the project plans, or if no finish is noted, they shall have either a raked or stiff broom finish. Aggregate shall not be loosened when roughening the surface. The fascia surfaces of bridge members shall be finished with a PCI Grade A Formed Finish. All other members shall be finished with a PCI Standard Grade Formed Finish. Concrete on exposed reinforcing steel and loose laitance on concrete surfaces to be in contact with cast-in-place concrete shall be removed from all members.

Fabrication holes, except box beam vent holes, in the bottom of all beams, shall be filled with nonshrink mortar and made flush with the surrounding surface. No patching is required for small holes and irregularities on the sides of adjacent box beams that are to be sandblasted prior to shipment. Care shall be taken in final cutting the ends of strands to avoid damaging the concrete surface.

603.10-WORKMANSHIP:

603.10.1-General: Holes and voids in the surface of concrete resulting from bolts, ties, or large air pockets shall be wetted and filled with mortar having the same proportion of fine aggregate and cement as in the concrete, after which exposed mortar surfaces shall be finished smooth and even with a wood float.

Surfaces to be repaired and finished shall be kept wet for at least one hour before hydraulic cement mortar is applied. Immediately following patching work, repaired areas shall be wet cured for at least 48 hours. The wet cure may be accomplished by the use of steam, wet burlap or continuous spray wetting. A liquid membrane-curing compound may be used on non-composite surfaces.

Beams or girders having honeycomb of such extent to affect their strength or resistance to deterioration will not be accepted.

603.10.2-Defects and Breakage: Defective or damaged members which cannot be satisfactorily repaired, or which are not acceptable to the Engineer will not be incorporated into the work. All other members that sustain damage during fabrication, handling, storage or transportation shall be evaluated in accordance with Chapter three of PCI Journal Vol. 30, # 3 entitled "Fabrication and Shipment Cracks in Precast or Prestressed Beams and Columns", hereinafter referred to as "specification". This specification is to be used to determine the severity of cracks. All cracks with a width of 4 mils (0.1 mm) or less may be repaired by silane treatment if the repair section of the specification allows repairs. All cracks over 4 mils (0.1 mm) to and including 16 mils (0.4 mm) shall be repaired by epoxy injection if allowed by the specification. Members with cracks over 16 mils (0.4 mm) shall not be incorporated into the work unless approved by the Engineer.

603.10.2.1-Epoxy Injection of Cracks: The work shall consist of repairing cracks with a width greater than 4 mils and up to and including 16 mils on prestressed concrete bridge beams.

603.10.2.1.1-Materials: The epoxy material used for epoxy injection crack repair shall meet the requirements specified for epoxy resin adhesives in ASTM C 881, Type IV, Grade 1, and Classes B or C. For the epoxy paste or material used to bond and cover the injection ports to the substrate, use the epoxy resin manufacturer's recommendation.

603.10.2.1.2-Equipment: The equipment to be used to inject the epoxy shall meet the recommendations of the epoxy injection material manufacturer and/or the following requirements:

1. Use equipment that has the ability to automatically proportion the material components within the mix ratio tolerances set by the epoxy materials manufacturer.
2. Use equipment that has the ability to automatically mix the epoxy component materials within the pump and injection apparatus.

603.10.2.1.3-Crack Surface Preparation and Cleaning Requirements: After the concrete beam has achieved 28 day shipping strength, clean the concrete surface along the crack of all deteriorated concrete, efflorescence and other contaminants which would be detrimental to the adhesion of the surface sealing epoxy compound. The substrate must be sound, dry on the surface, and free from oil and grease. Blow out the crack with oil free and dry compressed air.

603.10.2.1.4-Epoxy Injection: Place the base of the injection ports directly over the crack and bond to the substrate with an epoxy paste or the recommended product by the epoxy resin manufacturer. The injection ports should be spaced over the length of the crack at a spacing that will allow the epoxy resin to seal the entire crack traveling from one port to another. The ports spacing is dependent upon the viscosity of the resin.

Use an epoxy adhesive to seal over the surface ports and exposed cracks. The entire exposed crack is to be covered with the epoxy adhesive leaving only the port holes uncovered. The cure time for the epoxy will be based upon concrete temperature.

The temperature requirements of the concrete for the injected resin must be satisfied before the process can begin. Begin injecting at the lowest port on the beam and continue until the epoxy resin begins to "ooze" out of the port above it. The "ooze" out of the port above it is a sign that the crack has been filled to that level. Plug the first port with a cap and move up to the next port, repeating this procedure until the entire crack has been filled with epoxy. Use slow, constant pressure to inject the epoxy into the crack which will reduce the possibility of leaks or blow-outs and allow time for the repair material to fully penetrate the crack.

603.10.2.1.5-Post Epoxy Injection: After a minimum of 24 hours, the injection ports can be removed from the beam. Clean the concrete surface areas of excess epoxy injection work. Clean so as to not damage the concrete by scraping, light sand blasting, grinding, use of solvents, or any other appropriate method approved by the engineer. Clean the excess materials so that no epoxy material or injection ports extend beyond the plane surface of the concrete.

603.11-DIMENSIONAL TOLERANCES:

All tolerances shall be applied with respect to the theoretical positions and dimensions shown in the plans. The tolerances listed in this article represent the total allowable tolerance that will be accepted in the finished product.

The limits of tolerance do not necessarily represent fully acceptable construction; they are the limits at which construction becomes unacceptable. In general, workmanship shall be at a level of quality that will be well within the tolerance limits. Out of tolerance dimensions shall be handled in accordance with MP 603.10.40.

603.11.1-Prestressed Concrete I-Beams and Bulb Tee Beams:

<i>Characteristics</i>	<i>Value</i>
Depth (flanges)	±1/4 inch (± 6 mm)
Depth (Overall)	+1/2 inch, to -1/4 inch (+15 to -6 mm)
Width (flanges)	+3/8, to -1/4 inch (+10 to -6 mm)
Width (Web)	+3/8, to -1/4 inch (+10 to -6 mm)
Length of Beam	±1/8 inch per 10 feet, ±1 inch max. (± 1 mm/m, 25 mm max)
Sweep (variation from straight line parallel to centerline of member)	± 1/8 inch per 10 ft (± 1 mm/m)
Camber variation from design camber	± 1/8 inch per 10 feet ± 1/2 inch max up to 80 feet length ± 1 inch max. over 80 length (± 1 mm/m) (± 13 mm max. up to 24 m length) (± 25 mm max. over 24 m length)
Camber variation from design camber	±3/16 inch per 12 inches ± 1 inch (±15 mm/m, ± 5 mm max)
Position of plates	± 1 inch (± 25 mm)
Position of bearing plates	± 5/8 inch (± 16 mm)
Diaphragm Inserts (spacing between centers of inserts and from centers of inserts to the ends of the beams.)	± 1/2 in (± 15 mm)
Stirrup bars (Projection above top of beam)	± 3/4 inch (± 20 mm)
Stirrup bars (Longitudinal spacing)	± 2 inches (± 50 mm)
Concrete Cover	± 1/4 in (± 6 mm)
Position of inserts for structural connections	± 1/2 in (± 15 mm)
Position of hold-down points for draped strands	± 5 inches (± 125 mm)
Position of Inserts	± 1/2 inch (± 15 mm)
Position of handling devices:	
Parallel to length	± 6 inches (± 150 mm)
Transverse to length	± 1 inch (± 25 mm)
Prestressing strand position (vertical or horizontal).	± 1/4 inch (± 6 mm)

603.11.2 Precast/Prestressed Concrete Box Beams and Plank Beams:

<i>Characteristics</i>	<i>Value</i>
Depth (Overall)	±1/4 inch (± 6 mm)
Depth (top flange)	+1/2 inch (+15 mm)
Depth (bottom flange)	+1/2 inch to -1/8 inch (+15 to 3 mm)
Width (Overall)	±1/4 inch (±6 mm)
Width (Web)	±3/8 inch (±6 mm)
Length	± 3/4 inch (± 20 mm)
Sweep (variation from straight line parallel to centerline of member) Up to 40 feet (12 m) length member	±1/4 inch (± 6 mm)
40 to 60 feet (12 to 18 m) length member	±3/8 inch (±10 mm)
Greater than 60 feet (18 m) length member	± 1/2 in (± 15 mm)
Camber variation from design camber	±1/8 inch per 10 feet, ±1/2 inch Max. (±1 mm/m, ±15 mm Max)
Variation from specified end Squareness of skew:	
Horizontal	± 5/8 inch (± 16 mm)
Vertical	±1/8 inch per 12 inches ± 1/2 inch Max. (±1 mm/100 mm, ±15 mm Max)
Position of tendons Individual	± 1/4 in (± 6 mm)
Position of Inserts for structural connections	± 1/2 in (± 15 mm)
Position of handling devices:	
Parallel to length	± 6 inches (± 150 mm)
Transverse to length	± 1 in (± 25 mm)
Position of stirrups:	
Longitudinal spacing	± 1 inch (± 25 mm)
Projection above top	+ 1/4 inch (± 6 mm), - 3/4 inch (- 20 mm)
Position of dowels tubes	± 5/8 inch (± 16 mm)
Position of hold-down points for draped strands	± 5 inch (± 125 mm)
Position of tie rods tubes:	
Parallel to length	± 1/2 inch (± 15 mm)
Vertical	±3/8 inch (±10 mm)
Position of slab void:	
End of void to center of tie hole	± 1/2 inch (± 15 mm)
Adjacent to end block	± 1 inch (± 25 mm)
Concrete Cover	± 1/4 inch (± 6 mm) per 10 feet long. Bars (6 mm per 3 m)

603.11.3-Prestressed Concrete Deck Panels:

<i>Characteristics</i>	<i>Value</i>
Length	± 1/2 in (± 15 mm)
Width	± 1/2 in (± 15 mm)
Nominal Depth	+ 1/4 inch - 1/8 in (+6 mm, -3 mm)
Horizontal Alignment – Deviation from straightness of matting edge of panels	1/8 in (3 mm)
Deviation of ends from plan dimension Horizontal Alignment	± 1/2 in (± 15 mm)
Position of strands : Vertical	±1/8 (±3 mm)
Horizontal	± 1/2 in (± 15 mm)
Concrete Cover	± 1/4 inch (± 6 mm) 1/4 inch per 10 feet long. Bars (6 mm per 3 m)

603.12-HANDLING, STORING, TRANSPORTING, AND ERECTION:

The Contractor shall be responsible for proper handling, lifting, storing, hauling, and erection of all members so that they are placed in the structure without damage.

Prestressed members shall be maintained in an upright position at all times and shall be handled and supported in a manner which prevents torsion. No member shall be moved from the casting yard until the member has been accepted.

Storing of members shall be done with adequate blocking so that warpage or cracking will not occur. Blocking will be such that at least 6 inches (150 mm) clearance is maintained above the surface on which the blocking is placed. Placement of the blocking from beam ends shall be at locations not greater than (3) percent of the beam length. Concrete box beams shall be supported by the solid end block area during handling, storage, hauling, and erection. Members which are improperly stored and which become cracked, warped, or otherwise damaged in storage will be subject to rejection.

Members when stacked, shall be separated by blocking capable of supporting the members. The blocking shall be arranged in vertical planes. Stacking of members shall be arranged such that lifting devices will be accessible and undamaged. Stacking shall not exceed two members high.

All concrete beams or girders when erected, shall be securely tied and/or braced unless otherwise shown on the plans. When railroad or roadway traffic must be maintained beneath girders or beams already placed, traffic shall be protected against falling objects during the erection of diaphragms and other structural members, during the placing of cast-in-place concrete, and during the erection and dismantling of forms. Protection shall consist of nets or flooring with openings not larger than 1 inch (25 mm).

When precast / prestressed concrete adjacent box beams are erected, the fit of mating surfaces will be such that excessive grout leakage will not occur. If such fit is not provided the joint shall be filled with grout or sealed with an acceptable caulking suitable to the Engineer.

603.13-CONSTRUCTION OF DECK:

The variation in heights between beams shall not be more than 1/2 in (13 mm) between adjacent box beams where there is no wearing surface. For adjacent box beam bridges with wearing surfaces, the differential shall not exceed 3/4 inches (19 mm).

Dowel bar and lifting bolt holes shall be filled with non-shrink grout. Adjacent box beam units shall be transverse post tensioned by the use of high strength threaded bars, or by other methods as shown on the Plans.

603.14-MEASUREMENT AND PAYMENT:

603.14.1-Method of Measurement: Precast/Prestressed concrete structural members will be measured along the member centerline in linear feet (meter). Deck panels shall be measured by area in square feet (meter) complete in place.

Precast reinforced concrete three-sided structures shall be measured along the centerline of the erected structure in linear feet (meter).

Precast reinforced concrete headwalls and wingwalls for use with precast reinforced concrete three-sided structures shall be measured in square feet (meter) as measured on the exterior face of the member.

603.14.2-Basis of Payment: Precast/Prestressed concrete beams, deck panels, precast reinforced concrete three-sided structures, and precast reinforced concrete headwalls and wingwalls will be paid for at the contract unit price bid for the items listed below, which price and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner including the cost of furnishing and manufacturing the concrete members; for labor, concrete, forms, conventional reinforcing steel, prestressing strands, inserts, anchorage devices, bearing pads, shims, grout, wingwalls and headwall connection hardware, joint sealing/waterproofing, and other devices, and for moving, transporting and erecting the finished product in accordance with the Plans and Specifications. For precast reinforced concrete three-sided structures where the headwall is cast integral with the end structure unit, the headwall will be paid for in square feet (meter) as if it were not integral cast. Cast-in-place concrete diaphragms, curb, parapet, railing, and reinforcing steel for cast-in-place concrete are not included in this item.

603.14.2.1-Price Adjustments: Members found not in compliance with the requirements of 603.6.5 for compressive strength, but for which the evaluation indicates may still be used, will be paid for at a reduced price in accordance with the following formulas, depending on who purchased the members:

FORMULA 1: Use the following price reduction formula when the members are used in a project constructed by a Contractor:

$$\text{Price Reduction} = \left(\frac{f'_c - \bar{X}}{0.5f'_c} \right) \times 40\% \text{ of the Contract Unit Bid Price}$$

FORMULA 2: Use the following price reduction formula when the beams are used in a project constructed by the Division:

$$\text{Price Reduction} = \left(\frac{f'_c - \bar{X}}{0.5f'_c} \right) \times \text{IC}$$

Where:

f'_c = 28-Day Design Compressive Strength, psi (Mpa)

$\bar{X}$ = Average 28-day Compressive Strength as determined in 603.6.5

$\text{IC}_{(\text{Formula 2 only})}$ = The invoiced cost of the member itself, as billed to the Division by the Fabricator. This cost shall not include other items associated with the member such as guardrail, bearing pads, etc.

603.15-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
603016-*	“size” Prestressed Concrete Box Beam	Linear Feet (Meter)
603017-*	“size” Prestressed Concrete Plank Beam	Linear Feet (Meter)
603018-*	“size” Prestressed Concrete I Beam	Linear Feet (Meter)
603019-*	“size” Prestressed Concrete Bulb T Beam	Linear Feet (Meter)
603020-*	“size” Prestressed Concrete Deck Panel	Linear Feet (Meter)
603021-*	“size” Precast Concrete Deck Panel	Linear Feet (Meter)

* Sequence number

SECTION 604 PIPE CULVERTS

604.1-DESCRIPTION:

This work shall consist of the construction or reconstruction of pipe culverts, referred to as "conduit", in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions, and locations shown on the plans or established by the Engineer.

604.2-MATERIALS:

Materials shall conform to the requirements of the following Subsection of Division 700:

MATERIAL	SUBSECTION
Acrylonitrile-Butadiene-styrene (ABS) Pipe	714.21
Aluminum Alloy Structural Plate Arch	713.18
Aluminum Alloy Structural Plate Pipe or Pipe Arch	713.18
Aluminum Coated Corrugated Steel Pipe and Pipe Arch	713.24
Asphalt Cement for Field Paving Structural Plate Pipe or Pipe Arches	705.5, Grade 40-50
Bituminized Fiber Pipe (non-perforated)	714.14
Bituminous Coated and Paved Invert Corrugated Aluminum Alloy Pipe or Pipe Arch	713.15
Bituminous Coated and Paved Invert Corrugated Steel Pipe or Pipe arch	713.3
Bituminous Coated Corrugated Steel Pipe or Pipe Arch	713.3
Bituminous Coated Structural Plate Arch	713.9
Bituminous Coated Structural Plate Pipe or Pipe Arch	713.9
Bituminous Plastic Cement	708.9
Clay Pipe, Extra Strength	714.10
Clay Pipe, Standard Strength	714.10
Clay-Lined Reinforced Concrete Pipe	714.9
Controlled Low Strength Material	219
Corrugated Aluminum Alloy Pipe or Pipe Arch	713.14
Corrugated Polyethylene (PE) Pipe	714.19
Corrugated Polyethylene Underdrain	714.19
Corrugated Stainless Steel Pipe	713.7
Crushed Aggregate Backfill	704.6, Class I or Class 3
End Section for Corrugated Aluminum Alloy Pipe or Pipe Arch	713.21
End Section for Corrugated Steel Pipe or Pipe Arch	713.20
Fiber Bonded Full Bituminous Coated and Full Paved Corrugated Steel Pipe	713.6
Fiber Bonded Full Bituminous Coated and Paved Invert Corrugated Steel Pipe	713.5
Fiber Bonded Full Bituminous Coated Corrugated Steel Pipe	713.5
Fiber Bonded Full Bituminous Coated Corrugated Steel Pipe Arch	713.5
Fiberglass Reinforced (FRP) Pipe	714.16

MATERIAL	SUBSECTION
Fine Aggregate	*
Flexible Watertight Gaskets for Circular Concrete Pipe	708.7
Full Bituminous Coated and Full Paved Corrugated Steel Pipe	713.4
Granular Material for Culvert Bedding	716.1.1.2
Hot Pour Mineral Filled Joint Sealer	708.6
Joint Mortar	708.8
Metallic Coated Corrugated Steel Pipe or Pipe Arch	713.2
Miscellaneous Concrete	715.12
Non-Reinforced Concrete Sewer Pipe	714.1
Perforated Plastic Semicircular Pipe	714.20
Polyvinyl Chloride (PVC) Pipe	714.22
Precast Reinforced Concrete Box Culverts	714.23
Precoated and Full Paved Metallic Coated Steel Pipe	713.23
Precoated and Paved Invert Metallic Coated Steel Pipe or Pipe Arch	713.23
Precoated, Metallic Coated steel Pipe	713.23
Precoated, Metallic Coated Steel Pipe Arch	713.23
Reinforced Concrete Elliptical Pipe	714.4
Reinforced Concrete End Section for Arch-Shaped Concrete Pipe	714.18
Reinforced Concrete End Section for Elliptical Concrete Pipe	714.18
Reinforced Concrete End Section for Round Concrete Pipe	714.18
Reinforced Concrete Pipe	714.2
Reinforced Concrete Pipe Arch	714.3
Reinforced Plastic Mortar (RPMP) Pipe	714.17
Safety Slope End Sections	713.20
Stainless Steel Structural Plate Pipe	713.10
Structural Plate Arch	713.8
Structural Plate Pipe or Pipe Arch	713.8
Vitrified Clay Pipe Joints	708.5

* Fine aggregate used to level the bedding foundation shall consist of crushed or uncrushed natural or synthetic (blast furnace slag) mineral aggregate and consist of particles smaller than 3/8 inch (10 mm) as determined by visual inspection. Other synthetic aggregate may be used at the discretion of the Engineer.

When the locations of manufacturing plants allow, the plants may be inspected periodically for compliance with specified manufacturing methods, and material samples may be obtained for laboratory testing for compliance with material quality requirements. This may be the basis for quality acceptance of manufactured lots.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

All references to "corrugated steel pipe" are considered applicable to uncoated pipe and the various combinations of coated pipes (bituminous coated, fiber bonded, precoated, etc.) and paving classes (paved invert, full paved, etc.) for which the base metal conforms to AASHTO M 218 or AASHTO M 274.

The sheet thickness for corrugated steel pipe and corrugated aluminum alloy pipe shall be as designated on the Plans.

Corrugated metal pipe of 2-2/3 by 1/2 inches (68 mm by 13 mm) corrugation shall be furnished unless otherwise specified.

Corrugated steel pipe and pipe arch with 2-2/3" x 1/2", 3" x 1", and 5" x 1" (68 mm by 13 mm, 75 x 25 mm and 125mm x 25mm) corrugations shall be helically fabricated, except for fiber bonded pipe which may be fabricated with annular corrugated of 2-2/3" x 1/2" and 3" x 1" (68 mm x 13 mm and 75 mm x 25 mm). Corrugated aluminum alloy pipe with 2-2/3" x 1/2", 3" x 1", and 6" x 1" (68 mm x 13 mm, 75 mm x 25 mm, 75 mm x 25 mm, and 150 mm x 25 mm) corrugations and corrugated aluminum alloy pipe arch with 2-2/3" x 1/2" (68 mm x 13 mm) corrugations shall be helically fabricated. Where 5" x 1" (125 mm x 25 mm) corrugations are specified for corrugated steel pipe and pipe arch, 3" x 1" (75 mm x 25) corrugations may be substituted.

604.2.1-Quality Control Testing: Quality control of the granular material and crushed aggregate backfill is the responsibility of the Contractor as specified in 106.1.

The Contractor shall maintain necessary equipment and qualified personnel to perform all sampling and testing necessary to determine the magnitude of the various properties of the material governed by the Specifications and shall maintain these properties within the limits of the Specifications.

The Contractor shall submit a quality control plan detailing the methods by which the quality control program will be conducted. This plan, prepared in accordance with the guidelines set forth in the appropriate portions of MP 307.00.50 and MP 717.04.21, shall be submitted to the Engineer at the preconstruction conference. The work shall not begin until the plan is reviewed for conformance with the contract documents.

604.2.2-Acceptance Testing: Quality control sampling and testing performed by the Contractor may be used by the Division for Acceptance.

604.2.3-Sampling and Testing: Frequency of sampling and testing shall be in accordance with the contractor's quality control plan. The minimum sampling and testing frequencies for gradation shall be as indicated in Attachment 1 of MP 307.00.50. The material shall be sampled in accordance with MP 700.00.06. The minimum sampling and testing frequency for compaction will be in accordance with MP 717.04.21.

604.2.4-Acceptance Plan:

604.2.4.1-Compaction: Compaction of backfill material shall meet 604.8.

604.2.4.2-Gradation: Acceptance for gradation shall be on the basis of test results on consecutive random samples from a lot. A lot shall be considered the quantity of material represented by an average test value, not to exceed five sublots. Generally at the beginning of the project, the average shall be started on the second sample in accordance with MP 300.00.51. A subplot is the quantity of material represented by a single gradation test. In the case where only one sample is taken, this subplot shall be considered the lot. When the average, or when the most recent three consecutive individual test values fall outside the limits specified in Table 704.6.2A, the lot of material represented will be considered nonconforming to the extent that the last of its sublots is nonconforming. When this occurs,

the last subplot shall have its price adjusted in accordance with Table 604.13.1. In the case where the average is nonconforming and the last subplot contained is conforming, then there would be no price adjustment. In no event, however, shall a subplot of material have its price adjusted more than once, and the first adjustment, which is determined, shall apply.

604.2.4.3-Degree of Nonconformance: When a subplot of material is to have its price adjusted, the percentage point difference between the nonconforming test value and the specification limit shall be determined for each sieve size determined to be nonconforming, and this value shall be multiplied by its appropriate multiplication factor as set forth in Table 604.2.4.3

TABLE 604.2.4.3

Nonconforming Sieve Size	Multiplication Factor
1 ½ in. (37.5 mm)	1.0
¾ in. (19 mm)	1.0
No. 4 (4.75 mm)	1.0
No. 40 (425 µm)	1.0
No. 200 (75µm)	2.0

The total measure of nonconformance of an individual subplot is the sum of all nonconformance of an individual sieve sizes of that subplot.

When the total degree of nonconformance has been established and it is 12.0 or less, the material will be for at an adjusted contract price as specified in Table 604.13.1.

When the degree of nonconformance is greater than 12.0, the nonconforming subplot shall be resolved on an individual basis, requiring a special investigation by the Engineer to determine the appropriate course of action to be followed.

CONSTRUCTION METHODS

604.3-GENERAL:

Subject to the provisions prescribed, the flow line of a conduit may be altered from that shown on the plans. If a firm conduit foundation is not encountered at the specified elevation, the unsatisfactory material shall be replaced with suitable material to a depth directed by the Engineer.

Galvanized steel pipe or bands shall not come in contact with aluminized steel pipe or bands.

The diameter of conduit, as used in this Section, is the largest dimension, horizontal or vertical.

604.4-TRENCH EXCAVATION:

604.4.1-Conduits 18 Inches (450 mm) Through 54 Inches (1400 mm): In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a minimum distance of six diameters on each side of the conduit and to a height of 2 feet (600 mm) over the top of the conduit or to the surface of the completed embankment if less than 2 feet (600 mm) above the top of the conduit. The width of the trench, in either cut or fill sections, shall not be less than the outside diameter of the conduit or encasement plus 18 inches (450 mm) on each side of the conduit measured to the face of the trench or to the sheeting when used.

604.4.2-Conduits 60 Inches (1500 mm) Through 108 Inches (2700 mm): In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the conduit and to a minimum height of 25 percent of the vertical dimension of the conduit. The width of the trench shall not be less than the outside horizontal diameter of the conduit plus one diameter on each side of the conduit. When using a Controlled low strength material the width of the trench shall not be less than the outside horizontal diameter of the conduit plus one half diameter on each side of the conduit.

In rock or shale cut section, the width of the trench shall not be greater than required to obtain the backfill compaction specified. Soil cut trenches shall be treated as complete or partial fill sections. For rigid pipe, the width of the trench shall not be less than the outside horizontal diameter of the conduit plus 24 inches (600 mm) on each side of the conduit.

604.4.3-Conduit Greater Than 108 Inches (2700 mm): In complete or partial fill sections, before trenching is begun, the fill shall be constructed for a distance of six diameters on each side of the conduit and to a minimum height of 25 percent of the vertical dimension of the conduit.

Installation of the conduit shall be as detailed in the plans, including the type and amount of backfill and bedding.

For flexible conduit, the Contractor shall submit shop drawings detailing all erection procedures including anticipated movements during backfilling operations. Backfill operations shall also be detailed to show lift thicknesses, sequence of lifts and shape of the conduit during these operations.

The Contractor shall submit a plan of field control for the installation insuring the conduit is erected in accordance with the shop and erection drawings.

604.4.4-Structural Plate Arches: Excavation for the foundations of structural plate arches shall be as for box culverts and structures and in accordance with 212.3.

604.5-BEDDING:

604.5.1-General: The conduit bedding shall conform to one of the classes described below as specified. When no bedding class is specified, the requirements for Class B bedding shall apply.

When a firm foundation is not found at grade due to the presence of foreign material or trash, or due to the presence of moisture eight percent in excess of optimum, the unsatisfactory material shall be removed for the width of the conduit plus 18 inches (450 mm) on each side and replaced with granular material.

604.5.2-Class A Bedding: Class A bedding shall consist of a continuous concrete cradle conforming to the plan details.

604.5.3-Class B Bedding: Class B bedding shall consist of bedding the conduit in an earth foundation of uniform density, carefully shaped by means of a template to fit the lower conduit exterior for at least 15 percent of the overall height of the conduit. Exception is made in the case of structural plate pipe where the length of the bedding arc need not exceed the width of the bottom plate. However, if the structural plate pipe is first assembled and then placed in the trench, the 15 percent embedment specified above shall apply. Recesses shall be made in the

trench bottom to accommodate the bell when bell and spigot type conduit is used. Fine aggregate shall be used to level the foundation. When rock is encountered, it shall be removed and replaced with specified material having a thickness under the conduit of 2 inches per foot (40 mm per m) height of fill over the top of the conduit, with a minimum thickness of 12 inches (300 mm) and a maximum thickness of 24 inches (600 mm).

604.5.4-Class C Bedding: Class C bedding shall be in accordance with the details shown on the Plans. Recesses shall be made in the trench bottom to accommodate the bell when bell and spigot type conduit is used.

604.6-LAYING AND JOINING:

604.6.1-Rigid and Flexible Conduits: The conduit placing, unless the Contractor is otherwise directed, shall begin at the downstream end of the conduit. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid conduits and outside circumferential laps of corrugated steel pipe and corrugated aluminum alloy pipe conduits shall be placed facing upstream.

Paved or partially lined conduit shall be laid so that the longitudinal centerline of the paved segment coincides with the flow line.

Rigid conduits may be of either bell and spigot or tongue and groove design, unless one type is specified. The method of joining conduit sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints for rigid conduits shall be made with (1) Portland cement mortar or grout, (2) flexible watertight gaskets, (3) bituminous plastic cement, (4) oakum and mortar, (5) oakum and joint compound, (6) vitrified clay pipe joints, (7) hot pour mineral filler joint sealer, or by a combination of these types.

When mortar joints are used for tongue and groove and bell and spigot conduit, they shall be made by plastering up to the quarter point the joint mortar before the succeeding joint is placed. Thickness of mortar shall be sufficient to maintain proper invert grade. The accessible outer joint shall then be filled with an excess of mortar to form a bead around the outside of the conduit and finished smooth on the inside. For grouted joints, molds or runners shall be used to retain the poured grout. When Portland cement mixtures are used, the completed joints shall be protected against rapid drying by suitable covering material. Where oakum is used, the joint shall be caulked with oakum and then sealed with the joint compound. When rubber or plastic gaskets are used, they shall be installed to form a flexible watertight seal.

Flexible conduits shall be joined by couplings in accordance with manufacturer's recommendations, and the pipe shall be fastened to preserve the alignment and prevent the separation of sections.

Conduit shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be removed and re-laid or replaced.

604.6.2-Structural Plate Pipe and Pipe Arches: The bottom plates of structural plate pipe and pipe arches shall be assembled in a line, placing each section in the order recommended by the manufacturer. Side and top plates shall then be placed in the order recommended by the manufacturer. Bolts shall be placed in the location and number as recommended by the manufacturer. Plates shall lap each other the width of one corrugation, and bolts shall be inserted and nuts hand tightened as each plate is placed. Drift pins may be

used to facilitate matching holes. When all the plates are in position and all bolts placed, all bolts shall be gone over a second time to insure proper tightening. Steel bolts shall be torqued during installation to a minimum of 100 feet-lbs. (135 Newton meters), and a maximum of 300 feet-lbs. (400 Newton meters) Aluminum bolts shall be torqued during installation to a minimum of 100 feet-lbs. (135 Newton meters), and a maximum of 150 feet-lbs. (200 Newton meters). For power driven tools, the hold-on period may vary from 2 to 5 seconds. Bolts shall be of sufficient length to provide for a full nut. When the structure is bituminous coated, all bolts and nuts shall be coated inside and outside of the structure, after completion of bolt tightening, with bituminous material conforming to the requirements of 713.3.

604.6.3-Structural Plate Arches: Plate arches shall be set on footings as shown on the Plans. Beginning at the upstream end, the first side plates shall be set on the base angles. Then the remaining side plates and the top plates of the arch shall be bolted into place using only enough bolts to hold them without tightening securely. Drift pins may be used to assist in matching bolt holes. Temporary props may be used to hold plates in place until connections are made. After the plates comprising the first arch have been assembled, the next set shall be placed in the same manner, finishing each set of side plates with a top plate before placing in the same manner, finishing each set of side plates with a top plate before placing the next set of side plates. New plates shall be lapped one corrugation on the outside of the preceding plates. When all the plates are in position, the remaining bolts shall be inserted and all nuts firmly tightened. Steel bolts shall be torqued during installation to a minimum of 100 feet-lbs. (135 Newton meters), and a maximum of 300 feet-lbs. (400 Newton meters), Aluminum bolts shall be torqued during installation to a minimum of 100 feet-lbs., (135 Newton meters), and a maximum of 150 feet-lbs. (200 Newton meters). For power driven tools, the hold-on period may vary from 2 to 5 seconds. Bolts shall be of sufficient length to provide for a full nut. When the structure is bituminous coated, all bolts and nuts shall be coated inside and outside of the structure, after completion of bolt tightening, with bituminous material conforming to the requirements of 713.3.

604.7-ELONGATION:

When specified on the plans, factory elongation of flexible pipe shall be not less than four percent and not more than six percent vertically. Elongation shall be maintained during shipping, storing and handling.

604.8-BACKFILLING:

Backfill material shall be suitable random material free from particles larger than 3 inches (75 mm), crushed aggregate backfill, or controlled low strength material. After the conduit is installed, random material and crushed aggregate backfill shall be placed along the conduit in layers not to exceed 4 inches (100 mm) compacted. Controlled low strength material shall be placed according to Section 219. Any of the types of controlled low strength material may be used. For flexible conduit 60 inches (1 500 mm) through 108 inches (2 700 mm), the backfill material shall be crushed aggregate backfill or controlled low strength material. Unless otherwise specified in the plans, the controlled low strength material can be used as a substitute for random material or crushed aggregate backfill at the contractor's option.

The quality control testing and acceptance of controlled low strength material shall be according to 219.

The quality control testing and acceptance for compaction of the random backfill material shall be in accordance with applicable sections of 207 and 716 and crushed aggregate backfill according to 717, with the following exception:

Testing will be conducted on both sides of the conduit and testing within a lot may include tests on both sides of the conduit. For conduit installations in an embankment where existing tests are on file for the adjacent embankment material, the target percentage of dry density for the conduit backfill will be equal to the average of the X values for the tests in the adjacent lots of embankment material or a minimum value of 95, whichever is greater. For embankments where no tests are on file, the target percentage of dry density will be 95. A lot shall have five (5) density tests performed for quality control.

For conduits less than 60 inches (1500 mm) in diameter, a lot will normally consist of the quantity of backfill required for each 75 linear feet (23 m) of conduit installed.

For conduits 60 inches (1500 mm) in diameter and larger, a lot will normally consist of not more than 5 lifts of backfill. For conduit with lifts of backfill placed for the full length of the conduit, a subplot will normally consist of a lift of backfill placed on both sides for the full length of the conduit. For conduits that are backfilled in segments, a subplot will normally consist of a lift of backfill placed on both sides for the length of each segment of conduit backfilled.

Backfill placed outside embankments and roadbed is to be compacted to or better than the average total dry density for the existing soil. An average total dry density will be determined from representative density tests conducted for each existing soil. Quality control testing will normally consist of one test per 100 linear feet (30 m) of conduit installed and lot evaluations are not required. The moisture tolerance is not applicable.

The use of a bulldozer or other bladed equipment in placing backfill is expressly forbidden. Mechanical equipment with various type buckets may be used. Care shall be taken to compact the material under the haunches of the conduit, to place the backfill evenly on each side of the conduit to retain its vertical axis, and to avoid displacement. This method of backfilling and compacting shall be followed until the top of the trench is reached. In the case of conduit 60 inches (1500 mm) through 108 inches (2700 mm) in diameter, not in trench condition, this backfilling and compacting shall be carried to a height of 2 feet (600 mm) over the top of the conduit and to a width not less than the outside diameter of the conduit plus one diameter on each side. Above this elevation, the embankment shall be placed and compacted in the normal manner. All conduit, after being bedded and backfilled, shall be protected by a four foot (1200 mm) cover of fill, or more if necessary, before heavy equipment is permitted to cross during the construction of the roadway. The Contractor will be held responsible for any damage to the conduit resulting from movement of equipment over the structure.

604.9-FIELD PAVING:

When field paving is required for structural plate pipe and pipe arches, the following provisions shall govern:

The surface to be field paved shall be thoroughly cleaned and dried, and the priming material shall be sufficiently applied with a brush or a mop to coat the surface and to fill all seams or joints. After the priming material has been applied, a wire mesh, having not less than Size # W 1.4 wire and having openings not more than 4 inches (100 mm) by 6 inches (150 mm), shall be placed on top of the corrugations and securely fastened to the bolts with wire or suitable clips.

The reinforcing mesh shall have a width 1 foot (300 mm) less than the width of the finished paving and shall be fastened to the structure near each edge and at the center of the mesh at points

not more than 2 feet (600 mm) apart along the longitudinal barrel of the structure. The paving material shall consist of five parts of clean fine sand, three parts of cement or other fine filler such as limestone dust or lime, and approximately two parts of asphalt cement. The quantity of asphalt may be adjusted to provide a plastic workable mix. Before mixing, the mortar sand shall be dried by heating to approximately 300° F (150° C). After drying, the sand shall be mixed with the fine filler in a steel mortar box or other suitable equipment and heated to 300° F (150° C). The asphalt shall be heated in a separate container to a temperature of 400° F (200° C) and then thoroughly mixed with the sand and filler until a workable mix is obtained. All lumps shall be removed by mixing with a mortar hoe or other suitable implement. The mixture shall be kept hot and shall be applied to the primed surface before cooling. The mixture shall be applied in such a manner that smooth pavement will be formed in the invert, filling the corrugations for at least 25 percent of the circumference of a pipe or 38 percent of the circumference of a pipe arch. The paving thickness shall be sufficient to cover the crests of the corrugations a minimum of 1 inch (25 mm). The placing of the mastic shall be followed closely by the application of a seal coat and hot asphalt cement to be poured uniformly over the paving. The seal coat shall be applied while the paving material is still hot.

The Contractor may pave with Portland cement concrete or use shotcrete. If practicable, such paving shall be delayed until completion of the fill over the structure. Before the placing of the paving, the surface of the plates shall be cleaned to the plates or to the asphalt coating if asphalt coated plates are used. When paving with Portland cement concrete or shotcrete, mesh reinforcement, fastening of mesh, and paving dimensions shall be as specified for bituminous paving except that the minimum thickness over the crest of the corrugations shall be 1-½ inches (40 mm).

Concrete used shall have a design 28-day compressive strength of 3,000 psi (21 MPa) (equivalent to Class B in 601.3); concrete may be hand mixed and shall be handled and placed as directed by the Engineer. After initial set has taken place, the paving shall be flooded or kept moist by sprinkling for three days. Liquid membrane-forming compound, conforming to 707.9 may be used for curing at a minimum application rate of one gallon per 150 square feet (0.25 liters per m²) of concrete surface. Other methods of curing may be used if approved by the Engineer.

Field paving with shotcrete shall conform to the applicable provisions of 623. When paving with shotcrete, the exposed surface shall be brought to a uniform surface by screeding or troweling. After completion of the shotcrete paving, the rebound material shall be cleaned from the culvert above the paved surface. Shotcrete shall be cured by (a) covering with burlap mats and keeping them wet for at least seven days after placing, (b) flooding for a period of at least seven days or, (c) applying liquid membrane curing compound, conforming to 707.9, at a minimum rate of one gallon per 150 per foot (0.25 liters per m²) of shotcrete surface for each application. Shotcrete cured by membrane forming compound shall receive two applications; the second application shall be made after the first application has set. Other methods of curing may be used if approved by the Engineer.

After the completion of the fill over the pipe or pipe arch, any gaps which develop between the plates and the concrete or shotcrete paving shall be filled by pouring heated bituminous material complying with requirements of 713.3.

When field paving is specified for metal pipes and metal pipe arches, the methods and materials used shall be the same as specified except that the wire mesh shall be tied to the corrugated metal at points not exceeding 30 inches (750 mm) in any direction and not exceeding 9 inches (225 mm) from the edges of paving. Attachment may be by use of ½" diameter (12 mm)

(minimum) commercially-available galvanized or cadmium-plated lag screws twisted firmly into holes drilled in the valleys of the corrugations or by other approved means.

Prior to using Portland cement concrete or shotcrete for paving aluminum alloy culverts or culverts with coatings containing aluminum, the aluminum-concrete contact area shall be coated with commercially-available paint.

604.10-RELAID CONDUIT:

The construction requirements in this Section shall apply equally in the case of re-laid conduits. All conduits salvaged for relaying shall be cleaned of all foreign material prior to reinstallation.

604.11-JACKING CONDUIT:

Jacking or tunneling may be designated on the Plans or may be permitted if written approval is obtained. Conduit to be jacked may be either reinforced concrete or corrugated steel, as called for in the Plans. The strength of conduit designated in the Contract will be designated as required for vertical load only. Additional reinforcement or strength of conduit required to withstand jacking pressure shall be determined and furnished by the Contractor without additional cost to the Division. Variation from theoretical alignment and grade at the time of completion of jacking placement shall not exceed 0.2 feet for each 20 feet (10 mm per m) of conduit so placed. Corrugated steel pipe section to be jacked shall be prepared for making field joints either by riveting or bolting. Concrete pipe to be jacked shall be tongue and groove type.

An approach trench shall be constructed on the side from which jacking operations shall take place. The end of the approach trench away from the jacking face shall be cut perpendicular to the axis of the jacking operation to provide bearing surface for the back stop and the jack blocking. The length of the approach trench shall be such that the distance between the jack blocking and the face of the bore shall be equal to 5 feet (1500 mm) plus the length of the individual pipe sections in the case of corrugated steel pipe. When concrete pipe is jacked, the maximum length of the approach trench shall be equal to two lengths of pipe plus a minimum of 7 feet (2.1 m) for jack and blocking. The jacking face shall be a minimum of 3 feet (1 m) above the top of the pipe; the face shall be cut vertically and shall be shored to prevent raveling and slipping. A sump shall be constructed in one corner of the trench to provide drainage. In the case of corrugated steel pipe, a transverse trench shall be constructed at the jacking face to provide clearance for the riveting and bolting of joints. The back stop shall be constructed of heavy timbers or steel rails capable of withstanding the jacking force.

In the event the site of jacking operations is such that an approach trench cannot be constructed, the jack blocking shall be constructed to carry the reaction of the jack to the ground. This may be accomplished by means of timber, steel, or concrete vertical back stops set into the ground with the tops supported by diagonal members bearing against an embedded anchorage.

Directly opposite the approach trench, an exit trench shall be constructed to line and grade. The exit trench shall be constructed in the same manner as the approach trench except that no back wall is necessary.

Jacks shall be of sufficient capacity to overcome soil resistance to the jacking operation and shall be operated in pairs. As a guide, capacity of jacks for corrugated steel pipe shall be a minimum of 35 tons (32 Mg) each and for concrete pipe a minimum of 50 tons (45 Mg) each. For large pipe, more than one pair of jacks may be required. Small track jacks may be used to start the pipe.

Pipe guides shall be constructed in the approach trench and may be either timber or steel rail or concrete guides on a cradle. Since the pipe guides will support the pipe as it enters the jacking face, the pipe guides shall be accurately set to line and grade, and excavation for the guides shall be made to grade to avoid occurrence of settlement. Guides shall be spaced at $\frac{1}{2}$ the pipe diameter inside face to inside face of the guides for corrugated steel pipe and at $\frac{4}{10}$ the outside diameter for concrete pipe.

Reaction of the jack to the pipe shall be transmitted by either a jacking frame or jacking beams constructed of timber or steel. Jacking frames and beams shall be so placed as to exert equal pressure on each side of the pipe. For pipes 36 inches (900 mm) in diameter or smaller, a steel jacking ring may be used in lieu of the jacking frame.

The pressure from the jacking frame or beams may be transmitted to a jacking collar or head on the pipe itself. In the case of corrugated steel pipe, a jacking band reinforcing the end of the pipe receiving the thrust shall be used. Jacking collars or heads for concrete pipe shall be constructed to prevent damage to the pipe ends. Jacking collars and jacking frames shall be constructed to allow passage of men and material.

Joints of concrete pipe shall be cushioned and protected from infiltration of fine materials occurring during the jacking operation by insertion of a cushioning material into each pipe joint. After the pipe is in position, the joints shall be pointed from the inside with mortar joint compound.

Steel cutting edges on the lead section of pipe may be used, and the use of a jacking shield is permitted.

To prevent the pipe from "freezing" and becoming incapable of movement, jacking operations should, if possible, be carried out on a 24-hour basis. A minimum of two 8-hour shifts shall be worked. Alignment and grade of the pipe guides shall be checked at least once each shift. To aid in the prevention of "freezing," the pipe may be lubricated in a manner and with a material meeting the approval of the Engineer.

Excavation for the bore shall be to grade at the bottom and approximately 1 inch (25 mm) greater than the diameter of the pipe at the top and sides. Initial jacking of concrete pipe shall begin with two sections of pipe in the trench. As excavation proceeds, the jacking shall proceed until the effective limit of the jacking is reached, at which time additional blocking shall be added. This process shall be continued until there is room for an additional pipe section. For long runs of pipe, the use of intermediate jacking stations will be allowed as approved by the Engineer.

Pipe cover shall be a minimum of one diameter or 3 feet (900 mm) from top of pipe to bottom of the subgrade of ballast when jacking under a bituminous concrete highway. When jacking under reinforced concrete pavement, the cover may be reduced to the depth of the base course plus the pavement thickness with a minimum cover of the pavement thickness plus 6 inches (150 mm).

After the pipe has been jacked into place, the backfill shall be tightly compacted around both ends of the culvert to prevent erosion. Any departure from the above specifications necessitated due to site conditions shall be approved in writing by the Engineer.

Areas resulting from caving or excavation outside the above limits shall be backfilled with sand or grout by a method which will fill the voids. Joints shall be completed as specified for the type of conduit being installed.

604.12-METHOD OF MEASUREMENT:

Conduit of the different types and sizes, both new and re-laid, will be measured by the linear foot (m) in place, the measurement being made along the centerline of each pipe installed.

Branch connections, tees, wyes, and elbows will be measured along their centerlines and these lengths included in the total lengths of the appropriate conduit. Wyes, tees, and other branch connections will be measured along the centerlines to points of intersection. Conduit with sloped or skewed ends will be measured along the invert. The portion of pipe extending through to the inside face of headwalls of all types, manholes, inlets, boxes, or other structures shall be included in the measurement.

End sections will be measured by the number of units installed.

Conduit designated on the Plans to be installed by the jacking method will be measured separately by the linear foot (m) in place and shall be the actual portion jacked, completed in place, and accepted.

604.13-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed in 604.14, which prices and payments shall be full compensation for excavation and bedding, except as otherwise provided, backfilling, jacking when called for, furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work. The unit price bid for end sections shall include excavation and backfill.

When, by the authority of the Engineer, the flow line of a conduit is lowered from that shown on Plans, or due to a lack of a firm foundation, or due to a solid rock foundation, unsatisfactory material is removed and replaced with suitable material, the work of excavation, replacement, and compaction of material will be paid for in accordance with 109.4.

1. For conduits less than 48-inches (1200 mm) diameter, the work of excavation, measured in excess of 1 foot (300 mm) below the original planned conduit elevation, will be paid for under the provisions of 109.4. When suitable material is not available from the project excavation, payment for replacement material below final grade line will be made in accordance with 109.4.
2. For conduits 48-inches (1200 mm) diameter or larger, all additional excavation below the original planned conduit elevation and for a width not in excess of the outside conduit diameter plus 18 inches (450 mm) on each side of the conduit, will be paid for at the unit bid price for Item 207001-* "Unclassified Excavation". When no Item 207001-* is included in the Proposal, payment for excavation, backfill compaction and replacement material will be made in accordance with 109.4. When suitable material is not available from the project excavation, replacement material will be paid for in accordance with 109.4.

604.13.1-Price Adjustment: Crushed aggregate backfill not conforming with the gradation requirements as described in 604.2.4.2 will be paid for at the adjusted contract price base on the degree of nonconformance as specified in Table 604.13.1.

A revised unit price for calculation purposes in 307.9.1 will be established based on the unit bid cost minus the cost of the pipe.

TABLE 604.13.1

Adjustment of Contract Price for Gradation not Within Specifications	
Degree of Nonconformance	Percent of Contract Price to be Reduced
1.0 to 3.0	2
3.1 to 5.0	4
5.1 to 8.0	7
8.1 to 12.0	11
Greater than 12	*

* The Division will make a special evaluation of the material and determine the appropriate action.

604.14-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
604001-*	“size” Metallic Coated Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604002-*	“size” Full Bituminous Coated Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604003-*	“size” Half Bituminous Coated And Paved Invert Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604004-*	“size” Full Bituminous Coated And Paved Invert Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604005-*	“size” Full Bituminous Coated And Full Paved Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604006-*	“size” Fiber Bonded Full Bituminous Coated Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604007-*	“size” Half Bituminous Coated Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604008-*	“size” Fiber Bonded Full Bituminous Coated And Full Paved Corrugated Steel Sewer Pipe, YZ	Linear Foot (Meter)
604010-*	“size” Metallic Coated Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604011-*	“size” Full Bituminous Coated Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604012-*	“size” Half Bituminous Coated And Paved Invert Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604013-*	“size” Full Bituminous Coated And Paved Invert Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604014-*	“size” Fiber Bonded Full Bituminous Coated Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604015-*	“size” Fiber Bonded Full Bituminous Coated And Paved Invert Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604017-*	“size” Structural Plate Pipe, YZ	Linear Foot (Meter)
604018-*	“size” Full Bituminous Coated Structural Plate Pipe, YZ	Linear Foot (Meter)
604019-*	“size” Full Bituminous Coated And Field Paved Structural Plate Pipe, YZ	Linear Foot (Meter)
604020-*	“size” Structural Plate Pipe Arch, YZ	Linear Foot (Meter)
604024-*	“size” Full Bituminous Coated Structural Plate Arch, YZ	Linear Foot (Meter)
604025-*	“size” Corrugated Aluminum Alloy Pipe, YZ	Linear Foot (Meter)
604026-*	“size” Corrugated Aluminum Alloy Pipe, Field Paved, YZ	Linear Foot (Meter)

ITEM	DESCRIPTION	UNIT
604027-*	“size” Half Bituminous Coated And Paved Invert Corrugated Aluminum Alloy Pipe, YZ	Linear Foot (Meter)
604028-*	“size” Corrugated Aluminum Alloy Pipe End Section,	Each
604029-*	“size” Corrugated Aluminum Alloy Pipe Arch, YZ	Linear Foot (Meter)
604032-*	“size” Corrugated Aluminum Alloy Pipe Arch End Section	Each
604033-*	“size” Aluminum Alloy Structural Plate Pipe, YZ	Linear Foot (Meter)
604034-*	“size” Aluminum Alloy Structural Plate Pipe Arch, YZ	Linear Foot (Meter)
604036-*	“size” Nonreinforced Concrete Sewer Pipe , Class **	Linear Foot (Meter)
604037-*	“size” Reinforced Concrete Pipe, Class **	Linear Foot (Meter)
604038-*	“size” Reinforced Concrete Pipe End Section	Each
604039-*	“size” Reinforced Concrete Pipe Arch, Class **	Linear Foot (Meter)
604040-*	“size” Reinforced Concrete Pipe Arch End Section	Each
604041-*	“size” Reinforced Concrete Elliptical Pipe, Y	Linear Foot (Meter)
604043-*	“size” Clay Lined Reinforced Concrete Pipe, Class **	Linear Foot (Meter)
604045-*	“size” Clay Pipe, Extra Strength	Linear Foot (Meter)
604050-*	“size” Corrugated Polyethylene Pipe,	Linear Foot (Meter)
604052-*	“size” Polyvinylchloride Pipe	Linear Foot (Meter)
604053-*	“size” Relaid Conduit	Linear Foot (Meter)
604054-*	“size” Jacked Conduit, Reinforced Concrete Pipe, Class **	Linear Foot (Meter)
604057-*	“size” Precoated Galvanized Steel Pipe	Linear Foot (Meter)
604062-*	“size” Metallic Coated Corrugated Steel Pipe, Field Paved, YZ	Linear Foot (Meter)
604065-*	“size” Structural Plate Pipe Arch, Field Paved, YZ	Linear Foot (Meter)
604070-*	“size” Precast Concrete Box Culvert	Linear Foot (Meter)
604071-*	“size” Reinforced Concrete Pipe Safety Slope End Section	Each
604073-*	“size” Elliptical Reinforced Concrete Pipe Safety Slope End Section, Y	Each
604074-*	“size” Aluminum Box Culvert, YZ	Linear Foot (Meter)
604075-*	“size” Field Paved Aluminum Box Culvert, YZ	Linear Foot (Meter)
604076-*	“size” Aluminum Coated Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604077-*	“size” Aluminum Coated Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604078-*	“size” Half Bituminous Coated Corrugated Steel Pipe, YZ	Linear Foot (Meter)
604079-*	“size” Half Bituminous Coated Corrugated Steel Pipe Arch, YZ	Linear Foot (Meter)
604080-*	"size" Aluminum Coated Corrugated Steel Pipe Half Bituminous Coated And Paved Invert	Linear Foot (Meter)
604081-*	“size” Steel Box Culvert	Linear Foot (Meter)
604090-*	“size” Corrugated Steel Pipe End Section, YZ	Each
604091-*	“size” Corrugated Metal Pipe Arch End Section	Each
604092-*	“size” Corrugated Steel Pipe Safety Slope End Section	Each

* Sequence number

** Class designated by Roman numerals

Y = a letter, if present, designating base metal thickness or type of elliptical concrete pipe in accordance with the following table.

Z = a one digit number designating metal pipe corrugations or Roman numerals designating concrete pipe class or a one digit number designating elliptical concrete pipe class in accordance with the following table.

For Aluminum Box Culverts, haunch and crown plate thicknesses as specified on the Plans

Y	Mil Thickness	
	Steel	Aluminum
A	64 (1.63)	60 (1.52 mm)
B	79 (2.0)	75 (1.90 mm)
C	109 (2.77)	105 (2.67 mm)
D	138 (3.51)	135 (3.43 mm)
E	168 (4.27)	164
F	188 (4.78)	---
G	218 (5.54)	---
H	249 (6.32)	---
J	4 BOLTS/FT (13 BOLTS/M) 280 (7.11)	--
K	6 BOLTS/FT (19 BOLTS/M) 280 (7.11)	100 (2.54 mm)
L	8 BOLTS/FT (26 BOLTS/M) 280 (7.11)	125 (3.18 mm)
M	313 (7.95)	150 (3.81 mm)
N	375 (9.52)	185 (4.41 mm)
P	---	200 (5.08 mm)
Q	---	225 (5.72 mm)
R	---	250 (6.35 mm)

Z	Metal Corrugations	Pipe Class
1	1½" x ¼" (37.5 x 6.25 mm)	---
2	2/3" x ½" (66.8 x 12.5 mm)	---
3	3" x 1" (75 x 25 mm)	---
5	5" x 1" (125 x 25 mm)	---
6	6" x 2" (150 x 50 mm)	---
7	7½" x ¾" x ¾" (190 x 19x 19)	---
I or 1	---	I
II or 2	---	II
III or 3	---	III
IV or 4	---	IV
V or 5	---	V
Y	Concrete Pipe	
H	Horizontal Elliptical	
V	Vertical Elliptical	

SECTION 605

MANHOLES AND INLETS

605.1-DESCRIPTION:

This work shall consist of the construction of new and adjustment of existing manholes and inlets in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions and locations shown on the Plans or established by the Engineer. Types of manholes and inlets shall be as shown on the Plans.

605.2-MATERIALS:

Cast-In-Place concrete and reinforcing steel for manholes and inlets shall meet the requirements of 601 (Class B) and 602 respectively. Precast concrete manholes shall conform to 715.19. Portland cement concrete for precast inlets shall meet the requirements in 715.19. Other requirements and details for precast inlets shall be as specified on the Plans.

Other materials shall meet the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Aggregate for Slot Inlets (Aggregate For Fabric Underdrain)	606.2
Clay or Shale Brick	715.16
Concrete Brick	715.17
Concrete Masonry Blocks	715.18
Fabric for Slot Inlets	715.11
Gray Iron Castings	709.10
Joint Mortar	708.8
Manhole Steps	709.10, 715.19, 715.38
Pipe for Slot Inlets	713.2

Lean grout backfill, where specified on the Plans, shall consist of 3 bags of cement per cubic yard (167 kg of cement per m³) of material suitable to the Engineer.

Component materials shall be sampled, tested, and approved prior to the start of manufacture. Manholes and inlets shall be inspected at the manufacturing plant, if acceptable they shall be identified in accordance with MP 700.00.01.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

Covers and frames for manholes and grates, frames, and grate support bars for inlets shall be gray iron castings except for Type G Inlets which require structural steel meeting 709.12.

605.3-CONSTRUCTION METHODS:

Concrete construction shall conform to the requirements for 601. Masonry shall conform to the requirements for the respective type. Exposed masonry surfaces shall be cured with wet burlap for a period of not less than 48 hours. Concrete surfaces shall be cured in accordance with 601.12.

Metal frames for inlets shall be set in a full mortar bed or cast into the concrete. Pipe sections shall be flush on the inside of the structure wall and project outside sufficiently for proper connection with the next pipe section. Masonry shall fit neatly and tightly around the pipe. The flowline of the outlet pipe shall match the bottom elevation of the inlet or manhole. When the bell or groove of concrete pipe is placed in an inlet, the inside of the bell or groove shall be filled with concrete up to the flowline.

Bearing areas of frames, covers, and grates shall be so fitted and finished as to provide a firm, even seat for the entire cover or grate in the frame. No projections shall exist on the bearing areas of the castings; and the cover or grate shall seat in the frame without rocking.

Concrete inlets and manholes may be precast when shapes and dimensions conform to those shown on the Plans and when final installed top surfaces are flush with adjacent finish surfaces such as pavement, gutters, curbs, and sidewalks. Precast units shall include lifting hooks which will be out of sight after placement of the units and sufficient reinforcement to resist handling stresses.

Excavation and backfill shall be done in accordance with 212.

Weep holes shall be installed in the sidewalls of inlets during construction. These weep holes shall be constructed of non-rusting material, approximately 4 inches (100 mm) in diameter, located at or below subgrade elevation as directed or approved by the Engineer to properly drain subsurface material. Loose rock shall be placed around the outside of the structure at the openings or similar protective measures taken to prevent excessive backfill material from passing through the weep holes. The cost of weep hole installations shall be included in the unit price bid for the inlets. No deduction in concrete quantities shall be made for weep holes in the inlets.

When grade adjustment of existing structures is specified, the work shall be accomplished by one of the following methods:

- i. Carefully remove the existing frame; reconstruct the walls as necessary; clean and reset the existing frame in a full mortar bed at the required elevation.
- ii. Carefully remove the existing cover or grate and furnish and install an approved adjusting ring or casting.

Upon completion, each structure shall be cleaned of any accumulations of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

605.4-METHOD OF MEASUREMENT:

Manholes and inlets, new or adjusted will be measured by the unit; slot inlets will be measured by the linear foot (m) in place.

605.5-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for as provided below, which prices and payments shall be full compensation for furnishing the excavation, backfill, concrete, aggregate, reinforcing steel, fabric, grates, covers, frames, hardware, and other materials shown on the Plans and for doing all the work, including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

When changes in Plans during construction require increases of depth in excess of 1 foot (300 mm), the equitable price adjustment will be equal to the bid amount increased by a factor of the constructed depth less 1 foot (300 mm) divided by the Plan depth.

When grade and drain contracts are bid separately from paving contracts, the structure may be designated to be partially built by the grade and drain Contractor and later completed by the paving Contractor.

605.6-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
605001-*	Type A Manhole	Each
605002-*	Type B Manhole	Each
605003-*	Type A Inlet	Each
605004-*	Type B Inlet	Each
605005-*	Type C Inlet	Each
605006-*	Type D Inlet	Each
605007-*	Type E Inlet	Each
605008-*	Type F Inlet	Each
605009-*	Type G Inlet	Each
605010-*	Type H Inlet	Each
605011-*	Type J Inlet	Each
605012-*	Adjusting Inlet Type, "type"	Each
605013-*	Adjusting Junction Box	Each
605015-*	Adjusting Manhole Type, "type"	Each
605039-*	Junction Box	Each
605040-*	"size" Perforated Slot Inlet Riser	Each
605041-*	"size" Slot Inlet Riser	Linear Foot (Meter)
605050-*	Adjust Concrete Headwall	Each
605051-*	Type U Inlet	Each

* Sequence number

SECTION 606 UNDERDRAINS

606.1-DESCRIPTION:

This work shall consist of constructing underdrains and free draining base trenches using pipe and granular material, blind drains, aggregate filled engineering fabric, prefabricated pavement edge drain and underdrain pipe outlets in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions and locations shown on the Plans or established by the Engineer.

When Item 606025-*, Underdrain Pipe, is included as a pay item in the Contract, any of the following pipe types may be furnished for construction of the underdrain: bituminous coated corrugated steel underdrain pipe, corrugated aluminum alloy underdrain pipe, nonreinforced perforated concrete underdrain pipe, porous concrete pipe, standard strength perforated clay pipe, extra strength perforated clay pipe, perforated bituminous fiber underdrain pipe, corrugated stainless steel underdrain pipe, precoated, galvanized steel pipe for underdrains, corrugated polyethylene underdrainage pipe or perforated plastic semicircular pipe.

606.1.1-Free Draining Base Trench: This work shall consist of constructing free draining base trenches and Outlet Pipes in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions, and locations shown on the plans or established by the Engineer.

606.2-MATERIALS:

Material shall meet the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION	TYPE OR GRADATION
Bituminous Coated Corrugated Aluminum Alloy Pipe for Underdrains***	713.17	Type I, II, III or IV
Bituminous Coated Corrugated Steel Pipe for Underdrains*	713.12	Class I, II or III
Bituminous Fiber Pipe**:		
Non-Perforated	714.14	
Perforated	714.15	
Concrete for Miscellaneous Uses	715.12	
Corrugated Aluminum Alloy Pipe for Underdrains***	713.16	Type I, II, III or IV
Corrugated Polyethylene Underdrain	714.19	
Corrugated Stainless Steel Pipe for Underdrains	713.7	
Cradle Invert Clay Pipe	714.10	
Crushed Aggregate for Free Draining Base Trench*****	703.1, 703.2, 703.3, 703.4	AASHTO 57, 67, 357, or 467
Crushed gravel for Aggregate Filled Fabric Underdrains*****	703.2 & 703.4 or 703.2.3	AASHTO #2 thru #57 or Pea Gravel

MATERIAL	SUBSECTION	TYPE OR GRADATION
Crushed gravel for Underdrains*****	703.2 & 703.4	AASHTO Size # 57, 67, 7 or 78
Crushed Stone for Aggregate Filled Fabric Underdrains*****	703.1 & 703.4	AASHTO #2 thru #57 inclusive
Crushed Stone for Underdrains*****	703.1 & 703.4	AASHTO Size # 57, 67, 7 or 78
Engineering Fabric	715.11.8	
Extra Quality Clay Drain Tile	714.8	
Extra Quality Concrete Drain Tile	714.7	
Extra Strength Perforated Clay Pipe	714.10	
Heavy Duty Clay Drain Tile	714.8	
Metallic Coated Corrugated Steel Pipe for underdrains	713.11	Class I, II or III
Miscellaneous Concrete	715.12	
Non-Reinforced Perforated Concrete Pipe for Underdrain	714.5	Class 1, 2 or 3
Perforated Plastic Semicircular Pipe	714.20	
Porous Concrete Pipe	714.6	Class I or II
Precoated Metallic Coated Steel Pipe for Underdrains*	713.23	Class I or II, Type B Coating
Prefabricated Pavement Edge Drain	715.10.1	
Silica Sand for Underdrains	702.1.2, 702.1.3 & 702.6	
Special Quality Concrete Drain Tile	714.7	
Standard Clay Drain Tile	714.8	
Standard Quality Concrete Drain Tile	714.7	
Standard Strength Perforated Clay Pipe	714.10	

- * Unless otherwise specified, Class IV, semicircular pipe 4 5/8 inches (117 mm) in diameter, may be furnished when 6 inch (150 mm) diameter pipe is called for on the Plans.
- ** Unless otherwise specified. Perforated pipe shall be used.
- *** Unless otherwise specified. Type V, semicircular pipe 4-5/8 inch (117mm) in diameter, may be furnished when 6 inch diameter pipe is called for on the Plans.
- **** Plastic semicircular pipe may be furnished only when six inch (150 mm) diameter is called for on the Plans.
- ***** Only one size may be used at any one installation.

When the locations of manufacturing plants allow, the plants may be inspected periodically for compliance with specified manufacturing methods, and material samples may be obtained for laboratory testing for compliance with material quality requirements. This may be the basis for acceptance of manufacturing lots as to quality. All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

606.2.1-Quality Control Testing: Quality control is the responsibility of the contractor as specified in 106.1. The contractor shall develop a quality control plan in accordance with applicable sections of MP 307.00.50 excluding the attachment page.

Samples will be obtained at a minimum frequency of one sample per day of aggregate placement. Aggregate for underdrain shall be evaluated for specification compliance in accordance with MP 606.03.50. Aggregate for aggregate filled underdrain shall be evaluated for specification compliance in accordance with MP 606.03.50 except Section 6.0 through 6.2 are excluded.

606.2.2-Acceptance Testing: Acceptance sampling and testing of aggregates used for underdrain is the responsibility of the Division, Except for furnishing the necessary materials. Quality control sampling and testing performed by the Contractor may be used by the Division for Acceptance.

606.2.3-Free Draining Base Trench Materials: The perforated pipe as detailed on the plans shall meet the requirements of this Section. The Outlet pipe as detailed on the plans shall meet the requirements of Subsection 715.10.1.5

606.3-CONSTRUCTION METHODS:

606.3.1-Pipe Installation:

606.3.1.1-Trenching: Trenches shall be excavated to a width of the outside diameter of the pipe plus 1 ft. (300 mm), to a depth of 4 inches (100 mm) below the flow line, and to the grade required by the Plans or as directed. Trench walls shall be as nearly vertical as practicable.

606.3.1.2-Bedding and Placing Pipe: A minimum 4 inch (100 mm) bedding layer of crushed gravel or crushed stone shall be placed in the bottom of the trench for its full width and length.

Subdrainage pipe of the type and size specified shall be embedded firmly in the bedding material. Upgrade ends of all underdrainage pipe installations shall be closed with suitable plugs to prevent entry of soil materials.

Perforated pipe shall normally be placed with the perforations down. Flexible pipe sections shall be joined with couplings or bands as recommended by the manufacturer. Non-perforated pipe and rigid pipe shall be firmly set and laid with the bell and groove ends upgrade and with open joints, wrapped with suitable material when specified, to permit entry of water.

606.3.1.3-Placing Filter Material: After the pipe installations have been inspected and approved, crushed stone or crushed gravel shall be placed to a height of 6 inches (150 mm)

above the top of pipe. The trench shall then be filled with silica sand to a minimum thickness of 12 inches (300 mm) over the top of the filter stone or crushed gravel. In the event damp trench sides indicate the necessity; the Engineer may direct an increase in the thickness of the silica and cover. When the underdrain is used to drain the base or subbase, course, the sand filter shall be carried vertically to the bottom of the base or subbase. Care shall be taken not to displace the pipe or the covering at open joints. When there is a heavy percolation of water into the trench at underdrain level, the Engineer may substitute sand for the crushed stone or crushed gravel bedding, cover and filter.

606.3.1.4-Backfill: Above the sand filter, when underdrains are not used to drain the base or subbase, the trench shall be filled with suitable random material, as shown on the Plans or as directed by the Engineer, in layers not exceeding 4 inches (100 mm) after compaction. The use of bulldozers or other blade equipment in backfilling is expressly prohibited.

The quality control testing and acceptance of suitable soil, soft shale or granular material will be according to applicable sections of 207 and 716, with the following exceptions:

1. A lot normally consist of the quantity of backfill material required to backfill 100 linear ft. (30 m) of the installation, or as directed by the Engineer.
2. For underdrain installations in an embankment, where existing tests are on file for the adjacent embankment material, the target percentage of dry density for the suitable random backfill will be equal to the X value of the tests in the adjacent lot of embankment material or a minimum value of 95, whichever is greater. For embankments where no tests are on file, the target percentage of dry density will be 95.

606.3.1.5-Underdrain Outlets: Trenches for underdrain outlets shall be excavated as for underdrains, except that the depth of the trench shall be limited to the flow line. Pipe shall be laid in the trench with all ends firmly joined by the applicable methods and means. The use of perforated pipe may be omitted or, if used, it shall be laid with perforations up. No filter material shall be used. After inspection and approval of the pipe installation, the trench shall be backfilled with suitable material in layers and compacted as provided for underdrains.

606.3.2-Underdrain Structures:

606.3.2.1-Underdrain Junction Boxes: Underdrain junction boxes shall be constructed to the dimensions and elevations at locations as shown on the Plans or as directed.

606.3.2.2-Slope Walls for Underdrains: Slope walls for underdrains shall be constructed of concrete conforming to the requirements of 715.12 of the Specifications and shall be constructed to the dimensions and elevations at locations as shown on the Plans or as directed.

606.3.2.3-Spring Control: Underdrain spring boxes and underdrain for spring control shall be constructed to the dimensions and elevations at locations as shown on the Plans,

or as directed. Any remaining upper portion of the trench shall be filled and compacted as for underdrains.

606.3.3-Aggregate Filled Fabric Underdrain and Blind Drains: Trenches for aggregate filled fabric underdrains and blind drains shall be excavated to the width and depth shown on the plans. The trench shall be prepared to a relative smooth state, free of sharp protrusions, depressions, and debris.

When fabric is used, it shall be placed with the long dimension parallel to and centered with the alignment of the trench. It shall be placed in the trench in reasonable conformance with the shape of the trench and shall be smooth and free of tension, stress, folds, wrinkles or creases. The fabric shall be installed so that any splice joints have a minimum overlap of at least 2 feet (600 mm) in the direction of flow. The overlap of the closure at the top shall be approximately the width of the trench and shall be temporarily used to cover the excavated material on either side of the trench.

The aggregate shall be placed by any method which will result in the trench being completely filled to the line shown. The filling process shall not cause the permeability of fabric to be impeded.

The fabric, when used, shall be overlapped at the top of the aggregate. Any portion of the trench not filled with aggregate shall be backfilled in accordance with 606.3.4.

606.3.4-Prefabricated Pavement Edge Drain: Trenches for prefabricated pavement edge drain shall be excavated to the dimensions and grade shown on the Plans.

The edge drain shall be placed against the pavement side of the trench and held firmly in place while backfill is placed to a compacted height of not more than 6 inches (150 mm). For one-sided drains, the more open side shall be placed toward the pavement. After the first lift is compacted and any tears in the fabric have been satisfactorily repaired, the remainder of the backfill shall be placed and compacted in layers not exceeding 6 inches (150 mm) deep. All compaction shall be accomplished with a vibratory compaction system. The backfill shall be the material excavated from the trench. Unless otherwise approved by the Engineer, the excavation of the trench, the placement of the edge drain, and the placement of the first lift of backfill shall be accomplished in a single continuous operation.

Each segment of edge drain shall be joined to the adjacent segment prior to installation. Splices shall keep the adjoining edge drain in proper alignment and shall not separate during installation.

Four inch (100 mm) diameter non-perforated outlet pipes shall be installed to provide positive drainage at low points of sags, at the low ends of all runs and at intervals not exceeding 500 ft. (150 m) on continuous runs, except edge drains with two separate flow channels shall have a crossover coupling at approximately 250 ft (75 m). The manufacturers' recommended fitting shall be provided for attaching the edge drains to the outlet pipes. A standard underdrain concrete slopewall shall be used at each pipe outlet unless the pipe is connected to a drainage structure. Slopewalls shall be fitted with a galvanized rodent screen.

The outlet pipe trench shall be constructed in accordance with 606.3.1.4 and 606.3.1.5 using as backfill the material excavated from the trench.

606.3.5-Free Draining Base Trench Construction Methods:

606.3.5.1-Trench: The FDB trench shall be excavated to the width and depth as detailed on the plans. Trench walls shall be as nearly vertical as practicable.

606.3.5.2-Bedding and Placing Perforated Pipe: After excavating the trench, Engineering fabric shall be placed in the trench in reasonable conformance with the shape of the trench. The Engineering fabric shall be smooth and free of tension, stress, folds, wrinkles, or creases. The Engineering fabric shall be installed so that any splice joints have a minimum overlap of at least 1 foot (300 mm) any direction. Enough Engineering fabric will be placed in order to properly tie to the mainline placement of Engineering fabric (Item 207034 -*). A 2 inch (50 mm) bedding layer of crushed stone or crushed gravel aggregate shall be placed in the bottom of the trench for its full width and length. The pipe shall then be placed in the trench. The pipe sections shall be joined with couplings or bands as recommended by the manufacturer. After pipe installation, the remainder of the trench will be backfilled with crushed stone or crushed gravel aggregate. (refer to table in section 606.2 for material requirements of aggregate)

606.3.5.3-Outlet Pipe:

606.3.5.3.1-Connection to Perforated Pipe: At locations designated on the plans or as directed by the Engineer, rigid outlet pipe will be connected to the perforated pipe. A drop connection utilizing a tee or wye or other means as satisfactory to the Engineer will be used for this connection. This operation may be performed concurrently with the placement of the perforated pipe or separately.

606.3.5.3.2-Trenching: The outlet pipe trench shall be excavated to the depth of the flow line of the outlet pipe. Minimum slope of the outlet pipe is to be 3%. Width of the trench will be that width which will allow proper room for pipe placement and backfilling operations.

606.3.5.3.3-Placing and Backfilling Pipe: The outlet pipe shall be placed in the trench with all ends firmly joined by couplings or bands as recommended by the manufacturer. The outlet pipe shall be backfilled with random material in accordance with Subsection 606.3.1.4.

606.3.5.3.4-Pipe End Treatment: The outlet end of all outlet pipes not tied to drainage structures shall be equipped with a slopewall. Outlet pipes shall be tied to inlets or culverts by the use of pipe saddles, grouting Cementing, or other means satisfactory to the Engineer.

606.4-METHOD OF MEASUREMENT:

The quantity of work done will be measured by the linear foot (meter) for pipe, including outlet pipe, for each of the types and sizes as specified, complete in place and accepted. Length will be determined from actual measurements after the pipe is in place. Angles, tees, and wyes, and other branches which may be required will be measured from centerline of main pipe along the centerline of the branch to the end and the length included in the pipe length. Crushed stone, crushed gravel, or silica sand for bedding, filter, and spring control will be measured by the

volume; the volume will be the product of the specified trench width and depth, and the length in place, less the volume of the pipe computed on the basis of the outside diameter of the barrel or corrugations. Blind drains will be measured by the volume of granular material. The quantity of work done for "Aggregate Filled Fabric Underdrains" will be measured in linear feet (meters) of trench, complete in place and accepted. The quantity of work done for "Prefabricated Edge Drain" will be measured in linear feet (meters) of edge drain and outlet pipe, complete in place and accepted. Volume will be computed on the basis of the specified trench depth and width, and the length in place. Underdrain junction boxes will be measured by the unit. Slopewalls for underdrains will not be paid for separately, but shall be included in the cost of the underdrain pipe.

606.4.1- Free Draining Base Trench Method Of Measurement:

606.4.1.1-FDB Trench: The quantity of work done will be measured by the LF (m) of FDB 606.3.5.1 trench installed, complete, in place, and accepted. The perforated pipe is a component of the FDB trench. Length will be determined from actual measurements once the FDB trench is in place. No deductions will be made for placement of the drop connection required at outlet pipe locations.

606.4.1.2-Outlet Pipe: The quantity of work done will be measured by the LF (m) of rigid pipe complete in place and accepted. Angles, tees, wyes, and other branches which may be required will be included in the length of the outlet pipe. Measurement shall begin at the intersection of the perforated pipe and the rigid pipe. Slopewalls for outlet pipe and the connection of outlet pipes to drainage structures will not be paid for separately, but shall be included in the cost of the outlet pipe.

606.5-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for as provided below, which prices and payments shall be full compensation for furnishing the materials, excavation, placing pipe, filter material, edge drain, outlet pipe, backfill, disposing all surplus material and doing all the work, including all labor, tools, equipment, supplies and incidentals necessary to complete the work. Payment for engineering fabric for Free Drain Base Trench will be as Item 207034-*.

606.6-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
606001-*	Metallic Coated Corrugated Steel Pipe For Underdrains	Linear Foot (Meter)
606002-*	Bituminous Coated Corrugated Steel Pipe For Underdrains	Linear Foot (Meter)
606003-*	Corrugated Aluminum Alloy Pipe For Underdrains	Linear Foot (Meter)
606004-*	Bituminous Coated Corrugated Aluminum Alloy Pipe For Underdrains	Linear Foot (Meter)
606005-*	Non-Reinforced Perforated Concrete Underdrainage Pipe	Linear Foot (Meter)
606007-*	Porous Concrete Pipe	Linear Foot (Meter)
606008-*	Standard Quality Concrete Drain Tile	Linear Foot (Meter)
606009-*	Extra Quality Concrete Drain Tile	Linear Foot (Meter)
606010-*	Special Quality Concrete Drain Tile	Linear Foot (Meter)
606007-*	Porous Concrete Pipe	Linear Foot (Meter)
606008-*	Standard Quality Concrete Drain Tile	Linear Foot (Meter)
606009-*	Extra Quality Concrete Drain Tile	Linear Foot (Meter)
606010-*	Special Quality Concrete Drain Tile	Linear Foot (Meter)
606011-*	Standard Clay Drain Tile	Linear Foot (Meter)
606012-*	Extra Quality Clay Drain Tile	Linear Foot (Meter)
606013-*	Heavy Duty Clay Drain Tile	Linear Foot (Meter)
606014-*	Standard Strength Perforated Clay Pipe	Linear Foot (Meter)
606015-*	Extra Strength Perforated Clay Pipe	Linear Foot (Meter)
606016-*	Cradle Invert Clay Pipe	Linear Foot (Meter)
606017-*	Fiber Cement Pipe For Underdrains	Linear Foot (Meter)
606018-*	Prefabricated Edge Drain	Linear Foot (Meter)
606019-*	Bituminized Fiber Pipe For Underdrains	Linear Foot (Meter)
606020-*	Aggregate Filled Fabric Underdrains**	Linear Foot (Meter)
606021-*	Blind Drain	Yard (Meter)
606022-*	Crushed Stone, Crushed Gravel, Or Silica Sand For Underdrains	Yard (Meter)
606023-*	Underdrain Junction Box	Each
606024-*	Corrugated Stainless Steel Pipe For Underdrains	Linear Foot (Meter)
606025-*	Underdrain Pipe	Linear Foot (Meter)
606026-*	Precoated, Galvanized Steel Pipe For Underdrains	Linear Foot (Meter)
606027-*	Corrugated Polyethylene Underdrainage Pipe	Linear Foot (Meter)
606028-*	Perforated Plastic Semicircular Pipe	Linear Foot (Meter)
606029-*	Free Draining Base Trench	Linear Foot (Meter)
606030-*	Outlet Pipe, "size"	Linear Foot (Meter)

* Sequence number

** Width in inches

SECTION 607 GUARDRAIL

607.1-DESCRIPTION:

This work shall consist of the construction or reconstruction of guardrail in accordance with these Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer.

The types of guardrail are designated as follows:

- Type 1, Galvanized Steel Deep Beam Type Guardrail
- Type 2, Blank
- Type 3, Blank
- Type 4, Blank
- Type 5, Galvanized Steel Double-Faced Guardrail (Deep Beam Type)

All installations of Type 1 & 5 Guardrail will be classified according to one of the designations specified. The guardrail class will be indicated in the pay items and on the Plans,

- Class I: – 6 feet - 3 inches (1 905 mm) post spacing with blocks
- Class II: – 12 feet - 6 inches (3 810 mm) post spacing with blocks
- Class III: – 12 feet - 6 inches (3 810 mm) post spacing without blocks.
- Class IV: 3 ft. – 1 ½ in. (952 mm) post spacing without blocks.
- Class V: 3 ft. – 1 ½ in. (952 mm) post spacing with blocks.

The construction of the guardrail shall include the complete furnishing, assembling and erecting of all component parts and materials at the location shown on the Plans or directed by the Engineer.

A Modified Cut Slope Terminal shall consist of supplying and installing additional length guardrail posts, an additional W-beam guardrail section (bottom beam), and standard guardrail cut slope terminal components

Tangent End Terminal Repair and Flared End Terminal Repair shall consist of carefully removing, and replacing the damaged components of the End Treatments. All components of the end treatment system shall be replaced with the respective manufacture's parts and are to conform to the original design of the system as outlined in the Standard Details Volume I and the manufacture's design.

607.2-MATERIALS:

Materials shall meet the requirements of the following Subsections of Division 700:

MATERIAL	SUBSECTION
Concrete for Footers	715.12
Galvanized Steel Deep Beam Type Guardrail Fasteners and Anchor Bolts	712.4
Miscellaneous Concrete	715.12
Offset Blocks	710.3, 710.5 *
Pressure Treated Wood Guardrail Posts	710.3, 710.5
Retroreflective Sheeting for Traffic Control	715.9.2.8
Steel Guardrail Posts	709.45
Zinc Rich Primer (Galvanized Repair)	711.21

* Other material types may be substituted from the division's approved list.

All materials must be protected from damage during storage and handling. All materials, including materials which have been approved previously, will be subject to inspection by the Engineer as to condition at any time prior to or during incorporation of the material in the work. Materials which have been damaged shall not be used.

CONSTRUCTION METHODS

607.3-SETTING POSTS AND PLACING FOOTERS:

607.3.1-General: Unless one type is specified, posts may be of steel, or wood, and the Contractor shall indicate at the preconstruction conference the type of post the Contractor elects to use and that type shall be used throughout the Project.

Post dimensions and details shall conform to the requirements shown on the Plans.

Guardrail posts shall be placed as shown on the Plans.

Posts shall be set plumb in holes dug by hand or mechanically. When posts are driven, the manner of driving shall be such as to avoid battering or distorting of posts. Post holes shall be backfilled with acceptance material placed in maximum six inch (150 mm) loose layers and thoroughly compacted. All posts damaged during erection or driving shall be removed and replaced without additional cost. Any damage to post galvanizing shall be repaired by a material meeting the requirements of 711.21.

Painting, when called for, shall not be done in damp or freezing weather and shall only be done when the posts are thoroughly dry.

607.3.2-Steel Posts: Galvanized steel posts shall not be painted except for touch up painting with zinc primer as specified.

607.3.3-Pressure Treated Wood Posts: All wood posts shall meet the requirements of Section 710.

607.3.4-BLANK

607.3.5-Offset Blocks: Offset blocks shall be used when called for by the Plans.

607.3.6-Footers for Breakaway Cable Terminal and Special Trailing End Terminal:

Footers for breakaway cable terminal and special trailing end terminal shall be constructed of cast-in-place concrete meeting the requirements of 715.12. Concrete shall be placed promptly and without segregation after mixing.

Concrete footers shall be carried down to at least the depth, and shall be not less than the dimensions shown on the Plans. The top of all footers shall be not less than the dimensions shown on the Plans. The top of all footers shall be flush with the ground line and shall be troweled to a smooth finish with a slope to drain away from the post.

After excavating for the footer, the earth coming in contact with the concrete must be moistened to a depth of at least 2 inches (50 mm) just prior to placing the concrete in the hole. No curing will be required other than the placing of not less than 4 inches (100 mm) of loose moistened earth, free from clods or gravel, over the top of the footer immediately after placing the concrete. All excess excavation from footers and loose material used for curing shall be disposed of in a manner satisfactory to the Engineer.

607.4-ERECTING RAIL ELEMENTS:

607.4.1-General: Rail elements shall be erected in a manner resulting in a smooth, continuous installation.

All bolts, except where otherwise required, such as expansion joint bolts and adjustment bolts, shall be drawn tight. Bolts through expansion joints shall be drawn up as tight as possible without being tight enough to prevent the rail elements from slipping past one another longitudinally. Bolts shall be sufficiently long to extend at least 1/4 inch (6 mm) beyond the nuts. Except where required for adjustment, bolts shall not extend more than 1/2 inch (13 mm) beyond the nuts. Bolts through variable thickness posts shall be cut off a maximum of 1/2 inch (13 mm) beyond the nuts.

All metal guardrail elements shall be fabricated in the shop. Field punching, cutting, and drilling of all guardrail elements other than rail may be permitted after it has been demonstrated that it will not result in damage to the surrounding metal and if approved by the Engineer.

When additional slotted holes are required in W-beam to secure rail to post, slotted hole shall be per Standard Details Volume I. Slotted hole shall be field punched or shop fabricated so that they are free from tears, jagged edges and damage to the surrounding metal. Drilling to create slotted holes is prohibited.

Galvanized surfaces which have been abraded so that the base metal is exposed, any field welded surfaces, threaded portions of all fittings and fasteners, and cut ends of bolts shall be protected with zinc rich primer or by field galvanizing, when approved by the Engineer.

607.4.2-Type 1 Guardrail (Galvanized Steel Deep Beam): The rail shall be erected so that the bolts at expansion joints will be located near the centers of the slotted holes. The rail elements shall be spliced by lapping in the direction of traffic. The rail elements at each splice shall make contact throughout the area of the splice. Shop-curved rail shall be used on curves with radii less than 150 feet (45 m).

Any surface damage to galvanized beams shall be repaired with a material meeting the requirements of 711.21.

When called for, guardrail end terminals conforming to the details shown on the Plans shall be constructed.

607.4.3 through 607.4.4-BLANK

607.4.5-Type 5 Guardrail (Galvanized Steel, Double-Faced): This rail shall be erected in accordance with the requirements of 607.4.2 and as shown on the Plans.

607.5-GUARDRAIL REMOVED AND REBUILT OR STORED:

This item shall consist of carefully dismantling, removing, and reerecting or storing, at the location specified on the Plans, of existing guardrail. Rebuilt units shall be of the same type, spacing of members, etc., as original guardrail.

New material specified on the Plans shall conform to the requirements for the construction of new guardrail of the type being reset.

All salvageable materials shall be removed and re-erected (or stored if so specified) with reasonable care. Posts, rails, fabric, and cables for reerected rails shall be obtained from salvage sources, but the Contractor shall furnish whatever additional bolts, clips, or incidental hardware as may be necessary to complete the guardrail.

Methods of re-erection shall conform to the requirements for the construction of new guardrail of the type being reset, except as modified on the Plans.

Where removal and storage is specified, the bolts, cables, and other hardware shall be carefully removed from all rails, posts, and other members, and all parts shall be sorted and stored at the locations specified. Rails shall be properly stacked, cable shall be free from kinks and rewound on the cable spools, and all such reasonable care shall be exercised in the handling, storing, and preserving of materials as will insure the maximum salvage value for the entire operation.

607.6-METHOD OF MEASUREMENT:

The quantity of work done will be measured in linear feet (meters) of guardrail of the type indicated on the Plans, complete in place and accepted, measured along the face of the rail from center to center of end posts. The linear feet (meters) of double-faced guardrail will be measured along the face of one rail only.

When end terminals or attenuators for steel beam type guardrail are used, they will be measured separately and will be the actual number of end terminals or attenuators constructed, complete in place and accepted.

Where 25 feet (1620 mm) sections of steel deep beam guardrail having 3 feet - 1½ inches (952.5 mm) or 6 feet - 3 inches (1905 mm) post spacings are utilized at bridges, they will be measured and paid for as 6 feet - 3 inches (1905 mm) post spacing with blocks (Class I) and in accordance with their appropriate guardrail type.

Where 18 feet - 9 inches (5 715 mm) sections of guardrail-bridge transitions, having 3 feet-1½ inches (952.5 mm) and 1 foot - 6¾ inches (476.25 mm) post spacings, are utilized at bridges or in conjunction with other structures, these sections shall be measured and paid for as W-Beam Guardrail Bridge Transition. The cost of the double, top w-beam (12 feet - 6 inch section (3 810 mm)), bottom w-beam (rubrail), guardrail end special hardware, connectors and incidentals utilized in guardrail - bridge transit shall be included in W-Beam Guardrail Bridge Transition.

Where w-thrie beam guardrail-bridge transitions consisting of two nested thrie beam panels and a transition section from w-beam to the thrie hewn guardrail having a total length of 18 feet - 9 inches (5 715 mm) are utilized at bridges or in conjunction with other structures, these sections shall be measured, and paid for as Thrie Beam Guardrail Bridge Transition. The cost of

the double thrie beam 12 feet - 6 inch sections (3 810 mm), the 6 feet - 3 inches (1 905 mm) section of w-thrie beam transition, the 6 feet - 6 inches (1 901.2 mm) length steel posts, guardrail terminal connectors, and all special hardware, connectors, and incidentals utilized in this guardrail - bridge transition shall be included in Thrie Beam Guardrail Bridge Transition.

Where guardrail end terminals, per the Division Approved Source/Product Listing, are utilized on projects, these terminals shall be measured and paid for as Flared End Terminal or Tangent End Terminal as shown in the plans. The cost of all hardware shown on the pre-approved shop drawings for the end terminals and the reflective sheeting on the nose of the terminal shall be included in the cost of the Flared End Terminal, per each or Tangent End Terminal, per each.

607.6.1-Tangent End Terminal Components: Tangent End Terminal Repair will be measured from the percentage shown in tables 607.6.1A and 607.6.1B for the parts that are used and accepted. The Tangent End Terminal (TET) has two approved manufactures. The different components of each system along with how much percentage each part is to the entire system can be found in the following tables:

Table 607.6.1A (SKT 350) Approval #1318593A

Part #	Component Description		Value in Percentage (per each)
S3000	Impact Head		41.6%
S1303 / 1305	#1 Deep Beam Guardrail 12 GA.	12.5' or 25' (3810 mm or 7620 mm)	2.1%
G1203 / 1205	#2 Deep Beam Guardrail 12 GA.	12.5' or 25' (3810 mm or 7620 mm)	5.8%
E735	Foundation Soil Tube	6" x 8" x 4'-6" (152 x 203 x 1372 mm)	3.3%
SP600	Soil Plate	24" x 18" x 1/4" (610 x 460 x 6 mm)	1.3%
E740	Pipe Sleeve		0.3%
E750	Bearing Plate	8" x 8" x 5/8" (200 x 200 x 16 mm)	0.8%
E760	Cable Anchor Box		2.3%
E770	BCT Anchor Cable Assembly		2.4%
E780	Ground Strut		2.1%
P650	Wood Posts	5.5" x 7.5" x 45" (140 x 190 x 1143 mm)	1.2%
P675	Timber Blockout	6" x 8" x 14" (150 x 200 x 360 mm)	0.4%
E3151	Impact Face Object Marker		1.5%

Table 607.6.1A (SKT 350) Approval #1318593A-Hardware Package:

Part #	Component Description		Value in Percentage (per each)
B580122	Splice Bolt	5/8” Dia. x 1 ¼”	4.5%
		(16 mm Dia. x 32 mm)	
B580754	Hex Bolt	5/8” Dia. x 7 ½”	
		(16 mm Dia. x 191 mm)	
B581004	Hex Bolt	5/8” Dia. x 10”	
		(16 mm Dia. x 254 mm)	
B581002	H.G.R Bolt (Post 2 Only)	5/8” Dia. x 10”	
		(16 mm Dia. x 254 mm)	
B581802	H.G.R Bolt (POST 3-8)	5/8” Dia. x 18”	
		(16 mm Dia. x 457 mm)	
N050	H.G.R Nut	(Splice 16/32, soil tubes 22, Strut 2, Post 2-8, 7)	
		5/8” Dia. (16 mm Dia.)	
W050	H.G.R Washer	5/8” Dia. (16 mm Dia.)	
N100	Anchor Cable Hex Nut	1” (25 mm)	
W100	Anchor Cable Washer	1” (25 mm)	
E350	Lag Screw	3/8” x 3” (10 x 76 mm)	
SB58A	Cable Anchor Box Shoulder Bolts		
N055A	A325 Structural Nut	1/2 ” (10 mm)	
W050A	A325 STR. Washer	1-1/16” OD x 9/16” ID (27 mm OD x 14 mm ID)	

Table 607.6.1B (ET-2000) Approval #1318592A

Part #	Component Description		Value in Percentage (per each)
62G	#1 Deep Beam Guardrail 12 GA.		9%
60G	#2 Deep Beam Guardrail 12 GA.		5%
740G	Steel Tube	6" x 8" x 54" x 3/16 (152 x 203 x 1372 x 5 mm)	3.3%
766G	Soil Plate	24" x 18" x 1/4" (610 x 460 x 6 mm)	1.3%
782G	Bearing Plate	8" x 8" x 5/8" (200 x 200 x 16 mm)	1.2%
704A	Cable Anchor Bracket		5.6%
3000G	Cable Assembly/ With Hex Nut & Washer	3/4" x 6'6" (75 mm x 1950 mm)	3.5%
985A	Guardrail Extruder		63%
9918A	Offset Strut		2.8%
705G	Pipe Sleeve	2" Std. x 5 1/2" (50 mm x 138 mm)	0.4%
4147B	Wood Posts	5.5" x 7.5" x 45" (140 x 190 x 1143 mm)	1.4%
4063B	Wood Posts	6" x 8" x 6' (150 x 200 x 1800 mm)	2.4%
4148B	Wood Block	5.5" x 7.5" x 14" (140 x 190 x 360 mm)	0.5%
3177A	Object Marker		

Table 607.6.1B (ET-2000) Approval #1318592A-Hardware Package:

Part #	Component Description		Value in Percentage (per each)
3478G	Hex Bolt (Soil Plate)	5/8" Dia. x 7 1/2" (16 mm Dia. x 191 mm)	0.6%
3497G	Hex Bolt (Top Of Tube)	5/8" Dia. x 9 1/2" (16 mm Dia. x 238 mm)	
3360G	H.G.R Splice Bolts	5/8" Dia. x 1 1/4" (16 mm Dia. x 31 mm)	
3580G	H.G.R Post Bolt	5/8" Dia. x 18" (16 mm Dia. x 457 mm)	
3340G	H.G.R Nut	(Splice 16, tubes 24A/12B, gr-7) 5/8" Dia. (16 mm Dia.)	
3300G	Washer (2 At Tubes 1 & 2 + 7 Posts)	5/8" Dia. (16 mm Dia.)	
4228G	Lag Screw	3/8" x 4" (10 x 100 mm)	

607.6.2-Flared End Terminal Components: The Flared End Terminal (FET) has three approved manufactures. The different components of each system along with how much percentage the part is to the entire system can be found in the following tables:

Table 607.6.2A (FLEAT 350) Approval #1318589A

Part #	Component Description		Value in Percentage (per each)															
S3000	Impact Head		40.4%															
F1303	W-Beam Guardrail End Section, 12 GA		2.8%															
F1304	W-Beam Guardrail Center Section, 12 GA		3%															
G1203	W-Beam Guardrail, 12 GA		7.8%															
S730	Foundation Soil Tube ^{Note 1}	6” X 8” X 6’ (152 x 203 x 1830 mm)	5.8%															
Note 1 Post 1 and 2 Foundation Tubes maybe substituted with the following options:																		
<table><tr><th>Part #</th><th colspan="2">Component Description</th></tr><tr><td>S730</td><td>Split Foundation Tubes</td><td>6’-0” (1830 mm)</td></tr><tr><td>E371</td><td>Solid Foundation Tubes</td><td>6’-0” (1830 mm)</td></tr><tr><td>SP600</td><td>Foundation Tubes S375 W/Soil Plates</td><td>5’-0” (1525 mm)</td></tr><tr><td>SP600</td><td>Foundation Tubes E735 W/Soil Plate</td><td>4’-6” (1350 mm)</td></tr></table>				Part #	Component Description		S730	Split Foundation Tubes	6’-0” (1830 mm)	E371	Solid Foundation Tubes	6’-0” (1830 mm)	SP600	Foundation Tubes S375 W/Soil Plates	5’-0” (1525 mm)	SP600	Foundation Tubes E735 W/Soil Plate	4’-6” (1350 mm)
Part #	Component Description																	
S730	Split Foundation Tubes	6’-0” (1830 mm)																
E371	Solid Foundation Tubes	6’-0” (1830 mm)																
SP600	Foundation Tubes S375 W/Soil Plates	5’-0” (1525 mm)																
SP600	Foundation Tubes E735 W/Soil Plate	4’-6” (1350 mm)																
E740	Pipe Sleeve		0.5%															
E750	Bearing Plate	8” X 8” X 5/8” (200 x 200 x 16 mm)	1%															
E760	Cable Anchor Box		3.1%															
E770	BCT Cable Anchor Assembly		3.3%															
E780	Ground Strut		2.8%															
P650	Wood Posts	5.5” X 7.5” X 45” (140 x 190 x 1143 mm)	1.6%															
P671	Wood CRT Posts	6” X 8” X 6’ (150 x 200 x 1830 mm)	2.3%															
P675	Timber Blockout	6” X 8” X 14” (150 x 200 x 360 mm)	0.5. %															

Table 607.6.2A (FLEAT 350) Approval #1318589A-Hardware Package:

Part #	Component Description		Value in Percentage (per each)
B580122	Splice Bolt	5/8” DIA. X 1 ¼”	4.9%
		(16 mm Dia. x 32 mm)	
B580754	Hex Bolt	5/8” DIA. X 7 ½”	
		(16 mm Dia. x 191 mm)	
B581004	Hex Bolt	5/8” DIA. X 10”	
		(16 mm Dia. x 254 mm)	
B581002	Bolt (Post 2 Only)	5/8” DIA. X 10” H.G.R	
		(16 mm Dia. x 254 mm)	
B581802	H.G.R. Bolt (Post 3-7)	5/8” DIA. X 18”	
		(16 mm Dia. x 457 mm)	
N050	H.G.R. Nut	(Splice 24, Soil Tubes 2, Strut 2, Post 2, 1; Post 3 Thru 7, 5.)	
		5/8” DIA	
W050	H.G.R. Washers	(16 mm Dia.)	
N100	Anchor Cable Hex Nut	1”	
		(25 mm)	
W100	Anchor Cable Washer	1”	
		(25 mm)	
E350	Lag Screw	3/8” X 3”	
		(10 x 76 mm)	
SB58A	Cable Anchor Bow Shoulder Bolts		
N055A	A325 Structural Nuts	1/2”	
		(13 mm)	
N050A	A325 Str. Washer	1-1/16” OD X 9/16” ID	
		(27 mm OD x 14 mm ID)	

Table 607.6.2B (SRT 350) Approval # 1318590A

Part #	Component Description		Value in Percentage (per each)
3G	Backup (Guardrail) 12 GA	12"	2.4%
		(3050 mm)	
34G	SRT-1 (Guardrail) 12 GA	12'6"	12.8%
		(3810 mm)	
63G	SRT-350 (Guardrail) 12 GA	25'6'3	16.2%
		(7620 mm/227 mm)	
9G	(Guardrail) 12 GA	12'6/6'3	5%
		(3810 mm/227 mm)	
35G	SRT-2 (Guardrail) 12 GA	12'6/6'3	12.8%
		(3810 mm/227 mm)	
700A	Cable Anchor Bracket		2.6%
705G	Pipe	2" Ø x 5 1/2"	0.5%
		(50 mm Ø x 138 mm)	
736G	Tube Sleeve	5'	8.2%
		(1650 mm)	
766G	Soil Plate	24" x 18" x 1/4"	2.4%
		(610 x 460 x 6 mm)	
775G	Bearing Plate	8" x 6" x 5/8"	2.6%
		(200 x 150 x 16 mm)	
923G	12 GA/Barrier (Terminal)	98"	2.6%
		(2450 mm)	
3000G	Cable With Nut And Washer	3/4 x 6'6	6.4%
		(75 x 1950 mm)	
9852A	Strut Assembly		5.1%
4075B	Block	6" X 8" X 14"	1%
		(150 x 200 x 360 mm)	
4063B	Posts	6" X 8" X 6'	4.4%
		(150 x 200 x 1830 mm)	
9960A	Slot Guard		2.1%
4147B	Wood Posts	5.5" X 7.5" X 45"	2.6%
		(140 x 190 x 1143 mm)	

Table 607.6.2B (SRT-350) Approval # 1318590A-Hardware Package:

Part #	Component Description		Value in Percentage (per each)
3360G	Splice Bolts	5/8” Dia. x 1 ¼”	10.3%
		(16 mm Dia. x 31 mm)	
3500G	Post Bolt	5/8” Dia. x 10”	
		(16 mm Dia. x 250 mm)	
3580G	Post Bolt	5/8” Dia. x 18”	
		(16 mm Dia. x 457 mm)	
3340G	Hex Nut	5/8” Dia.	
		(16 mm Dia.)	
3300G	Washer	5/8” Dia.	
		(16 mm Dia.)	
3320G	Washer	3/16 x 1 ¾ x 3”	
		(5 x 44 x 75 mm)	
3478G	Hex Head Bolts	5/8” Dia. x 7 ½”	
		(16 mm Dia. x 187 mm)	
3380G	Hex Head Bolts	5/8” Dia. x 1 ½”	
		(16 mm Dia. x 37 mm)	
3497G	Hex Head Bolts	5/8” Dia. x 9 ½”	
		(16 mm Dia. x 237 mm)	
9961G	Plate Washer	3/8 x 3 x 4	
		(10 x 75 x 100 mm)	
5968G	16d Standard Nail		
3900G	Washer	1”	
		(25 mm)	
3910G	Hex Nut	1”	
		(25 mm)	

Table 607.6.2C (REGENT) Approval # 318591A

Part #	Component Description	Value in Percentage (per each)
PTE05	Foundation Tube, ST, G	10.5%
PLS03	Soil Plate, St, G	1.5%
PFP01	Strut & Yoke Assemble, ST, G	4.5%
Regent Post 1	Regent Post 1	11%
Regent Post 2	Regent Post 2	4%
FAC PLT WLD	Regent Face Plate Weldment	3.5%
Rein Panel	Regent Rein Panel Weldment	4.4%
Brace	Brace Ch Standard	4%
Brace Support	Brace Support ¼ x 5" (7 x 125 mm) Bent With Holes	4%
FPA01	Cable Anchor Box	2%
FCA01	Cable Anchor, Nut And Washers	1.5%
CBL Arch SLV	Cable & Anchor Sleeve	3.5%
Bearing SLV	Regent Bearing Sleeve, Half	6%
Regent Line Po	Regent Line Post, Mod 2 ½" (63 mm) Holes	2%
PDB01	Timber Post Blockout	4%
Regent Rail 1	Regent Rail 1 (Mod Twm14a)	12%
Regent Rail 2	Regent Rail 2 (Mod Twm14a)	8%
Rwm04a	Regent Rail 3 (Rwm04a Or Rwm02a)	5.5%
Fpp02	"L" Shelf Angel Bracket	1.5%
Rwb01a	W-Beam Backup Plate	1.5%

Table 607.6.2C (REGENT) Approval # 318591A –Hardware Package:

Part #	Component Description		Value in Percentage (per each)
FBB01	Guardrail Bolt & Rail Nut	5/8” Dia. x 1 ¼”	5.1%
		(16 mm Dia. x 32 mm)	
FBB03	Guardrail Bolt & Nut, Hex Head	5/8” Dia. x 10”	
		(16 mm Dia. x 254 mm)	
FBB04	Guardrail Bolt & Nut, Hex Head	5/8” Dia. x 18”	
		(16 mm Dia. x 457 mm)	
FBX16a1	Hex Bolt & Hex Nut	5/8 x 1 9/16	
		(16 mm x 39 mm)	
FBX16a2	Hex Bolt & Hex Nut	5/8 x 7 7/8	
		(16 mm x 197 mm)	
FBX16a3	Hex Bolt & Hex Nut	5/8 x 9 7/8	
		(16 mm x 247 mm)	
FWC16a	Flat Washer, G	11/16” ID x 1 ¾” OD	
		(17 mm Dia. x 44 mm)	
FW4R03	Rectangular Guardrail Washer		
Standoff	Standoff	7/8 x 5/8 x ¼	
		(21 mm OD x 16 mm ID x 7 mm)	
C Bracket	C Bracket Bent With Hole	1/4 x 6”	
		(7 mm x 150)	
Post Breaker	FTB ST With Holes	1/4 x 3 x 16	
		(7 x 75 x 400 mm)	
Post Breaker	ANG ST With Hole	1/4 x 3 x 3x 9	
		(7 x 75 x 75 x 225 mm)	
N16D	Nail, 16D, G		

607.7-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall constitute full compensation for furnishing, preparing, placing, and erecting all materials, and all labor, tools, equipment, supplies such as nuts, bolts, washers, cables and any other incidentals necessary to complete the work.

Tangent End Terminal Repair and Flared End Terminal Repair will be paid for at the percentage calculated above of the unit price bid for that item.

Payment for Cut Slope Terminal Type A shall include extra-length guardrail posts as required, rubrail, excavating and backfilling the trench, reshaping, seeding and mulching of the cut slope, and either concrete block or soil plate anchor complete and in place. Payment for Cut Slope Terminal Type B shall include extra-length guardrail posts as required, drilling holes into the cut slope, and furnishing and installing rock bolts (2), end shoes (2), rubrail, and all other necessary hardware to complete the installation.

607.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
607001-*	Type 1 Guardrail, Class “class”	Linear Foot (Meter)
607005-*	Type 5 Guardrail, Class “class”	Linear Foot (Meter)
607006-*	Thrie Beam Guardrail Bridge Transition	Each
607007-*	W-Beam Guardrail Bridge Transition	Each
607009-*	“Type” Guardrail, Removed And Reset	Linear Foot (Meter)
607010-*	“Type” Guardrail, Removed And Stored	Linear Foot (Meter)
607025-*	Cut Slope Terminal, Type “type”	Each
607027-*	Bullnose Attenuator	Each
607030-*	Special Trailing End Terminal	Each
607035-*	Guardrail Element	Each
607036-*	Guardrail End Shoe	Each
607037-*	Buffer End Section	Each
607039-*	6x6x14 In (150x150x350 Mm) Treated Wood Block	Each
607040-*	8x6x14 In (200x150x350 Mm) Treated Wood Block	Each
607041-*	13 Ft – 6.5 In (4120 Mm) Curved Rail Element	Each
607042-*	6 Ft (1800 Mm) Steel Post	Each
607043-*	8 Ft (2400 Mm) Steel Post	Each
607044-*	8x6x72 In (200x150x1800 mm) Treated Wood Post	Each
607045-*	5.5x7.5x44 In (140x190x1100 mm) Treated Wood Post	Each
607046-*	7 In Round X 6 Ft (175 Round X 1800 mm) Treated Wood Post	Each
607047-*	10x10 In X 6 Ft (250x250x1800 mm) Treated Wood Post	Each
607048-*	Structure Mounted Post, Anchored	Each
607049-*	10 Ft (300 Mm) Steel Post	Each
607050-*	8x6 In X 5 Ft (200x150x1500 Mm) Steel Tube Sleeve	Each
607051-*	Remove And Reset Guardrail Post	Each
607065-*	Flared End Terminal	Each
607066-*	Tangent End Terminal	Each
607081-*	Tangent End Terminal Repair, “system name”	Each
607082-*	Flared End Terminal Repair, “system name”	Each

* Sequence number

SECTION 608 RIGHT-OF-WAY FENCE

608.1-DESCRIPTION:

This work shall consist of the construction of fences and gates of the types designated, in accordance with these Specifications and in reasonably close conformity with the lines, grades, locations, and dimensions shown on the Plans or established by the Engineer.

608.2-MATERIALS:

Materials shall meet the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Aluminum Paint (Aluminum-Coated Repair)	711.9
Barbed Wire	712.10
Chain Link Fence*	712.8
Concrete for Footers	715.12
Farm-Field Fence (Woven Wire)	712.9
Pressure Treated Wood Posts and Braces	710.3, 710.5
Steel Posts, Post Braces and Gate Frames	709.46
Zinc Rich Primer (Galvanized Repair)	711.21

* Chain link fence fabric may be zinc-coated steel or aluminum-coated steel

Posts for farm-field fence may be of either steel or wood, and the Contractor shall indicate at the pre-construction conference the type of post the Contractor elects to use and that type shall be used throughout the Project.

Gate frames shall be constructed of tubing having the dimensions and weights called for on the Plans. Gate frames may be constructed using pressed steel corner fittings or die-cast aluminum corner fittings, may be provided with heavy malleable iron corner fittings or otherwise shall be of an adequate, sturdy design. Gate frame corner attachments may be of welded construction, if the gate frame receives its coating protection after fabrication of the gate structure is completed. All gate frames shall have truss rods as shown on the Plans.

All gates shall be equipped with approved latches, stops, suitable locking devices, and satisfactory provisions for padlocking. Means shall be provided for securing and supporting the free ends of vehicular gates in the open position. Hinges shall be malleable iron, pivot type, heavy and strong, with large bearing surfaces for clamping onto the posts, or equal. Hinges shall not twist or turn under the action of the gate and shall be so arranged that a closed gate cannot be lifted off its hinges to obtain entry. Vehicular gates shall be capable of being operated easily by one person and shall be of the full 180 degree open swing type. Pedestrian gates shall be equipped with a positive stop which will not permit the gate to swing toward the highway and shall be provided with a satisfactory spring or other positive means to maintain the gate in a closed position.

The filler fabric for pedestrian gates and vehicular gates shall comply with the requirements for the fencing fabric of the fence in which the gate is to be installed.

Miscellaneous hardware and fittings shall conform to the details shown on the Plans or other alternate designs acceptable to the Engineer.

When the locations of manufacturing plants allow, the plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with materials quality requirements. This may be the basis for acceptance of manufacturing lots as to quality.

All materials must be protected from damage during storage and handling. All materials, including materials which have been approved previously, will be subject to inspection by the Engineer as to condition at any time prior to or during incorporation of the material in the work. Materials which have been damaged shall not be used.

CONSTRUCTION METHODS

608.3-GENERAL:

The Contractor's activities and operation shall be confined to the area immediately adjacent to the right-of-way fence and within the highway right-of-way. The Contractor shall be responsible for satisfactory arrangements for such permits as required by them from adjacent owners in performing the work.

If the installation of certain portions or lengths of the right-of-way fence is more essential than other portions or lengths, the Engineer may designate the portions or lengths of the fence that are most essential, and the Contractor shall conduct his operations so as to give priority to the erection of such portions or lengths.

When temporary fence is not provided as a separate bid item in the Contract, the Contractor may defer installation of the permanent right-of-way fence by erecting and maintaining adequate temporary fence. The Contractor shall be responsible for prohibiting livestock from entering upon the work area and to contain livestock in the property residues from which it is necessary to remove the existing fence.

608.4-CLEARING, GRUBBING, AND TRENCH EXCAVATION:

The Contractor shall perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment.

When necessary in areas of irregular ground to secure clearance between the ground line and the bottom of the fence fabric, to obtain the established grade, or to permit placing steel barbed wire below the bottom of the fence fabric at stream crossings and minor depressions, a trench shall be excavated to the grade and line established or designated. In the areas where rock is encountered, the rock shall be excavated as may be necessary, in the opinion of the Engineer, to the required grade and line. Any excavation of rock below the required grade shall be backfilled with suitable materials as directed. Trenches shall be so constructed as to insure proper drainage and shall be of the cross section shown on the Plans or as directed. In general, the bottom of the fence shall follow the contour of the ground in accordance with usual practice in constructing fence of the type specified, and it is not anticipated that a great amount of shallow trench excavation will be required.

608.5-CONCRETE FOOTERS:

Footers, where required, shall be constructed of cast-in-place concrete meeting the requirements of 715.12. Concrete shall be placed promptly and without segregation after mixing.

Concrete footings shall be carried down to at least the depth, and shall be not less than the dimensions, shown on the Plans. The top of all footings shall extend slightly above the ground

line and shall be steel troweled to a smooth finish with a slope to drain away from the post. Posts, braces, and other units shall be approximately centered in their footings.

If the ground is firm enough to permit excavation of a hole to neat dimensions, the concrete may be placed without forms by completely filling the hole. In this case, the earth coming in contact with the concrete must be moistened to a depth of at least 2 inches (50 mm) just prior to placing the concrete in the hole. No curing will be required other than the placing of not less than 4 inches (100 mm) on loose moistened earth, free from clods or gravel, over the top of the footing immediately after placing the concrete.

Where the ground cannot be satisfactorily excavated to neat dimensions, forms shall be used for footings. In this case, where the soil is not moist, not less than one gallon (4.0 liters) water shall be placed in the bottom of each hole; and, as soon as the water has been absorbed, the concrete shall be placed.

Forms shall be removed not sooner than 24 hours after placing of concrete. As soon as each form is removed, the footing shall immediately be backfilled with thoroughly moistened material in six inch (150 mm) loose layers and solidly tamped. The top shall be covered with not less than 4 inches (100 mm) of loose moistened earth. All excess excavation from footings and loose material used for curing shall be disposed of in a manner satisfactory to the Engineer.

608.6-SPACING AND SETTING POSTS:

608.6.1-General: Posts shall be spaced in the line of fence as shown on the Plans with a tolerance of minus 2 feet (600 mm). Spacing of posts shall be as uniform as practicable under local conditions.

In general, in determining the post spacing, measurements shall be made parallel to the ground slope, and posts shall be placed in a vertical position except in unusual locations where it would be more satisfactory to place the posts perpendicular to the ground slope and the Engineer so directs.

At all horizontal angle points, vertical angle points, and terminal points of the right-of-way fence, corner, pull, or end posts shall be placed, as the situation may demand, along with the necessary amount of bracing and number of approach posts as shown on the Plans. Steel line posts shall be spaced at a maximum of 10 feet (3 m) center to center, and wooden line posts shall be spaced at a maximum of 15 feet (4.5 m) center to center along the fence line. For chain link fence with steel posts and farm-field type fence with wooden posts, intermediate post assemblies shall be placed at 400 feet (120 m) intervals (maximum) center to center from corner, gate, pull, or end posts, except where the distance is 500 feet (150 m) or less between any combination of such posts. For farm-field type fence with steel posts, intermediate post assemblies shall be placed at 330 feet (100 m) intervals (maximum) center to center from corner, gate, pull, or end posts, except where the distance is 400 feet (120 m) or less between any combination of such posts. Gate posts shall be placed in the fence line where required and as directed by the Engineer. Details of all installations shall be as shown on the Plans.

Extra length posts shall be required at small ground depressions and also at stream crossings, less than 15 feet (4.5 m) for wooden posts and less than 10 feet (3 m) for steel posts, where it is not practicable for the fencing to closely follow the contour of the ground. Details of these installations shall be as shown on the Plans. The location of extra length shall be as dictated by the topography and as directed. Additional bracing shall be provided for extra length posts when shown on the Plans or directed. The Contractor shall close the space below the bottom of the fence fabric with barbed wire, stretched tautly between posts either on horizontal lines

or fanned, as shown on the Plans or directed. At stream crossings greater than 15 feet (4.5 feet) for wooden posts and greater than 10 feet (3 m) for steel posts, the fence shall be constructed as shown by special detail on the Plans or as directed. No special payment will be made for extra length posts, bracing, wire, fittings, etc., required at stream crossings or depressions.

Attention is directed to the fact that some posts may occur at or on existing roadway pavements, on old concrete foundations, or similar solid surfaces. There will be no additional compensation for breaking up such surfaces to set the posts. The Contractor may adjust the spacing to reduce the number of posts occurring on such surfaces subject to the maximum spacing specified, and there will be no additional compensation due to any increase in the number of posts when the Contractor elects to do so.

608.6.2-Wooden Posts: At the option of the Contractor, treated wood posts may be driven into place, provided the method of driving does not damage the post; or they may be installed in drilled or dug holes and backfill and compacted to the satisfaction of the Engineer. In any event, the posts shall be set solidly and any space left around the posts shall be backfilled and compacted as specified.

When posts are to be driven, the top of the posts shall be tapered to fit the driving head so that no gouging of the post will result. Any posts split or broken during driving operations shall be replaced at the Contractor's expense.

All wooden posts shall be placed with their large ends in the ground.

When setting posts in dug or drilled holes of dimensions larger than the post, the space around the posts shall be backfilled in layers of maximum six inch (150 mm) loose thickness, and each layer shall be thoroughly tamped. If the backfill material is too dry to compact to the satisfaction of the Engineer, it shall be dampened as it is placed.

608.6.3-Steel Posts: All steel end, corner, pull, gate, approach, intermediate assembly posts, and diagonal braces shall be set in concrete footings having the dimensions called for on the Plans. The dimensions of the footings may be varied as permitted by the Engineer but shall provide an equal volume of concrete. Except where rock is encountered, line posts shall be set or driven into the ground; and, in farm-field type fence, line posts shall be furnished with an approved plate or other satisfactory anchoring device to hold the post in proper alignment. The plate or anchor shall be satisfactory welded or riveted (not less than two rivets) to the post. Any post damaged by driving will be rejected.

608.6.4-Posts Set in Rock: If solid rock is encountered above the required elevation of the bottom of a post, a hole shall be drilled into the rock to the normal depth of the post or 18 inches (450 mm) into rock, whichever is less. In the latter case, the post shall be cut off at the bottom, if necessary, to provide the required post height above the ground surface. The diameter of post holes in rock shall be at least 3 inches (75 mm) greater than the largest dimension of the post.

For all posts, the portion of the post extending into rock shall be grouted in place. Grout shall consist of one part Portland cement and three parts of sand, thoroughly mixed with a sufficient quantity of water to bring the mixture to a thick, but workable, consistency. For all wood posts and metal line posts, the excavation above the top of the rock shall be backfilled with material placed in six inch (150 mm) (maximum) loose layers and each layer thoroughly

compacted. The anchor plate shall be removed when metal line posts (farm-field type) are to be set in rock. For all other metal posts, the concrete footings, as previously specified, shall be cast-in-place between the top of the rock and the ground surface.

608.7-ERECTION OF FENCING MATERIALS:

608.7.1-General: In cases where the controlled access line and the right-of-way line are not coincident, fence shall normally be erected along the controlled access line. When fencing follows either line, the fence shall normally be erected parallel to and 1 foot (300 mm) inside the line. If this would result in undesirable appearances or unsatisfactory operational characteristics, the fence location shall be adjusted accordingly. In any case, the fence shall be erected to the lines and grades shown on the Plans or established by the Engineer.

The Contractor shall clear the area, from the line of fence to a line approximately 4 feet (1200 mm) within the line of fence, of brush, undergrowth, etc., as directed by the Engineer. Such clearing shall be conducted in such a manner as to leave intact valuable trees and selected native growth. Only such trees as are directly on the line of the fence or that would otherwise, in the opinion of the Engineer, interfere with the construction of the fence, shall be removed by cutting then flush with the ground.

Materials removed in clearing shall be disposed of by the Contractor outside of the right-of-way and out of sight of any part of the highway in a manner approved by the Engineer, unless disposal within the right-of-way is specifically approved in writing by the Engineer.

The tension for stretching the fence shall be applied by use of mechanical fence stretchers and single wire stretchers designed and manufactured for that purpose and in accordance with the fence manufacturer's recommendations. The finished fence shall be true to line, taut, and solid at all points.

Posts shall be permanently positioned and concrete footings fully set before fabric is placed. Unless otherwise permitted, no fencing materials shall be installed on posts until seven days have elapsed from the time of placing of the concrete.

Barbed wire shall be placed at locations indicated on the Plans.

608.7.2-Farm-Field Fence (Wood Posts): Corner and pull posts shall be braced in two directions, and end and gate posts shall be braced in one direction. The braced post and the adjacent approach posts shall each be notched 1 inch (25 mm) deep at 8 inches (200 mm) from the top of the posts to the center of the notching to receive the horizontal brace. The horizontal wooden braces shall then be inserted into the notches and dowelled to the posts with 5/8 inch (16 mm) diameter galvanized steel pins 5 inches (125 mm) long.

Diagonal wire bracing shall consist of double strand # 9 gage wire, installed as shown on the Plans, which shall comply with the requirements for the fencing fabric. Two loops shall be made around each post at each point of attachment, the wires stapled to the posts, and the wires fastened back on themselves by means of at least three twists tightly wrapped. The strands of wire shall then be twisted together until the wooden brace is in compression. The compression shall not be great enough to cause lateral springing in the brace.

The placing and connecting of horizontal wooden braces and diagonal wire bracing for intermediate post assemblies shall be similar to that described above and shall be as shown on the Plans.

The bottom of the fabric of farm-field fence shall be placed a normal distance of 3 inches (75 mm) above the ground line; however, over irregular ground a minimum clearance of 2

inches (50 mm) and a maximum clearance of 6 inches (150 mm) will be permitted for a distance not to exceed 8 feet (2.4 m). Any necessary excavation and backfilling required in order to comply with these provisions shall be made as specified.

At all line and approach posts the fencing material shall be securely fastened to the posts by means of 1-½ inches (40 mm) minimum # 9 wire galvanized staples. At end, pull, corner, intermediate assembly, and gate posts the lateral wires of the fencing material shall be wrapped tightly around the posts and the wire fastened back on themselves by means of at least three twists tightly wrapped. The fence fabric and barbed wire shall be attached to all posts at the vertical spacings shown on the Plans.

Fence fabric and barbed wire shall be fastened tightly to corner, pull, end, gate, and intermediate assembly posts for each straight run of fence, with each wire of the fabric being stapled to the posts before the fabric and barbed wire are fastened to the in-between line and approach posts. At the line and approach posts, the top and bottom wires and every other in-between wire of the fabric shall be stapled, alternating the stapling of the in-between wires on successive posts.

608.7.3-Farm-Field Fence (Steel Posts): Corner, pull, and intermediate assembly posts shall be braced in two directions, and end and gate posts shall be braced in one direction. These posts shall be braced by means of diagonal steel rods, connected to the posts and anchored in the ground in concrete footings, installed and having the dimensions as shown on the Plans.

The bottom of the fabric of farm-field fence shall be placed a normal distance of 3 inches (75 mm) above the ground line; however, over irregular ground a minimum clearance of 2 inches (50 mm) and a maximum clearance of 6 inches (150 mm) will be permitted for a distance not to exceed 8 feet (2.4 m). Any necessary excavation and backfilling required in order to comply with these provisions shall be made as specified.

At all end, corner, pull, gate, and intermediate assembly posts, the lateral wires of the ends of the fencing material shall be wrapped tightly around the posts and the wires tied back on themselves with not less than three twists tightly wrapped. The fencing material shall be fastened to line posts by approved ties or clips. The fence fabric and barbed wire shall be attached to all posts at the vertical spacing shown on the Plans.

Fence fabric and barbed wire shall be fastened tightly to corner, pull, end, gate, and intermediate assembly posts for each straight run of fence, with each lateral wire of the fabric attached, as specified above, before the fabric and barbed wire are fastened to the in-between line posts. At line posts, the top and bottom wires and every other in-between wire of the fabric shall be fastened by approved ties or clips to the posts, alternating the in-between wires to be fastened on successive posts.

608.7.4-Chain Link Fence: Corner, pull, and intermediate assembly posts shall be braced in two directions, and end and gate posts shall be braced in one direction. These posts shall be braced as detailed on the Plans. # 7 gage tension wires shall be attached to both the top and the bottom of the fence fabric for the entire length of the fence.

The bottom of the fence fabric shall be placed a normal distance of 1-2 inches (38 mm) above the ground line; however, over irregular ground a minimum clearance of 1 inch (25 mm) and a maximum clearance of 6 inches (150 mm) will be permitted for a distance not to exceed 8 feet (2.4 m). Any necessary excavation and backfilling required in order to comply with these provisions shall be made as specified.

Top and bottom tension wires shall be placed and fastened to all posts before the fence fabric is placed. Tension wires shall be tautly stretched during erection. The ends of the fabric shall be secured by the use of stretcher bars threaded through the loops of the fabric and secured to corner, pull, end, gate, and intermediate assembly posts by means of clamps with bolts and nuts. The number of clamps shall be as indicated on the Plans. The fabric shall be placed by securing one end of the fabric to the stretcher bar and applying sufficient tension to remove all slack before making the attachment at the other end of the fabric. Following these attachments, the fabric shall be fastened to line and approach posts and to top and bottom tension wires with tie wires or clips. A sufficient quantity of individual fabric ties or clips shall be furnished to provide for attaching the fabric to line posts at 12 inch (300 mm) vertical spaces.

608.8-PAINTS AND PAINTING:

Zinc-coated, triple-coated and aluminum-coated metal parts in the fence structure shall not be painted. After erection is completed, all fence construction will be inspected by the Engineer. All parts of the fence and gates (including bolts and nuts) from which the coating has been abraded so that the base metal is exposed shall be spot-painted with a zinc rich primer in the case of zinc-coated and triple-coated steel and with aluminum paint in the case of aluminum-coated steel.

Wood posts and braces shall be painted when called for on the Plans.

608.9-ELECTRICAL GROUNDS:

All types of fences shall be grounded where a power line passes over the fence. The ground shall be installed immediately below the point of crossing. The ground shall be accomplished with a copper clad rod, 8 feet (2.4 m) long and 5/8 inch (16 mm) (nominal) in diameter, driven vertically until the top is approximately 6 inches (150 mm) below the ground. A # 6 solid copper conductor shall be clamped to the rod and to the fence in such a manner that each element of the fence is grounded. Similar grounds shall be installed at a maximum of every 2,000 feet (600 m) length of fence, whether or not there are power line crossings. For sections of fence less than 2,000 feet (600 m) one ground shall be provided midway between the end posts.

608.10-JUNCTIONS WITH EXISTING FENCES:

Where the right-of-way fence intersects or joins existing fence, the Contractor shall make the junction between the fences in the manner specified. An end post corresponding in strength to the type used in the right-of-way fence shall be set on the line of the existing fence and approximately 4 inches (100 mm) outside the centerline of the highway right-of-way fence. Existing fencing fabric, or similar, shall be stretched and tied to this end post in conformance with the construction requirements for the right-of-way fence. No direct connection shall be made between the existing fence and the highway right-of-way fence. All junctions shall be made in a workmanlike manner and will be subject to the approval of the Engineer.

608.11-TEMPORARY FENCE:

Temporary fence, when called for as a separate bid item, shall be erected at locations as shown on the Plans or as directed by the Engineer.

The Contractor shall set back and re-erect existing fences, erect temporary fences from salvaged fence material, or erect Electric fences at the direction of the Engineer.

608.12-METHOD OF MEASUREMENT:

Fence will be measured by the linear foot (m). Measurement will be along the bottom wire of the fence from outside to outside of end posts for each continuous run of fence. The lengths occupied by gates will not be included in this measurement.

For farm-field fence with wood posts, the distance between posts for each intermediate assembly will be measured only once; the lap in the fencing fabric at intermediate assemblies will be included in the cost of the fence.

Temporary fence and gates, subject to the provisions specified, will be measured along the bottom of the fence from outside to outside of end posts for each continuous run of fence.

Gates, except when used when temporary fence, will be measured as complete units of the size and type specified.

608.13-BASIS OF PAYMENT:

The accepted quantities of fencing materials will be paid for at the contract unit price per linear foot (meter) for fence and per each for gates of the types and sizes specified, complete in place.

This price will include the cost of clearing, grubbing, excavating, trenching, concrete footings, backfilling, drilling in rock, grouting posts in place, painting, electrical grounds, connections to existing fences where required, furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the work.

When a separate bid item for temporary fence or gate is not provided for in the Contract, there will be no compensation for constructing such a fence or gates and the cost will be included in the unit price bid for permanent right-of-way fence.

608.14-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
608001-*	"size" Right-Of-Way Fence, Chain Link	Linear Foot (Meter)
608002-*	"size" Right-Of-Way Fence, Farm Field	Linear Foot (Meter)
608003-*	"size" Temporary Fence	Linear Foot (Meter)
608004-*	"size" Pedestrian Gate, Chain Link	Each
608005-*	Vehicular Gate, Chain Link	Each
608006-*	Pedestrian Gate, Farm Field, "size"	Each
608007-*	Vehicular Gate, Farm-Field, "size"	Each

* Sequence number

SECTION 609 SIDEWALKS

609.1-DESCRIPTION:

This work shall consist of the construction of Portland cement concrete sidewalks in accordance with these Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer.

609.2-MATERIALS:

Materials shall meet the requirements specified in the following subsections of Division 700:

MATERIAL	SUBSECTION
Asphalt Plastic Cement	708.9
Bed Course Material	704.6 – Class 1 or Class 3
Expansion Joint Filler (Preformed)	708.1, 708.2
Joint Sealing Material	708.3
Sand	702.2

Concrete shall meet the requirements of 601, Class B, or 501.

609.2.1-Detectable Warning Surfaces: Detectable warning panels shall have a detectable warning surface meeting Proposed Accessibility Guidelines for Pedestrian Facility in Public Right of Way (PROWAG), latest edition, requirements. The panel dimensions shall not deviate more than 1/16 in (3 mm). The panel colors shall be as shown in the plans or as approved by the engineer. The color shall contrast to the adjacent sidewalk, sidewalk flares and pavement. The panels shall maintain a minimum skid resistance of .60 wet when tested with ASTM C 1028.

There shall be two types of warnings surfaces: Panels for fresh concrete surfaces while the concrete is still plastic, and products for cured concrete surfaces. A wet or plastic set-in- place system shall be installed at the time of the placement of the sidewalk, while the concrete is still plastic. Mold-in-place concrete domes, brick pavers, or iron or steel warning systems shall not be used. Products must be approved and on the WVDOH Approved Products List. The material approval for detectable warning panels will be based on results from WVDOH field evaluation tests. Detectable warning systems may also be accepted or rejected based on actual performance on WVDOH projects. All materials to be used shall be covered by a 5 year warranty under normal conditions.

609.2.2-Quality Control Testing: Quality control of bed course material is the responsibility of the Contractor as specified in 106.1.

The Contractor shall maintain necessary equipment and qualified personnel to perform all sampling and testing necessary to determine the magnitude of the various properties of the material governed by the Specifications and shall maintain these properties within the limits of the Specifications.

The Contractor shall submit a quality control plan detailing the methods by which the quality control program will be conducted. This plan, prepared in accordance with the

guidelines set forth in the appropriate portions of MP 307.00.50, shall be submitted to the Engineer at the preconstruction conference. The work shall not begin until the plan is reviewed for conformance with the contract documents.

609.2.3-Acceptance Testing: Quality control sampling and testing performed by the Contractor shall be used by the Division for Acceptance.

609.2.4-Sampling and Testing: Frequency of sampling and testing shall be in accordance with the contractor's quality control plan. The minimum sampling and testing frequencies for gradation shall be as indicated in Attachment 1 of MP 307.00.50. The material shall be sampled in accordance with MP 700.00.06.

609.2.5-Acceptance Plan:

609.2.5.1-Gradation: Acceptance for gradation shall be on the basis of test results on consecutive random samples from a lot. A lot shall be considered the quantity of material represented by an average test value, not to exceed five sublots. Generally at the beginning of the project, the average shall be started on the second sample in accordance with MP 300.00.51. A subplot is the quantity of material represented by a single gradation test. In the case where only one sample is taken, this subplot shall be considered the lot. When the average, or when the most recent three consecutive individual test values fall outside the limits specified in Table 704.6.2A, the lot of material represented will be considered nonconforming to the extent that the last of its sublots is nonconforming. When this occurs, the last subplot shall have its price adjusted in accordance with Table 609.2.4.2. In the case where the average is nonconforming and the last subplot contained is conforming, then there would be no price adjustment. In no event, however, shall a subplot of material have its price adjusted more than once, and the first adjustment, which is determined, shall apply.

609.2.5.2-Degree of Nonconformance: When a subplot of material is to have its price adjusted, the percentage point difference between the nonconforming test value and the specification limit shall be determined for each sieve size determined to be nonconforming, and this value shall be multiplied by its appropriate multiplication factor as set forth in Table 609.2.5.2.

TABLE 609.2.5.2

Nonconforming Sieve Size	Multiplication Factor
1½ in. (37.5 mm)	1.0
¾ in. (19 mm)	1.0
No. 4 (4.75 mm)	1.0
No. 40 (425 µm)	1.0
No. 200 (75µm)	1.0

The total measure of nonconformance of an individual subplot is the sum of all nonconformances on the various sieve sizes of that subplot.

When the total degree of nonconformance has been established and it is 12.0 or less, the material will be paid for at an adjusted contract price as specified in Table 609.10.1.

When the degree of nonconformance is greater than 12.0, the nonconforming subplot shall be resolved on an individual basis, requiring a special investigation by the Engineer to determine the appropriate course of action to be followed. Pending resolution of the matter, additional lifts of base or pavement shall not be placed over the nonconforming material.

609.3-SUBGRADE PREPARATION:

The subgrade shall be constructed true to grade and cross section as shown on the Plans or directed by the Engineer. It shall be watered, if required, and thoroughly compacted before placing the concrete or bed course material. All soft and yielding material shall be removed and replaced with suitable material.

The completed subgrade shall be tested for grade and cross section by means of a template supported on the side forms.

609.4-DRY BED:

When called for on the Plans, bed course material shall be placed on the subgrade to the depth and width specified and compacted.

609.5-FORMS:

Forms shall be of wood or metal and shall extend for the full depth of the concrete. All forms shall be straight, free from warp, and of sufficient strength to resist the pressure of the concrete without springing. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. All forms shall be cleaned and oiled before being used.

609.6-MIXING AND PLACING CONCRETE:

The foundation and surfaces not oiled shall be thoroughly moistened immediately prior to the placing of the concrete. The proportioning, mixing, and placing of the concrete shall be in accordance with the requirements for the class of concrete specified.

609.7-EXPANSION JOINTS:

Expansion joints $\frac{1}{4}$ inch (6 mm) wide shall be constructed at 30 ft. (9 m) intervals, at all returns, and opposite expansion joints in adjacent curb. A longitudinal expansion joint $\frac{1}{4}$ inch (6 mm) wide shall be placed between sidewalk and curb. Expansion joints shall be filled with preformed joint filler, which shall be shaped to fit the concrete section being placed.

Where sidewalks are to be placed around or adjacent to manholes, drop inlets, or other miscellaneous structures in sidewalk areas, such structures shall not be constructed to final grade until after the sidewalk has been constructed for a reasonable distance on each side of the structure. Expansion joints, of the type specified above, shall be constructed between all such appurtenances and the sidewalk.

Expansion Joints shall be provided around all sidewalk ramps and ramp flares.

With the approval of the Engineer, preformed filler in longitudinal expansion joints between sidewalks and curbs may be eliminated, and the opening remaining after sidewalk has been placed shall be filled with joint sealing material.

609.8-FINISHING:

609.8.1-Concrete: Fresh concrete shall be struck off and compacted until a layer of mortar has been brought to the surface. The surface shall be finished to grade and cross section with a float, troweled smooth, and finished with a broom. The float shall be not less than 10 feet (3 m) in length and not less than 6 inches (150 mm) in width. Brooming shall be transverse to the line of traffic, and the broom shall be kept clean.

All outside edges of the slab and all joints shall be edged with a ¼ inch (6 mm) radius edging tool.

The surface of sidewalks shall be marked into rectangles of not less than 12 sq. ft. (1 sq. m) with a scoring tool which will form dummy joints and rounded sidewalk edges. The dummy joints shall extend into the concrete inch (9 mm) depth and shall be approximately 1/8 inch (3 mm) wide.

The finished surface shall not vary more than ¼ inch (6 mm) from a 10 ft. (3 m) straightedge, except at grade changes, and shall be free from blemishes.

609.8.2 Detectable Warning Surface: The detectable warning panels may be designed for placement while the concrete is plastic or after the concrete has cured. The sidewalk concrete shall cure a minimum of 72 hours prior to placement of the detectable warning surface. The area where the surfaces are to be installed in shall be thoroughly cleaned and allowed to dry. The joints between the panels shall not exceed 1/8 inch. The panels shall not deviate more than 1/16" from the finished grade of the ramp surface. The grade will be measured from the top of the panel excluding any texture. The panels shall be cut as recommended by the manufacture. The domes shall be aligned in the direction of pedestrian travel.

609.9-METHOD OF MEASUREMENT:

Sidewalks will be measured in square yards (meters), complete in place and accepted, which will be determined by the length measured upon the surface times the width constructed, as authorized by the Engineer. Removal of existing sidewalks and any excavation shall be considered Unclassified Excavation and shall be paid as specified in Section 207. Detectable warning surfaces shall be measured and paid for separately complete in place and accepted. Bed course material will be measured by the cubic yard (meter), complete in place and accepted.

Curb Ramps will be measured and paid for separately complete in place and accepted. Where a driveway crosses a sidewalk, the intersecting area shall be constructed to the driveway typical section and shall be measured and paid for the entire length of the driveway and transitions by the pay items shown in the driveway typical section or the Standard Details.

609.10-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

609.10.1-Price Adjustment: Bed course material not conforming to the gradation requirements as described in 609.2.5.1 will be paid for a the adjusted contract price based on the degree of nonconformance as specified in Table 609.10.1.

TABLE 609.10.1

Adjustment of Contract Price for Gradation not Within Specifications	
Degree of Nonconformance	Percent of Contract Price to be Reduced
1.0 to 3.0	2
3.1 to 5.0	4
5.1 to 8.0	7
8.1 to 12.0	11
Greater than 12	*

* The Division will make a special evaluation of the material and determine the appropriate action.

609.11-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
609001-*	Concrete Sidewalk	Square Yard (Meter)
609002-*	Bed Course Material	Cubic Yard (Meter)
609005-*	Curb Ramp	Each
609006-*	Detectable Warning Surface	Each

* Sequence number

SECTION 610

CURBS, COMBINATION CURBS AND GUTTERS AND MEDIANS

610.1-DESCRIPTION:

This work shall consist of the construction or resetting of curbs, combination curbs and gutters, and medians in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions, and locations shown on the Plans or established by the Engineer.

The types of curbing, combination curbs and gutters, or medians are as follows:

1. Plain Concrete Curbing
2. Integral Concrete Curbing
3. Combination Concrete Curb & Gutters
4. Reflecting Concrete Curbing
5. Asphalt Curbing
6. Medians

610.2-MATERIALS:

Except as provided below, materials shall meet the requirements of the following Subsections of Division 700:

MATERIAL	SUBSECTION
Asphalt Emulsion for Paint Coat	705.4 or 705.11
Asphalt for Tack Coat	705.4 or 705.11
Expansion Joint Filler Preformed	708.1
Joint Sealing Material	708.3 or 708.4
Joint Tie Bolt Assembly	709.7
PG Binder for Asphalt Curb	705.5*
Reinforcing Steel	709.1, 709.4

* Standard grade specified for local area unless indicated otherwise on the Plans.

Concrete shall meet the requirements of 601, Class B, or 501. In addition, the requirements in 610.4 shall govern when reflecting concrete curbing is called for.

Concrete, asphalt mixes, and manufactured curbing materials will be subject to inspection and tests at the plants for compliance with quality requirements.

All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

Asphalt curbing component materials shall meet the applicable requirements of Section 401 and the composition of the mix shall meet the following Table 610.2:

TABLE 610.2 (MASTER RANGE CRITERIA)

½ inch (12.5 mm)	100
3/8 inch (9.5 mm)	80 - 100
# 4 (75 mm)	50 - 80
# 8 (2.36 mm)	30 - 60
# 16 (1.18 mm)	20 - 50
# 30 (600 µm)	12 - 36
# 50 (300 µm)	5- 25
# 200 (75 µm)	3- 9
% Asphalt	4 - 10

No mix design approval will be required for asphalt curbing, however, the Contractor shall establish a Plant Mix Formula (PMF) for asphalt content and gradation which meets the above requirements and submit it to the District for approval. The District shall review the design and submit a completed T-400 form to the Materials Control, Soil, and Test Division. The Materials Division will assign a laboratory number to the design. This PMF shall also include the percentage of any additive that may be used as a stiffener for the curbing mix. If lime or other similar granular additive is used, then this material should be included in the PMF gradation. The mix shall be produced within the allowable tolerances of the following table.

Plant Mix Formula	Plant Mix Tolerance Range
Percentage Passing Sieve Sizes 3/8 inch (9.5 mm), # 4 (4.75 mm)	± 7 Percentage Points
Percentage Passing Sieve # 8 (2.36 mm)	± 6 Percentage Points
Percentage Passing Sieve Sizes # 16 (1.18 mm), # 30(600µm)	± 5 Percentage Points
Percentage Passing Sieve Size # 50 (300µm)	± 4 Percentage Points
Percentage Passing Sieve Size # 200 (75µm)	± 3 Percentage Points
Percentage of Asphalt	± 0.5 Percentage Points

The Contractor shall perform quality control sampling and testing of the asphalt curbing mix by taking a random sample once per day of production and testing for asphalt content and gradation to verify the materials composition. If testing indicates that the plant mix formula tolerances are not being met, then production shall halt until the reason for any deficiencies are determined and adjustments are made to correct these deficiencies and documented in the plant diary.

CONSTRUCTION METHODS

610.3-PLAIN CONCRETE CURBING, INTEGRAL CONCRETE CURBING, AND COMBINATION CONCRETE CURB AND GUTTER:

610.3.1-Excavation: Excavation shall be made to the required depth, and the base upon which the curb is to be set shall be compacted to a firm, even surface. All soft and unsuitable material shall be removed and replaced with suitable material which shall be thoroughly compacted. When called for on the Plans, the base upon which the curb is to be set shall be constructed of bed course material in accordance with 609.

610.3.2-Form: Forms shall be of wood or metal, straight, free from warp, and of such construction that there will be no interference with the inspection of grade or alignment. All form shall extend for the entire depth of the curb and shall be braced and secured sufficiently so that no deflection from alignment or grade will occur during the placing of the concrete. Forms shall be cleaned and oiled just prior to placing the concrete.

610.3.3-Mixing, Placing, and Finishing: Concrete shall be proportioned, mixed, and placed in accordance with the requirements for the class of concrete specified. Concrete shall not be transported in nonagitating trucks. Compaction of concrete placed in forms shall be by vibration or other acceptable methods. Drainage openings shall be made through the curb, where indicated, or as directed by the Engineer, at the elevation and of the size required. Forms shall be left in place for 24 hours unless the concrete has set sufficiently prior to that time to permit their removal without injury to the curbing. Upon removal of the forms, the exposed curbing face shall be immediately rubbed to a uniform surface. Rubbing shall be accomplished by the use of water and a wood block or carborundum brick. For the purpose of matching adjacent concrete finishes or for other reasons, the Engineer may permit other methods of finishing. No plastering will be permitted. All damaged and rejected curb shall be removed and replaced.

610.3.4-Sections: All concrete curbing shall be constructed in sections having an approximate length of 10 feet (3 m) unless otherwise indicated on the Plans or directed. In the construction of integral concrete curb or combination concrete curb and gutter abutting concrete pavement, the sections shall be such that the contraction and expansion joints are located opposite the contraction and expansion joints respectively in the pavement. Sections shall be separated by joints 1/8 in. (3mm) wide except at expansion joints. All joints shall be filled with joint sealing material conforming to the requirements of 708.3.

610.3.5-Expansion Joints: Expansion joints shall be formed at the intervals shown on the Plans using a preformed expansion joint filler having a thickness of 3/4 inch (19 mm). When the curb is constructed adjacent to or on concrete pavement, expansion joints shall be located opposite or at expansion joint in the pavement.

610.3.6-Curing: Immediately upon completion of the rubbing, the curbing shall be moistened and kept moist for three days, or the curbing shall be cured by the use of membrane forming material. The methods and details of curing will be subject to the approval of the Engineer.

610.3.7-Backfilling: After the concrete has set sufficiently, the spaces in front and back of the curb shall be refilled to the required elevation with suitable materials, which shall be thoroughly tamped in loose layers of not more than 6 inches (150 mm).

610.3.8-Curb Machine: Where a concrete curb or curb and gutter is not required to be constructed integral with or tied to a concrete base and pavement it may be placed with a self-propelled machine consisting of a hopper and having a power driven screw or screws. The proper density and cross section shall be obtained by forcing the concrete through a mold of the specified cross section. Where a track is used, the track on which the machine operates shall be set and held to the line and grade given by the Engineer. The concrete shall be of such consistency that it can be molded into the desired shape and will remain as placed without slumping of the vertical or sloping faces.

The consistency test may be omitted, and the yield determined from the volume required, adjusted for waste.

610.4-REFLECTING CONCRETE CURBING:

Construction methods for this item shall conform to the requirements of 610.3 with the following supplements:

The reflecting surface of the curbing shall be a mortar mix consisting of one part white Portland cement to 1¾ parts of light colored, washed mortar sand. This mortar mix shall have a thickness of approximately 1 inch (25 mm). Alternately, the entire curbing may be constructed of concrete with white Portland cement. When this alternate procedure is used, it shall conform to "Placing of Concrete Curb by Separate Methods" shown on the Plans.

Washed mortar sand shall meet all the requirements for mortar sand and shall be of a light color satisfactory to the Engineer. The reflecting surface mortar shall be placed immediately after placing of the base concrete. In no case shall more than 20 minutes elapse between the placing of the base concrete and the placing of the reflecting surface.

Scoring or surface deformation of finish of the reflecting surface shall conform to the details shown on the Plans. Care shall be taken to prevent discoloration during and after construction of the curb, and, if discolored, it shall be adequately cleaned by a method approved by the Engineer.

610.5- ASPHALT CURBING:

610.5.1-Equipment & Tools: All equipment, tools, and plant machinery to be used for executing the work prescribed will be subject to the approval of the Engineer.

Asphalt curbing shall be constructed by the use of self-propelled automatic curber or curb machine or a paver with curbing attachments. This automatic curber or machine shall meet the following requirements:

- i. The weight of the machine shall be such that required compaction is obtained without the machine riding above the bed of which curbing is constructed.
- ii. The machine shall form curbing that is uniform in texture, shape, and density.

610.5.2-Excavation: Excavation, when required, shall conform to the requirements of 610.3.1.

610.5.3-Preparation of Bed: When curbing is to be constructed on a fresh laid asphalt surface, the curb shall be laid only after the surface has been cleaned.

When curbing is to be constructed on a cured or aged Portland cement concrete base, asphalt pavement, or asphalt treated base, the bed shall be thoroughly swept and cleaned by compressed air. The surface shall be thoroughly dried and, immediately prior to placing of the asphalt mixture, shall receive a tack coat of asphalt material. The rate of application of tack coat material shall be between 0.05 to 0.15 gallons per square yard (0.226 to 0.679 liters per square meter) of surface. The Contractor shall prevent the spread of this tack coat to areas outside of the area to be occupied by the curb.

610.5.4-Mixing and Placing: The asphalt mixture specified in 610.2 shall be homogeneously mixed and shall be delivered to the hopper of the curb laying machine at a temperature of not less than 200° F (93° C) nor more than 300° F (150° C). Each hopper load of asphalt plant mix shall be run through the curb laying machine which has been adjusted to form and properly compact the asphalt curb.

The Engineer may permit the construction of curbing by means other than the automatic curber or machine when short sections or sections with short radii are required or for such other reasons as may seem to warrant it. The resulting curbing shall conform in all respects to the curbing produced by the use of the machine.

610.5.5-Joints: Unless conditions warrant, asphalt curb construction at the specified temperature shall be a continuous operation in one direction to eliminate curb joints. However, where conditions are such that this is not possible, the joints between successive days' work shall be carefully made in such a manner as to insure a continuous bond between the old and new sections of the curb. All contact surface of previously constructed curb shall be given a thin, uniform coat of hot asphalt material just prior to placing the fresh asphalt curb material.

610.5.6-Curing: The newly laid curb shall be protected from traffic by barricades or other suitable methods until the heat of the asphalt mixture has dissipated and the mixture has obtained its proper degree of hardness.

610.5.7-Painting Curb: The completed curb shall be painted with a diluted emulsified asphalt paint coat or emulsified asphalt slurry to prevent moisture absorption. The paint coat shall be prepared with a 50-50 blend of water and emulsified asphalt, grade SS-1.

610.5.8-Seasonal Limitations: No asphalt material shall be laid when the temperature of the air is 50° F (10° C) or less, or during other unfavorable weather conditions.

610.6-MEDIANS:

Medians shall be constructed to the details shown on the Plans. Construction methods shall conform to the applicable requirements in 610.3.

610.7-RESETTING CURB:

610.7.1-Salvage of Curbing: The Contractor shall carefully remove, store, and clean any curbing specified for resetting. The Contractor shall replace any existing curbing, specified to be reset, which is lost, damaged, or destroyed as a result of their operations or because of their failure to store and protect it in a manner that would eliminate its loss or damage.

610.7.2-Excavation: Excavation and bedding shall conform to the requirements of 610.3.1.

610.7.3-Placing Curb: The curb shall be set on a firm bed with the front top arris line conforming to the required line and grade. All sections of curbing shall be set so that the maximum opening between adjacent sections, for the entire exposed top and face, is not more than 1/4 inch (6 mm), except that the maximum opening at expansion joints shall be not more than 3/4 inch (19 mm). Any dressing of the ends of the curbing necessary to meet this requirement shall be done by the Contractor.

Expansion joints shall be filled with 3/4 inch (19 mm) thick expansion joint fillers, which shall be placed concurrently with the curb.

610.7.4-Backfilling: The spaces in front and back of the curb shall be refilled to the required elevation with suitable material. This material shall be placed in loose layers of not more than 6 inches (150 mm) and thoroughly tamped.

610.7.5-Cutting and Fitting: Cutting or fitting shall be done, when necessary, in order to install the curbing at the locations directed.

610.8-METHOD OF MEASUREMENT:

Curbing will be measured by the linear foot (meter) along the front face of the section at the finished grade elevation. Combination curb and gutter will be measured by the linear foot (meter) along the face of the curb. No deduction in length will be made for drainage structures installed in the curbing. Medians will be measured in linear feet (meters) on the surface and along the centerline of the median.

Bed course material will be measured by the cubic yard (meter).

610.9-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

610.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
610001-*	Plain Concrete Curbing, Type "type"	Linear Foot (Meter)
610002-*	Integral Concrete Curbing, Type "type"	Linear Foot (Meter)
610003-*	Combination Concrete Curb And Gutter, Type "type"	Linear Foot (Meter)
610004-*	Reflecting Curbing, Type "type"	Linear Foot (Meter)
610005-*	Asphalt Curb, Type "type"	Linear Foot (Meter)
610006-*	Median, Type "type"	Linear Foot (Meter)
610007-*	Resetting Curb, Curb Type "type"	Linear Foot (Meter)
610008-*	Bed Course Material	Cubic Yard (Meter)

* Sequence number

SECTION 611

PRECAST CONCRETE TRAFFIC DIVIDERS

611.1-DESCRIPTION:

This work shall consist of furnishing precast white Portland cement concrete traffic dividers of the kind and size specified, and installing such dividers at the locations specified in accordance with the Plans and these Specifications.

611.2-MATERIALS:

Materials shall meet the requirements specified in the following Subsections of Division 700:

<u>MATERIAL</u>	<u>SUBSECTION</u>
Joint Mortar	708.8
Joint Sealer	708.3
Precast Concrete Traffic Dividers	715.20

611.3-CONSTRUCTION METHODS:

When the traffic dividers are to be placed in bituminous concrete, they shall not be placed until the bituminous concrete surface has been completed. The opening remaining between the bituminous concrete and the traffic dividers shall be filled with joint mortar or joint sealer.

When the traffic dividers are to be placed in Portland cement concrete, openings into which the traffic dividers are to be set shall be formed by a method acceptable to the Engineer at the time the Portland cement concrete pavement is being placed. The opening remaining between the Portland cement concrete pavement and the traffic dividers shall be filled with joint mortar or joint sealer.

After the traffic dividers are firmly set in the pavement, the lifting holes shall be filled to within $\frac{3}{4}$ in of the surface with dry sand and either sealed with joint mortar or joint sealer.

The Contractor shall keep the traffic dividers free of any material tending to deface or discolor them. Any dividers damaged shall be removed and replaced at the Contractor's expense.

611.4-METHOD OF MEASUREMENT:

The quantity of work done will be measured as the number of traffic dividers furnished and installed in place and accepted.

611.5-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for this item, which price and payment shall constitute full compensation for furnishing, preparing, and installing the traffic dividers and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, materials, equipment, supplies, and incidentals necessary to complete the work.

611.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
611001-*	Precast Concrete Traffic Dividers	Each

* Sequence number

SECTION 612

TUNNEL LINER PLATE PIPE

612.1-DESCRIPTION:

This work shall consist of tunneling, lining and field paving for tunnel liner plate pipe, galvanized and asphalt coated, in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions and locations shown on the Plan or established by the Engineer.

612.2-MATERIALS:

612.2.1-Liner Plates: Tunnel liner plate pipe shall have the neutral axis diameter specified on the Plans, shall be hot dipped galvanized and shall be double dipped in asphalt cement. The plates shall be of the thickness specified, punched for bolting on both longitudinal and circumferential seams, and shall be so corrugated that they have a moment of inertia of not less than that specified on the Plans. Moment of inertia shall be expressed in inches (mm) to the fourth power per inch (mm) of plate based upon the average for one ring of plates. A minimum of 10 percent of the plates shall be provided with grout plugs for grouting the space between the excavation and the plates. Base material for tunnel liner plates shall conform to the requirements of ASTM A 569. Galvanizing of the plates shall conform to the requirements of AASHTO M 167. Plate design shall be such that complete erection of plates can be accomplished from the inside of the tunnel.

Plates shall be fabricated in accordance with the applicable detail drawings on pages 298, 300, and 301 of "Handbook of Steel Drainage and Highway Construction Products", Latest Edition, published by American Iron and Steel Institute.

612.2.2-Hardware: Bolts and nuts used with lapped seams shall be not less than 5/8 inch (16 mm) in diameter. The bolts shall conform to the specifications of ASTM A 449 for plate thickness equal to or greater than 0.209 inches (5.3 mm) and ASTM A 307 for plate thickness less than 0.209 inches (5.3 mm). The nuts shall conform to ASTM A 563, grade a for A307 bolts and A563 DH for A449 bolts.

Bolts and nuts used with four flanged plates shall be not less than ½ inch (12 mm) in diameter for plate thicknesses up to and including 0.179 inches (4.5 mm) and not less than 5/8 inch (16 mm) in diameter for plates of greater thickness. The bolts and nuts shall be quick acting coarse thread and shall conform to ASTM A 307, Grade A.

Hardware shall be galvanized or cadmium plated in accordance with ASTM A 153, or ASTM B 766, Cl.25 respectively.

612.2.3-Bituminous Coating: Bituminous coating shall conform to the applicable requirements of 713.3. The plates shall be fully coated.

612.2.4-Paving: Field paving shall be of Class B Concrete, conforming to the applicable requirements of 601.3.

612.2.5-Grout: Grout shall consist of Portland cement and sand conforming to the requirements of 218.2 and 218.3.3, except that proportions of cement and sand may be modified to suit conditions encountered in the field.

CONSTRUCTION METHODS

612.3-GENERAL:

The Contractor shall furnish shop drawings showing a typical section of the tunnel, details of the plates, seams, size and length of bolts, and the moment of inertia of the plates in inches (mm) to the fourth power per inch (mm) of width for the ring of plates.

At all times during the construction period the work shall be under the supervision of a superintendent with a proven record of tunneling and the use of tunnel liner plates.

612.4-TUNNELING AND LINING:

Work may begin at either the outlet or inlet end. If necessary to reach the entrance grade, a shaft of minimum 8 feet (2.5 m) width and 12 feet (3.7 m) length shall be dug and the shaft sheeted and shored if necessary. Tunnel mucking shall be carried out not greater than 24 inches (600 mm) ahead of the bolting up of plates. Disposal of the removed spoil shall be in accordance with the directions of the Engineer. Mucking shall be done smoothly to fit the outside of the liner plates. The Contractor shall be responsible for adherence the line and grade, and deviations from line and grade more than 3 inches (75 mm) shall require the approval of the Engineer. If necessary, due to the type of soil encountered, jacking type shield shall be used.

At the end of each working day, the Contractor shall construct a bulkhead inside the pipe at the construction face.

612.5-GROUTING:

Grout blocks shall be installed at each end after bolting up is completed. Grouting shall start at one end and shall be carried forward until the area between the excavation and the plates is completely filled with grout. Grouting should be performed on a daily basis and progressed simultaneously with the installation of the tunnel liner plate.

612.6-FIELD PAVING:

Field paving, using Portland cement concrete, shall be accomplished in accordance with the applicable requirements of 604.9.

612.7-METHOD OF MEASUREMENT:

The quantity of work done will be measured in linear feet (meters) of Tunnel Liner Plate Pipe, complete in place and accepted.

612.8-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid per linear foot (meter), which price and payment will be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

612.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
612001-*	“size” Tunnel Liner Plate Pipe, 2-Flange Design	Linear Foot (Meter)
612002-*	“size” Tunnel Liner Plate Pipe, 4-Flange Design, Type “type”, Y	Linear Foot (Meter)

* Sequence number

Y = a letter designating base metal (zinc-coated) thickness in accordance with the following table:

Y	MILS (mm)
B	79 (2.0 mm)
C	109 (2.7 mm)
D	138 (3.5 mm)
E	168 (4.3 mm)
F	188 (4.8 mm)
G	218 (5.5 mm)
H	249 (6.3 mm)
J	280 (7.1 mm)

SECTION 613-BLANK

SECTION 614 PILING WALLS

614.1-DESCRIPTION:

This work shall consist of furnishing and placing steel piles in predrilled holes, concrete or grout, backfill and lagging, of the kinds and dimensions designated, in accordance with these provisions and in reasonably close conformity with the lines, grades, dimensions, and locations shown on the Plans or established by the Engineer. Painting of the exposed steel is included.

Careful attention shall be given to assuring the pile wall will tie directly into an existing stable slope. Prior to ordering any materials, the contractor in conjunction with the Engineer shall conduct a project site review in order to verify the limits of the pile wall.

614.2-MATERIALS:

Materials shall conform to the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Fine Aggregate	702.1
Fly Ash	707.4
Portland Cement	701.1
Prestressing Steel	709.2
Reinforcing Steel	709.1
Steel Lagging and Wales	709.12
Steel Piles and Splices	709.12
Treated Timber Lagging	710

614.3-DRILLING:

A drilled hole is required for the buried length of the pile.

A minimum of 1/3 the total pile length or 10 feet (3 m), whichever is greater, is to be placed in bedrock/shale. Deviation from this requirement will be controlled by a Plan note. The total estimated pile length and the depth to the estimated bedrock/shale line are shown on the piling profile. Should the elevation of the actual bedrock/shale vary from the estimated elevation by more than 2.5 feet (0.8 m), the Engineer must approve the hole prior to placement of the pile. The material from the drilled hole shall be removed and disposed of by the Contractor in an approved site.

Particular care must be taken in the drilling operation to avoid deflecting the bit along a sloping bedrock/shale line. To verify proper alignment, the Contractor shall measure and record the vertical alignment of the hole using a plumb bob or other acceptable method.

Preferably, the diameter of the drilled hole shall be a size that will allow the pile, while being slowly lowered into the hole, to reach the bottom of the hole under the impetus of the pile weight. The minimum hole diameter shall be 2 inches (50 mm) larger than the diagonal distance across the pile cross section.

Light tapping (ten blows with at least 3 inches (75 mm) of penetration per blow) with a pile hammer exerting no more than 12,000 ft/lbs (16 kJ) of energy is permitted at the direction of the Engineer to advance the pile past minor obstacles in the hole.

Temporary casing of holes may be needed to maintain an open clean hole through the soil overburden. There will be no additional compensation for temporary casing. The cost of any casing used shall be included in the unit price bid for piling.

614.4-INSTALLATION OF PILES:

Piles shall be located as shown on the Plans or as directed by the Engineer. Piles shall be installed with the pile center within 1 inch (25 mm) of the Plan location. The piles must be prevented from rotating, so that the pile axis is within five degrees of the position shown on the Plans.

The maximum permissible vertical deviation for piles shall be one percent of the total pile length, as measured at the actual pile location.

It is desirable that piles be installed without splicing; however, at the direction of the Engineer splices may be made. Splice lengths at the top of the piles may be butt welded provided the splice lengths are less than the required splice plates. No payment will be made for cut-offs. Welding shall be in accordance with 615.5.7.

Accurate records shall be maintained by the Contractor showing the depth to which each pile was placed, the plumbness, the amount of material used, elevation of bedrock/shale, and any unusual conditions encountered during the pile installation. These records shall be incorporated into the permanent records of the project.

614.5-CORROSION PROTECTION:

Piles will be protected from corrosion and sealed by the placement of concrete or grout, from the bottom of the hole to the bottom of the lagging or as directed by the Engineer. Vibration of the concrete or grout is not required. The Contractor shall complete all concrete or grout operations for holes drilled during the work day.

The drilled hole shall be pumped free of water and shall be reasonably free of fall-in soil or other debris prior to the placement of the concrete or grout. The concrete or grout in the bedrock/shale portion of the hole will be pumped or tremied through a pipe beginning at the bottom of the drilled hole. The pipe shall be slowly raised ensuring the pipe end remains at least 2 feet (600 mm) below the surface of the concrete or grout. A means of positively measuring the elevation of the concrete or grout as it is placed shall be provided by the Contractor.

After placing the concrete or grout in the bedrock/shale, the Contractor has the option of either pumping or pouring directly into the hole the remainder of the concrete or grout. Placing the concrete or grout from the bottom of the hole to the bottom of the lagging shall be accomplished in one continuous operation.

The Contractor will inform the Engineer, at the preconstruction conference, as to the type of corrosion protection that will be used. Intermixing of concrete and grout will not be allowed, unless approved by the Engineer.

Concrete shall be in accordance with Section 601, Class B. The job site testing is waived.

Grout will be furnished and placed in accordance with the requirements specified herein.

The acceptance sampling and testing of the grout is the responsibility of the Division.

Quality Control of the concrete or grout is the responsibility of the Contractor as designated in Materials Procedure MP 601.03.50. The Contractor shall maintain equipment and qualified personnel, who shall direct all field inspection, sampling, and testing necessary to determine the magnitude of the various properties of the concrete and grout governed by the Specifications and shall maintain these properties within the limits of this Specification. The

Quality Control Plan designated in MP 601.03.50 shall be submitted to the Engineer at the pre-construction conference. Work shall not begin until the Plan is reviewed for conformance with the contract documents.

The required 7-day compression strength of the grout shall be a minimum of 2,000 psi (14 MPa). Grout which does not attain the 2,000 psi (14 MPa) strength in 7 days but exceeds a strength of 1,600 psi (11 MPa) shall be subject to price reduction based on the percentage of strength attained.

A grout strength test shall consist of testing three 6 in x 12 in (150 mm x 300 mm) cylindrical specimens. The test results shall be the average of the three specimens. One set of three specimens shall be made for each day's operations.

The bid price for the piling with grout compressive strengths greater than or equal to 2,000 psi (14 MPa) will be paid at 100 percent unless the piling installation does not meet Specifications for other reasons. Between 1,600 psi (11 MPa) and 2,000 psi (14 MPa) compressive strengths, the cost of the grout will be deducted from the actual grout cost on a proportional basis with 2,000 psi (14 MPa) being 100 percent and 1,600 psi (11 MPa) being zero percent payment. With 1,600 psi (11 MPa) grout, the piling installation would be considered to meet 80 percent of the Specifications and the penalty being zero payment for the grout.

The penalty would involve only the quantity of grout represented by the failing compressive strength results.

The bid price for the piling will be reduced for the piles grouted with grout having less than 1,600 psi (11 MPa) compressive strengths as follows:

$$F = D + [BC - D] 10.80 - (A + E)$$

Where:

- A = Compressive strength of grout
- B = Total foot (meter) of piling grouted with
- C = Unit bid price per foot (meter) of piling
- D = Cost of grout (from Contractor)
- E = 2,000 psi (14 Mpa)
- F = Total penalty

614.6-PAINTING:

All surfaces from the top of the steel pile, down to and including 2.0 feet (600 mm) below the top of the anticipated grout line shall be cleaned and painted. The method of surface preparation shall be hand tool cleaning to SSPC-SP-2. The paint system shall consist of one-coat of aluminum epoxy mastic meeting the requirements of 711.12 applied at a minimum dry film thickness of 5 mils (125 µm).

614.7-LAGGING AND BACKFILLING:

Lagging of the type and size as specified on the Plans shall be installed between the piles. Backfilling and restoration of the roadway template shall be as shown on the Plans.

Timber lagging shall be Grade # 3 or better treated rough cut oak, 3 in (75 mm) wide by 8 in (200 mm) deep for heights up to 11 ft (3.4 m); and for wall heights exceeding 11 ft (3.4 m) the timber lagging shall be double 3 in (75 mm) wide by 8 in (200 mm) deep. The boards shall be cut to their required length prior to preservative treatment.

The timber lagging shall conform to Sections 710.3 and 710.4 of the West Virginia Division of Highways Standard Specifications.

614.8-METHOD OF MEASUREMENT:

The quantity of piles will be measured in linear feet (meters) of piles installed and accepted for the wall.

The quantity of lagging will be measured in square feet (meters) installed and accepted as measured by the total area of wall as measured through all wall elements, without deductions for gaps between lagging, piles, etc.

614.9-BASIS OF PAYMENT:

The quantities will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all materials and doing all the work herein prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work. The cost of drilling, concrete, grout, wales, and painting shall be included in the price bid for the piles. The cost of painting and welding steel lagging shall be included in the price bid for steel lagging.

614.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
614001-*	"size" Steel Pile	Linear Foot (Meter)
614002-*	Steel Lagging, Thickness "thickness"	Square Foot (Meter)
614003-*	Concrete Lagging, Thickness "thickness"	Square Foot (Meter)
614004-*	Timber Lagging	Square Foot (Meter)

* Sequence number

SECTION 615

STEEL STRUCTURES

615.1-GENERAL:

615.1.1-Description: The work shall consist of furnishing, fabricating, and erecting steel structures and structural steel portions of other structures in accordance with these Specifications, the Special Provisions, and the details shown on the plans.

Fabricators of bridges that have welded shop splices shall be certified under the American Institute of Steel Construction's (AISC) Quality Certification Program "Major Steel Bridges" category. The fabricators of fracture critical members shall be certified as category: "Major Steel Bridges" and, in addition, shall possess an "F" endorsement by AISC. Fabrication of grades HPS 50W and HPS 70W steel shall only be performed by fabricators possessing an "F" endorsement. Fabricators of rolled beam bridges shall be certified by AISC in either the "Major Steel Bridges" category or the "Simple Steel Bridges" category. Ancillary bridge components such as expansion dams, drains, scuppers, and pedestrian handrail may be fabricated in shops that are AISC certified as "Bridge and Highway Metal Component Manufacturers."

The fabricator shall provide a quality control plan to the Engineer for approval. This plan shall contain information concerning the fabricator's internal control process. Information concerning the contents of the quality control plan can be found in the FHWA Region Three, Structural Committee for Economic Fabrication's Guidelines for the Development of a Quality Control Plan. The plan shall be approved by the Division prior to the start of fabrication.

Structural components designated on the plans or in the special provisions as "fracture critical" shall conform to the provisions of Section 12 of the ANSI/AASHTO/AWS Bridge Welding Code D1.5.

Painting shall conform to the provisions of Section 688.

615.1.2-Notice of Beginning of Work: The Contractor shall give the Engineer a minimum of two weeks notice prior to the beginning of work at the fabrication shop, so that inspection may be provided. No material shall be manufactured, or work done in the shop, before the Engineer has been so notified. Prior to beginning work, Engineer and Contractor representatives shall identify individuals who are responsible for the following functions: preparation, submittal, review, approval, and distribution of shop drawings; submittal and control of material test reports (MTRs). The Engineer will identify individuals or agents responsible for handling shop detail drawings, approving welding procedures, providing quality assurance, and accepting proposed repairs. Before work begins a prefabrication meeting may be held at the discretion of the Engineer or if requested by the Fabricator or Contractor.

615.1.3-Inspection: Structural steel shall be inspected in the fabrication shop. The Contractor shall furnish the Engineer with a copy of all mill orders and shop lists showing heat numbers to be used for each piece. Mill test reports that document the chemical analysis and physical test results for each heat of steel to be used in the work shall also be furnished. Final approval of the material in the shop will not be given until the above data is approved.

With the approval of the Engineer, certificates of compliance shall be furnished in lieu of mill test reports for material that normally is not supplied with mill test reports, and for items

such as fills, minor gusset plates and similar material when quantities are small and the material is taken from stock.

Certified mill test reports for steels with specified minimum impact values shall include, in addition to other test results, the results of Charpy V-Notch impact tests. When fine grain practice is specified, the test report shall confirm that the material was so produced. Copies of mill orders shall be furnished at the time orders are placed with the manufacturer. Certified mill test reports and Certificates of Compliance shall be furnished prior to the start of fabrication of material covered by these reports. The Certificate of Compliance shall be signed by the manufacturer and shall certify that the material is in conformance with the specifications to which it has been manufactured.

Material to be used shall be made available to the Engineer so that each piece can be examined. The Engineer shall have free access at all times to any portion of the fabrication shop where the material is stored or where work on the material is being performed.

615.1.4-Inspector's Authority: The Inspector shall have the authority to reject materials or workmanship which do not fulfill the requirements of these Specifications. In cases of dispute, the Contractor may appeal to the Engineer, whose decision shall be final.

Inspection at the shop is intended as a means of facilitating the work and avoiding error, and it is expressly understood that it will not relieve the Contractor of any responsibility in regard to defective material or workmanship and the necessity for replacing same.

The acceptance of any material or finished members by the Inspector shall not be a bar to their subsequent rejection, if found defective. Rejected materials and workmanship shall be replaced as soon as practical or corrected by the Contractor.

615.2-WORKING DRAWINGS:

Working drawings must be submitted in accordance with section 105.2.

615.2.1-Erection Drawings: The contractor shall submit drawings illustrating fully their proposed method of erection. The drawings shall show details of all falsework bents, bracings, guys, dead-men, lifting devices, and attachments to the bridge members: sequence of erection, location of cranes and barges, crane capacities, location of all lifting points on the bridge members, and weights of the members. The plans and drawings shall be complete in detail for all anticipated phases and conditions during erection. Design calculations, sealed by a West Virginia Registered Professional Engineer, shall be submitted by the Contractor to the Engineer seven days prior to commencing work. Receipt of plans, drawings and calculations does not constitute review or approval or relieve the contractor of their responsibility to satisfactorily design the erection plan. The design calculations shall demonstrate that allowable stresses for falsework and steel members being erected are not exceeded and that member capacities and final geometry shall be correct.

When the designated concrete deck overhang exceeds 30 inches from the edge of the beam flange, the erection drawings submitted by the Contractor/fabricator shall include complete details of the forming and bracing for the overhang and shall transmit the concrete dead load to an area of the beam or stringer which will prevent distortion.

615.2.2-Camber Diagram: A camber diagram shall be furnished to the Engineer by the Fabricator, showing the camber at each panel point in the cases of trusses or arch ribs, and at

the location of field splices and fractions of span length ($\frac{1}{4}$ points minimum) in the cases of continuous beam and girders or rigid frames. The camber diagram shall show calculated cambers to be used in preassembly of the structure in accordance with Section 615.5.3.

615.3-MATERIALS:

615.3.1-Structural Steel:

615.3.1.1-Quality: Steel shall be furnished according to the following specifications. The grade or grades of steel to be furnished shall be as shown on the plans or as specified. Material meeting equivalent AASHTO and ASTM specifications may be supplied under either specification. All steel for use in main load-carrying member components subject to tensile stress, including splice plates, shall conform to Zone 2 Charpy V-Notch Impact Test requirements of AASHTO M270.

615.3.1.2-Certifications and verification: Fabricators of structural steel shall provide certified mill test reports (MTRs) for all steel materials used in fabrication. MTRs must originate from the producer of the material and not a supplier.

615.3.1.3-High Performance Steel: Structural Steel designated on the plans as grades HPS 50W and HPS 70W shall conform to the requirements of AASHTO M270/M270M-04(or later version). All fabrication for grades HPS 50W and HPS 70W must conform to the current edition of the AASHTO/AWS D1.5 2008 Bridge Welding Code and by the latest edition of the AASHTO Guide Specification for Highway Bridge Fabrication with HPS 70W Steel. Only submerged arc welding (SAW) and shielded metal arc welding (SMAW) are permitted when welding grade HPS 70W steel.

615.3.1.4-Non-Destructive Testing (NDT): All NDT shall be performed in accordance with the AASHTO/AWS D1.5 2008 Bridge Welding Code. Whenever magnetic particle testing (MT) is performed only the yoke technique will be allowed, as described in section 6.7.6.2 of AWS D1.5, modified to test using alternating current only.

615.3.1.5-Weld procedure qualification: The procedure qualification test record (PQR) and proposed welding procedure specification (WPS) must be submitted to the Engineer for review and approval prior to the start of fabrication. In general, post weld heat treatment shall not be required. If proposed by the Contractor for production or repair welding, such post weld heat treatment must be included in the procedure qualification testing, or qualified by additional PQR's, as appropriate.

615.3.2-High-Strength Fasteners: Bolts, nuts, and washers shall conform to Section 709.24 and shall be mechanically galvanized in accordance with ASTM B695. Hot-dip galvanizing or coating with a zinc rich primer may be used only when specified by the Contract documents.

615.3.2.1-Weathering Steel Bridges: High strength fasteners shall meet Section 709.24 and shall be Type 3 (weathering steel), per ASTM A325. High strength fasteners used in regions of the structure that require painting shall be Type 1 or 3, per ASTM A325, and mechanically galvanized in accordance with ASTM B695.

615.3.3-Welded Stud Shear Connectors: When design requires the use of welded stud shear connectors, they shall meet the requirements of Section 7 of the ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

The connectors shall be attached in the field. With the exception of worker fall protection as described in section 615.3.3.1, no shop installation of welded stud shear connectors shall be permitted. The field installation of the welded stud shear connectors shall not commence prior to the installation of the deck forms in the area surrounding the welded stud shear connectors. Overhanging deck forms may be installed after the welded stud shear connectors are installed. The welded stud shear connectors and deck forms shall be installed in a sequence that permits workers access through the deck area without walking through installed welded stud shear connectors.

615.3.3.1- Shear Studs for Worker Fall Protection: The Contractor may shop install shear studs to the beam or girder for the purpose of attaching a worker fall protection system. Only the shear studs required to properly install and support the worker fall protection system may be installed in the shop. The remaining shear studs at this location for an individual transverse row across the beam or girder flange may also be installed in the shop. All shop installed shear studs shall be shown on the drawings.

615.3.4-Steel Forgings and Steel Shafting:

615.3.4.1-Steel Forgings: Shall conform to 709.13.1.

615.3.4.2-Cold Finished Carbon Steel Shafting: Shall conform to 709.13.2.

615.3.5-Steel Castings: Shall conform to 709.14.

615.3.6-Iron Castings: Shall conform to 709.10.

615.3.7-Coating of Anchor Bolts, Nuts and Washers: All anchor bolts, nuts and washers shall be hot dip galvanized in accordance with AASHTO M232 after fabrication.

615.4-FABRICATION:

615.4.1-Identification and traceability: Ensure that all structural steel materials are identified in accordance with ASTM A6. Maintain heat numbers on all primary bridge materials until the material is permanently joined into a piece-marked member. Use low stress steel die stamps or a firmly attached tag. Maintain documentation of all primary member material for shop records and provide this documentation to the Quality Assurance Inspector (QAI) for the Engineer's records.

615.4.2-Storage of Materials: Steel members must not be gouged, scratched, dented, or allowed to rub against other members that would result in damage to the steel member or coating. Members shall be handled using softeners and slings instead of chokers and chains.

Store members in the fabrication shop and on the project site in such a manner as to be kept free and clean of all foreign substances such as grease, oil, mortar and concrete splatter, chalk and crayon marks, paint, and dirt. All storage must be above ground and sloped to allow free drainage of melted snow, rainwater, and dew. If the members are stored for periods longer

than three months, the members must be placed on metal supports. For a period of storage up to three months, members may be placed on clean, untreated wood timbers. Do not allow treated lumber or treated timber to contact steel members.

Store plate girders and rolled beams with the web in the upright position. The members may be stacked on metal or wood supports provided, as noted above; individual members must be kept separate. Under no circumstances shall members be nested together or bundled.

615.4.3-Plates:

615.4.3.1-Direction of Rolling: Unless otherwise shown on the plans, steel plates for main members and splice plates for flanges and main tension members, not secondary members, shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile and/or compressive stresses.

615.4.3.2-Plate Cut Edges:

615.4.3.2.1-Edge Planing: For primary members more than 5/8 inch in thickness, 3/16 inch shall be planed off sheared edges that remain exposed after fabrication.

615.4.3.2.2-Thermal Cutting: Shall conform to the requirements of the ANSI/AASHTO/AWS Bridge Welding Code D1.5.

615.4.3.2.3-Visual Inspection and Repair of Plate Cut Edges: Shall conform to the requirements of ANSI/AASHTO/AWS Bridge Welding code D1.5.

615.4.3.3-Bent Plates:

615.4.3.3.1General: Unwelded, load-carrying, rolled-steel plates to be bent shall conform to the following:

They shall be so taken from the stock plates that the bend line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic-deck bridges may be bent with bend lines in the direction of rolling if permitted by the Engineer.

Before bending, the corners of the plates shall be rounded to a radius of approximately 1/16 inch (2 mm) throughout the portion of the plate at which the bending is to occur.

615.4.3.3.2-Cold Bending: Do not cold bend fracture critical materials. Cold bending shall be such that no cracking of the plate occurs. Visibly inspect all load points, and check any suspected damage by magnetic particle testing. Material with non-specified kinks or sharp bends, cracks, large dents, or visible reduction of section shall be rejected. Minimum bend radii, measured to the concave face of the metal, are shown in table 615.4.3.3.2.

TABLE 615.4.3.3.2

Minimum Cold-Bending Radii				
Material		Radius in Terms of Plate Thickness, t mm (in.)		
ASTM Specification	Grade	t<25 (1)	25 (1) <t<50 (2)	50 (2)<t
A36/A36M	---	1.5t	1.5t	2.0t
A572/A572M	290 (42)			
A709/A709M	250 (36)			
A572/A572M	345 (50)	1.5t	2.0t	2.5t
A588/A588M	---			
A709/A709M	345 (50), 345W (50W)			
A572/A572M	380 (55)	1.5t	2.5t	3.0t
A709/A709M	HPS 485 (70W)			

Allowance for springback of Grades 100 and 100W steels should be about three times that for Grade 36 steel. For break press forming, the lower die span should be at least 16 times the plate thickness. Multiple hits are advisable.

615.4.3.3-Hot Bending: If a radius shorter than the minimum specified for cold bending is essential, the plates shall be bent hot at a temperature not greater than shown in Table 615.4.7.

615.4.4-Fit of Stiffeners: Bearing stiffeners for girders and stiffeners intended as supports for concentrated loads shall have full bearing (either milled, ground or on weldable steel in compression areas of flanges, welded when shown on the plans or specified) on the flanges to which they transmit load or from which they receive load and shall meet the requirements of paragraph 3.5.1.9 of the 2008 ANSI/AASHTO/AWS Bridge Welding Code D1.5. Intermediate stiffeners not intended to support concentrated loads, unless shown or specified otherwise, shall have a tight fit against both flanges which is defined as having a gap of no more than 1/16 inch between stiffener and flange. Diaphragm, crossframes or floorbeam connection plates shall be welded to both top and bottom flanges.

615.4.5-Abutting Joints: When specified by the contract plans, butting joints in compression members of trusses and columns shall be milled or saw-cut to give a square joint and uniform bearing. At other joints, not required to be faced, the opening shall not exceed 3/8 inch (10 mm).

615.4.6-Facing of Bearing Surfaces: The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the ANSI surface roughness requirements as defined in ANSI B46.1, Surface Roughness, Waviness and Lay, Part I:

Steel slabs	ANSI 2,000
Heavy plates in contact in shoes to be welded	ANSI 1,000
Milled ends of compression members, milled or ground ends of stiffeners and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

615.4.7-Straightening Material: The straightening of plates, angles, other shapes, and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other injury to the metal. Straighten bridge member parts, such as plates, angles or shapes, before the parts are assembled. If members are cold straightened, follow the applicable provisions of Section 615.4.3.3.2. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by carefully planned procedures and supervised application of a limited amount of localized heat, except that heat straightening of Grades 70W, 100 and 100W steel members shall be done only under rigidly controlled procedures, each application subject to the approval of the Engineer. In no case shall the maximum temperature exceed values shown in Table 615.4.7.

Table 615.4.7

Maximum Heat Straightening and Hot Bending Temperature {ENGLISH}	
Grade 70W > 6" from weld	1,075° F
Grade 70W < 6" from weld	900° F
Grade 100 or 100W > 6" from weld	1,125° F
Grade 100 or 100W < 6" from weld	950° F

In all other steels, the temperature of the heated area shall not exceed 1,200° F as controlled by temperature indicating crayons.

Parts to be heat straightened shall be substantially free of stress and from external forces, except stresses resulting from mechanical means used in conjunction with the application of heat.

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

615.4.8-Bolt Holes:

615.4.8.1-Holes for High-Strength Bolts and Unfinished Bolts: (See Section 615.5.5 for bolts included in designation "Unfinished Bolts").

615.4.8.1.1-General: All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 inch (2 mm) larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than ¾ inch (20 mm) for structural carbon steel, 5/8 inch (16 mm) for high-strength steel or ½ inch (12 mm) for quenched and tempered alloy steel, unless subpunching and reaming are required under Section 615.4.8.5.

When there are more than five thicknesses or when any of the main material is thicker than $\frac{3}{4}$ inch (20 mm) for structural carbon steel, $\frac{5}{8}$ inch (16 mm) for high-strength steel, or $\frac{1}{2}$ inch (12 mm) for quenched and tempered alloy steel, all holes shall either be subdrilled and reamed or drilled full size.

When required, all holes shall be either subpunched or subdrilled (subdrilled if thickness limitation governs) $\frac{3}{16}$ inch (5 mm) smaller and, after assembling reamed $\frac{1}{16}$ inch (2 mm) larger or drilled full size to $\frac{1}{16}$ inch (2 mm) larger than the nominal diameter of the bolts.

When shown on the plans, enlarged or slotted holes are allowed with high-strength bolts.

615.4.8.1.2-Punched Holes: The diameter of the die shall not exceed the diameter of the punch by more than $\frac{1}{16}$ inch (2 mm). If any holes must be enlarged to admit the bolts, such holes shall be reamed. Holes must be clean cut without torn or ragged edges. Do not punch holes full size in primary members. Apply these maximum thickness limits when punching: Grade 36- $\frac{3}{4}$ inch; Grade 50/50W- $\frac{5}{8}$ inch; Grade HPS 70W- $\frac{1}{2}$ inch.

615.4.8.1.3-Reamed or Drilled Holes: Shall be cylindrical, perpendicular to the member, and shall comply with the requirements of Section 615.4.8.1.1 as to size. Where practical, reamers shall be directed by mechanical means. Burrs on the outside surfaces shall be removed. Reaming and drilling shall be done with twist drills, twist reamers or rotobroach cutters. Connecting parts requiring reamed or drilled holes shall be assembled and securely held while being reamed or drilled and shall be match marked before disassembling. Parts shall not be held by welding.

615.4.8.1.4-Accuracy of Holes: Holes not more than $\frac{1}{32}$ inch (1 mm) larger in diameter than the true decimal equivalent of the nominal diameter that may result from a drill or reamer of the nominal diameter are considered acceptable. The slightly conical hole that naturally results from punching operations is considered acceptable. The width of slotted holes which are produced by thermal cutting or a combination of drilling or punching and thermal cutting shall be not more than $\frac{1}{32}$ inch (1 mm) greater than the nominal width. The thermal cut surface shall be ground smooth. Do not thermally cut holes in quenched and tempered steel.

615.4.8.2-Accuracy of Hole Group:

615.4.8.2.1-Accuracy Before Reaming: All holes punched full size, subpunched, or subdrilled shall be so accurately punched so that after assembling (before any reaming is done) a cylindrical pin $\frac{1}{8}$ inch (3 mm) smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If the requirement is not fulfilled, the improperly punched pieces will be rejected. If any hole will not pass a pin $\frac{3}{16}$ inch (5 mm) smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

615.4.8.2.2-Accuracy after Reaming: When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch (1 mm) between adjacent thickness of metal.

All steel templates shall have hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. The centerlines shall be used in locating accurately the template from the milled or scribed ends of the members.

615.4.8.3-Numerically-Controlled Drilled Field Connections: In lieu of subsized holes and reaming while assembled, or drilling holes full-size while assembled, the Contractor shall have the option to drill or punch bolt holes full-size in unassembled pieces and/or connections including templates for use with matching subsized and reamed holes by means of suitable numerically controlled (N/C) drilling or punching equipment. Full-size punched holes shall meet the requirements of Section 615.4.8.1.

If N/C drilling or punching equipment is used, the Contractor, by means of check assemblies, will be required to demonstrate the accuracy of this drilling or punching procedure in accordance with the provisions of Section 615.5.3.3.

Holes drilled or punched by N/C equipment shall be drilled or punched to appropriate size either through individual pieces, or drilled through any combination of pieces held tightly together. Pieces shall not be held by welding.

615.4.8.4-Holes for Ribbed Bolts, Turned Bolts, or Other Approved Bearing Type Bolts: All holes for ribbed bolts, turned bolts, or other approved bearing-type bolts shall be subpunched or subdrilled 3/16 inch (5 mm) smaller than the nominal diameter of the bolt and reamed when assembled, or drilled to a steel template or, after assembling, drilled from the solid at the option of the Fabricator. In any case the finished holes shall provide a driving fit.

615.4.8.5-Preparation of Field Connections: Holes in all field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames shall be subpunched or subdrilled and subsequently reamed while assembled or drilled full size to a steel template. Holes for field splices of rolled beam stringers continuous over floor beams or cross frames may be drilled full size unassembled to a steel template. All holes for floor beams or cross frames may be drilled full size unassembled to a steel template. All holes for floor beam and stringer field end connections shall be subpunched and reamed while assembled or drilled full size to a steel template. Reaming or drilling full size of field connection holes through a steel template shall be done after the template has been located with utmost care as to position and angle and firmly bolted in place. Templates used for reaming matching members, or the opposite faces of a single member, shall be exact duplicates. Templates used for connections on like parts or members shall be so accurately located that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, the fabricator may, at his option, drill holes full size with all thicknesses or material assembled in proper position.

615.4.9-Pins and Rollers:

615.4.9.1-General: Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. Pins and rollers more than 9 inches (225 mm) in diameter shall be forged rollers and annealed. Pins and rollers 9 inches (225 mm) or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than 9 inches (225 mm) in diameter, a hole not less than 2 inches in (50 mm) diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent damage by too rapid cooling, and before being annealed.

615.4.9.2-Boring Pin Holes: Pin holes shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.

The diameter of the pin hole shall not exceed that of the pin by more than 1/50 0.015 inch (500 μ m) for pins 5 inches (125 mm) or less in diameter, or by 1/32 inch (1 mm) for larger pins.

The distance outside to outside of end holes in tension members and inside to inside of end holes in compression members shall not vary from that specified more than 1/32 inch (1 mm). Boring of pin holes in built-up members shall be done after the member has been assembled.

615.4.9.3-Threads for Bolts and Pins: Threads for all bolts and pins for structural steel construction shall conform to the Unified Standard Series UNC ANSI B1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 1-3/8 inches (36 mm) or more shall be threaded six threads to the inch (25 mm).

615.4.10-Eyebars: Pin holes may be thermal cut at least 2 inches (50 mm) smaller in diameter than the finished pin diameter. All eyebars that are to be placed side by side in the structure shall be securely fastened together in the order that they will be placed on the pin and bored at both ends while so clamped. Eyebars shall be packed and match-marked for shipment and erection. All identifying marks shall be stamped with steel stencils on the edge of one head of each member after fabrication is completed so as to be visible when the bars are nested in place on the structure. Steel die stamps shall be low stress type.

The eyebars shall be straight and free from twists and the pin holes shall be accurately located on the centerline of the bar. The inclination of any bar to the plane of the truss shall not 0.5 percent.

The edges of eyebars that lie between the transverse centerline of their pin holes shall be cut simultaneously with two mechanically operated torches abreast of each other, guided by a substantial template, in such a manner as to prevent distortion of the plates.

615.4.11-Annealing and Stress Relieving: Structural members which are indicated in the contract to be annealed or normalized shall have finished machining, boring, and straightening done subsequent to heat treatment. Normalizing and annealing (full annealing) shall be as defined in ASTM A941. The temperatures shall be maintained uniformly throughout the

furnace during the heating and cooling so that the temperature at no two points on the member will differ by more than 100° F (38° C) at any one time.

Members of Grades 100/100W or Grade 70W (690/690W or Grade 480W) steels shall not be annealed or normalized and shall be stress relieved only with the approval of the Engineer.

A record of each furnace charge shall identify the pieces in the charge and show the temperatures and schedule actually used. Proper instruments, including recording pyrometers, shall be provided for determining at any time the temperatures of members in the furnace. The records of the treatment operation shall be available to and meet the approval of the Engineer. The holding temperature for stress relieving Grades 100/100W and Grade 70W (690/690W and Grade 480W) steels shall not exceed 1,125° F and 1075° F (610° C and 580° C, respectively).

Members, such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together shall be stress relieved in accordance with the ANSI/AASHTO/AWS Bridge Welding Code D1.5 when required by the plans, specifications, or special provisions governing the contract.

615.4.12-Curved Girders:

615.4.12.1-General: Flanges of curved, welded girders may be cut to the radii shown on the plans or curved by applying heat as specified in the succeeding Sections providing the radii is not less than allowed by Article 10.15.2 of Division I of the AASHTO Standard Specifications for Highway Bridges.

615.4.12.2-Heat Curving Rolled Beams and Welded Girders

615.4.12.2.1-Materials: BLANK

615.4.12.2.2-Type of Heating: Beams and girders may be curved by either continuous or V-type heating as approved by the Engineer. For the continuous method, a strip or intermittent strips along the edge of the top and bottom flange shall be heated simultaneously depending on flange widths and thicknesses; the strip shall be of sufficient width and temperature to obtain the required curvature. For V-type heating, the top and bottom flanges shall be heated in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange; the spacing and temperature shall be as required to obtain the required curvature, and heating shall progress along the top and bottom flange at approximately the same rate.

For V-type heating, the apex of the truncated triangular area applied to the inside flange surface shall terminate just before the juncture of the web and the flange is reached. To avoid unnecessary web distortion, special care shall be taken when heating the inside flange surfaces (the surfaces that intersect the web) so that heat is not applied directly to the web. When the radius of curvature is 1,000 feet (300 m) or more, the apex of the truncated triangular heating pattern applied to the outside flange surface shall extend to the juncture of the flange and web. When the radius of curvature is less than 1,000 feet (300 m), the apex of the truncated triangle heating pattern applied to the outside flange surface shall extend past the web for a distance equal to one-eighth of the flange or 3 inches (75 mm), whichever is less. The truncated triangular pattern shall have an included angle of approximately 15 to 30 degrees, but the base of the triangle shall not exceed 10 inches (250

mm). Variations in the patterns prescribed above may be made with the approval of the Engineer.

For both types of heating, the flange edges to be heated are those that will be on the inside of the horizontal curve after cooling. Heating both inside and outside flange surfaces is only mandatory when the flange thickness is 1¼ inches (32 mm) or greater, in which case, the two surfaces shall be heated concurrently. The maximum temperature shall be prescribed as follows.

615.4.12.2.3-Temperature: Bring the steel within the planned temperature as rapidly as possible without overheating. The heat-curving operation shall be conducted in such a manner that the temperature of the steel does not exceed 1200° F for grade 36 and grade 50 steel, and 1100° F for grades HPS 70W and HPS 100/100W steel as measured by temperature indicating crayons, pyrometers, or infrared non-contact thermometers. Measure the temperature 5-10 seconds after the heating flame leaves the area to be tested. The girder shall not be artificially cooled until after naturally cooling to 600° F. Cooling with dry compressed air after the steel has cooled to below 600° F is permitted. Do not cool the steel with water or mist. Allow steel to cool below 250° F before applying another set of heating patterns. Do not handle, support, or load the member in a manner that causes material to yield without the application of heat.

615.4.12.2.4-Position for Heating: The girder may be heat-curved with the web in either a vertical or a horizontal position. If the radius is less than 1000 feet, heat curve only with the web in the horizontal position or preload to induce stress prior to heating. Do not heat curve portions of members where the required radius of curvature is less than 1000 feet and the flange width exceeds 30 inches. When curved in the vertical position, the girder must be braced or supported in such a manner that the tendency of the girder to deflect laterally during the heat-curving process will not cause the girder to overturn.

When curved in the horizontal position, the girder must be supported near its ends and at intermediate points, if required, to obtain a uniform curvature; the bending stress in the flanges due to the dead weight of the girder must not exceed the usual allowable design stress. When the girder is positioned horizontally for heating, intermediate safety catch blocks must be maintained at the mid-length of the girder within 2 inches (50 mm) of the flanges at all times during the heating process to guard against a sudden sag due to plastic flange buckling.

615.4.12.2.5-Sequence of Operations: The girder shall be heat-curved in the fabrication shop before it is painted. The heat curving operation may be conducted either before or after all the required welding of transverse intermediate stiffeners is completed. However, unless provisions are made for girder shrinkage, connection plates and bearing stiffeners shall be located and attached after heat curving. If longitudinal stiffeners are required, they shall be heat-curved or oxygen-cut separately and then welded to the curved girder. When cover plates are to be attached to rolled beams, they may be attached before heat curving if the total thickness of one flange and cover plate is less than 2½ inches (37.5 mm) and the radius of the curvature is greater than 1,000 feet (30 meters). For other rolled beams with cover plates, the beams must be heat-curved before the cover plates are attached; cover plates must be either heat curved or oxygen-cut separately and then welded to the curved beam.

615.4.12.2.6-Camber: Girders shall be cambered before heat curving. Camber for rolled beams may be obtained by heat-cambering methods approved by the Engineer. For plate girders, the web shall be cut to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat curving. However, subject to the approval of the Engineer, moderate deviations from specified camber may be corrected by a carefully supervised application of heat.

615.4.12.2.7-Measurement of Curvature and Camber: Horizontal curvature and vertical camber shall be measured for final acceptance after all welding and heating operations are completed and the flanges have cooled to a uniform temperature. Horizontal curvature shall be checked with the girder in the vertical position.

615.4.13-BLANK

615.4.14-Full Size Tests: When full size tests of fabricated structural members or eyebars are required by the contract, the Contractor shall provide suitable facilities, material, supervision, and labor necessary for making and recording the required tests. The members tested in accordance with the contract shall be paid for in accordance with Section 615.7.2.

615.4.15-Marking and Shipping: Each member shall be painted or marked with an erection mark for identification and an erection diagram showing these marks shall be furnished to the Engineer.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements, and erection diagrams as the Engineer may direct. The weights of the individual members shall be shown on the statements. Members weighing more than 3 tons (2.75 Mg) shall have the weights marked thereon. Structural members shall be loaded on trucks or railcars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

High strength bolts, nuts, and washers shall be packaged as required by Section 709.24.9.1. Pins and small parts shall be shipped in boxes, crates, kegs, or barrels, but the gross weight of any package shall not exceed 300 pounds (136 kg). A list and description of the contained material shall be plainly marked on the outside of each shipping container.

615.5-ASSEMBLY:

615.5.1-Bolting: Surfaces of metal in contact shall be clean before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together before drilling, reaming, or bolting is commenced. Assembled pieces shall be taken apart for the removal of burrs and shavings produced by the operation. The member shall be free from twists, bends and other deformation.

The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal.

615.5.2-Welded Connections: Surfaces and edges to be welded shall be smooth, uniform, clean and free of defects which would adversely affect the quality of the weld. Edge preparation shall be done in accordance with ANSI/AASHTO/AWS Bridge Welding Code D1.5.

615.5.3-Preassembly of Field Connections:

615.5.3.1-General: Field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers and rigid frames shall be preassemblies prior to erection to verify the geometry of the completed structure of unit and to verify or prepare field splices. Attaining accurate geometry is the responsibility of the Contractor and they shall propose and appropriate method of preassembly and submit the plan to the Engineer. The method and details of preassembly shall be consistent with the erection procedure shown on the erection plans and camber diagrams prepared by the Contractor and submitted to the Engineer. Receipt of plans, drawings and calculations does not constitute review or approval or relieve the contractor of their responsibility to satisfactorily design the erection plan. As a minimum, the preassembly procedure shall consist of assembling three contiguous panels accurately adjusted for line and camber.

Successive assemblies shall consist of at least one section or panel of the previous assembly (repositioned if necessary and adequately pinned to assure accurate alignment) plus two or more sections or panels added at the advancing end. In the case of structures longer than 150 feet (45 meters), each assembly shall be not less than 150 feet (45 meters) long regardless of the length of individual continuous panels or sections. At the option of the fabricator, sequence of assembly may start from any location in the structure and proceed in one or both directions so long as the preceding requirements are satisfied.

615.5.3.2-Bolted Connections: For bolted connections, holes shall be prepared as outlined in Section 615.4.8. Where specified by the contract documents, major components shall be assembled with milled ends of compression members in full bearing and then shall have their subsized holes reamed to the specified size while the connections are assembled.

615.5.3.3-Check Assembly-Numerically Controlled Drilling: When the Contractor elects to use numerically controlled drilling, a check assembly shall be required for each major structural type, unless otherwise designated on the plans or in the special provisions, and shall consist of at least three contiguous shop sections or, in a truss, all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices). Check assemblies should be based on the proposed order of erection, joints in bearing, special complex points, and similar considerations. Special points could be the portals of skewed trusses, for example. More than one check assembly may be required by the Engineer.

The check assemblies shall include the first sections of each major structural type to be fabricated and additional assemblies as required by the Engineer.

Shop assemblies other than the check assemblies will not be required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required by the Engineer for which there shall be no additional cost to the Division.

615.5.3.4-Field Welded Connections: For field welded connections the fit of members including the proper space between abutting surfaces shall be prepared and verified with the segment preassembled in accordance with Section 615.5.3.1.

615.5.3.5-Assembly Verification: Each assembly, including camber, alignment, accuracy of holes, and fit of milled or field welded joints, shall be approved by the Engineer before reaming or drilling is commenced or before an N/C drilled check assembly or field welded assembly is dismantled.

615.5.4-Match Marking: Connecting parts preassembled in the shop to assure proper fit in the field shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

615.5.5-Connections Using Unfinished, Turned or Ribbed Bolts:

615.5.5.1-General: When unfinished bolts are specified, the bolts shall be unfinished, turned, or ribbed bolts, conforming to the requirements of Grade A Bolts of the Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners, ASTM A 307. Bolts shall have single self-locking nuts or double nuts unless otherwise shown on the plans or in the Special Provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis. The requirements of this Section do not pertain to the use of high-strength bolts. Bolted connections using high-strength bolts shall conform to Section 615.5.6.

615.5.5.2-Turned Bolts: The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed with bolts furnished to provide for a tight driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

615.5.5.3-Ribbed Bolts: The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch (2 mm) greater than the nominal diameter specified for the bolts.

Ribbed bolts shall be furnished with round heads conforming to ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement.

615.5.6-Connections Using High-Strength Bolts:

615.5.6.1-General: This specification covers the assembly of structural connections using high-strength bolts and nuts with hardened washers where initial tension in the bolt produces friction on the contact surfaces of the connected pieces sufficient in magnitude to resist shear.

615.5.6.2-Bolted Parts: Surfaces of bolted parts in contact with the bolt head and nut shall not have a slope of more than 1 to 20 with respect to a plane normal to the bolt axis.

Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Holes may be punched, subpunched, reamed or drilled and shall be of nominal diameter not more than 1/16 inch (2 mm) in excess of the nominal bolt diameter.

When assembled, all joint surfaces, including those adjacent to the washers, shall be free of dirt, oil, loose scale, burrs, pits, and other defects that would prevent solid seating of the parts. All bolted surfaces shall be painted in accordance with Section 688.

615.5.6.3-Installation: Fasteners shall be protected from dirt and moisture at the job site. Only the fasteners anticipated to be installed and tightened during a work shift shall be removed from protected storage. Fasteners not used shall be returned to protected storage at the end of the shift. Lot identification of all components shall be maintained at all times. Galvanized and zinc coated nuts shall be checked to verify that a visible lubricant is on the threads and nut faces. Fasteners shall not be cleaned of lubricant that is present in the delivered condition. Where galvanized fasteners must be tensioned by turning the bolt head, a visible lubricant that meets the requirements of AASHTO M 164, shall be applied to the washer that will be placed under the bolt head. The lubricant may be applied to the washer by the manufacturer prior to shipment, by the fabricator at the fabrication shop, or by the erector in the field. Fasteners which have accumulated rust, dirt or have been wet, shall be cleaned and relubricated, prior to installation. Bolt, nut and washer combinations as installed shall be from the same rotational-capacity lot.

A tension measuring device and torque wrench, suitable to the Engineer, shall be provided and maintained by the Contractor at all job sites where high-strength fasteners are being installed. The tension measuring device shall be used to confirm: (1) the suitability to satisfy the requirement of Table 615.5.6.3 A of the completed fastener assembly, including lubricant, to be used in the work, (2) rotational capacity testing requirements, and (3) that the bolting crew understands proper installation procedures. The tension measuring device and torque wrench shall be calibrated by an approved testing agency at least yearly. Documentation of calibration shall be provided to the Engineer.

Immediately prior to installation in the fabrication shop or on the project site, all high-strength fasteners shall be subjected to rotational-capacity testing by the fabricator or the contractor. Testing shall be in accordance with Section 709.24.5 and shall be conducted at a frequency of two assemblies per rotational-capacity lot number as identified on the shipping containers. Test results shall meet the requirements of Section 709.24.5. When fasteners have been cleaned and relubricated, the rotational-capacity testing, on the affected fasteners, shall be reconducted. The Engineer may request additional tests as necessary to provide assurance of product compliance.

Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening. A flat washer may be used when the abutting surface adjacent to the bolt head or nut does not have a slope of more than 1 to 20 with respect to a plane normal to the bolt axis, a smooth beveled washer shall be used to compensate for the lack of parallelism.

The threaded end of bolts shall be placed on the inside, where practicable, to protect them from the weather.

All fasteners shall be tightened to give at least the required minimum bolt tension shown in Table 615.5.6.3 A on completion of the joint. Tightening shall be done by the Turn-of-Nut Method.

TABLE 615.5.6.3 A

FASTENER TENSION {ENGLISH}	
Bolt Size (inches)	Required Minimum Fastener Tension (kips)
½	12
5/8	19
¾	28
7/8	39
1	51
1-1/8	56
1¼	71
1-3/8	85
1½	103

TABLE 615.5.6.3 A

FASTENER TENSION {METRIC}	
Bolt Size (mm)	Required Minimum Fastener Tension (kN)
M16	91
M20	142
M22	176
M24	205
M27	276
M30	326
M36	475

Impact wrenches shall be of adequate capacity and sufficiently supplied with air to perform the required tightening in approximately 10 seconds. Tightening may be done by turning the bolt while the nut is prevented from rotating when it is impractical to turn the nut.

A representative sample of not less than three bolt, nut and washer assemblies of each diameter, length, and grade to be used in the work shall be checked at the start of work, by the contractor, in a device capable of indicating bolt tension. The test shall demonstrate that the method for estimating snug tight condition, and controlling the turns from snug tight to be used by the bolting crew will develop a tension at least 5 percent greater than the tension required by Table 615.5.6.3 A. All additional fasteners (bolts, nuts, and washers) necessary for inspection and testing shall be provided by the Contractor as required by Section 105.5.

Bolts shall be installed in all holes of the connection and brought to "snug tight" condition. Snug tight is defined as that tightness which exists when the plies of the joint

are in firm contact and a tension is induced in the bolts of approximately 40-50 percent of the required tension specified in Table 615.5.6.3 A.

Snug tightening shall progress systematically from the most rigid part of the connection to the free edge, and then the bolts of the connection shall be again retightened to snug tight in a similar systematic manner until all bolts are simultaneously snug tight and the connection is fully compacted. Following this initial operation, all bolts in the connection shall be tightened further by the applicable amount of rotation in Table 615.5.6.3 B. During the tightening operation, there shall be no rotation of the part not turned by the wrench. Tightening shall progress systematically from the most rigid part of the joint to its free edges.

TABLE 615.5.6.3 B

NUT ROTATION FROM SNUG TIGHT CONDITION^{a, b}			
Disposition Of Outer Faces Of Bolted Parts			
Bolt Length in Diameters (measured from underside of head to end of bolt)	Both faces normal to bolt axis	One face normal to bolt axis other face sloped not more than 1:20 (bevel washers not used)	Both faces sloped not more than 1:20 from normal to bolt axis (bevel washers not used)
Up to & including 4	1/3 turn	½ turn	2/3 turn
Over 4 but not exceeding 8	½ turn	2/3 turn	5/6 turn
Over 8 but not exceeding 12^c	2/3 turn	5/6 turn	1 turn

- a. Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by ½ turn and less, the tolerance shall be plus or minus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance shall be plus or minus 45 degrees.
- b. Applicable only to connections in which all material within the grip of the bolt is steel.
- c. No research or testing has been performed to establish the Turn-of-Nut procedure for bolt lengths exceeding 12 diameters. Therefore, the required rotation must be determined by the Contractor by actual test in a suitable tension measuring device which simulates conditions of solidly fitted steel. Testing is subject to approval by the Engineer

615.5.6.4-Inspection: The Engineer will determine the following requirements are met in the work.

Before the installation of fasteners in the work, the Engineer will check the markings, lot identifications, surface condition and lubrication, storage of all bolts, nuts and washers and the faying surfaces of joints for compliance with requirements of Sections 615.3.2, 615.5.6.2, 615.5.6.3 and 709.24.9. The Engineer will observe calibration and testing procedures required in Section 615.5.6.3 to confirm the procedure is properly used and, when so used with the fastener assemblies supplied, the tensions specified in Table 615.5.6.3 A are provided. The Engineer will observe the installation of fasteners in the work to assure the procedure, as demonstrated in the initial testing to provide specified tension, is routinely properly applied. Bolts installed by the turn-of-nut method may reach

tensions substantially above the values given in Table 615.5.6.3 A, but this shall not be cause for rejection.

615.5.7-Welding: Fabrication of welded members, welding, welder qualifications, prequalification of weld details and inspection of welds shall conform to the requirements of the ANSI/AASHTO/AWS Bridge Welding Code D1.5. Ultrasonic testing (UT) may be used for nondestructive testing of butt welded joints in lieu of radiographic testing (RT) at the Contractor's option.

No field welding is permitted unless shown on the plans or approved by the Engineer.

Exercise caution while making field or shop welds while an elastomeric bearing pad is in contact with the steel. In no case shall the elastomer or elastomer band be exposed to instantaneous temperatures greater than 400 degrees F. Any damage to the elastomeric bearing due to welding will be cause for rejection. The temperature shall be monitored by heat crayons furnished by the Contractor.

Brackets, clips, shipping devices or other material not required by the plans or Special Provisions shall not be welded or tacked to any member unless shown on the shop drawings and approved by the Engineer.

All of the above requirements apply equally to both shop and field welding operations.

615.6-ERECTION:

615.6.1-General: The Contractor shall provide all tools, machinery, and equipment necessary to erect the structure. The Contractor shall submit to the Engineer, plans for falsework or for changes in the existing structure necessary for maintaining traffic prior to commencing work. The falsework shall be properly designed and substantially constructed and maintained for the loads which will come upon it (see 615.2.1). Submission of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility. In addition to the above, the Contractor's West Virginia Registered Professional Engineer shall certify to the Engineer that the falsework system has been assembled according to the falsework drawings, prior to placing loads on the falsework.

615.6.2-Handling and Storing Materials: Material to be stored at the job site shall be placed on skids above the ground. It shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection. If the contract is for erection only, the Contractor shall check the material against the shipping lists and report promptly in writing any shortage or damaged discovered. The Contractor shall be responsible for the loss of any material while in their care, or for any damage caused to it after being received by the Contractor.

615.6.3-Bearings and Anchorage's: Masonry bearing plates shall not be placed upon bridge-seat bearings which are improperly finished, deformed, or irregular. Bearing plates shall be set level in exact position and shall have a full and even bearing upon the masonry. Preformed fabric pads, of the thickness shown on the Plans, shall be placed between the bearings and the masonry. The preformed fabric pads or other material when specified, shall be included in the price bid for structural steel.

The Contractor shall drill the holes and set the anchor bolts, except where the bolts are built into the masonry. The bolts shall be set accurately and fixed with Portland cement grout completely filling the holes. The location of anchor bolts in relation to the slotted holes in the expansion shoes shall correspond with the temperature at the time of erection. The nuts or anchor bolts at the expansion ends of spans shall be adjusted to permit the free movement of the span.

615.6.4-Erection Procedure:

615.6.4.1-Conformance to Drawings: The erection procedure shall conform to the erection drawings submitted in accordance with Section 615.2.1. Any modifications to or deviations from this erection procedure shall require revised drawings and verification of stresses and geometry by the Contractor's registered West Virginia Professional Engineer. The proposed revisions shall be approved by a West Virginia Registered Professional Engineer.

615.6.4.2-Erection Stresses: Any erection stresses that are induced in the structure as a result of the use of a method of erection or equipment which differs from that shown on the plans or specified, and which will remain in the finished structure as locked-in stresses shall be accounted for by the Contractor. The Contractor may provide additional material at their expense to keep both temporary and final stresses within the allowable limits used in design.

The Contractor will be responsible for providing temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.

615.6.4.3-Maintaining Alignment and Camber: During erection the Contractor will be responsible for supporting segments of the structure in a manner that will produce the proper alignment and camber in the completed structure. Cross frames and diagonal bracing shall be installed as necessary during the erection process to provide stability and assure correct geometry. Temporary bracing, if necessary at any stage of erection, shall be provided by the Contractor.

615.6.5-Field Assembly: The parts shall be accurately assembled as shown on the plans or erection drawings, and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken, or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have all holes filled with high strength bolts before snug tightening begins. Snug tightening and final tightening shall be in accordance with Section 615.5.6.3.

Fitting-up bolts may be the same high-strength bolts used in the installation provided all requirements of Section 615.5.6 are strictly adhered to. If other fitting-up bolts are used they shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 1/32 inch (1 mm) larger.

615.6.6-Pin Connections: Pilot and driving nuts shall be used in driving pins. They shall be furnished by the Contractor without charge. Pins shall be so driven that the members will

take full bearing. Pin nuts shall be screwed up tight and the threads burred at the face of the nut with a pointed tool.

615.6.7-Misfits: The correction of minor misfits involving minor amounts of reaming will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

The Contractor shall be responsible for all misfits, errors, and damage and shall make the necessary corrections and replacements. The Engineer's approval shall be obtained by the Contractor before any reaming of holes or other corrections are undertaken.

615.6.8-Removal of Falsework and Cleaning Up of Site: Upon completion of the erection and before final acceptance, the Contractor shall remove all falsework, excavated or useless materials, rubbish, and temporary buildings, shall restore, in an acceptable manner, all property which may have been damaged during the prosecution of the work, and shall leave the structure site and adjacent highway in a neat and presentable condition, satisfactory to the Engineer. All falsework or other obstructions placed in stream beds shall be removed by the Contractor.

615.6.9-Final Cleaning of Weathering Steel Bridges: Upon completion of all concrete curing operations, the contractor shall clean all steel surfaces to remove all grease, oil, concrete residue, dirt, and other foreign substances to the satisfaction of the Engineer.

Cleaning may be by high pressure water, powered or hand wire brushing, or by Brush off Blast Cleaning according to SSPC-SP 7. Cleaning shall be followed by a clean water rinse to remove all residues of detergents and cleaners if they were used. All grease and oil shall be removed prior to the clean water rinse by solvent cleaning.

Do not use acids to remove stains.

Areas of the shop applied paint system which are damaged during erection and high strength bolted connection areas that were only prime painted shall be properly cleaned and painted according to Section 688 of the Standard Specification, Painting Steel Structures, and to the satisfaction of the Engineer.

After completion of all tightening operation, mechanical galvanized fasteners shall be solvent cleaned and field painted as specified for the structural steel.

For integral or semi-integral abutment structures, the crevice/interface between the embedded steel and the concrete shall be suitably chamfered to provide for placement of a sealant. Sealant material shall meet the requirements of ASTM C920, Type S, Grade NS, Class 25, Uses NT and M. Sealant shall be suitable for bonding between concrete and the top coat of the specified paint system. Acid-cure sealants shall not be permitted.

615.7-MEASUREMENT AND PAYMENT:

615.7.1-General: Structural steel will be measured on a lump sum basis or on a pound (kilogram) basis, as required by the terms of the Contract, but it will be on a lump sum basis unless stipulated otherwise on the Plans.

Under contracts containing an item for structural steel, all metal parts, other than metal reinforcement for concrete, such as anchor bolts, nuts, shoes, rockers, rollers, bearing, and slab plate, pins and nuts, bolts embedded in concrete cradles and brackets, railing and railing posts, waterstops, preformed fabric or other type of bearing pads, and roadway drainage system when

this material is connected to the metal work, will be paid for as structural steel unless otherwise noted, stipulated, or listed as separate pay items.

Steel grid flooring will be measured and paid for as structural steel only if noted on the Plans.

615.7.2-Lump Sum Contracts: In the case of a lump sum bid, it shall be the Contractor's responsibility to determine the weight on which he bases his bid, for the weight of structural steel shown on the Plans is approximate only. In the event of discrepancy between the Plan weight and the actual weight, no increase or decrease in the Contract lump sum price bid for the item will be made on account of such discrepancy.

615.7.3-Pound Price Contracts:

615.7.3.1-General: The payment in pound-price contracts will be based on the computed net weight of metal in the fabricated and erected structures, or on certified scale weights when so specified on the Plans. The weight of temporary erection bolts, drift pins, shop and field paint, boxes, crates and other containers used for shipping, and materials used for supporting members during transportation and erection will not be included.

615.7.3.2-Computed Weights Net: The weight of the metal work to be paid for under the Contract for structural steel will be computed on the following basis:

	Unit Weights Per Cubic Foot	Unit Kg Per Cubic Meter
Aluminum cast or wrought	173.0	2772
Bronze, cast	536.0	8586
Copper-alloy	536.0	8586
Copper sheet	558.0	8938
Iron, cast	445.0	7128
Iron, malleable	470.0	7529
Iron, wrought	487.0	7801
Lead, sheet	707.0	11 325
Steel: rolled, cast, copper bearing, silicon, nickel and stainless	490.0	7849
Zinc	450.0	7208

- i. The weights of rolled shapes will be computed on the basis of their nominal weights per foot (meter) as shown on the drawings or listed in the handbooks. The weights of plates will be computed on the basis of the nominal weight of the width and thickness as shown on the drawings, plus an estimated overrun computed as one-half of the "Permissible Variation in Thickness and Weight" as tabulated in AASHTO M160.
- ii. The weights of castings will be computed from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight will be added five percent allowance for fillets and overrun. Scale weights may be substituted for computed weights in the case of castings or of small complex parts for which accurate computations of weight would be difficult.
- iii. For members comprising both carbon steel and other special steel or material, when separate unit prices are provided for such members, the weight of each class of steel in each such member will be separately computed and paid for at the Contract unit price.

- iv. In computing pay weight on the basis of computed net weight, the following additional stipulations will apply:

The weight of all high-strength bolt heads, nuts, single washers and thread stick-throughs, both field and shop, will be included on the basis of Table 615.7.3.2.

TABLE 615.7.3.2 {ENGLISH}

Nominal Diameter of High-Strength Bolt in Inches	Weight Per 100 Units In Lb
	Bolt Head, Nut, One Washer and Stick-Through
½	22
1/8	33
¾	55
7/8	84
1	120
1-1/8	169
1¼	216

TABLE 615.7.3.2 {METRIC}

Nominal Diameter of High-Strength Bolt in Millimeters	Weight Per 100 Units in kg
	Bolt Head, Nut, One Washer and Stick-Through
M16	15.1
M20	26.2
M22	37.7
M24	51.4
M27	72.4
M30	92.6

The weight of weld metal will be computed on the basis of the theoretical volume from dimensions of the welds.

615.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the material and doing all the work herein prescribed in a workmanlike and acceptable manner including all labor, tools, equipment, supplies, falsework, painting, and incidentals necessary to complete the work.

615.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
615001-*	Steel Superstructure	Lump Sum
615002-*	Prefabricated Steel Bridge Superstructure	Lump Sum
615003-*	Fabricated Structural Steel	Lump Sum
615004-*	Fabricated Structural Steel	Pound (Kilogram)

* Sequence number

SECTION 616 PILING

616.1-DESCRIPTION:

This work shall consist of furnishing and driving concrete, or steel bearing piles, of the kind and dimensions designated, to the required bearing or penetration in accordance with these Specifications and in reasonably close conformity with the lines and spacing shown on the Plans or established by the Engineer.

616.2-MATERIALS:

Materials shall conform to the requirements specified in the following sections/subsections:

MATERIAL	SUBSECTION
Precast Concrete Piles	601
Prestressed Concrete Piles	603
Steel Bearing Piles and Splices*	709.12
Steel Pile Points	709.50

* The piling section shall be of the H form and with total flange width substantially equal to the depth of the section. No section shall have a thickness of metal less than 0.4 inches (10 mm), nor a depth less than 8 inches (200 mm).

CONSTRUCTION METHODS

616.3-PREPARATION FOR DRIVING:

616.3.1-General: Piles shall not be driven until required excavation or embankment is completed. Material forced up between the piles shall be removed to correct elevation, without cost to the Division, before concrete for the foundation is placed.

616.3.2-Caps: The heads of all concrete piles shall be protected by caps of approved design, preferably having a rope or other suitable cushion net to the pile head, and fitting into a casting which, in turn, supports a timber shock block when the nature of the driving is such as to unduly injure them. A cast or structural steel cap or driving head shall be used for driving steel piles, if required, to keep the pile heads from upsetting excessively under hard driving conditions.

616.4-EQUIPMENT FOR DRIVING:

616.4.1-General: When a steam or air hammer is used for driving any type of piles, both the volume and pressure of steam or air recommended by the manufacturer of the hammer, as well as the rated number of strokes per minute, shall be maintained at all times to insure full energy of the driving blows.

Before pile driving is started, the Contractor shall provide written certification to the Engineer that the pile hammer, air compressors, and air valves have been inspected and found to be in good working condition.

In case the required penetration is not obtained by the use of a hammer complying with the minimum requirements in 616.4.2 and 616.4.3, the Contractor shall provide a heavier hammer or resort to jetting at their own expense, unless jetting is specifically prohibited.

616.4.2-Hammers for Steel Piles: Gravity hammers for driving steel piles shall weigh not less than 2,000 and 3,000 lb. (907 to 1 360 kg) respectively, and in no case shall the weight of the hammer be less than the combined weight of the driving head and pile, unless noted otherwise on the Plans. The fall shall be so regulated as to avoid injury to the piles and in no case shall exceed 15 ft. (4.5 m).

Steam or air hammers used for driving steel piles shall develop an energy per blow, at each full stroke of the piston, of not less than 12,000 ft.-lb. (16.3 kJ) unless noted otherwise on the Plans.

616.4.3-Hammers for Concrete Piles: Steam or air hammers used for driving precast concrete piles with a mandrel shall develop an energy per blow, at each full stroke of the piston, of not less than 15,000 ft.-lb. (20.3 kJ) or not less than one foot-pound for each pound of weight driven.

616.4.4-Leads: Pile driver leads shall be constructed in such a manner as to afford freedom of movement to the hammer, and they shall be held in position by guys or still braces to insure firm support to the pile during driving to the lowest point the hammer must reach.

616.4.5-Water Jets: When water jets are used, the numbers of jets and the volume and pressure of water at the jet nozzles shall be sufficient to freely erode the material adjacent to the piles. The plant shall have sufficient capacity to deliver at all times at least 100 psi (689 kPa) pressure at two $\frac{3}{4}$ inch (19 mm) jet nozzles.

616.5-METHOD OF DRIVING:

Precast concrete piles shall be driven by means of a combination of steam or air hammer and water jet, but the water jet may be omitted if approved by the Engineer. Other piles shall preferably be driven with an approved steam or air hammer, an approved diesel hammer, or a combination of these hammers, and water jet, except that jetting of steel piles will not be permitted unless special written permission of the Engineer is obtained. The jets, if used, shall be withdrawn before the desired penetration is reached, and the piles shall be driven with the hammer to secure the final penetration.

Pile driver leads shall be used in driving unless otherwise directed by the Engineer in writing. Underwater hammers may be used only when held in rigid leads extending to the full depth.

616.6-ACCURACY OF DRIVING:

All piles shall be driven with a variation of not more than 2% from the vertical or from the batter line indicated. The plan elevation for cut off shall be measured from the lowest point of the pile head with a maximum deviation of 2 inches (50 mm) above plan cut off providing this deviation does not interfere with other construction requirements. The cut off shall be made at right angles to the pile. The concrete cover from the face of the concrete to any face of the pile shall not be less than 9 inches (225 mm) except on the side the pile penetrates the structure. Additional concrete cover may be monolithically added to the structure to maintain the minimum 9 inches (225 mm) cover at no cost to the Division.

616.6.1-Foundations: The location in plan for piles in foundations may have a maximum deviation of 6 inches (150 mm) from that shown in the contract documents except as provided in 616.6.2.

616.6.2-Abutments with Single Lines of Piles: The location in plan for piles in an abutment with a single line of piles may have a maximum deviation of 3 inches (75 mm) from that shown in the contract documents.

616.6.3-Combination Pile and Trestle Bents: The location of the top of a combination pile and trestle bent may have a maximum plan deviation of 1 1/2 inches (38 mm).

616.7-DEFECTIVE PILES:

The procedure incident to the driving of piles shall not subject them to excessive and undue abuse producing crushing and spalling of concrete or deformation of the steel. Any pile driven out of its proper location or any pile damaged by reason of internal defects or by improper driving shall be removed or, at the option of the Engineer, a second pile may be driven adjacent thereto if this can be done without detriment to the structure. All piles so driven shall be at the expense of the Contractor.

616.8-DETERMINATION OF BEARING VALUES:

616.8.1-Loading Tests: When required, the size and number of piles shall be determined by actual loading tests. In general, these tests shall consist of the application of a test load placed upon a suitable platform supported by the pile, together with suitable apparatus for accurately measuring the load and the settlement of the pile under each increment of load. The safe allowable load shall be considered at 50% of that load which produces a permanent settlement not greater than 3 inches (75 mm), measured at the top of the pile, after 48 hours of application. This maximum settlement shall not be increased by a continuous application of the test load for a period of 60 hours. In general, one pile for each group of 100 piles shall be tested.

616.8.2-From Blow Count at Refusal: The size of piles, energy rating of hammer, and design load will be designated on the Plans. All piles shall be driven to refusal into the foundation strata as indicated by the estimated pile lengths or pile tip elevations. Refusal is defined as the equivalent of 20 blows for 1 inch (25 mm) of penetration with a power hammer developing the minimum designated foot pounds per blow. The minimum number of blows in the last inch of penetration shall be as specified on the Plans. If a larger hammer is used, the Engineer will specify the blow count to determine refusal.

616.9-PRECAST CONCRETE PILES:

616.9.1-General: Precast concrete piles shall be constructed in accordance with the size, shape, and reinforcement, shown on the Plans.

Class B concrete shall be used, and the applicable provisions of 601 shall govern.

616.9.2-Formwork: Forms for precast concrete piles shall conform to the general requirements for concrete form work as provided in 601. Forms shall be accessible for tamping and consolidation of the concrete. Under good weather conditions, side forms may be removed

24 hours after placing concrete, but the entire pile shall remain supported for at least seven days and shall not be subjected to any handling stress until the concrete has set for at least 14 days or for a longer period in cold weather, according to the judgment of the Engineer. Where control cylinders are made, bottom forms may be removed when the concrete has developed a compressive strength of 2,000 psi (14 MPa).

616.9.3-Placing and Finishing: Piling may be cast in either a vertical or horizontal position. Special care shall be taken to consolidate the concrete around the reinforcement and to avoid the formation of stone pockets, honeycomb, or other such defects. To secure uniformity and remove surplus water, the concrete in each pile shall be placed continuously and shall be compacted by vibrating or by other means satisfactory to the Engineer. The forms shall be overfilled, the surplus concrete screeded off, and the top surfaces finished to uniform, even texture similar to that produced by the forms.

As soon as the forms are removed, concrete piles shall be pointed with a 1 to 2 mortar and finished. Trestle piling exposed to view shall be finished above the ground line in accordance with the provisions governing the finishing of concrete columns. Foundation piling and that portion of the trestle piling which will be below the ground surface shall not be finished except by pointing as specified.

616.9.4-Curing: Concrete piles shall be cured in accordance with the general provisions governing the curing of concrete as specified in 601. As soon as the piles have hardened sufficiently, they shall be removed from the forms and placed in a curing pile, separated from each other by wood spacing blocks. No pile shall be driven until it has cured for at least 21 days and in cold weather for a longer period as determined by the Engineer.

616.9.5-Handling: Removal of forms, curing, storing, transporting, and handling precast concrete piles shall be done in such a manner as to avoid excessive bending stresses, cracking, spalling, or other injurious results. Piles shall be lifted by means of suitable bridles or slings attached to the pile along its length. The arrangement shall be such that no stresses in excess of 12,000 (82.7 MPa) psi are developed in the reinforcement, and the maximum compressive stress in the concrete is not over 600 psi (4 Mpa) allowing 100 % of the calculated load for impact and shock.

616.10-PRESTRESSED CONCRETE PILES:

Prestressed concrete piles shall conform to the requirements of 603.

616.11-STEEL PILING:

616.11.1-General: Steel piles shall consist of structural steel shapes of the kind and size specified. Full-length steel piles shall be used where practicable. Splicing of piles is permitted subject to the approval of the Engineer and shall be in accordance with this Specification. The number of welded connections in the length of a pile shall be preferably as few as practicable.

616.11.2-Splicing Steel Piles: If splices are made in steel piles by welding, the abutting surfaces must be true planes. The top surface of the lower pile shall be straightened if bent during the driving process or cut off (flame cutting permitted, 615.4.3.2.2) below the bent portion if it cannot be satisfactorily straightened. The bottom surface of the upper pile shall be

beveled on the inside edges of the flanges and along one edge of the web. The bevel shall be made at an angle of approximately 40° with the horizontal. A surface of 1/8 inch (3 mm) may be left unbeveled. The upper pile shall be securely clamped to the lower pile and separated there from 1/8 inch (3 mm), care being taken to make the axis of the two piles coincide. The entire periphery of the pile joint shall then be butt welded, by properly certified welders, with sufficient passes to completely fill the joint, the slag of each pass being removed before beginning the next pass.

616.11.3-Cutting off Steel Piles: Steel piles shall be cut off at the required elevation. If capping is required, the connection shall be made according to details shown on the Plans.

616.12-PREDRILLED PILING:

Holes shall be drilled or bored through the fill material to original ground or into the rock strata, when specified on the Plans, before driving the piles. The predrilled holes for H-piling shall have a diameter of approximately 85 % of the depth of the pile section when the piling is not required to penetrate into rock and shall be a minimum of 100 % of the diagonal dimension of the pile section when the piling is required to be socketed into rock. Holes for round piles may vary from 2 inches (50 mm) less to 4 inches (100 mm) more than the diameter of the pile, the exact diameter to be approved by the Engineer to produce satisfactory pile driving results.

All voids remaining after driving operations shall be filled with concrete sand or other aggregate of a size no larger than No. 8. Test requirements for this material are waived, except that the material shall be dry and free flowing in order to fill the voids around the piles to the satisfaction of the Engineer.

616.13-EXTENSIONS OR “BUILD-UPS”:

Extensions, splices or build-ups on concrete piles, when necessary and permitted by the Engineer, shall be made as follows:

After the driving is completed, the concrete at the end of the pile shall be cut away, leaving the reinforcement steel exposed for a length of 40 diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement similar to that used in the pile shall be securely fastened to the projecting steel and the necessary formwork shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to placing concrete, the top of the pile shall be thoroughly wetted and covered with a thin coating of neat cement, retempered mortar or other suitable bonding material. The forms shall remain in place not less than seven days and shall then be carefully removed and the entire exposed surface of the pile finished as specified in 616.9.3.

616.14-METHOD OF MEASUREMENT:

The number of linear feet (meters) of piles of the type specified to be paid for will be the actual length of piles remaining in the finished structure. All cut-offs remain the property of the Contractor for disposition.

Extension, splices, or “build-ups” will not be measured for payment as such, but, they will be included as footage in the length of piling remaining in the finished structure. In determining the amount to be included, no allowance will be made for cut-offs necessary to accomplish the extensions, splices, or “build-ups”.

“Pile Loading Tests” will be measured separately and will be the actual number of tested piles in place.

616.15-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work. The cost of preboring, filling of voids, splicing, and metal shoes or points shall be included in the price bid for the piles.

Loading tests will be paid for at the contract unit price for “Pile Loading Tests”, or, in the absence of such a price bid, they will be paid for as extra work.

616.16-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
616003-*	Concrete Piles	Linear Foot (Meter)
616004-*	“size” Steel Bearing Piles, Driven	Linear Foot (Meter)
616005-*	Steel Bearing Piles, Pre-Drilled and Driven	Linear Foot (Meter)
616007-*	Pile Loading Tests	Per Pile
616016-*	Sheet Piling Left In Place	Linear Foot (Meter)
616017-*	Sheet Piling, Driven	Linear Foot (Meter)

* Sequence number

SECTION 617 RAILINGS

617.1-DESCRIPTION:

This work shall consist of furnishing, constructing, and erecting a pipe railing or other fabricated metal railing of the type specified, on a bridge, wall, or other structure, in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions, and sections shown on the Plans.

617.2-MATERIALS:

Materials shall conform to the applicable requirements of Division 700.

All ferrous pipe used for railing shall be wrought iron, and fittings for pipe railing shall be in accordance with the requirements for malleable iron castings in 709.10.

Caulking compounds, for use on surfaces where aluminum is in contact with other metal except stainless steel, shall be as approved by the Engineer.

Elastomeric bearing pads shall conform to the requirements of 715.15.

Mortar for grouting anchor bolts shall be of the following proportion by weight: one part nonshrink aggregate, one part silica sand (702.1), and one part Type I cement (701.1).

CONSTRUCTION METHODS

617.3-LINE AND GRADE:

The line and grade of railing shall conform to that shown on the Plans and not follow any unevenness in the structure. All railing posts shall be vertical.

617.4-PIPE RAILING:

Pipe railing shall be built in accordance with details shown on the Plans.

617.5-FERROUS METAL RAILING:

617.5.1-Fabrication and Erection: Fabrication and erection of ferrous metal railing shall be done in accordance with the applicable requirements of 615. In the case of welded railing, all exposed joints shall be finished by grinding or filing, after welding, to provide a neat appearance.

Railings shall be carefully adjusted prior to fixing in place to insure proper matching at abutting joints and correct alignment and camber throughout their length. The railing shall be so fabricated as to allow for minor adjustments in both horizontal and vertical directions. In the bottom of the sealed end, a ½ inch (12 mm) hole for drainage shall be provided.

617.5.2-Painting: Ferrous metal railing shall be given one shop coat of paint and two coats of paint after erection. Painting shall conform to the requirements for painting metal structures in 615. No painting is required on railing or posts where galvanizing is specified on the Plans.

617.6-ALUMINUM RAILING:

617.6.1-Fabrication and Erection: Post base castings shall be accurately set and the bolts tightened to obtain full bearing on the base. Additional aluminum shims shall be furnished to permit adjustment in the field to assure compliance with the grade and alignment shown on the Plans.

Material ½ inch (12 mm) thick or less may be sheared, sawed, or milled. Material over ½ inch (12 mm) thick shall be sawed or milled. Cut edges shall be true, smooth, and free from excessive burrs or ragged breaks. Reentrant cuts shall be filleted by drilling prior to cutting. Flame cutting will not be permitted. Welding will not be permitted except as specifically called for in the Contract.

Rivet or bolt holes shall be drilled or subpunched 3/16 inch (4 mm) smaller than the nominal diameter of the fastener and reamed to size. The finished diameter of holes shall not be more than seven percent greater than nominal diameter of the fasteners. Anchor bolt holes and slotted bolt holes to take care of expansion shall be provided as called for on the Plans.

617.6.2-Protection: Where aluminum alloys, except anchor bolts, come in contact with materials other than aluminum and stainless steel, the surfaces in contact shall be protected as follows:

- i. The contact surfaces shall be thoroughly coated with a suitable caulking compound when in contact with other metals except stainless steel.
- ii. Elastomeric bearing pads shall be placed under each post. The pad shall cover the entire contact area between the post and concrete and shall be neatly trimmed to the shape of the post base. The pads shall meet the requirements of Section 715.15.

617.6.3-Finishing: After the concreting has been completed, the aluminum bridge railing shall be thoroughly cleaned, removing any accumulation of oil, grease, dirt, or other foreign materials. An approved solvent cleaner may be used. Where mechanical means are used to remove stains, grease, minor scratches, etc., the resulting finish shall be uniform in appearance over the entire tube. Tubing for a single structure shall present the same uniform finish at time of final acceptance.

Finished tubing shall be free from grease and stains, gouges, dents and burrs, and shall have a minimum of rubs, scratches, and minor extrusion marks from the dies.

617.7-GROUTING OF ANCHOR BOLTS:

Where anchor bolts for railing brackets or posts on concrete are not cast-in-place during the original pour, they shall be grouted in place with mortar as specified in 617.2

617.8-METHOD OF MEASUREMENT:

The quantities of work done will be measured by the linear foot (meter) of "Pipe Railing", "Ferrous Metal Railing", or "Aluminum Railing", as the case may be, complete in place and accepted, which will be determined by the overall length as shown on the Plans, or as authorized by the Engineer. When metal railing is used with concrete posts, the pay length for the railing will be the sum of all the net lengths between posts.

Reinforcing steel required in concrete posts for "Ferrous Metal Railing" will be measured and paid for as provided in 602.

Concrete posts for "ferrous Metal Railing" will be measured and paid for as provided in 601.

617.9-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work described in a workmanlike and acceptable manner, including all the labor, tools, equipment, supplies, and incidentals necessary to complete the work.

617.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
617001-*	Pipe Railing	Linear Foot (Meter)
617002-*	Ferrous Metal Railing	Linear Foot (Meter)
617003-*	Aluminum Railing	Linear Foot (Meter)

* Sequence number

SECTION 618

CAST BRONZE AND ROLLED COPPER-ALLOY EXPANSION PLATES

618.1-DESCRIPTION:

This work shall consist of furnishing and erecting cast bronze or rolled copper-alloy expansion plates, to be used as friction type expansion or bearing plates, in accordance with the details and dimensions shown on the Plans and in accordance with this Specification.

618.2-MATERIALS:

Materials shall conform to the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Bronze Castings for expansion Plates	709.18
Rolled Copper-Alloy Expansion Plates	709.19

CONSTRUCTION METHODS

618.3-GENERAL:

Plates shall be accurately set in position as shown on the Plans and shall have a uniform bearing over the entire area. Provisions shall be made to keep the plates in position while masonry is being placed. When finishing is indicated on the Plans or directed, the surfaces shall comply with the American Standards Association surface roughness requirements as defined in ASA B46, 1-55, ASA 125.

618.4-CAST BRONZE PLATES:

Cast bronze plates shall be cast according to details shown on the Plans. Sliding surfaces shall be planed parallel to the movement of the span and polished unless otherwise detailed.

When self-lubricated bronze plates are specified, they shall conform to 709.18 unless otherwise provided. They shall be trepanned in a geometric pattern of recesses to receive a lubricating material suitable for long-life service of the bearing face. The lubricated area shall comprise a minimum of 25 percent of the bearing face to provide a coefficient of friction for bronze on steel of approximately 10 percent for loads of 1,000 to 2,000 psi. (7 to 14 MPa). Only the sliding surfaces shall be lubricated.

618.5-ROLLED COPPER-ALLOY EXPANSION PLATES:

Rolled copper-alloy expansion plates shall be furnished according to the details shown on the Plans. Finishing of rolled plates will not be required if they have a plane true and smooth surface. If finishing is indicated on the Plans or directed, it shall be in the direction of the movement of the span.

618.6-METHOD OF MEASUREMENT:

The quantity of work done will be measured by the pound (kilogram). Unless otherwise provided, the weight to be paid for shall be the certified scale weight in pounds (kilograms) of the plates placed in the structure but not to exceed the weight as computed from the net dimensions shown on the Plans. The weight per cubic foot of cast bronze or copper-alloy plates shall be considered as 536 lb. (8.6 Mg per cubic meter).

618.7-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all materials, labor, tools, equipment, supplies, and incidentals necessary to complete the work.

618.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
618001-*	Cast Bronze Expansion Plates	Pound (Kilogram)
618002-*	Rolled Copper-Alloy Expansion Plates	Pound (Kilogram)

* Sequence number

SECTION 619 WATERPROOFING

619.1-DESCRIPTION:

This work shall consist of waterproofing concrete retaining walls, abutments, earth-filled arches, and concrete decks, either in the form of dampproofing (primers with bituminous paint coat) or membrane waterproofing (primers with bituminous membrane fabric, with or without protection course) as specified on the Plans. Dampproofing shall consist of a primer and two coats of bituminous materials. Membrane waterproofing shall consist of a primer, two layers of fabric, and three moppings of hot bituminous material. The work shall be done in accordance with the Specifications and as shown on the Plans.

619.2-MATERIALS:

The materials shall conform to the requirement of the several Subsections of Division 700 of these Specifications as follows:

MATERIAL	SUBSECTION	TYPE
Dampproofing Agent	705.4, 705.11 705.7	SS-1 or SS-1h CSS-1 or CSS-1h
Dampproofing Primer	705.4, 705.11 or 705.8	SS-1 or SS-1h CSS-1 or CSS-1h
Hot-Poured Elastic Type Concrete Joint Sealer	708.3	
Membrane Waterproofing	705.8	
Membrane Waterproofing	705.7	
Reinforcing Steel	709.3	
Waterproofing Fabric	715.8	

When the dampproofing agent is SS-1, the primer shall be SS-1 to which shall be added a maximum of 15 percent water by weight.

Membrane fabric shall be stored in a dry, protected place. The rolls shall not be stored on end.

CONSTRUCTION METHODS

619.3-PREPARATION OF SURFACE:

Before applying the primer coat, all rod holes and other voids shall be pointed, and all projections, loose material, and excess dust shall be removed from the surface.

When emulsion is used, the surface may be damp.

When asphalt is used, the surface shall be thoroughly dry. Should the surface be damp, it shall be covered with a 2 inches (150 mm) layer of hot sand which shall be allowed to remain for two hours, after which it shall be swept back, uncovering sufficient surface for beginning of work, and the operation repeated as the work progresses. For surfaces too steep to hold sand, other satisfactory methods to produce a dry surface shall be used. No waterproofing shall be done in wet weather or when the temperature is below 35° F (2° C), without written authority of the Engineer.

619.4-DAMPPROOFING:

The entire surface to be dampproofed shall be covered with the required primer by use of a mop. After this primer has been allowed to cure, two successive moppings with an asphalt cement or asphalt emulsion shall be applied. All coats shall be of uniform thickness throughout, and the total bituminous material used shall be not less than 11 gallons per 100 square feet (4.5 liters per square meter) of surface. Each coat shall be allowed to dry thoroughly before the following coat is applied.

Before dampproofing is started, all construction joints shall be waterproofed in accordance with 619.5, with fabric membranes 24 inches (600 mm) wide for the full length of the joint.

619.5-MEMBRANE WATERPROOFING:

The asphalt primer shall be heated to a temperature between 100 and 125° F (38° C and 52° C), with frequent stirring to avoid local overheating. The asphalt for waterproofing shall be heated to a temperature between 300 and 350° F (150° C and 175° C), with frequent stirring to avoid local overheating. The heating kettles shall be equipped with thermometers.

In all cases, the waterproofing shall begin at the low point of the surface to be waterproofed so that water will run over and not against or along the laps. The first strip of fabric shall be of half width, the second shall be of full width, lapped the full width of the first sheet, and the third and each succeeding strip shall be the full width and lapped so that there will be two layers of fabric at all points with three-layer lap for a distance not less than 2 inches (50 mm). All two-layer end laps shall be at least 12 inches (300 mm).

The procedure for applying primer and waterproofing with membrane fabric shall be as follows:

- i. Beginning at the low point of the surface to be waterproofed, the entire surface shall be mopped with a primer of cutback asphalt and allowed to cure.
- ii. A section slightly more than half the width of the membrane fabric and for the full length of the surface shall be mopped with an asphalt cement and a half width of the fabric pressed into place.
- iii. The half width of fabric and an adjacent section of the surface equal to slightly more than half the width of the fabric shall be mopped with an asphalt cement and a full width of fabric pressed into place, completely covering the first strip.
- iv. Slightly more than half of this second strip and an adjacent section of the concrete surface equal to slightly more than half the width of the fabric shall be mopped with an asphalt cement, and the third strip of fabric shingled on so as to lap the first strip more than 2 inches (50 mm). This process shall be continued until the entire surface is covered with two layers of fabric.
- v. The entire surface shall then be given a final mopping with an asphalt cement.

The completed waterproofing shall be firmly bonded membrane composed of two layers of fabric and three moppings of asphalt, together with a coating of primer. Under no circumstances shall one layer of fabric touch another layer at any point, or touch the surface of the structure, unless separated from that layer or surface by one coat of asphalt.

On horizontal surfaces, not less than 13 gallons of asphalt shall have been used for each 100 square feet (5 liters of asphalt shall have been used for each square meter) of finished work; and on vertical surfaces, not less than 16 gallons (6.5 liters) shall have been used. The work shall be so regulated that at the close of a day's work all fabric that is laid shall have received the final mopping of asphalt. Special care shall be taken at all laps to see that they are thoroughly sealed.

619.6-DETAILS:

At the edges of the membrane and at any point where it is punctured by drain, pipes, etc., suitable provisions shall be made to prevent water from getting between the waterproofing and the surface waterproofed. All flashing at curbs and against girders, spandrel walls, etc., shall be done with separate sheets lapping the main membrane not less, than 12 inches (300 mm) Flashing shall be closely sealed either with a metal counter flashing or by embedding the upper edges of the flashing in a groove poured full of joint sealing material.

Joints which are essentially open joints, but which are not designed to provide for expansion, shall first be caulked with oakum and leadwool and then filled with hot joint sealing material.

Expansion joints, both horizontal and vertical, shall be provided with sheet copper in "U" or "V" form, in accordance with the details shown on the plans, and shall be filled with hot joint filler sealing material. The membrane shall be carried continuously across all expansion or construction joints. At the ends of the structure, the membrane shall be carried well down on the abutments and suitable provision made for all movement.

Care shall be taken to prevent injury to the finished membrane by the passage over it of men, wheelbarrows, etc., or by throwing any material on it. Any damage which may occur shall be repaired by patching. The first layer of the membrane patch shall extend at least 12 inches (300 mm) beyond the outermost damaged portion, and the second ply shall extend at least 3 inches (75 mm) beyond the first ply.

619.7-PROTECTION COURSE:

Over the waterproofing membrane constructed as specified above, there shall be placed a protection course which shall be 3 inches (75 mm) of Class A concrete. This concrete shall be reinforced midway between its top and bottom surface with wire mesh having six inch (150 mm) openings each direction and using size # W 1.4 wire. The construction of the protection course shall immediately follow the waterproofing operations and shall conform to the applicable requirements of 601.

619.8-METHOD OF MEASUREMENT:

The quantities of work done will be measured in square yards (meters) of "Dampproofing", "Membrane Waterproofing without Protection Course", or "Membrane Waterproofing with Protection Course", as the case may be, complete in place and accented, determined from actual measurement of the work.

619.9-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

619.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
619001-*	Dampproofing	Square Yard (Meter)
619002-*	Membrane Waterproofing Without Protection Course	Square Yard (Meter)
619003-*	Membrane Waterproofing With Protection Course	Square Yard (Meter)

* Sequence number

SECTION 620

THREE-SIDED REINFORCED CONCRETE BRIDGE/CULVERT

620.1-DESCRIPTION:

This work shall consist of furnishing the design, construction plans, materials, and construction of single piece precast or cast-in-place reinforced concrete three-sided flat-topped bridge/culverts or single piece precast reinforced concrete three-sided arch-topped bridge/culverts or a two-piece precast reinforced concrete continuous arch bridge/culverts, with headwalls and wingwalls, in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown in the plans.

620.2-GENERAL:

The bridge/culvert design and detail plans for construction shall be submitted to the Engineer for approval. The time required for preparation and review of these submittals shall be charged to the allowable contract time. Delays caused by untimely submittals or insufficient data will not be considered justification for time extensions. No additional compensation will be made for any additional material, equipment, or other items found necessary to comply with the project specifications as a result of the Engineer's review.

The proposed bridge/culvert design shall be compatible with the Contractor's proposed method of construction, and shall be compatible with any method of construction shown in the plans. The Division does not assume nor warrant any bridge/culvert system's compatibility with any particular construction methods.

620.3-DESIGN CRITERIA:

620.3.1-General: The following data will be provided on the contract plans:

- a. maximum allowable headwater elevation,
- b. maximum allowable velocity through the bridge/culvert,
- c. the tailwater depth used for design,
- d. minimum required open-end area,
- e. bearing capacity to be used for the design of the foundation, at the required location,
- f. design year ADT,
- g. design year percent trucks,
- h. roadway profile and elevation
- i. For tunnels or underpass structures the division will provide the required clearance box in addition to the bearing capacity and roadway profile.

The size of all structural elements shall be determined such that the design load stresses do not exceed the allowable stresses found in the AASHTO LRFD Bridge Design Specifications, latest edition. The structural design of the two-piece precast reinforced concrete arch bridge/culverts shall provide for a structurally reinforced section at the crown/closure section such that the completed arch bridge/culvert is structurally continuous.

If parapets are used on any portion of the headwalls and wingwalls as shown in the plans, they shall be designed to resist traffic loads in accordance with the AASHTO LRFD Bridge Design Specifications, latest edition. The load shall be a HL-93 (HS25) test level 3.

The length and height of the wingwalls and headwalls must be designed to accommodate the specified fill slope without fill encroaching on the underlying streambed, waterway or edge

of roadway template. Wingwalls with a tapered bottom surface shall not be used due to compaction difficulties beneath the wingwall. Wingwall options other than cast-in-place shall only be systems that have been evaluated by HITEC.

Except those on roads with a design year ADT less than 500 and where the product of the design year percent trucks times the ADT is less than 100, all flat-topped structures with less than two feet of cover shall have approach slabs per the Divisions Structural Design Manual.

620.3.2-Precast Three-Sided Bridge/Culvert: The bridge/culvert unit dimension and reinforcement details shall be as prescribed in the plan and the shop drawings provided by the manufacturer. The minimum concrete compressive strength shall be 4000 psi (28MPa). The minimum steel yield strength shall be 60 ksi (414 MPa). The minimum required strength for form removal and handling shall be 70% of Design Strength unless otherwise specified by the Designer.

The top exterior surface shall have positive drainage with a minimum slope of 2% from the centerline of the span to the exterior corner of the structure.

Unless noted otherwise on the shop drawings and designed accordingly, a minimum of one foot of cover above the crown of the bridge/culvert unit is required in the installed condition.

620.3.2.1-Placement of Reinforcement: The cover of concrete over the outside reinforcement shall be 2 inches (50mm) minimum. The cover of concrete over the inside reinforcement shall be 1-1/2 inches (37.5mm) minimum. The clear distance of the end shall not be less than one inch (25mm) nor more than two inches (50mm) from the ends of the bridge/culvert unit. Reinforcement shall be assembled utilizing single or multiple layers of welded wire fabric, or utilizing a single layer of deformed billet-steel bars. The welded wire fabric shall be composed of circumferential and longitudinal wires meeting the spacing requirements of 620.3.2.3 and shall contain sufficient longitudinal wires extending through the unit to maintain the shape and position of the reinforcement. Longitudinal distribution reinforcement may be welded wire fabric or deformed billet-steel bars and shall meet the spacing requirements of 620.3.2.3. The ends of the longitudinal distribution reinforcement shall be not more than 3 inches (75mm) from the ends of the unit.

620.3.2.2-Bending of Reinforcement: The outside and inside circumferential reinforcing steel for the corners of the bridge/culvert unit shall be bent to such an angle that is approximately equal to the configuration of the unit's outside corner.

620.3.2.3-Laps, Welds, and Spacing: Tension splices in the circumferential reinforcement shall be made by lapping. Laps may be tack welded together for assembly purposes. For smooth welded wire fabric, the overlap shall meet the requirements of ACI 12.8 and 12.19. For deformed welded wire fabric, the overlap shall meet the requirements of ACI 12.7 and 12.18. For deformed billet-steel bars, the overlap shall meet the requirements of ACI 12.2. For splices other than tension splices, the overlap shall be a minimum of 12 inches (300mm) for welded wire fabric or deformed billet-steel bars. The spacing center-to-center of the circumferential wires in a wire fabric sheet shall be not less than 2 inches (50mm) nor more than 4 inches (100mm). For the wire fabric, the spacing center-to-center of the longitudinal wires shall not be more than 8 inches (200mm). The spacing center-to-center of the longitudinal distribution steel for either line of reinforcing in the top slab shall be not more than 16 inches (400mm).

620.3.3-Cast-In-Place Three-Sided Bridge/Culvert: Cast-in-place structures shall be constructed per section 601.

620.4-SUBMITTALS:

620.4.1-General: The Contractor shall submit complete design calculations, explanatory notes, and detail plans for the proposed bridge/culvert system. The detail plans shall include all details, dimensions, quantities, and cross sections necessary to construct the bridge/culvert and shall include but not be limited to the following items:

1. Hydraulic calculation, using Form 8-1 in the WVDOH Drainage Manual, latest edition, to determine the headwater elevation and velocity of flow for the proposed culvert, plus all supporting hydraulic calculations on separate sheets.
2. Structure span and rise.
3. Bridge/culvert section details showing all concrete dimensions and reinforcing steel requirements.
4. Design computations and details for pedestals, when required.
5. Footing details showing all concrete dimensions, elevations, and reinforcing steel with bar size, length, and spacing indicated. Footing plan and section views shall be provided. The soil bearing pressure used in the design shall be noted on the footing detail sheets.
6. Wingwall design computations and details showing all concrete dimensions, reinforcing steel and anchorage details. Wingwall plan, elevation, and section views shall be provided.
7. Headwall details, showing all concrete dimensions, reinforcing steel and anchorage details. Headwall elevation and section views shall be provided.
8. Structure backfill type and limits for bridge/culvert units and wingwalls.
9. Lifting handling points shown on drawings.

At the time the detail plans are submitted for review, they shall be accompanied by design calculations and explanatory notes. These documents shall be legible and shall demonstrate that the design criteria have been met.

The plans shall be prepared on reproducible sheets 11 x 17 inches (280 mm x 432 mm) including borders. Each sheet shall have a title block in the lower right hand corner. The title block shall include the sheet number of the drawing, name or designation of the structural unit detailed on the sheet, the state and federal project designation, project name, fabricator and Contractor name. Design calculations and notes shall be prepared on sheets 8½ x 11 inches (216 mm x 280 mm), and shall contain the project designation, structural unit designation, date of preparation, initials of designer and checker, and page number at the top of the page. The Detail Plans, Design Calculations, and Explanatory Notes shall be signed and stamped by a Professional Engineer registered in West Virginia and knowledgeable in the proposed bridge/culvert system.

The initial submission shall include three sets of the detail plans, calculations, and notes. One set of notes and plans will be returned to the Contractor with any indicated corrections. When the plans and notes are stamped approved by the Engineer, the Contractor shall furnish the Engineer with the requested number of sets of prints and a Mylar set of the plans for distribution by the Division. The Contractor shall perform no work or ordering of materials for the structures until the Engineer has approved the submittal.

620.4.2-Precast Three-Sided Bridge/Culvert: The details and material specifications for the bridge/culvert system elements and incidental accessories shall be included with the detail plans for approval by the Engineer.

620.4.3-Cast-in-Place Three Sided Bridge/Culvert: The plans for the cast-in-place bridge/culvert shall contain a complete reinforcing bar schedule showing all bending details and bar marks. The plans shall also show the location of all construction joints, expansion joints, or other joints in the bridge/culvert.

620.5-MATERIALS:

620.5.1-Concrete: The concrete for the bridge/culvert units shall be air-entrained composed of Portland cement, fine and coarse aggregates, admixtures and water. Concrete shall contain 7 ± 2 percent air. The air entraining admixture shall conform to section 707.1.

620.5.1.1-Portland Cement: Shall conform to the requirements of sections 701.1 and 701.3.

620.5.1.2-Coarse Aggregate: Shall consist of stone having a maximum size of 1 inch (25mm). Aggregate shall meet the requirements of sections 703.1, 703.2 or 703.3.

620.5.1.3-Water Reducing Admixture: The manufacturer may submit for approval by the Engineer, a water-reducing admixture, per section 707.3, for the purpose of increasing workability and reducing the water requirement for the concrete.

620.5.1.4-Calcium Chloride: The addition to the mix of calcium chloride or admixtures containing calcium chloride will not be permitted.

620.5.1.5-Fine Aggregates: Shall conform to section 702.1. Only siliceous sand shall be used when the top of the structure is to be the driving surface.

620.5.1.6-Mixing Water: Shall conform to section 715.7.

620.5.1.7-Water Reducers / Retarding Admixtures: Shall conform to section 707.2.

620.5.1.8-Joint Material: Shall conform to Section 708.7.

620.5.1.9-Pozzolanic Additives: Shall conform to Section 707.4.

620.5.2-Reinforcing Steel: All reinforcing steel for the bridge/culvert units shall be fabricated and placed in accordance with the detailed shop drawings submitted by the manufacturer.

Reinforcement shall be grade 60 or as specified in the plans, and shall comply with sections 709.1, 709.4 or 709.6. Longitudinal distribution reinforcement may consist of welded wire fabric or deformed billet-steel bars.

Steel reinforcing shall be epoxy coated per AASHTO M-284 or galvanized per AASHTO M-111 for structures installed at an elevation such that the top or crown of the structure is above the bottom of the subgrade in the pavement section.

620.5.3-Permissible Variations:

620.5.3.1-Internal Dimensions: The internal dimensions shall not vary from the design dimensions by more than 1 percent or 1-1/2 inches (37mm), whichever is less. The haunch dimensions shall vary not more than 3/4 inch (19mm) from the design dimension.

620.5.3.2-Slab and Wall Thickness: The slab and wall thickness not be less than that shown in the design by more than 1/4 inch (6mm). A thickness more than that required in the design shall not be cause for rejection.

620.5.3.3-Length of Opposite Surfaces: Variations in laying lengths of the two opposite surfaces of the culvert shall not be more than 5/8 inch (16mm) in any bridge/culvert unit, except where beveled ends for laying of curves are specified by the purchaser.

620.5.3.4-Length of Unit: The underrun in length of a unit shall not be more than 1/2 inch (13mm) in any unit.

620.5.3.5-Position of Reinforcement: The maximum variation in position of the reinforcement shall be + 1/2 inch (13mm). In no case shall the cover over the reinforcement be less than 1-1/2 inch (38mm) for the outside circumferential steel or be less than 1 inch (25mm) for the inside circumferential steel as measured to the external or internal surface of the bridge/culvert unit. These tolerances or cover requirements do not apply to mating surfaces of the joints.

620.5.3.6-Area of Reinforcement: The areas of steel reinforcement shall be the design steel areas as shown in the manufacturer's shop drawings. Steel areas greater than those required shall not be cause for rejection. The permissible variation in diameter of any reinforcement shall conform to the tolerances prescribed in the ASTM Specification for that type of reinforcement.

620.5.4-Curing: All Bridge/Culvert units shall be cured in accordance with Section 601.12 except that curing may be discontinued once 70% of the design Strength is achieved.

620.5.5-Testing and Inspection:**620.5.5.1-Precast Three-Sided Bridge/Culvert Units:**

620.5.5.1.1-Type of Test Specimen: Concrete compressive strength shall be determined from compression tests made on cylinders or cores. For cylinder testing a minimum of 5 cylinders shall be fabricated during each production day. For core testing, one core shall be cut from a unit selected at random from each group of 15 units or less of a particular size and production run. For each continuous production run, each group of 15 units of a single size or fraction thereof shall be considered separately for the purpose of testing and acceptance. A production run shall be considered continuous if not interrupted for more than 3 consecutive days.

620.5.5.1.2-Compression Testing: Cylinders shall be made and tested as prescribed by the AASHTO T-22 and T-23 Specifications. Cores shall be obtained and tested for

compressive strength in accordance with the provisions of the AASHTO T280 Specification.

620.5.5.1.3-Acceptability of Cylinder Tests: Each compressive strength test used for acceptance shall consist of the average strength of a minimum of two compressive strength test cylinders fabricated from a single randomly selected batch of concrete as it is being placed in the forms. Failure of any of the individual 28 day test cylinders to meet 90 percent of the minimum compressive strength requirement can be cause for rejection. The average of all cylinders comprising a strength test must meet or exceed the design strength.

620.5.5.1.4-Acceptability of Core Tests: The compressive strength of the concrete in each group of units as defined in 620.5.4.1.1 is acceptable when the core test strength is equal to or greater than the design concrete strength. When the compressive strength of the core tested is less than the design concrete strength, the unit from which that core was taken may be recored. When the compressive strength of the recore is equal to or greater than the design concrete strength, the compressive strength of the concrete in that group of units is acceptable.

When the compressive strength of any recore is less than the design concrete strength, the unit from which that core was taken shall be rejected. Two units from the remainder of the group shall be selected at random and one core shall be taken from each. If the compressive strength of both cores is equal to or greater than the design concrete strength, the compressive strength of the remainder of that group of units is acceptable. If the compressive strength of either of the two cores tested is less than the design concrete strength, the remainder of the group of units shall be rejected or, at the option of the manufacturer, each culvert of the remainder of the group shall be cored and accepted individually, and any of these units that have cores with less than the design concrete strength shall be rejected.

Plugging Core Holes-The core holes shall be plugged and sealed by the manufacturer in a manner such that the unit will meet all of the test requirements of this specification. Units so sealed shall be considered satisfactory for use.

Test Equipment-Every manufacturer furnishing unit under this specification shall furnish all facilities and personnel necessary to carry out the test required.

620.5.5.2-Cast-In-Place Three-Sided Bridge/Culvert: Cast-in-place testing and inspection shall be per section 601.

620.5.6-Joints:

620.5.6.1-Precast Three-Sided Arch-Topped Bridge/Culvert Units: The bridge/culvert units shall be produced with flat butt ends. The ends of the unit shall be such that when the sections are laid together they will make a continuous line of units with a smooth interior free of appreciable irregularities, all compatible with the permissible variations in 620.5.3.

The joint width shall not exceed 3/4 inches (19mm).

The outside edges of the ends of each bridge/culvert unit shall be chamfered.

The butt joint made by two adjoining units shall be covered with a piece of preformed bituminous joint sealant and a minimum of a nine inch wide joint wrap.

620.5.6.2–Precast Three-Sided Flat-Topped Bridge/Culvert Units: The bridge/culvert units for flat-topped culverts shall be produced with a minimum 4 inches (100mm) deep by 1-1/2 inches (38mm) wide keyway joint. Shear key grout in accordance with Section 715.5 shall be placed in the keyway joint. Field Testing of shear key grout shall be performed by the Contractor in accordance with ASTM C109, as modified by ASTM C1107. Compressive strength of the grout shall be at least XXXX psi at X days as determined by the average result of three test specimens.

620.5.7-Workmanship and Finish: The bridge/culvert units shall be substantially free of fractures. The ends of the units shall be normal to the walls and centerline of the unit section, within the limits of the variations given in 620.5.3, except where beveled ends are specified. The inside and outside surfaces of the units shall be a smooth steel form finish.

620.5.8-Repairs: All repairs are to be performed in accordance with 620.10.2.

620.5.9-Inspection: The quality of materials, the process of manufacture, and the finished bridge/culvert units shall be subject to inspection by the engineer.

620.5.10-Rejection: Bridge/culvert units shall be subject to rejection on account of any of the specification requirements. Individual units may be rejected because of any of the following:

- a. Fractures or cracks passing through the wall, except for a single end crack that does not exceed one half the thickness of the wall.
- b. Defects that indicate proportioning, mixing, and molding not in compliance with Section 5.
- c. Honeycombed or open texture of surfaces greater than 6" x 6" (150mm x (150mm) whereby voids greater than 1/2" (13mm) diameter and over 1" (25mm) deep occur.
- d. Damaged joint mating surfaces where such damage prevents construction of a satisfactory joint. For butt type joints, damaged surfaces greater than 12" (300 mm) long and over 2" (50mm) deep will be cause for rejection of the units.
- e. For shear key type joints, damages surfaces of the shear key greater than 12" (300mm) long and deeper than the shear key may be cause for rejection.

620.5.11-Marking: Each culvert shall be clearly marked by waterproof paint. The following shall be shown on the inside of the vertical leg of the culvert section:

Bridge/Culvert Unit Span X Bridge/Culvert Unit Rise
Date of Manufacture
Name of the manufacturer
WV State and Federal Project Number
Project Contract Number

620.5.12-Backfill: Backfill material shall be select material for backfilling in accordance with 626.5.3. Backfilling shall be according to 626.6.1.3. The backfill material is to be placed in a zone with a minimum width that extends to a point located 4 feet (1.2 meters) outside the base of each leg and with a height being equal to the outside height of the structure plus two feet or the minimum cover, whichever is less. This material is also to be placed to a depth of at least 4 feet (1.2 meters) behind each wingwall.

Additional granular material requirements are the responsibility of the contractor and the bridge/culvert supplier.

620.6-CONSTRUCTION METHODS:

620.6.1-Precast Three-Sided Bridge/Culvert:

620.6.1.1-Footings: The bridge/culvert units shall be installed on cast-in-place concrete footings. The elevation of the bottom of the footing shall be equal to or lower than the elevation as shown on the plans. A keyway for grouting with a minimum depth of 3 inches (75mm) shall be formed in the top surface of the footing and the keyway shall extend to where 3 inches (75mm) clear of the inside and outside faces of the bridge/culvert unit, unless specified otherwise on the plans or by the bridge/culvert system supplier. The footings shall be given a rough float finish and shall reach a compressive strength of 2,000 psi (14 Mpa) before placement of the bridge/culvert units. The completed footing surface shall be constructed in accordance with grades shown on the plans. When tested with a 10 foot (3 meter) straight edge, the top surface of the footings shall not vary more than 1/4 inch (6mm) in 10 feet (3 meters).

The foundation is to be constructed in accordance with the approved shop drawings.

620.6.1.2-Placement of the Bridge/Culvert Units: A representative of the manufacturer shall be present during the first three days the structure is being placed. The units shall be placed as shown on the Engineer's plan drawings. Special care shall be taken in setting the units to the true line and grade. The units shall be set on masonite or steel shims at least 5 inches (125mm) square, or on a concrete leveling pad cast inside the keyway. When set on shims a minimum of a 1/2 inch (13mm) gap shall be provided between the footing and the base of the unit leg.

Prior to grouting three sided structures with legs that have a curved exterior surface, the legs shall be supported horizontally using hardwood wedges driven between the outside of the structure leg and the wall of the keyway. The requirements for the grout will conform to 715.5 and testing of the grout shall be performed by the Contractor in accordance with ASTM C109, as modified by ASTM C1107. Compressive strength of the grout shall be at least XXXX psi at X days as determined by the average result of three test specimens. Wedges shall be spaced no more than two feet (600mm) apart along both sides of the structure.

620.6.1.3-External Waterproofing: When specified on the plans and the limits of application are shown, a waterproofing membrane as described below shall be applied to the top and the sides of the structure unless the top of the structure is to be the driving surface. The material should be installed per the waterproofer manufacturer's instructions.

Property	Value ¹	Test Method
Strip Tensile	50 lbs./in. (8.7 kN/m)	ASTM D 882 ²
Puncture Resistance	200 lbs. (890 N)	ASTM E 154
Permeance	0.10 perms (max.)	ASTM E 96, Method B
Pliability	No cracks in fabric or rubberized asphalt	ASTM D 146 ³

1 Minimum average roll values unless otherwise noted

2 Using 12 in/min (300mm/min) test speed and 1" (25mm) initial distance between grips.

3 Using 180° bend on ¼ inch (6mm) mandrel at -25°F (-32°C)

The surface shall be free of dirt before applying the waterproofing material. A primer compatible with the waterproofing membrane to be used shall be applied before the membrane is installed. The structure should be covered continuously from the bottom of one bridge/culvert unit leg, across the top of the structure and to the bottom of the opposite bridge/culvert unit leg. The joint between the end unit and the headwall shall also be sealed by carrying the membrane up the headwall at least 4 inches (100mm). If precast wingwalls are used, the joint between the wingwall and the end units should be covered in a similar fashion, or, at the discretion of the engineer, filter fabric can be substituted.

620.6.1.4-Backfill Placement: Backfill shall be considered as all replaced excavation and new embankment adjacent to the precast bridge/culvert units and wingwalls. The project construction and material specifications, which include the specifications for excavation for structures and roadway excavation and embankment construction, shall apply except as modified in this section.

No backfill shall be placed against any structural elements until they have been approved by the Engineer. No backfill shall be placed against the structure until the grout has cured for a minimum of 12 hours. On three sided structures with legs that have a curved exterior surface the grout shall be cured for a minimum of 72 hours before placing backfill against the structure.

Backfill against the waterproofing membrane when specified on the plans shall be placed carefully to avoid damage to the waterproofing material.

Mechanical tampers or approved compacting equipment shall be used to compact all backfill and embankment immediately adjacent to each side of the bridge/culvert and over the top of the bridge/culvert until it is covered to a minimum depth of one foot. The backfill within 4 feet (1.2 meters) of each side of the bridge/culvert shall be placed in lifts of 8 inches (200mm) or less (loose depth). Heavy compaction equipment shall not be operated in this area or over the bridge/culvert until it is covered to a depth of 1 foot (300mm).

Lightweight dozers and graders may be operated over culverts having 1 foot (300mm) of compacted cover, but heavy earth moving equipment (larger than a D-4 Dozer weighing in excess of 12 tons (11 Mg) and having track pressures of eight psi (55 kPa) or greater) shall require two feet (600mm) of cover unless the design cover is less than two feet (600mm). In no case shall equipment operating in excess of the design load be permitted over the bridge/culvert unless approved by the Engineer.

Any additional fill and subsequent excavation required to provide this minimum cover shall be made at no additional cost to the project. When placing backfill at no time shall the difference between the heights of fill on opposite sides of the bridge/culvert exceed 18” (450mm). Backfill in front of wingwalls shall be carried to ground lines shown in the plans.

620.6.2-Cast-in-Place Reinforced Concrete: Except as otherwise shown in the plans or herein, construction methods for cast-in-place three-sided structures shall comply with the Standard Specifications. When specified on the plans, a waterproofing membrane per section 620.6.1.3 shall be applied to the exterior top and the sides of the structure. Construction methods for the following shall be per the indicated section of the Standard Specifications:

ITEM	SECTION
Unclassified Borrow Excavation	211
Structure Excavation	212
Rock Excavation	212
Wet Excavation	212
Select Material for Backfilling	613.5.11
Concrete	601
Reinforcing Steel	602

620.7-METHOD OF MEASUREMENT:

Excluding headwalls and wingwalls, three-sided bridge/culverts shall be measured by the linear foot, the measurement being along the centerline of the bridge/culvert and extending from the exposed face to exposed face of the headwalls.

Wingwalls shall be measured by the unit. A wingwall is the entire end section for the three-sided structure including but not limited to headwalls, aprons, foundations for the wingwall, cut-off walls and appurtenances. There shall be no measurement and payment for headwalls. Headwalls shall be incidental to and included in the unit bid price of the wingwalls.

There shall be no separate measurement and payment for the excavation required for installing the bridge/culvert, including any undercut to establish an adequate foundation. Excavation, whether unclassified, structure, rock or wet excavation shall be incidental to and included in the unit bid price for the bridge/culvert and wingwalls.

There shall be no separate measurement and payment for backfill below an elevation two feet above the top or crown of the outside of the bridge/culvert whether such backfill is unclassified borrow, select rock fill, select backfill or salvaged existing streambed material. All such backfill shall be incidental to and included in the unit bid price for the bridge/culvert and wingwalls.

There shall be no separate measurement and payment for waterproofing membrane if the waterproofing membrane is specified on the plans and the limits of application are shown.

Concrete and backfill shall be placed under dry conditions. Should cofferdams, pumping or other methods be necessary to maintain dry conditions, the cost of these methods shall be incidental to and included in the unit bid price for the bridge/culvert and wingwalls.

If the maintenance of traffic scheme necessitates the use of sheet piling or bulkheads during the installation of the bridge/culvert, the cost of piling and bulkheads shall be incidental to and included in the unit bid price for the bridge/culvert and wingwalls.

If the design necessitates undercutting the foundation and backfilling to the footing elevation with select rock fill, the select rock fill shall be separated from soils with fabric for separation per subsection 715.11.8. The cost of the fabric shall be incidental to the unit bid price for the bridge/culvert and wingwalls.

The cost of the construction layout work shall be incidental to and included in the unit bid price for the bridge/culvert and wingwalls.

Additional work arising from changed conditions found during the construction from those shown on the approved drawings shall be paid in accordance with 109.4.

620.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each pay item listed below and shown in the bid schedule, which prices and payment will be full compensation for the work prescribed in this section.

620.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
620001-*	Precast Reinforced Concrete Arch-Topped Bridge/Culvert, "vendor name"	Linear Foot (Meter)
620002-*	Precast Reinforced Concrete Flat-Topped Bridge/Culvert, "vendor name"	Linear Foot (Meter)
620003-*	Cast-In-Place Reinforced Concrete Culvert	Linear Foot (Meter)
620004-*	Wingwall for Concrete Culvert	Each
620005-*	Two-Piece Precast Reinforced Concrete Arch Bridge/Culvert	Linear Foot (Meter)

* Sequence number

SECTION 621 STEEL GRID FLOORING

621.1-DESCRIPTION:

Steel grid flooring shall be of the open type or concrete filled type as shown on the Plans. The floor shall meet the requirements for the design of steel grid floors of the current issue of AASHTO Standard Specifications for Highway Bridges. Before fabrication or construction is undertaken, the Contractor shall submit complete shop and assembly details to the Engineer for approval, and no work shall be done until written approval of such details has been received.

621.2-MATERIALS:

621.2.1-Steel: All steel except as noted below shall conform to the requirements of ASTM A 36 and shall have a copper content of not less than 0.2 percent. Form strips used in concrete filled grid floors shall conform to the requirements of ASTM A 569.

621.2.2-Concrete: All concrete in filled steel grid floors shall conform to the requirements for Class A Concrete as specified in 601.

CONSTRUCTION METHODS

621.3-ARRANGEMENT OF SECTIONS:

All steel shall be straight and true to line and shall be assembled in a workmanlike manner.

Where the main elements are transverse to the centerline of roadway, the units generally shall be of such length as to extend over the full width of the roadway for roadways up to 40 feet (12 meters), but in no case shall the units extend over less than four supports. Where joints are required, the ends of the main elements shall be welded at the joints over their full cross sectional area or otherwise connected to provide full continuity.

Where the main elements are parallel to the centerline of roadway, the sections shall be as long as practicable, but in no case shall the units extend over less than four supports. The ends of the abutting units shall be welded over their full cross sectional area or otherwise connected to provide full continuity in accordance with the design.

621.4-PROVISION OF CAMBER:

Provisions for camber shall be made as follows:

Rigid units that will not readily follow the roadway camber or the roadway crown, as the case may be, shall be cambered in the shop.

Longitudinal stringers shall be mill cambered or provided with varying thickness bearing bars along their centerlines so that the completed floor, after dead load deflection, shall conform to the camber shown on the Plans.

Transverse stringers shall be mill cambered or provided with varying thickness bearing bars along their centerlines so that the completed floor shall conform to the crown shown on the Plans. These stringers shall also be placed normal to the crown of the roadway to provide even bearings for the grid sections.

Where bars are used, the design span length of the grid shall be governed by the width of the bar.

621.5-FIELD ASSEMBLY:

Areas of considerable size shall be assembled before the floor is welded to its supports. The main elements shall be made continuous, and sections shall be connected together along their edges by welding of bars or by other methods meeting with the approval of the Engineer.

621.6-CONNECTION TO SUPPORTS:

The floor shall be connected to its steel supports by welding. Provisions shall be made to provide bearing of all sections on the supporting members by shimming or added weldment. The location, length, and size of welds shall be as per the Manufacturer's recommendations or as shown on the Plans.

The ends of all the main steel members of the slab shall be securely fastened together at the sides of the roadway for the full length of the span by means of steel plates or angles welded to the ends of the main elements or by thoroughly encasing the ends with concrete where the main members are parallel to traffic; suitable side trim shall be used connecting the cross members.

621.7-WELDING:

All shop and field welding shall be done in accordance with 615.5.7.

Surfaces to be welded shall be free from paint, grease, loose scale, rust and other material that will prevent a proper weld. A thin coating of linseed oil, without pigment, need not be removed. Any clinkers or slag resulting from flame cutting or other causes shall be removed before welding.

621.8-CONCRETE FILLER:

Floor types with bottom flanges not in contact shall be provided with bottom forms of sheet metal to retain the concrete filler without excessive leakage. These strips shall fit tightly on the bottom flanges of the floor members but shall extend a minimum distance on the flanges in order that there shall be adequate bearing area of the slab on the support.

The concrete shall be Class A, mixed, placed, and cured in accordance with the requirements outlined in 601. The concrete shall be thoroughly compacted by vibrating the steel grid floor in a manner satisfactory to the Engineer.

621.9-PAINTING:

All painting shall conform to the provisions in section 688. The paint system shall be specified in the contract documents.

621.10-METHOD OF MEASUREMENT:

Steel grid flooring will be measured by the number of square feet (meters) complete in place, not including Class A concrete. The volume of Class A Concrete will be computed on the basis of a slab equal to the thickness of the steel grid flooring as called for on the Plans, minus the volume of metal in the steel grid flooring. The volume of metal will be determined from the weight of the steel grid flooring as listed by the fabricator. The cost of construction of roadway drains, scuppers, downspouts, etc., where specified, shall be included in the price bid for Class A Concrete. The expansion devices will be included in the item of structural steel.

621.11-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which price and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work; except that Class A concrete will be paid for under Item 601001-*.

621.12-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
621001-*	Steel Grid Flooring, Filled Type	Square Foot (Meter)
621002-*	Steel Grid Flooring, Open Type	Square Foot (Meter)

* Sequence number

SECTION 622

TIMBER BRIDGE STRUCTURES

622.1-GENERAL:

622.1.1-This work shall consist of the fabrication and erection or fabrication and delivery of timber bridge structures in accordance with these specifications and in reasonably close conformity with the lines, grades, dimensions and locations shown on the Plans. All work shall be done and all materials shall meet the requirements of this specification and plan notes.

622.1.2-These specifications apply to the following types of timber bridge structures:

Type A: Longitudinal Stress-Laminated Plank Deck

The superstructure is formed by longitudinal vertical sawn lumber laminations which are clamped together on their wide faces by high-strength steel stressing thread bars through holes in the laminations. Stressing pressure is transferred to the timber by bearing plates located along the outer laminations at the edge of the deck and develops sufficient friction between the laminations to cause them to perform structurally as a unit.

Type B: Cellular Structural Glued-Laminated Beams with Longitudinal Stress-Laminated Plank Deck

The superstructure is formed by longitudinal glued-laminated beams which are stress-laminated into two layers of longitudinal vertical sawn lumber laminations. One layer of vertical lumber is at the top surface of the glued-laminated beam and forms the deck. The second layer is at the bottom surface of the beam. The resulting cross-section is a closed cell box beam configuration.

Type C: Structural Glued-Laminated Beams with Longitudinal Stress-Laminated Plank Deck.

The superstructure is a Tee cross-section formed by longitudinal glued-laminated beams which are stress-laminated with a layer of vertical sawn lumber to form the deck.

Type D: Structural Glued-Laminated Beams with Transverse Glued-Laminated Deck Panels.

The superstructure consists of longitudinal glued-laminated beams with a non-composite transverse glued-laminated deck panels over the beams.

Type E: Structural Glued-Laminated Longitudinal Deck Panels with Transverse Glued-Laminated Stiffener Beams

The superstructure consists of longitudinal glued-laminated deck panels with transverse glued-laminated stiffener beams.

622.2-MATERIALS:

622.2.1-Stress Laminated Plank Deck, Solid Sawn Curbs, Guardrail Posts and Guardrail: All structural lumber used in the bridge construction will be Northern Red Oak except when Structural Glued-Laminated Timber is specified on the Plans.

All lumber and timber shall be graded in accordance with the Standard Grading Rules for Northeastern Lumber, as published by the Northeastern Lumber Manufacturer's Association Incorporated (NELMA), 272 Tuttle Road, P.O. Box 87A, Cumberland Center, Maine 04021, Telephone # (207) 829-6901.

Lumber for stress-laminated plank decks shall be # 3 Grade or better except wane shall meet # 1 Grade, as specified in the above grading standards Section 20.0 for Structural Joists and Planks. Grading may be performed after rough sawing to approximate dimensions, however crook shall meet the grading rules after preservative treatment. Stress-laminated deck lumber shall be sawed, surfaced two sides (S2S), resawed or otherwise processed so that the resulting fit between adjacent planks will meet the applicable Manufacture-Standard as defined by the NELMA grading rules for the faces.

The thickness of planks shall be from 1-½ inches (40 mm) through 2 inches (50 mm) with only one size to be used in a bridge deck. Stress-laminated deck lumber shall contain not less than 12% nor more than 19% moisture (oven dry basis) after preservative treatment and prior to fabrication. Moisture content is to be confirmed in accordance with AWP A6, using a minimum sample size of 40 cores per lot of deck lumber taken at random throughout the lot. The length of each core sample shall be one-half the thickness of the deck plank.

Timber for guardrail posts and blockouts, curbs, curb blocks, and guardrail when specified on the Plans shall be "# 2 Grade" or better as specified in the above grading standards Section 25.0 for Beams and Stringers. Material may be rough saw cut to the approximate dimensions shown on the Plans so that after conditioning and preservative treatment the actual dimensions are within plus or minus 3/16 inch (5 mm) of plan cross sectional dimensions.

All lumber and timber shall be graded, approved and stamped or tagged by a lumber grader, certified by an agency who has been approved by The Board of Review of the American Lumber Standards Committee.

All dimensions shown on the Plans for structural lumber shall be actual dimensions.

When structural glued-laminated timber members are specified on the Plans they shall meet the requirements of Section 622.2.6.

622.2.2-Timber Substructures: All beams, stringers, posts, timber and lumber for timber substructures shall be "# 2 Grade" or better Northern Red Oak as specified in the above grading standards Section 25.0 for Beams and Stringers, Section 26.0 for Posts and Timbers or Section 20.0 for Structural Joists and Planks as appropriate.

All beams, posts, timber, stringers and lumber shall be graded, approved and stamped or tagged by a lumber grader, certified by an agency who has been approved by The Board of Review of the American Lumber Standards Committee.

All dimensions shown on the Plans for structural beams, stringers, posts, timber and lumber shall be actual dimensions.

When structural glued-laminated timber members are specified on the Plans they shall meet the requirements of Section 622.2.6.

622.2.3-Metal:

622.2.3.1-Steel Products: Structural shapes, plates and bars (except steel thread bars and fabrication bars) shall meet the requirements of AASHTO M 270M Grade 250. Components requiring fabrication will be made in accordance with Section 615 of the Standard Specifications. Where welded fabrication is required, all work shall be in accordance with ANSI/AASHTO/AWS Bridge Welding Code D1.5. Nondestructive testing of welds is not required. All steel products shall be hot-dip galvanized, after fabrication to AASHTO M 111 except where otherwise noted. Properly documented

certified mill test reports shall be provided for all above steel products. Certifications for hot-dip galvanizing shall be provided by the galvanizing plant.

622.2.3.2-Thread Bars: Steel thread bars shall be the size shown in the Plans and shall be designed to allow the use of anchor nuts and couplers that thread onto the deformations. Anchor nuts and couplers shall be of a design and material recommended by the thread bar manufacturer to develop the full tensile strength of the bar. Thread bars shall meet the following:

622.2.3.2.1: Steel thread bars shall be manufactured by a suitable process which will produce bars meeting the chemical, mechanical and physical requirements of AASHTO M 275M, Type II. Where 5/8 inch (15 mm) diameter nominal size bars are specified on the Plans, bars may be supplied to the following requirements in lieu of the above.

622.2.3.2.2: Alternate bars for 5/8 inch (15 mm) size shall meet the following Table:

Nominal Diameter (max.)	¾ inch (19 mm)
Effective cross sectional area	0.28 square inches (181 mm ²) min 0.33 square inches (213 mm ²) max.
Height of deformations	0.045 inches (1.14 mm) min. 0.060 inches (1.52 mm) max.
Weight per linear meter	1.15 lbs (1.71 kg) min. 1.35 lbs (2.01 kg) max.
Yield strength (min.)	34,000 lbs (151.2 kN) (0.2% offset or 0.7% extension under load)
Ultimate strength (min.)	40,000 lbs (177.9 kN)
Elongation, min. (20 bar diameters) or Elongation, min. (10 bar diameters)	4.0% 7.0%
Heat analysis:	
Phosphorus content (max.)	0.040%
Sulfur content (max.)	0.050%

All tension tests to be performed in accordance with AASHTO M 275M.

622.2.3.2.3: Properly documented certified mill test reports will be provided for each heat of steel thread bars. Mill test reports will document compliance with paragraph 622.2.3.2.1 or 622.2.3.2.2 as applicable.

622.2.3.2.4: All thread bars, anchor nuts, couplers and ancillary hardware shall be hot-dip galvanized to AASHTO M 111. Prior to galvanizing, thread bars shall be blast cleaned to Steel Structures Painting Council Surface Preparation Specification Number 6 (Commercial Blast Cleaning). Acid pickling of thread bars will not be permitted. To provide for proper assembly after galvanizing, excess zinc shall be removed by machining using suitable thread taps and dies from the threads of nuts, couplings and thread-bars as necessary. Removal of excess zinc by heating will not be permitted.

622.2.3.3-Timber Fasteners: Dome head drive spikes and washer head drive spikes noted on the Plans shall be Sealtite Dome Head Drive Spikes and Lewis Washer Head Timber Drive Spikes as manufactured by Lewis Bolt and Nut Company, Minneapolis, Minnesota, or as approved by the Engineer. Round head bolts noted on the Plans shall be metric round head square neck bolts (carriage bolts) meeting the requirements of ANSI/ASME Specification B18.5.2.2M. Dome head bolts noted on the Plans shall have a circular dome shaped head and shall meet the requirements of ASTM A 307, except head markings are not required. Hex head bolts shall be hex or heavy hex and shall meet ASTM A 307. 1¼ inches (30 mm) dome head bolts shall have a minimum head diameter of 3 inches (75 mm) and a minimum head height of 9/16 inch (14 mm). Nuts shall be hex or heavy hex meeting AASHTO M 291M or AASHTO M 292M. Round washers shall be Type A, Wide Series meeting the requirements of ASTM F 844. Washers noted on the Plans as "timber washers" shall be oversize in diameter and thickness, manufactured from cast or malleable iron, hot-dip galvanized and of a style and design typically used in heavy timber construction. Fluted steel dowels (spiral dowels) shall be as manufactured by Wadsworth Equipment Company, Akron, Ohio or as approved by the Engineer. All timber fasteners shall be hot-dip galvanized to meet AASHTO M 232M. Mill test reports, certifications or testing of above fasteners is not required. Acceptance will be based on visual inspection at the project site or at the fabricator's plant.

622.2.3.4-Anchor Bolts at Abutments or Piers: Anchor bolts at bridge abutments or piers shall be ¾ inch (20 mm) diameter steel "all thread" rods meeting the requirements of ASTM A 307, hot-dip galvanized to AASHTO M 232M. Bolt length is governed by deck, timber or steel angle thickness and embedment in concrete as noted on the Plans. Nuts and washers shall be as specified in paragraph 622.2.3.3. Mill test reports, certifications or testing of anchor bolts, nuts or washers is not required. Acceptance will be based on visual inspection at the project site or at the fabricator's plant.

Anchor bolts in concrete are to be installed using Molly "Parabond" Capsule Chemical Anchor System as manufactured by Molly Fastener Group, 504 Mt. Laurel Avenue, Temple, Pennsylvania 19560, Telephone: (215) 929-5674, or Sup-R-Set Capsules Chemical Anchor System as manufactured by Gunnebo Fastening Corp., P.O. Box 1589, York, PA 17405, Telephone (717) 846-2200, or Rawl Chem-Stud #6500 as manufactured by the Rawl Plug Co., Inc., Two F.B. Powers Square, New Rochelle, NY, 10802, Telephone (914) 235-6300, or approved equal. Installation of anchor bolts is to be in accordance with the chemical capsule manufacturer's recommendations. The end of each anchor bolt is to be ground to the configuration recommended by the chemical capsule manufacturer.

Certification or testing of chemical anchor system is not required.

622.2.3.5-Split Rings, Shear Plates and Nails: Split rings shown or noted on the Plans shall be TECO Wedge-Fit Split Rings, Type M-2, as manufactured by TECO, Colliers, West Virginia or approved equal. Shear plates shown or noted on the Plans shall be TECO Shear Plates Type 143-D Galvanized, as manufactured by TECO, Colliers, West Virginia or approved equal. Split rings and shear plates shall be furnished hot-dip galvanized. Mill test reports, certifications or testing of split rings is not required. Acceptance will be based on visual inspection only.

Miscellaneous nails required during fabrication will be sized by the fabricator considering the intended function. Certification or testing is not required.

622.2.3.6-Steel Beam Guardrail: Steel beam guardrail, fasteners and accessories, when specified on the Plans, shall be in accordance with AASHTO M 180, Type II, Class A, unless otherwise noted. All materials shall be supplied by companies which are included on the Division's list of Certified Suppliers of Guardrail and Associated Hardware.

The Contractor will be responsible for drilling additional holes in the rail, if required, to fit the post spacing shown on the Plans.

622.2.3.7-Anchor Bolts For Guardrail and Diaphragm Fasteners: Anchor bolts connecting steel beam guardrail to wood guardrail shall meet AASHTO M 164M with appropriate nuts and washers, all hot-dip galvanized to AASHTO M 232M. Pipe sleeves at guardrail connection are to be DN25 standard galvanized steel pipe, schedule 40, and may be cut to specified length by pipe cutter or saw cut without repair of cut surface.

Lag screws and standard washers for installation of diaphragms between structural glued-laminated beams shall be standard hex head lag screws and standard mild steel washers all hot-dip galvanized to AASHTO M 232M.

Steel rods, threaded both ends, for installation of diaphragms and guard rail post supports to structural glued-laminated beams shall be manufactured from steel rod meeting AASHTO M 270M Grade 250 or AASHTO M 169 Grade 1018 thru 1045. Nuts and timber washers shall meet the requirements of Section 622.2.3.3. All materials shall be hot-dip galvanized to AASHTO M 232M.

Mill test reports, certifications or testing of anchor bolts, nuts, washers, lag screws or pipe sleeves is not required. Acceptance will be based on visual inspection at the project site or at the supplier's plant.

622.2.3.8-Fabrication bars and accessories for modular construction: Fabrication bars shall be nominal $\frac{3}{4}$ inch (20 mm) O.D. all thread high strength steel bar with the following properties:

Nominal diameter	$\frac{3}{4}$ inch (19 mm)
Yield Strength (min.)	34,000 lbs (151.2 kN) (0.2% offset or 0.7% extension under load)
Ultimate strength (min.)	40,000 lbs (177.9 kN)
Elongation, min (20 bar diameter) or Elongation, min (10 bar diameter)	4.0% 7.0%
Chemical Analysis:	
Phosphorus content (max.)	0.040%
Sulfur content (max.)	0.050%

Tension tests shall be performed on full size samples in accordance with ASTM A 370. Threads shall be 10 Threads per inch (2.5 mm per thread) Unified Coarse Thread Series as specified in ANSI B1.1 and shall have Class 2A tolerances.

Nuts for use with fabrication bars shall be heavy hex series and shall meet AASHTO M 291M Grade C, D or DH, or shall meet AASHTO M 292M Grade 2 or 2H.

Bearing and anchor plates shall be carbon steel and shall meet AASHTO M 270M Grade 250.

All material supplied under this paragraph is to be plain, uncoated. Hot dip galvanizing is not required.

The Contractor will provide the Engineer with mill test reports or certifications from the material producers which indicate the materials supplied are in conformance with the referenced specifications.

622.2.3.9-Aluminum Deck Bracket: Cast aluminum brackets connecting glulam deck panels to glulam stringers shall be of a design and dimensions as shown on the Plans and shall meet the requirements ASTM B 108 Alloy 356.0 Temper T6. The Contractor shall provide the Engineer with a letter of certification from the foundry producing the castings. Acceptance shall be based on the certification and visual inspection at the fabrication plant or on the project site.

622.2.4-Preservative Treatment: Treatment of all sawn timber and lumber shall be by the Empty Cell process in accordance with the American Wood Preserver's Association (AWPA) Standard C2. Treating solution shall be Coal Tar Creosote conforming to AWPA Standard P1. Treatment retention shall be 7.0 pcf (112.1 kilogram per cubic meter (kg/m^3)) minimum and shall be determined by the gauge or weight method.

All lumber and timber members shall be dimensioned, cut, machined and drilled prior to preservative treatment except stress-laminated deck lumber 2 inches (50 mm) or less in thickness, which can be drilled or cut to length after treatment. Deck lumber cut to length after pressure treatment shall have the saw cut ends treated in accordance with AWPA Standard M4. Holes in deck boards drilled to accept steel thread bars, to provide for void drains, or to attach guardrail and curbs do not require treatment of holes.

All surfaces shall be free of excess treatment solutions at the time of delivery to the job site.

622.2.5-Elastomeric Bearing Pads: Elastomeric bearing pads shall be of the size and type shown on the Plans and shall conform to the AASHTO M 251 with a durometer hardness of 60.

622.2.6-Structural Glued-Laminated Timber (Glulam): All structural Glued-Laminated Timber members shall be visually graded Southern Pine or visually graded Douglas Fir-Larch as shown on the drawings and specified below.

Materials, manufacture and quality control shall be in accordance with American National Standards Institute/American Institute of Timber Construction (ANSI/AITC) Standard A 190.1, Structural Glued-Laminated Timber, and shall provide allowable design values as shown on the Plans. All design values are based on wet condition of service. Adhesives shall meet the requirements of wet-use for wet conditions of service. Appearance of the members shall be industrial grade. Surfaces of members shall be not sealed and members shall not be wrapped. Members shall be marked with a Quality Mark and, in addition, a Certificate of Conformance shall be provided to the Engineer to indicate conformance with ANSI/AITC A 190.1, Structural Glued-Laminated Timber.

All Structural Glued-Laminated Timber members shall be preservative treated in accordance with AITC Standard 109, Standard for Preservative Treatment of Structural Glued-

Laminated Timber and AWP Standard C28, Standard for Preservative Treatment of Structural Glued-Laminated Timber. Treating solution shall be Coal Tar Creosote conforming to AWP Standard P1. Treatment retention shall be 12.0 pcf (192.2 kilogram per cubic meter (kg/m³)) minimum, and shall be determined by the assay method. Incising is required prior to treatment for members manufactured from Douglas Fir-Larch.

At the completion of the treating cycle, all structural glued-laminated material shall be cleaned by final steaming for three (3) hours at a temperature between 220° F (105° C) and 240° F (115° C).

All surfaces shall be free of excess treatment solution at the time of delivery to the job site.

All Structural Glued-Laminated Timber members shall be dimensioned, machined, have holes bored and cut to proper length prior to preservative treatment except diaphragms for Type B and C bridges may be trimmed to length for up to 1 inch (25 mm) after treatment provided the trimming is followed by re-treatment in accordance with AWP Standard M4. Holes bored for lag screws for Type B and C bridges may be done after preservative treatment provided all holes are treated in accordance with AWP Standard M4.

622.3-QUALITY CONTROL:

622.3.1-Contractor's Responsibility: The Contractor is responsible for control of the product through all manufacturing operations to assure that the completed work is in conformance with these specifications.

As required by paragraphs 622.2.1 and 622.2.2, all lumber and timber shall be graded, approved and stamped or tagged by a certified grader. The Contractor shall schedule, contract and otherwise arrange for the specified grading inspection. Cost of the inspection is to be included as incidental to the work. The Contractor will provide the Engineer suitable reports which document the acceptance of the lumber by the certified grader.

622.3.2-Manufacturers of Structural Glued-Laminated Timber: All manufacturers of Structural Glued-Laminated Timber (Glulam) members shall be a "licensed laminator" by the AITC as required by ANSI/AITC Standard 190.1. A list of AITC licensed laminators can be obtained from the American Institute of Timber Construction, 11818 S.E. Mill Plain Boulevard, Suite 415, Vancouver, Washington 98684, Telephone (206) 254-9132 or (800) 525-1625.

622.3.3-Wood Preserving Plant: The wood preserving plant shall comply in all respects with AWP Standard M3, Standard Quality Control Procedures for Wood Preserving Plants. The quality control inspector's responsibilities and inspection procedures are to be in accordance with AWP Standard M3, Standard Quality Control Procedures for Wood Preserving Plants and AWP Standard M2, Standard for Inspection of Treated Lumber Products. The quality control inspector shall conduct all inspections and tests and maintain all records and reports required by the above mentioned AWP Standards and shall provide copies to the Engineer. Upon completion of all treating operations the treater will also supply a Certificate of Compliance as required by paragraph 7.1 of AWP Standard M3.

622.3.4-Division's Inspection: The Division shall conduct routine inspections of all laminating, manufacturing, sawing, machining, grading and treating operations to assure the Contractor is complying with the specification requirements. Where deficiencies in material

or procedures are noted by the Division inspector, the Contractor shall take immediate steps to correct the deficiency. Any materials found defective or deficient will be rejected and shall be replaced with acceptable material at no cost to the Division.

622.4-SHOP AND ERECTION DRAWINGS:

The Contractor shall submit to the Engineer, in the required number of copies, a complete set of shop and erection drawings as required by Section 105.2 of the Standard Specifications. The drawings shall consist of such detail Plans as may be reasonably required for the successful completion of the work. Shop drawings shall include detailed dimensions and arrangement of the stress-laminating system, deck lumber dimensions including joint locations where full length boards are not utilized, full dimensions and bolting layout of the curb and guardrail when specified, and all bearing details. Shop drawings shall also include details of all Structural Glued-Laminated Timber members.

Upon completion of all fabrication operations and shipment of all material to the project site the Contractor shall forward to the Engineer a complete set of as-built shop drawings in reproducible quality (Mylar or equivalent). The set will consist of the latest revisions of each individual shop drawing that has been previously submitted and approved by the Engineer.

All drawings shall be submitted to the Engineer for approval a minimum of two (2) weeks prior to the start of fabrication. All dimensions shall be in metric units only.

CONSTRUCTION METHODS

622.5-CONSTRUCTION METHODS:

Stress-laminated and structural glued-laminated timber bridges are to be fabricated and erected in accordance with the Plans and these specifications.

622.5.1-Handling: Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising, or penetrating the surface with tools. Treated members shall be handled with web slings. Cant hooks, peaveys, pikes, cables, chains or hooks shall not be used. When metal bands are used to bundle members, corner protectors shall be provided to prevent damage. Structural glued-laminated beams shall be tipped and lifted on edge using web slings at as many points as necessary to prevent damage. Steel spreader beams shall be utilized to prevent eccentric loading of long members. Glulam plank deck panels may be lifted flat using fabricated steel C-shaped brackets that fit over the member ends. The contractor has complete responsibility for utilizing proper shipping and handling techniques. Any damage shall be repaired or replaced to the satisfaction of the Engineer at no additional cost.

622.5.2-Stress-Laminated Deck Assembly: Stress-laminated decks may be prefabricated at a manufacturing or fabrication facility. The full width or sections of the deck may be prefabricated and stressed, or panels may be fabricated, joined and stressed in the field.

If decks are fabricated in sections and stressed using bearing plates under the thread bar coupler, the bearing plates must be removed after all sections have been joined.

Butt joints are permitted in the lamination provided: a) Lamination length is not less than 4 ft (1200 mm); b) No butt joints are located within a distance equal to the deck thickness from a stressing bar, and; c) No more than one butt joint occurs in any five adjacent laminations within a distance of 2 ft (600 mm). The joint layout is to be shown on the shop drawings.

Gaps between butt ends of deck boards shall be 1 inch (25 mm) or less. The height differential between adjacent deck boards shall be $\frac{3}{4}$ inch (20 mm) or less.

Holes for stressing bars shall be large enough to allow a bar with a coupler, if used, to be removed from the stressed deck, but shall not exceed 20% of the width of the board, but may be $1\frac{3}{4}$ inch (45 mm) maximum on a 7 inches (175 mm) board.

Holes into the deck for attaching the deck to the substructure and for attaching curbs and posts to the deck shall not be drilled until after Stage 2 of the stressing procedure is completed. Holes in the substructure shall not be drilled until the deck is in place and after Stage 2 of the stressing procedure is completed.

622.5.3-Stressing: Stressing bars shall be tensioned with a hydraulic jack. The jack shall be calibrated at least yearly to provide an accurate indication of load.

Stressing bars shall be tensioned to the specified load shown on the Plans. Stressing shall be done in accordance with the following procedure:

Stage 1: Load each bar to 50 percent of the specified load using a bar stressing sequence which will prevent distortion and maintain a uniform bridge (panel) width for the full length of the bridge. Repeat using the full specified load until all bars are properly tensioned.

Stage 2: A minimum of five (5) days but not more than seven (7) days after the completion of Stage 1, reload all bars to the specified load.

Stage 3: A minimum of four (4) but not more than six (6) weeks after the completion of Stage 2, reload all bars to the specified loads shown on the Plans.

During the stressing procedure, the load in the first bars that were stressed will most likely decrease as the other bars are stressed. In all three (3) stages, after the Contractor is satisfied that all bars are stressed to the proper load, Contractor shall return to the first three (3) full width bars that were stressed and verify on the hydraulic stress gauge that all three (3) maintained a minimum of 90% of the specified load. If any of the first three (3) full width bars did not maintain at least 90% of the specified load, all the bars on the bridge shall be stressed again. The checking of the first three (3) full width bars and subsequent stressing of all bars shall be repeated until they maintain at least 90% of the specified load.

The Engineer shall be notified at least two (2) days prior to beginning each stressing stage. No vehicles shall be allowed on the bridge until the completion of Stage 2 stressing.

622.5.4-Camber: An upward curve or camber shall be provided in each bridge as noted on the Plans. The camber shall be a uniform curve in the length of the bridge and shall show maximum offset at the approximate center of the span. Camber shall be consistent across the bridge width and measurement shall be made at both edges and the centerline.

622.5.4.1-Type A Bridges: When the full bridge width, or sections, are prefabricated and stressed at the fabrication facility, the fabricator shall introduce sufficient initial camber, prior to stressing, so that under full dead load the final camber will be as specified. When panels or individual members are delivered loose, they shall be erected over a temporary support to induce the required camber across the full width of the bridge and shall be adjustable so that it can be lowered to allow full dead load on the bridge, or can be raised to induce additional camber should it become necessary.

If 75% of the final camber is not provided under full dead load the Contractor shall support the structure on a temporary support, loosen all stressing bars, induce additional camber by raising the support, re-stress all bars and lower support to verify proper camber.

622.5.4.2-Type B, C, D and E Bridges: Structural Glued-Laminated Timber members shall be manufactured with the camber shown on the Plans. The camber specified is with no load on the member.

622.5.5-Modular Construction: When specified on the Plans the bridge will be fabricated and erected using modular techniques as described below. The applicable provisions of 622.5.1 through 622.5.4 also apply to modular fabrication and erection.

Modular construction does not apply to Type D and E bridges.

622.5.5.1-Module Assembly: Each module shall consist of the appropriate number of rows of individual deck planks so when mated to the exterior glued-laminated beams the total module width will be as noted on the Plans after the third stressing. The Contractor is responsible for including as many additional rows of deck planks as may be necessary to compensate for lumber compression or shrinkage thru all three stages of stressing.

The deck planks shall be assembled with the two module beams using jigs, pipe guides and nails or other means so that proper alignment and beam camber can be maintained prior to inserting stressing bars. After the two beams and rows of deck planks are properly assembled, steel thread bars meeting the requirements of 622.2.3.2, except the bars need not be coated, shall be inserted in all 2 ft (600 mm) center holes. Stage 1 stressing shall be performed before each module is moved from the assembly jig or the module is handled in any manner. Handling of modules is to be in accordance with 622.5.5.4. In addition, high strength steel fabrication bars meeting the requirements of 622.2.3.8 shall be inserted in all 6 ft (1800 mm) center holes. The 2 ft (600 mm) center bars can be removed before shipping from the fabrication shop and must be removed before the modules are erected on the project site. The fabrication bars on 6 ft (1800 mm) centers will remain permanently in the bridge, except for the exterior (fascia) modules where the bars shall be removed after completion of the field stressing operation. Galvanized bearing plates shall be used on the outside of the fascia modules for all 2 ft (600 mm) center bars. All other bearing plates may be uncoated.

The Contractor is responsible for maintaining the squareness of each module. This may require additional diaphragms, stressing rods, braces, etc. either temporary or permanent. All materials required for this purpose shall be clearly shown on the shop drawings and shall be noted as either temporary or permanent. Materials noted as permanent shall meet all quality requirements of this specification. Attachment of temporary materials shall be such that the preservative envelope of the bridge members is not damaged in any way. Holes in structural glued-laminated members shall be bored prior to preservative treatment and temporary holes shall be filled with treated wood plugs to the satisfaction of the Engineer. Regardless of the method chosen by the Contractor to control module squareness, each completed and fully stressed module at any cross-section throughout its length shall not be out-of-square by more than 1/8 inch (1 mm) per ft (100 mm) of web depth when measured at the top or bottom outer surface of either module web. No more than 0.01 inch (1 mm) of sweep, measured at the module centerline, is allowed

per ft (1000 mm) of length. When fully assembled, no more than 0.03 inch (3 mm) of sweep, measured at the bridge centerline is allowed per ft (1000 mm) of length. When fully assembled the bridge width shall be at least as wide as the plan dimension but not more than 1½ inches (40 mm) wider than the plan dimension at any point. No separate payment will be made for these additional materials or labor used to control module squareness. Cost to be included in the unit price for the fabricated bridge members.

622.5.5.2-Shop Module Stressing: All steel thread bars in the 2 ft (600 mm) center holes shall be stressed to the load shown on the Plans. All three stages of stressing shall be performed in the fabrication shop. Upon completion of each stage of stressing, the hex nuts on the fabrication bars on 6 ft (1800 mm) centers shall be fully tightened using the full effort of a man on an ordinary spud wrench.

622.5.5.3-Curbs, Guardrail Posts and Diaphragms: Curbs and guardrail posts for Type A bridges shall be shop installed after the second stressing and at any phase for Type B or C. Diaphragms shall be shop installed after the third stressing. Diaphragms and end blocks shall be fabricated such that a maximum gap of 3/16 inch (5 mm) exists between each side of the diaphragm or end block and the webs of the beams. Some trimming to length of the diaphragms may be necessary to compensate for the loss of module width due to stressing. See 622.2.6 for treating requirements after trimming to length.

622.5.5.4-Handling, Shipping and Erection: As each module is assembled in the fabrication shop, a handling and erection lifting ring system shall be installed after the Stage 1 stressing. Details of the lifting ring system are shown on the Plans. All handling of the modules shall be performed using the lifting rings. Use of fork lifts under the modules, slings, choker cables, grab hooks, etc. is prohibited.

Two (2) days after the Stage 3 stressing is completed, the bars on 2 ft (600 mm) centers (not the bars on 6 ft (1800 mm) centers) can be removed, or, all the bars can remain in for shipping. If the Contractor elects to leave all bars in place for shipping, the bars on 2 ft (600 mm) centers must be removed prior to erection. After the Stage 3 stressing and prior to erection, the fabrication bars on 6 ft (1800 mm) centers shall be saw cut off flush with the face of the hex nut, except for the bars on the fascia side of the exterior module which can remain long to facilitate removal of the fabrication bars after erection.

The first module should be positioned on the abutments as precise as possible and secured to the bridge seat. Careful alignment of the remaining modules will facilitate installation of the full width stressing rods.

The modules shall be stressed together after inserting stressing rods and placement of bearing plates. Only one stressing operation is required in the field, although several passes over all the bars may be required to meet the 90% load requirement of 622.5.3.

Upon completion of erection, the fabrication bars in the fascia modules shall be removed and the holes plugged with a treated wood plug.

The handling and erection lifting ring system components shall be removed and will remain the property of the Contractor. Cost of the lifting ring system is considered incidental to Item 622020-*, Stressing Hardware. Holes in the stressed deck shall be plugged with treated wood plugs.

Field nailing to any treated bridge component is prohibited.

622.5.6-Backwall Installation: Backwalls shown on the Plans shall not be placed until after completion of erection of all superstructure components. The end of the bridge members may be used as a form for placement of concrete backwalls provided the preformed joint filler is suitably secured to the bridge. The end diaphragms may require additional bracing or blocking to prevent damage from use as a concrete form. The Contractor is responsible to provide the necessary additional support and will repair any damage to the satisfaction of the Engineer.

622.6-METHOD OF MEASUREMENT:

622.6.1-Stress-Laminated Timber Bridge Fabricated and Installed: The quantity of work done will be measured in 1,000 ft board measure (Mfbm) (cubic meter (m^3)) which is based on actual plan sizes of all lumber and timber including structural glued-laminated timber shown on the Plans, and shall include bearings and bearing pads if specified, preformed joint sealer, hot-poured joint sealer, timber connectors and all necessary hardware, except stressing hardware and steel beam guardrail, complete in place and accepted in the finished structure for the structure type noted on the Plans.

Stressing hardware will be measured as a separate item.

Steel beam guardrail and hardware will be measured as Section 607 Items.

622.6.2-Stress-Laminated Timber Bridge Fabricated and Delivered: The quantity of work done will be measured in 1,000 ft board measure (Mfbm)(cubic meter (m^3)) which is based on actual plan sizes of all lumber and timber including structural glued-laminated timber shown on the Plans, and shall include bearings and bearing pads if specified, timber connectors and all necessary hardware, except stressing hardware and steel beam guardrail, and delivered in the manner and to the site set forth in the contract documents for the structure type noted on the Plans.

Note: Stressing hardware will be measured as a separate item.

622.6.3-Structural Glued-Laminated Timber Bridge Fabricated and Installed: The quantity of work done will be measured in 1,000 ft board measure (Mfbm)(cubic meter (m^3)) which is based on actual plan sizes of all structural glued-laminated members and other timber components as shown on the Plans, and shall include bearings and bearing pads if specified, preformed joint sealer, hot-poured joint sealer, timber connectors and all necessary hardware, except steel beam guardrail, complete in place and accepted in the finished structure for the structure Type noted on the Plans.

Steel beam guardrail and hardware will be measured as section 607 Items.

622.6.4-Structural Glued-Laminated Timber Bridge Fabricated and Delivered: The quantity of work done will be measured in 1,000 ft board measure (Mfbm)(cubic meter (m^3)) which is based on actual plan sizes of all structural glued-laminated members and other timber components as shown on the plans, and shall include bearings and bearing pads if specified, timber connectors and all necessary hardware, except steel beam guardrail, and delivered in the manner and to the site set forth in the contract documents for the structure Type noted on the Plans.

622.6.5-Timber Substructure: The quantity of work done will be measured in 1,000 ft board measure (Mfbm)(cubic meter (m^3)), computed on the basis of actual plan sizes of all

lumber and timber members shown on the Plans, and shall include all necessary hardware complete in place and accepted in the finished structure.

622.6.6-Stressing Hardware: The quantity of work for "Stressing Hardware" will be measured and paid for as lump sum. Stressing hardware includes stressing bars, plates, nuts, handling and erection lifting ring system components and any other hardware related to the stressing of the timber.

For 622.6.1 "Stressing Hardware" shall include the initial stressing and restressing at five (5) days and four (4) weeks.

For 622.6.2 "Stressing Hardware" shall include all material delivered in the manner and to the site set forth in the contract documents. When modular construction is specified, "Stressing Hardware" shall also include the initial stressing and restressing at five (5) days and four (4) weeks.

622.7-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials, except as above noted, and doing all the work herein prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

622.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
622005-*	Stressed Timber Bridge, Type A, Fabricated and Installed	Thousand Board Feet (Cubic Meter)
622006-*	Stressed Timber Bridge, Type A, Fabricated and Delivered	Thousand Board Feet (Cubic Meter)
622007-*	Stressed Timber Bridge, Type B, Fabricated and Installed	Thousand Board Feet (Cubic Meter)
622008-*	Stressed Timber Bridge, Type B, Fabricated and Delivered	Thousand Board Feet (Cubic Meter)
622009-*	Stressed Timber Bridge, Type C, Fabricated and Installed	Thousand Board Feet (Cubic Meter)
622010-*	Stressed Timber Deck, Type C, Fabricated and Delivered	Thousand Board Feet (Cubic Meter)
622011-*	Structural Glue-Laminated Timber Bridge, Type D	Thousand Board Feet (Cubic Meter)
622012-*	Structural Glue-Laminated Timber Bridge, Type D, Fabricated And Delivered	Thousand Board Feet (Cubic Meter)
622013-*	Structural Glue-Laminated Timber Bridge, Type E,	Thousand Board Feet (Cubic Meter)
622014-*	Structural Glue-Laminated Timber Bridge, Type E	Thousand Board Feet (Cubic Meter)
622019-*	Timber Substructure	Thousand Board Feet (Cubic Meter)
622020-*	Stressing Hardware	Lump Sum

* Sequence number

SECTION 623

PNEUMATICALLY APPLIED MORTAR

623.1-DESCRIPTION:

This work shall consist of repair of concrete structures, protection of structural steel, or any other type of work as may be designated on the Plans, using pneumatically placed mortar, in accordance with these Specifications and in reasonably close conformity with the dimensions and design shown on the Plans or as directed by the Engineer. It shall include removal of all loose, soft, honeycombed, and disintegrated concrete, the removal of sound surface concrete in areas designated for repair, the preparation of the surface, the furnishing and placing of reinforcing steel, including wire fabric, dowels, and expansion anchor bolts, and mixing and applying pneumatically placed mortar composed of Portland cement and sand.

Pneumatically placed mortar will be designated as Shotcrete. Shotcrete shall generally be used where the depth of repair does not exceed 6 inches (150 mm).

623.2-MATERIALS:

All materials shall conform to the applicable requirements of Division 700, unless otherwise indicated.

For sandblasting operations the sand shall conform to the requirements in 688.2.4.1 and 688.2.4.3, III.

The reinforcing wire mesh shall be three inch (75 mm) by three inch (75 mm) by Size # W 1.4 wire, unless noted otherwise on the Plans.

CONSTRUCTION METHODS

623.3-PROPORTIONING AND MIXING:

Shotcrete shall consist of a mixture of Portland cement and sand (three to five percent moisture) in the proportion of one cubic foot or 0.94 cwt of cement to three cubic feet of sand (one cement to three sand) (dry, loose measurement, due allowance being made for bulking). The materials shall be thoroughly mixed dry in a batch mixer. Before placing the mixture in the hopper, all lumps over ¼ inch (6 mm) shall be removed by screening.

623.4-CLEANING:

In concrete repair work, disintegrated concrete shall first be removed with pneumatic or hand tools. The surfaces shall then be thoroughly blasted to remove all dirt and loose materials, special care being taken in concrete repair work to thoroughly clean exposed reinforcing rods. Prior to applying each coat of Shotcrete, the concrete surfaces shall be cleaned and washed down with water and compressed air.

Structural steel shall be thoroughly cleaned of paint, rust, grease, and other foreign material. The Contractor may be required to Abrasive Blast Clean for this purpose.

623.5-PLACING REINFORCING MESH:

623.5.1-Repairing Concrete Work: In repairing concrete work, the reinforcing mesh shall be fastened to the concrete with ¼ by 4 (6 x 100 mm) expansion bolts spaced approximately 30 inches (750 mm) each way. Lapping of adjacent sheets shall be at least 4 inches (100 mm) in each direction and all laps shall be firmly tied together at intervals not

exceeding 18 inches (450 mm). Care shall be taken to place the mesh away from the proposed finished concrete surface so that approximately a 3/4 inch (19 mm) layer of Shotcrete shall be maintained outside of the plane of the mesh. In places where repairs are necessary for depths of 3 inches (75 mm) or more over considerable areas, two or more layers of mesh shall be used, the first layer being placed about 3/4 inch (19 mm) out from the existing concrete.

623.5.2-Covering Structural Steel: In placing reinforcing mesh around structural steel, the mesh shall be cut in sheets of the proper size and separate sheets shall be bent carefully over templates in such a manner as to follow closely the outlines of the members to be covered and shall be securely held about 3/4 inch (19 mm) out from the surfaces of the members. Adjacent sheets of mesh shall lap at least two meshes.

In placing the mesh, the rods shown on the Plans shall first be fastened to the steel, and subsequently the mesh shall be securely tied outside of these rods with wires spaced at approximately 1 foot (300 mm) intervals. To allow for fasteners for holding the rods, holes not less than 9/16 inch (14 mm) diameter shall be punched or drilled in the webs of members as near as possible to the top and bottom flanges. These holes shall be spaced on approximately 36 inches (900 mm) centers. Where steel members are more than 48 inches (1200 mm) in depth, an additional row of holes, spaced on approximately 36 inches (900 mm) centers, shall be provided on the centerline of the web.

623.6-PLACING SHOTCRETE:

623.6.1-General: Only experienced men shall be employed in placing Shotcrete.

No Shotcrete shall be placed during freezing weather or against surfaces on which there remains any frost.

623.6.2-Pressures: The pressure in the lower chamber of the cement gun shall be that which will produce a nozzle velocity of 375 to 500 feet (115 to 150 m) per second when a tip with a three-fourths or 1 inch (20 or 25 mm) opening is used, and a nozzle velocity of 425 to 550 feet (130 to 165 m) per second when a tip with a 1¼ inches (32 mm) opening is used. These velocities must be steadily maintained and shall be determined by a suitable nozzle velocity meter attached to the cement gun.

Water used for hydration at the nozzle shall be maintained at a uniform pressure, which shall not be less than 15 psi (100 kPa) greater than the air pressure in the cement gun. In no case shall a greater amount of water be used than that necessary to produce proper hydration, especially when vertical surfaces are shotcreted.

623.6.3-Thickness of Covering: In repairing concrete, the Shotcrete shall be placed to a minimum total thickness of 1 inch (25 mm) in two or more coats.

In covering structural steel, the shotcrete shall be placed to a thickness of 1½ inches (40 mm) and in two layers.

In all cases, the final coat shall be shotcreted to a thickness of ½ inch (15 mm) against the previously straightened and thoroughly cleaned and wetted surfaces.

The stream of materials from the nozzle shall impinge as nearly as possible at right angles to the surface being covered. Any deposit of loose sand shall be removed prior to placing any original or succeeding layers of Shotcrete. After placing, all mortar patches shall be sounded and any indications of pockets shall be investigated and repaired as directed by the Engineer.

623.6.4-Joints: At the end of any day's work or similar stopping period, the Shotcrete shall be sloped off to a thin edge. Before shooting the adjacent section, the sloped portion shall be thoroughly cleaned and wetted. No square joints will be allowed.

623.6.5-Forms: Forms shall be structurally sufficient and of such design that rebound or accumulated loose sand can freely escape or be readily removed. Shooting strips shall be used at corners, edges, and on surfaces where necessary to obtain true lines and proper thickness.

623.6.6-Finishing and Curing: Following applicable layers of Shotcrete, the concrete surface shall be wood or steel finished as directed by the Engineer. The Shotcrete shall be covered with burlap mats and kept wet for at least one week after placing; but where not practicable to use mats, it shall be kept wet by sprinkling for the same length of time.

623.7-METHOD OF MEASUREMENT:

623.7.1-Repairing Concrete Structures: Measurements will be based on the amount of cement in hundredweight (cwt) (hundred kilograms) used in the Shotcrete, the pound (kilogram) of Shotcrete reinforcing mesh, and the number of hook expansion bolts.

623.7.2-Covering Structural Steel: Measurement of all areas of Shotcrete shall be based on the actual area of the members to be covered, following the lines of the members, and payment per square foot (meter) will be made of such basis.

623.8-BASIS OF PAYMENT:

623.8.1-Repairing Concrete Structures: The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed in 623.9.1, which prices and payments shall be full compensation for furnishing all the material and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

623.8.2-Covering Structural Steel: The quantity, determined as provided above, will be paid for at the contract unit price bid for the item in 623.9.2, which price and payment shall be full compensation for furnishing all the materials, including reinforcing mesh and rods, and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

623.9-PAY ITEMS:

623.9.1-Repairing Concrete Structures:

ITEM	DESCRIPTION	UNIT
623001-*	Cement For Shotcrete	Hundred Weight (100 Kilogram)
623002-*	Reinforcing Mesh	Pound (Kilogram)
623003-*	Hook Expansion Anchor Bolt	Each

* Sequence number

623.9.2-Covering Structural Steel:

ITEM	DESCRIPTION	UNIT
623004-*	Shotcrete	Square Foot (Meter)

* Sequence number

SECTION 624

PREFORMED ELASTOMERIC JOINT SEALER

624.1-DESCRIPTION:

This work shall include furnishing and installing preformed elastomeric joint sealers for bridge decks in accordance with these Specifications and in reasonably close conformity with the lines and grades shown on the Plans or established by the Engineer. The joint sealer, to serve both as a filler and a sealer, shall be furnished in the form of an extruded compartmented tube.

624.2-MATERIALS:

Material for preformed elastomeric joint sealer shall conform to the requirements of 708.2.

624.3-PREPARATION OF JOINT:

The joint shall be formed to provide the nominal opening at the specified temperature as shown on the Plans, edges of concrete or epoxy mortar adjacent to the joint shall be rounded to a radius of not more than ¼ inch (6 mm). A joint having insufficient opening may be required to be sawed or ground to the proper size. Where a joint opening is larger than that specified, the Contractor may be required to build up the joint with epoxy mortar or to furnish a larger size sealer as determined by the Engineer. The cost of any such additional work or material shall be borne by the Contractor.

Before placement of the sealer, the joint shall be thoroughly cleaned by brushing, compressed air or other means, so that it is free from dust, oil, grease or other foreign materials.

624.4-INSTALLATION:

The sealer shall be installed by suitable hand or machine tools which will not cause injury to the material during installation. A lubricant or lubricant-adhesive shall be used if, and as, recommended by the manufacturer of the sealer. During installation, the sealer shall not be subjected to lengthwise stretching; the length to be installed shall be measured prior to installation and cut or marked to indicate the installed length. Sealer for transverse joints shall be in one continuous length; longitudinal joint sealers may be spliced at intervals of not less than 50 feet (15 meters) except where intersected by transverse joints. The top surface of the sealer after installation shall be ¼ inch (6 mm), with a plus 1/16 inch (2 mm) tolerance, below the adjacent roadway surface.

624.5-METHOD OF MEASUREMENT:

When this Item is called for on the Plans, the filler and joint sealer will be measured in place in linear feet (meters).

624.6-BASIS OF PAYMENT:

The cost of preformed elastomeric joint sealer, complete in place, including lubricant or lubricant-adhesive will be paid for at the contract unit price bid for the item listed below, which price and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

624.7-PAY ITEM:

ITEM	DESCRIPTION	UNIT
624001-*	Preformed Elastomeric Joint Sealer	Linear Foot (Meter)

* Sequence number

SECTION 625

DRILLED CAISSON FOUNDATIONS

625.1-DESCRIPTION:

The work of this section includes the furnishing of all materials and the construction of foundations consisting of reinforced concrete caissons placed within drilled excavations. Each drilled caisson foundation shall consist of a shaft section, with the lower portion in a drilled rock socket and with the upper portion in a steel casing. This casing will normally be removed during concrete placement unless otherwise shown in the plans or directed by the Engineer.

625.2-TESTS AND SUBMITTALS:

The Contractor shall deliver all submittals required by this specification to the Engineer no later than one month prior to constructing any drilled caissons shown in the plans. No drilled caissons shall be constructed prior to the Engineer's review and acceptance of all submittals and test hole results.

625.2.1-Experience:

1. A satisfactory record of experience in drilled caisson construction is considered to be of the utmost importance in obtaining a satisfactory drilled caisson installation. The installation of the drilled caisson is required to be performed by a contractor or specialty subcontractor specializing in installing drilled caissons and having experience with caissons of similar length, diameter, and subsurface conditions as those shown in the contract documents.
2. The Contractor shall submit data on at least two projects performed during the past ten years, for which the Contractor (or the Subcontractor if applicable) has installed drilled caissons of a range of diameters and lengths similar to those shown in the plans, in similar quantities, and under similar subsurface conditions. The list of projects shall contain names and phone numbers of owners' representatives who can verify the participation in those projects.
3. The Engineer shall review and approve the Contractor's (Subcontractor's) caisson installation qualifications. If in the opinion of the Engineer the Contractor's qualifications are not adequate, the Contractor shall submit to the Engineer a proposed method of obtaining the necessary qualifications.
4. The installation of all components of the drilled caisson including; drilling, reinforcement placement, concrete placement, and required wet hole condition work, casing installation and removal, slurry placement, and any other work required to complete the drilled caisson, shall be performed by the approved contractor or specialty subcontractor.

625.2.2-Site Inspection: A signed statement shall be submitted affirming that the Contractor (or the Subcontractor if applicable) has inspected the project site and the available subsurface information including any available soil or rock samples.

625.2.3-Installation: The Contractor Shall plan for compliance with applicable environmental regulations, including but not limited to the protection of river water from degradation due to material excavated from drilled caisson locations or due to other harmful erosion, protection of the environment from slurry spillage or discharge if slurry is used, and general environmental protection of the area from all operations related to drilled caissons.

The Installation shall be in accordance with the Contractor's proposed Safety Plan per Section 625.5.2.7.

The Contractor shall provide a projected schedule of work to the MCS&T Division thirty (30) days in advance of construction of caissons. This projected schedule shall include start date of caisson construction, date of when each caisson would need to be inspected for cleanliness and when CSL tests are to be performed for each caisson. This projected schedule will be used by the MCS&T Division to project workload and schedule manpower.

625.2.4-As-Built Records: Within 24 hours of the completed construction of each drilled caisson, the Contractor shall submit a report on the actual location, alignment, elevation, and dimensions of the drilled caisson, and will also submit a completed drilled caisson log as specified herein.

625.2.5-Test Hole: A test hole shall be drilled at the location and to the diameter and depth shown in the plans. The test hole shall be reinforced and constructed the same as other drilled caissons in the plans. This shall include casing extraction if required by the project or the Contractor's proposed installation plan. CSL testing will not be required for the test hole, however the Contractor may, at his own expense perform CSL testing. The Contractor shall revise his methods and equipment as necessary during construction of the test hole when he is unable to carry out the requirements of the plans. Completed test holes shall be left in place except that the top of the caisson shall be removed to a depth of 2 ft (600 mm) below final ground line. Disturbed areas at the site of the test hole shall be restored to their original condition. If the Contractor fails to demonstrate the adequacy of his methods or equipment, the Engineer shall require additional test holes be provided at the Contractor's expense.

625.2.6-Nondestructive Testing

625.2.6.1-General Requirements: The nondestructive testing method known as Crosshole Sonic Logging (CSL) shall be used on any drilled caisson which is constructed with the placement of concrete underwater or as required in the plans. The testing shall not be conducted until at least three (3) days after placement of concrete is concluded in the caisson, and will be completed within fourteen (14) calendar days after such placement.

The CSL tests shall be conducted by the Contractor in conformance with ASTM D6760 and shall be certified (signed and sealed by a Professional Engineer licensed in West Virginia knowledgeable in drilled caisson installation). The CSL tests must be performed by one of the approved testing companies as listed on the MCS&T approved list. The Engineer may approve the use of an alternate company if they show experience and a certification in conducting the CSL test procedure. The cost of this testing shall be incidental to the caisson installation.

The Contractor shall give MCS&T Division five (5) calendar days notice prior to conducting the actual CSL testing. This will allow MCS&T Division to provide a qualified technician to observe the CSL test as it is being performed. MCS&T Division will determine if this observation is required. The observation by MCS&T Division is to satisfy the division's Quality Assurance part of the CSL testing.

625.2.6.2-Preparation for Testing: To accommodate the CSL test requirements, the Contractor shall install a number of tubes in each caisson to be tested. The number of tubes per caisson shall be as tabulated below:

TABLE 625.2.6.2

Caisson Diameter	Number of Tubes	Tube Spacing
Up to 42" (1049 mm)	3	120°
42" to 60" (1050 mm to 1499 mm)	4	90°
60" to 96" (1500 mm to 2399 mm)	6	60°
96" (2400 mm) and Larger	8	45°

The tubes shall be per section 625.4.4. Each tube shall have a round, regular internal diameter free of defects or obstructions including defects or obstructions at pipe joints; in order to permit the free, unobstructed passage of 1½ inch (35 mm) diameter source and receiver probes. The tubes shall be watertight and free from corrosion with clean internal and external faces to ensure passage of the probes inside and a good bond with the concrete outside.

Each tube shall be fitted with a watertight shoe on the bottom and a removable cap or plug on the top. The tubes shall be securely attached to the interior of the reinforcing steel cage. The tubes are typically wire-tied to the reinforcing cage every 40 inches (1 000 mm), or otherwise secured such that the tubes stay in position during placement of the cage and during placement of concrete. The tubes shall be installed in each shaft in a regular, symmetric pattern such that the tube spacing in degrees will correspond to that shown in the table above.

The tubes shall be as near to parallel as possible. They shall extend from 6 inches (150 mm) above the caisson bottom to at least 40 inches (1 000 mm) above the caisson top. No tube may be allowed to rest on the bottom of a drilled excavation. If the caisson top is sub-surface, then the tubes shall extend at least 2 ft (600 mm) above the ground surface or above the water surface if the ground surface is below water. Any joints required to achieve full length tubes shall be made watertight. Care shall be taken during placement of the reinforcing steel cage so as not to damage the tubes.

After placement of the cage, and before placement of concrete, the tubes shall be filled with clean water and the tube tops shall be capped or sealed to keep debris or other foreign matter out of the tubes. Care shall be exercised in the removal of caps or plugs so as not to apply excess torque, hammering, or other stresses that could break the bond between the tubes and the concrete.

625.2.6.3-CSL Logging Procedures: Before placement of concrete, the Contractor shall investigate at least one tube per shaft. This investigation is to make sure that there are no bends, crimps, obstructions or other impediments to the free passage of the testing probes. A record of the tube length or lengths, including a note of the projection of the tubes above the top of the shaft shall be made. The Contractor shall provide information on the shaft bottom and top elevations, length and construction dates to the Engineer prior to the CSL tests.

The Contractor shall conduct the CSL tests. Any defects indicated by tests shall be evaluated by the Contractor and further tests may be conducted in regard to the extent of such defects. Any time required by such tests will be considered incidental to the work and will not be cause for extra compensation related to a claim or extension of contract.

625.2.6.4-CSL Testing Results: The CSL test results will be compiled into a caisson integrity testing report for each caisson. The report will summarize and analyze any defect zones indicated on the logs. A copy of each report will be provided to the Engineer.

625.2.6.5-Evaluation of CSL Test Results: The Contractor shall submitted to the Engineer a certified (signed and sealed by a Professional Engineer licensed in West Virginia knowledgeable in drilled caisson installation) caisson integrity testing report contain the CSL test results and an Evaluation of each caisson installation determining whether or not the drilled caisson as constructed is acceptable. The Engineer shall review the report and if the report determines that the drilled caisson is acceptable, he shall submit to the Contractor in writing within seven (7) calendar days approval to proceed with the work.

The acceptance of each drilled caisson shall be the decision of the Engineer, based on the results of the caisson integrity testing report and other information on the caisson placement. Rejection of a caisson shall require conclusive evidence that a defect exists in the caisson, which will result in inadequate or unsafe performance under service loads. If the Non Destructive Testing records are complex or inconclusive, the Engineer may require the Contractor to verify caisson conditions, in accordance with 625.2.6.6. If a defect is confirmed, the Contractor shall pay for all coring and grouting costs. If no defect is encountered, compensation for all coring and grouting will be in accordance with 104.3 and 109.4 of the Standard Specifications.

In the case that any caisson is determined to be unacceptable, the Contractor shall submit a plan for remedial action to the Engineer for approval. The approval or rejection of the remediation plan may take up to fourteen (14) calendar days. If the remediation plan is rejected the Contractor shall revise the plan and submit it for approval and the approval time is restarted. Any modifications to the foundation caisson and load transfer mechanisms caused by the remedial action will require calculations and working drawings stamped by a Professional Engineer licensed in the State of West Virginia for all foundation elements affected. All labor and materials required to perform remedial caisson action shall be provided at no cost to the Division and with no extension of the contract time.

625.2.6.6-Evaluation by Core Drilling: A drilled caisson that is found to be unacceptable shall be cored by the Contractor using double tube core barrels. One or more core holes shall be drilled at the location(s) as determined by the Contractor and/or Engineer. An accurate log of the core shall be kept and the core shall be crated and properly marked showing the caisson depth at each interval of core recovery. The core, one copy of the coring log and a revised certified (signed and sealed by a Professional Engineer licensed in West Virginia knowledgeable in drilled caisson installation) caisson integrity testing report indicating the condition of the caisson shall be provided to the Engineer.

The Engineer shall review the report and if the report determines that the drilled caisson is acceptable he shall submit to the Contractor in writing within seven (7) calendar days approval to proceed with the work. If the quality of the caisson is determined to be unacceptable, then the Contractor shall proceed in accordance with 625.2.6.5.

625.3-DIMENSIONAL REQUIREMENTS:

The dimensional requirements for Placement Tolerances and Caisson Diameters shall be met prior to placement of reinforcing steel. The Contractor shall submit his corrective plan for any deviation from the caisson location, alignment and elevation tolerances, and reinforcement dimensional requirements to the Engineer for approval. This approval may take up to fourteen (14) calendar days. The corrective plan shall be certified (signed by a Professional Engineer licensed in West Virginia knowledgeable in drilled caisson installation). The cost of any corrective action shall be borne by the Contractor.

625.4-MATERIALS:

625.4.1-Concrete: Concrete for the drilled caissons shall be Class DC and shall conform to the requirements of Section 601 of the Standard Specifications.

The design 28-day compressive strength shall not be less than 4500 psi (31 Mpa) unless shown otherwise in the Plans. The Contractor shall prepare a mix design in accordance with MP 711.023.23 to attain this strength. Slump for dry placement will be 7 inches (175 mm) plus-or-minus 1 inch (25 mm). Unless otherwise specified in the Plans, the cement shall be Type I.

For placement of caisson concrete by tremie or pumping, the cement factor shall be increased by 94 lbs. (43 kg) from the original design cement factor, the slump shall be 8 inches (200 mm) plus-or-minus 1 inch (25 mm) and shall maintain a slump in excess of 4 inches (100 mm) throughout the concrete placement.

625.4.2-Reinforcing Steel: Reinforcing steel for main vertical bars and ties shall conform to Section 709.1, deformed type, grade 60 (400). Reinforcing steel for use as spirals shall conform to Section 709.1, plain type, grade 60 (400).

625.4.3-Casing: Metal casing shall be used whenever required to prevent caving of the soil material or to exclude ground water. Casing shall be metal, of unit or sectional construction, be strong enough to withstand handling stresses, withstand the pressures of concrete and of the surrounding earth and ground water, and prevent seepage of water. Also, the casing used shall be selected by the Contractor to control dimensions and alignment of excavations within tolerances, to seal the casing into impervious materials, and to execute all other construction operations.

Casing pipe used for permanent applications shall be new material and conform to ASTM A 252/A 252M, Grade 2. Casing pipe when used for temporary applications only, will initially be required to meet the requirements of permanent pipe but when removed can be transferred to the contractors stock and reused on subsequent projects.

Any required casing splices shall be welded in accordance with Section 625.2.3 e) of this specification with no interior splice plates, producing true and straight casing. All welding shall be in accordance with ANSI/AWS D1.1.

Permanent casing is required in all caissons where noted on the plans. All temporary casing shall be removed during placement of concrete unless otherwise noted on the plans. Should the Contractor be unable to remove the temporary casing or if conditions require the temporary casing remain in place, the Contractor shall pressure grout the annular space between the casing and soil. Materials and methods for grouting operation shall be submitted to the Engineer for approval for the grouting operation. There shall be no additional cost to the Division for the grouting operation.

625.4.4-CSL Testing Tubes: Tubes required for CSL Tests shall be ASTM A53, Grade B, nominal 2 inch (50 mm) diameter. Hydrostatic test requirements are waived. Threaded Couplings shall be used per ASTM A 865.

625.5-CONSTRUCTION:

625.5.1-General: The following sequence describes a generalized construction method that is expected to be appropriate for the installation of the drilled caissons. Deviations will be permitted with the Engineer's approval.

- a. Excavate to top of shaft elevation.
- b. Drilling of a “Preinstallation Core Hole” prior to drilling of caisson hole. The drilling and sampling of the preinstallation core holes shall be done by use of double tube core barrels. Additional preinstallation core holes in other locations may be required where directed by the Engineer. Such additional core holes shall be paid for at the contract unit bid price. The preinstallation core hole will be drilled from the ground surface, downward a distance equal to the caisson diameter below the expected bottom of rock socket. Its purpose is to assure that the rock just below the socket is sound and able to carry the loads that will be imposed on it.

A preinstallation core hole is a 2 inches (50 mm) nominal diameter hole, with coring, where the quality of the rock core and the rate of drilling are used to determine if there is satisfactory rock of sufficient type and thickness, and to locate the presence of open joints, voids, soft rock or other deleterious material. Logs of the core hole shall be provided to the Engineer within 24 hours of completion of coring. All cores shall be maintained by the Contractor until completion of the project and shall then become the property of the Engineer.

- c. Drilling of cased hole through the soil overburden down to top of competent rock. Seating bottom of casing to minimize entry of ground water.
- d. Drilling of rock socket to the minimum diameter shown in the plans and to a depth shown on the drawings or otherwise directed by the Engineer.
- e. Cleaning of the drilled hole, particularly the rock socket and the inside face of the casing; inspection of the hole and approval for placement of the caisson material.
- f. Placement of the pre-assembled cage of reinforcing steel and securing it in place against movement during concreting and during casing withdrawal. It also must be secured in such a way that the minimum clear cover over the bars is maintained. Placement of tubes as required for CSL testing.
- g. Placement of concrete in either dry or wet conditions. If the temporary casing is to be removed it shall be withdrawn carefully and slowly so as not to leave any voids in the concrete and so as not to dislocate any reinforcing steel. Any concrete not meeting this specification's slump requirements shall be rejected.
- h. For any parts of any caisson that extend above either the existing or permanent grade, that portion shall be placed by use of forms of the diameters shown in the plans. Curing, stripping, and finishing shall be the same as for other structural concrete. Casing may be used as forms.
- i. CSL testing if required, corrective measures for any unacceptable caissons, removal of water from the CSL tubes and filling with an approved grout. All core holes must be filled with an approved grout.

625.5.2-Excavation:

625.5.2.1-Scope: The Contractor shall drill one preinstallation core hole at each caisson location unless otherwise noted on the plans. The Contractor shall perform all excavations required for the caissons and the rock sockets, through whatever materials are encountered, to the dimensions shown in the plans, or required by the site conditions, or directed by the Engineer. The Contractor shall make each caisson excavation available to the Engineer for inspection, providing tools, equipment, and safety measures as hereinafter specified. Based on preinstallation core hole information or on general inspection of the rock socket, the Contractor shall drill the rock socket deeper if directed by the Engineer.

625.5.2.2-Excavation through Overburden: Unless otherwise shown in the plans, drilled caisson excavations in the overburden shall be vertical bored holes extending from the ground surface down to the surface of competent rock. Temporary or permanent casings may be required down to the competent rock surface and shall be seated in rock in a manner that prevents caving and minimizes the entry of ground water. In the event of a groundwater condition, appropriate measures shall be taken subject to the Engineer's approval. Such measures may include pumping from within the excavation, external dewatering, or excavation through a slurry-filled hole until the casing can be seated and sealed. In cases in which the water is difficult to control, the Engineer may permit wet excavation which could require later inspection by diving methods and would require later placement of concrete by underwater methods.

625.5.2.3-Excavation in Rock: Rock sockets shall be excavated to the dimensions and depths shown in the plans, forming a flat bearing area at the bottom of the socket. Each socket shall be excavated into continuous rock for the indicated length, by use of methods subject to the Engineer's approval. Blasting methods will not be permitted.

Upon completion of each rock socket excavation, the Engineer may (1) accept the socket, or (2) order deeper excavation based upon preinstallation core hole data or general inspection of the socket. The adequacy of each socket will depend on the soundness of its bottom surface and on the soundness of its underlying layers. The Contractor shall drill required preinstallation core holes as directed and shall excavate sockets to the depth directed by the Engineer.

Contractor is cautioned not to over-drill the rock sockets. Unauthorized over-drilling will be at the Contractor's expense. In the case where over-drilling would bring the caisson base too close to a coal seam or other weak layer, then drilling must be extended through such weak layer, at the Contractor's expense, to a satisfactory deeper bearing level as determined by the Engineer.

No portion of the rock socket shall be exposed to drilling fluid or groundwater for more than 96 hours. Any portion of the rock socket exposed to drilling fluid or water for more than 96 hours, and any portion of the rock socket which, in the opinion of the Engineer, has deteriorated due to exposure to air or water, shall be reamed with an approved grooving tool to a depth of not less than $\frac{1}{4}$ inch (6 mm), or as directed by the Engineer. Reaming of the socket, if necessary, is considered incidental to the cost of drilling the rock socket, and no separate payment will be made for this work.

625.5.2.4-Providing for Socket Inspection: Upon completion of the excavation of each rock socket, and upon mechanical cleaning of the socket, the Contractor shall make the socket available to the Engineer for inspection. The Contractor shall provide suitable access for inspection, electric lighting, devices for checking dimensions, alignment and plumbness, ventilation equipment, the protective cage, radio communication, and auxiliary safety line. The air in the caisson shall be tested for noxious and/or explosive gases prior to and during entry of inspection personnel, to assure a safe working environment.

625.5.2.5-Disposal of Materials: Disposal of excavated materials shall be accomplished under the general provisions of Section 207.6 of the Standard Specifications.

625.5.2.6-River Area: Drilled caisson construction in the river shall employ whatever special methods the Contractor finds necessary for access and for accomplishing the work. These methods may include cofferdams, temporary sand islands, or other suitable measures. The Contractor will be responsible for conforming to all regulatory and environmental requirements related to the river and for obtaining any permits that are required by his river operations.

625.5.2.7-Safety Measures: Safety of all persons is to be considered an objective of the utmost importance on this project. Therefore, the Contractor will take whatever measures are necessary to protect his own personnel, his subcontractors' personnel, the Engineer or other agents of the state, regulatory personnel, and others including the general public. The following list is presented as representative of issues that the Contractor must address. It is not intended as all-inclusive and does not relieve the Contractor of conforming to other regulations, laws, requirements, or other measures reasonably required for safe excavating operations. The Contractor shall develop a safety plan in accordance with these requirements and provide this plan to the Engineer for his review.

- a. Any required equipment within an excavation shall be operated by air or electricity. The use of gasoline-driven engines or diesel engines within an excavation will not be permitted. All lighting shall be electric and precautions shall be taken in regard to potential short circuits of electric current within ground water.
- b. The Contractor will take precautions to assure that no explosive or noxious gases are present. Fresh air shall be supplied into the excavation and foul air shall be removed whenever any personnel are present in the hole.
- c. A safety harness or chair lift, with separate safety line, protective cage, and two-way radio communication shall be used for any entry into an excavation.
- d. No open excavation shall be left unattended. During non-working hours excavations shall be protected by the use of solid, safe covers that are firmly fastened in place.

625.5.3-Reinforcing Steel Installation: Prior to installation of reinforcing steel, the steel cage shall be checked and cleaned of any materials that would tend to prevent bonding. The excavated hole shall also be checked and any remaining or newly deposited debris shall be removed. Immediately upon the Engineer's approval of the condition of the cage and his acceptance of the socket, and just prior to placement of concrete, the fully assembled cage of reinforcing steel shall be installed into the excavation.

The cage will consist of longitudinal (vertical) bars, spiral or tie bars, cage stiffener bars as required, spacing devices, and any other appurtenances required to maintain alignment, shape, and clearances. Cages shall include steel tubes in shafts where CSL testing is to occur. Each cage shall be placed in one unit by lowering into the hole in a manner that will prevent distortion. Concrete spacers or other approved noncorrosive spacing devices shall be used at sufficient intervals (near the bottom and at intervals not exceeding 10 ft (3 000 mm) along the caisson) to ensure concentric spacing for the entire cage length. The minimum number of centering devices at each level shall be three. All steel centering devices with less than 3 inches (75 mm) of concrete cover shall be epoxy coated. The cage shall be supported from the top by use of a ground surface frame or other positive means. Setting the cage on the socket bottom without support will not be permitted. The Contractor may with the approval of the Engineer, remove the top support after sufficient concrete has been placed to adequately support the cage vertically and prevent distortion or racking of the cage.

The bottom of the reinforcing steel cage shall be a minimum of 3 inches (75 mm) and a maximum of 24 inches (600 mm) from the bottom to the drilled caisson excavation. Additional clearance may be approved by the engineer.

All intersections of drilled caisson reinforcing steel shall be tied with cross or “figure 8” ties. The reinforcing steel in the caisson shall be 100% tied and supported so that the reinforcing steel will remain within allowable tolerances for position. Unless otherwise shown in the plans, splicing shall be by mechanical connectors or couplers which develop at least 125% of yield strength of the reinforcing bar. No more than 50% of the longitudinal reinforcing shall be spliced within 60 bar diameters of any lapped splice location or within 2 ft (600 mm) of any mechanical splice or coupler location. Cage stiffener bars shall be used as required to provide a reinforcement cage of sufficient rigidity to prevent racking, permanent deformations, etc. during installation. If the concrete is to be placed by the free-fall method, these bars must first be removed.

In the event that the caisson has been excavated below the anticipated tip elevation, the reinforcing cage may be extended at the tip (low) end by lap splices, mechanical connectors, or welded splices in conformance with the Standard Specifications. In this instance, splices need not be staggered and 100% of the reinforcing bars may be spliced at a given location. Lap splice lengths shall be as shown in the plans or approved by the Engineer.

Prior to placing the reinforcement cage, the Contractor shall demonstrate to the satisfaction of the Engineer that the fabrication and handling methods to be used will result in a reinforcing cage placed in the proper position, with the proper clearances, and without permanent bending or racking of the reinforcement cage.

The elevation of the top of the steel cage shall be checked before and after the concrete is placed. If the rebar cage is not maintained within the specified tolerances, corrections shall be made by the Contractor to the satisfaction of the Engineer. No additional caissons shall be constructed until the Contractor has modified his rebar cage support system in a manner satisfactory to the Engineer.

625.5.4-Placement of Concrete: Prior to concrete placement, the Contractor shall make all necessary arrangements to assure the uninterrupted delivery of concrete so that there will not be any cold joints in the caissons. Placement of concrete shall generally conform to the applicable portions of Section 601.10 of the Standard Specifications. The rate of placement of concrete, as related to the height of fresh concrete at any time, will be subject to the Engineer's approval. The placement method will be developed by the Contractor, taking account of set time, hydraulic pressures and casing removal.

All costs of replacement of defective caissons shall be the responsibility of the Contractor and shall be at no cost to the Department.

After the concrete level has reached the required top elevation, it will be forced to overflow in the case of tremie or pump placement, leaving only fresh, uncontaminated concrete. In the case of placement by free fall (dry conditions), the concrete will be continued high enough to compensate for any settlement due to removal of casing.

The top 10 ft (3000 mm) of each drilled caisson shall be vibrated except, when more than 10 ft (3000 mm) is to be exposed above the ground line or the riverbed, then the entire exposed portion shall be vibrated. Exposed portions of each drilled caisson shall be cured in accordance with Section 601.12 of the Standard Specifications.

625.5.5-Removal of Casing: Removal of the casing from a shaft may occur gradually as concrete is placed. Insofar as possible, casing extraction shall be done at a slow uniform rate by application of a steady vertical upward pull in the direction of the axis of the shaft. To facilitate extraction, tapping on the casing, exertion of temporary downward pressure, slight rotation, or the controlled use of a vibratory hammer will be permitted, but care must be taken to avoid harmful impacts or disturbances to the fresh concrete. Vibration or rodding may not be used to break the casing loose for extraction.

If, during extraction of casing, upward movement of concrete and/or reinforcing steel occurs, the Engineer shall be notified immediately. If he considers the movement to be minor, he may permit the extraction of the casing to continue. If, however, the movement is deemed significant and indicative of squeezing of the surrounding soil thus resulting in a reduction of the caisson diameter, then he may order the casing to be left in place, or he may permit extraction to proceed and order a later non-destructive load test, or may order other procedures as appropriate at no additional cost to the Division.

For the upper portions of drilled caissons that will be exposed and visible, the casing may remain in place as a form until the concrete has attained a strength that enables it to stand alone without further deformation. Casing shall then be removed.

625.6-INSPECTION OF SOCKETS:

625.6.1-Depth of Rock Socket: Each rock socket shall be drilled to the shaft diameter shown in the plans unless otherwise directed by the Engineer based on subsurface conditions encountered.

The top elevation of competent rock must be confirmed as the socket drilling is started. The effective "top elevation" is based on observation of the boundary zone where broken or weathered rock becomes competent rock, and is also influenced by the presence of any shale or coal seams. Based on that elevation, and the information from the preinstallation core hole, the Engineer will determine the final depth of socket and bottom elevation. The drilled rock socket will then be inspected per 625.5.2.3 and will either be accepted or drilled deeper as determined by the Engineer.

625.6.2-Inspection Under Water: In a case where it is considered unfeasible to dewater a caisson, the Contractor shall provide drilled caisson logs and screenings to the Engineer for evaluation. If this material is not sufficient for a proper judgement, the Engineer will reserve the right to order an inspection by diving or other methods either through a separate specialty subcontractor or through the Contractor in which case compensation would be under Sections 104.3 and 109.4 of the Standard Specifications. Any time required for inspection under water will be considered incidental to the work and will not be cause for extra compensation related to a claim or extension of contract time.

625.7-METHOD OF MEASUREMENT:

Drilled caissons and Rock Socket foundations will be measured by the linear foot (meter). Drilled Caissons are the portion from the finished top of each caisson to the top of competent rock. Rock Socket is the portion from the top of competent rock to the bottom of the caisson as shown in the plans or as directed by the Engineer. Each measured caisson is to be complete in place, accepted, and ready to function. "Top of caisson" is the top of concrete as shown in the plans. "Top of competent rock" is as tabulated in the drilled shaft schedules in the plans unless a difference of one 1 foot (300 mm) or more is found during drilling.

Drilled Caisson test hole will be measured in Lump Sum basis.

Preinstallation core hole shall be measured by the linear foot (meter) based upon actual length drilled. The plan quantity shall be based on one core hole, per drilled caisson, measured from the top shaft elevation to one caisson diameter below the bottom of rock socket unless otherwise noted in the plans. No payment shall be made for additional length of Preinstallation core hole drilled above the top of the drilled caisson.

625.8-BASIS OF PAYMENT:

The accepted quantities of drilled caisson foundations, measured as provided above, will be paid for at the contract unit price per linear foot (meter); complete in place including excavation, slurry if required, temporary or permanent metal casing, steel reinforcing, concrete, curing, and any required forming and finishing. No additional payment will be made for temporary casing that remains in place and pressure grouting due to the Contractor's inability to stabilize a drilled excavation, for the need to place concrete by tremie or pumping, for the need to use slurry for drilling, or for extra excavation and concrete that may be required due to drilling diameters larger than the minimum diameters specified. No additional payment will be made for methods employed to gain access to drilled caisson construction or for means required to provide a dry working environment within the drilled caissons. Tubes for CSL testing, other responsibilities related to testing and inspection assistance are incidental, with no separate payment being made.

Drilled caisson test holes will be paid for at the contract lump sum price for each such hole.

Preinstallation core hole will be paid for by the linear foot (meter).

625.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
625001-*	Drilled Caissons "D" Diameter	Linear Foot (Meter)
625003-*	"D" Rock Socket Foundation	Linear Foot (Meter)
625004-*	"D" Drilled Caisson Test Hole	Lump Sum
625005-*	Preinstallation Core Hole	Linear Foot (Meter)

* Sequence number

D = Diameter of drilled caisson, in inches (millimeters)

SECTION 626

RETAINING WALL SYSTEMS

626.1-DESCRIPTION:

This work shall consist of furnishing the design, wall construction plans, materials, and construction of cast-in-place reinforced concrete or Mechanically Stabilized Earth (MSE) walls in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown in the plans.

626.2-GENERAL:

Unless specified otherwise in the contract documents the wall may be, at the Contractor's option, any one of the wall systems on the approved source list corresponding to the applicable Pay Item; this list is posted on the MCS&T web page under the heading Approved Source/Product Listing.

The Contractor shall indicate which wall system is to be constructed by the bid alternative chosen in the proposal. No change of the wall system indicated in the bid proposal shall be permitted after the bid opening unless approved by the Engineer.

The wall design and detail plans for construction shall be submitted to the Engineer for approval. The time required for preparation and review of these submittals shall be charged to the allowable contract time. Delays caused by untimely submittals or insufficient data will not be considered justification for time extensions. No additional compensation will be made for any additional material, equipment, or other items found necessary to comply with the project specifications as a result of the Engineer's review. The proposed wall design shall be compatible with the Contractor's proposed method of construction, and shall be compatible with any method of construction shown in the plans. The Division does not assume nor warrant any wall system's compatibility with any particular construction methods.

626.3-DESIGN CRITERIA:

626.3.1-General: The size of all structural elements shall be determined such that the design load stresses do not exceed the allowable stresses found in the AASHTO LRFD Bridge Design Specifications, latest edition.

Analysis of external stability of the in-place retaining wall system will be the responsibility of the Division. Any staged or temporary construction affecting wall stability shall be the responsibility of the Contractor.

The parapets on any portion of the retaining walls as shown in the plans shall be designed to resist traffic loads in accordance with the AASHTO LRFD Bridge Design Specifications, latest edition.

626.3.2-Mechanically Stabilized Earth: The design for the MSE wall shall consider the internal stability of the wall mass. The design shall conform to the requirements found in AASHTO LRFD Bridge Design Specifications, latest edition.

External loads, which affect the internal stability such as those, applied through piling, bridge footings, temporary construction, etc. shall be accounted for in the design. A design life of 100 years shall be used throughout the design. The factor of safety for pullout resistance shall not be less than 1.50 based on pullout resistance at $\frac{3}{4}$ inch (19 mm) deflection.

The allowable bearing pressure under the stabilized mass shall be as shown in the plans. The minimum length of the soil reinforcing system, as measured from the back of the front face to the end at the back of the soil stabilized mass, shall be as shown in plans, and shall be the same from top to bottom of the wall at any cross section.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other items shown in the plans must be accounted for in the design of the wall.

626.3.3-Cast-in-Place Reinforced Concrete: When a Cast-in-Place Reinforced Concrete option is included in the plans the following shall be applicable.

The information shown in the plans for the cast-in-place alternative is schematic; however, all dimensions shown in the plans shall be considered minimums.

The allowable bearing pressure of the foundation soils, the unit weight of the retained soils, and the characteristics of the retained soils necessary for design purposes shall be as shown in the plans.

626.4-SUBMITTALS:

626.4.1-General: The Contractor shall submit complete design calculations, explanatory notes, and detail plans for the proposed wall system. The detail plans shall include all details, dimensions, quantities, and cross sections necessary to construct the wall and shall include but not be limited to the following items:

A plan and elevation sheet or sheets for the wall which shall contain the following:

1. An elevation view of the wall which shall indicate the elevations at the top of the wall at all horizontal and vertical break points and at least every 50 feet (15 m) along the face of the wall, all steps in the footings or leveling pads, the original and final ground lines, the maximum bearing pressures, and the summary of quantities for each wall.
2. A plan view of the wall which shall indicate the offsets from the construction centerline to the face of the wall at all changes in horizontal alignment and the centerline of any drainage structure or drainage pipe behind, passing through, or under the wall.
3. A typical cross section or cross sections showing elevation relationship between existing ground conditions and proposed grades.
4. All general notes required for constructing the wall. The required batter to compensate for the elongation of the soil reinforcing during erection shall be shown for each different required height.
5. All horizontal and vertical curve data affecting the wall.
6. All details for footings or leveling pads shall be shown including details for steps in the footings or leveling pads.
7. All details for construction of walls with appurtenances behind, under, mounted upon, or passing through the wall such as drainage structures or utilities shall be clearly indicated.
8. The wall manufacture shall submit copies of their Quality Assurance/Quality Control Manuals on each project.
9. Required architectural treatments shall be as indicated and as detailed in the plans. All details for any required architectural treatments shall be shown including:

- a. Product data and installation instructions for manufactured form systems, form liners, release agents, ties, and accessories. The release agent manufacturer shall certify that the products supplied comply with regulations controlling the use of volatile organic compounds (VOC's).
- b. Shop drawings for fabrication and erection. These drawings shall show all items that visually affect the exposed concrete, including, but not limited to, general form construction, jointing, specially formed joints or reveals, and patterns of placement. The Engineer's review will be for general architectural applications and features only. Formwork design for structural stability and sufficiency is the Contractor's responsibility and shall not be submitted for the Engineer's review.
- c. Mockup or Sample Facing elements. The Contractor shall construct a mockup or sample facing element using the proposed formwork and facing materials in order to demonstrate the required finishes and textures. Actual construction of concrete shall not proceed until the Engineer has accepted the sample units.

At the time the detail plans are submitted for review, they shall be accompanied by design calculations and explanatory wall notes. These documents shall be legible and shall demonstrate that the design criteria have been met. Specified minimum factors of safety and the maximum soil pressure beneath the wall footing or earth stabilized mass shall be clearly indicated.

The plans shall be prepared on reproducible sheets 22 x 34 inches (550 mm x 850 mm) including borders. Each sheet shall have a title block in the lower right hand corner. The title block shall include the sheet number of the drawing, name or designation of the wall, the state and federal project designation, project name, fabricator and Contractor name. Design calculations and notes shall be prepared on sheets 8½ x 11 inches (216 mm x 280 mm), and shall contain the project designation, wall designation, date of preparation, initials of designer and checker, and page number at the top of the page. The Detail Plans, Design Calculations, and Explanatory Notes shall be signed and stamped by a Professional Engineer registered in West Virginia and knowledgeable in the proposed alternative wall system.

The initial submission shall include three sets of the detail plans, calculations, and notes. One set of notes and plans will be returned to the Contractor with any indicated corrections. When the plans and notes are stamped approved by the Engineer, the Contractor shall furnish the Engineer with the requested number of sets of prints and a Mylar set of the plans for distribution by the Division. The Contractor shall perform no work or ordering of materials for the structures until the Engineer has approved the submittal.

626.4.2-Mechanically Stabilized Earth: The details and material specifications for the wall facing elements and incidental accessories shall be included with detail plans for approval by the Engineer.

The designation as to the type of facing element, the length of the soil reinforcing systems, the distance along the face of the wall where changes in lengths of the soil reinforcing systems occur, and the limit of mesh, strip, or anchor shall be clearly shown in the plans.

All wall facing elements shall be detailed. The details shall show all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of soil reinforcing system devices embedded in the elements.

626.4.3-Cast-in-Place Reinforced Concrete: The plans for the cast-in-place wall shall contain a complete reinforcing bar schedule showing all bending details and bar marks. The plans shall also show the location of all construction joints, expansion joints, or other joints in the wall. All wall thickness shall be shown and transition details at wall thickness changes.

626.5-MATERIALS:

626.5.1-Mechanically Stabilized Earth Components: The Contractor shall make arrangements to purchase the facing elements, reinforcing mesh or strips, attachment devices, joint materials, and all other necessary components. Materials not conforming to this section of the specifications or from sources not listed in the contract documents shall not be used without written consent from the Engineer.

626.5.1.1-Facing Elements:

626.5.1.1.1-Reinforced Concrete Facing Elements: The facing elements shall be fabricated in accordance with Section 601 of the Standard Specifications with the following exceptions and additions:

- A. Concrete for the reinforced concrete facing elements shall attain a minimum compressive strength of 4,000 psi (27 Mpa) at 28 days. All concrete shall have air entrainment of 7 % plus or minus 2.5 % with no other additives. Specified concrete properties are to be tested in accordance with applicable provision of Section 601.4.1 of the Standard Specifications. Acceptance of a Production Lot will be made if the compressive strength test result is greater than or equal to, 4,000 psi (27 Mpa). A Production Lot is defined as a group of panels that will be represented by a single compressive strength test result is greater than or equal to, 4,000 psi (27 Mpa). A Production Lot is defined as a group of elements that will be represented by a single compressive strength sample and will consist of a single day's production. A minimum of two cylinders shall be required for every compressive strength sample.
- B. The units shall be fully supported until the concrete reaches a minimum compressive strength of 1,000 psi (7 Mpa).
- C. Unless otherwise indicated in the plans or elsewhere in the specifications, the concrete surface for the front face shall have a Class 1 finish as define by Section 601.11 and a uniform surface finish for the rear face. The rear face of the element shall be screeded to eliminate open pockets of aggregate and surface distortions in excess of ¼ inch (6 mm). The panels shall be cast on a flat area. The clevis loops, tie strip guide, or other galvanized devices shall not contact or be attached to the face element reinforcement steel.
- D. The date of manufacture, the production Lot number, and the piece mark shall be clearly scribed on an unexposed face of each element.
- E. All units shall be handled, stored, and shipped in such a manner as to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Elements in storage shall be supported in firm blocking to protect the element connection devices and the exposed exterior finish.
- F. All units shall be manufactured within the following tolerance

1. Element Dimensions: Position of element connection devices within 1 inch (25 mm), except for coil and loop embeds which shall be 3/16 inch (5 mm). All other dimensions within 3/16 inch (5 mm).
2. Element Squareness: Squareness as determined by the difference between the two diagonals shall not exceed ½ inch (13 mm).
3. Element Surface Finish: Surface defects on smooth formed surfaces measured over a length of 5 feet (1.5 m) shall not exceed ¼ inch (6 mm). Surface defects on the textured-finished surfaces measured over a length of 5 feet shall not exceed 5/16 inch (8 mm).

Units shall be rejected because of failure to meet any of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection:

1. Defects that indicate imperfect molding.
2. Defects indicating honeycombed or open textured concrete.
3. Cracked or severely chipped elements.
4. Color variation on front face of panel due to excess form oil or other reasons.

All reinforcing steel shall be in accordance with Section 602 of: the Standard Specifications and shall be epoxy coated.

626.5.1.1.2-Modular Block Facings: The length and width of each block shall be within $\pm 1/8$ inch (3.2 mm). The height of each block shall be within $\pm 1/16$ inch (1.6 mm). Hollow units shall have a minimum wall thickness of 1.25 inch (32 mm). When a broken face finish is used the dimension of the front face shall be within 1 inch (25 mm) of the theoretical dimension of the unit.

All units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or performance of the construction. Cracks greater than 1/64 inch (0.5 mm) wide and greater than 25% of the block height is grounds for rejection.

The front fact or faces of units that are to be exposed shall be free of chips, cracks or other imperfections that can be seen when viewed from a distance of 30 feet (10 m) under diffused lighting. Up to 5% of the shipment may contain slight cracks or small chips not larger than 1 inch (25 mm).

Color and finish shall be shown on the shop drawings and shall be erected with a running bond configuration.

When cap units are used they shall be cast to or attached to the top of the modular block wall in strict accordance with the manufacturer's recommended procedure.

626.5.1.1.2.1-Modular Block Mix Design: Each manufacturing facility shall provide a copy of their mix design, including test results and material sources, to the MCS&T Division for each type of block. An approved independent lab shall perform the testing when establishing the mix design. The manufacturing facility shall submit to MCS&T Division yearly test results, from an approved independent lab, to verify each mix design. If there are any changes in the mix, such as changes in material sources, any materials such as pigments are added, or the pigment color is changed, then a new mix design is required. The modular block units shall conform to the following:

All of the units shall conform to ASTM C 1372, except that:

- (a) The minimum compressive strength requirements shall be 4000 Psi (28 Mpa) for any individual unit. The average of five units shall be used as the mix design strength.
- (b) The maximum 24 hour water absorption shall not exceed 7 %. The average of five units shall be used as the mix design absorption.
- (c) The freeze/thaw durability of wall units tested in accordance with ASTM C 1262 in a 3% saline solution shall be the minimum of the following:
 - 1. The weight loss of each of five test specimens at the conclusion of 90 cycles shall not exceed 1% of its initial weight.
 - 2. The weight loss of each of 4 of the 5 test specimens at the conclusion of 100 cycles shall not exceed 1.5% of its initial weight, with the maximum allowable weight loss for the 5th specimen to not exceed 10%.
- (d) The freeze/thaw durability of cap units shall be tested in accordance with ASTM C 1262 in a 3% saline solution shall be the minimum of the following:
 - 1. The weight loss of each of five test specimens at the conclusion of 40 cycles shall not exceed 1% of its initial weight;
 - 2. The weight loss of each of 4 of the 5 test specimens at the conclusion of 50 cycles shall not exceed 1.5% of its initial weight, with the maximum allowable weight loss for the 5th specimen not to exceed 10%.
- (e) ASTM C 1262 test results shall be recorded and reported in 10 cycle intervals.

626.5.1.1.2.2-Modular Block Production: Each manufacturing facility shall provide the Engineer with a copy of their quality control plan and procedures.

Sampling and Testing shall conform to ASTM C 140, except: Section 6.2.4 shall be deleted and replaced with the following:

"The specimens shall be coupons cut from a face shell of each unit and sawn to remove any face shell projections. The coupon size shall have a height to thickness ratio of 2 to 1 before capping and a length to thickness ratio of 4 to 1. The coupon shall be cut from the unit such that the coupon height dimension is in the same direction as the unit height dimension. Compressive testing of full size units will not be permitted. The compressive strength of the coupon shall be assumed to represent the net area compressive strength of the whole unit."

Each manufacturing facility is required to sample and test each block type at the rate of one sample per 5000 units of continuous production from each mix design or fraction thereof (if production is interrupted) as part of their overall quality control testing. Each manufacturing facility shall forward all quality control test reports and documentation to the MCS&T Division. The manufacturing facility or other testing facilities may perform this quality control testing.

The average compressive strength of each lot of the modular block units shall be a minimum of 90% of the mix design strength, and the average absorption of each lot shall be between 1.5% less than to 0.5% greater than the mix design absorption. If the

compressive strength or absorption criteria are not met, then the modular block in that lot are rejected and cannot be incorporated into the work unless that lot is tested and found to be acceptable under section 626.5.1.1.2.1.

Cap units and wall units shall be sampled and tested as separate block types.

Minimum manufacturer testing shall include 6 randomly selected units and the following testing:

- a. Compressive strength (average of 3 units)
- b. 24 hour absorption (average of 3 units)

The MCS&T Division will randomly select 6 units for testing by the Division for every 15,000 units of continuous production from each mix design or fraction thereof (if production is interrupted). MCS&T may require the manufacturer to conduct freeze/thaw durability testing when inconsistencies in the test results arise.

626.5.1.1.2.3-Modular Block Sealing: All modular block retaining wall surfaces shall be sealed. This work shall consist of preparation, furnishing and applying the surface sealer to the exposed front face, of all the wall units, as well as the back side of the upper courses of the wall layer of reinforcement, and the top of the uppermost block or cap unit.

Sealers shall be silane and/or siloxane based and specifically formulated for use on porous surfaces such as concrete block.

Sealers shall be tested in accordance with ASTM E514 on a block wall, and shall provide a minimum of 90% reduction in leakage.

Three dry-cast concrete block specimens shall be treated with the sealer and tested for absorption in accordance with ASTM C140. The sealer shall provide a minimum of 90% reduction in water absorption when tested in this manner.

Due to the potentially hazardous ingredients contained in sealer formulations extreme care must be exercised in their handling and use, and the manufacturer's recommendations shall be closely followed.

Construction Requirements:

1. The Contractor shall comply with the manufacturer's written instructions for preparing, handling and applying the surface sealer.
2. The surface to be treated shall receive a light water-blast to the extent that the surface is clean and free of oils.
3. Before the surface sealer is applied, the surface shall be dry and free of all dust, debris, and frost.
4. Surface sealers shall be applied at the heaviest application rate specified by the manufacturer.

All materials and work performed as specified above will be incidental to the construction of the wall.

626.5.1.1.3-Wire Facings: Wire facing shall be shop fabricated of cold drawn steel wire conforming to the minimum requirements of AASHTO M 32 M/M 32 and welded into the finished configuration in accordance with AASHTO M 55 M/M 55. Galvanizing shall conform to the minimum requirements of AASHTO M 111.

Retention material shall be placed along the back face of the wire facing to retain the backfill behind the wall. Retention material shall be capable of retaining the backfill, UV resistant and shall have a high permittivity.

626.5.1.1.4-Soil Reinforcing and Attachment Devices: All reinforcing and attachment devices shall be carefully inspected to insure they are true to size and free from defects that may impair their strength and durability. Ensure that pins used to align the precast components during construction are of the size, shape and material required for the wall system chosen.

626.5.1.1.5-Metal Soil Reinforcing or Attachment Devices: Cutting of reinforcing strips or mesh at vertical obstacles shall not be permitted. Care must be taken to avoid damage to the galvanized coating during handling, storing, and shipping.

The following requirements shall apply to all soil reinforcing and attachment devices:

- A. Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Their physical and mechanical properties shall conform to ASTM A-36. Galvanization shall be required and shall conform to the minimum requirements of AASHTO M-111.
- B. Reinforcing mesh shall be shop fabricated of cold drawn steel wire conforming to the requirements of paragraph one of Section 709.4. Galvanization shall be applied after the mesh is fabricated and shall conform to the minimum requirements of AASHTO M-111.
- C. The tie strips shall be shop fabricated of a hot rolled steel conforming to the minimum requirements of ASTM A-570, Grade 50 or equivalent. Galvanization shall be required and shall conform to AASHTO M-111.
- D. Loop embedments shall be fabricated of cold drawn steel wire conforming to ASTM A-510, UNS G-10350 or AASHTO M-32. Loop embeds shall be welded in accordance with ASTM A-185. Both shall be galvanized in accordance with ASTM B-633 or AASHTO M-111.
- E. Bolts shall meet the requirements of AASHTO M-164. Nuts shall meet the requirements of AASHTO M-291 Grade DH or AASHTO M-292 2H. Fasteners shall be galvanized in accordance with AASHTO M-232.
- F. Connector pins and mat bars shall be fabricated from cold drawn steel conforming to AASHTO M-32 and welded to the soil reinforcement mats as shown in the plans. Galvanization shall be required and shall conform to AASHTO M-111.

626.5.1.1.6-Geosynthetics Soil Reinforcing or Attachment Devices: Cutting of geosynthetic reinforcing longitudinal to the wall face at vertical obstacles shall not be permitted. End to End splicing of geosynthetic material will not be permitted.

The geosynthetic used shall meet the minimum requirements shown on the shop drawings. Each roll of geosynthetic material shall be labeled as to its properties. Geosynthetics shall be made of polypropylene, high-density polyethylene or high tenacity polyester fibers having cross-sections sufficient to permit significant mechanical interlock with the soil/backfill. Geosynthetics shall have a high tensile modulus in relation to the soil/backfill. Geosynthetics shall have a high resistance to deformation under sustained long

term design loads while in service and resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced.

Store the geosynthetics in conditions above 20° F [-7° C] and not greater than 140° F [60° C]. Prevent mud, wet cement, epoxy, and like materials from coming into contact with and affixing to the geosynthetic material. Rolled geosynthetic may be laid flat or stood on end for storage. Cover the geosynthetic and protect from sunlight prior to placement in the wall system.

Carefully inspect all reinforcement to ensure they are the proper size and free from defects that may impair their strength and durability.

The geosynthetic reinforcement structure shall be dimensionally stable and able to retain its geometry under construction stresses and shall have high resistance to damage during construction. The contractor shall submit a manufacturer's certification that the geosynthetics supplied meets the design criteria shown on the shop drawings, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Engineer can require the contractor to supply test data from an approved laboratory to support the certified values submitted.

The Contractor's submittal's package shall include actual test results for tension/creep, durability/aging, construction damage, pullout, quality control and a copy of the Manufacturers installation procedures. Also included should be the Long-Term Design Strength (LTDS) of the Geosynthetic material. The Manufacturer shall also provide written certification that all resin used to produce the geosynthetic is virgin and classified as high density polyethylene, polypropylene, or high tenacity polyester and is capable of withstanding direct exposure to sunlight for 14 days with no measurable deterioration as per ASTM D4355.

The allowable tensile strength shall not exceed 30% for class 1 walls and 25% for all other walls of the ultimate tensile strength of the reinforcement used. The allowable tensile properties of geosynthetic reinforcement as shown on the shop drawings shall be calculated using the following method.

<u>Property</u>	<u>Method</u>
Tensile Strength Ultimate, kN/m	ASTM D4595
Long-term (Ta), kN/m	FHWA/SA-93-025

Where: $T_a = T_{ult} / \{(RF_{cr}) (RF_{id}) (RF_{du})\}$

T_{ult} Ultimate Tensile Strength shall be the minimum average roll value ultimate tensile strength as tested per ASTM D4595.

RF_{cr} Partial Factor for Creep Deformation is the ratio of T_{ult} to the creep limited strength determined in accordance with ASTM D5262. The test results shall be extrapolated for a 100 year design life per GRI GG4. Creep performance data of a polymer product at a designed temperature is limited to one order of magnitude in extrapolation. Creep performance data at an elevated temperature permits an additional order of magnitude in extrapolation with time temperature superposition principals. Elevated temperature testing of the specific geogrid for 10,000 hours or creep testing at room temperature for 100,000 hours is required. Creep limited strength testing is required on representative samples of the finished product for each product proposed for use and not a single component of the geogrid (i.e. polymer strand). Default values for RF_{cr} are not allowed.

RF_{id} Partial Factor for Installation Damage, shall be determined from construction damage tests for each product proposed for use with project specific representative or more severe backfill and construction techniques. The backfill soil used if other than project specific, shall have a D50 > 1" (30 mm) sieve. Testing shall be consistent with GRI GG4. A Maximum RF_{id} value shall be used if such testing has not been conducted.

RECOMMENDED VALUES FOR RF_{id}		
Geosynthetic	Min. RF_{id}	Max. RF_{id}
HDPE uniaxial geogrid	1.20	1.45
PP biaxial geogrid	1.20	1.45
PVC - coated PET geogrid	1.30	1.85
Acrylic-coated PET geogrid	1.30	2.05
Woven geotextiles (PP and PET)	1.40	2.20
Nonwoven geotextiles (PP and PET)	1.40	2.50
Silt – film woven PP geotextiles	1.60	3.00

RF_{du} Partial Factor for Durability/ Aging is the combined partial factor for potential chemical and biological degradation. RF_{du} shall be determined from polymer specific (HDPE and PP as identified by specific gravity and melt flow index and PETP as identified by CEG number and intrinsic viscosity) durability testing covering the range of expected soil environments. Prior to approval by the Engineer, the manufacturer shall submit test results from a minimum of at least four (4) tests conducted in accordance with EPA 9090 at temperatures of 73° and 122° F (23° and 50° C). EPA 9090 test results shall include the following minimum number of leachate types:

PH	Minimum # of test results
3≤pH≤7	1
7<pH<9	1
9<pH<11	1
1≤pH≤14	1

As a minimum, the following tests should be performed for geogrids after immersion in the above-described leachates:

TEST	TEST PROCEDURE	MAX % CHANGE ALLOWED
Mass per Unit Area	EPA 9090	±1.0
Dimensions	EPA 9090	±1.0
Thickness	ASTM D374C	±5.0
Wide Width Strip Tensile	ASTM D374C	-2.0

FS_d shall not be less than the recommended minimum values discussed in FHWA/RD-89-186 and listed below:

High Density Polyethylene (HDPE)	1.10
Coated High Tenacity Polyester (PETP)	1.15
Polypropylene (PP)	1.25
Geotextiles	1.60
Uncoated High Tenacity Polyester (PETP)	1.60

1. Composite (flexible/coated) geogrids shall be evaluated based on the durability characteristics of the interior reinforcement polymer. Therefore, any protective coating shall be removed prior to durability testing unless a minimum 40-micron coating thickness is used on flexible geogrids and certified by the manufacturer.
2. For soils of potential concern, as presented below (modified soils shall include lime stabilized soil, cement stabilized soil or concrete), only polymers listed as “no effect” shall be used within or adjacent to (3 feet shortest measurable distance) these soil environments (Ref: Table 28, FHWA/RD-89-186).

<u>SOIL ENVIRONMENT</u>	<u>PETP</u>	<u>PE</u>	<u>PP</u>	<u>PVC</u>
Acid Sulfate Soils	?	NE	?	?
Organic Soils	NE	NE	NE	?
Salt Affected Soils	?	NE	NE	NE
Ferroginous	NE	NE	X	?
Calcareous	X	NE	NE	?
Modified Soils	X	NE	NE	?

NE = No Effect

? = Questionable Use

X = Not Recommended

RECOMMENDED MINIMUM VALUES FOR RF_{du}					
Products	Aging Reduction factor, RF _{du} – 100 years				
	pH ≤ 3	3 < pH ≤ 5	5 < pH < 8	8 < pH < 9	pH > 9
PET Geotextiles Mn < 20,000 40 < GEG < 50	*	2.0	1.6	2.0	*
PET Coated Geogrids Mn > 25,000 GEG < 30	*	1.3	1.15	1.3	*
Polypropylene and HDPE Geogrids	1.1	1.1	1.1	1.1	1.1

* Use of materials in this pH range is not recommended but can be used if product specific testing is done.

626.5.1.3-Joint Materials: Joint materials are to be installed to the dimensions and thicknesses in accordance with the plans or approved shop drawings, unless otherwise indicated:

- A. Provide either preformed EPDM rubber pads conforming to ASTM D-2000 for 4AA, 812 rubbers; neoprene elastomeric pads have a Durometer Hardness of 55 ± 5; or polyethylene bearing pads meeting the density requirements of ASTM D-1505 in horizontal joints between elements.
- B. Cover all joints between elements on the backside of the wall with a geotextile fabric that meets the requirements of Section 715.11.4 of the Standard Specifications. The minimum width and lap of the fabric shall be as follows:

Vertical and horizontal joints: 12" (300 mm); lap-4" (100 mm).

626.5.1.4-Acceptance: The Contractor shall furnish the Engineer a Certificate of Compliance certifying the above materials comply with the applicable contract specifications.

626.5.2-Concrete Leveling Pad: All concrete used in the leveling pad shall as a minimum conform to Section 601 of the Standard Specifications for Class C Concrete.

626.5.3-Select Granular Backfill:

626.5.3.1-Test Requirements: All backfill material used in the structure volume shall conform to the following gradation limits as determined by AASHTO T-27:

Sieve Size	Percent Passing
4 inches (100mm)	100
No. 40 (425 µm)	0-60
No. 200 (75 µm)	0 - 15

Bottom Ash or Fly Ash material will not be considered as select granular backfill unless it is specified in the contract documents.

The backfill shall conform to the following additional requirements:

- A. The plasticity index (P.I.) as determined by AASHTO T-90 shall not exceed 6, or the material is described as non-plastic.
- B. The material shall exhibit an angle of internal friction of not less than 34 degrees (unless otherwise stated in the plans), as determined by the standard Direct Shear Test, utilizing a sample of the material compacted to 95% of AASHTO T-99, Methods C or D (with oversized correction as outlined in Note 7) at optimum moisture content. No angle of internal friction testing is required for backfills where 80% of sizes are greater than $\frac{3}{4}$ inch (19 mm).
- C. Soundness: The materials shall be substantially free of shale or other soft, poor durability particles. The material shall have a magnesium sulfate soundness loss of less than 30% after Four cycles as determined by AASHTO T-104 or a sodium sulfate loss of less than 15% after five cycles as determined in accordance with AASHTO T-104.
- D. Electrochemical Requirements: The backfill materials shall meet the following criteria:

Requirements	Test Methods
***Resistivity greater than 3,000 ohm Centimeters	AASHTO T-288
**Ph 5-10	AASHTO T-289
*Chlorides less than 100 parts per Million	AASHTO T-291
*Sulfates less than 200 parts per million	AASHTO T-290
Organic Content: 1% maximum	AASHTO T-267

* If resistivity is greater than 5,000 ohm-cm, the chlorides and sulfates requirements may be waived. Requirement is waived if geosynthetics are used for soil reinforcements and attachment devices.

** May be adjusted if geosynthetic material is used for soil reinforcements or attachment devices see shop drawings and section 626.5.1.1.6.

*** Requirement is waived if geosynthetics are used for reinforcements and attachment devices.

- E. Steel slag as defined in 703.3.1 shall not be used in this item.

626.5.3.2-Quality Control Testing: Quality control of the select granular backfill material for backfill is the responsibility of the Contractor as specified in 106.1.

The Contractor shall maintain necessary equipment and qualified personnel to perform all sampling and testing necessary to determine the magnitude of the various properties of the material governed by the Specifications and shall maintain these properties within the limits of the Specifications. The Contractor shall submit a Quality Control Plan detailing the methods by which the Quality Control Program will be conducted. The plan prepared in accordance with the guidelines set forth in the appropriate portions of MP 307.00.50 and MP 717.04.21, shall be submitted to the Engineer at the preconstruction conference. The work shall not begin until the plan is reviewed for conformance with the contract documents.

626.5.3.3-Sampling and Testing: Frequency of sampling and testing shall be in accordance with the Contractor's Quality Control Plan. The minimum sampling and

testing frequencies for gradation and Atterberg limits shall be as indicated in Attachment 1 of MP 307.00.50. The material shall be sampled in accordance with MP 700.00.06. The minimum sampling and testing frequency for compaction will be in accordance with MP 717.04.21. Material failing gradation requirements during placement shall be evaluated immediately and may be subject to retesting to verify the angle of internal friction at the expense of the contractor.

626.5.3.4-Acceptance: The Contractor shall furnish certified test results that the select granular backfill meets the contract specifications. The test results for the select granular backfill shall not be used to verify compliance for a period exceeding one year. The Division may request that the tests be performed at any time if the material changes. Additional tests for gradations and plastic limits shall be determined during the placement of the material.

Acceptance for compaction shall be on a lot-by-lot basis. A lot shall be divided into five approximately equal sized sub-lots. A sub-lot shall consist of the quantity of material to backfill a single lift for 100 feet (30 m) of wall and at least one test per lift. One nuclear moisture and density measurement shall be made at a random location within each of the five sub-lots; random locations shall be determined in accordance with MP 712.21.26. For material having 40% or more retained on the $\frac{3}{4}$ inch (75mm) sieve, MP 700.00.24 shall be used to determine the target maximum dry density. For material having less than 40% retained on the $\frac{3}{4}$ inch (75 mm) sieve, the target dry density shall be the maximum dry density as determined by the AASHTO T-99 five point laboratory proctor performed on the material in accordance with section 626.5.3.1 (B). The moisture content of the material shall be maintained at a level sufficient to facilitate compaction. For applications where spread footings are used to support a bridge or other structural loads, the target percentage of dry density shall be 100% for other applications the target percentage of dry density shall be 95%. If the results of five density tests on a Lot indicates that at least 80% of the material, in accordance with 106.3.1 (West Virginia AP-A), has been compacted to the specified target percentage of dry density, the Lot will be accepted. If less than 80 % has been compacted to the specified target percentage of dry density and/or the moisture content is outside the tolerance range, no additional material shall be placed until the Lot has been reworked to meet the specified requirements. Reworking and retesting shall be at the expense of the Contractor. When the Division performs the testing in the evaluation of reworked Lots, the testing will be at the expense of the Contractor at the unit cost specified in 109.2.2.

The backfill material must compact to a stable condition. If the material is not stable under the weight of construction equipment, the contractor must correct the problem or replace the material even if test results indicate that the material meets the moisture and density specifications.

The contractor's gradation data shall be evaluated in accordance with applicable sections of Section 307 except that Table 704.6.2 shall not apply. Gradation limits shall be in accordance with Table 703.4. The certification is to include the test results. A revised unit price for calculation purposes will be established based on the delivered quantities and delivered aggregate cost.

626.6.1-Mechanically Stabilized Earth:

626.6.1.1-Foundation Preparation: The foundation for the structure shall be graded level for a width equal to the length of reinforcement elements plus one (1) foot (300 mm) or as shown in the plans. Prior to wall construction, except where constructed on rock, the foundation shall be compacted with a smooth wheel vibratory roller. Any foundation soils found to be unsuitable shall be removed and replaced with select granular backfill as per Section 614.5.1.4 of the specifications.

Construction methods for the following shall be per the indicated section of the Standard Specifications:

<u>Item</u>	<u>Section</u>
Unclassified Borrow Excavation	211
Structure Excavation	212
Wet Excavation	212
Rock Excavation	212
Select Material for Backfilling	212
Concrete	601
Reinforcing Steel	602

626.6.1.2-Wall Erection: A MSE wall supplier representative shall be present a minimum of three (3) days and as required thereafter during erection of the wall to assist the fabricator, contractor, and Engineer. The cost of the representative shall be considered incidental to the unit price of the MSE Wall System.

When facing elements are handled by means of lifting devices they shall be lifted by connecting to the upper edge of the element.

Facing elements shall be placed so that their final position is vertical or battered as shown in the plans. Facing elements shall be placed in successive horizontal lifts in the sequence shown in the plans as backfill placement proceeds. As backfill material is placed behind the elements, the elements shall be maintained in position by means of temporary wedges or bracing according to the wall supplier's recommendations. The Contractor shall not have more than two levels of temporary wedges in place at any time during wall erection. Concrete facing vertical tolerances and horizontal alignment tolerances shall not exceed $\frac{3}{4}$ inch (19 mm). The overall vertical tolerance of the wall (top to bottom) shall not exceed $\frac{1}{2}$ inch (13 mm) per 10 feet (3 m) of wall height.

Reinforcement elements shall be placed normal to the face of the wall, unless otherwise shown in the plans. Prior to placement of the reinforcing elements, backfill shall be compacted in accordance with these Specifications.

626.6.1.3-Backfill Placement: Construction methods shall be in accordance with section 212 of the Standard Specifications which requires separation fabric between random material and the select granular backfill material. A minimum non woven geotextile of 6 ounces per square yard shall be placed on the back face of the excavation between the granular backfill material and the random excavated material.

Backfill placement shall closely follow erection of each course of facing elements. Backfill shall be placed in such a manner as to avoid any damage or disturbance of the wall materials or misalignment of the facing or reinforcing elements. Any wall materials that become damaged during backfill placement shall be removed and replaced at the Contractor's expense. The Contractor at his expense shall correct any misalignment or

distortion of the wall facing elements due to placement of backfill outside the limits of this specification. At each reinforcement level, the backfill shall be placed to the level of the connection. Backfill placement methods near the facing shall assure that no voids exist directly beneath the reinforcing elements.

The backfill required to be placed in front of the wall, from the leveling pad to finished ground, shall be placed immediately after the select granular backfill is above the first layer of soil reinforcing.

The maximum lift thickness after compaction shall not exceed 6 inches (150 mm) unless approved by the Engineer. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill materials shall have placement moisture content less than or equal to the optimum moisture content. Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable throughout the entire lift. The moisture content of the select granular material shall be maintained at a level sufficient to facilitate compaction.

Compaction within 3 ft. (900 mm) of back face of the wall shall be achieved by at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

At the end of each day's operation, the Contractor shall slope the last level of the backfill away from the wall facing to rapidly direct runoff away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

One foot (300 mm) behind the modular block units and the modular block unit cores shall be filled with crushed granular material with less than 2% passing the #200 (75 μ m) sieve and shall be consistent with the manufacture recommendation. If the modular block unit cores are not accessible the engineer may upon the advice of the wall designer omit the fill in the modular block cores.

626.6.2-Cast-in-Place Reinforced Concrete:

626.6.2.1-General: Except as otherwise shown in the plans or herein, construction methods for cast-in-place retaining walls shall comply with the Standard Specifications.

Construction methods for the following shall be per the indicated section of the Standard Specifications:

<u>Item</u>	<u>Section</u>
Unclassified Borrow Excavation	211
Structure Excavation	212
Wet Excavation	212
Rock Excavation	212
Select Material for Backfilling	212
Concrete	601
Reinforcing Steel	602

626.6.2.2-Architectural Forms:

626.6.2.2.1-General: Construct forms to sizes, shapes, lines, and dimensions shown, and as required to obtain accurate alignment, location, level, and plumb work in finished structures. Provide for openings, offsets, keyways, recesses, chamfers, blocking, screeds, bulkheads, and other items as required.

Fabricate forms to prevent cement paste from leaking while placing concrete and for easy removal without hammering or prying against exposed concrete surfaces. Provide crush plates where stripping might damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete. Solidly butt joints and provide backup material at joints to prevent leakage and fins. Assemble forms so that they may be easily removed without damaging exposed concrete surfaces

Provide temporary form openings where inaccessible formwork interior can be cleaned and inspected before placing concrete. Place temporary form openings as inconspicuously as possible, consistent with project requirements.

When drilling forms used for exposed concrete, drill from the contact face to the outside to suit the ties used and to prevent leakage of concrete mortar. Do not splinter the forms by driving ties through improperly prepared holes.

Unless otherwise shown in the plans:

Provide sharp, clean corners at intersecting planes with no visible edges or offsets; or provide accurately formed chamfered corners using $\frac{3}{4}$ x $\frac{3}{4}$ inch (19 x 19 mm) strips, surfaced to produce uniformly straight lines and tight edge joints.

626.6.2.2.2-Form Coatings: Coat form contact surfaces with form-release agent before placing reinforcement. Do not allow excess material to accumulate in forms or to come into contact with reinforcement or surfaces that will be bonded to fresh concrete. Apply coating according to manufacturer's instructions.

Coat steel forms with non-staining, rust-preventative release agent, or otherwise protect from rusting. Rust-stained steel formwork is not acceptable.

626.6.2.2.3-Reusing Forms: Split, frayed, delaminated, or otherwise damaged form-facing materials are not acceptable. Clean and apply a new form-release agent to concrete contact surfaces.

626.7-METHOD OF MEASUREMENT:

626.7.1-General: The unit of measurements shall be the gross area in square feet (meters) lying in a plane outside the front face of the structure as determined by the dimensions in the contract documents. The gross area shall not include barriers, footings, or leveling pads. The gross area shall be the number of square feet (square meters) measured, subject to adjustment as provided in Sections 104.2 and 109.2 of the Standard Specifications. No adjustments of pay quantity shall be allowed for changes in wall design to facilitate the Contractor's methods of construction of wall type.

Unless otherwise specified in the contract documents, items such as concrete barriers that are not part of normal retaining wall construction shall be measured separately for payment.

The quantity of earthwork shown in the plans does not include any work within the wall pay limits shown in the plans. Any adjustments to the required amount of embankment or

select granular backfill due to the particular wall system proposed by the contractor shall be considered incidental to the project. No separate payment shall be made for increased embankment or increased select granular backfill requirements. The Contractor shall be responsible for any of the cost of changes in waste, borrow, or earthwork quantities from those shown in the plans caused by the requirements of the proposed wall system.

626.7.2-Mechanically Stabilized Earth: The unit price shall include in place: facing elements, soil reinforcing and attachment devices and associated hardware, coping and trim, or similar items that are normal parts of wall construction. No separate measurement of these items shall be made.

The unit price shall also include, in place, all the following items shown within the wall pay limits in the plans: select granular backfill, fabric for separation, excavation, embankment, foundation preparation, and leveling pads. No separate measurement of these items shall be made.

626.7.3-Cast-in-Place Reinforced Concrete: The unit price shall include in place: concrete, reinforcing, joint materials, underdrains, weepholes, or similar items that are normal parts of wall construction. No separate measurement of these items shall be made.

The unit price shall also include in place: all the following items shown within the wall pay limits in the plans: select material for backfilling, excavation, embankment, fabric for separation, and foundation preparation. No separate measurement of these items shall be made.

626.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each pay item listed below and shown in the bid schedule, which prices and payment will be full compensation for the work prescribed in this section.

626.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
626001-*	Retaining Wall, Cast-In-Place Reinforced Concrete	Square Foot (Meter)
626002-*	MSE Retaining Wall , “vendor name”	Square Foot (Meter)
626003-*	MSE Modular Block Retaining Wall , Class “class”	Square Foot (Meter)
626004-*	MSE Wire Face Retaining Wall, “vendor name”	Square Foot (Meter)

* Sequence number

“class” = a number designating class in accordance with the following table:

Class	Wall Height	Allowable substitutions for each class
I	40 ft. or less	-----
II	20 ft. or less	Class I
III	10 ft. or less	Class I or II
IV	5 ft. or less	Class I, II, or III

See Division Approved Source/Product Listing page for approved vendor list.

SECTION 627 THROUGH SECTION 630-BLANK

SECTION 631 ELECTRICAL WORK

631.1-DESCRIPTION:

This work shall consist of furnishing and installing electric motors, control panels, lighting systems, traffic control systems, conduits, and other electrical equipment and supplies in accordance with this Specification and as shown on the Plans.

631.2-MATERIALS:

The Contractor shall submit, in triplicate, an itemized bill of electrical equipment and materials, showing the rating, make, style, type, and catalog number of each item, which shall be approved by the Engineer before such equipment or materials are purchased or installed. The Contractor shall also submit for the approval of the Engineer, before beginning installation of conduit or electrical equipment, a complete wiring diagram for the work to be done, unless appropriate wiring diagrams are shown on the Plans. All equipment and materials shall meet the requirements of the National Electric Code and all local codes.

631.3-CONSTRUCTION METHODS:

All workmanship for electrical work shall be in accordance with the details shown on the Plans and with the requirements of the current National Electric Code in addition to any local codes as specified under Proposal Requirements.

631.4-METHOD OF MEASUREMENT:

Electrical work will be measured as a complete unit on a lump sum basis or in such units as indicated on the Plans, Proposal, or by Authorization.

631.5-BASIS OF PAYMENT:

Basis of payment will be the contract price bid for the item, which includes all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

631.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
631001-*	Electrical Work	Lump Sum

* Sequence number

SECTION 632

HORIZONTAL DRAINS

632.1-DESCRIPTION:

This work shall consist of furnishing and installing plastic horizontal drains and associated plastic outlet pipes, in borings drilled into the faces of cuts, fills, and retaining walls. The installation shall be at locations and at angles as shown on the Plans or directed by the Engineer during construction and shall be in accordance with these Specifications. This work shall also consist of constructing terminal chambers, or collector pipes, when required, in accordance with these Specifications.

632.2-MATERIALS:

632.2.1-Horizontal Drains: Horizontal drains shall be constructed of slotted and solid plastic pipe. The pipe shall consist of nominal 1½ inch I.D. Schedule 80, Type II PVC 2110 pipe conforming to the requirements of ASTM Designation D 1785.

The pipe shall have three rows of slots cut circumferentially in the pipe on the third points (120 degrees apart). The average configuration shall be from 22 slots, plus or minus one slot, per row per foot (300 mm) using 0.050 inch (1 mm) slots, to 46 slots plus or minus one slot, per row per foot (300 mm), using 0.010 inch (250 µm) slots. The number and width of slots will be as specified on the Plans or as approved by the Engineer depending upon the type of soil or rock. Perforated pipe shall not be used.

Solvent cement shall meet the requirements of ASTM D 2564.

632.2.2-Terminal Chamber: Horizontal drain terminal chambers shall be constructed of 48 inch (0.109" Th.) (1200 mm (2.7 mm)) metallic coated corrugated steel pipe meeting the requirements of 713.2.

Concrete used for the chamber foundation and incidentals shall meet the requirements of 715.12.

Pipe used to drain the chambers shall meet the requirements of 714.22.

632.2.3-Collector Pipes: Collector pipes, if any, shall be nominal 1½ inch unslotted or unperforated PVC pipe meeting the requirements of 714.22.

Fittings for collector pipes shall be rigid PVC, Type II, high impact fittings and shall be the solvent weld type. The fittings shall have a bursting pressure equal to or exceeding that of the pipe.

632.3-GENERAL:

The Contractor shall provide a method to determine the end elevations of all plastic horizontal drains. It shall be the Contractor's responsibility to control the drain elevations to avoid all utilities and drainage structures existing at the site.

632.4-DRILLING:

The holes shall be drilled with approved rotary equipment capable of drilling three to six inch (75 to 150 mm) diameter holes through soil or rock formations or retaining walls to the lengths and angles designated on the Plans.

Steel drill casing with an expendable bit having a "J" slot adaptor on the first section, or an equivalent substitute, shall be used for drilling the hole.

632.5-INSTALLATION OF HORIZONTAL DRAIN PIPE:

Prior to removing the casing, the slotted and solid section of the horizontal drain pipe shall be inserted. The end of the first section of the horizontal drain pipe inserted into each hole shall be plugged with an approved stopper. Each successive length of pipe shall be cemented to the previous section.

The last 10 feet (3 meters) of horizontal drain pipe, nearest the slope or wall face, shall be unslotted pipe.

Each drain shall be identified with a two inch by two inch (50 by 50 mm) or two inch (50 mm) diameter copper tag with the identification number stamped on the tag. The tag shall be permanently attached to the outlet end of the drain.

After all the horizontal drains are installed, bentonite pellets shall be thoroughly tamped or packed in the annuli to eliminate all voids between the drill hole and the plastic pipe. The Contractor shall pack the bentonite a minimum of 3 feet (900 mm) into each annulus as measured from the surface. To verify this measurement a bulkhead must be fashioned around the pipe at a distance of three 3 (900 mm) from the surface. The bulkhead may consist of rope or other similar material i.e., oakum.

632.6-TERMINAL CHAMBER INSTALLATION:

After the horizontal drains have been installed, the terminal chamber shall be constructed of metallic coated corrugated pipe meeting the requirements of 713.2, and placed at the locations and elevations shown on the Plans.

The metal portion of the chamber may be fabricated at the site or in the shop.

After the chamber is in place and the concrete has cured, the area around the chamber shall be backfilled, site graded to drain, seeded, and mulched, as directed by the Engineer. Before the backfill is placed around the horizontal drains and the chamber, the Contractor shall ensure the bentonite placed between the circumference of the drill holes and the drains is still properly placed. When directed by the Engineer, the Contractor shall place and compact more bentonite.

All bare metal and welded areas shall be thoroughly cleaned and painted with one coat of zinc rich paint meeting the requirements of 711.21.

The horizontal drains, installed at each horizontal drain terminal chamber in location, shall be left in a condition that will ensure proper connections can be made to the finished chamber and that the water will be drained into and away from the chamber construction area.

632.7-COLLECTOR PIPE INSTALLATION:

After the horizontal drains have been installed, the collector pipes shall be attached to the horizontal drains as shown on the Plans.

When a collector pipe system is required, the outlet ends of all horizontal drains shall be connected to the collector pipe by means of approved fittings; i.e., tees, plugs, street ells, etc.

632.8-METHOD OF MEASUREMENT:

The quantity of work done for "Horizontal Drains" will be measured in linear 3 (meters) of pipe, which measurement will include the actual length of drain pipe, and outlet pipe, complete in place and accepted. The installation shall include the drilling, fittings, and bentonite.

The quantity of work performed in installing the horizontal drain terminal chamber and the furnishing of all materials necessary to complete the installation will be measured per each terminal chamber in place and accepted.

The quantity of work performed in installing the collector pipes will be measured per each for collector pipes, which will include the total length of all collector pipes and fittings; i.e., tees, plugs, street ells, etc., for each installation complete in place and accepted.

632.9-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the Contract unit bid price for the items below, which price and payment will be full compensation for drilling, site grading, seeding, and furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all tools, equipment, supplies, labor and incidentals necessary to complete the work.

632.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
632001-*	Horizontal Drain	Linear Foot (Meter)
632002-*	Horizontal Drain Terminal Chamber	Each
632003-*	Horizontal Drain Collector Pipe	Each

* Sequence number

SECTION 633

CONCRETE GUTTER, INVERT PIPE GUTTER, OR DUMPED ROCK GUTTER

633.1-DESCRIPTION:

This work shall consist of the construction of open flow-ways for surface drainage, using concrete, dumped rock, or invert pipe sections of cast iron, corrugated metal, precast concrete, or vitrified clay, in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions, and cross sections shown on the Plans or established by the Engineer.

633.2-MATERIALS:

Materials shall conform to the following Subsections of Division 700, except as modified:

MATERIAL	SUBSECTION
Cement for Grout	701.1 or 701.3
Dumped Rock Gutter	704.4
Expansion Joint Material (Preformed)	708.1, 708.2
Joint Sealing Material	708.3
Reinforcing Steel	709.1, 709.4
Sand for Grout	702.1.1 through 702.1.5 and 702.2 or 702.6
Waterstops (Elastomer Materials)	708.10

Class B concrete for gutters shall meet the requirements of 601.

Invert pipe gutter shall be of the shape, size and materials shown on the Plans, conforming as nearly as practicable to the Specifications for whole pipe of similar radius and material.

CONSTRUCTION METHODS

633.3-GENERAL:

Excavation for all gutters shall be made to the required depth. For invert pipe and concrete gutters, the base upon which the gutter is to be constructed shall be compacted to a firm, even surface. All soft and unsuitable material shall be removed and replaced with suitable material which shall be thoroughly compacted. Where the location of any gutter falls on rock of a suitable nature, the Engineer may eliminate the gutter within the limits of the rock. When necessary, the rock shall be shaped to direct the flow of water back to the gutter beyond the limits of the rock.

633.4-CONCRETE GUTTER:

633.4.1-Forms: Forms shall be of wood or metal of sufficient strength to retain the concrete and shall be set and securely fastened in place, true to the lines and grades given.

633.4.2-Placing and Finishing Concrete: Class B concrete shall be placed and screeded true to profile and contour either by hand or machine methods. The surface finish shall be a wood float finish when placed by hand methods. When placed by machine method, the hand finishing shall be held to the minimum required to attain the Plan profile and cross section.

633.4.3-Joints and Cut-Off Walls: Expansion joints of the type and thickness specified on the Plans shall be installed at intervals not to exceed 50-ft unless otherwise shown. If adjacent to a pavement in which joints have been used, expansion joints shall be placed opposite those in the pavement. Contraction joints shall be provided at approximately 12½ feet (4 meter) intervals. Contraction joints shall have a minimum depth of one-fourth of the specified gutter thickness plus ¼ inch (6 mm) tolerance, shall be 5/8 inch (3 mm) (nominal) in width, and shall be formed by using removable templates, scoring, sawing, or other methods approved by the Engineer. No filler material will be required for construction or contraction joints.

A concrete cut-off wall, reinforced as detailed on the Plans, shall be constructed at the beginning and at the end of each gutter and at locations designated on the Plans or by the Engineer. Cut-off walls shall be constructed at approximately 150 feet (45 m) intervals along the gutter for grades 5 to 25 percent and at approximately 50 feet (15 m) intervals for grades greater than 25 percent.

633.4.4-Curing: The concrete gutter shall be protected and cured by wetting for a period of three days after placing, or it shall be cured by white membrane curing materials in accordance with 501.14.4.

633.4.5-Waterstops: Waterstops shall be placed at all expansion joints in the gutter and where a concrete gutter abuts a proposed structure. Provisions shall be made to properly place the waterstop in the structure. In case of a concrete gutter which abuts an existing structure, a groove ¾ inch (20 mm) by 2 inches (50 mm) shall be left and filled with joint sealer. Waterstops shall conform to the requirements shown on the Plans.

633.5-INVERT PIPE GUTTER:

Sections of gutter of the type called for on the Plans, conforming to the segment of circular arc of the dimensions designated, shall be set in a manner conforming to the applicable requirements of 604, unless otherwise modified by the Engineer. If set in concrete, the base shall be of Class C concrete of the dimensions and sections shown and shall be cured as specified for concrete gutter.

633.6-DUMPED ROCK GUTTER:

Dumped rock gutter may be dumped from trucks and bulldozed into place in a manner similar to the placing of rock fill. Hand placement will not be required. The rock gutter shall be constructed to the thickness and grade shown on the Plans. A thickness deficiency in excess of 10 percent will not be permitted.

The dumped rock gutter may be obtained from the unclassified excavation. If suitable material is not available from the unclassified excavation, it shall be the responsibility of the Contractor to furnish this material at no additional cost. Locations of probable sources for dumped rock gutter will be listed in the Plans.

633.6.1-Grout for Dumped Rock Gutter: Grout for Dump Rock Gutter shall be defined as per Section 633.2 with interstices filled with spalls and grouted cement grout. The grout filler shall be composed of a mixture of one part Portland cement and three parts sand, mixed with water to produce a workable consistency. The amount of water shall be that designated

by the Engineer. The stone shall be thoroughly wet immediately before grout is applied. As soon as the grout is deposited on the surface, it shall be thoroughly worked into the joints. The stones shall then be brushed so that their top surfaces are exposed.

Grouted Dump Rock Gutter shall be cured in accordance with any of the methods specified in 501.15, with a blanket of earth kept wet for 72 hours, or by sprinkling with a fine spray of water every two hours during the day-light hours for a period of three days.

633.7-METHOD OF MEASUREMENT:

The quantity of work done for "Concrete Gutter" will be measured in square yards (meters), complete in place and accepted, determined by the length, measured along the centerline, time the width. All measurements will be made on the surface of the gutter.

The quantity of work done for "Invert Pipe Gutter" will be measured in linear feet (meters), complete in place and accepted, measured along the centerline and upon the surface of the gutter.

The quantity of work done for "Dumped Rock Gutter" will be measured in cubic yards (meters), complete in place and accepted, determined by the dimensions shown on the Plans or established by the Engineer. No excess thickness will be measured for pay quantity.

The quantity of work done for "Grouted Dump Rock Gutter" will be measured in cubic yards (meters), complete in place and accepted as determined by the dimensions as shown on the Plans or established by the Engineer. No excess thickness will be measured for pay quantity and no separate payment will be made for the cement grout.

Cut-off walls at the beginning and end of the concrete gutter, those cut-off walls constructed on steep grades (five percent or over) in accordance with these specifications and any other cut-off walls designated on the Plans will not be measured separately but will be included in the cost of the gutter. If additional cut-off walls are required by the Engineer during construction, they will be paid for as square yards (meters) of concrete gutter; the area will be measured on the vertical face of the cut-off wall and will be the area bounded by the lower extremity of the gutter and the sides and bottom of the wall.

633.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials, including reinforcing steel, expansion joint material, joint sealer, waterstops, concrete base for invert pipe gutter when called for on the Plans, and all labor, tools, equipment, supplies and incidentals necessary to complete the work. No separate payment will be made for the excavation.

633.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
633001-*	Concrete Gutter	Square Yard (Meter)
633002-*	"size" Invert Pipe Gutter, Type "type"	Linear Foot (Meter)
633003-*	Dumped Rock Gutter	Cubic Yard (Meter)
633004-*	Grouted Dump Rock Gutter	Cubic Yard (Meter)

* Sequence number

SECTION 634 CONCRETE CRIBBING

634.1-DESCRIPTION:

This work shall consist of the furnishing and installing of precast concrete units to form a crib wall or similar structure, including the placing of interior and backfill material, in accordance with these Specifications and in reasonably close conformity to the lines, grades, dimensions, locations, and sections shown on the Plans.

634.2-MATERIALS:

Concrete shall be Class A, meeting the requirement of 601.

Joint mortar shall conform to 708.8.

Interior filling material shall conform to the requirements of select borrow as specified in 211. Shale or cinders shall not be used.

Reinforcing steel shall conform to 709.1 or 709.3.

The details of the crib members and their arrangements shall be as shown on the Plans. If manufactured on the Project, crib members shall be cured in accordance with 601. All members shall be free from depressions and spalled, patched, or plastered surfaces or edges, or any other defects which may impair their strength or durability. Cracked, untrue, or otherwise defective members will be rejected.

CONSTRUCTION METHODS

634.3-PLACING CRIB MEMBERS:

The prepared foundation bed for the cribbing shall be firm and normal to the face of the cribbing and will be approved by the Engineer before any of the crib work is placed. The crib members shall be erected as shown on the Plans. Care shall be taken to insure the correct alignment and batter on the crib wall. If a slight adjustment is needed, a shim made of shingles may be used.

Asphalt bearing pads having a thickness of 1/4 inch (6 mm), and having a dimension of 1/2 inch (12 mm) greater than the bearing width in any direction, shall be placed between all bearing surfaces. When concrete cribbing is placed without batter, the asphalt bearing pads shall be eliminated and the cribbing members laid with a 1 to 2 cement mortar joint. The crib members shall be handled carefully, and members that become cracked or otherwise damaged shall be removed and new members substituted without extra compensation.

634.4-FILLING CRIB:

The filling of the interior and backfilling behind the crib shall progress simultaneously with the erection of the cribbing. The interior shall be filled with approved granular material. The space back of the cribbing shall be filled with suitable random material. All material shall be free of particles larger than 3 inches (75 mm), frozen lumps, wood or other extraneous material. All material shall be placed in layers not exceeding 4 inches (100 mm) after compaction. This method of filling and compacting the interior and backfilling shall be continued until the embankment is level with the top of the structure, except, where the backfill is accessible to a roller, the backfill shall be compacted in accordance with 212.10. In any event, the greatest care shall be exercised in the placing and compacting of material between and back of the crib cells so that damage will not occur to the crib members.

The quality control testing and acceptance of the interior and backfill material will be according to the applicable sections of 207 and 716 or 717 with the following exceptions:

A lot will normally consist of the quantity of material required to fill the interior of the cribbing and backfill, except where the filling material and backfill material are different and in this case, each type of material would constitute a lot. For large installations, a lot should not exceed the quantity of material to fill or backfill 100 linear feet horizontal and 20 feet vertical. If either of these dimensions is exceeded, a new lot should be established.

The target percentage of density will be 95 percent, and each lot will have 5 density tests performed for quality control.

634.5-METHOD OF MEASUREMENT:

The quality of work done will be measured in cubic feet (meters) of "Concrete Cribbing", complete in place and accepted, determined by a tabulation of the number of pieces of each size and variety of separate members used, times the volume of the respective members calculated from their dimensions.

"Structure Excavation" will be limited to a plane 18 inches (450 mm) from and parallel to the faces of the cribbing.

634.6-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item below, which price and payment shall be full compensation for furnishing all the material and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work, except that the necessary structure excavation with limitations as specified above, will be paid for as Item 212001-*, "Structure Excavation". The cost of asphalt bearing pads or joint mortar, granular filling of the interior, and backfilling behind the crib shall be included in the bid price for "Concrete Cribbing".

634.7-PAY ITEM:

ITEM	DESCRIPTION	UNIT
634001-*	Concrete Cribbing	Cubic Foot (Meter)

* Sequence number

SECTION 635 METAL CRIBBING

635.1-DESCRIPTION:

This work shall consist of the furnishing and installing of metal crib members, including the placing of the interior and backfill material, in accordance with these Specifications and in reasonably close conformity with the lines, grades, dimensions, locations, and sections shown on the Plans.

635.2-MATERIALS:

The crib members shall consist of metallic headers and stretchers with the appurtenances necessary for complete assembly in the field. Each header and stretcher shall be fabricated completely in the plant prior to shipment to the site. If indicated on the Plans, fillers for placing between the stretchers on the face of the wall and end caps for the outside ends of the headers shall be furnished.

The sheets from which all headers and stretchers are manufactured shall be made of material meeting the requirements for chemical composition and spelter coating specified under 713.2 for corrugated iron or steel pipe.

The various members of the crib shall be constructed of metal having a minimum thickness of 0.064 inch (1.6 mm).

The details of the crib members and their arrangements shall be as shown on the Plans. Interior filling material shall conform to the requirements of select borrow in 211.

CONSTRUCTION METHODS

635.3-PLACING CRIB MEMBERS:

The prepared foundation bed for the cribbing shall be firm and normal to the face of the cribbing and will be approved by the Engineer before any of the crib work is placed.

The crib members shall be erected as shown on the Plans. The members shall be handled carefully, and members that are damaged shall be removed and new members substituted in their place without extra compensation.

635.4-FILLING CRIB:

The filling of the interior and backfilling of the crib shall progress simultaneously with the erection of the cribbing and shall be as specified in 634.

635.5-METHOD OF MEASUREMENT:

The quantity of work done will be measured in square feet (meters) of "Metal Cribbing", complete in place and accepted, determined by actual overall measurements of the outside face of the structure.

"Structure Excavation" will be limited to a plane 18 inches (450 mm) from and parallel to the faces of the cribbing.

635.6-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item below, which price and payment will be full compensation for furnishing all the

materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work, except that the necessary structure excavation, with limitations as specified above, will be paid for as Item 212001-*, "Structural Excavation". The cost of granular filling of the interior and backfilling behind the crib shall be included in the unit price bid for "Metal Cribbing".

635.7-PAY ITEM:

ITEM	DESCRIPTION	UNIT
635001-*	Metal Cribbing	Square Foot (Meter)

* Sequence number

SECTION 636 MAINTAINING TRAFFIC

636.1-DESCRIPTION:

This work shall consist of all necessary measures to maintain and to protect traffic, to protect the work in process, to protect adjacent property from excess dust resulting from the construction area and to maintain traffic through, around or adjacent to the construction area, in accordance with these Specifications or as directed. The work shall include the furnishing and maintaining of all traffic control devices, flaggers and pilot truck; construction of temporary structures when required; labor, equipment and materials to keep the traveled road smooth; and the furnishing and application of dust palliatives.

636.2-MATERIALS:

Materials shall conform to the following requirements of Division 700, except as otherwise noted:

MATERIAL	SUBSECTION
Aggregate	704.6 Class 1 *
Asphalt Emulsion	705.4 SS-1, SS-1h, CBAEP, or AEM-1 **
Calcium Chloride	715.1
Cationic Emulsified Asphalt	705.11 CSS-1 or CSS-1h **
Day	As used in this Specification, a day is considered to be a 24-hour period.
Pilot Truck	A Vehicle of the pick-up or jeep type, equipped with a prescribed sign mounted on the rear portion of the vehicle in such a manner as to be easily visible by following motorists.
Raised Pavement Markers and Other Pavement Marking Material	715.40
Traffic Control	715.9
Traffic Zone Paint	711.41 (Type II) or 711.40 (Temporary Paint)

* When aggregate for maintaining traffic is not to be part of any succeeding base or pavement course, the appropriate aggregate size shall be determined by the Engineer. If the aggregate is from an approved aggregate source, then it shall be accepted by visual inspection. If the contractor elects to use aggregate from an unapproved source, test results shall be provided to show that the liquid limit and plasticity index meet the requirements in Table 704.6.2B.

** SS-1, SS-1h, CSS-1 and CSS-1h may be diluted with water.

When aggregate is to become part of any succeeding base, all requirements of Section 307 for base course shall apply.

CONSTRUCTION METHODS

636.3-CONTROL OF TRAFFIC THROUGH WORK AREAS:

Control and protection of traffic through work areas shall comply with these Specifications and the provisions of the Plans. Traffic shall be maintained over the project, over such other routes as shown on the Plans, or as directed by the Engineer. The traffic route shall be kept as smooth as possible, passable and safe for anticipated speeds.

All traffic control devices shall be fabricated and installed according to the manual, "*Manual on Temporary Traffic Control for Streets and Highways*", latest version, published by the Division. The type of construction operation being performed will dictate the traffic control case (scheme) to be used as outlined in this manual and as called for on the Plans.

All stockpiles of materials shall be located so that they will not interfere with traffic being routed through or adjacent to work areas. Stockpiles of materials shall be located a minimum of 30 feet (10 m) from the edge of the traveled roadway unless traffic is protected by a positive barrier. Parking areas for the Contractor's employees, and all other vehicles shall be at locations which do not interfere with the safety of the traveling public, and on freeway type facilities shall be a minimum of 30 feet (10 m) from the edge of the traveled roadway unless traffic is protected by a positive barrier. At the end of a day's operation the Contractor shall have no equipment or materials on the traveled roadway, median area or shoulders or in any areas which interfere with the safe movement of traffic.

The traffic control plan specified in the contract for each traffic control situation is considered the plan to be followed by the Contractor. However, should the Contractor desire to adopt another traffic control plan during construction, this alternate method shall be submitted to the Engineer for review and approval at least 14 days in advance of the commencement of work in the affected areas.

The traffic control devices shall be installed immediately before the beginning of construction and shall remain in place only as long as they are needed and shall be removed immediately. Any traffic control device that does not apply to the existing condition shall be removed, covered or turned so as not to be readable by oncoming traffic.

All traffic control devices erected by the Contractor shall be maintained as indicated by the outcome of a weekly inspection, cleaned when directed by the Engineer and removed by the Contractor when conditions no longer warrant the devices.

The Engineer may require more frequent inspections if, in his opinion, the conditions warrant this measure.

Maintaining the traffic control devices shall include keeping them in good condition, correct position, and unobscured by weeds, brush, trees, work material or equipment.

The Contractor shall designate a trained person with authority to take all actions necessary for the safe control of traffic through the work zone. If noted on the plans, this person shall be American Traffic Safety Services Association (ATSSA) certified as a Traffic Control Technician or a Traffic Control Supervisor or shall demonstrate equal qualifications, approved by the Division. The Contractor shall provide the Engineer with the telephone number and applicable proofs of certification of this person, along with the telephone number of any other person who is in charge of traffic control devices, in case of emergencies at night or on weekends.

All conflicting pavement markings, as determined by the Engineer, shall be eradicated by the Contractor as soon as practicable. The eradication shall be performed prior to shifting traffic.

Positive barriers shall be either temporary concrete barrier, or temporary guardrail barrier. Temporary guardrail barrier shall be installed with 6 feet 3 inches (1.905 meter) post spacing with block outs, unless otherwise specified. The end treatment for temporary guardrail barrier shall be FET or TET as specified on the Standard Details. Payment for the end treatment shall be made under the regular pay item. The ends of the temporary concrete barrier shall be either flared or protected, as indicated on Plans. Where temporary guardrail barrier is used, a minimum clearance behind the barrier of 4 feet (1.2 m) from the face of the guardrail shall be provided.

Barricades shall be used only as channelizing devices. When temporary guardrail barricades (mounted on barrels) are used, the ends of the guardrail shall be either flared or tapered as shown on the Plans.

636.4-AGGREGATES AND DUST PALLIATIVES:

Aggregates required for the maintenance of traffic, water, liquid asphalt, asphalt emulsion, cationic emulsified asphalt or calcium chloride for use as dust palliatives, shall be furnished and applied as directed by the Engineer. Water or other dust palliative shall be used on haul roads and any location on the project to minimize pollution from dust, when dust is creating a nuisance to the traveling public or adjacent property owners. No payment will be made for other dust control. Temporary roads shall be constructed when called for, and such roads, as well as the road under construction, shall be surfaced and maintained with aggregates, as shown on the Plans or as directed by the Engineer.

636.5-TEMPORARY STRUCTURES:

Temporary structures shall be constructed and maintained as shown on the Plans or as called for in the Proposal. The use of used material is acceptable; such material shall be inspected visually and accepted by the Engineer prior to its use. The design and plans for the temporary structure shall be in accordance to Section 105.2.

636.6-PILOT TRUCK AND DRIVER OR SHADOW VEHICLE:

636.6.1-Pilot Truck & Driver: A vehicle and a qualified driver shall be furnished by the Contractor when shown on the Plans or directed by the Engineer.

636.6.2-Shadow Vehicle: A shadow vehicle shall be furnished by the Contractor when called for on the Plans or directed by the Engineer. This vehicle shall be a standard truck weighing between 10,000 GVW (4 536 kg) and 24,000 GVW (10 880 kg) maximum, and shall be equipped with a flashing or rotary yellow beacon which can be seen in all directions and a truck-mounted attenuator mounted on the rear.

The shadow vehicle shall be used at the locations shown on the Plans where a lane is closed and work is in progress. When work is completed for the day, the shadow vehicle shall be relocated behind a positive barrier or off the job site in a safe location.

636.7-ERADICATION OF PAVEMENT MARKINGS:

All markings which may conflict with desired traffic movement, as determined by the Engineer, shall be fully eradicated as soon as practicable. Eradication shall be performed prior to shifting of traffic.

Eradication shall be performed by hydro-blasting, sand blasting, chemicals, burning with excess oxygen or other suitable method.

Full eradication shall be defined as the removal of at least 90 percent of the existing marking. A 90 percent removal will be determined by the Engineer by comparison with the Eradication Visual Standard. This Standard can be obtained from the Engineer. In addition to the visual comparison, the 90 percent removal level is defined such that there will not be any remaining surface of the original paint film in the eradicated area. The remaining 10 percent of the existing marking will appear to be as part of the texture of the pavement.

The method used shall not materially damage the surface or texture of the pavement. Any damage caused by the Contractor's operations shall be corrected at the Contractor's expense and in a manner approved by the Engineer.

The Contractor shall take precaution to protect the public from any damage due to their operations. Accumulation of sand, water, dust or other residue resulting from the eradication operation shall be removed as the work progresses.

636.8-TEMPORARY PAVEMENT MARKINGS AND RAISED PAVEMENT MARKERS:

Temporary pavement markings and raised pavement markers shall be in accordance with 663.

Temporary pavement markings, to be used in delineating pavement lane and edge lines, shall be either temporary reflectorized pavement marking tape or reflectorized paint as approved by the Engineer.

When placing temporary pavement lane markings to separate traffic traveling in the opposite directions, it should be noted that, if there is no passing in both directions, double-yellow solid lines shall be placed; i.e. single-yellow solid lines are prohibited for separating opposite flowing traffic. In addition to temporary marking tape or paint, temporary raised, reflectorized pavement markers shall be placed, when called for on the Plans, for added delineation, at approximately 40 feet (12 meter) intervals along the lane lines that separate traffic traveling in the opposite directions, with the markers centered transversely between double-yellow lines, or at the spacing required on the Plans.

When temporary raised pavement markers are specified as an alternate to temporary paint or to temporary tape, the configurations shall be as follows: solid line-markers shall be placed on five foot (1.5 m) centers along the entire length of line; lane line - four markers shall be placed on three foot four inch (1 m) centers with 40-foot (12 m) spacing, first marker to first marker; double yellow-markers shall be placed on five foot (1.5 m) centers in pairs.

Temporary pavement markings and raised markers shall be placed as soon as practicable after construction of a detour or other roadway requiring this type of delineation.

Temporary raised pavement markers shall be shipped, stored, and placed in accordance with the recommendations of the marker manufacturer. The Contractor shall supply a copy of the manufacturer's placement recommendations to the project Engineer upon request. If temporary raised pavement markers are to be placed on a newly placed asphalt final wearing course or a newly placed concrete surface, markers with a manufacturer pre-applied "peel and stick" adhesive pad, as allowed for in the Materials Specifications, shall be used.

636.9-TRAFFIC CONTROL DEVICES:

Traffic control devices for work areas include, but may not be limited to, signs, barricades, drums, cones, channelizer cones, delineators, and flashers. They shall be installed in accordance with standards detailed in the manual "*Manual on Temporary Traffic Control for Streets and Highways*", latest version, published by the Division, or as shown on the plans.

If the Total Contact Bid Amount is over \$500,000 or otherwise noted on the plans Traffic Control Devices also include work area signs indicating fines. These signs shall be installed 500' (150 m) after the first maintenance of traffic sign installed for each project. The signs shall be installed in both directions on the road under construction. The sizes, messages, and designs shall as shown in the Sign Fabrication Manual or as directed by the Engineer. With the larger size used for four lane expressway roadways with speeds of 55 MPH or greater and the smaller sign used

for two lane roadways with speeds of 50 MPH or greater and with an ADT at 3,000 or greater. A 12' x 6' expressway sign (Item 636011-* - 300 units) placed behind guardrail on 3-4 #BB U-Channel or on 3 - 4" x 4" wood post (breakaway) or 8' x 4' - two lane highway sign (Item 636011-* - 180 units) placed behind guardrail on 2 - 4 #BB U-Channel or on 2 - 4" x 4" wood post (breakaway).

If the project is on an Interstate Highway, an APD (Appalachian Highway Corridor), a controlled access highway with posted speed limit of 40 Miles Per Hour (MPH) or greater, or if otherwise noted on the plans, Traffic Control Devices shall include work area signs designated "GIVE 'EM A BRAKE" (GEAB). The sign size, message, and design shall be as shown on Sign Fabrication G30-1 or as directed by the Engineer.

The sign (Item 636011-*, 300 units) shall be installed 500'-1500' after the first lead-in work area sign unless the work zone is greater than one (1) mile, in length, in which case the GEAB sign shall be installed approximately ¼ mile in advance of the active work area. At no time shall the GEAB sign be closer than 500' from any other work area signing. The sign shall be installed in both directions on the right side of the highway. All GEAB signs shall be installed on three, 3 pound per foot u-channel posts driven to a depth of 3 ½ feet. The u-channel posts shall be continuous in length, or a combination of a stub driven to a depth of 3 ½ feet, an approved splice arrangement and an appropriate length supporting post.

GEAB sign shall only be installed in active work areas where workers are present and visible to passing motorists. During periods of inactivity in the work area, the GEAB sign(s) shall be covered or removed.

All traffic control devices installed shall be devices which meet the mandatory crash testing performance requirements of National Cooperative Highway Research Program Report 350 (NCHRP-350) and/or the American Association of State and Highway Transportation Officials publication Manual for Assessing Safety Hardware (AASHTO-MASH), latest version. With the exception of Category 1 work zone devices, as defined by the FHWA, all devices shall have a supporting NCHRP-350 and/or AASHTO-MASH acceptance letter from the FHWA. Category 1 work zone devices shall have supporting self-certification from the device manufacturer that the device meets the mandatory crash testing performance requirements of NCHRP-350 and/or AASHTO-MASH.

All devices shall be assembled and utilized in a manner that is consistent with the crash testing of the devices. For example, portable traffic control sign stands shall only be used within the parameters of the crash testing of the stands unless otherwise allowed for by the FHWA in the FHWA acceptance letter or by other written FHWA guidance or policy. These parameters include, but are not necessarily limited to sign mounting height, sign substrate material, maximum sign size, and the application of warning lights. Unless included as part of the testing of the device or allowed for as part of the manufacturer's self-certification for Category 1 work zone devices, additional ballast added to devices shall only be as allowed for by the FHWA in the FHWA acceptance letter or by other written FHWA guidance or policy.

Devices utilized by the Contractor shall be a model listed on the Division's Approved Products List (APL), as applicable. Devices approved and/or certified at Test Level 2, but not Test Level 3, shall not be utilized on roads having a normal posted speed limit greater than forty (40) MPH. Devices approved and/or certified at Test Level 1 only shall not be utilized on roads having a normal posted speed limit greater than twenty-five (25) MPH.

636.10-CLEANING OF TRAFFIC CONTROL DEVICES:

Cleaning of all traffic control devices, when directed by the Engineer, shall consist of hand cleaning with a mild detergent followed by a thorough rinse with clear water. No harsh chemical, abrasive cleaner or tool shall be used that will damage the reflectorized surfaces or otherwise reduce the useful life of the device.

636.11-FLAGGER-TRAFFIC DIRECTOR:

The flagger-traffic director are separate functions and therefore, shall not be interchanged.

All flaggers shall be furnished by the Contractor, and it shall be the Contractor's responsibility to provide flaggers at any location necessary to assure the safety of the travelling public. When flaggers are required at locations as a result of operations considered reasonable and necessary by the Engineer to complete the project, payment will be made under this provision.

Hand signaling devices, and approved vests shall be used by the Contractor's personnel assigned to traffic control responsibilities. Approved headgear, if worn, and vests worn by the Contractor's personnel shall not bear the Division symbol. Wireless two-way communication shall be provided to the flaggers when they are out of sight of each other.

The traffic control plan (TCP) and any approved revisions will be strongly considered in determining the appropriateness of payment. Flagger-Traffic Director required for operations that are not necessary but are initiated by the Contractor for their benefit or ease of operations shall not receive payment under this provision. Flagger-Traffic Director required outside of the project limits as a result of any of the Contractor's operations shall not receive payment. Flagger-Traffic Director required within the project limits in regards to the Contractor's transportation to or from waste areas, borrow pits, concrete plants or other necessary sites shall receive payment if considered reasonable and necessary as previously discussed.

636.12-TEMPORARY IMPACT ATTENUATING DEVICE:

This device shall be a "stationary crash cushion" as described within Section F.82 of the manual *"Manual on Temporary Traffic Control for Streets and Highways, 2006 Edition"*.

The device utilized shall be a model listed on the WVDOT Approved Products Listing (APL) for Safety Devices specifically noted as being approved for temporary work zone use. Specific device selection in regards to manufacturer and model shall be at the Contractor's discretion; however, unless the characteristics of the obstacle to be shielded dictate otherwise, the device utilized shall be a non-tapered, non-gating device. If it is not possible, based on the width of the obstacle to be shielded, to utilize a non-tapered, non-gating device, the Contractor shall utilize an approved Sand Barrel system.

Notes included on the APL characterize non-gating devices by their National Cooperative Highway Research Program Report 350 (NCHRP-350) crash testing approval level (Test Level 2 or Test Level 3). The Test Level certification required for each particular device to be qualified at shall be based on the normal (non work zone) posted speed limit in effect at the location of the device. A Test Level 2 or Test Level 3 device shall be utilized if the normal posted speed limit is 40 MPH or less. Otherwise, a Test Level 3 device shall be required. Sand Barrel arrays shall be designed for an impact speed 5 MPH greater than the normal posted speed limit.

All Temporary Impact Attenuating Devices shall be installed and maintained fully in accordance with the specifications and recommendations of the device manufacturer. This shall include, but shall not be limited to, characteristics of the roadway profile along the approach to the nose of the device and along the adjacent (traffic) side of the device, changes in the roadway grade within the length of the device, side slope and changes in the side slope at the location of the

device, anchoring (base to be anchored to as well as the anchoring system), backup, attachment to the obstacle being shielded, transitioning to the obstacle being shielded, winterization, delineation, repair, and cleaning. If the installation requires deviations from the specifications and recommendations of the device manufacturer, the Contractor shall obtain written approval from the device manufacturer and shall produce this written approval for review upon request.

Impacted devices shall be maintained and returned to full impact capacity in a timely manner. Beginning 12 hours from the time and date upon which the Contractor is given documented notice of damage to an Impact Attenuating Device requiring repairs, the Contractor shall be subject to a penalty of \$1,000 per Calendar Day (24 hrs.), or fraction thereof, until the necessary repairs are completed. This penalty shall not be temporarily suspended for any reason and shall apply regardless of the cause of the damage to the device.

All labor, equipment, and materials required for the repair of impact attenuating devices shall be incidental to Bid Item 636060.

636.13-CHANNELIZER CONES:

If specified in the project plans, Channelizer Cones may be utilized for channelization of traffic in lieu of drums. Note, when used for closures that will be in effect at night, these devices shall be spaced at a maximum of forty (40) feet where a spacing of fifty (50) feet is normally called for in the Traffic Control Manual. In addition, the maximum spacing of these devices in all lane or shoulder tapers, day or night, shall be twenty-five (25) feet. Traffic control setups utilizing Channelizer Cones are to be reviewed at least once every twelve (12) hours during non-work periods by the Contractor responsible for traffic control on the project.

636.14-TEMPORARY BARRIER:

Furnish, install, maintain, remove and dispose of temporary barrier in accordance with this specification and the contract plans.

636.14.1-Materials: Temporary Barrier shall meet the requirements of NCHRP Report 350 and/or MASH-08 for the different test levels as shown in Table 3.1 “Test Matrix for Longitudinal Barriers” in NCHRP Report 350. Specific types of temporary barrier will not be used unless crash tested and approved by the Engineer. Historical performance will help determine use of a product. Poor performance may be grounds for non-acceptance.

Temporary Barriers shall have adequate drainage slots to allow runoff to pass through.

Temporary Barrier shall have 8” x 12” Type B-1 Delineators (white or yellow as appropriate) facing traffic at 40 foot centers.

636.14.2-Installation: This barrier type shall conform to the details on the Plans, set as directed on the Plans, with the barrier sections securely connected together by satisfactory fastening devices to provide a more stable structure against impact.

A Temporary Barrier Installation Plan shall be approved according to Section 105.2.1.2 “Contractor Approval Method”. It shall have information adequate to ensure it meets the installation conditions below and shall include barrier type, barrier connection type, NCHRP test approval and data, individual segment length, anchorage details, end treatments, and transition details.

The temporary barrier shall be placed to match test conditions as determined by the Engineer. These conditions may include, but not be limited to, anchorages, total length of

barrier, individual segment length and connection details. Only one type of temporary barrier shall be used for any one continuous run of barrier in a project. To clarify, the entire length of temporary barrier shall not be intermixed in regard to type of barrier, connection type, or individual barrier length unless that configuration has been tested.

Anchorage spacing and installation, if required, shall be per manufacturer subject to shop drawing review and approval and meet or exceed test conditions. Shop drawing information shall include details for anchor removal and patching and /or repair of pavement or bridge deck.

Where temporary barrier adjoins guardrail barrier, regardless if one is temporary and the other is permanent (newly constructed or previously in existence) or if both are temporary, they must be connected with a Temporary Guardrail Connector conforming to 636.16.2.

Where temporary barrier adjoins bridge parapet or other essentially non-yielding barrier or obstacle, they must be joined in a manner to maintain barrier continuity and prevent vehicle snagging during impact. If they cannot be joined in this manner, a connection device must be used to assure barrier continuity and to prevent vehicle snagging during impact.

When the temporary barriers are no longer needed, they will become the property of the Contractor, unless otherwise noted on the Plans.

J-J Hook connections shall be tensioned by pulling the barrier segments apart to make this type connection “tight”.

Vehicles, materials or any other equipment shall not be stored in the Temporary Barrier buffer area. Unless required as a part of the contract, vehicles and equipment shall not work in the Temporary Barrier buffer area and if required, shall be limited to that time that it is necessary to be in that area.

636.15-REMOVING AND RESETTING TEMPORARY BARRIERS:

Temporary barriers that are to be relocated within a project shall be salvaged and reinstalled as specified in 636.14 and set as indicated on the Plans.

636.16-TEMPORARY GUARDRAIL:

636.16.1-Temporary Guardrail Barrier: Temporary guardrail barrier shall consist of guardrail (beam) mounted on 6 feet 3 inches (1.905 m) post spacing with blockouts, conforming to the requirements of 607. Where temporary guardrail barrier adjoins concrete barrier, bridge parapet, or other essentially non-yielding obstacle, regardless if one is temporary and the other is permanent (newly constructed or previously in existence) or if both are temporary, they must be connected with a Temporary Guardrail Connector conforming to 636.16.2.

636.16.2-Temporary Guardrail Connector: This connector shall consist of the last 25 feet (7.62 m) of guardrail (beam) prior to the physical connection to a non-yielding barrier or obstacle, mounted on 3 feet 1½ inches (0.9525) post spacing with blockouts, conforming to Standard Sheet G.R. 5 and an End Shoe conforming to Standard Sheet G.R. 2A. Four bolts shall be used in the End Shoe and standard posts may be substituted for the oversized wood posts.

636.17-REMOVING AND RESETTING TEMPORARY GUARDRAIL BARRIER:

Temporary guardrail barrier that is to be relocated within the project shall be salvaged and reinstalled as specified in 636.16.

636.18-ELECTRIC ARROW:

The electric arrow panel shall be located as shown in the manual, "Traffic Control for Street and Highway Construction and Maintenance Operations", published by the Division, or as shown on the Plans. For construction areas, the electric arrow shall be portable, trailer mounted on a nonreflective flat black panel 48 inches high by 96 inches (1.2 meters high by 2.4 meters) wide with a minimum legibility distance of one mile (1.6 km). Minimum mounting height, measured from the roadway to the bottom of the panel, shall be 7 feet (2.1 m) except on vehicle mounted panels which shall be as high as practicable. The electric arrow shall have the capability of the following mode selection: Left Arrow, Right Arrow, Left and Right Arrow and Caution, with Caution mode consisting of four or more lamps arranged in a pattern which will not indicate a direction. Arrow panels shall automatically dim 50 percent from their rated lamp voltage during hours of darkness. The flashing rate of the lamps shall be between 25 and 40 flashes per minute. Minimum lamp "on time" shall be 50 percent.

636.19-PORTABLE MESSAGE SIGNS:

636.19.1-General: Portable Message signs shall consist of the furnishing, installing and maintaining of a variable message sign on a portable trailer. Each unit shall be self-contained and consist of a display board, controller, power supply, electrical cable and adjustable height structural support system. It shall be equipped to accept power supply from a completely self-contained diesel generator, existing commercial electrical service, or battery pack which is recharged automatically by solar panels. The trailer system assemblage shall conform to the laws of the State of West Virginia and all articles of the licensing regulations presently in effect. The sign shall only be attached to its tow vehicle when installation or removal is in progress. The trailer and its leveling jacks shall be designed to keep the unit from changing its deployed position once placed. Devices that lock the wheels and/or leveling jacks into place shall be employed. Sandbagging of the frame and/or leveling jacks is not an acceptable manner of lock down.

The unit shall be kept in good repair at all times. The Contractor shall maintain the device if failures occur. Failure, malfunction or damage to the unit for any reason shall require the Contractor to expedite the repair and furnish adequate signing and flaggers as deemed necessary by the Engineer to safely control traffic through the work area. Maintenance shall include periodic cleaning of the unit.

All parts of the system shall comply with codes annotated in the National Fire Protection Association and Underwriters Laboratory and all local electrical codes. Earth ground shall be tied to the sign's chassis. Lightning protection shall be supplied for the load site.

636.19.2-Display: The Portable Message Sign shall be the disc matrix or LED lamp matrix panel type capable of operating in temperatures from -30° to $+160^{\circ}$ F (-36° to 72° C) and capable of displaying alphanumeric characters and arrows. The sign panel assembly, including the mounting brackets, shall not exceed 128 inches (3.15 meters) in overall width. The bottom of the sign panel shall be a minimum of 7 feet (2.13 m) above the roadway. A minimum character height of 18 inches (450 mm), and character spacing at a minimum of two dots or one half the character width, unless otherwise approved by Engineer.

The trailer shall be marked with a minimum of 200 square inches (1.29 square meters) of four-inch (100 mm) alternating red/white conspicuity marking material (WV Type VI / Fed.

Type IX Retroreflective sheeting) to be visible by motorists approaching the trailer from any direction.

If battery backup (in event of power interruption) is called for on the plans, all functional operations to include sign lighting shall be operational up to two hours. Fluorescent lighting or LED lamp matrix shall be applied to provide nighttime visibility and the intensity of the sign shall be adjustable by automatically dimming or manual control.

636.19.3-Sign Types:

636.19.3.1-Changeable Message Sign: The Changeable Message Sign system shall have three (3) lines, unless otherwise noted on the plans and shall conform to the general requirements of 636.19.1. The unit shall have several preprogrammed messages and be capable of programming at least fifty new messages and storing such. The controller shall be housed in a weatherproof lockable cabinet that is accessible from a suitable mounting on the trailer. The controller shall be a microprocessor controller or laptop computer with an incorporated keyboard and CRT that allows the users to access, generate, and store messages. The controller display shall be a miniaturized approximation of the actual display or a message being assembled. The display shall be yellow or amber character on black background, a 7 x 5-character font.

The cycle time and duration of message for a changeable message sign is a function of the highway operating speeds and the size letters displayed. The entire message should be visible at least twice at the operating speed. When traveling at 65 MPH (105 km/h) (freeway speeds), a driver has approximately seven (7) seconds to read the message, the message should not be longer than four (4) words or numbers and not longer than two (2) units of information. The message displayed from each unit shall be visible from one-half mile (805 meters).

The sign shall be capable of changing to and displaying a programmed default message or four corner dots flashing in the event of power failure.

636.19.3.2-Speed Monitoring Trailer: A Speed Monitoring Trailer system shall conform to the general requirements of 636.19 and shall consist of a trailer, radar, and display. The unit should be operational only while work is in progress.

636.19.3.2.1-Radar: The radar unit shall be capable of an output in miles per hour (mph) or kilometers per hour (km/h) operating at a frequency of 24.15 GHz (K-Band) $\pm$ 100 MHz accurate to within 3 mph at a target speed of 10 to 199 mph (16 to 230 km/h).

636.19.3.2.2-Display: The display board shall be a minimum two-digit, high brightness, amber display on a black background. The system shall be equipped with a violator alert feature. This feature shall change the display from steady amber to flashing amber and flash the speed reading when a vehicle exceeds a programmable speed threshold. This threshold shall be adjustable. The display shall be mounted a minimum height of 4 feet (1.2 meters) above the roadway.

A 7-inch (175 mm) by 36-inch (900 mm) plaque reading "YOUR SPEED" in black letters on a yellow background shall be mounted directly above or directly below the display. The rack shall be secured with a lockable fastener and shall provide room to mount a minimum 30-inch (750 mm) by 36-inch (900 mm) speed limit sign (R2-1) above the display.

636.19.4-Placement: Site selection, protection from traffic, and message displayed shall be approved by the Engineer. A changeable message sign and a speed monitoring trailer are not to be placed where they conflict with one another.

The changeable message sign shall always be located behind the channelizing devices or barriers away from moving traffic lanes. In work zones, it shall be located in clear buffer barricades without reducing the sign's visibility.

The speed monitoring trailer system shall be located within the area of the reduced work zone speed limit, but shall not be located within or before a transition or taper. At locations where the shoulder is open, cones shall be tapered at 25 feet (7.5 meters) centers for a distance of 200 feet (61 meters) on the approach to the unit to differentiate it to oncoming motorists.

636.20-TEMPORARY TRAFFIC SIGNAL(S) OR TEMPORARY LIGHTING:

Temporary traffic signal(s) shall consist of furnishing, installing, maintaining and subsequent removal of various types of traffic signal systems as necessary due to the maintenance of traffic plan. It shall include, but not be limited to, traffic signals and traffic signal interconnections to be installed in accordance with Section 660 and Subsection 715.42 of the Specifications. As a minimum, the temporary traffic signal(s) shall be equipped with a three-dial fixed time controller. When the temporary traffic signal(s) are no longer needed, they will become the property of the Contractor.

Temporary lighting shall consist of furnishing, installing, maintaining, and subsequent removal of various types of lighting systems as necessary due to the maintenance of traffic plan. It shall include but not be limited to lighting to be installed in accordance with Section 662 of the Specifications. When the temporary lighting is no longer needed, it will become the property of the Contractor.

636.21-TEMPORARY PIPE FOR MAINTAINING TRAFFIC:

Temporary pipe for maintaining traffic shall conform to the requirements of 604.

636.22-WARNING LIGHTS:

Warning lights shall consist of the furnishing, installation and maintenance of a portable, lens directed, enclosed light. The warning lights shall be in accordance with the requirements of 715.9.5 of the Standard Specifications.

636.23-METHOD OF MEASUREMENT:

The quantities of work done will be measured as follows:

636.23.1-Aggregate: The quantity of "Aggregate for Maintaining Traffic" will be measured in tons (megagrams) of aggregate applied and accepted.

The number of tons (megagrams) shall be determined by the total of the weights shown on receipted railroad freight bills when materials are shipped by rail; by actual measured displacement of barges certified by the producer when water shipments are made, providing materials delivered by the methods are not stockpiled or stored; or determined by the Contractor from the total of weigh slips for each vehicle load weighed on an approved standard scale or from digital printout slips from an automatic batching plant, and certified by the Contractor to be correct.

Truck scales shall be provided by the producer or Contractor, except that truck scales are not required where the material is weighed at properly calibrated automatic batching plant

facilities which are equipped with digital print-out equipment. The scales shall be of sufficient size and capacity to weigh the heaviest loaded trucks that are used for delivery of the material.

All truck scales shall be mounted on solid foundations which will insure their remaining plumb and level. All truck scales shall be inspected and sealed by the West Virginia Division of Labor, Bureau of Weights and Measures, or other appropriate agencies of the State or its political subdivisions. The Division may, at its option, accept inspection and sealing by out of state agencies when the material is weighed outside West Virginia.

A weigh person shall be provided by the producer. The weigh person shall certify that the weight of the material, as determined either by the truck scales or from the digital print-out of the weights, is correct.

Each truck shall be weighed empty prior to each load, except at automatic batch plants approved to operate without truck scales. A digital recorder and print-out shall be required on all truck scales. The digital recorder shall produce a printed record of the gross, tare and net weights, and the time, date, truck identification and project number.

Provision shall be made for constant zero compensation and further provision shall be made so that scales may not be manually manipulated during the printing process. The system shall be interlocked so as to allow printing only when the scale has come to rest. In case of a breakdown of the automatic equipment, the Engineer may permit manual operation for a reasonable time, normally not to exceed 48 hours, while the equipment is being repaired.

636.23.2-Bituminous Material: The quantity of "Bituminous Material for Dust Palliative" shall be the number of gallons (liters), prior to dilution in the field, incorporated into the completed work and will be measured as prescribed in 109.1.

636.23.3-Calcium Chloride: The quantity of "Calcium Chloride for Dust Palliative" shall be the number of tons (megagrams) actually used for the work, determined by the total of the weights of the individual units when shipped in packages.

636.23.4-Temporary Structures: "Temporary Structures for Maintaining Traffic", as detailed on the Plans or called for by the Engineer, shall be on a lump sum basis for completing, maintaining and removal of the work. Earthwork required for erection or removal of the structure, not measured and paid for by a specific item, shall not be measured or paid for and shall be incidental to Item 636005-*, Temporary Structure For Maintaining Traffic.

636.23.5-Pilot Truck and Driver: "Pilot Truck and Driver" shall be on a per day basis and shall include auxiliary barriers and warning signs of all necessary types used in conjunction with the pilot truck.

636.23.6-Traffic Control Devices: "Traffic Control Devices" will be measured by the number of units of traffic control devices used and accepted. The relative value of each traffic control device in units shall be as shown in the traffic control device rate schedule. The total units of traffic control devices shown in the Contract is an estimated amount only and may be adjusted up or down by the Engineer in accordance with the needs of the project. When more than one sign is attached to a post(s), mount(s) or barricade, the signs will be measured as a sign assembly and not as individual signs.

The price bid per unit of traffic control devices shall include furnishing, maintaining and removing, filling drums with sand as required, providing sand bags as ballast on barricades,

replacement batteries for flashers, turning, covering or otherwise causing signs to be unreadable to traffic when the message does not pertain to the existing condition and all other miscellaneous items required for maintaining traffic.

Traffic control devices completely destroyed by traffic or any other means shall be replaced by the Contractor, with no additional payment to the Contractor.

A payment of $\frac{1}{4}$ the rate shown shall be made to the Contractor for any traffic control devices that the Contractor moves more than 500 feet (150 m) when directed by the Engineer.

This rate shall not apply for continuous type operations such as resurfacing projects. Payment for continuous type operations shall be made for the initial placement only. No additional compensation will be made for the moving of traffic control devices made necessary due to the nature of continuous type work.

When Cones are specified as the temporary channelizing device in a project, the Contractor may, at their option, utilize Channelizer Cones in lieu of Cones. However, the unit value assigned to the Channelizer Cones in this case shall be equal to the established unit value assigned to Cones.

TRAFFIC CONTROL DEVICES RATE SCHEDULE		
Device #	Description	Value in Units Each Traffic Control Device
1	Signs on portable mounts and barricades (Total sign area 16 sq. ft. (1.5 sq. meters) or greater)	170
2	Signs on portable mounts and barricades (Total sign area less than 16 sq. ft. (1.5 sq.meters))	80
3	Signs on permanent posts (Total sign area 16 sq. ft. (1.5 sq. meters) or greater)	180
4	Signs on permanent posts (Total sign area less than 16 sq. ft. (1.5 sq.meters))	90
5	Barricades-Type I	35
6	Barricades-Type II	60
7	Barricades-Type III	90
8	Drums	60
9	Cones	5
10	Vertical Panel or Ground Mounted Delineators	10
11	Barrier or Guardrail Mounted Delineators (Bid Incidental to Barrier or Guardrail)	0
12	Channelizer Cones	40
13	Oversize signs	300

1. Orange sign sheeting to be retroreflective fluorescent-orange. WVDOT approved Type ASTM-VI material shall be used for roll-up signs. WVDOT approved Type ASTM-IX or ASTM-XI material shall be used for rigid signs on projects advertised prior to April 1, 2019. WVDOT approved Type ASTM-XI material shall be used for rigid signs on projects advertised on or after April 1, 2019. All other signs shall be manufactured using WVDOT approved Type ASTM-IV material unless fluorescent-yellow or fluorescent-yellow-green material is specified, in which case WVDOT approved Type ASTM-XI material shall be used.
2. Drum and Channelizer Cone sheeting to be six (6) inch WVDOT approved Type ASTM-IV material.
3. Barricade and cone sheeting shall be WVDOT approved Type ASTM-IV material.

4. Only those Drums, Channelizer Cones, Sheetings, Soil Anchored Flexible Delineator Posts, Surface Mounted Tubular Markers, Guardrail Mounted Flexible Delineators, and B-1 Delineators which have been field tested and approved by the Division will be permitted. A list of the approved suppliers and their code numbers may be obtained by contacting:

West Virginia Division of Highways
Materials Division
190 Dry Branch Dr.
Charleston, WV 25306

Payment for furnishing, installing, and maintaining the work area signs indicating fines shall be as part of Item 636011-*. "Traffic Control Devices." And all the previous provisions of this Article shall apply.

636.23.7-Water for Dust Palliative: Water for dust palliative will be measured and paid for under Item 637001-*.

636.23.8-Eradication of Pavement Marking: The quantity of "Eradication of Pavement Markings" shall be the equivalent linear feet (meters) of 4 inches (100 mm) solid line actually removed from the pavement. As an example, an 8 inches (200 mm) solid line would double the linear quantity.

636.23.9-Temporary Pavement Markings-Paint: The quantity of "Temporary Pavement Markings-Paint" shall be the linear feet of 4 in. (100mm), 6 in. (150 mm), or 8 in. (200 mm) solid line actually placed on the pavement.

636.23.10-Temporary Pavement Markings-Tape: The quantity of "Temporary Pavement Markings-Tape" shall be the linear feet of 4 in. (100mm), 6 in. (150 mm), or 8 in. (200 mm) solid line actually placed on the pavement.

636.23.11-Temporary Raised Pavement Markers: The quantity of "Temporary Raised Pavement Markers" shall be the actual number of markers placed on the pavement. Payment shall include the subsequent removal of the temporary pavement markers.

636.23.12-Cleaning of Project Traffic Control Devices: The quantity of "Cleaning of Project Traffic Control Devices" shall be the actual number of times that all of the traffic control devices, including all channelizing devices, are cleaned on the entire project. Payment will be made for each time all the devices on the whole project are cleaned.

636.23.13-Cleaning of Individual Traffic Control Devices: The quantity of "Cleaning of Individual Traffic Control Devices" shall be the actual number of individual traffic control devices cleaned. When temporary guardrail barricades are cleaned, each barrel will be considered an individual device when payment is made under this item.

No additional payment shall be made for the cleaning of any delineator regardless of the type of material. Such costs shall be incidental to the cost of cleaning other traffic control devices. For cleaning purposes, any traffic control device attached to a barricade shall be considered part of the barricade. Similarly, any warning light attached to a sign shall be considered part of the sign.

636.23.14-Flagger-Traffic Director: Flagger shall include the cost of furnishing, installing, maintaining and moving of the "Advance Flagger" signs along with the actual flagging of traffic. The flaggers shall be paid for the actual authorized time controlling traffic and up to 30 minutes travel from a previous assignment.

The quantity "Traffic Director" shall be the actual number of hours worked in traffic control. The traffic director shall be paid for the actual authorized time controlling traffic which includes the cost for the police vehicle.

636.23.15 through 636.23.16-BLANK

636.23.17-Temporary Barrier: The quantity of "Temporary Barrier" shall be the linear feet (meters) of barrier actually placed. Payment shall include terminal connecting devices, delineators, anchoring, maintaining, dismantling, removal and disposal of the barrier and devices when no further use is required.

636.23.18-Removing and Resetting Temporary Barrier: The quantity of "Removing and Resetting Temporary Barrier" shall be the linear feet (meters) of barrier reused in a different location. Payment shall include temporary storage if necessary, re-erecting, maintaining, dismantling, removal and disposal of the barrier.

636.23.19-Temporary Guardrail Barrier: The quantity of "Temporary Guardrail Barrier" shall be the linear feet (meters) of barrier actually placed, including the last twenty five foot (7.62 M) connector section. Payment shall include the dismantling, removal and disposal of the barrier and temporary connectors when no further use is required.

636.23.20-Removing and Resetting Temporary Guardrail Barrier: The quantity of "Removing and Resetting Temporary Guardrail Barrier" shall be the linear feet (meters) of barrier reused in a different location. Payment shall include temporary storage, if necessary, re-erecting, maintaining, dismantling, removal and disposal of the barrier.

636.23.21-Electric Arrow: The quantity of "Electric Arrow" shall be the actual number of days that the arrow is used on the project.

636.23.22-Portable Message Sign: The quantity of "Changeable Message Sign" and "Speed Motoring Trailer" shall be the actual number of days that the sign is used on the project.

636.23.23-Temporary Traffic Signal(s) or Temporary Lighting: "Temporary Traffic Signal(s)" shall include the furnishing, installation, maintaining and subsequent removal of all equipment and material necessary to adequately meet the requirements of the Traffic Control Plan and shall be measured as complete units and paid by the month, or fraction thereof.

"Temporary Lighting" shall be on a lump sum basis and shall include the furnishing, installing, maintaining and subsequent removal of all equipment and material necessary to adequately meet the requirements of the Traffic Control Plan.

636.23.24-Temporary Pipe for Maintaining Traffic: The quantity of "Temporary Pipe for Maintaining Traffic" shall be the linear feet (meters) of pipe actually placed, as detailed on the Plans. Payment shall include the removal and disposal of the pipe when no longer needed.

636.23.25-Warning Lights: The quantity of "Warning Lights" shall be the actual number of days that a light is used on the project.

636.23.26-Shadow Vehicle: A shadow vehicle shall be on a per-day basis and shall include the flashing beacon, fuel, crew and truck-mounted attenuator used in conjunction with the vehicle.

636.23.27-Temporary Impact Attenuating Device: One unit of "Temporary Impact Attenuating Device" shall be paid at the time of initial installation of a device, as described in Section 636.12, at each unique location within the project. However, over the life of the project the Contractor shall not be paid for a quantity of this item exceeding the maximum number of individual devices required to be in place on the project at a specific time. Each installation beyond this quantity shall be paid for using the "Remove and Reset Attenuator Device" item.

636.23.28-Remove and Reset Attenuator Device: This item shall be measured and paid for in accordance with the provisions of Section 636.23.27.

636.24-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which prices and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies and incidentals necessary to complete the work. When aggregate for maintaining traffic, dust palliatives, flagger, traffic director, cleaning of traffic control devices or the electric arrow are contained in the contract as pay items, payment for such pay items will not be made subsequent to the date of required completion of the project.

When a portable message sign or speed monitoring trailer is to become the property of the Division, each unit shall be delivered with the following items:

- i Operator's manual for sign-raising mechanism and sign operations.
- ii Schematic wiring diagram of the sign, remote control console and the control unit.
- iii Service manual for the sign, sign-raising mechanism control unit and the remote control console.
- iv Record of Serial Numbers, Model Numbers, and Model Types for the Portable message sign and any attendant diesel engine.
- v Warranty on the sign-raising mechanism, sign remote control console and control unit.
- vi Inspection and operational tests.

If during the prosecution of the work, additional items under this Section, not included in the contract, are found to be necessary as determined by the Engineer, payment for such additional items will be made under the provisions of 104.3.

636.25-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
636002-*	Aggregate For Maintaining Traffic, ***	Ton (Megagram)
636003-*	Bituminous Material For Dust Palliative	Gallon (Liter)
636004-*	Calcium Chloride For Dust Palliative	Ton (Megagram)
636005-*	Temporary Structure For Maintaining Traffic	Lump Sum
636006-*	Pilot Truck And Driver	Day

ITEM	DESCRIPTION	UNIT
636007-*	Eradication Of Pavement Marking	Linear Foot (Meter)
636008-*	Temporary Pavement Marking-Paint	Linear Foot (Meter)
636009-*	Temporary Pavement Marking-Tape	Linear Foot (Meter)
636010-*	Temporary Raised Pavement Marker	Each
636011-*	Traffic Control Device	Unit
636012-*	Project Traffic Control Device Cleaning	Each
636013-*	Individual Traffic Control Device Cleaning	Each
636014-*	Flagger	Hour
636014-*	Traffic Director	Hour
636017-*	Temporary Barrier, TL-1, **	Linear Foot (Meter)
636017-*	Temporary Barrier, TL-2, **	Linear Foot (Meter)
636017-*	Temporary Barrier, TL-3, **	Linear Foot (Meter)
636017-*	Temporary Barrier, TL-4, **	Linear Foot (Meter)
636017-*	Temporary Barrier, TL-5, **	Linear Foot (Meter)
636018-*	Remove and Reset Temporary Barrier	Linear Foot (Meter)
636019-*	Temporary Guardrail Barrier	Linear Foot (Meter)
636020-*	Remove And Reset Temporary Guardrail Barrier	Linear Foot (Meter)
636021-*	Electric Arrow	Day
636022-*	Changeable Message Sign	Day
636023-*	Temporary Traffic Signal, "location" ^{Note 1}	Month
636024-*	Temporary Pipe For Maintaining Traffic	Linear Foot (Meter)
636025-*	Warning Lights, Type "Type"	Day
636026-*	Temporary Lighting	Lump Sum
636027-*	Traffic Control	Site
636028-*	Shadow Vehicle	Day
636030-*	Speed Monitoring Trailer	Day
636060-*	Temporary Impact Attenuating Device	Each
636060-*	Remove and Reset Attenuator Device	Each

* Sequence number

** Deflection range (see below)

Example: "636017 Temporary Barrier TL-3, IV "

*** Type of aggregate such as stone, gravel, slag

Note 1: "location" shall be designated as "01", "02", etc. for each different physical location as designated on the plans.

Deflection Ranges:

Supplemental Description	Deflection Criteria
I	Minimal Deflection < 6 in.
II	Low Deflection < 24 in.
III	Medium Deflection < 60 in.
IV	High Deflection < 96 in.

Deflection values are based on NCHRP testing for corresponding level and is permanent deflection measured at the bottom of the barrier.

SECTION 637 WATER

637.1-DESCRIPTION:

This work shall consist of furnishing, and applying or incorporating, as the case may be, water required for compacting embankments, for stabilizing soils or other materials, as a dust palliative, or for any other specially designated purpose, in accordance with these Specifications and in accordance with the requirements of the Plans or as directed by the Engineer.

637.2-MATERIALS:

Water shall conform to the pertinent requirements set forth in these Specifications for its specific uses or, in the absence of such specific requirements for the designated use, the water shall be suitable for the purpose intended and shall be free of substances which would be deleterious to the work involved.

637.3-CONSTRUCTION METHODS:

The equipment to be used with the water operation involved will be approved by the Engineer as adequate and suitable for the purpose intended. Water shall be incorporated in the manner, in the amounts, at the times, and for the purposes prescribed in these Specifications or as directed by the Engineer.

637.4-METHOD OF MEASUREMENT:

When the Contract includes a separate item for "Water", it will be measured by the gallon (liter), expressed in thousand-gallon (liter) units, and the quantity to be measured for payment will be the amount of water furnished and used for the purposes specifically designated as being included under the pay item. Measurements will be by means of tanks or tank trucks of predetermined capacity or by means of satisfactory and approved meters furnished by the Contractor.

Water used by the Contractor for purposes other than those specifically included in the item shall not be paid for separately.

When the excavation is less than 10,000 cubic yards (meters) and separate payment for water is not included in the plans the water shall be incidental to the work and shall not be paid for separately.

637.5-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item below which price and payment will be full compensation for furnishing all the material and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

637.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
637001-*	Water For Dust Palliative	Thousand Gallon (Thousand Liters)

* Sequence number

SECTION 638

PROJECT MARKERS, RIGHT-OF-WAY MARKERS, SURVEY MARKERS, AND OUTLET MARKERS

638.1-DESCRIPTION:

This work shall consist of furnishing, and placing or installing at the points designated on the Plans, in the Contractor's Proposal or by the Engineer, metal (signpost) project markers, right-of-way markers, concrete survey markers, and outlet markers in accordance with these Specifications and in reasonably close conformity to the lines, grades, dimensions, locations, and sections shown on the Plans, in the Contractor's Proposal or established by the Engineer.

638.2-MATERIALS:

Right-of-way Markers shall consist of # 6 (# 20) deformed reinforcing steel bars meeting the requirements of AASHTO M 31 and caps provided by the Division. Materials for project markers shall conform to the requirements specified on the Plans. Survey markers shall be constructed of concrete conforming to 715.12 or 715.19.

Survey Markers constructed without reinforcement shall contain sufficient steel near the top to provide magnetic detection.

The materials for Outlet Marker Signs, such as for the sign panels, their supports, and for the legend and background, are to be of a type and method of fabrication that will be consistent with the conditions and estimated period of use. Signs shall have black letters for the legend on a white background. Reflective sheeting will be permitted, but not required.

CONSTRUCTION METHODS

638.3-RIGHT-OF-WAY MARKERS:

638.3.1-Right-Of-Way Marker Installation: Markers shall be set plumb and to a minimum depth of 36 inches (1 meter) and shall be flush to the ground. When rock is encountered in areas of proposed markers, they shall be grouted to a depth of 18 inches (0.5 meters) into the rock. Right-of-way markers shall be installed at points designating the right-of-way boundaries and at each break in the right-of-way line as shown on the Plans or as directed by the Engineer.

638.3.2-Installation: Markers shall be set plumb and to the depth shown on the Plans. The holes shall be backfilled with suitable material and thoroughly tamped.

Right-of-way markers shall be set at points designating the right-of-way boundaries and at each break in the right-of-way line as shown on the Plans or as directed by the Engineer. Right-of-way markers shall be accurately set to the mark given by means of intersecting strings. If approved by the Engineer, other equally accurate methods may be substituted.

638.4-CONCRETE SURVEY MARKERS:

Survey markers shall be installed where indicated on the Plans or as designated by the Engineer. When locations for survey markers conflict with other construction, the survey markers shall be offset as directed by the Engineer. Precast concrete markers shall be set plumb and to the depth shown on Plans. Installation shall be backfilled with suitable material and thoroughly tamped to obtain a very rigid installation. If a manufactured point on the bronze casting does not

coincide with the survey point after installation, it shall be filed and the actual survey point shall be center punched and outlined by a cross.

638.5-METAL (SIGN-POST) PROJECT MARKERS:

Project markers shall be constructed in accordance with details and requirements on the Plans.

Project markers shall be placed at the beginning and end of projects, on the right side of the road or highway at the points designated by the Engineer. Project markers shall be located at the maximum practical distance not to exceed 30 feet (10 meters) from the edge of the pavement without obscuring or detracting from the effectiveness of other official signs. Project markers shall be driven in place, plumb and to the depth shown on the Plans. Defective or damaged markers will be rejected.

638.6-OUTLET MARKERS:

638.6.1-General: Outlet Markers Signs shall be furnished by the Contractor and placed during the mobilization of the project. The Outlet Marker Sign shall be in accordance with Figure 638.6.1 below. The Outlet Marker Signs shall become the property of the Division and remain in place upon completion of the project unless otherwise directed by the Engineer. No shop drawings shall be required.

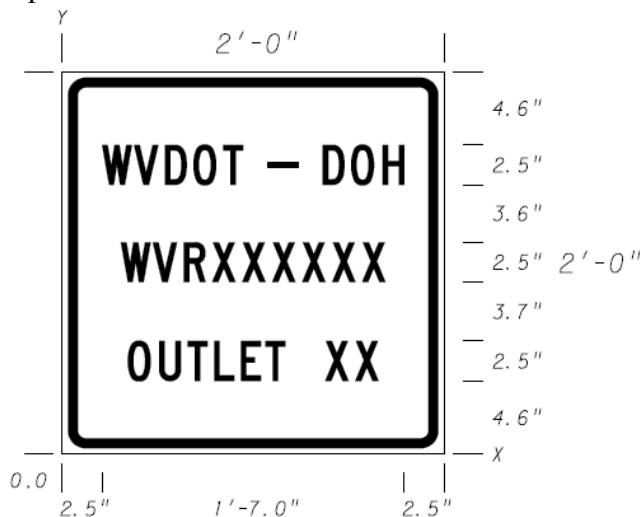


Figure 638.6.1: Outlet Marker

638.6.2-Location And Content: The Outlet Marker Signs for projects shall be placed at each discharge point as indicated in the Special Provision for NPDES permits contained within the Contractor's Proposal and conform to the example as shown on the attached drawing.

The following information shall be placed on the Outlet Marker Signs:

1. WVDOT-DOH
2. NPDES Registration Number
3. Outlet Number

638.6.3-Installation: Mounting, transverse location, and similar features for Outlet Marker Signs shall be consistent with practices used for the installation in 636.9 on wooden or steel U-channel supports to comply with small sign support safety practices. The sign shall be mounted as directed by the Engineer.

638.7-METHOD OF MEASUREMENT:

The quantity of work done will be the actual number of "Project Markers", "Right-of-Way Markers", "Survey Markers" or "Outlet Markers", complete in place and accepted.

638.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for excavating, backfilling, disposing of surplus material, furnishing all the material and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

638.9-PAY ITEM:

ITEM	DESCRIPTION	UNIT
638001-*	Project Marker	Each
638002-*	Right-Of-Way Marker	Each
638003-*	Survey Marker	Each
638004-*	Outlet Marker	Each

* Sequence number

SECTION 639 CONSTRUCTION SURVEYING

639.1-DESCRIPTION:

This work consists of construction surveying, calculations, and staking, in accordance with these specifications.

639.2-MATERIALS:

Provide the necessary materials to complete the specified surveying services.

CONSTRUCTION METHODS

639.3-CONSTRUCTION LAYOUT STAKES:

The Division shall provide, to the Contractor, reference points along the line of improvement for proper layout of work. The reference points will serve as the horizontal and vertical control for the project.

The Contractor shall provide field forces and shall set all additional stakes needed, such as offset stakes, reference point stakes, slope stakes, pavement and curb line and grade stakes, stakes for bridges, sewers, roadway drainage, pipe underdrains, paved gutter, fence, culverts or other structures, supplementary bench marks, and any other horizontal or vertical controls necessary to secure a correct layout of the work. The Contractor shall also do all layout work and shall set stakes necessary for carrying out utility changes when such utility changes are an obligation of the Contractor under the Contract. The location of the slope stakes for grading work shall be determined by a calculation method. Stakes for line and grade of pavement and curb shall be set at station intervals of 25 feet (10 meters) maximum distance on curves and at 50 feet (20 meters) maximum distance on tangents. Elevation control points with guard stakes shall be set, at a convenient distance outside the construction limits, opposite every 50-ft (20 meters) station and all stations where original cross-sections have been taken. The centerline station, the distance from centerline, and the elevation of the hub shall be recorded on each guard stake. For right-of-way staking, iron pins (WVDOT CAP on #5 Bar, 36" in length) with guard stakes shall be set on both sides of roadway at all locations where right-of-way changes width; the station number and the distance from the centerline shall be marked on each guard stake.

The Contractor shall be responsible for having the layout staking work conform to the lines, grades, elevations, and dimensions called for on the Plans. The Contractor shall furnish a copy of their survey records for checking by the Engineer and for the Division's permanent file. These records shall be furnished as they are completed during the progress of the work. Any inspection or checking of the Contractor's layout by the Engineer and the acceptance of all or any part of it shall not relieve the Contractor of their responsibility to secure the proper dimensions, grades, and elevations of the several parts of the work.

The Contractor shall exercise care in the preservation of stakes and bench marks and shall have them reset at their expense when any are damaged, lost, displaced or removed. The Contractor shall use competent personnel and suitable equipment for the layout work required and shall provide that it be done under the supervision of, or directed by, a Registered Professional Engineer or Professional Surveyor. The Contractor shall not engage the services of any person or persons in the employ of the Division for the performance of any of the work covered by this item.

639.4-AS-BUILT UTILITY SURVEY:

The Contractor shall locate and submit to the Division an “As-Built” survey of all of the specified items being performed as part of the project under Sections 631, 657, 658, 659, 660, 661, 662, and 664. Meeting the following minimum survey requirements:

- a. Coordinate system – UTM Zone 17N with a reference to datum of NAD83 (2011). Elevation reference is NAVD88. All units shall be US Survey Feet.
- b. Horizontal and tolerance – No single observed point shall be greater than one foot from the true location of the point.
- c. Features to be collected – See Table 639.3.2.

Survey data shall be submitted in a comma separated value (.csv) formatted file. The file structure shall be as defined below:

POINT NAME, NORTHING, EASTING, SURFACE ELEVATION, CODE, ATTRIBUTE, DEPTH

The elements of the file structure shall be defined below:

1. POINT NAME: This shall be an alpha or alpha numeric value unique to a single point.
2. NORTHING: This shall be the reported northing value in US Survey Feet to the nearest tenth of a foot.
3. EASTING: This shall be the reported easting value in US Survey Feet to the nearest tenth of a foot.
4. SURFACE ELEVATION: This shall be the orthometric height referenced to NAVD88 in US Survey Feet reported to the nearest tenth of a foot.
5. CODE: This shall be the predefined feature code provided in Table 639.3.2.
6. ATTRIBUTE: This value shall be a descriptive note specific to this feature used to further define the point as described in Table 639.3.2.
7. DEPTH: This value shall only be applicable to underground conduit and shall be a field measured distance from the top of the conduit to the top of the trench in US Survey Feet to the nearest tenth of a foot.

TABLE 639.3.2

Feature Codes And Attributes		
Feature Code	Attribute	Description
DOH_CNDT	Conduit diameter and material type	This value shall be for any underground conduit, as surveyed in the trench.
	i.e. "6-Inch Plastic"	Point shall be the location(s) of the terminal. Intermediate points shall be at significant transitions (i.e. – elbow, tee, bends, etc.) and/or within 75' of adjacent conduit point.
DOH_CNSTA	Mounting type (Pole or ground) and electrical service (underground or /overhead)	This value is for a DOH Lighting Control Station or DOH Signal Control Cabinet.
	i.e. "Ground -Overhead"	Four (4) corner points of the concrete pad or fence whichever is the greatest in width.
DOH_JBOX	Box size	This value is a single point in the center top of a DOH electrical Junction Box
	i.e. "18x18"	
DOH_SGNP	Signal Pole Type (C1, C1L, A1, A1L, E)	This value is a single point at a DOH Signal Pole
	i.e. "E"	
DOH_LITP	Light Type (I thru VII)	This value is a single point at a DOH Light Pole
	i.e. "III"	
DOH_LITSGN	Sign Type (advanced flasher, school zone, overhead cantilever structure, overhead truss structure, etc)	This value is a single point at a DOH Lighted Sign.
	i.e. "Overhead Truss Structure"	
DOH_MISC	Description of item	This value is for all other DOH Utility items.
	i.e. "RWIS"	Such as CCTV, RWIS, Free Pass, Message Sign, Weigh in Motion, Signal Loop

The survey records generated shall be the property of the Division and shall be available to the Engineer for inspection or reproduction at all times. All survey records shall be transmitted before final project acceptance.

639.4-METHOD OF MEASUREMENT:

"Construction Layout Stakes" will be measured as a complete unit.

"As-Built Utility Survey" will be measured as a complete unit.

639.5-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for at the contract unit price bid for the item below, which price and payment shall be full compensation for furnishing, setting, maintaining, and resetting, when necessary, the stakes, and for furnishing all engineering personnel, equipment, materials, and all incidentals.

639.6-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
639001-*	Construction Layout Stake	Lump Sum
639003-*	As-Built Utility Survey	Lump Sum

* Sequence number

SECTION 640

FIELD OFFICE AND STORAGE BUILDING

640.1-DESCRIPTION:

This work shall consist of furnishing and maintaining in good condition suitable offices for the exclusive use of the Engineer as a field office or for making field tests, a storage building for concrete cylinder curing tanks, and equipment for the field office, all in accordance with these Specifications.

640.2-MATERIALS:

Not specified.

640.3-LOCATION AND TIME OF ERECTION:

The field office and storage building shall be set up at approved locations on or in the immediate vicinity of the Project. They shall be separated from any building used by the Contractor.

The field office and storage building shall be set up, equipped, and made ready for use at least three days prior to the beginning of the work on the project.

640.4-FIELD OFFICE:

640.4.1-General: The office shall be entirely enclosed, waterproofed, and sealed inside with wall board which will provide efficient insulation against heat and cold. With the exception of a minimal field office, the office must be decent, safe and sanitary in accordance with Health Department regulations.

The office shall be provided with an approved type of heating and cooling equipment that will maintain a comfortable seasonable temperature throughout the project life. It shall be furnished with satisfactory electric lighting and lighting service. A minimum of two duplex convenience outlets shall be provided in each room. The building shall be provided with neat, sanitary, enclosed toilet with exhaust fan accommodations for the exclusive use of the Engineer, and such facilities shall meet the requirements of the State Department of Health or other authorities having jurisdiction. It shall be stocked with lavatory and sanitary supplies at all times during the period of the contract. Additionally the Contractor shall provide, maintain, and pay for internet access via service such as Cable, DSL, Satellite or other system along with a wireless router for the field office. The wireless router and internet specifications such as minimum upload and download speeds can be located at the following WVDOH website:

<http://www.transportation.wv.gov/highways/contractadmin/specifications/640.11fieldoffice/Pages/default.aspx>

The office shall be attractively painted on the outside and shall be provided with a sign at least 4 feet (1.2 m) by 1 ft. (300 mm), with the sign content as follows:

FIELD OFFICE-THE WEST VIRGINIA DIVISION OF HIGHWAYS

The letters shall not be less than 3 inches (75 mm) high and shall be white on a black background. The sign shall have a white border at least 1½ inches (38 mm) wide.

The office shall be equipped per section 640.10 and shall include OSHA approved steps and entrance porch with railing.

640.4.2-Large Field Office: The large field office shall have a minimum floor space of 800 sq. ft. (80 sq. meters). This may be accomplished by the use of two (2) standard field offices or one large equivalent office. The office shall contain the following additional equipment:

1. One office type desk having at least two drawers on each side and one secretarial type desk each having minimum top dimension of 30 inches by 60 inches (750mm by 1 500 mm).
2. One plan rack.
3. One utility table 30 inches (750 mm) high and having top dimensions not less than 30 inches by 72 inches (750 mm by 1 800 mm).
4. One sanitary-type water cooler supplied with water that shall be kept cooled electrically or with gas.
5. One desk model electronic adding machine with, tape totaling a minimum of 10 digits.
6. One desk model, and two hand held model electronic calculators (all equipped with scientific functions), with a minimum entry of 10 digits and a minimum readout of 10 digits.

640.4.3-Standard Field Office: The standard field office shall have a minimum floor space of 400 sq. ft. (40 square meters) and shall contain two rooms, each with a minimum plan dimension of 20 ft. by 10 ft. (4 by 5 meters). One room shall contain sufficient floor area to include such soil equipment necessary to perform the various compaction control tests as may be required as the work progresses.

640.4.4-Small Field Office: The small field office shall have a minimum floor space of 250 sq. ft. (23.2 sq. m) and shall contain two rooms, each with a floor space of approximately 10 ft. by 12 ½ ft. (3.1 by 3.75 m).

640.4.5-Minimal Field Office: The field office shall have a minimum floor space of 100 square feet (9.3 square meters) with a minimum plan dimension in one direction of 6 ft. (1.8 m). When a sanitary enclosed toilet is not provided, a chemically treated portable toilet shall be provided. The office shall be furnished with a desk, chair, one fireproof filing cabinet equipped with locks, one desk top copier capable of producing 8½ x 11 and 8½ by 14 copies and a phone, fax and answering (message) machine that utilizes the same phone line. The door for the field office shall be provided with a suitable lock. A sanitary water cooler using bottled water or approved equal shall be provided. The requirements of sections 640.10 shall not apply.

640.5-STORAGE BUILDING:

The storage building for concrete cylinder tanks shall have a minimum floor space of 80 sq. ft. (7.4 m) preferably 8 feet by 10 feet (2.4 by 3.1 m). The ceiling height shall not be less than 7 feet (2.1 m). The storage building shall be well insulated and capable of maintaining a reasonably constant temperature. It shall be provided with water, as required, and satisfactory electric lighting. Chairs, tables, and stools, as required, shall be furnished.

The Contractor shall furnish curing tanks with sufficient capacity to handle peak cylinder curing requirements. The tanks shall be equipped with thermostatically controlled units which are capable of maintaining specification water temperature in the tanks, and power shall be furnished.

640.6-LIABILITY FOR PROPERTY IN OFFICE/STORAGE STRUCTURES:

The Contractor shall assume the risk of direct physical damage to or loss of all Division property in the project field office and storage building, and shall compensate the Division for any such damage or loss valued on a replacement cost basis to a maximum total of twenty thousand dollars.

The contractor's responsibility for this risk will remain in effect until the Division has removed all its property and vacated the office and storage building.

640.7-MAINTENANCE:

The Contractor for the duration of the project shall maintain the field office and storage building in good condition and appearance. No compensation will be allowed for loss by fire or by vandalism caused by non-Division personnel or for loss due to normal wear and tear.

640.8-REMOVAL:

After all field records pertinent to the project have been completed, the office and storage building shall be removed and disposed of by the Contractor and the site cleaned up and left in a neat and acceptable condition. The field office and storage building shall be allowed to remain for 45 days after final acceptance of the project, and shall be completely removed prior to 60 days after final acceptance of the project.

640.9-ALTERNATE FOR OFFICE BUILDING:

The Contractor, in lieu of the field office building, may furnish adequate trailer space equivalent to the minimum floor space requirements. Minimum requirements for heat, lights, toilet facilities, insurance, maintenance, etc., shall be furnished for the trailer as for the office building.

640.10-EQUIPMENT:

The following equipment shall be furnished for any field office.

1. One office-type desk having at least two drawers on each side and one secretarial-type desk each having minimum top dimension of 30 inches by 60 inches (750 by 1 500 mm).
2. One filing cabinet when the total project bid is less than \$1,000,000; two filing cabinets when the total project bid is \$1,000,000 and less than \$3,000,000; and three filing cabinets when the total project bid is \$3,000,000 or more. Cabinets shall be fireproof, four-drawer, legal size, and equipped with locks.
3. One plan rack.
4. One utility table 30 inches (750 mm) high and having top dimensions not less than 30 inches (750 mm) by 72 inches (1 800 mm).
5. One sanitary-type water cooler supplied with water that shall be kept cooled electrically or with gas.
6. One closet extending the full height from floor to ceiling measuring not less than 24 by 30 inches. (600 by 750 mm) in plan, having at least two shelves, and equipped with a lock.
7. One desk model electronic adding machine with tape totaling a minimum of 10 digits.
8. One desk model, and two hand held model electronic calculators (all equipped with scientific functions), with a minimum entry of 10 digits and a minimum readout of 10 digits.
9. Comfortable chairs and stools as required.

10. The Contractor shall provide at their own expense all utilities and janitor service. Telephone service, limited to the best available local facilities, shall be furnished unless Plan notes require alternate communication facilities. Telephone service shall include installation, local monthly charges, long distance service, maintenance and removal costs.
11. Provide two telephones for a large or standard office and one telephone for a small office. One answering (message) machine shall be provided.
12. If any of the equipment items are included as “in-built” in the field office or trailer, they may be omitted from the list.
13. Provide on project specific weather monitoring system. The minimum requirements for the weather monitoring system shall be:
 - a. Measure and record total rainfall as well as hourly rainfall averages.
 - b. Measure and record wind speed.
 - c. Measure and record relative humidity.
 - d. Measure and record temperatures.
 - e. Present data in a neat and orderly fashion.
 - f. The weather monitoring systems sensors shall be located as close to the project limits as practical and shall not exceed 1,000 feet without the Engineer’s written approval.
 - g. All data collected must be transferable to the Department/ Project’s computer system.
 - h. If the weather monitoring system supplied is capable and high speed internet service is available at the site, the weather monitoring system shall be connected to the internet for remote viewing.

The weather monitoring system ,including hardware, software and manuals, will be furnished and maintained throughout the life of the project and shall be removed when the field office has been vacated by the Division of Highways staff in accordance with 640.8.

640.11-BLANK

640.12-METHOD OF MEASUREMENT:

The “Large Field Office and Storage Building”, “Standard Field Office and Storage Building” shall include the field office and the storage building and shall be measured as one complete unit and paid by the month. The “Small Field Office” and “Minimal Field Office” shall be measured as one complete unit and paid for by the month. “Building Equipment” will be measured as complete unit and paid as a lump sum unit.

640.13-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing, erecting, insuring, maintaining and removing the field office and storage building computer system, and sanitary conveniences for the Engineer; all labor and materials, and all other work necessary and incidental thereto. All costs associated with the weather monitoring system will be paid for by the contractor. The field office, storage building equipment, furniture, fixtures, and facilities shall remain the property of the Contractor and shall be removed in accordance with 640.8 and the area dressed and restored.

Telephone service installation, local monthly charges, long distance charges, maintenance charges and removal costs will be paid by the Contractor. In the event long distance charges exceed the \$100.00 per month average for the duration of the project, the Contractor may request compensation for the portion above the \$100.00 per month average.

640.14-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
640001-*	Standard Field Office And Storage Building	Month
640002-*	Large Field Office And Storage Building	Month
640003-*	Building Equipment	Lump Sum
640005-*	Minimal Field Office	Month
640006-*	Small Field Office	Month

* Sequence number

SECTION 641 MITIGATION DEVICES

641.1-GENERAL:

These devices include deflectors, weirs, random bolder placements, and rootball placements. These deflectors are to be built in accordance with the details contained in the plans and at the location as noted on the plans.

641.2-PLACEMENT:

Log deflectors and weirs are to be tied together as shown on the details or by a means approved by the Engineer. Double deflectors may be either log or rock and are indicated in the plans. The random boulder placements are to be sized in accordance with the data on the detail sheet. Placement of these boulders is to be such as to allow free movement of water through and around them.

Rootball placements are to be as shown on the details contained within the plans.

All the devices with the exception of the rootballs all other devices are to be placed in a manner that they raise above normal flow approximately 1'-2' (300 mm-600 mm), unless otherwise noted on the plans.

641.3-BASIS OF PAYMENT:

The payment for this work shall include all the materials, doing the work in a workmanlike and acceptable manner, labor, tools, equipment, supplies and incidentals necessary to complete the work and will be paid for at the Contract Unit Price Bid for the items below.

641.4-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
641001-*	Deflector "type"	Each
641002-*	Weir	Each
641003-*	Random Boulder Placement	Each
641004-*	Rootball Placement	Each

* Sequence number

SECTION 642

TEMPORARY POLLUTION CONTROL

The Contractor shall exercise every reasonable precaution throughout the life of the project to control water pollution. Construction of permanent drainage facilities as well as performance of other contract work which will contribute to the control of siltation shall be accomplished at the earliest practicable time during the life of the Contract. Pollutants such as chemicals, fuels, lubricants, bitumens, raw sewage, and other harmful waste shall not be discharged into or alongside of rivers, streams, impoundments (lakes, reservoirs, etc.) or into natural or manmade water courses leading thereto. The Contractor shall also comply with the applicable regulations of the Department of Natural Resources and other statutes relating to the prevention and abatement of pollution. The purpose of these Specifications is to set forth certain temporary water pollution control measures which shall be required by the Contract in addition to the above.

642.1-DESCRIPTION:

This work shall consist of temporary control measures performed during the life of the Contract to control water pollution through use of berms, ditch checks, check dams, sediment structures (traps, ponds, or dams), mulches, fiber mats, seeding slope drains, and other erosion control devices or construction methods, in accordance with these Specifications and in reasonably close conformity with the lines, grades, thickness and typical cross sections shown on the Plans or established by the Engineer.

The temporary pollution control provisions contained shall be coordinated with the permanent erosion control features specified elsewhere in the Contract to the extent practical to keep total erosion control costs to a minimum. These provisions shall also apply to work conducted outside the project right-of-way, such as operations in a borrow pit or waste site, where such work occurs as a result of the construction of the project.

These temporary water pollution control measures shall be continued until; permanent controls have been established; the need has been eliminated as determined by the Engineer; or the project has been accepted.

642.2-MATERIALS:

Materials will be considered acceptable when they are capable of accomplishing the intended purpose, do not in themselves contribute to pollution and comply with the following:

- i. Mulches may be hay, straw, wood cellulose fiber, wood chips, bark, matting or other material acceptable to the Engineer. Mulch materials shall be reasonably free of noxious weeds. Asphalt for anchoring hay or straw mulch shall be of a commercial grade. Chemical mulch binders shall conform to the requirements in 715.27.1.
- ii. Slope drains may be constructed of pipe, fiber mats, rubble, Portland cement concrete, bituminous concrete, or other material that will adequately control erosion and is acceptable to the Engineer.

- iii. Temporary seed, such as annual ryegrass (Italian ryegrass), weeping lovegrass, cereal rye or wheat, barley or oats, and millet, used in temporary seed mixture or seed mixtures B or D, shall be of a commercial grade meeting requirements of the State Seed Law, Temporary seed labeled with the notation "germination below standard" will not be acceptable for use on projects. Temporary seed shall not be used on the project after one year from the date of germination test shown on the label. Seed other than that specified above shall meet the requirements of 715.28.
- iv. Fertilizer shall be a commercial grade of 1-2-1 ratio, meeting requirements of the governing state and federal laws.
- v. Others as shown on the Plans or specified by the Engineer (i.e. Temporary Pipe, Temporary Structures, etc.).
- vi. Ground agricultural limestone shall be of a commercial grade.
- vii. Engineering fabric for silt fence shall meet the requirements of 715.11.5 and have a minimum width of 3 feet (900 mm). Wood, steel, or synthetic support posts having a minimum length of 3 feet (900 mm) plus the burial depth shall be used. They shall be of sufficient strength to resist damage during installation and to the support applied loads due to material or water build up behind the silt fence.
- viii. Dewatering Device shall meet the requirements of 715.11.10.

CONSTRUCTION METHODS

642.3-PRECONSTRUCTION CONFERENCE:

At the pre-construction conference, the Contractor shall submit for approval their schedules and methods for accomplishing the required temporary and permanent pollution control work during the construction stages involving clearing and grubbing; grading and drainage; structures; bases and pavement; and others as applicable. The Contractor shall also submit for approval proposed schedules and method for pollution control on haul roads, borrow pits, waste sites, and other project related operations, as applicable, conducted outside the right-of-way.

No work shall be started until the above pollution control schedules and methods have been approved by the Engineer.

642.4-GENERAL REQUIREMENTS:

The Engineer has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, to limit the surface area of erodible earth material exposed by excavation, borrow and fill operations and to direct the Contractor to provide immediate permanent or temporary pollution control measures as necessary to prevent contamination of adjacent streams or other watercourses, lakes, ponds, or other areas of water impoundment. Such work may involve the construction of temporary berms, ditch checks, check dams, sediment structures (traps, ponds or dams), slope drains, and use of temporary mulches, mats, seeding or other control devices or methods as necessary to control erosion.

The Contractor shall incorporate all permanent erosion control features into the project at the earliest practicable time as outlined in their acceptable schedule. Temporary pollution control measures shall be used to correct conditions that develop during construction that were not foreseen during the design stage; that are needed prior to installation of permanent pollution control features, or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the project.

Where erosion is likely to be a problem, clearing and grubbing operations shall be so scheduled and performed that grading operations and permanent erosion control features can follow immediately if the project conditions permit; otherwise temporary erosion control measures may be required between successive construction stages.

The Engineer will limit the area of excavation, borrow and embankment operations in progress commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding, and other such permanent pollution control measures current in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified.

Unless otherwise approved in writing by the Engineer, construction operations in rivers, streams, and impoundments shall be restricted to those areas where channel changes are shown on the Plans and to those areas which must be entered for the construction of temporary or permanent structures. Rivers, streams, and impoundments shall be promptly cleared of all falsework, piling, debris or other obstructions placed or caused by the construction operations.

Excavation from any source shall not be deposited in or near rivers, streams, or impoundments or otherwise located in such a manner which might be susceptible to erosion due to high water, flooding, or runoff.

Frequent fording of live streams with construction equipment will not be permitted; therefore, temporary bridges or other structures shall be used wherever an appreciable number of stream crossings are necessary. Unless otherwise approved in writing by the Engineer, mechanized equipment shall not be operated in live streams except as may be required to construct channel changes and temporary or permanent structures.

The location of all local material pits other than commercially operated sources, and all waste areas will be subject to the approval of the Engineer, and construction operations shall be conducted and pollution control measures implemented so that, both during and after completion of the work, erosion will not result in water pollution.

The Contractor shall, in accordance with the guidance contained in 642.3, submit schedules and methods in complete consonance with the intent of this Specification to prevent water pollution to the maximum extent possible. To provide a positive guide in this area, no more than 750,000 square feet (7 hectares) each of erodible soil shall be exposed as a result of (1) clearing and grubbing and (2) excavation, embankment, borrow or waste for a maximum cumulative total of 1,500,000 square feet (14 hectares) without the approval of the Engineer. Approval to proceed beyond this point will be contingent upon (1) the Engineer's satisfaction, based on performance, as to the Contractor's ability to proceed with their operation and still maintain pollution control at the level contemplated by this Specification, and (2) seeding and mulching of disturbed areas at the Contractor's expense.

It is further understood that regardless of an approval such as the above or compliance with an approved schedule as set forth in 642.3, the Engineer may impose whatever limitations deemed necessary to assure an operation providing for pollution control consistent with the intent of this Specification. Reimbursement for such necessary temporary control measures required to eliminate the need for such limitation will be in accordance with the pertinent sections of this Specification. There will be no additional reimbursement to the Contractor due to losses from delays, production decreases or other causes resulting from the imposition of such a limitation.

In the event of conflict between these requirements and pollution control laws, rules, or regulations of other Federal, State, or local agencies, the more restrictive shall apply.

A Dewatering Device shall be installed on a slight slope so incoming water flows downhill through the Device without creating more erosion. The neck of the Dewatering Device shall be tightly strapped to the discharge hose. The contractor may place the bag on an aggregate or hay bale bed to maximize water flow through the surface area of the bag.

The Dewatering Device is full when it no longer can efficiently filter sediment or pass water at a reasonable rate. Flow rates will vary depending on the size of the Dewatering Device, amount of sediment discharged into the Dewatering Device, the type of ground, rock, or other substance under the bag and the degree of the slope on which the bag lies. The Dewatering Device will normally accommodate flow rates of 1000 gallons per minute (3 785 liters per minute). Use of excessive flow rates or overfilling the Dewatering Device with sediment will cause ruptures of the bag or failure of the hose attachment straps.

The Dewatering Device shall be disposed of as directed by the engineer.

642.5-SEEDING AND MULCHING:

642.5.1-General: Seeding paid for under this section will include seed mixtures as defined in 642.5.3. The mixtures to be used will be determined by the Engineer. Seeding and mulching shall be performed on a continual basis starting when earth moving begins in the spring and stopping when the work stops in the winter or weather becomes too cold to operate seeding or mulching equipment. Embankments and cuts constructed during the winter season shall be treated as specified under 642.5.4, iii.

Seeding or mulching, or both, shall be performed on all cut and fill slopes, including waste sites and borrow pits, during the construction process. All disturbed areas such as diversion ditches, sediment dams, areas around sediment structures, haul road slopes, cleared and grubbed areas to remain exposed during a period of critical erosion, storage areas, location of batch plants, etc. shall be seeded when and where necessary to eliminate erosion.

Any areas failing to establish a satisfactory stand of grass due to weather conditions, adverse soil conditions, or due to erosion, shall be reseeded, refertilized and remulched as directed by the Engineer.

Final seeding, or second and third step seeding following the original seeding shall be performed in accordance with 652.

642.5.2-Schedule of Seeding Operations: Fill slopes, embankments, and waste sites shall be seeded and mulched in 10-ft lifts or once every two weeks, whichever occurs first.

Cut slopes and borrow pits shall be seeded and mulched each 15-ft depth of excavation or once every two weeks, whichever occurs first. However, benched areas shall be seeded after completion of each bench, regardless of height.

642.5.3-Seed Mixtures and Planting Seasons: Temporary seed mixtures shall be used on any embankment or area which will be subject to further construction work before the project is completed. Seed mixtures B or D shall be used on cut slopes and fill or other areas not likely to be destroyed by further construction activities. It is the intent of the specifications that fill slopes be constructed to template and seeded with Type B or D mixtures, in successive stages, without fill slopes being fine graded or dressed. The type of seed mixture to be used on any area will be determined by the Engineer in accordance with Tables 642.5.3.1 and 642.5.3.2.

TABLE 642.5.3.1

Temporary Seeding Mixtures			
Variety of Seed	Spring Mar. 1-May 15	Summer May 15-Aug. 15	* Fall & Winter Aug. 15-Mar. 1
	lb per acre (kg per ha)	lb per acre (kg per ha)	lb per acre (kg per ha)
Annual ryegrass	10 (11.25)		10 (11.25)
Barley or Oats (local seeds)	50 (56)		
Millet (Hungarian, German or Japanese)		50 (56)	
Cereal rye or Cereal wheat			50 (56)
TOTAL	60 (67.25)	50 (56)	60 (67.25)

* See Paragraph 642.5.4. iii.

TABLE 642.5.3.2

Seed Mixtures B, D, & L			
Variety of Seed	Seed Mixtures		
	*Type B	**Type D	Type L
	Median, Shoulders (Ditch Slope), Waterways, and Movable Areas of Interchanges	Cut and Fill Slopes (Including Benches)	All Areas
	lb per acre (kg per ha)	lb per acre (kg per ha)	lb per acre (kg per ha)
Kentucky 31 Fescue	65 (72.9)	20 (22.4)	
Red Fescue (Pennlawn)	20 (22.4)	20 (22.4)	41 (46.0)
Crown Vetch		20 (22.4)	
White Dutch Clover	3 (3.4)		
Hard Fescue Mixture***			63 (70.6)
Annual Ryegrass Aug 1 to May 15 or Weeping Lovegrass May 15 to Aug. 1	7 (7.8) 3 (3.4)	7 (7.8) 3 (3.4)	12 (13.5) 5 (5.6)

* Areas shall be considered mowable when slopes are 3 to 1 or flatter.

** 30 lb. (13.6 kg) of cereal rye or cereal wheat shall be added to Type D mixture when wood cellulose fiber is used as a mulch for fall seeding, after October 1, at no additional cost to the Division.

*** A combination of approved certified varieties with no one variety exceeding 50% of the total hard fescue component.

642.5.4-Mulch, Fertilizer and Lime: Mulching, fertilizing and liming shall be in accordance with the following requirements:

- i. Two tons per acre (4.5 Mg per ha) of straw or hay mulch shall be applied on slopes of 1½ to 1 or flatter. Asphalt material to anchor the mulch shall be used at the rate of 50 gallons per ton (210 L per Mg) of straw or hay mulch. Other types of chemical mulch binders may be used in lieu of asphalt material. These mulch binders shall be applied according to the manufacturer's specifications through the asphalt spray system or by agricultural crop sprayer.

Wood cellulose fiber mulch shall be applied on slopes steeper than 1½ to 1 at the rate of 1,500 lb. per acre (1 680 kg per ha).

Fertilizer shall be applied at the rate of 800 lb. per acre (900 kg per ha) of 10-20-10 fertilizer or equivalent.

Lime application rate will be determined by the Engineer based upon pH test conducted in accordance with MP 700.04.10.

- ii. Wood chips, recovered from clearing and grubbing operations, or bark will be acceptable as a mulch for seeding and shall be used at a rate of 35 cubic yard per acre (66 cubic meters per hectare) in lieu of straw or hay.

- iii. Mulch Alone-For embankments or cuts 1½ to 1 or flatter, susceptible to critical erosion during periods of cold weather, the Engineer may require a two ton per acre (4.5 Mg per ha) application of straw or hay mulch for temporary erosion control and later seeding. Asphalt for anchoring mulch shall be at the rate of 50 gallons per ton (210 L per Mg) of mulch. The straw or hay may be rolled immediately with a sheep foot roller to anchor the mulch in lieu of using asphalt. A chemical mulch binder may be used for anchoring mulch in accordance with the provisions in paragraph i. above.

When the weather becomes favorable in the spring, these areas shall be seeded using the normal application rates of seed, fertilizer and lime. If additional mulch is needed, wood cellulose fiber, hay or straw shall be used; the rate of application and areas to be mulched with wood cellulose fiber, hay or straw shall be as determined by the Engineer.

642.6-TEMPORARY PIPE, CONTOUR DITCHES, BERMS, SLOPE DRAINS, DITCH CHECKS, SILT FENCE, PREMANUFACTURED DITCH CHECKS AND SUPER SILT FENCE:

642.6.1-Temporary Pipe: Temporary pipe and contour ditching shall be provided as necessary to control erosion.

642.6.2-Contour Ditches and Berms: Prior to suspension of construction operations for any appreciable length of time due to seasonal or other conditions, the Contractor shall shape the top of earthwork in such a manner as to permit and facilitate the runoff of rain water and shall construct earth berms along the top edges of embankments to intercept runoff water. The berm construction shall not be permitted to decrease the stability of the embankment section. In addition, the Contractor shall construct a berm at the end of each day's operation at the top edges of the embankment.

642.6.3-Slope Drains: Temporary slope drains shall be provided to accommodate the runoff water intercepted above. These drains shall be located as needed and at no greater than 500 ft. (150 m) intervals.

642.6.4-Ditch Checks: Silt fence or bales of hay or straw shall be used to control erosion and trap sediment as required. Ditch checks shall be constructed in cut or median ditches by installing silt fence or by using wood, plywood, logs, rocks, steel, or other devices to control velocity and to aid in sediment control.

642.6.5-Silt Fence: The minimum height above ground for the silt fence shall be 2 feet (600 mm). Minimum embedment depth shall be 8 inches (200 mm). The maximum post spacing shall be based on elongation of the geotextile as measured in accordance with Test Method D 4632. Silt fence geotextile with elongation 50 % shall have a maximum post spacing of 4 feet (1.2 m). Silt fence geotextile with elongation < 50 % shall have a maximum post spacing of 6.5 feet (2 m). When silt fence is installed in valleys where water can pond behind the fence then the post spacing shall be half of the maximum post spacing for the geotextile used.

When silt fence is installed by the trenching method the geotextile at the bottom of the fence shall be buried in a "J" configuration to a minimum depth of 8 inches (200 mm) in a trench so that no flow can pass under the silt fence. Backfill the trench and compact the soil over the geotextile.

When silt fence is installed by the soil slicing method the geotextile shall be installed in a slit in the soil 8 to 12 inches (200 to 300 mm) deep so that no flow can pass under the silt fence. Create the slit such that a horizontal chisel point (approx. 3 inches (75 mm) wide) at the base of a soil slicing blade (approx. $\frac{3}{4}$ inches (18 mm) wide) that slightly disrupts soil upward as the blade slices through the soil. This upward disruption minimizes horizontal compaction and creates an optimal soil condition for mechanical compaction against the geotextile. Overturning of the soil shall not be permitted. The geotextile shall be mechanically inserted directly behind the soil slicing blade in a simultaneous operation, achieving consistent placement and depth.

The silt fence geotextile shall be spliced together with a sewn seam only at a support post, or two sections of fence may be overlapped.

Silt fence posts shall be driven to a minimum of 20 inches (500 mm) into the ground. This depth shall be increased to 2 feet (600 mm) if the fence is placed on a slope of 3:1 (1:3) or greater. Where the minimum depth is impossible to attain, the posts shall be adequately secured to prevent overturning of the fence due to loading. The geotextile shall be properly fastened to the upslope side of the fence posts.

Silt fences shall be continuous and transverse to the flow. The silt fence shall follow the contours of the site as closely as possible. Place the fence such that the water cannot runoff around the end of the fence.

The silt fence trench shall be compacted on the upstream side first, and then the downstream side. The silt fence trench shall be compacted to a minimum of 90% of the original ground density and the posts must be installed after compaction of the trench. The trench compaction will be based on visual inspection and the engineer may require compaction testing to verify the visual inspection.

The contractor shall inspect all silt fences immediately after each rainfall and at least daily during prolonged rainfall. The contractor shall immediately correct any deficiencies. The contractor shall also make a daily review of the location of silt fences in areas where construction activities have altered the natural contour and drainage runoff to ensure that the silt fences are properly located for effectiveness. Where deficiencies exist as determined by

the engineer, additional silt fence shall be installed as directed by the engineer. When the sediment deposits reaches half the height of the fence the sediment shall be removed or a second silt fence shall be installed as directed by the engineer. The cost of this work shall be paid as "Sediment Removal" or "Silt Fence".

The silt fence shall remain in place until the engineer directs it be removed. Upon removal the contractor shall remove and dispose of any excess sediment accumulations, dress the area to give it a pleasing appearance, and vegetate all bare areas. Removed silt fence may be used at other locations provided the geotextile and other material requirements continue to be met to the satisfaction of the engineer.

642.6.6-Super Silt Fence: Fence shall be in accordance with the latest specifications for Section 608: Right-of-Way Fence. The details shall be as shown in the latest version of the standards detail book: Standard Detail F4 (Sheet 1 of 2) except as noted below:

Once sedimentation has reached half of the Super Silt Fence height, all accumulated sediment shall be removed and disposed of as directed by the Engineer.

The Contractor shall inspect all super silt fences after each rainfall event of at least 0.5 inches or greater. Any deficiencies or damage shall be repaired by the Contractor. If the Super Silt Fence is damaged or inadvertently moved during the sedimentation removal process, the contractor shall immediately replace and/or repair any Super Silt Fence after the damage occurs. The Contractor shall be responsible for all details, devices, accessories and special construction necessary to properly furnish, install, adjust and place in continuous satisfactory service and complete the work in an acceptable manner.

642.7-METHOD OF MEASUREMENT:

The work will be measured for payment at the unit bid prices for the items specified in 642.9.

Berms constructed prior to suspension of construction operations and slope drains will be measured in linear feet (meters); check dams will be measured by the unit; sediment traps, ponds, or dams and sediment removal will be measured by the cubic yard (meter); for sediment dams, risers will be measured by the unit and conduit for principal spillway under the dam will be measured in linear feet (meters) and included under Item 642008-*; seed will be measured by the pound (kilogram); straw, hay and wood cellulose fiber mulch will be measured by the ton (megagram); wood chips or bark mulch will be measured by the cubic yard (meter); fertilizer and agricultural limestone will be measured by the ton (megagram); matting will be measured by the square yard (meter); contour ditching will be measured by the linear foot (meter). Measurements will be made on the surface of the work done when applicable. Asphalt for anchoring mulch or other chemical binders will not be measured separately, but their cost shall be included in the unit price bid for mulch. Cereal rye or cereal wheat added to Type D mixture in fall seeding will not be included for payment but its cost shall be included in the unit prices in 642.9.

Temporary pipe will be measured by the linear foot (meter) complete and in place. If the Contractor elects to utilize a series of small pipes in lieu of one large pipe, measurement for payment will be made only for a length necessary to extend one conduit under the haul road or sediment dam.

Berms constructed at the end of each day's operation will not be measured for payment but their cost shall be included in the unit bid price for Item 207001-*, "Unclassified Excavation."

Ditch checks will be measured by the unit.

Dewatering Device will be paid per each device used.

Wood chips or bark will be measured by the cubic yard (meter). It is assumed that 17.5 cubic yards (14.75 cubic meters) of chips or bark are equal to one ton (megagram) of straw for seeding. Wood chips or bark mulch will be measured by the truck load or other loose volume measurement, and payment will be made on a one ton (megagram) equivalent of straw for each 17.5 cubic yards (14.75 cubic meters) of wood chips or bark mulch.

Quantities reseeded, refertilized, or remulched will be measured and included for payment.

The bid price for fertilizer shall be based on 10-20-10 type. When other types of fertilizer are used, pay quantities will be determined using the following table:

Type of Fertilizer	Actual Quantity Used Pounds (kg)	Pay Quantity Pounds (kg)
5-10-5	100	50
8-16-8	100	80
10-20-10	100	100
12-24-12	100	120
15-30-15	100	150

When fertilizer types other than those shown above are used, the relationship between the pay quantity and the actual quantity used will be established by the Engineer.

Silt fence will be measured by the linear foot (meter) at the bottom of the fence, excluding laps. Decomposed or ineffective fabric in the silt fence which is required to be replaced after six months from the installation date will be measured and paid for, however, such replacement prior to six months after installation will not be measured for payment.

In the event that temporary erosion and pollution control measures are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled, or as ordered by the Engineer, such work shall be performed by the Contractor at their own expense. Temporary erosion and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, shall be performed as ordered by the Engineer. Where the work to be performed is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls and falls within the Specifications for a work item that has a contract price, the units of work will be paid for at the proper contract price. Should the work not be comparable to the project work under the applicable contract items, the Contractor shall perform the work in accordance with 104.3.

In case of repeated failure on the part of the Contractor to control erosion, pollution, or siltation, the Engineer reserves the right to employ outside assistance or to use their own forces to provide the necessary corrective measures. Such incurred direct costs plus project engineering costs will be charged to the Contractor and appropriate deductions made from the Contractor's monthly progress estimate.

Temporary pollution control may include construction work outside the right-of-way where such work is necessary as a result of roadway construction such as borrow pit and waste site operations, haul roads and equipment storage sites.

Super Silt Fence will be measured by the linear foot complete and in place.

642.8-BASIS OF PAYMENT:

Except where provided for elsewhere in these specifications, the quantities determined as provided above, will be paid at the contract unit prices bid for the items listed below, which prices and payment shall be full compensation for furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work, including necessary maintenance, and removal where applicable.

642.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
642001-*	Temporary Berm	Linear Foot (Meter)
642002-*	Slope Drain	Linear Foot (Meter)
642004-*	Seed Mixture, "type"	Pound (Kilogram)
642005-*	Mulch, "type"	Ton (Megagram)
642006-*	Fertilizer	Ton (Megagram)
642007-*	Fiber Matting	Square Yard (Meter)
642008-*	Temporary Pipe	Linear Foot (Meter)
642009-*	Contour Ditch	Linear Foot (Meter)
642010-*	Agricultural Limestone	Ton (Megagram)
642011-*	Hay or Straw Bale	Each
642012-*	Silt Fence	Linear Foot (Meter)
642015-*	Super Silt Fence	Linear Foot (Meter)
642031-*	Ditch Check	Each
642032-*	Check Dam	Each
642033-*	Sediment Trap	Cubic Yard (Meter)
642034-*	Sediment Dam	Cubic Yard (Meter)
642035-*	Riser	Each
642036-*	Sediment Removal	Cubic Yard (Meter)
642037-*	Sediment Pond	Cubic Yard (Meter)
642050-*	Dewatering Device	Each

* Sequence number

SECTION 643 THROUGH SECTION 644-BLANK

SECTION 645

REINFORCED SOIL SLOPES

645.1-DESCRIPTION:

The following are specification guidelines for Reinforced Soil Slope (RSS) construction. Work shall consist of constructing the proposed RSS as specified and furnishing all materials for use in construction of reinforced soil slopes. The minimum length of the soil reinforcing as measured from the slope face to the back of the soil stabilized mass, is as shown in the plans. Any staged or temporary construction affecting the RSS stability shall be the responsibility of the Contractor.

The Engineer shall approve the geosynthetic material and supplier.

645.2-MATERIALS:

645.2.1-Geosynthetics Soil Reinforcing: Cutting of geosynthetic reinforcing longitudinal to the Slope face or at vertical obstacles shall not be permitted. End to End splicing of geosynthetic material will not be permitted.

The geosynthetic used shall meet the minimum requirements shown on the plans. Each roll of geosynthetic material shall be labeled as to its properties. Geosynthetics shall be made of polypropylene, high-density polyethylene or high-tenacity polyester fibers having cross-sections sufficient to permit significant mechanical interlock with the soil/backfill. Geosynthetics shall have a high tensile modulus in relation to the soil/backfill. Geosynthetics shall have a high resistance to deformation under sustained long term design loads while in service and resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced.

Store the geosynthetics in conditions above 20° F [-7° C] and not greater than 140° F [60° C]. Prevent mud, wet cement, epoxy, and like materials from coming into contact with and affixing to the geosynthetic material. Rolled geosynthetic may be laid flat or stood on end for storage. Cover the geosynthetic and protect from sunlight prior to placement in the wall system.

Carefully inspect all reinforcement to ensure they are the proper size and free from defects that may impair their strength and durability.

The geosynthetic reinforcement structure shall be dimensionally stable and able to retain its geometry under construction stresses and shall have high resistance to damage during construction. The contractor shall submit a manufacturer's certification that the geosynthetics supplied meets the design criteria shown on the plans, measured in full accordance with all test methods and standards specified. In case of dispute over validity of values, the Engineer can require the contractor to supply test data from an approved laboratory to support the certified values submitted.

The Contractor's submittal's package shall include actual test results for tension/creep, durability/aging, construction damage, pullout, quality control and a copy of the Manufacturers installation procedures. Also included shall be the Long -Term Design Strength (LTDS) of the Geosynthetic material with the assumptions used to calculate it. The Manufacturer shall also provide written certification that all resin used to produce the geosynthetic is virgin and classified as high density polyethylene, polypropylene, or high tenacity polyester and is capable of withstanding 150 hours of testing per ASTM D4355 with no measurable reduction in the ultimate tensile strength or the deterioration of the coating of the geosynthetic material.

If the geosynthetic material is to be used to wrap the face of the slope then the testing per ASTM D4355 will be 500 hours with no measurable reduction in the ultimate tensile strength or the deterioration of the coating of the geosynthetic material.

The allowable tensile strength shall not exceed 25% of the ultimate tensile strength of the reinforcement used. The (LTDS) of geosynthetic reinforcement shall be calculated using the following method.

Property	Method
Tensile Strength	
Ultimate, kN/m	
Geotextiles	ASTM D4595
Geogrids	ASTM D6637
Long-Term Design Strength (T_a), kN/m	FHWA/SA-93-025

$$\text{Where: } T_a = T_{ult} / \{(RF_{cr})(RF_{id})(RF_{du})\}$$

(as described in FHWA/SA-93-025)

T_{ult} , Ultimate Tensile Strength shall be the minimum average roll value ultimate tensile strength as tested per ASTM D4595 for geotextiles and for geogrids ASTM D6637 with the minimum tested value of the single-rib and multi-rib test.

RF_{cr} , Partial Factor for Creep Rupture, is the ratio of T_{ult} to the creep limited strength determined in accordance with ASTM D5262 and FHWA NHI-00-043. The test results shall be extrapolated for a 100-year design life at 68° F (20° C) per FHWA NHI-00-043. Creep rupture data of a polymer product at a designed temperature is limited to one order of magnitude in extrapolation. Creep rupture data at an elevated temperature can permit an additional order of magnitude in extrapolation with time temperature superposition principals. Creep Rupture limited strength testing is required on representative samples of the finished product for each product proposed for use and not a single component of the geogrid (i.e. polymer strand and / or yarn).

Default values for RF_{cr} are not allowed. If product specific testing is not provided the product shall be rejected for use. However, in no event shall the minimum value for Creep Rupture be less than the following:

MINIMUM VALUES FOR RF_{cr}	
Geosynthetic	Min RF_{cr}
High Density Polyethylene (HDPE)	2.65
Polypropylene (PP)	4.50
High Tenacity Polyester (PET)	2.00

RF_{id} , Partial Factor for Installation Damage, shall be determined from construction damage tests for each product proposed for use with project specific representative or more severe backfill and construction techniques. Testing shall be consistent with GRI GG4. A Maximum RF_{id} value shall be used if such testing has not been conducted.

RECOMMENDED VALUES FOR RF_{id}		
Geosynthetic	Min RF_{id}	Max RF_{id}
HDPE uniaxial geogrid	1.20	1.45
PP biaxial geogrid	1.20	1.45
PVC-coated PET geogrid	1.30	1.85
Acrylic-coated PET geogrid	1.30	2.05
Woven geotextiles (PP and PET)	1.40	2.20
Nonwoven geotextiles (PP and PET)	1.40	2.50
Silt-film woven PP geotextiles	1.60	3.00

RF_{du} , Partial Factor for Durability / Aging is the combined partial factor for potential chemical and biological degradation. RF_{du} shall be determined from polymer specific (HDPE and PP as identified by specific gravity and melt flow index and PETP as identified by CEG number and intrinsic viscosity) durability testing covering the range of expected soil environments. Prior to approval by the Engineer, the manufacturer shall submit test results from a minimum of at least four (4) tests conducted in accordance with EPA 9090 at temperatures of 73° and 122° F (23° and 50° C). EPA 9090 test results shall include the following minimum number of leachate types:

pH	<u>Minimum # of test results</u>
3≤pH≤7	1
7<pH≤9	1
9<pH<11	1
11≤pH≤14	1

As a minimum, the following tests should be performed for geogrids after immersion in the above-described leachates:

TEST	TEST PROCEDURE	MAX % CHANGE ALLOWED
Mass per Unit Area	EPA 9090	±1.0
Dimensions	EPA 9090	±1.0
Thickness	ASTM D374C	±5.0
Wide Width Strip Tensile	ASTM D4595	-2.0

1. Composite (flexible/coated) geogrids shall be evaluated based on the durability characteristics of the interior reinforcement polymer. Therefore, any protective coating shall be removed prior to durability testing unless a minimum 40 micron coating thickness is used on flexible geogrids and certified by the manufacturer.
2. For soils of potential concern, as presented below (modified soils shall include lime stabilized soil, cement stabilized soil or concrete), only polymers listed as “no effect” shall be used within or adjacent to (3 feet shortest measurable distance) these soil environments (Ref: Table 28, FHWA/RD-89-186).

SOIL ENVIRONMENT	PETP	PE	PP	PVC
Acid Sulfate Soils	?	NE	?	?
Organic Soils	NE	NE	NE	X
Salt Affected Soils	?	NE	NE	NE
Ferruginous	NE	NE	X	X
Calcareous	X	NE	NE	?
Modified Soils	X	NE	NE	?

NE = No Effect
 ? = Questionable Use
 X = Not Recommended

RF_{du} shall not be less than the recommended minimum values discussed in FHWA/RD-89-186 and listed below:

MINIMUM VALUES FOR RF_{du}					
Products	Aging Reduction factor, RF _{du} – 100 years				
	pH < 3	3 ≤ pH < 5	5 ≤ pH ≤ 8	8 < pH ≤ 9	pH > 9
PET Uncoated Mn < 20,000 40 < CEG < 50	*	2.0	1.6	2.0	*
PET Coated Mn > 25,000 CEG < 30	*	1.3	1.15	1.3	*
HDPE	1.1	1.1	1.1	1.1	1.1
Polypropylene	1.25	1.25	1.25	1.25	1.25
Geotextiles Mn < 20,000 40 < CEG < 50	*	2.0	1.6	2.0	*

* Use of materials in this pH range is not recommended but can be used if product specific testing is done
 Mn = Number of Molecular Weight
 CEG = Carboxyl End Group

645.2.2-Backfill Material: All backfill material used in the structure volume shall be reasonably free from organic or otherwise deleterious materials and shall conform to the following gradation limits as determined by AASHTO T-27:

<u>Sieve Size</u>	<u>Percent Passing</u>
100 mm (4 in.)	100
No. 4	100-30
No. 20	0-60
No. 200	0-50
Plasticity Index (PI) ≤ 20 (AASHTO T-90)	

A. Backfill pH Testing

The contractor prior to incorporating the soil into the RSS shall perform one pH test in each soil type each day of operation and the pH of the soil shall be within the allowable limits of the design for the geosynthetic material used.

B. Payment

Payment for the backfill will be incidental to the various excavation items.

CONSTRUCTION METHODS

645.3-FOUNDATION PREPARATION:

All areas immediately beneath the installation area for the geosynthetic reinforcement shall be properly prepared for a width equal to the length of reinforcement elements plus one 3 ft (1m) or as detailed on the plans or as directed by the Engineer. The surface shall be level, free from deleterious materials, loose, or otherwise unsuitable soils. Prior to placement of Geosynthetic reinforcement, foundation shall be proof-rolled to provide a uniform and firm surface. Any soft areas, as determined by the Engineer, shall be removed and replaced with backfill as per Section 207 of these specifications. Foundation surface shall be inspected and approved by the Engineer prior to fill placement. Benching the backcut into competent soil is recommended to improve stability. The backslope shall not be steeper than 1.5:1 (1:1.5).

645.4-GEOSYNTHETIC INSTALLATION:

A representative of the geosynthetic supplier shall be present a minimum of three (3) days and as required thereafter during construction of the reinforced slope to assist the Contractor and Engineer. The cost of the representative shall be considered incidental to the unit cost of the geosynthetic reinforcement.

Geosynthetic reinforcement shall be placed horizontally unless otherwise shown in the plans. Prior to placement of the geosynthetic reinforcements, backfill shall be compacted in accordance with these specifications.

645.5-BACKFILL PLACEMENT:

Backfill placement shall closely follow the installation of each geosynthetic reinforcement layer. Backfill shall be placed in such a manner as to minimize the development of wrinkles in and/or movement of the geosynthetic material. A minimum fill thickness of 6 inches (150 mm) is required prior to the operation of tracked vehicles over the geosynthetic reinforcement.

Turning of vehicles should be kept to a minimum to prevent tracks from displacing the fill and damaging the geosynthetic. Rubber tired equipment may pass over the geosynthetic reinforcement at low speeds provided that no sharp turns are made. Geosynthetic material damaged during installation shall be replaced by the Contractor at no additional cost.

The maximum lift thickness after compaction shall not exceed 6 inches (150 mm), The Contractor shall decrease this lift thickness, if necessary to obtain the specified density.

Acceptance for compaction shall be in accordance with Section 626.5.3.4. The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill materials shall have placement moisture content as per Section 716.3.

At the end of each day's operation, the Contractor shall slope the last level of the backfill away from the slope to rapidly direct runoff away from the slope face and construction area. In

addition, the Contractor shall not allow surface runoff from adjacent areas to enter the reinforced soil slope construction site.

645.6-EROSION CONTROL MATERIAL PLACEMENT:

The erosion control material shall be placed and anchored on a smooth graded, firm surface approved by the Engineer. Anchoring terminal ends of the erosion control material shall be accomplished through use of key trenches. The material in the trenches shall be anchored to the soil maximum 2 ft (0.5 m) centers. The erosion control material shall meet the specifications of section 715.24.

645.7-ACCEPTANCE:

The Contractor shall furnish the Engineer a Certificate of Compliance certifying the above materials, excluding backfill, comply with the applicable contract specifications. A copy of all test results performed by the Contractor necessary to assure contract compliance shall also be furnished to the Engineer.

The backfill shall be in accordance with 626.5.3.4.

645.8-METHOD OF MEASUREMENT:

The pay items shall be measured in square yards (meters) geosynthetic reinforcement as determined by the dimensions in the plans. No adjustment of pay quantity shall be allowed for changes in Reinforced Soil Slope design to facilitate the Contractor's methods of construction or geosynthetic type used.

Any adjustments to the required amount of embankment backfill due to the particular geosynthetic reinforcement proposed by the contractor shall be considered incidental to the project. No separate payment shall be made for increased embankment backfill requirements. The contractor shall be responsible for any of the cost of changes in waste, borrow, or earthwork quantities from those shown in the plans caused by the requirements of the geosynthetic reinforcement.

645.9-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each pay item listed below and shown in the bid schedule, which prices and payment will be full compensation for the work prescribed in this section.

645.10-PAY ITEM:

ITEM	DESCRIPTION	UNIT
645001-*	"type" Reinforcement, "long-term design strength" lb/ft (kn/m)	Square Yard (Meter)

*Sequence number

"type" Primary or Secondary

SECTION 646 THROUGH SECTION 650-BLANK

SECTION 651 FURNISHING AND PLACING TOPSOIL

651.1-DESCRIPTION:

This work shall consist of acquiring sites outside the right-of-way from which topsoil can be obtained and the hauling and placing of such material, or hauling and placing of topsoil from stockpiles within the right-of-way, all in accordance with these Specifications and at locations indicated on the Plans or designated by the Engineer.

651.2-MATERIALS:

Topsoil shall consist of the uppermost layers of fertile and friable soil that contains humus material. This material varies in thickness in accordance with soil groups and usually possesses a darker color than the subsoil. The texture of the topsoil may vary within the range of natural loam, silty clay loam, and sandy loam. Acceptable topsoil shall contain organic matter in the range of 1.5% to 20%.

CONSTRUCTION METHODS

651.3-STRIPPING TOPSOIL:

Prior to removal from the site, the soil will be tested by the Division to determine the humus and nutrient value. Care shall be exercised as to the depth of stripping, and any loads with an excess of subsoil shall be discarded. The Contractor shall mow or otherwise remove all heavy grass, weeds, or other vegetation over the areas before stripping. Approval by the Engineer must be obtained prior to transporting any material from the stripping site.

651.4-TRANSPORTING:

Topsoil material shall not be placed until the entire roadway (including surfacing) has been completed, unless otherwise provided for on the Plans or approved in writing. During hauling operations, the surface of the highway shall be kept reasonably clean to avoid creating a traffic hazard.

651.5-PLACING AND MANIPULATING:

Areas to be topsoiled shall be brought reasonably close to the lines and grades shown on the Plans or established by the Engineer.

The Contractor shall scarify the surface of the subsoil before the topsoil is placed, unless otherwise permitted, for bonding the topsoil layer with the subsoil.

Scarification shall be accomplished by disking, harrowing, raking, or other approved methods. Depressions and ridges formed by construction equipment, during final grading or scarifying, shall be parallel to the contours.

Topsoil shall not be spread to a greater depth than that required to make the work conform to the natural terrain after shrinkage and settlement have taken place. After spreading the soil, all deleterious materials (large lumps or clods, brush, litter, or other foreign material, and stones exceeding 2 inches (50 mm) approximately in any dimension) shall be raked up and removed from the site.

The Contractor shall take all reasonable precautions to avoid injury to existing plant growth, structures, and roadway surface.

651.6-METHOD OF MEASUREMENT:

The quantity of work done will be measured in cubic yards (meters) of "Furnishing and Placing Topsoil" or "Placing Stockpiled Topsoil", which shall be the material actually removed from previously selected site or sites outside the right-of-way of from stockpiles within the right-of-way, and acceptably placed and spread on the areas designated to receive it, as determined from the net total of load tickets of vehicles.

651.7-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

No separate payment will be made for stripping topsoil within the right-of-way limits and transporting or stockpiling of such material.

651.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
651001-*	Furnishing And Placing Topsoil	Cubic Yard (Meter)
651002-*	Placing Stockpiled Topsoil	Cubic Yard (Meter)

* Sequence number

SECTION 652 SEEDING AND MULCHING

652.1-DESCRIPTION:

This work shall cover all operations incidental to the establishment of grass and legume vegetation, including the furnishing and sowing of seed, furnishing and applying fertilizer, agricultural limestone, and mulch material, all in accordance with these Specifications and at locations indicated on the Plans or designated by the Engineer.

652.2-MATERIALS:

Materials shall meet the requirements in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Fertilizers	715.26
Ground Agricultural Limestone	715.25
Inoculating Bacteria	715.29
Matting for Erosion Control	715.24
Mulch Materials	715.27
Water	*

- * Water shall be reasonably free from injurious chemicals and other toxic substances harmful to plant life. The source of water used is subject to the approval of the Engineer.

Temporary seed, such as annual ryegrass (Italian ryegrass) and weeping lovegrass, used in the seed mixtures B, C, or D, shall be of a commercial grade meeting the requirements of the State Seed Law. Temporary seed labeled with the notation "germination below standard" shall not be used. Temporary seed shall not be used after one year from date of germination test shown on the label.

Seed other than that specified above shall meet the requirements of 715.28.

Asphalt for anchoring mulch shall be of a commercial grade. Chemical mulch binders shall conform to the requirements in 715.27.1.

Topsoil, if called for, shall conform to the requirements in 651. All materials will be subject to approval or rejection, in part or in whole.

CONSTRUCTION METHODS

652.3-SEASON OF WORK:

Permanent seeding or second and third seeding following the original seeding, under 652, shall be performed between the dates of March 1 to June 15 and August 1 to October 15. Seeding under 642 shall be applied following construction at any time the weather will allow seeding equipment to operate; without regard to seasons.

652.4-AREA PREPARATION FOR SEEDING AND MULCHING:

Seeding and mulching shall not be applied until the specified areas have been brought to lines and grades shown on the Plans. Topsoil, when called for, shall be spread to the depths indicated on the Plans.

The application rate for agricultural limestone will be determined by a pH test after cuts and embankments are completed just prior to seeding. The Plans will show the estimated tons (megagrams) of lime needed for the job based on general knowledge of the soils in the area. The final application rate will be determined by the Engineer based on the pH test, conducted in accordance with MP 700.04.10.

Interchanges, medians and similar areas with 3 to 1 slope or flatter, excluding areas involving subsurface drainage from base course material, shall be scarified sufficiently to produce a seed bed as directed by the Engineer. All large sticks, brush, loose roots, stones exceeding 2 inches (50 mm) approximately in any dimension, and other debris shall be removed prior to seeding operations. The area shall be back dragged to eliminate depressions, ruts, or equipment track marks on slopes. Seed bed preparation will not be necessary on slopes steeper than 3 to 1.

Preparation of Lawn Type Area for Seeding: All areas to be seeded to "Type C-2" lawn mixture, and "Type C-1" mixture in rest areas shall be fine graded. The finished grade shall be uniform and free of irregularities or water pockets. The finished grade shall be free of weed and plant growth, stones over 1 inches (25 mm) in diameter, or other debris. This debris will be disposed of as directed by the Engineer. Immediately prior to seeding, all areas shall be cultivated to provide a reasonably firm but friable seedbed. The depth of tillage shall be 3 inches (75 mm) or as directed by the Engineer. Limestone as required and fertilizer as specified shall be worked into the upper 3 inches (75 mm) of the seedbed before seeding.

652.5-SOWING SEED:

Immediately following area preparation, seed shall be sown. Legume seed shall be inoculated with approved cultures, in accordance with the instruction of the manufacturer. When using a hydroseeder, the inoculant shall be increased to five times the normal rate.

Seed shall be sown by approved methods which provide for uniform distribution of seed. Rates of application and type of seed mixture shall be in accordance with Table 652.5 unless otherwise specified on the Plans.

For lawn areas, the broadcast seeding shall be made in two applications, using one half the seed each time and the second sowing to be at right angles to the first. After broadcasting or otherwise applying the seed, the seedbed shall be firmed by means of a roller or cultipacker.

TABLE 652.5-SEED MIXTURES

Variety of Seed	Type B	Type C		Type D	Type L
		C-1	C-2		
	Medians, Shoulders (Ditch Slope) Waterways, and Mowable Areas of Interchange	Coarse Lawn Grass ----- For Use in Urban and Rest Area Locations	Fine Lawn Grass ----- For Use where a Fine Lawn is Desired	Cut and Fill Slopes ----- (Including Benches and Bifurcated Median)	All areas
	Lb. per acre (kg per ha)	Lb. per acre (kg per ha)	Lb. per acre (kg per ha)	Lb. per acre (kg per ha)	Lb. per acre (no. per hr.)
Kentucky 31 Fescue	65 (72.9)	45 (50.4)		20 (22.4)	
Red Fescue (Pennlawn)	20 (22.4)	20 (22.4)	20 (22.4)	20 (22.4)	41 (46.0)
Kentucky Bluegrass		25 (28.0)	40 (44.8)		
Merion Bluegrass			30 (33.6)		
Crown Vetch				20 (22.4)	
Hard Fescue Mixture***					63 (70.6)
White Dutch Clover	3 (3.4)				
Annual Ryegrass Aug 1 to May 15 or Weeping Lovegrass May 15 to Aug 1	7 (7.8) 3 (3.4)	7 (7.8) 3 (3.4)	7 (7.8)	7 (7.8) (3.4)	12 (13.5) 5 (5.6)

* Areas will be considered mowable when slopes are 3 to 1 or flatter. Type C-1 and C-2 seed mixtures shall be used in all urban, suburban, and rest areas where lawn type turf is desired with mowing maintenance intended. C-2 lawn mixture shall be used along sidewalks, adjacent to private lawns.

*** A combination of approved certified varieties with no one variety exceeding 50% of the total hard fescue component.

Reseeding, Refertilizing and Remulching: Any area failing to establish a stand due to weather conditions or adverse soil conditions shall be reseeded, refertilized and remulched as directed by the Engineer.

652.6-APPLYING MULCH AND FERTILIZER:

652.6.1-General: Whenever permanent or temporary seeding is made on bare soil or newly completed construction work, the following criteria shall be followed in regard to mulching.

Straw mulch (including hay) shall be used on all areas and slopes $1\frac{1}{2}$ to 1 or flatter. Wood cellulose fiber mulch shall be used on cut slopes steeper than $1\frac{1}{2}$ to 1. The Engineer may make adjustments in the type of mulch to meet local conditions on the job.

When using straw mulch, the mulch shall be anchored with an acceptable binder as described in Section 652.6.2 below. The sequence of application, when using straw mulch shall be as follows: (1) Seed and fertilizer shall be sown prior to mulching. (2) Mulch and mulch binder shall be placed within 24 hours of sowing seed.

When permanent seeding follows a temporary cover crop, wood cellulose fiber mulch shall be used and the quantity of mulch shall be determined by the amount of living and dead plant residue on the soil surface in accordance with 652.6.3.2.

Where the temporary seeding has been destroyed by subsequent construction, the mulch will be the same type and amount as required for bare soil or new construction.

652.6.2-Straw Mulch: Straw shall be applied at the rate of approximately two tons per acre (4.5 Mg per hectare). The straw mulch may be anchored with 100 gallons of asphalt per acre (93.5 L of asphalt per hectare). The asphalt may be sprayed on the straw as it leaves the blower or it may be applied in a separate operation. The Contractor shall be responsible for any damage to the structures from the asphalt spray.

Straw mulch around buildings, sidewalks or other structures may be held in place with a form of netting or may be sprayed with asphalt by hand while protecting the structures from the asphalt spray.

Other types of chemical mulch binders may be substituted for asphalt material. These mulch binders shall be applied according to the manufacturers' specifications through the asphalt spray system or by an agricultural crop sprayer.

652.6.3-Hydraulic Application of Wood Cellulose Fiber as a Mulching Agent:

652.6.3.1-Equipment: Hydraulic equipment shall be used for the application of a slurry of fertilizer, seed, prepared wood cellulose fiber, and water. This equipment shall have a built-in agitation system with an operating capacity sufficient to agitate, suspend, and homogeneously mix a slurry of the specified amount of fiber, fertilizer, seed, and water. The slurry distribution lines shall be large enough to prevent stoppage. This discharge line shall be equipped with a set of hydraulic spray nozzles which will provide even distribution of the mixture or slurry in the various areas to be seeded. The slurry tank shall have a minimum capacity of 1,000 gal (3 750 L) and shall be mounted on a traveling unit which may be either self-propelled or drawn, with a separate unit which will place the slurry tank and spray nozzles within sufficient proximity to the areas to be seeded to provide uniform distribution without waste.

652.6.3.2-Preparation of Slurry and Application of Fertilizer, Seed, and Mulch: Wood cellulose fiber shall be applied at a minimum rate of 1,500 lbs. (1 680 kg) net dry weight per acre (ha) when seeding bare soil or new construction. When seeding into a residue or growth where temporary seeding has previously been performed, the rate will

be determined by the Engineer, usually 1,000 lbs. net dry weight per acre (1 120 kg per ha). The seed, fertilizer, wood cellulose fiber, and water shall all be combined into the slurry tank for distribution of all ingredients in one operation by the hydraulic seeding method. The agitator shall be operating at a rate sufficient to keep all materials in suspension at the time such material is added. Seed shall be added first, shall be thoroughly mixed, and the fertilizer then added and put into suspension. When the tank is 40 percent full, the mulch material may be added and shall be in complete suspension by the time the tank is 75 percent full. Such increased mixing speed as is necessary for putting the entire admixture in suspension shall be maintained until the tank is emptied. Spraying may commence at such time as the full complement of water has been mixed into the slurry. It is the intent of this Specification to maintain the slurry, during the spraying operation, as a homogenous mixture of suspended solids in the tank until the tank is emptied.

652.6.4-Fertilizer: The kind and amount of fertilizer per acre (ha) shall consist of any type with 1-2-1 ratio (nitrogen, phosphoric acid, and potash) providing the minimum nutrient equivalent of 1,000 lb. (450 kg) of 10-20-10. In addition, 300 lb. per acre (335 kg per hectare) of slow release urea formaldehyde fertilizer shall be added whenever second step seeding and fertilizing is not feasible due to the Contract completion date. When hydraulic seeding methods are used, the fertilizer shall be applied concurrently with the seeding and mulching operation as part of the slurry mix. When commercial fertilizer is applied by the spray or hydraulic method, it need not be worked into the soil.

Fertilizer applications for second and third step seeding shall be in accordance with 652.8.

652.6.5-Wood Chips: Wood chips, recovered from clearing and grubbing operations, or bark will be acceptable as a mulch for seeding and shall be used at a rate of 35 cubic yard per acre (66 cubic meters per hectare) in lieu of straw or hay.

652.7-MAINTENANCE OF SEEDED AND MULCHED AREAS:

The Contractor shall maintain all seeded areas until final acceptance of the project. All areas shall be protected from equipment traffic and any damaged areas shall be repaired and reseeded.

652.8-SECOND AND THIRD STEP SEEDING, FERTILIZING AND MULCHING:

The Engineer will require second or third step seeding, or both, depending upon the completion date and estimated completion time of any remaining items on the project.

The second application of fertilizer, seed and mulch shall be applied as directed by the Engineer. The application rates will be based on the stand of grass, severity of erosion and condition or growth of grass as described. Spring seedings shall be refertilized and reseeded as needed in the fall from August 15 to October 15. Fall seeded areas shall be given a second step seeding and fertilizing, as required, the following spring from March 15, to May 15.

The following shall be used as a guide for second step application:

- i. For areas with less than 50 percent stand or subject to sever erosion, apply the complete amount of seed, fertilizer, and mulch (wood cellulose fiber) as specified in the original seeding.
- ii. For areas with over 50 percent of grass and slight to moderate erosion, apply one half the original fertilizer and seed. If erosion is a problem apply one half the original wood fiber mulch.

The third step seeding, mulching, and fertilizing shall consist of spot application on areas not showing a satisfactory stand after the second step application. The quantity of material will be determined on the same basis as for the second step application. No urea formaldehyde fertilizer will be needed for third step seeding.

652.9-METHOD OF MEASUREMENT:

Ground agricultural limestone, fertilizer, and mulch will be measured by the ton (megagram). Seed will be measured by the pound (kilogram).

Wood chips or bark will be measured by the cubic yard (meter). It is assumed that 17.5 cubic yard (14.75 cubic m) of chips or bark are equal to one ton (megagram) of straw for seeding. Wood chips or bark mulch will be measured by truck load or other loose volume measurement, and payment will be made on one ton (megagram) equivalent of straw for each 17.5 cubic yard (14.75 cubic m) of wood chips or bark mulch.

Second and third step seeding operations will be measured and included for payment under items in 652.11.

Asphalt for anchoring mulch, or other chemical mulch binders, will not be measured separately, but their cost shall be included in the unit price bid for mulch.

652.10-BASIS OF PAYMENT:

The quantities determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be considered full compensation for furnishing all materials and performing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

Topsoil will be measured and paid for in accordance with the provisions of 651.

The bid price for fertilizer is based on 10-20-10 type. When other types of fertilizer are used, pay quantities will be determined using the following table.

Type of Fertilizer	Actual Quantity Used Pounds (kg)	Pay Quantity Pounds (kg)
5-10-5	100	50
8-16-8	100	80
10-20-10	100	100
12-24-12	100	120
15-30-15	100	150

When fertilizer types other than those shown above are used, the relationship between the pay quantity and the actual quantity used will be established by the Engineer.

652.11-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
652001-*	Agricultural Limestone	Ton (Megagram)
652002-*	Fertilizer, "type"	Ton (Megagram)
652003-*	Seed Mixtures, "type"	Pound (Kilogram)
652004-*	"type" Mulch	Ton (Megagram)

* Sequence number

SECTION 653

VINE AND GROUND COVER PLANTING

653.1-DESCRIPTION:

This work shall consist of furnishing and planting vine and ground cover of the species called for on the Plans and in the manner prescribed or as directed by the Engineer.

653.2-MATERIALS:

653.2.1-Topsoil: Topsoil shall conform to the applicable requirements of 651.

653.2.2-Water: Water shall conform to the requirements of 652.2.

653.2.3-Ground Agricultural Limestone: Ground agricultural limestone shall conform to the requirements of 715.25.

653.2.4-Fertilizer: Fertilizer for landscape plantings shall conform to the applicable requirements of 715.26.

653.2.5-Mulch and Mulch Anchor: Mulch material for landscape plantings shall conform to the requirements of 715.27.2.

653.2.6-Vine and Ground Cover Plants: Vine and ground cover plants shall conform to the requirements specified of 715.33. The vine and ground cover plants shall be true to the type and size indicated on the Plans.

CONSTRUCTION METHODS

653.3-PLANTING OF VINES AND GROUND COVER PLANTS:

The method of planting vine and ground cover plants will be determined to a great extent by the site conditions, namely soil, slope, and type of cover. Two methods of planting ground cover are basically row planting and bed planting, as shown on the Plans.

Row Planting--On areas covered with grass or weed mass, the equivalent of one square foot (300 mm) of sod including roots shall be removed and replaced on the lower side of the plant hole to help retain moisture runoff. The foot (300 mm) square area around each individual plant shall be mulched as directed by the Engineer.

Bed Planting--All plant beds shall be free of weeds and grass prior to planting. The bed preparation can be accomplished with either herbicide spray or tillage as described on the Plans.

Bed areas shall be mulched as shown on the Plans.

Plant backfill mixture for vines and ground covers shall be three parts top soil to one part peat moss with one hundred lb. (45.5 kg) fertilizer added per cubic yard (meter) of backfill. For plants in containers or pots three inch (75 mm) size or less, the backfill mix shall be applied at the rate of one pint per plant. For plants in larger containers, the planting specifications will be shown on the Plans. Any other additives will be shown on the Plans. In loose shale or sand without a sod cover, selection of plant location shall be where the soil is stable and not subject to rapid accumulation or erosion. On steep banks 1½ to 1 or steeper, a slit shall be opened large enough to receive the plant roots and the replaced soil tamped leaving a slight depression to collect moisture.

On slopes 2 to 1 or flatter, a small rain basin shall be formed by tamping with the heel and placing sod or excess soil on the slopes below the plant. Plants shall be watered during planting operations as directed by the Engineer.

The Contractor shall furnish material and mark location of all vine and ground cover plants for future reference. A row shall be identified by a stake at each end and a bed or mass identified by stakes around the perimeter. Wire stakes with flags are acceptable as markers.

Planting Season: All initial planting shall be performed between March 15 and July 1.

653.4-CARE OF VINES AND GROUND COVER:

The Contractor shall maintain the plants in a healthy, living condition during the life of the contract, and shall maintain an adequate supply of moisture in the root zone at all times.

The Contractor and the Engineer shall make a monthly inspection of the plantings to determine the need for maintenance and water during the first growing season, June through October. Any maintenance determined necessary shall be taken care of during the two-week period immediately following the inspection. When moisture in the root zone is deficient, watering shall be started within 48 hours with sufficient labor and equipment to completely water all the plants within a two-week period unless otherwise directed by the Engineer. Other maintenance required during the contract period shall include:

- i. The control of weeds and grass growth in beds and around individual plants.
- ii. Protect plants from damage by insects and diseases.
- iii. Any other practices necessary to maintain the plants in a healthy, live condition.

653.5-REPLACEMENT OF VINES AND GROUND COVER:

Between August 1 and 10 following the initial planting period, the Contractor and Engineer will make an inspection of all vines and ground cover plants to determine the replacement necessary.

If it is estimated that 85 percent or more of the Plan quantity of any individual item in a specific area is living, healthy and in good growing condition, replacements will not be required for that area. Any specific grouping shall have a reasonable distribution of live plants and the allowable 15 percent loss shall not be concentrated.

If it is determined there is a loss of more than 15 percent in any specific area, the Contractor shall be required to replace all the dead, missing or defective plants in the specific area. All replacements shall be completed during the period September 1 to 15 and maintained until the completion of the Contract.

653.6-CARE DURING AND AFTER DELIVERY:

There is a tendency for bare-root plants to dry out during shipment and during the planting operation; therefore it is important that the roots of all plant material shall be kept moist during shipment and during their planting period.

653.7-METHOD OF MEASUREMENT:

Measurement of vines and ground cover plants shall be the number of plants originally planted, providing a survival of 85 percent was established, or the necessary replacements were made as directed.

The final acceptance and payment for any particular plant will be made after completing proper care and replacement as described in 653.4 and 653.5.

Water for maintenance during the period of establishment will be measured by the gallon (liter), expressed in thousand-gallon (liter) units.

653.8-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials, including water required during the process of planting, topsoil, ground limestone, fertilizer, and mulch, and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

Maintenance work other than watering shall be included in the contract unit price bid for each plant.

The accepted quantities of watering during the period of establishment will be paid for at the contract unit price per 1,000 gallons (L), which price shall be full compensation for furnishing, delivering, applying and performing all other work. No payment will be made for watering at the time of original planting or when planting replacements.

653.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
653001-*	Vines, Fast Growing, "scientific name"	Each
653002-*	Vines, Medium Growing, "scientific name"	Each
653003-*	Vines, Clump Type, "scientific name"	Each
653004-*	Ground Covers, "scientific name"	Each
653005-*	Water For Plants	Thousand Gallon (Liter)

* Sequence Number

SECTION 654 TREE AND SHRUB PLANTING

654.1-DESCRIPTION:

This work shall consist of furnishing, delivering, and planting nursery-grown or collected plants, in accordance with these Specifications and at locations shown on the Plans or designated by the Engineer. This work shall include the furnishing of topsoil and related materials together with all other work including clean-up of planted areas.

654.2-MATERIALS:

654.2.1-Topsoil: Topsoil for plant backfill shall conform to the applicable requirements of 651.

654.2.2-Water: Water shall conform to the requirements in 652.2.

654.2.3-Ground Agricultural Limestone: Ground agricultural limestone shall conform to the requirements of 715.25.

654.2.4-Fertilizer: Fertilizer for landscape plantings shall conform to the applicable requirements of 715.26.

654.2.5-Mulch and Mulch Anchor: Mulch for landscape plantings shall conform to the requirements of 715.27.2.

654.2.6-Trees and Shrubs: Trees and shrubs shall conform to the requirements of 715.35. The trees and shrubs shall be true to the type and size indicated on the Plans.

Collected plants may be used in place of nursery grown plants only when called for on the plans.

654.2.7-Tree Paint: Tree paint shall conform to the requirements of 715.36.

654.2.8-Miscellaneous Materials: Wire, hose, stakes, tree wrapping paper, anti-desiccant spray, and other incidental materials shall conform to the requirements of 715.37.

CONSTRUCTION METHODS

654.3-INSPECTION AND DELIVERY OF PLANT MATERIAL:

The Contractor shall notify the Engineer at least five days in advance of digging or shipping of plants from the nursery or collecting source. All plants will be subject to inspection where growing in the nurseries or collecting areas.

All plants shall be dug with care by experienced workmen, retaining essential roots and avoiding mechanical damage to root systems. All plants shall arrive with their roots in a moist and healthy condition. Each species or variety shall be handled and packaged in an approved manner and as required by soil and climatic conditions at the time of digging, with due regard to conditions of shipment and time to be consumed in transit and delivery. All plants shall be legibly tagged with name and size. All balled and burlapped plants shall be handled by the earth ball only.

All evergreen and all deciduous trees, regardless of size, and all other plants so designated on the Plans shall be balled and burlapped for shipment. All such plants shall be so dug and transported as to provide and retain a firm ball of earth. All balled and all bare-root material shall be adequately protected from severe changes in temperature and wind-burn while in transit.

Upon delivery to the Project, plants will be inspected for number, type, species, size, quality, and condition. Defects or injuries, such as dried out or broken roots and tops, evidence of "sweating", mildew, freezing, or broken or manufactured rootballs, will be cause for rejection, and immediate steps shall be taken to replace rejected plants.

654.4-CARE AFTER DELIVERY:

Plant material delivered to the Project and accepted shall be planted immediately, or "heeled-in" in moist soil or other approved moist material in a manner as shown on the Plans. All "heeled-in" plants shall be kept moist and protected until planted.

654.5-DIGGING HOLES FOR PLANTS:

Planting holes shall be excavated according to the following table:

Planting Hole Diameter			
Rootball Inches (mm) (Specified)	Planting Hole Inches (mm) (Approximate)	Rootball Inches (mm) (Specified)	Planting Hole Inches (mm) (Approximate)
8 (200 mm)	20 (500 mm)	28 (700 mm)	49 (1225 mm)
10 (250 mm)	22 (550 mm)	32 (800 mm)	56 (1400 mm)
12 (300 mm)	24 (600 mm)	38 (950 mm)	66 (1650 mm)
14 (350 mm)	28 (700 mm)	42 (1050 mm)	73 (1825 mm)
16 (400 mm)	32 (800 mm)	48 (1200 mm)	84 (2100 mm)
18 (450 mm)	34 (850 mm)	54 (1350 mm)	94 (2350 mm)
20 (500 mm)	36 (900 mm)	60 (1500 mm)	105 (2625 mm)
22 (550 mm)	38 (950 mm)	72 (1800 mm)	126 (3150 mm)
24 (600 mm)	42 (1050 mm)	---	---

The depth of the hole shall extend 8 inches (200 mm) below the depth of the rootball. During normal weather conditions, digging and planting holes may be allowed as much as two weeks in advance of planting. During hot dry weather, the planting holes shall be dug just prior to planting. When holes present a hazard along the highway, they should be dug immediately prior to planting.

Planting holes for container grown plants shall be dug to the size required for the equivalent balled and burlapped plants.

654.6-PLANT BACKFILL:

All backfill for planting shall be four parts topsoil mixed with one part peat moss (loose measurement) or other approved additive. Eight pounds (4.75 kg) of fertilizer shall be added per cubic yard (meter) of backfill and bulk mixed with the topsoil and peat moss.

Any adjustment needed in the pH reaction of the backfill material will be specified in the Plans.

The rate of fertilizer application for individual plant replacement shall be as follows:

Deciduous trees-1 lb/in. (0.02 kg/mm) diameter

Evergreen trees-One pound (0.5 kg) per tree

Small flowering trees-One pound (0.5 kg) per tree

Shrubs-One-half pound (0.25 kg) per plant.

No backfill in a frozen or muddy condition shall be used.

654.7-PLANTING:

654.7.1-Planting Season: Planting season for balled and burlapped evergreens shall begin September 15. Planting season for all deciduous balled and burlapped plants and all bare root plants shall begin October 15. No bare root plants shall be planted during freezing temperature. The cut-off date for fall planting and the starting date for spring planting will be determined by the Engineer. All initial planting shall be completed by May 20.

Any extension of time granted due to a delay in giving notice to proceed, as indicated in the Proposal, is not intended to extend the initial planting deadline of May 20. It is the intent of this specification that all plants shall be in the planting holes by May 20. Should there be a delay in giving notice to proceed, the staking, guying, wrapping, and other incidental items may be deferred by the Engineer until all plants are placed in the planting holes. Such approval of the planting procedure will not relieve the Contractor of their responsibility for loss of any plants.

654.7.2-Planting Method: All balled and burlapped plants shall be planted so the top of the ball is slightly above the natural ground level to allow for normal settlement unless otherwise specified on the Plans. When planting beds, the individual plants shall be selected and arranged according to spread and height to present a uniform appearance.

Backfill material under the rootball or roots shall be tamped prior to placing the plant in the hole.

When planting balled and burlapped plants, the burlap and twine may be left intact; however, any twine attached to the stem and considered to have a girding or detrimental effect shall be removed. Bare-rooted plants shall be placed in the planting holes with the roots spread out in a natural position while the specified backfill is placed. Nonplantable containers shall be carefully removed from all container grown or potted plants immediately prior to planting.

Planting beds shall be prepared by destroying the existing vegetation before excavating the planting holes. Recommendations for control of existing vegetation will be shown on the Plans.

Sufficient amounts of water, without puddling, shall be used in the process of planting to settle the backfill material around the roots or ball. Additional backfill material shall be placed and further compaction accomplished by tamping. This watering is not to be confused with the maintenance procedure in 654.14.1.

During the initial planting period, September 15 to May 20, any plant determined by the Engineer not to be in an acceptable growing condition, or failing to meet other requirements of these specifications, shall be removed from the project and replaced immediately with nursery stock meeting the specifications. It is the intent of this specification that all plants shall be alive at the beginning of the growing season.

654.8-PRUNING:

Primarily, all dead and broken branches shall be removed from deciduous and evergreen plant material during the process of planting. Further pruning shall be carried on in accordance with the normal nursery practice or as directed by the Engineer. All cuts over 1 inch (25 mm) shall be painted with a tree paint.

654.9-STAKING AND GUYING:

All deciduous and evergreen trees and all ornamental flowering trees (including multiple stem) shall be staked in accordance with tree staking details shown on the Plans and to the satisfaction of the Engineer.

654.10-MULCHING:

Mulch material shall be furnished and placed around the plants as soon as possible after planting. However, during extremely wet periods, the application of mulch shall be delayed and placed as directed by the Engineer.

The mulch shall be applied in the saucer areas of individual trees and shrubs and over the entire area of shrub beds. Heavy mulches like woodchips and wood bark products shall be applied to a depth of 3 inches (75 mm). Light mulch material shall be applied 4 inches (100 mm) deep. When black polyethylene film is specified for weed control, the mulch depth shall be reduced to 2 inches (50 mm).

654.11-WRAPPING AND FOLIAGE PROTECTION:

The trunks of all deciduous and small flowering trees shall be wrapped with four inch (100 mm) waterproof sisal paper. The wrapping shall start from the ground and extend up the trunk in a spiral manner with one-third overlap, ending with one wrap above the lowest branch. The wrapping shall be neatly secured with binder twine at approximately 18-in spacing and at the top and bottom.

All evergreens shall be thoroughly sprayed at the nursery prior to delivery, with an anti-desiccant spray (protective emulsion) at the rate specified by the manufacturer. All deciduous trees and shrubs in any stage of leafing out, at the time of delivery, shall receive the anti-desiccant spray. Certification of this spray application will be required by the Division. Deciduous trees and shrubs that have leafed out while in the "heeling-in" area will require the anti-desiccant spray before being transported to the planting site.

654.12-RAIN BASINS:

A shallow rain basin equal to the diameter of the planting hole shall be formed by shaping the soil around each tree or shrub and shall be maintained until final inspection and acceptance of the work.

654.13-CLEAN-UP AFTER PLANTING:

After the planting has been completed, all planting sites shall be cleaned up. Subsoil, rock, excess topsoil, and other waste material shall be removed and disposed of as directed.

All holes dug and not used, or areas disturbed in attempting to find a suitable planting site, shall be refilled by the Contractor, and the area shall be restored to its original condition and reseeded.

654.14-CARE AND REPLACEMENT OF PLANTS:

654.14.1-Care: The Contractor shall maintain the plants in a healthy, living condition during the life of the Contract, which includes any warranty period indicated in the Contract, and shall maintain an adequate supply of moisture in the root zone at all times.

The Contractor and the Engineer shall make a monthly inspection of the plantings to determine the need for maintenance and water during the first growing season, June through October. Any maintenance determined necessary shall be taken care of during the two-week period immediately following the inspection. When moisture in the root zone is deficient, watering shall be started within 48 hours with sufficient labor and equipment to completely water all the plants within a two-week period unless otherwise directed by the Engineer.

Other maintenance required during the contract period shall include:

- i. The control of weed and grass growth, by destroying the top growth as well as roots, in plant beds and individual plant saucers.
- ii. Protect plants from damage by insects and diseases.
- iii. Repair rain collars and replace any lost mulch.
- iv. Maintain stakes and guys supporting trees, and any other practices necessary to maintain the plants in a healthy, living condition.

654.14.2-Replacement of Plants: The Contractor and the Engineer will make an inspection of the plantings between September 1 and 10 following the initial planting period, to determine the number of dead, missing or defective plants, for which replacement will be required.

During this fall replacement period, September 15 through November 30, all maintenance including stake and wire tightening, mulch replacement, rain collar repair, pruning or trimming, trunk wrapping, and removal of any wire tags shall be accomplished.

The replacement plants shall be planted in the same manner as the original plants with necessary backfill and mulch added to accomplish the job. The fertilizer shall be added in the hole prior to replacing the plant. However, when a plant has been lost due to poor drainage or other adverse soil condition, the replacement shall be planted at a more acceptable location, and the old site shall be restored to its original condition.

All replanting and maintenance shall be completed by November 30 for final acceptance of the Contract by December 15.

654.15-METHOD OF MEASUREMENT:

The quantity of plants to be paid for will be the number of living trees or shrubs planted in accordance with these Specifications and accepted. Only living plants in healthy condition at the time of final inspection will be accepted.

Progress payment for the initial planting of trees and shrubs will be based on the premise that 90 percent of the work has been completed when the plants have been completely planted. The remaining 10 percent withheld will be considered for maintenance, plant replacement, and for any delayed mulching when authorized by the Engineer. Retainage, from the amount determined as above, will be in accordance with 109.6.

The final acceptance and payment for any particular plant will be made after completing proper care and replacement as described in 654.14.

Water for maintenance during the period of establishment will be measured by the gallon (liter), expressed in thousand-gallon (liter) units.

654.16-BASIS OF PAYMENT:

The number of plants, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments will constitute full compensation for furnishing and delivering plants and all incidental materials including water required during the process of planting, topsoil, mulch, fertilizer, ground agricultural limestone, and additives; for planting, staking, pruning and for performing all the work prescribed in a workmanlike and acceptable manner, including all labor, equipment, tools, and incidentals necessary to complete the work.

Maintenance work other than watering will be included in the contract unit prices bid for each plant.

The accepted quantities of water used during the period of establishment will be paid for at the contract unit price per 1,000 gallons (L), which price shall be full compensation for furnishing, delivering, applying, and performing all other work. No payment will be made for watering at the time of original planting or when planting replacements.

654.17-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
654001-*	Tree, Deciduous, "scientific name"	Each
654002-*	Tree, Ornamental Flowering, "scientific name"	Each
654003-*	Shrub, Deciduous, "scientific name"	Each
654004-*	Shrub, Evergreen, "scientific name"	Each
654005-*	Tree, Evergreen, "scientific name"	Each
654006-*	Water For Plants	Thousand Gallon (Liter)

* Sequence number

SECTION 655

MATTING FOR EROSION CONTROL

655.1-DESCRIPTION:

This work shall consist of furnishing and placing erosion control matting in accordance with these specifications and at the locations shown on the plans or designated by the Engineer.

655.2-MATERIALS:

The matting shall meet the requirements specified in 715.24. Devices used to anchor the mat shall be as recommended by the manufacturer of the matting and be of sufficient strength and size to secure the mat until it is anchored by vegetation, siltation, etc.

CONSTRUCTION METHODS

655.3-PLACING:

The area to be covered shall be prepared as a fine seedbed, fertilized and seeded before the matting is applied.

The erosion control mat shall be placed and anchored in accordance with the recommendations of the manufacturer of the matting. The mat shall be adequately watered to firmly bond the mat to the soil and aid in the germination of the seed.

655.4-MAINTENANCE AND REPAIRS:

The Contractor shall maintain the areas upon which the matting is placed until all work on the Contract has been completed and accepted.

Maintenance shall include the repair of areas damaged by erosion, wind, fire, or other causes. Repair may include reestablishing the condition and grade of the soil, replacement of the matting, and refertilizing and reseeding in accordance with the applicable portions of 652.

655.5-METHOD OF MEASUREMENT:

The quantity of work done will be measured by the square yard (meter) of matting placed. Measurements will be made on the surface of the matting exclusive of laps and material that may have been placed in slots.

655.6-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

655.7-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
655001-*	Matting	Square Yard (Meter)
655002-*	Permanent Erosion Matting, Type "type"	Square Yard (Meter)

* Sequence number

SECTION 656 SEEDLING PLANTING

656.1-DESCRIPTION:

This work shall consist of furnishing and planting seedlings of the species called for on the Plans and in the manner prescribed or as directed by the Engineer.

656.2-MATERIALS:

656.2.1-Topsoil: Topsoil shall conform to the applicable requirements of 651.

656.2.2-Water: Water shall conform to the requirements in 652.2.

656.2.3-Ground Agricultural Limestone: Ground agriculture limestone shall conform to the requirements in 715.25.

656.2.4-Fertilizer: Fertilizer for landscape plantings shall conform to the applicable requirements in 715.26.

656.2.5-Seedling Plants: Seedling plants shall conform to the requirements specified in 715.34. The seedling plants shall be true to the type and size indicated on the Plans.

CONSTRUCTION METHODS

656.3-PLANTING SEEDLING PLANTS:

The method of planting seedling plants will be determined to a great extent by the site conditions, namely soil, slope, and type of cover. On areas covered with grass or weed mass, the equivalent of about one square foot (300 square mm) area shall be cleared, including roots. The cleared material shall be placed on the lower side of the plant hole to help retain moisture runoff. A hole large enough for the plant roots shall then be dug, and the plant placed and backfilled with one pint backfill mix and completed with excavated material. The soil then shall be packed around the roots with the foot or heel.

Plant backfill mixture for seedlings shall be three parts topsoil to one part peat moss, with 100 lbs. of fertilizer adder per cubic yard (60 kg of fertilizer adder per cubic meter) of backfill. Any other additives will be shown on the Plans. In loose shale or sand without sod cover, selection of plant location shall be where the soil is stable and not subject to rapid accumulation or erosion. On steep banks a slit shall be opened large enough to receive the plant roots and the replaced soil shall be tamped with the heel.

Seedling plants shall be individually mulched and watered during the planting operations as directed by the Engineer.

The Contractor shall furnish material and mark the location of all seedling plants for future reference. A row shall be identified by a stake at each end and a bed or mass identified by stakes around the perimeter. Wire stake flags will be accepted as markers.

656.4-REPLACEMENT OF SEEDLING PLANTS:

At the discretion of the Engineer, or in the event that it is determined that the survival is not satisfactory, replacement may be required. Only such replacements as are ordered and

countered by the Engineer shall be made. All replacement planting shall be in accordance with the requirements of the Contract application to initial plantings.

656.5-CARE DURING AND AFTER DELIVERY:

There is a great tendency for bare-root plants to dry out during shipment and during the planting operation; therefore it is extremely important that the roots of all plant material shall be kept moist during shipment and during the construction period.

656.6-METHOD OF MEASUREMENT:

Measurement of seedling plants will be by the number of plants initially planted in an acceptable manner and all such replacements as are ordered and planted in accordance with this Specification.

656.7-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials, including water, topsoil, peat moss, limestone, fertilizer, and mulch, and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

All replacements ordered by the Engineer will be paid for at the contract unit price for the item listed.

656.8-PAY ITEM:

ITEM	DESCRIPTION	UNIT
656001-*	Seedling, "scientific name"	Each

* Sequence number

SECTION 657

ROADSIDE SIGN SUPPORTS

657.1-DESCRIPTION:

This work shall consist of the fabrication and erection of all supports for roadside mounted signs in accordance with the requirements of the Plans and of these Specifications. This shall include the supports for all signs which are located outside of the shoulder and do not extend over the shoulder.

All details not specified or not shown on the Plans shall conform to the details and requirements set forth in the following specifications and publications:

- i. The Manual on Uniform Traffic Control Devices for Streets and Highways, latest issue, as printed by the Federal Highway Administration, U.S. Department of Transportation. (Referred to as the MUTCD).
- ii. Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, latest issue, including revisions, American Association of State Highway and Transportation Officials.

657.2-MATERIALS:

Materials furnished by the Contractor shall be of new stock, shall be the product of reputable manufacturers of signing equipment, shall conform to the Division's Specifications, and shall meet the approval of the Engineer.

All materials shall conform to Division 700 of the Standard Specifications and specifically as follows. All referenced specifications for materials shall be understood to mean the latest available specifications and revisions at the time of award of the Contract.

657.2.1-Aluminum:

657.2.1.1-Tapered Tubular Supports: Supports shall be void of circumferential welding except at the base. Subject to the Engineer's approval, other alloys may be used in place of those called for. The Contractor shall submit, for approval of the Engineer, design calculations for the above substitutions prior to the fabrication of the supports.

Tapered tubular aluminum supports shall be fabricated from Alloy 6063-T6, ASTM B 221, or ASTM B 429. Taper of the supports shall be uniform and continuous from the base to the top of the support.

657.2.1.2-Structural Supports: Structural aluminum supports shall be of a standard wide-flange shape and of Alloy 6061-T6, conforming to ASTM B 308. Each support shall be fabricated from one piece of metal.

Posts built up by welding short pieces together will be rejected. The support shall include a base plate which shall be designed for anchoring to a concrete footing with galvanized steel bolts as shown on the Plans.

657.2.1.3-Support Bases: Bases for roadside mounted signs shall be fabricated from either plates, Alloy 6061-T6, ASTM B 209, or from castings Alloy SG70B-T61, ASTM B 108, or Alloy SG70A-T6, ASTM B 26, or ASTM B 108. Only one of the above type bases will be used on a project. The underside of the bases shall be coated with an alkali-resistant bituminous paint.

657.2.1.4-Support Caps: Castings form aluminum support caps shall be Alloy S5A, ASTM B 26, or Alloy SG70A, ASTM B 26 or ASTM B 108 and shall be held in place by stainless steel set screws. The same type cap must be used throughout a project.

657.2.2-Steel: All steel items shall be galvanized in accordance to ASTM A 123 or ASTM A 153, unless otherwise specified.

657.2.2.1-Tapered Tubular Supports: Supports shall be void of circumferential welding except at the base. Subject to the Engineer's approval, other types of steel may be used in place of those called for. The Contractor shall submit, for the approval of the Engineer, design calculations for all substitutions prior to the fabrication of the supports.

Tapered tubular supports shall be fabricated from SAE 1020 sheet. These sheets shall be formed and welded, using only one longitudinal weld, then cold processed to the final shape and to minimum yield strength of 55,000 psi. (380 MPa) Taper of the supports shall be uniform and continuous from the base to the top.

657.2.2.2-Structural Supports: Galvanized structural steel supports shall be standard wide flange shapes fabricated from steel conforming to ASTM A36 or ASTM A572 Grade 50 as specified (Breakaway Supports). These supports shall be galvanized in accordance with ASTM A123.

Each wide-flange section shall be fabricated from one piece of metal. Those supports built up by welding short pieces together will be rejected. The steel base plate shall be welded to the support and shall be designed for anchoring to a concrete footing with galvanized steel bolts or to an embedded post stub for break-away sign supports as shown on the Standard Drawings.

657.2.2.3-Pipe Posts: Pipe shall conform to the requirements of ASTM A 53, TYPE E or S, Grade B. Hydrostatic tests are not required.

The steel base plate shall be welded to the support and shall be designed for anchoring to an embedded post stub or anchor bolts as shown in the Plans.

657.2.2.4-Channel Bar Supports: Steel channel post shall comply with the requirements of ASTM A499, Grade 60 and shall be galvanized in accordance with the requirements of ASTM A123. Steel channel posts shall be supplied to the WVDOT in accordance with MP707.02.13.

657.2.2.5-Support Bases: Bases shall be fabricated from steel plate conforming to ASTM A 36 or from cast steel meeting the requirements of ASTM A 27, Grade 65-35. Only one type base shall be used throughout a project.

657.2.2.6-Friction Caps for Pipe Post: Caps shall be fabricated from a good commercial grade steel of either hot rolled or cold rolled steel sheets. Caps shall have an electrodeposited coating of zinc in accordance with the requirements of B 663, Class 12.

657.2.2.7-Support Caps: Support caps castings shall be cast steel conforming to ASTM A 27, Grade 60-30, or cast aluminum Alloy S5A, ASTM B 26, or Alloy SG70A,

ASTM B 26 or ASTM B 108. Caps shall be held in place by stainless steel set screws. Only one type cap shall be used throughout the project.

657.2.2.8-Reinforcing Steel: Reinforcing steel shall conform to the requirements of 602.

657.2.2.9-Anchor Bolts: Anchor bolts shall be of sufficient size and strength to fully develop the bending moment of the shaft. Anchor bolts (unless otherwise directed on the Plans) shall be fabricated from high strength steel, meeting the requirements specified in ASTM F 1554, Grade 55. Each bolt shall have the threaded end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Nuts shall be hot-dipped galvanized and meet the physical, chemical and dimensional requirements of ASTM A-563, Grade A.

657.2.3-Wood:

657.2.3.1-Posts: Material for wood sign posts shall conform to the requirements of 710. The posts shall meet the structural requirements of the current AASHTO Standard Specifications for Highway Bridges for the grade specified. They shall consist of select structural grade posts, seasoned and treated in accordance with these Specifications and the Standard Drawings. Prior to the preservative treatment, the posts shall be cut as indicated on the drawings. Preservatives for treatment shall conform to the requirements of 710.

657.2.4-Concrete: Concrete for sign foundations shall be Class B in accordance with 601.

657.2.5-U-Channel Breakaway Mounting Device: When specified to be used in the project plans, this device shall be used in order to enable either 2# per foot or 3# per foot flanged “U-channel” to be installed into an anchor, which shall be imbedded in an existing asphalt or concrete surface. The device shall be designed as described in Materials Section 709.51.

CONSTRUCTION METHODS

657.3-FABRICATION:

657.3.1-General: Fabrication of all parts of supports shall be in accordance with dimensions shown on the Plans and Standard Drawings. Work shall be done in a uniform workmanlike manner.

657.3.2-Shop Drawings: If supports vary from the Standard Drawings, the Contractor shall submit for the Engineer's approval complete detail drawings, eight copies, showing all structural steel, structural aluminum, aluminum castings, light fixtures and supports, sign brackets and any miscellaneous accessories.

657.3.3-Packaging: All aluminum supports shall be protected by tire wrapping during shipment and storage. The wrapping shall be adequate to prevent damage to the support. Supports delivered for use on a project shall be stored off the ground and under cover in a manner meeting the approval of the Engineer.

657.4-ERECTION:

657.4.1-General: All signs and delineators shall be supported at the points designated on the Plans or by the Engineer in accordance with these specifications and approved shop drawings and shall be erected in reasonably close conformity to the locations, elevations, and angles shown on the Plans or established by the Engineer.

The Contractor shall take full responsibility for checking all cross sections at approved sign locations to determine final support lengths.

Before starting the excavation for footings, the Contractor shall establish the location of each sign in accordance with the Plans or as directed by the Engineer, and shall mark each site with construction stakes. The Contractor shall furnish stakes, paint, other materials, and labor for performing the locating and staking as described. When the sites have been staked and are ready for inspection, the Contractor shall inform the Engineer, who will check and approve the site or make necessary changes. Centerline station information will be furnished to the Contractor by the Engineer.

Galvanized coating damaged for any reason shall be repaired by the application of a zinc-rich paint conforming to Military Specification MIL-21035 or Federal Specification TIP-461 or as directed by the Engineer.

657.4.2-Setting Posts: All sign posts shall be set vertically so that the sign will be level and at the proper angle with the roadway as shown on the Plans. Posts with bolt-down plates shall be securely bolted to the cast-in-place concrete footings. Leveling shall be accomplished by the use of two nuts and washers on each anchor bolt. One nut with washer shall be turned on each anchor bolt to its approximate position. After setting, the post top nuts and washer shall then be turned into place loosely and the post adjusted to the vertical position by adjusting both upper and lower nuts. The upper nuts shall then be snugly tightened. After leveling the posts, the space between the base plate and the concrete footing shall be filled with grout consisting of one part cement to 1-½ parts of sand, with the addition of an approved admixture to produce high strength and minimum shrinkage grout, or other nonshrink grout approved by the Engineer. Exposed edges of the grout shall be finished to present a neat appearance.

Channel posts shall be driven either by hand or by mechanical devices to the required line and grade, and they shall be plumb above the ground. During driving, posts shall be protected by a special driving cap. Any post bent or otherwise damaged so as to be unfit for use in the finished work shall be removed from the site and replaced by the Contractor at their expense.

All channel posts which are to be erected back-to-back shall be bolted together with 5/16 inch (8 mm) steel bolts for the entire length of the post at the following spacing:

- i. From the ground level to the top of the posts, shall be spaced at 18 inches (457 mm) centers.
- ii. From the ground level to the bottom of the posts, bolts shall be spaced at four inch (102 mm) centers.
- iii. All bolts shall be sufficiently tightened.

When posts are to be located in existing concrete such as dividers or islands, the concrete shall be carefully opened by drilling or other suitable methods. The post shall then be placed to the required depth of embedment and backfilled with base course material to a point approximately 2 inches (50 mm) from the top of a liquid, rubberized asphalt compound in accordance with 708.3. Alternatively, if specified to be used in the project plans on either

existing concrete or asphalt surfaces, the supports shall be installed using U-channel Breakaway Mounting Device shall be installed as specified by the device manufacturer.

Post mounted delineators shall be supported by channel bar posts of the material, design, and dimensions specified, driven in earth or inserted in concrete dividers or island. Posts shall be driven plumb in undisturbed earth to a minimum of 24 inches (600 mm) and with the top 4 feet (1.2 m) above the near pavement edge, as shown on the Standard Drawings, and faced toward approaching traffic.

Posts shall be spaced laterally 2 feet (600 mm) beyond the shoulder; in curbed sections 2 feet (600 mm) behind the face of curb; in areas protected by guardrail, in the line of guardrail posts; and in the center of dividers less than 8 feet (2.4 m) in width or as shown on the Standard Drawings.

657.4.3-Structural Excavation: The Contractor shall do all excavation for each sign installation to the levels and dimensions shown on the Plans or as directed by the Engineer to obtain a suitable foundation. Excavation may be accomplished manually or by mechanical means. The Contractor is advised that the grading specifications permit the construction of embankment of rock fill to at least 12 inches (300 mm) below the bottom of subbase.

If rock or a boulder is encountered in excavation, it shall be removed to a depth sufficient, in the opinion of the Engineer, to obtain the stability which would have been obtained had the excavation been made in earth to the depth required by the Plans.

The Contractor shall remove all excavated material from the site that is not needed to backfill and level the disturbed area and restore the site to its original condition.

The Standard Drawings are compiled on the basis of average soil conditions. When, in the opinion of the Engineer, soil conditions will permit lesser foundations or require larger foundations, the Contractor shall propose to the Engineer for written approval the necessary revisions to either post or foundations, or both. Any work in such cases shall be performed without change in the unit bid price.

If the soil tends to cave in, forms shall be used to support the sides of the excavation. The forms shall be placed in such a manner as not to disturb the adjacent soil. If the Contractor elects to remove the form, the removal shall be done immediately after the concrete is poured so that the flowing concrete may fill the space occupied by the form. Otherwise, the form shall become a permanent part of the installation. In the latter case the top portion of the form shall be removed to a minimum of 6 inches (150 mm) below the ground.

The Engineer will determine when forms are necessary. This form work shall be performed at the expense of the Contractor and no compensation will be allowed therefor.

657.4.4-Footings: Concrete footings are required for all sign supports, except for those specified to be driven. Footings for each sign will vary according to the size of the sign. The Contractor shall construct footings based on the size of the sign and in accordance with these Specifications and the Standard Drawings and Plans, unless otherwise directed by the Engineer. Both circle data as supplied by the manufacturer of the supports shall be followed by the Contractor. All concrete footings shall be flush with the uphill side of the ground line as shown on the Plans or approved drawings. The tops of foundations for embedded posts shall be flush with the ground and sloped to assure proper water drainage away from the posts. When forms for encasement above ground are used, they shall not be removed for at least 18 hours after the concrete is poured.

The concrete footing shall not be loaded by mounting sign support on the anchor bolts until the concrete has cured in accordance with 601 for a period of seven days.

All concrete pedestals shall be given an ordinary finish.

657.4.5-Backfilling: All excavations shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. Each lift shall be compacted to the satisfaction of the Engineer. Testing is not required. All surplus material shall be removed from the right-of-way and the backfill finished flush with surrounding natural ground, including replacement of any damaged facilities or appurtenances. The Contractor shall restore all areas disturbed by this excavation or other operations to their original conditions including grading, seeding, mulching and fertilizing as directed by the Engineer.

No separate payment will be made for backfilling materials.

657.4.6-Field Painting of Posts: All aluminum and steel supports shall be painted as specified below. No painting shall begin until the concrete foundations are firmly set.

657.4.6.1-Channel Posts: The 4 inches (100 mm) of a channel post above the concrete foundation shall receive sufficient coats of an asphaltic paint, conforming to the requirements of 705.7, to provide a film of paint approximately 5/8-in. (3 mm) thick. Three coats shall be lapped onto the concrete foundations to provide seal between the post and concrete. Care shall be taken to cover no more of the footing than necessary to provide a proper seal.

657.4.6.2-Aluminum: Protection of aluminum is required where aluminum members are to be attached to steel members or concrete masonry. To avoid the possibility of galvanic corrosion, aluminum members attached to steel shall be coated at the points of contact with a zinc chromate primer. The surface of non-galvanized steel members shall be coated at the points of contact with suitable paint, followed by a coat of aluminum paint. Where aluminum surfaces are to be in contact with concrete or masonry, they shall first be given a heavy coat of an alkali-resistant bituminous paint.

657.5-METHOD OF MEASUREMENT:

657.5.1-Class B Concrete Footing, Plain: The quantity of work done for Class B Concrete Footing, Plain will be measured in cubic yards (meters), complete in place and accepted, as determined by the dimensions on the Plans or Contract documents, subject to adjustment as provided for in 104.2 and 109.2.

Payment will be made at the contract unit price per cubic yard (meter) for "Class B Concrete Footing Plain". Such price will be full compensation for furnishing all labor, materials, and equipment necessary to construct all footings, including staking out footings and stakes for this purpose; excavation for footings regardless of the type of material encountered; constructing and removing forms when required; furnishing, placing, finishing, and curing the concrete; and all other incidentals necessary to complete the work.

657.5.2-Class B Concrete Footing, Reinforced, Roadside: The quantity of work done for Class B Concrete Footing, Reinforced, Roadside will be measured in cubic yards (meters),

complete in place and accepted, as determined by the dimensions on the Plans or Contract documents, subject to adjustment as provided for in 104.2 and 109.2.

Payment will be made at the concrete unit price per cubic yard (meter) for "Class B Concrete Footing, Reinforced, Roadside". Such price will be full compensation for furnishing all labor, materials, and equipment necessary to construct all footings, including staking out footings and stakes for this purpose; excavation for footings regardless of the type of material encountered; constructing and removing forms; furnishing and installing reinforcing steel, anchor bolts, washers and nuts; furnishing and installing electrical grounding and conduit sleeves when required; furnishing, placing, finishing, and curing the concrete; furnishing and placing grout as required by the Plans; and all other incidentals necessary to complete the work.

657.5.3-Wood Supports: Measurements for payment for "Wood Supports" will be based on the linear feet (meters) of wood supports for each size necessary to complete the work. The quantity to be paid for shall be the Plan quantity unless the Engineer orders changes in the lengths of posts or determines the Plan quantity is in error. In such cases the Plan quantity shall be recomputed to the nearest foot (0.25 meter).

Payment will be made at the contract unit price per linear foot (meter) of support and shall be full compensation for furnishing and erecting the supports, furnishing and installing the galvanized steel sleeve inserts in footings if required on the Plans, furnishing and installing aluminum angles, and all other materials, equipment, tools, and labor necessary to complete the work.

657.5.4-Channel Posts: Measurement for payment of "Channel Posts" will be based on the linear feet (meters) of steel channel post of each size necessary to complete the work. The length shall be the Plan quantity unless the Engineer orders changes in the lengths of posts or determines that the Plan quantity is in error. In such case the Plan quantity shall be recomputed to the nearest foot (meter).

Payment will be made at the contract unit price per linear foot (meter) for each size of post required by the Plans. For back to back installations the price per linear foot (meter) shall include all necessary hardware. Such price and payment shall be full compensation for furnishing and erecting the posts, and all labor, equipment, tools, materials, and incidentals necessary to complete the work.

657.5.5-A 36 Supports: Measurement for payment of "A 36 Supports", as specified for A 36 steel in 657.2.2.2, will be based on the number of linear feet (meters) of supports for each size necessary to complete the work. The quantity to be paid for shall include the supports and base plates. The length shall be the Plan quantity unless the Engineer orders changes in the lengths of posts or determines that the Plan quantities are in error, in which cases the Plan quantities will be recomputed. Lengths will be computed to the nearest ½ foot (150 mm) for each installation and the nearest 1 foot (300 mm) for the total length. This item does not include brackets or clamps for attaching the sign to the supports.

Payments will be made at the contract unit price per linear foot (meter) of supports for each size and shall be full compensation for furnishing and erecting all supports and materials, tools, labor, and equipment necessary to complete the work.

657.5.6-Structural Supports, Aluminum: Measurement for payment of "Structural Supports, Aluminum" for Alloy 6061-T6 as specified in 657.2.1.2 will be based on the number of linear feet (meters) of supports for each size necessary to complete the work. The quantity to be paid for shall include the supports and base plates. The length shall be the Plan quantity unless the Engineer orders changes in the lengths of posts or determines that the Plan quantities are in error, in which cases the Plan quantities will be recomputed. Lengths will be computed to the nearest ½ foot (150 mm) for each installation and the nearest 1 foot (300 mm) for the total length. This item does not include brackets or clamps for attaching the sign to the supports.

Payment will be made at the contract unit price per linear foot (meter) of support for each size and shall be full compensation for furnishing and erecting all supports and materials, tools, labor, and equipment necessary to complete the work.

657.5.7-Tubular Supports: Measurement for payment of "Tubular Supports" will be based on the number of linear feet (meters) of supports for each size necessary to complete the work. This material shall be either steel or aluminum, as required by the Plans. The quantity to be paid for shall include the supports, base plates, and pole caps. The length shall be the Plan quantity unless the Engineer orders changes in the lengths of posts or determines that the Plan quantities are in error, in which cases the Plan quantities will be recomputed. Lengths will be computed to the nearest ½ foot (150 mm) for each installation and the nearest 1 foot (300 mm) for the total length. This item does not include brackets or clamps for attaching the sign to the supports.

Payments will be made at the contract unit price per linear foot (meter) of supports for each size and shall be full compensation for furnishing and erecting all supports and materials, tools, supplies, labor, and equipment necessary to complete the work.

657.5.8-A572 Supports, Galvanized: Measurement for payment of "A572 Supports, Galvanized" as specified for A572 Grade 50 steel in 657.2.2.2 will be based on the number of linear feet (meter) of supports for each size necessary to complete the work. The quantity to be paid for shall include the supports and all special items included in the break-away support design configuration. The length shall be the Plan quantity unless the Engineer orders changes in the lengths of posts or determines that the Plan quantities are in error, in which cases the Plan quantities will be recomputed. Lengths will be computed to the nearest ½ foot (150 mm) for each installation and the nearest 1 foot (300 mm) for the total length. This item does not include brackets or clamps for attaching the sign to the supports.

Payment will be made at the contract unit price per linear foot (meter) of support for each size and shall be full compensation for furnishing and erecting all supports and materials, tools, labor, and equipment necessary to complete the work.

657.5.9-A572 Supports, Painted: Measurement for payment of "A572 Supports, Painted" as specified for A572 Grade 50 steel in 657.2.2.2 will be based on the number of linear feet (meter) of supports for each size necessary to complete the work. The quantity to be paid for shall include the supports, all special items included in the break-away support design configuration, and painting of these supports. The length shall be the Plan quantity unless the Engineer orders changes in the lengths of posts or determines that the Plan quantities are in error, in which cases the Plan quantities will be recomputed. Lengths will be computed to the

nearest ½ foot (150 mm) for each installation and the nearest 1 foot (300 mm) for the total length. This item does not include brackets or clamps for attaching the sign to the supports.

Payment will be made at the contract unit price per linear foot (meter) of support for each size and shall be full compensation for furnishing and erecting all supports and materials, tools, labor, and equipment necessary to complete the work.

657.5.10-Pipe Posts: Measurement for payment of "Pipe Posts" will be based on the actual number of pipe posts of each type necessary to complete the work. This quantity shall be the Plan quantity unless the Engineer determines the Plan quantity to be in error and changes the quantity of pipe posts per type.

Payment will be made at the contract unit price per type of pipe post and shall be full compensation for furnishing and erecting all posts and materials, tools, labor, and equipment necessary to complete the work.

657.5.11-Post Removal: Measurement for payment of "Post Removal" will be based on the actual number of posts that are designated on the Plans and are necessary to complete the work. This quantity shall be the Plan quantity unless the Engineer determines the Plan quantity to be in error and changes the quantity of posts to be removed.

Payment will be made at the contract unit price per post. This price shall also be full compensation for the removal and disposal of the signs and sign assemblies, including hardware and bracing, the removal and disposal of the post supports and the restoration of the ground surface to its original condition.

657.5.12-U-Channel Breakaway Mounting Device: Any U-channel Breakaway Mounting Devices specified to be installed in the project plans shall be paid incidental to either Bid Item 657008-001 2.00 Lb Channel Post, or Bid Item 657010-001 3.00 Lb Channel Post, as applicable. This shall include all labor, materials, equipment, or other incidental expenses associated with the installation of the devices.

657.6-BASIS OF PAYMENT:

The quantities, determined as provided, will be paid for at the contract unit price for the items listed below, which prices and payment shall be full compensation for furnishing all the material and doing all the work prescribed in a workmanlike and acceptable manner, including all tools, equipment, supplies and incidentals necessary to complete the work. All incidental work and materials for which no basis of payment is provided will be considered as completely covered by the prices bid for the items included in the Contract.

657.7-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
657001-*	“size” A36 Support, **	Linear Foot (Meter)
657002-*	Structural Support, Aluminum, **	Linear Foot (Meter)
657003-*	Tubular Support, Steel, **	Linear Foot (Meter)
657004-*	Tubular Support, Aluminum, **	Linear Foot (Meter)
657005-*	Wood Support, **	Linear Foot (Meter)
657006-*	“size” , A572 Support, Galvanized, **	Linear Foot (Meter)
657007-*	“size” A572 Support, Painted, **	Linear Foot (Meter)
657008-*	2.00 Lb Channel Post	Linear Foot (Meter)
657010-*	3.00 Lb Channel Post	Linear Foot (Meter)
657012-*	4.00 Pound Back to Back Channel Post	Linear Foot (Meter)
657014-*	6.00 Pound Back to Back Channel Post	Linear Foot (Meter)
657016-*	Class B Concrete Footing, Plain	Cubic Yard (Meter)
657017-*	Class B Concrete Footing, Reinforced, Roadside	Cubic Yard (Meter)
657018-*	Post Removal	Each
657019-*	Pipe Post, **	Each
657021-*	Breaksafe Couplings For A572 Support	Each
657022-*	Breaksafe Couplings For Channel Post	Each

* Sequence number

** Key number

SECTION 658 OVERHEAD SIGN STRUCTURES

658.1-DESCRIPTION:

This item shall consist of the fabrication and erection of overhead bridge, cantilever, and butterfly sign supports and fastening accessories in accordance with the requirements of the Plans and of these Specifications. All details not specified or not shown on the Plans shall conform to the details and requirements set forth in the following Specifications and publications:

The Manual on Uniform Traffic Control Devices for Streets and Highways, latest issue, including revisions, as printed by the Federal Highway Administration, U.S. Department of Transportation. (Referred to as the MUTCD).

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, latest issue, including revisions, American Association of State Highway and Transportation Officials.

658.2-MATERIALS:

Materials furnished by the Contractor shall be of new stock conforming to the requirements of the Standard Specifications, and shall meet with the approval of the Engineer.

All materials shall conform to the requirements of Division 700 of the Standard Specifications and shall also conform to the following requirements unless otherwise modified on the Plans. All referenced specifications for materials shall be the latest available specifications and revisions at the time of award of the contract.

658.2.1-Aluminum: Tubular aluminum supports of a uniform diameter shall be fabricated from Alloy 6061-T6 or Alloy 6063-T6, ASTM B221, B429, or B 241 for extruded sections or ASTM B 209 for sheet sections.

Structural shapes and bars shall be Alloy 6061-T6, ASTM B 221, or B 308. Plates shall be Alloy 6061-T6, ASTM B209.

Castings for support top caps and horizontal member end caps shall be ASTM B 26 Alloy 356-F or Alloy 43, and shall be held in place by stainless steel set screws. The same type cap must be used throughout a project.

Aluminum hardware shall meet the requirements of 658.2.1.3. Steel nuts, bolts and washers used on aluminum structures shall be stainless. Welding wire shall be in accordance with 658.4.

658.2.2-Steel:

658.2.2.1-Galvanized Steel: All steel items shall be galvanized in accordance with ASTM A 123 or ASTM A 153, unless otherwise specified.

Vertical poles, transverse horizontal beams and horizontal arms shall be tapered tubular sections or tubular sections of uniform diameter and shall have a minimum yield strength of 55,000 psi (380 MPa) after fabrication. All tubular sections shall have only one longitudinal weld. Any taper shall be uniform and continuous. Other tubular structural members shall be uniform in diameter and shall be fabricated from seamless or welded pipe conforming to ASTM A 501 or ASTM A 53, Type E or S, Grade B (hydrostatic tests are waived).

Tubular sections of a uniform diameter shall be fabricated from seamless and welded pipe conforming to ASTM A 501 or ASTM A 53, Type E or S, Grade B (hydrostatic tests not required).

Steel for other structural members, plates and structural shapes shall conform to ASTM A 36, except plates over 1 inch (25 mm) thick shall conform to ASTM A 572, Grade 42.

Support top and horizontal end cap castings shall be ASTM B 26 Alloy S5A or Alloy 356-F. Caps will be held in place by stainless steel set screws. The same type cap shall be used throughout the project.

Stainless steel bolts, nuts and washers for splicing flanges shall be AISI 300 series, commercial grade and passivated. High strength bolts and nuts for splicing flanges shall conform to ASTM A 325 or ASTM A 193-B7.

Reinforcing materials shall be in conformance with 709.1 to 709.4, inclusive, except that welded wire fabric may be furnished in rolls.

Anchor bolts shall be of sufficient size and strength to fully develop the bending moment of the shaft. Anchor bolts (unless otherwise directed on the Plans) shall be fabricated from high strength steel, meeting ASTM F 1554, GRADE 105. Each bolt shall have the threaded end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Each bolt shall be provided with two heavy hex nuts and two heavy washers. Both nuts and washers shall be hot-dipped galvanized in accordance with ASTM A 153 and the nuts shall meet the physical, chemical and dimensional requirements of ASTM A 563, Grade DH or ASTM A 194-2H.

Detailed properties, dimensions, bolt circles and appropriate backup calculations for any proposed alternate design anchor bolts shall be submitted to and approved by the Division before fabrication.

658.2.2.2-Weathering Steel: All components of the overhead sign supports including miscellaneous fixtures, shall be fabricated from plates, bars, standard W, M, and S shapes produced from steel conforming to AASHTO M270, Grade 50W T-2, and tubes produced from steel conforming to ASTM A 618, Grade 1 with AASHTO M270 supplementary section S83, zone 2 toughness requirements.

Expanded metal screen shall be fabricated from steel sheets conforming to ASTM A 606, Type 4, with special alloys to provide weathering properties equivalent to ASTM A 588 or ASTM A 618 steel. Framing plates for expanded metal screen shall be fabricated from steel conforming to ASTM A 588 or ASTM A 242.

Bolts, nuts and washers for field splices and connections shall conform to ASTM A 325, Type 3. When allowed by the Engineer, they shall conform to ASTM A 325, Type 1 or 2, with hot-dipped galvanizing in accordance with ASTM A 153. Etching and painting shall be performed to match 595 standard color 20062.

The truss of post connections for box truss overhead supports shall be cast steel conforming to ASTM A 486, Class 90. Pins shall conform to ASTM A 108, Grade 1118. Pin holes in the casting shall be reamed to true size.

Reinforcing materials shall be in conformance with 709.1 to 709.4, inclusive, except that welded wire fabric may be furnished in rolls.

Anchor bolts shall be of sufficient size and strength to fully develop the bending moment of the shaft. Anchor bolts shall be fabricated from high strength steel having a minimum yield strength of ASTM A1554, Gr. 105 Each bolt shall be provided with two

heavy hex nuts. Both nuts shall be hot-dipped galvanized and, as a minimum, meet the physical, chemical and dimensional requirements of ASTM A 307. Washers shall be of standard commercial grade steel having the dimensions shown on the Detail Drawings and be hot-dipped galvanized in accordance with ASTM A 153.

Filler metal for welds shall conform to the requirements of 615.5.7.

658.2.3-Concrete: Concrete for sign foundations shall be Class B in accordance with 601.

658.2.4-Reinforcing Steel Bars: Reinforcing steel bars shall conform to the applicable requirements of 602.

CONSTRUCTION METHODS

658.3-FABRICATION:

658.3.1-General: Before fabrication of any sign structure, the Contractor shall submit for the Engineer's approval complete detail drawings, eight copies, of each structure. This shall include drawings of all structural steel or aluminum framing and bracing, aluminum or steel castings, lighting fixtures and supporting brackets, sign brackets and any miscellaneous accessories for the above. It is expressly understood that the review by the Engineer of these drawings relates to the requirements for strength and general details, and will not relieve the Contractor from responsibility for errors in detail, dimension, or quantity of materials, etc.

Overhead sign supports shall be fabricated in accordance with the Plans and this Specification. Any alternate design or significant departure from the Plans proposed by the Contractor must be presented in written or plan form for approval. The Division will approve or disapprove alternate proposals in writing. All materials in any alternate proposal which is a significant departure from the Specifications shall conform to the requirements of current AASHTO and ASTM Specifications. The Division will not approve substitution of material or design detail changes which constitute a reduction in quality, workmanship or strength of the structures.

Ends of sections shall be cut true and smooth, free from burrs and ragged breaks. Open ends of tubular sections shall be capped as shown on the Plans. Drain holes and handholes shall be provided wherever shown or necessary.

Sign supports, either aluminum or steel, shall be void of circumferential welding except at the base, flanges, or intersection of diagonals.

The welding of steel shall be in accordance with the requirements of American Welding Society D1.1 and shall be done by qualified welders. Aluminum Alloy Welding shall be accomplished in accordance with 658.4.

The loading, transporting, unloading, and piling of structural materials shall be conducted so that the metal will be kept clean and free from injury in handling. Structural materials shall be stored above the ground upon platforms, skids, blocks, or other supports. They shall be kept free from accumulation of dirt, oil, acids, or other foreign matter. Any structural material which has been deformed shall be straightened by approval methods before being laid out, punched, drilled, or otherwise worked upon in the shop. Sharp kinks or bends will be cause for rejection.

Where required or indicated on the Plans, a sufficient number of reinforced handholes and electrical wire inlets and outlet fittings shall be built into the structures. Where a cable passes through a hole or runs along a surface at any point through or on the complete assembly, such

holes and surfaces shall be deburred and void of any sharp edges through or along the surface. A "J" hook shall be provided on the inside of the top of the vertical support on which the electrical wiring shall be placed as shown on the Detail Drawings.

658.3.2-Structures Utilizing Galvanized Steel: The flanges at the center of the cross beam and at the ends of the horizontal arms shall be fastened to the tapered or straight sections by means of two circumferential welds. One of the circumferential welds shall firmly weld the outside of the flange to the tube. Any alternate flange connection offered shall be designed to develop fully the strength of the tubular sections being jointed together by means of the flange connection.

It is essential that all exposed surfaces of the completed steel structure be finished with a galvanized coating. The frame shall be fabricated into sections as large as can be handled in pickling and galvanizing tanks and then dipped as complete units, ready for field bolted connections wherever possible. Field welding and the need for repairing zinc coatings damaged by assembly shall be kept to an absolute minimum.

Galvanized coatings damaged for any reason shall be repaired by the application of a zinc rich paint conforming to the requirements of 711.21.

The places to be painted shall be thoroughly cleaned before the paint is applied.

658.3.3-Structures Utilizing Weathering Steel: Overhead sign structures of weathering steel are to have a natural weathering finish and shall be kept clear of all paint, grease, or other agents which will tend to cause an uneven finish on the posts. Any identification marks shall be painted on the bottom of the base plates, inside faces of loose column components and the top surface of horizontal members. All structures shall be delivered to the job site at least three months prior to completion of the work and stored in a manner that will allow them to obtain initial natural weathering. If they are stacked on the job site during this period, they shall be rotated at least once each two months. All members shall be shop cleaned in accordance with 615.6.4, utilizing commercial blast cleaning throughout. No corrosion inhibitors shall be used in the processes.

All welding shall conform to the requirements of AWS D1.1.

658.4-WELDING OF ALUMINUM ALLOYS:

These specifications apply to the welding of aluminum alloys used in sign structures, bridge rails, lamp posts, etc.

The welding terms used in these specifications shall be interpreted in accordance with the definitions given in the latest edition of AWS Definitions--Welding and Cutting (AWS A3.0) of the American Welding Society.

The welding symbols used on plans shall be those shown in the latest edition of Standard Welding Symbols (AWS A2.0) of the American Welding Society. Special conditions shall be fully explained by added notes or details.

658.4.1-Base Metals: The aluminum alloys to be welded under these specifications may be any of the following alloy designations (ASTM designations):

- i. Wrought non-heat-treatable alloys
 - Alloy 3003
 - Alloy 3004
 - Alloy 5052
 - Alloy 5083
 - Alloy 5086
 - Alloy 5456
- ii. Wrought heat-treatable alloys
 - Alloy 6061
 - Alloy 6063
- iii. Cast heat-treatable alloys
 - Alloy 356.1
 - Alloy A356.2

658.4.1.1-Materials used for permanent backing shall be at least equivalent in weldability to the base metal being welded.

658.4.2-Welding Processes: These Specifications include provisions for welding by the gas metal-arc process and the gas tungsten-arc process. Other processes shall not be used except as permitted by the Engineer.

658.4.3-Filler Metal: Bare wire electrodes for use with gasmetal-arc process and welding rods for use with the gas tungsten-arc process shall conform to the requirements of the latest edition of Specifications for aluminum and aluminum alloy rods and bare electrodes AWS A5.10.

Tungsten electrodes for the gas tungsten-arc process shall conform to the requirements of the latest edition of Specifications for Tungsten-Arc-Welding Electrodes, AWS A5.12.

Filler metals to be used with particular base metals shall be as shown in Table 658.4.3. Other filler metals may be used as approved by the Engineer.

TABLE 658.4.3

Base Metal	Filler Material
3003 to 3003	ER1100
3004 to 3004	ER4043
5052 to 5052	ER5356*
5083 to 5083	ER5183
5086 to 5086	ER5356*
5456 to 5456	ER5556
5670B to 6061	ER4043*
5670B to 6063	ER4043*
356.1 to 6061	ER4043
A356.2 to 6063	ER4043
6061 to 6063	ER4043 or ER5356
6061 to 6061	ER4043 or ER 5356
6063 to 6063	ER 4043 or ER5356

* ER5183, ER5356, and ER 5556 may be used interchangeably for these base metals.

Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures. Original rod or wire containers shall not be opened until time to be used. Rod and wire shall be free of moisture, lubricant, or other contaminants. Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid contamination by dirt and grease collecting on the wire. If a spool of wire is to be unused for more than a short length of time, it shall be returned to the carton and the carton tightly resealed.

658.4.4-Shielding Gases: Shielding gases shall be welding grade or better.

Shielding gas for gas metal-arc welding shall be argon, helium, or a mixture of the two (approximately 75 percent helium and 25 percent argon).

Shielding gas for gas tungsten-arc welding done with alternating current shall be argon.

Shielding gas for gas tungsten-arc welding done with direct current, straight-polarity, shall be helium.

Hose used for shielding gases shall be made of synthetic rubber or plastic. Natural rubber hose shall not be used. Hose which has been previously used for acetylene or other gases shall not be used.

658.4.5-Preparation of Materials: Joint details shall be in accordance with design requirements and detail drawings. The locations of joints shall not be changed without the approval of the Engineer.

Edge preparation shall be by sawing, machining, clipping, or shearing. Gas tungsten-arc or gas metal-arc cutting may also be used. Cut surfaces shall meet the American Standards Association surface roughness rating value of 1,000. Oxygen cutting shall not be used.

Surfaces and edges to be welded shall be free from fins, tears, and other defects which would adversely affect the quality of the weld.

Dirt, grease, forming or machining lubricants or any organic materials shall be removed from the areas to be welded by cleaning with a suitable solvent or by vapor degreasing.

On all edges and surfaces to be welded, the oxide shall be removed just prior to welding by wire brushing or by other mechanical methods such as rubbing with steelwool or abrasive cloth, scraping, filing, rotary planing, or sanding. If wire brushing is used, the brushes shall be made of stainless steel. Hand or power driven wire brushes which have been used on other materials shall not be used on aluminum.

Where mechanical methods of oxide removal are found to be inadequate, a standard chemical method shall be used. Welding shall be done within 24 hours after chemical treatment.

When gas tungsten-arc welding with direct current, straight polarity is being used, all edges and surfaces to be welded shall have the oxide removed by a standard chemical method.

Welding shall not be done on anodically treated aluminum, unless the condition is removed from the joint area to be welded.

658.4.6-Welding Procedure: All butt welds requiring 100 percent penetration, except those produced with the aid of backing, shall have the root of the initial weld chipped or machined out to sound metal before welding is started from the second side. Butt welds made with the use of backing shall have weld metal thoroughly fused with the backing. Where accessible, backing for welds that are subject to computed stress or which are exposed to view on the completed structure and which are not otherwise parts of the structure, shall be removed

and the joints ground or machined smooth. In tubular members, butt welds subjected to computed stresses shall be made with the aid of permanent backing rings or strips.

The procedure used for production welding of any particular joint shall be the same as used in the procedure qualification for that joint.

All welding operations, either shop or field, shall be protected from air currents or drafts so as to prevent any loss of gas shielding during welding. Adequate gas shielding shall be provided to protect the molten metal during solidification.

The work shall be positioned for flat position welding whenever practicable.

In both shop and field, all weld joints shall be dry at the time of welding.

The size of the electrode, voltage and amperage, welding speed, gas or gas mixture, and gas flow rate shall be suitable for the thickness of material, design of joint, welding position and other circumstances attending the work.

Gas metal-arc welding shall be done with direct current, reverse polarity.

Gas tungsten-arc welding shall be done with alternating current or with direct current straight polarity.

When the joint to be welded requires specific root penetration, the Contractor shall make a sample joint and a macroetched cross section of the weld to demonstrate that the joint welding procedure to be used will attain the required root penetration. The sample joint shall have a length of at least 1 foot (300 mm) and shall be welded with the electrode, polarity, amperage, voltage, speed, gas mixture and gas flow rate that are proposed to be used in production welding. The Engineer, at their discretion, may accept evidence on record in lieu of the preceding test.

Where preheat is needed, the temperature of preheat shall not exceed 350° F (175 ° C) for heat-treated alloys or 600° F (315° C) for non-heat-treated alloys. The temperature shall be measured by temperature indicating crayons or by pyrometric equipment. Heat treated alloys shall not be held at the maximum preheat temperature or at temperatures near the maximum for more than 30 minutes.

658.4.7-Weld Quality: Regardless of the method of inspection, the acceptance or rejection of welds shall be determined by the following conditions:

- i Cracks in welds or adjacent base metal will not be acceptable.
- ii Copper inclusions will not be acceptable.
- iii Porosity in excess of that permitted by Appendix IV, Section of the ASME Boiler and Pressure Vessel Code will not be acceptable.
- iv Lack of fusion, incomplete penetration, or tungsten or oxide inclusions will be acceptable only if small and well dispersed.

Undercut shall not be more than 0.01 inch (250 µm) deep when its direction is transverse to the primary stress in the part that is undercut.

Undercut shall not be more than 1/32 inch (800 µm) deep when its direction is parallel to the primary stress in the part that is undercut.

No overlap shall be allowed.

All craters shall be filled to the full cross section of the welds.

Welds having defects greater than the levels of acceptance specified above shall be considered as rejected unless corrected in accordance with 658.4.9.

658.4.8-Inspection: To determine compliance with 658.4.7, all welds shall be visually inspected and, in addition, all welds subjected to computed stress shall be inspected by the dye penetrant method except as specified in 658.4.8.3.

658.4.8.1-For highway sign structures, the dye penetrant method shall be used on butt welds in columns and main chord members, and on fillet welds connecting columns to bases and main chord members, including the associated flanges, gussets, or main load carrying brackets or members; also, on fillet welds connecting flanges to the main truss chord members.

658.4.8.2-The dye penetrant tests shall be performed in accordance with the requirements of ASTM E 165, Method B, Procedures B-2 or B-3.

658.4.8.3-Dye penetrant inspection may be omitted provided that the inspector examines each layer of weld metal with a magnifier of 3X minimum before the next successive layer is deposited.

658.4.9-Corrections: In lieu of rejection of an entire piece or member containing welding which is unacceptable, the corrective measures listed below may be permitted by the Engineer, whose approval shall be obtained prior to making each repair.

658.4.9.1-Defective welds shall be corrected by removing and replacing the entire weld, or as follows:

- i. Cracks in welds or base metal: Determine full extent of crack by dye penetrant method or other positive means. Remove crack throughout its length and depth, and reweld.
- ii. Excessive porosity, lack of fusion: Remove defective portions and reweld.
- iii. Copper or tungsten inclusions: remove defective portions and reweld.
- iv. Excessive concavity of crater, undercut, undersize weld: Clean and deposit additional weld metal.
- v. Overlap: Reduce by removal of excess weld metal.

658.4.9.2-The defective areas shall be removed by chipping or machining. Oxygen cutting shall not be used. Before rewelding, the joint shall be inspected to assure that all the defective weld has been removed. If dye penetrant has been used to inspect the weld, all traces of penetrant solutions shall be removed with solvent, water, heat, or other suitable means before rewelding.

658.4.10-Qualification of Procedures, Welders and Welding Operators: Joint welding procedures which are to be employed in executing contract work under these specifications shall be previously qualified by tests prescribed in Part B, Section IX, of the ASME Boiler and Pressure Vessel Code. The qualifications shall be at the expense of the Contractor. The Engineer, at their discretion, may accept evidence of previous qualification of the joint welding procedures to be employed.

All welders and welding operators to be employed under these specifications shall be previously qualified by tests as prescribed in Part B, Section IX, of the ASME Boiler and

Pressure Vessel Code. The Engineer, at their discretion, may accept evidence of previous qualification of the welders and welding operators to be employed. The same process and type of equipment that is required for execution of the construction work shall be used in qualifying welders and welding operators.

658.5-ERECTION:

Erections of sign structures shall be in accordance with the applicable provisions of the current edition of the Standard Specifications and the requirements given below. The Contractor shall provide all tools, equipment and appliances necessary for the expeditious handling of the work, all of which shall be subject to the approval of the Engineer. Materials and workmanship not previously inspected will be inspected on the site of the work and all rejected material shall be removed from the site of the work.

In order to reduce the hazards of performing work over roadways and to provide sign loads to sign bridges immediately, the sections of a horizontal strut of any bridge shall be spliced together for the full length of one span and all sign panels, lighting and other accessories required thereon, as described elsewhere in these Specifications, shall be fully installed before erecting the complete assembly between the previously erected columns or as directed by the Engineer. The fully assembled structure shall be handled and erected in such a manner as not to damage any of the installations thereon.

Overhead sign supports shall provide a vertical clearance, between the bottom edge of the sign or luminaire support for the full width of the pavement and shoulders of not less than 17 feet (5.2 m).

The Contractor shall take full responsibility for checking all cross sections at approved sign locations to determine final sign structure dimensions.

Where cylindrical concrete footings are used, the concrete shall be placed against undisturbed earth. Earth augers, if used shall be of the same diameter as the footings. Where a trench is required, it shall be only as wide and long as is necessary to accommodate the work. The excavation shall be made in accordance with the applicable provisions of the Standard Specifications. All excavations shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. Each lift shall be compacted to the satisfaction of the Engineer. Testing is not required. All surplus material shall be removed from the right-of-way and the backfill finished flush with surrounding natural ground, including replacement of any damaged facilities or appurtenances. The Contractor shall restore all areas disturbed by this excavation or other operations to their original conditions including grading, seeding, mulching and fertilizing as directed by the Engineer.

If rock or boulders are encountered during the excavation, they shall be removed to a depth sufficient, in the opinion of the Engineer, to obtain the stability necessary to support the complete sign structure.

The footings shall be of Class B concrete, reinforced, of the types shown on the Plans. Steel reinforcement, anchor bolts and conduit for the footings shall be as shown on the Plans.

All overhead sign structures shall have ground rods, irregardless of whether they have sign lighting or other electrical components. Ground rods shall be copperclad steel, $\frac{3}{4}$ inches (19 mm) in diameter with a minimum length as noted on the Plans and shall be one piece. Sectional or segmented ground rods are not permitted. The ground rods shall be complete with ground clamp and square head bolt.

The anchor bolts shall be set accurately, by means of a template in the position shown on the drawings and held rigidly in the forms so as to avoid displacement during the pouring of concrete. The steel reinforcement and conduit shall have been properly placed and secured before the pouring of concrete. The Contractor shall make periodic checks of the bolt positions and elevations during concreting operations. It is essential that the distance between the centers of anchor bolt groups of the two or three foundations of a frame be exactly the span lengths shown on the Plans.

Two inch (50 mm) diameter galvanized conduit shall be furnished and installed in the post foundations at locations as specified on the Plans. The conduit shall terminate above the top of the foundation and shall be fitted with a 2 inches (50 mm) capped grounding bushing above the foundation. The lower end of the conduit shall emerge from the side of the footing to be joined to conduit from the junction box.

The entire structure shall be erected and adjusted for plumbness, grades and alignment by the manipulation of the leveling nuts on the anchor bolts.

Electrical materials and other installations need not be in place on the columns at the time of column erection.

Brackets for attaching signs shall be spaced as shown on the Standard Drawings or the Plans. There shall be a minimum of two brackets per sign.

The field assembling of the component parts of a structure shall be done in a manner not likely to produce damage by twisting, bending, or otherwise deforming the metal. Any member slightly bent or twisted shall have all defects corrected in an approved manner before being placed. Members seriously damaged will be rejected. All exposed surfaces shall be free of blemishes and scratches. Painting will not be allowed. Just prior to erection, the aluminum shall be thoroughly cleaned and any accumulations of oil, grease, dirt or foreign materials shall be removed by the use of an approved solvent cleaner.

Protection of aluminum is required where aluminum members are to be attached to concrete masonry or steel which is neither galvanized nor stainless. To avoid the possibility of corrosion, aluminum members attached to such bare steel shall be coated at the points of contact with a zinc chromate primer or as called for on the Plans. The surfaces of steel members, nongalvanized, shall likewise be coated at the points of contact with a suitable priming paint and this shall be followed by a coat of aluminum paint. Where aluminum surfaces are to be in contact with concrete or masonry, they shall first be given a heavy coat of an alkali-resistant bituminous paint.

658.5.1-Erection of Columns or Cantilever Uprights:

- I. Place leveling nuts, then washers on anchor bolts at level position.
- II. Insure anchor bolts and the bolt holes in base plate are properly aligned.
 - a. No cold working of bolts will be allowed.
 - b. No cutting or reaming of holes will be allowed without prior approval from the Traffic Engineering Division.
- III. Place column or cantilever upright onto the anchor bolts.
- IV. Hold column or cantilever upright at true plumb.
 - a. Adjust leveling nuts as necessary (column may not always be exactly perpendicular to base plate due to welding distortion, etc.).

- V. All bolts will be coated with either of the following waxes; Jon Cote 639 or MacDermid Torque 'N Tension Control Fluid. The top anchor bolt nuts must be installed the same day that the wax is applied to the anchor bolts.
- VI. Place washers, then the top anchor bolt nuts on the anchor bolts.
- VII. Snug the anchor bolt nuts alternating corner-to-corner and side-to-side. Snug tight is defined as the tightness which exists due to the full effort of a man using a spud wrench with the appropriate length handle for the bolt being tightened. The following chart indicates the size of the wrench to be used when snugging bolts:

<u>BOLT DIAMETER</u>	<u>HANDLE LENGTH OF WRENCH</u>
3/4 in (19.05 mm)	23" (575 mm)
7/8 in (22.23 mm)	23" (575 mm)
1 in (25.40 mm)	23" (575 mm)
1-1/4 in (31.75 mm)	23" (575 mm)
1-1/2 in (38.10 mm)	36" (900 mm)
1-3/4 in (44.45 mm)	36" (900 mm)
2 in (50.80 mm)	36" (900 mm)
2-1/4 in (57.15 mm)	36" (900 mm)

- VIII. Apply 1/3 turn to each nut in the same sequence as snugging. Mark top anchor bolt nuts, anchor bolts, and base plate for reference to insure proper rotation is achieved. A hydraulic torque wrench meeting the minimum requirements specified must be used to properly tension the anchor bolt nuts. Breaker bars, cheater bars, air wrenches, or other mechanical devices will not be allowed as they cannot achieve the proper tension.
- IX. Release any load by crane or other erection device. The anchor bolt nuts must be properly tightened before removal of the crane.
- X. Check structure. If problems exist such as the anchor connections are loose, then repeat the nut tightening procedure.

658.5.2-Connection of Spans:

- I. Lift span, with signs, lighting and other accessories attached, to columns and insure bolts and bolt holes properly aligned.
- II. Insure connecting plates fit with no burrs or other seating inhibitors.
- III. Install bolts, nuts, and washers to snug tight, corner-to-corner and side-to-side. Use the above chart to determine a proper size wrench for snugging bolts. All bolts will be properly waxed before the nuts are installed.
- IV. Apply appropriate rotation to turning element in the same sequence as snugging and for high strength bolts in accordance with Table 615.3.214B of the Standard Specifications.
- V. Check structure. If problems exist, such as loose arm connections or showing gaps, the load must be removed from the area in question and steps repeated as necessary.

658.5.3-Hydraulic Torque Wrench Specifications: Anchor bolt nuts may only be tightened by a hydraulic wrench with a Minimum Capacity of 5300 feet lbs. (7,180 Newton Meter), and must be capable of tightening or loosening.

658.5.4-Verification of Contractor's Equipment and Personnel: The Contractor will contact the Materials Control, Soils and Testing (MCS&T) Section ten working days prior to erection of the first sign structure. MCS&T personnel will meet with the inspector and contractor to verify installation procedures.

658.6-METHOD OF MEASUREMENT:

658.6.1-Class B Concrete Footing, Reinforced, Overhead: The quantity of work done for Class B Concrete Footings, Reinforced, Overhead will be measured in cubic yards (meters), complete in place and accepted, as determined by the dimensions on the Plans or Contract documents, subject to adjustment as provided for in 104.2 and 109.2.

658.6.2-Overhead Sign Structures: Measurement for payment for overhead sign structures will be based on each unit complete in place, which will include the various elements of the structure consisting of vertical end support units, horizontal units, vertical sign brackets, structural framing for signing if required, sign lighting support hardware if required (horizontal brackets, pads, bolts, nuts, plates, etc.) and any other accessories or hardware as required to make a complete installation as called for on the Plans or as directed by the Engineer.

658.7-BASIS OF PAYMENT:

The quantities, determined as provided above, shall be paid for at the contract unit price for the items listed below, which prices and payment shall be full compensation for furnishing all the materials and doing all work prescribed in a workmanlike and acceptable manner, including staking out footings and stakes therefore; excavating for footings regardless of the type of material encountered; constructing and removing forms; furnishing and installing reinforcing steel, anchor bolts, washers and nuts; furnishing and installing electrical grounding and conduit sleeves; furnishing, placing, finishing and curing the concrete; furnishing and placing grout as required by the Plans; fabrication, delivery and erection of each overhead sign; and including all tools, equipment, supplies and incidentals necessary to complete the work. All incidental work and materials for which no basis of payment is provided will be considered as completely covered by the prices bid for the items included in the contract.

658.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
658001-*	Class B Concrete Footings, Reinforced, Overhead	Cubic Yard (Meter)
658002-*	Overhead Sign, Steel-Aluminum Combination	Each
658003-*	Overhead Sign, Galvanized Steel	Each
658004-*	Overhead Sign, Weathering Steel	Each

* Sequence number

SECTION 659 SIGN LIGHTING

659.1-DESCRIPTION:

Sign lighting shall consist of furnishing and installing or modifying sign illumination systems, including all necessary accessories, in accordance with the Plans and the following Specifications or as directed by the Engineer.

All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), the Underwriters' Laboratories, Inc. (UL), or the Electronic Industries Association (EIA), whichever is applicable. In addition to the requirements of the Plans and these Specifications, all materials and workmanship shall conform to the requirements of the National Electrical Code (NEC), referred to as the Code; the American Society for Testing Materials (ASTM); the American National Standards Association (ANSI); The American Wire Gauge (AWG), and any local ordinances which may apply.

Wherever reference is made in these Specifications to the Code or to the standards mentioned above, the references shall mean the code or standard, including revisions, that is in effect at the time of the award of the contract.

659.2-MATERIALS:

The materials furnished and used shall be new, except as may be specifically provided on the Plans. The materials shall be manufactured, handled, and used in a workmanlike manner to insure a completed installation in accordance with the Plans and Specifications.

All electrical materials shall conform to the special requirements and to the Standardization Rules of the Institute of Electrical and Electronic Engineers, IPCEA and, when governing, shall also conform to the National Electrical Code, local and special laws or ordinances, and the Underwriter's Laboratories.

659.2.1-Equipment Lists and Drawings: The Contractor shall submit to the Engineer for approval detailed drawings in duplicate of switch box and luminaire equipment and of any proposed deviations from the Plans. Following checking, correction, and approval, not less than eight complete sets shall be submitted to the Engineer. The Division will not be liable for any material purchased, labor performed, or delay to the work prior to such approval.

If ordered by the Engineer, the Contractor shall submit for approval sample articles of the materials proposed for use. Parts list, service instructions, and all apparatus warranties packaged with or accompanying the electrical equipment to be installed on the project shall be delivered to the Engineer.

659.2.2-Conduit: All conductors shall be run in conduit, except for overhead or temporary installations and where conductors are run inside poles. Conduit to be installed underground, on the surface of poles, or in structures, except as shown on the Plans, shall be Type R, Type F, or Type P as follows:

- i. Type R (Rigid Steel Conduit) shall meet the requirements of Section 715.42.10.1.
- ii. Type F (Flexible, Liquid-Tight Conduit) shall meet the requirements of Section 715.42.10.2.
- iii. Type P (Polyvinyl Chloride Conduit) shall meet the requirements of Section 715.42.10.3.

Standard and expansion couplings and other fittings for the Type P conduit shall all be of the same materials as the conduit.

Other fittings for metal conduit shall be threaded malleable iron conforming to the requirements of ASTM A 338 and shall be galvanized in accordance with the requirements of ASTM A 153.

The size of conduit used shall be as shown on the Plans or as specified. If size is not shown on the Plans, the National Electrical Code shall govern as to the necessary conduit size.

659.2.3-Pull or Junction Boxes: Pull or junction boxes for structure installation shall be as shown on Plans or Type L. Boxes for ground (including sidewalk) installation shall be Type H (10x10). Type L shall meet the requirements of 715.42.11.1. Type H (10x10) shall meet the requirements of Section 715.42.11.2.

659.2.4-Cable: All wire and cable for sign lighting branch circuits shall conform to the requirements of the current edition of the National Electrical Code and shall meet all relevant ASTM Specifications. Conductors shall be coated softdrawn copper, unless otherwise noted on the Plans or in these Specifications. Insulation shall be Type THWN. Cable shall be UL approved. Conductor sizes shall be standard American Wire Gauge sizes and shall be as noted on the Plans. All conductors shall be stranded. Stranded wire shall have a minimum of 19 strands.

Wire and cable for sign lighting projects included with roadway lighting projects shall be the same type as specified for the roadway lighting project. All wire and cable shall have the size, voltage rating, and type of insulation and manufacturer's name permanently marked on the outer covering at regular intervals. The Manufacturer shall furnish to the Engineer and the Contractor all splicing or terminating information necessary for proper installation of the cable.

Color coding for sign lighting cables shall be permanent solid color as follows:

Single Phase		Three Phase	
Leg A	Black	Phase A	Black
Leg B	Red	Phase B	Red
Neutral	White or Natural Gray	Phase C	White or Natural Gray
Equipment Ground	Green	Equipment Ground	Green

Color coding of electrical conductors by use of phase tape or field paint is not acceptable. Conductors shall be manufacturer-colored, striped or ridge-marked.

Bare ground conductors shall be softdrawn copper, unless otherwise specified.

659.2.5-Connectors: Cable connections in boxes and handholes shall be made by means of connector kits, fused or non-fused, as indicated on the Plans. Splices for the signs shall be made by means of straight through or "Y" connector kits as required and as noted on the Plans. Where these connector kits cannot be used, as verified by the Engineer, connections on cables in junction boxes shall be made by splicing as described elsewhere.

Fused "Y" connectors, if required, shall be composed of "Y" line side housing assembled with a load side and fuse terminal housing.

The housing shall be formed from water-resistant synthetic rubber. Each housing shall provide a water seal around the cables and when fully assembled shall form a watertight connector.

The interior shall be arranged to receive and retain line side wiring and the fuse contacts. The fuse contacts shall be spring-loaded copper designed for 30 amperes, 600 volts; shall have 90 percent minimum conductivity and shall be suitable for gripping a 10 amp, 600 volt cartridge-type midget fuse, 13/32 inch (10.3 mm) in diameter and 1-1/3 inches (33.9 mm) long. The contacts shall be fully annealed. The load side conductors shall be connected by crimping and the line side conductors shall be connected with screws. The connector shall be of the nonlocking type that will break off under extreme tensile stress leaving no exposed metal contacts on the line side of the connector.

The cable diameters used shall determine the size of each housing. The load side housing shall retain the fuse when disconnected.

Non-fused connectors shall be similar to the fused "Y" connectors. The cable diameter shall determine the size of each housing of each connector.

Fuses for connectors shall be rated at 10 amperes, unless otherwise noted.

659.2.6-Bonding and Grounding: Metallic cable sheaths, conduit, transformer cases, anchor belts, and metal poles and pedestals shall be made mechanically and electrically secure to form a continuous system and shall be effectively grounded. Bonding and grounding jumpers shall be copper wire or copper strap of the same cross sectional area as #4 AWG for all lighting systems.

Ground rods shall be copper clad steel, 3/4 inches (19 mm) in diameter with a minimum length as noted on the plans and shall be one piece. Sectional or segmented ground rods are not permitted. The ground rods shall be complete with ground clamp and square head bolt.

659.2.7-Service: Service equipment for a sign lighting system shall be provided as required by the Plans unless changed by the Engineer to meet a local condition. Where a meter is required, a meter base complete with sealing rings shall be installed by the Contractor. Installation of electric meter and final hookup shall be done by the serving utility company. A circuit breaker mounted in a NEMA Type 4 (dust and moisture proof) enclosure shall be installed as indicated on the Standard Drawings.

659.2.8-Wood Poles: All wood poles shall meet the requirements of Section 710.8.

659.2.9-Enclosures: Pole mounted enclosures for sign lighting shall be of the type shown on the Plans and shall be NEMA Type 4 (dust and moisture proof). The design shall be of AISI 300 Series stainless steel with a flange mounted switch handle and a double defeater cover lock mechanism. Enclosure locks shall be such that all enclosures on the project can be opened with the same key. Locks shall be of quality bronze construction with bronze keeper chains.

Enclosure mounting brackets for mounting the enclosure on the sign support shall be as shown on the Plans.

659.2.10-Sign Lighting Fixtures: Type 3 (Mercury Vapor Sign Light) 100, 175 or 250 Watt:

The Type 3 luminaire shall be of the remote ballast, 100, 175 or 250-watt as indicated on the plans, mercury vapor type, furnished complete with housing, mounting bracket, reflector, refractor, lamp socket, ballast and lamp; Holograph, Guth, G.E. or equal as approved by the Engineer. The luminaire shall be 250 watt unless otherwise indicated.

The housing shall be die-cast aluminum with captive closed cell neoprene and felt double gasketing. Closure shall be positive by use of stainless steel pressure latches and stainless steel hinges.

The reflector shall be asymmetric polished aluminum. The refractor shall be molded prismatic thermal shock resisting borosilicate glass.

The lamp socket shall be of a heavy duty type and be provided with adjustable settings for varying beam pattern.

The ballast shall be 100, 175 or 250 watt high power factor constant wattage or constant wattage auto transformer for use with appropriate lamp and system voltage.

The lamp shall be 100, 175 or 250 watt deluxe white mercury vapor heavy glass type with rated life of 24,000 hours, equal to ANSI Code H38-4HT (100), H39-22KB (175) or H37-5KB (250).

The complete luminaire optical assembly consisting of reflector, refractor, lamp socket position and lamps shall produce a light distribution conforming to the Isofootcandle and Utilization Curves of Guth Vertol Signlites, Holograph 780 Express lite or equal as approved by the Engineer.

659.2.11-Photoelectric Controls (For Independent Sign Light System Only): WVDOH shall not need or require a photocell at each overhead sign structure containing sign lighting to turn sign lights On and Off if a control station running the sign lights already contains a photocell either by design in the Plans or previously field installed. Photoelectric controls shown on the Plans shall be capable of switching multiple fluorescent luminaires directly.

The photocell shall consist of a light-sensitive element connected directly to a control relay and shall be equipped with circuitry designed to accept a supply voltage of 120 volts, unless otherwise indicated on the Plans.

The unit shall be preset to "turn on" between 1.0 and 3.5 foot candles. "Turn off" shall be at least two times the "turn on" level; however, "turn off" must be greater than 3.0 and less than 15.0 foot candles.

The unit shall meet all relevant NEMA standards and shall be twist-lock type equipped for pole-top mounting using a slip fitter or conduit stem, or where pole-top mounting is impossible, bracket mounting to the side of the pole. The unit shall be north oriented. The unit shall be utility grade locking-type photo controls with a 2 to 5 second time delay.

659.2.12-Marking: Each overhead sign structure containing sign lighting shall be identified by control station number (as applicable) and circuit number (as applicable) with adhesive labels applied 6 feet (1.8m) above the grade line normal to the roadway. Adhesive labels shall be designed to be exposed to the weather. Legend shall be 3 inches (75mm) black on white. Also, each corresponding control station feeding sign lighting shall be identified by "WVDOH" label and control station number (as applicable) and corresponding voltage (as applicable) with adhesive labels on the control station door. The same adhesive label specifications apply as are stated above for the sign lighting labels.

CONSTRUCTION METHODS

659.3-GENERAL:

Existing electrical systems (traffic signal, highway and street lighting, flashing beacon, and sign illumination), or approved temporary replacements thereof, shall be in effective operation for the benefit of the traveling public during the progress of the work, except when shut-down is permitted to allow for alterations or final removal of the systems.

All systems shall be complete and in operation to the satisfaction of the Engineer upon completion of all the work. This includes field focusing of lamp fixtures.

659.3.1-Excavating and Backfilling: The excavations required for the installation of conduit, foundations, and other appurtenances shall be performed in such a manner as to cause the least possible damage to streets, sidewalks, landscaping, and other improvements. The trenches shall not be excavated wider than necessary for the proper installation of the electrical appurtenances and foundations. Excavation shall not be performed until immediately before the installation of conduit and other appurtenances. The material from the excavation shall be placed in a position that will not cause damage or obstruction to vehicular and pedestrian traffic or interfere with surface drainage.

All excavations shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. Each lift shall be compacted to the satisfaction of the Engineer. Testing is not required. All surplus material shall be removed from the right-of-way and the backfill finished flush with surrounding natural ground, including replacement of any damaged facilities or appurtenances. The Contractor shall restore all areas disturbed by this excavation or other operations to their original conditions including grading, seeding, mulching and fertilizing as directed by the Engineer.

The Contractor shall employ hand excavation methods in areas where underground facilities exist, in order to avoid damaging these facilities. Any damage caused by the Contractor to existing facilities shall be repaired by the Contractor at his own expense, to the satisfaction of the Engineer. The Contractor will be responsible for all claims and damages for interrupted service and all other damage suits which may result from such interrupted service.

659.3.2-Removing and Replacing Improvements: Improvements such as sidewalks, curbs, gutters, Portland cement and asphalt concrete pavement, bituminous surfacing, base material, lawn and plants, and any other improvements removed, broken or damaged by the Contractor's operations shall be replaced or reconstructed with materials of equal quality. The new work shall be left in a serviceable condition satisfactory to the Engineer.

Whenever a part of a square or slab of existing concrete sidewalk or driveway is broken or damaged, the entire square or slab shall be removed and the concrete reconstructed as specified.

The outline of all areas to be removed in Portland cement concrete pavements shall be cut to a minimum depth of 4 inches (100 mm) with an abrasive type saw prior to removing the pavement material. The cut for the remainder of the required depth may be made by a method satisfactory to the Engineer. Cuts shall be neat and true with no shatter outside the removal area.

659.3.3-Conduit Installation:

659.3.3.1-Type R Conduit: Where pull boxes are installed adjacent to the base of a standard or a sign structure post, conduit installed between pull boxes and base shall not be less than 2 inches (50 mm) in diameter.

It shall be the option of the Contractor, at his expense, to use conduit of larger size than specified and where used, the larger size shall be for the entire length of the run from outlet to outlet. No reducing coupling will be permitted.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true so that the ends will butt or come together for the full circumference. Slip joints or running threads will not be permitted for coupling conduit. When a standard coupling cannot be used, an approved threaded union coupling shall be used. The treads on all conduit shall be painted with a compound meeting specification MIL-P-21035 before the couplings are made up. All couplings shall be screwed up until the end of the conduits are brought together, providing a good structural connection throughout the entire length of the conduit run. Where the coating on the conduit has been damaged in handling or installation, such damaged places shall be painted with an approved rust preventative paint.

So far as practical, all conduit shall be run without traps. Where dips are unavoidable, a pull box or drainage tee shall be placed at each low point to drain any moisture accumulation. Conduit runs shall be made with as few couplings as standard length will permit and the total angle of all bends between any two boxes shall not exceed two quarter bends (180 degrees) unless otherwise approved by the Engineer.

Two cubic feet (600 cubic mm) of coarse aggregate (crushed stone or gravel) of a size and grade approved by the Engineer shall be placed at drainage tees for underground conduits.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used, the conduit shall be bent without crimping or flattening, using the longest radius practicable.

Conduit shall be laid at a depth of not less than 18 inches (450 mm) below the curb grade in the sidewalk area, 36 inches (900 mm) below the highway pavement grade in the road areas, and 24 inches (600 mm) below the finished grade in all other areas. All conduit placed under paved roads shall have a minimum diameter of 2 inches (50 mm).

Conduit shall be placed under existing pavement by jacking or drilling methods. Pavement shall not be disturbed without the approval of the Engineer. All local subterranean utility maps shall be checked before any jacking or drilling operations begin.

The near side of the jacking or drilling pits shall have a four foot (1.2 m) horizontal clearance from the edge of any type of pavement wherever possible. Water jetting will not be permitted.

Conduit terminating in standards or pedestals shall have a projection above the foundation of 4 inches (100 mm) and shall be sloped towards the handhole opening.

Conduit ends shall extend into concrete Junction boxes at least 1½ inches (40 mm) and be equipped with approved bonding bushings. Conduit shall be 2 inches (50 mm) above the bottom, and shall be sloped to facilitate pulling of conductors. Conduit entering through the bottom of a pull box shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduits shall enter from the direction of the run.

Expansion or deflection fittings, or both, shall be installed in metallic conduit runs at all joints in the structure to compensate for deflection and expansion. Expansion fittings shall be bonded with approved flexible tinned copper bonding jumpers.

Where new pull boxes are placed in existing conduit runs, the conduit shall be fitted with threaded bushings and bonded as shown on the Plans.

Conduit run on the surface of bridge structures shall be secured with approved strapping spaced not more than 5 feet (1.5 m) apart. Expansion fittings, as detailed on the structure Plans, shall be installed where the conduit crosses an expansion joint in the structure. Each expansion fitting shall be provided with a bonding jumper of at least # 6 AWG copper wire or equal.

Conduit leading to soffit, wall or other lights or fixtures below the grade of the pull box shall be sealed by means of an approved sealing fitting and sealing compound.

A # 12 AWG copperclad pull wire shall be installed in all conduits which are to receive future conductors. At least 2 feet (600 mm) of pull wire shall be doubled back into the conduit at each termination.

After backfilling is completed and prior to the installation of cable, all conduits, existing and new, shall be rodded throughout their entire lengths with a mandrel $\frac{1}{4}$ inch (6 mm) smaller in diameter than the conduit and 2 inches (50 mm) in length, and with a cylindrical wire brush the same diameter as the conduit.

659.3.3.2-Type P Conduit: Type P conduits shall be installed in accordance with the applicable methods as prescribed for Type R conduits, with regard to parallel conduit installations, coordinated with the existing or newly installed facilities.

Type P conduit shall be made watertight by joining with solvent in accordance with manufacturer's specifications. Ends terminating in junction boxes shall be terminated with expansion couplings and end bells. Ends joining to metal conduit elbows at lighting standard foundations shall be connected through expansion couplings and adapters.

659.3.4-Luminaires: No luminaire shall be installed until the lamp socket position has been inspected and approved by the Engineer for conformance to the manufacturer's recommended position for the specified distribution.

The connections between the luminaire and connector kits shall be made with # 10 wires.

659.3.5-Pull Boxes: Pull boxes shall be installed at the locations shown on the Plans or, in long runs, shall be spaced at not more than 250 feet (75 meters). It shall be the option of the Contractor, at his expense, to install additional pull boxes to facilitate his work.

Pull boxes shall be installed so that the covers are flush with the curb or sidewalk or 2 inches (50 mm) above the surrounding ground when no finished grade is established.

659.3.6-Cables: The Contractor shall provide adequate equipment for installation of cable, shall pull all wires through conduits in such a manner as not to overstress or stretch any wire, and shall use precautions so as not to score, cut, twist or damage the protective covering or insulation. In the pulling of cables in conduits, where the strain on the cables is likely to prove excessive, the Contractor shall use soapstone powder or other approved lubricant. Where two or more cables are to occupy the same conduit, they shall be drawn in together and kept parallel to each other by the use of a pulling head.

The Contractor, in connecting sockets, outlets and other similar equipment, shall ground the most accessible bare parts of each piece of equipment. In order to ensure that this has been done, each piece of equipment shall be tested after installation, and under the supervision of the Engineer, with a test lamp, one leg of which has been connected to a definite ground, or by other approved means of testing.

All cables in pull boxes and handholes shall be tested for circuit connections which shall be in conformity with those indicated on the detail drawings. All cables in junction boxes (pull boxes), manholes and standard bases shall be provided with individual non-corrosive metal (minimum 1½ inches (40 mm)) tags, die-stamped with control station, circuit and phase designation as applicable. Similarly designed tags shall be used in the switch boxes. The tags shall be securely attached to the cables with nylon cord of 1/16 inch (2 mm) minimum diameter.

Splices where necessary to form continuous circuits, complete and ready for operation, shall be made by the Contractor. Cable splices will be permitted only in accessible locations. Cable splices shall be accomplished by the use of manufactured splice kits. Splice design with a final wrap of tape will not be acceptable. Splice kits shall be installed strictly in accordance with the manufacturer's instructions.

Upon the completion of each wiring system, and before any connection is made to operating equipment, it shall be the responsibility of the Contractor to perform, in the presence of the Engineer, the following tests of each circuit to determine whether the installations are in acceptable working order:

- i. Tests for continuity
- ii. Tests for grounds
- iii. Tests for insulation resistance between circuit wires and from circuit wires to ground.

Upon completion of the electrical system, with fuses removed and before energizing, the insulation resistance shall be not less than five megohms.

659.3.7-Grounding:

659.3.7.1-General: The necessary conduit, conductors, bonding jumpers, clamps, connectors, ground rods, etc. for the grounding system shall be furnished, installed and connected by the Contractor.

Conduit systems must be effectively and permanently grounded with a cross section as required by the National Electrical Code and of capacity sufficient to ensure continuity and continued effectiveness of the ground connections for fault current. Ground conductors shall be as short and straight as possible, protected from mechanical injury and, if practicable, without splice or joint.

659.3.7.2-Codes and Approvals: All grounding work shall be done in accordance with the latest edition and revisions of the National Electrical Code and the regulations of State and local codes.

All connections in ground network shall be those of a type approved by NEC, Article 250.

659.3.7.3-Metal Conduits: All metal conduit ends shall be bonded and grounded by means of a # 4 bare copper cable. The grounding shall be accomplished by driving ground rods as detailed on the Plans and connecting it through a # 4 copper conductor in the foundation as shown on the Plans; or by driving ground rods through the junction box drainhole, and connecting it through a # 4 copper connector attached to a grounding stud on the sign lighting standard junction box frame, etc. The connection of the bonding cable to the junction box frames and to the shafts of the metallic sign lighting standard shall be done by means of a grounding stud, Burndy's Type K2C, Dossert Type DCM, or approved equal. Where the supply voltage is greater than 120/140, the neutral conductor shall be grounded at the service panels only with the neutrals of dry transformers.

At each service point, a ground electrode shall be furnished and installed. Ground electrodes shall be one-piece lengths of copperclad rod, diameter and length as shown on the Plans. Ground electrodes shall be installed in accordance with the provisions of the Code and as indicated on the Plans.

659.3.8-Service: Service points shown on the Plans are approximate only. The Contractor shall determine the exact locations from the serving utility.

Poles shall be placed in the ground to a depth of at least 5 feet (1.5 m).

The Contractor shall furnish conduit, conductors and all other necessary material to complete the installation of the service riser. Service riser conduit shall terminate with a weather head to prevent the entrance of water, as approved by the serving utility.

Where a meter is required, a meter base, furnished by the serving utility, shall be installed by the Contractor.

Each multiple service installation shall be grounded in accordance with the provisions in the Code.

Where an approximate service point is shown on the Plans, installation and materials for the connection between the actual service point, as established by the serving utility, and the nearest pull box of the electrical system shown on the Plans, shall be paid for by the Contractor.

Where a service point is omitted from the Plans, installation and materials for the connection between the service point, as established by the serving utility, and the nearest pull box of the electrical system shown on the Plans, shall be paid per section 109.4 and 104.3.

Upon request of the Contractor, the Engineer will arrange with the serving utility to complete the service connections and the Contractor shall pay all costs and fees required.

Upon request of the Contractor, the Engineer will arrange for furnishing electrical energy. Energy used prior to the completion of the contract will be charged to the Contractor, except that the cost of energy used for the public benefit, when such operation is ordered by the Engineer, will be borne by the Division.

When the power service is within a roadway lighting system, it shall be necessary only to provide the connections as shown on the Plans.

659.3.9-Field Tests: Prior to the completion of the work, the Contractor shall cause the following tests to be made on all lighting circuits, in the presence of the Engineer.

- i. Each circuit shall be tested for continuity.
- ii. Each circuit shall be tested for unspecified grounds.
- iii. A megger test shall be made on each circuit between the circuit and the ground. The insulation resistance shall not be less than the values specified in the provisions of the Code.

- iv. A functional test shall be made in which it is demonstrated that each and every part of the system functions as specified or intended.

After the installation is completed, the Contractor shall conduct a continuous 24-hour operating test for approval. In addition, final acceptance of an installation will not occur until 30 days of operation termed satisfactory by the Engineer.

During the 30 days of operation, the Contractor shall be responsible for repairing or replacing any defective equipment within 24 hours after being notified by the Engineer. After any malfunctioning equipment has been repaired or replaced, the 30-day test shall begin anew.

Where the sign lighting installation is a part of, and connected to, a roadway lighting installation, the functional test shall be the same as the functional test for the roadway lighting system.

659.3.10-Ballasts and Isolating Transformers: Splices at ballasts and transformers shall conform to the Code. Where more than one conductor enters a ballast or transformer sleeve, the insulation and taping shall be applied between the conductors in such a manner as to provide a watertight joint. The splice installation shall be capable of satisfactory operation under continuous submersion in water.

659.4-METHOD OF MEASUREMENT:

Measurement for payment for sign lighting will be based on each individual lighting system (normally one per overhead sign structure) complete in place, which will include power service, service poles, meter bases, switch box, pole mounted enclosure, transformers, photoelectric controls, disconnects, junction boxes, cable, conduit, luminaires, lamps, ballasts, impact-proof shields and any other accessories or hardware as required to make a complete installation as called for on the Plans or as directed by the Engineer.

659.5-BASIS OF PAYMENT:

The quantity, determined as provided above, shall be paid for at the contract price for each installation for the item listed below, which price and payment shall be full compensation for furnishing all the materials and doing all the work prescribed in a workmanlike and acceptable manner. This price shall include all compensation for fabrication, delivery, erection and for any additional materials, tools, equipment, incidentals and labor not shown on the Plans or called for which are necessary to complete the installation of the various systems and as directed by the Engineer, including any necessary excavating and backfilling, restoring sidewalk, pavement and appurtenances damaged or destroyed during construction, salvaging existing materials and making all required tests.

659.6-PAY ITEM:

ITEM	DESCRIPTION	UNIT
659001-*	Sign Lighting, Type "type"	Lump Sum

* Sequence number

659-SIGN LIGHTING-APPENDIX A Standard Spacing For Type 3 Luminaire Using Delux White Mercury Lamp (Where two or more signs have 3.0 feet (1 m) or less between the two signs, treat as one sign.)			
Sign Or Group Length Feet (Meter)	Number Of Luminaries	Distance Of First Luminaire From Left Edge Feet (Meter)	Distance Between Luminaires Feet (Meter)
5.0 (1.5 m)	1	2.5 (0.750 m)	
6.0 (1.80 m)	1	3.0 (0.900 m)	
7.0 (2.10 m)	1	3.5 (1.05 m)	
8.0 (2.40 m)	1	4.0 (1.200 m)	
9.0 (2.70 m)	1	4.50 (1.35 m)	
10.0 (3.00 m)	1	5.0 (1.50 m)	
10.5 (3.15 m)	2	2.75 (0.825 m)	5.0 (1.5 m)
11.0 (3.30 m)	2	3.0 (0.90 m)	5.0 (1.5 m)
12.0 (3.60 m)	2	3.50 (1.05 m)	5.0 (1.5 m)
13.0 (3.90 m)	2	4.0 (1.20 m)	5.0 (1.5 m)
14.0 (4.20 m)	2	4.50 (1.35 m)	5.0 (1.5 m)
15.0 (4.50 m)	2	5.0 (1.50 m)	5.0 (1.5 m)
15.5 (4.65 m)	2	3.25 (0.975 m)	9.0 (2.7 m)
16.0 (4.80 m)	2	3.50 (1.05 m)	9.0 (2.7 m)
17.0 (5.10 m)	2	4.0 (1.2 m)	9.0 (2.7 m)
18.0 (5.40 m)	2	4.50 (1.35 m)	9.0 (2.7 m)
19.0 (5.70 m)	2	5.0 (1.50 m)	9.0 (2.7 m)
20.0 (6.00 m)	2	5.50 (1.65 m)	9.0 (2.7 m)
20.5 (6.15 m)	3	1.25 (0.375 m)	9.0 (2.7 m)
21.0 (6.30 m)	3	1.50 (0.45 m)	9.0 (2.7 m)
22.0 (6.60 m)	3	2.0 (0.60 m)	9.0 (2.7 m)
23.0 (6.90 m)	3	2.5 (0.75 m)	9.0 (2.7 m)
24.0 (7.20 m)	3	3.0 (0.90 m)	9.0 (2.7 m)
25.0 (7.50 m)	3	3.50 (1.05 m)	9.0 (2.7 m)
26.0 (7.80 m)	3	4.0 (1.20 m)	9.0 (2.7 m)
27.0 (8.10 m)	3	4.50 (1.35 m)	9.0 (2.7 m)
28.0 (8.40 m)	3	5.0 (1.50 m)	9.0 (2.7 m)
29.0 (8.70 m)	3	5.50 (1.65 m)	9.0 (2.7 m)
29.5 (8.85 m)	4	1.25 (0.375 m)	9.0 (2.7 m)
30.0 (9.00 m)	4	1.50 (0.45 m)	9.0 (2.7 m)
31.0 (9.30 m)	4	2.0 (0.60 m)	9.0 (2.7 m)
32.0 (9.60 m)	4	2.50 (0.75 m)	9.0 (2.7 m)
33.0 (9.90 m)	4	3.0 (0.90 m)	9.0 (2.7 m)
34.0 (10.20 m)	4	3.50 (1.05 m)	9.0 (2.7 m)
35.0 (10.50 m)	4	4.0 (1.20 m)	9.0 (2.7 m)

659-SIGN LIGHTING-APPENDIX A Standard Spacing For Type 3 Luminaire Using Delux White Mercury Lamp (Where two or more signs have 3.0 feet (1 m) or less between the two signs, treat as one sign.)			
Sign Or Group Length Feet (Meter)	Number Of Luminaries	Distance Of First Luminaire From Left Edge Feet (Meter)	Distance Between Luminaires Feet (Meter)
36.0 (10.80 m)	4	4.50 (1.35 m)	9.0 (2.7 m)
37.0 (11.10 m)	4	5.0 (1.50 m)	9.0 (2.7 m)
38.0 (11.40 m)	4	5.50 (1.65 m)	9.0 (2.7 m)
38.5 (11.55 m)	5	1.25 (0.375 m)	9.0 (2.7 m)
39.0 (11.70 m)	5	1.50 (0.45 m)	9.0 (2.7 m)
40.0 (12.00 m)	5	2.0 (0.60 m)	9.0 (2.7 m)
41.0 (12.30 m)	5	2.50 (0.75 m)	9.0 (2.7 m)
41.5 (12.45 m)	5	2.75 (0.825 m)	9.0 (2.7 m)
42.0 (12.60 m)	5	3.0 (0.90 m)	9.0 (2.7 m)
43.0 (12.90 m)	5	3.50 (1.05 m)	9.0 (2.7 m)
43.5 (13.05 m)	5	3.75 (1.125 m)	9.0 (2.7 m)
44.0 (13.20 m)	5	4.0 (1.20 m)	9.0 (2.7 m)
45.0 (13.50 m)	5	4.50 (1.35 m)	9.0 (2.7 m)
46.0 (13.80 m)	5	5.0 (1.5 m)	9.0 (2.7 m)
47.0 (14.10 m)	5	5.50 (1.65 m)	9.0 (2.7 m)
48.0 (14.40 m)	6	1.50 (0.45 m)	9.0 (2.7 m)
49.0 (14.70 m)	6	2.0 (0.60 m)	9.0 (2.7 m)
49.5 (14.85 m)	6	2.25 (0.675 m)	9.0 (2.7 m)
50.0 (15.00 m)	6	2.50 (0.75 m)	9.0 (2.7 m)
51.0 (15.30 m)	6	3.0 (0.90 m)	9.0 (2.7 m)
52.0 (15.60 m)	6	3.50 (1.05 m)	9.0 (2.7 m)
53.0 (15.90 m)	6	4.0 (1.20 m)	9.0 (2.7 m)
54.0 (16.20 m)	6	4.50 (1.35 m)	9.0 (2.7 m)
55.0 (16.50 m)	6	5.0 (1.5 m)	9.0 (2.7 m)
56.0 (16.80 m)	6	5.50 (1.65 m)	9.0 (2.7 m)
56.5 (16.95 m)	7	1.25 (0.375 m)	9.0 (2.7 m)
57.0 (17.10 m)	7	1.50 (0.45 m)	9.0 (2.7 m)
58.0 (17.40 m)	7	2.00 (0.60 m)	9.0 (2.7 m)
59.0 (17.70 m)	7	2.50 (0.75 m)	9.0 (2.7 m)
60.0 (18.00 m)	7	3.0 (0.90 m)	9.0 (2.7 m)

SECTION 660 TRAFFIC SIGNALS

660.1-DESCRIPTION:

This work shall consist of furnishing and installing various types of traffic signal systems. It shall include, but not be limited to, traffic signals and traffic signal interconnection systems to be installed in accordance with this Specification, as shown on the Plans or as directed by the Engineer.

All electrical work shall conform to current requirements of the *National Electrical Code*, latest edition, all local codes and Section 631 of the Standard Specifications.

All details not specified or not shown on the Plans shall conform to the requirements of the latest issue of the Manual on Uniform Traffic Control Devices, (referred to as the MUTCD). This Manual is published by the Federal Highway Administration of the U.S. Department of Transportation and supplemented by the publication "Official Ruling on Request" and the West Virginia Division of Highways Traffic Engineering Division Directives.

660.2-MATERIALS:

All materials shall be new and shall conform to the requirements of the following subsections of 715.42, Traffic Signals.

MATERIALS	SUBSECTION
Adjustable Face Signal Heads	715.42.6
Auxiliary Traffic Signal Equipment	715.42.7
Cabinets	715.42.8
Conductors	715.42.13
Electrical Conduit	715.42.10
Junction Boxes	715.42.11
Local Coordinating Units	715.42.4
Messenger Cable	715.42.12
Pre-Timed, Fixed Cycle Traffic Signal Controllers	715.42.1
Priority Control System Detector	715.42.7.4
Priority Control System Emitter	715.42.7.4
Signal Supports	715.42.9
Solid State Traffic Actuated Signal Controllers	715.42.2
Supplemental Flashing Beacons & Mountings	715.42.14
Traffic Adjusted Master Controller (Type OPV)	715.42.3
Traffic Detectors	715.42.5

Within 15 day following the award of the Contract, the Contractor shall submit to the Engineer a list of equipment and materials which the Contractor proposes to install. The list shall be complete as to the name of manufacturer, size, and identifying number of each item. The list shall be supplemented by such other data as may be required, including detailed scale drawings and wiring diagrams of any special equipment. A signed statement shall accompany the materials list stating that the materials meet the applicable requirements of these Specifications.

CONSTRUCTION METHODS

660.3-GENERAL:

Construction methods shall conform to the requirements of the Plans and the latest issue of the West Virginia Division of Highways Standard and Supplemental Specifications, except as modified.

660.4-MAINTAINING TRAFFIC:

During the installation of traffic signals and appurtenances, the roadway shall be kept open to all traffic by the Contractor in such a way that both local and through traffic will be adequately and safely accommodated through the work area. See the Manual, "Traffic Control for Street and Highway Construction and Maintenance Operations", and applicable sections of the Standard Specifications.

660.5-REMOVING EXISTING SIGNAL EQUIPMENT:

Existing traffic signal equipment at the intersection shall be removed by the Contractor. If there is not a pay item in the proposal, the Contractor shall remove the signal heads, controller and poles and render the equipment unusable as traffic control devices. If there is a pay item in the Proposal for signal removal, the Contractor shall remove the controller, signal heads, hardware and poles, if required, in such a manner so as not to damage the equipment. These heads, controllers and poles shall be turned over to the Engineer and become the property of the Division. Salvaged wire and conduit shall become the property of the Contractor.

When a foundation is to be abandoned, the top of foundation, anchor bolts, and conduits shall be removed to a depth of not less than 6 inches (150 mm) below the surface of the sidewalk or unimproved ground. The resulting hole shall be backfilled with material equivalent to the surrounding material.

660.6-REMOVING AND REPLACING IMPROVEMENTS:

Existing improvements, such as sidewalks, curbs, gutter, Portland cement and asphalt concrete pavement, underlying material, lawns and plants, and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of material as found on the work or with materials of equal quality. The new work shall be left in a serviceable condition.

Whenever a part of a square or slab of existing concrete sidewalk, curb, gutter, or driveway is broken or damaged, the entire square, section or slab shall be removed and the concrete reconstructed as specified above.

The outline of all areas to be removed in Portland cement concrete sidewalks and driveways and in pavements shall be cut to a minimum depth of 2 inches (50 mm) with an abrasive-type saw prior to removing the sidewalk, driveway and pavement material. Cuts shall be neat and true with no shatter outside the removal area.

660.7-EXCAVATING AND BACKFILLING:

Excavations required for the installation of foundations, conduit and other appurtenances shall be performed in such a manner as to avoid any unnecessary damage to streets, sidewalks, landscaping, and other improvements. Pavement cuts and excavations shall be no wider than

necessary for the proper installation of the electrical appurtenances and foundations, or as required for the proper replacement of pavements or other improvements.

Excavation shall not be performed until immediately before installation of conduit, foundations or other appurtenances. The material from the excavation and the equipment used in the excavation shall be placed in a position that will least interfere with surface drainage and that will least obstruct vehicular and pedestrian traffic.

At the end of each day's work, and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from the portion of the roadway open for use by vehicular and pedestrian traffic. All surplus excavation material shall be removed and disposed of, within 48 hours, outside of the highway right-of-way, unless otherwise directed by the Engineer.

All excavations shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. When the trench width is less than 12 inches (300 mm), each lift shall be compacted to the satisfaction of the Engineer. Testing is not required. When the trench width is 12 inches (300 mm) or greater, each lift shall be compacted to 95 percent of the maximum dry density. All surplus material shall be removed from the right-of-way and the backfill finished flush with surrounding natural ground, including replacement of any damaged facilities or appurtenances. The Contractor shall restore all areas disturbed by this excavation or other operations to their original conditions including grading, seeding, mulching and fertilizing as directed by the Engineer.

660.8-FOUNDATIONS:

Foundations for controller cabinets and signal support structures shall be of Class B Portland cement concrete and shall be proportioned, mixed and placed in accordance with Section 601 of the Standard Specifications or as specified.

All reinforced material used in signal support structures shall be in conformation with Sections 602 and 709 of the Standard Specification.

The Contractor shall inform the Engineer when the excavation is complete and no concrete shall be placed until the Engineer has approved the excavation for each individual foundation. No foundation shall be set over recent fill of extensive depth or muck except by the approval of the Engineer. For foundations set in solid rock see Standard Details.

Foundations shall conform to the sizes and shapes shown on the Plans and shall be monolithic. Forms shall be used for the top 12 inches (300 mm) of a foundation; they shall be true to line and grade and securely braced in place. Tops of foundations shall be finished to curb or sidewalk grade or as directed by the Engineer.

When embedded poles are used, a pre-cast concrete block or concrete cast in place 24 hours before setting the pole, shall be set in the bottom of the foundation excavation as shown on the Standard Detail sheet. Suitable anchoring devices to hold the embedded pole in the proper positions, until the surrounding concrete has set for at least 12 hours, must be provided. These devices must be approved by the Engineer and the pole shall not be allowed to be set without such devices.

Anchor bolts shall be accurately set in accordance with a detail furnished by the pole manufacturer. Conduit ends and anchor bolts shall be held in the proper position and to the proper height by means of a template until the concrete sets.

Forms shall be oiled and excavation surfaces that come in contact with the concrete shall be thoroughly moistened before concrete placement. Forms shall not be removed until the concrete has thoroughly set.

Ordinary surface finish as described in Section 601 of the Standard Specifications shall be applied to exposed surfaces of concrete.

All concrete foundations shall be allowed to set for 72 hours before any support structures are installed.

Support structures shall be plumb or raked as directed by the Engineer.

Foundations for wooden poles shall be excavated to dimensions slightly larger than the pole diameter and the excavation around the pole shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. Each lift shall be compacted to the satisfaction of the Engineer. Testing is not required.

Depth of the pole foundation shall be as specified on the Plans. A device to hold the wooden pole in place with the proper rake until backfilling is complete shall be provided. Blocks wedged between the excavation and the pole are not acceptable.

Ground rods shall be $\frac{3}{4}$ inch in diameter with a minimum length as shown on the Plans and shall be one piece. Sectional or segmented ground rods are not permitted. All signal supports shall have ground rods. The ground rods shall be complete with ground clamp and square head bolt.

660.9-LOOP TRAFFIC DETECTORS:

Installation shall conform to the details and notes shown on the Plans.

Slots cut in the pavement for the loop conductor shall be neat and true to the dimensions shown on the Plans. Slots shall be blown out and dried before loop conductors are installed.

The # 14 THWN stranded loop conductor shall run continuous and unspliced from the roadway loop to a junction box or conduit as indicated in the Plans. Each loop shall consist of a single separate wire and shall be connected to the detector by a separate lead-in wire. The loops shall consist of three turns of wire, unless otherwise specified.

All loop wire installation shall be made without damage to the wire or its insulation and all damaged wires shall be replaced. The wire must be so placed that there are no kinks or curls and no straining or stretching of the insulation. It shall be installed and secured as deep in the slot as possible. A blunt object, similar to wooden paint stirrer shall be used to seat the loop wire. A screwdriver or other sharp tool shall not be used for this purpose.

Prior to placing the loop slot sealant, the loop wire shall be checked for continuity, resistance and insulation integrity. Insulation integrity shall be checked by applying a megger between each end of the loop wire and the nearest reliable electrical-ground street light, fire hydrant, etc. If no available ground exists, a suitable ground shall be established for the measurement, (e.g., driven metal spike). The megger reading shall be in excess of ten megohms under all conditions, (500 volts DC). The continuity and megger checks shall be recorded by the Engineer.

Lead-in wire from the loop conductor to the detector terminal strip shall be two # 14 AWG solid copper.

The lead-in wire shall also be continuous and unspliced from junction box or conduit to the detector terminal strip in the cabinet.

Splices between the loop conductor and the lead-in wire shall be soldered with fuseable metal or alloy. These splices shall first be joined and made mechanically secure and tested

electrically. No spring connectors will be allowed for splicing. When the mechanical connection has been shown to be electrically functional under operational conditions, it shall then be soldered. Each splice shall then be insulated with a permanent, waterproof covering as specified or as approved by the Engineer. Waterproof adhesive shall be applied to the splice and on at least 2 inches (50 mm) of loop wire and lead-in wire insulation on both sides of the splice. The splice shall then be covered with half-lapped, $\frac{3}{4}$ inch (19 mm), self-bonding electrical tape; starting at the center of the splice and proceeding to $\frac{3}{4}$ inch (19 mm) onto the wire insulation, returning to the center of the splice. The entire splice shall then be wrapped with half-lapped, $\frac{3}{4}$ inch (19 mm), all-weather electrical tape using the same procedure as above. When both ends of the loop wire and lead-in wires are so spliced and wrapped, both splices shall then be wrapped together with $\frac{3}{4}$ inch (19 mm), all-weather electrical tape. The entire splice area to the end of the adhesive coating shall be covered. The splice shall then be completed by inserting a four-inch (100 mm) piece of all-weather electrical tape into the "V" formed by the loop wires.

The loop slot cuts in the pavement shall be filled with a permanent, flexible weatherproof sealant after the placement of the loop wire in the slots. The sealant shall be resistant to traffic, water, gasoline, chemical fumes, mild alkalies, oils and mild acids; no noticeable deterioration of the sealant shall be apparent after exposures to temperatures ranging from minus 20° F (-6° C) to plus 160° F (71° C). Before sealing the loop, slots must be clean and dry and blown out with oil-free air. The sealant shall be placed to within 5/8 inch (3 mm) of the pavement surface and surplus sealant shall be removed from the adjacent road surfaces without the use of solvents.

The loop slot sealant shall be of "Weatherban 101 Sealer" as manufactured by the 3-M Company or an approved equal.

The Contractor shall be responsible for replacement of damaged loops and lead-in cable to the existing splice box or otherwise designated junction box.

The Contractor shall be responsible for replacing all damaged traffic signal loops within the construction limits within fourteen (14) calendar days of when damage occurs.

Standard (6 foot x 6 foot) detector loops shall consist of three (3) turns of stranded #14 AWG copper wire, with Quadrupole presence loops consisting of two (2) turns of stranded #14 AWG copper wire meeting IMSA conductor specifications. All detector loops shall conform to WVDOT Standard Specifications 715.42.2 and 715.42.13.

660.10-SIGNAL HEADS:

All signal heads shall be either plumb or level, symmetrically arranged, and securely assembled. All suspended heads shall be provided with leveling hangers and balance adjusters. In addition, all signal head faces shall be aimed and secured in the direction of traffic they control.

Signal heads suspended from messenger cable and mast-arm suspended heads that are not rigidly mounted shall be attached directly to the cable or mast-arm hanger and balance adjuster. If approved by the Engineer, one head per span or mast arm may be lowered to the proper height by use of 1½ inches galvanized steel piping connecting the signal head to the cable or mast-arm hanger. If piping is used, it must be painted to match the signal-head housing and a positive permanent means of securing the head to the pipe to prevent rotation shall be provided. In all cases, piping of signal heads should be avoided if possible.

All red sections of signal heads on a single span or mast arm shall be at the same elevation.

Optically programmed signal heads shall have a permanent, rigid mount fitting to assure reliable control of visibility. Programmed heads shall be aimed, fixed and programmed to control

vehicle or pedestrian traffic only in the cut-off area specified on the Plans and as directed by the Engineer.

All type signal heads that are installed before a signal system is made operative shall be hooded with a black plastic material that will completely conceal the signal faces (even when lit) as well as cover the entire signal head. The material shall be weather resistant and fastened in such a way that it will be completely wind resistant.

660.10.1-Light Emitting Diode Signal Modules (L.E.D.):

1. When specified, L.E.D. traffic signal modules shall be used for replacement of either eight or twelve inch heads operating at 120 Vac. Total power consumption at each section shall not consume more than 22 watts.
2. L.E.D. traffic signal modules shall be designed for new or existing signal lamps which shall not require special tools for installation. Retrofit replacement L.E.D. signal modules shall fit into existing traffic signal housings built to VTCSH (Vehicle Traffic Control Signal Heads) standard without modification to the housing.
3. Installation of a retrofit replacement L.E.D. signal module into an existing signal housing shall only require the removal of the existing optical unit components, i.e., lens, lamp module, gaskets, and reflector; shall be weather tight and fit securely in the housing; and shall connect directly to existing electrical wiring.
4. The L.E.D. signal module shall be a single, self-contained device. The power supply must be designed to fit and mount inside the traffic signal module.
5. The assembly and manufacturing process for the L.E.D. signal assembly shall be designed to assure all internal L.E.D. and electronic components are adequately supported to withstand mechanical shock as per MIL-STD-883.
6. The L.E.D. signal module shall be rated for use in the ambient operating temperature range of -40C to +74C degrees.
7. The L.E.D. signal module shall be protected against dust and moisture intrusion per the requirements of NEMA Standard 250-1991, for Type 4 enclosures to protect all internal L.E.D. electronic, and electrical components.
8. The L.E.D. single module lens shall be UV stabilized.
9. Each module shall comprise a smooth surface convex UV stabilized polycarbonate outer shell. A mechanical alignment and assembly mechanism shall ensure that each L.E.D. shall be maximized by an internal beam controlling optical faceted lens designed and patented to meet the 44 points measurement of the VTCSH standard.
10. The multiple L.E.D. light source should be the latest technology available on the market. Materials shall meet all applicable ASTM specifications.
11. The measured chromaticity coordinates of L.E.D. signal modules shall conform to the chromaticity requirements of Section 8.04 and Figure 1 of the VTCSH standard.
12. All wiring and terminal blocks shall meet the requirements of Section 13.02 of the VTCSH standard. Two secured, color coded, 36 inch long 600V, 20 AWG minimum, jacketed wires, conforming to the NEC, rated for service at +105C, are to be provided for electrical connection.
13. The module shall operate on a 60 Hz AC line voltage ranging from 80 volts rms to 135 volts rms with less than 10% light intensity variation. Nominal rated voltage for all measurements shall be 120+/- volts rms. The circuitry shall prevent flickering over this voltage range.

14. The individual L.E.D. light sources shall be wired so that a catastrophic failure of one L.E.D. light source will result in the loss of not more than 20 percent of the signal module light output.
15. The L.E.D. lamp shall contain a disconnect that will show an open switch to the conflict monitor when less than 80% of the L.E.D. in the unit are operational.
16. The L.E.D. signal module shall be operationally compatible with NEMA TS-1 or later.
17. The power supply must permit the regulation of the current supplied to the L.E.D.s to maintain a constant current.
18. The L.E.D. signal and associated on-board circuitry must meet Federal Communications Commission (FCC) Title 47, SubPart B, Section 15 regulations concerning the emission of electronic noise.
19. The L.E.D. signal module shall provide a power factor of 0.90 or greater at 25C degrees and at the nominal operating voltage.
20. Total harmonic distortion, current and voltage, induced into an ac power line by a signal module shall not exceed 20 percent, over the operating voltage range specified in Section 14 and within the ambient temperature range specified in Section 4.
21. The signal module on-board circuitry shall include voltage surge protection to withstand high-repetition noise transients and low-repetition high-energy transients as stated in Section 2.1.6.NEMA Standard TS-2, 1992.
22. The L.E.D. signal module shall operate from a 60+/-3 Hz ac line over a voltage range from 80 Vac to 135 Vac, drawing a minimum of 100 mA rms over the entire voltage range. Load switches shall be compatible with NEMA TS-1 or later.
23. All L.E.D. signal modules shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, in an ambient temperature of 60C degrees.
24. Manufacturers shall provide a Certificate of Compliance to this specification for each shipment of L.E.D. signal modules to an end user. Each L.E.D. signal module shall be identified with a serial number.
25. Warranties shall include the replacement or repair of an L.E.D. signal module that fails to function as intended due to workmanship or material defects within the first 60 months from the date of delivery. Also, replacement or repair of L.E.D. signal modules that exhibit luminous intensity of less than the minimum values specified in Table 1 of ITE August, 1997, draft specification within the first 36 months from the date of delivery.

660.11-CABINETS:

The cabinets for all types of traffic controllers or flasher units shall be mounted and installed at the location shown on the Plans and in accordance with typical installation details. No mounting holes or special outlets shall be made through the cabinet walls without the specific approval of the Engineer.

Adjustable steel bands or universal cabinet mounting bands shall not be used for mounting cabinets to poles or pedestals. Cabinets mounted on wood poles shall be attached with wood pole mounting brackets, secured with lag screws.

660.12-SUPPORT STRUCTURES:

Strain and mast-arm poles shall be installed with the amount of rake recommended by the pole manufacturer. The rake shall assure a substantially vertical set when the load is applied. For anchor base type poles, threaded adjusting nuts shall be used to establish the rake. The use of shims or other leveling devices is not permitted. Hardware and fittings shall be installed as shown on the manufacturer's installation drawings. When embedded or wooden poles are used, the rake shall be established as the pole is set.

Pedestal poles supporting only a vertical dead load shall be installed in a true vertical plane.

The Contractor shall take full responsibility for checking all cross sections to determine final support lengths.

660.13-MESSENGER CABLE:

When completely loaded the messenger cable, cable rings and conductor wire shall present a straight, clean, neat appearance. Excessive slack shall be pulled out of conductor wire and the ring supports shall be set at 15-in. (375 mm) centers.

Span wire sag shall be kept at a practical minimum and in no case exceed five percent of the span.

660.14-CONDUIT:

Conduit runs shown on the Plans may be changed to avoid underground obstructions with the written approval of the Engineer. Approximate lengths of conduit are shown on the Plans. The Contractor shall determine the exact lengths of conduit in the field.

The ends of all conduits, whether shop or field cut, shall be reamed to remove burrs and rough edges. Cuts shall be made square and true so that the ends will butt or come together for the full circumference thereof. Standard conduit couplings shall be used for joining all metal conduit. Slip joints or running threads will not be permitted for coupling conduit. However, expansion fittings shall be installed where the conduit crosses an expansion joint on a structure. Continuity through the expansion fitting shall be provided by means of # 6 AWG copper wire jumper. Conduit runs on the surface of structures shall be secured with galvanized malleable iron clamps spaced not more than 5 feet (1.5 m) apart.

The threads on all ferrous metal conduit shall be painted with rust preventative paint before couplings are made up. All couplings for metal-type conduit shall be tightened until the ends of the conduit are brought together, providing a good electrical connection throughout the entire length of the conduit run. Where the coating on metal conduit has been damaged in handling or installing, such damaged places shall be painted with an approved rust preventive paint. Exposed ungalvanized threads on metal conduit resulting from field cuts shall be painted with an approved rust preventative paint.

All metal-type conduit ends shall be threaded and shall be capped with a standard pipe caps until wiring is started. When caps are removed, the threaded ends shall be provided with conduit bushings.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit. Where factory bends are not used, conduit shall be bent, without crimping or flattening, using the longest radius practicable.

A # 12 AWG galvanized pull wire shall be installed in all conduits which are to receive future conductors. At least 2 feet (600 mm) of pull wire shall be doubled back into the conduit at

each termination. All conduit runs shall be free of dirt, debris and excessive moisture before cable is pulled.

Existing underground conduit to be incorporated into the new system shall be cleaned with a mandrel or cylindrical wire brush and blown out with compressed air.

Conduit shall be laid to a depth of not less than 18 inches (450 mm) below finished grade in all areas, except that conduit may be laid on top of and secured to the existing pavement within new curbed medians being constructed on top of the pavement.

Rigid metal conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed without permission from the Engineer. In the event obstructions are encountered, upon approval of the Engineer, small test holes may be cut in the pavement to locate obstructions. Jacking or drilling pits shall be kept 2 feet (600 mm) clear of the edge of any type of pavement wherever possible. Water jetting will not be permitted.

Conduit terminating in pile or pedestal bases shall extend 4 inches (100 mm) vertically above the foundation and shall be sloped towards the hand-hole opening. At all conduit termini, the conduit shall enter the outlet from the direction of the run. Conduit size shall be the same for terminal point to terminal point. No reducing couplings will be permitted.

If it is determined by the Engineer that it is impractical to bore the conduit under concrete or asphaltic pavement due to unforeseeable obstructions, the Contractor may, with the Engineer's permission, cut the existing pavement. The pavement shall be cut along neat and true lines by means of a concrete saw. The depth of the trench shall be as specified and the width shall be the minimum required for proper excavation and backfilling. The trenching operation, along with replacement operation, shall be performed according to Standard Detail TES-04. Concrete shall be allowed to set for a minimum of 49 hours without being exposed to traffic. At no time shall more than one-half of the roadway be closed for any conduit placement operations.

Conduit to be placed beneath railroad tracks shall comply with the following:

The conduit shall be rigid metal type, 2 inches (50 mm) minimum size and shall be placed to a minimum depth of 5 feet (1.5 m) below the bottom of the tie. The near side of each conduit jacking pit shall be constructed not less than 12 feet (3.6 m) from the centerline of track. When the jacking pit is to be left overnight it shall be covered with substantial planking.

660.15-JUNCTION BOXES:

Junction boxes shall be installed at the locations shown on the Plans or, in long runs, they shall be spaced at not over 200 feet (60 m) intervals. The Contractor may, at his own expense and with the approval of the Engineer, install additional junction boxes to facilitate his work.

The tops of junction boxes installed in the ground or in sidewalk areas shall be flush with the surrounding grade or pavement.

Concrete junction boxes shall be poured in place. However, pre-cast junction boxes may be used, when in the opinion of the Engineer, the surrounding subgrade has sufficient bearing qualities to support the box and cast iron frame.

All junction boxes shall be set on at least 12-in. (300 mm) bedding of aggregate base material as shown on the Plans. Grouting shall be done prior to the installation of conductors. No junction boxes shall be set on uncompacted ground.

Concrete work shall be done in accordance with the applicable requirements of 660.8.

The Contractor shall be responsible for reconstruction and/or replacement of all damaged junction boxes. Damage junction boxes shall be defined as any junction box more than two (2) inches below grade, or is covered by the area roadway surface.

The adjustment of the junction box shall include the complete excavation and shall conform to WVDOT Standards Specifications, Section 660.8 and 660.15. All conduit, cable and attached appurtenances shall be incidental to this junction box.

The adjustment of the junction box shall be as per detail and shall conform to WVDOT Standards and Specifications Section 660.8 and 660.15.

660.16-WIRING:

Sufficient five-conductor signal light cables shall be provided to perform the functional operation of the signal system and, in addition thereto, one spare conductor of a size equal to the largest signal light conductor in the run, except neutral, shall be provided throughout the signal light system.

No more than two signal heads shall be on the same conductor run. When two signal heads are on the same conductor run, they must be of the same signal color sequence.

All signal light conductors shall be run continuously without splices from the terminal block located in a cabinet, compartment, or signal head, to a similarly located terminal block, unless otherwise specified on the Plans. Signal light conductors shall not run to a terminal block on a standard unless they are to be connected to a signal head that is mounted. All spare wires shall be placed on a special terminal block mounted in the controller cabinet for this purpose.

Five-conductor IMSA cable as specified shall be provided for all signal light circuits. This cable shall consist of red, orange, green, black and white insulated wires. The insulation color shall correspond as nearly as possible to the associated signal sequence color.

Permanent identification labels shall be attached to all controller and detector cabinet wiring to identify circuit and associated phase. Sequence color need not be identified if clearly indicated by conductor insulation color.

Wiring diagrams, detailing on one sheet all wires in the controller cabinet that are external to the controller itself, must be included with all signal systems. The diagrams must be complete and show all connections including switches, terminal block, connectors, relays and all other mechanisms in the cabinet. Other wiring for the controller shall be as required by the wiring diagrams and instructions furnished with the controller by the manufacturer.

Connection to each terminal of a pedestrian push button shall be by # 14 AWG single conductor in two-wire IMSA cable as required. The neutral for pedestrian push button circuits shall be separate from the signal light circuit neutral. Pedestrian push button circuits shall be limited to 12 volts AC or DC.

Conductors shall be pulled into conduit by hand. The use of winches or other power actuated pulling equipment will not be permitted. Powdered soapstone, talc, or other inert lubricants shall be used in placing conductors in conduit. When conductors are to be added to existing conductors in a conduit, all conductors shall be removed; the conduit shall be cleaned as provided in 660.14, and both old and new conductors shall be pulled into the conduit as a unit.

Where signal conductors are run in lighting standards containing high-voltage series street lighting conductors, either the signal conductors or the lighting conductors shall be encased in flexible or rigid metal conduit, to a point where the two type of conductors are no longer in the same raceway. Where telephone circuits are installed adjacent to signal and lighting circuits, the telephone conductors shall be encased in UL approved flexible metal conduit.

All wiring shall be installed in a neat and workmanlike manner. Conductors within fixtures or cabinets shall be cabled together with self clinching nylon cable ties, waxed lacing or other method permitted by the Engineer. Wiring within the controller cabinet shall be firm, neatly

arranged and laced, or enclosed in plastic tubing or raceways. The finished wiring shall present a neat, clean appearance so that individual wires may be easily traced to their terminal points. Unnecessary slack in the conductor wires will not be permitted. Wiring workmanship shall be subject to the approval of the Engineer.

The ends of wires which are to be attached to terminal blocks of the barrier screw type shall be provided with solderless terminals that meet the requirements of the National Electrical Code. These terminals shall be the pre-insulated positive grip type. The terminal crimping tool shall produce a transverse crimp on the wire. Wires which insert into a positive wire insert type terminal block will not require terminals. No more than two conductors shall be brought to any one terminal.

On all pin and receptacle type connections, the receptacle shall be on the line side of the circuit.

Conductor splices may be permitted only in the following types of circuits at the following locations:

- i. Loop conductor and lead-in wire in junction boxes at traffic detectors.
- ii. In modified traffic signal systems where shown on the Plans (low voltage only).

Splices, where permitted, may only be made at points of access in conductor runs or raceways (handholes, junction boxes, etc.) and no splices shall be permitted in controller cabinets. All splices, with or without connectors, shall be soldered by the pouring or dipping method, except that soldering of pressure connectors and terminals may be omitted provided the connectors and terminals are applied with the proper type tool as recommended by the manufacturer of the connector or terminal being applied. Finished connections and terminals shall comply with the requirements of Military Specification MIL-T-7928. Splices shall be insulated by one of the following methods:

- i. Cast insulation of self-curing epoxy resin which is compatible with the wire insulation to form a moisture resistant joint. The resin shall be resistant to weather, with aromatic, straight chain solvents, and shall not sustain combustion. The resin shall be cured into molds of dimensions suitable for the splice.
- ii. A minimum of two thicknesses of electrical insulating pad, composed of a laminate of 0.085-in. (2 mm) thickness of electrical grade polyvinyl chloride and a 0.125-in. (3 mm) thickness of butyl splicing compound with removable liner. Pads shall be applied to the splice in accordance with the manufacturer's recommendations. The ends of the applied pad shall be wrapped with the polyvinyl chloride tape half lapped over the conductor insulation.
- iii. Heat shrinkable insulating tubing shall be applied after completing the splicing procedure shown on the Plans. Insulation over the connector shall consist of a heat shrinkable, mastic lined, heavy wall polyolefin cable sleeve or cover, to which heat shall be applied at a temperature greater than 120EC until the sleeve or cover shrinks and covers the connector, and the mastic material has flowed completely around the cable to form a waterproof insulation.

Electrical tape shall be UL approved and be one of the following types:

- i. Self-fusing, oil and flame-resistant, synthetic rubber.
- ii. Pressure sensitive, adhesive, polyvinyl chloride, 0.007 inch (178 μ m) minimum thickness.

Where polyvinyl chloride tape is used for a final layer, an electrical insulating coating shall be used which shall be fast drying, resistant to oil, acids, alkalies and corrosive atmospheric conditions and compatible with the tape.

All splices shall be noted on the Plans and approved by the Engineer.

Unless otherwise specified, shown on the Plans or directed by the Engineer all signal system conductors shall run continuous and unspliced from terminal to terminal. Signal system conductors shall include but not be limited to power service wires, signal circuit conductors, controller panel wiring, controller wire harness, loop lead-in and loop wire. System interconnect cable shall be continuous and unspliced from controller cabinet terminal to controller cabinet terminal.

660.17-POWER SERVICE:

The power connection shall be made to a single-phase 120/240 volt, three-wire, 60Hz, AC supply. The approximate location of utility service points may be shown on the Plans; however, the Contractor shall determine the exact location of the power supply. Each signalized intersection or control unit shall have a separate power service and no more than one power service shall be utilized per intersection or unit.

Electrical service installation and materials shall conform to the requirements of the serving utility. The service equipment shall be installed as soon as possible to enable the utility to schedule work well in advance of the completion of the project.

Enclosed circuit breakers, external to the controller cabinets, shall be provided in the power service. Four single-pole breaker units rated at 30 amps each are required. The breaker enclosure shall be weathertight with a top hinge cover, hasp for sealing cover and provisions for padlocking the cover. The Contractor shall provide an all-weather padlock and two sets of keys with each power service. Circuit breakers shall be approved and listed by the Underwriter's Laboratory.

Breakers # 1 and 2 shall provide power for the signal control equipment (controller cabinet). Specifically circuit breaker # 1 shall power the controller circuits and # 2 shall power the flasher and associated circuitry. These two circuits must be of the same polarity. Breakers # 3 and 4 are spare terminals to accommodate future lighting circuits and breakers 3 and 4 must be of opposite polarity to provide a 240 volt circuit.

The Contractor shall make all arrangements for connection to the power supply and shall obtain a meter and meter socket from the power company at the time these are required. The Contractor shall furnish, install, pay installation fee and provide all materials necessary for the power connection not provided by the power company.

All external power service wiring from the service head or service point on shall be enclosed in rigid metal conduit; this includes equipment ground wires.

When complete and in place the power service shall provide in the signal controller cabinet, two separate fused 120 VAC, 60 Hz power sources rated at 30 amps each of the same polarity or phase.

660.18-TESTING:

660.18.1-Operational Field Tests: Upon completion of the installation of a traffic signal system, operational field tests shall be run on each and every part of the system. After the initial field tests are run satisfactorily, the Contractor shall conduct a continuous 12-hour operating test for approval.

Upon successful completion of the 12-hour test and with the approval of the Engineer, a 30-day test period will then be initiated. Final acceptance of an installation will not occur until 30 days of system operation are completed and termed satisfactory by the Engineer.

A final inspection may be conducted by the Division at any time prior to completion of the 30-day test. At the option of the Engineer, equipment found to be defective during this inspection may warrant the renewal of the full or any part of the operational test period.

In addition, the Contractor shall be responsible for equipment malfunctions that occur during any test period. The Contractor shall repair or replace any defective equipment within 24 hours after being notified by the Engineer. After the repair has been effected, the Engineer may at his option renew any or all of the operational test period.

660.19-METHOD OF MEASUREMENT:

660.19.1-Signal Controllers: Signal controllers shall be measured as a complete unit in place by intersection or control location. This item shall consist of the complete electrical mechanism for controlling the operation of traffic control signals, including the timing mechanism and all necessary auxiliary equipment mounted in a cabinet or other enclosure.

Included under signal controllers shall be traffic adjusted master controllers and computers and associated equipment. This item shall include cabinets or other enclosures as required.

660.19.2-Traffic Detectors: Traffic detectors shall be measured per unit complete and in place, mounted in a cabinet or enclosure as required. This item shall consist of the detector tuning unit only. Roadway traffic sensors such as loops, probes, etc. shall be considered "Miscellaneous Signal" items. Cabinets or other enclosures as required for the detector tuning units shall also be included in "Miscellaneous Signal".

660.19.3-Signal Sections: Signal heads shall be measured complete and in place by signal head section. Red, yellow, green, arrow and walk-don't walk signal sections shall be considered complete when assembled on the support structure in accordance with the signal head configuration shown on the Plans. Both vehicular and pedestrian heads shall be included in this item. In addition, this item shall include all the necessary hardware for mounting the signal heads to the support structures. Optical programming shall be included in this item.

660.19.4-Signal Supports: Signal supports shall be measured as a complete unit in place, per mast arm structure or per pole support, including foundation. This item includes guys, messenger cable and anchor bolts for support structures, but does not include such items as controller cabinet mounting brackets and signal head mounting hardware covered in other sections.

660.19.5-Junction Boxes: Junction boxes shall be measured as a complete unit in place. This item includes aggregate base, concrete, iron frame and cover as required. All junction boxes shall be included under this item, both units constructed for the signal system as well as those required for the signal interconnect.

660.19.6-Signal Interconnect: Signal interconnect shall be measured as a complete unit in place per interconnected system. This item includes most of the materials and construction related to the signal interconnection system only. Supports and wire-ways constructed

primarily for other purposes shall not be included in this item. Conduit, support structures, support hardware wire and messenger cable installed solely for the interconnect system shall come under this item. This item shall not include coordinating units or interconnect system junction boxes.

660.19.7-Miscellaneous Signal: Miscellaneous signal items as required to complete a traffic signal system in accordance with the Plans or these Specifications shall be measured complete in place by intersection or control location. This item shall include but not be limited to power services, electrical conduit, vehicle sensors (loops, probes, etc.), pedestrian push buttons and all wiring, appurtenances and work not included in other Contract items.

660.19.8-Signal Removal: Signal removal shall be measured as a complete unit by intersection. It shall include the furnishing of all necessary equipment and labor to adequately remove the existing signal equipment as necessary to meet the requirement of the Plans. The existing roadway and traffic control devices shall be maintained or revised as required during construction to assure the safe and expedient movement of traffic (See 660.4).

660.19.9-Priority Control System Emitter: Bid includes the furnishing, installation (mounting of EO on vehicle/structure), and testing of a P.C.S. emitter and measured per unit complete and in-place. This item shall include driver's training which will consist of one (1) hour of system management to the receiving agency, per intersection, by a qualified representative as designated by the P.C.S. manufacturer.

660.19.10-Priority Control System Detector: Bid includes the furnishing, installation and testing (1) P.C.S. detector, the mounting of this unit, all necessary wiring, card rack and interface unit, confirmation light and all other materials to operate the P.C.S. intersection system. This item shall be measured complete and in-place by intersection.

660.20-BASIS OF PAYMENT:

660.20.1-General: When accepted as complete, the quantities determined as provided above will be paid for at the contract unit price bid for the items listed below, which prices and payments shall be full compensation for furnishing all materials and doing all the work prescribed in a workmanlike manner, including excavating, backfilling, replacing sidewalks and pavements, replacing curb and gutter, disposal of waste and debris and for furnishing all labor, equipment, tools, and incidentals necessary to complete the work.

Unit bid prices shall be submitted as indicated on the Plans per code unit, type or intersection number.

660.20.2-Traffic Detectors: Pay item codes shall be as follows:

- (LPS)-Loops
- (PBS)-Probes

660.20.3-Signal Sections: Pay item codes shall be as follows:

- (V-8)--8" ((V-203) --203 mm) Vehicle Signal Sections (R, Y or G)
- (V-12)--12" ((V-305) -- 305 mm) Vehicle Signal Sections (R, Y, G or ARROW)
- (V-8P)--8" ((V-203) --203 mm) Programmed Vehicle Signal Sections (R, Y or G)
- (V-12P)--12" ((V-305) -- 305 mm) Programmed Vehicle Signal Sections (R, Y, G or Arrow)
- (P-9)--9" ((P-229) -- 229 mm) Pedestrian Signal Sections (W-DW)
- (P-12)--12" ((V-305) -- 305 mm) Pedestrian Signal Sections (W-DW)

660.20.4-Signal Supports: Pay item codes shall be as follows:

- (Type)--Poles and Mast Arms
- (PED)--Pedestal

660.20.5-Junction Boxes: Pay item codes shall be as follows:

- (Type)--H or L

660.20.6-Signal Removal: Payment for traffic signal removal shall be in accordance with one of the following:

- i. If there is a pay item in the Contract for Signal Removal, the Contractor shall remove the equipment as specified and payment shall be one lump sum, per intersection basis.
- ii. If there is not a pay item in the Contract for Signal Removal, and removal is required for completion of the Contract, existing signal equipment shall be removed by the Contractor unless otherwise specified. No additional compensation will be paid and removal work as well as salvage value of equipment if applicable, shall be considered in the bid price for "Miscellaneous Signal" items.

Removal and disposition of salvaged equipment shall be in accordance with 660.5 of these Specifications.

660.21-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
660001-*	Signal Controller	Lump Sum
660002-*	Traffic Detector, "type"	Each
660003-*	Signal Section, "type"	Each
660004-*	Signal Support, "type"	Each
660005-*	Junction Box, Type "type"	Each
660005-*	Adjust Junction Box, Box Number "number"	Each
660006-*	Signal Interconnect	Lump Sum
660007-*	Miscellaneous Signal	Lump Sum
660007-*	Miscellaneous Signal Loop Number "number"	Lump Sum
660008-*	Signal Removal	Lump Sum
660010-*	Priority Control System Detector, "OE"	Each
660010-*	Priority Control System Emitter, "code"	Each

* Sequence number

SECTION 661

TRAFFIC SIGNS AND DELINEATORS

661.1-DESCRIPTION:

This item shall consist of the fabricating, furnishing, and erecting of a complete system of traffic signs and delineators in accordance with the requirements of the Plans and of these specifications. All details not specified or not shown on the Plans shall conform to the details and requirements set forth in the following specifications and publications:

- i. *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, latest issue, including revisions, American Association of State Highway and Transportation Officials (AASHTO).
- ii. *Manual on Uniform Traffic Control Devices for Streets and Highways*, latest issue, including revisions, as printed by the Federal Highway Administration, U.S. Department of Transportation. (Referred to as the MUTCD).
- iii. *Standard Alphabets for Highway Signs*, as printed by the Federal Highway Administration, U.S. Department of Transportation. *West Virginia Manual of Uniform Traffic Control Devices, Fabrication Details*, latest issue, including revisions. (Referred to as the Fabrication Manual).

661.2-MATERIALS:

The criteria for sampling, inspection, and acceptance of signing material are documented in MP 661.02.40.

661.2.1-Aluminum:

661.2.1.1-Sign Panels: Panels shall be of the type specified in the Plans and shall meet the following Specifications:

661.2.1.1.1-Sheets: Aluminum for sheet sign panels shall be Alloy 6061-T6, ASTM B 209 or Alloy 5052-H38, and shall meet the ASD fabrication requirements for mill products. For signs using porcelain enamel background on sheet aluminum, the Contractor shall use an alloy which has been recommended by the manufacturer and approved by the Engineer, specially designed and prepared for the application of porcelain enamel.

661.2.1.1.2-Extrusions: Aluminum for the extruded panels shall be Alloy 6063-T6, ASTM B 221.

661.2.1.2-Structural Shapes: Structural shapes, rolled or extruded, used for sign framing or mounting brackets shall be of Alloy 6061-T6 or Alloy 6063-T6, ASTM B 211 or B221.

661.2.1.3-Hardware: Aluminum for hex lock nuts for use with post clip bolts and stitch bolts shall conform to Aluminum Alloy 2017-T4. Lock nuts shall have anodic coating conforming to MIL-A-8625. Thread fit shall be as recommended by the manufacturer.

Flat washers for use with stitch bolts and post clip bolts shall conform to current ASTM B 209, aluminum alloy 2024-T4 or Alclad 2024-T4. Washers shall be used with all lock nuts and stitch bolts.

Spring, lock-washers shall conform to current ASTM B 211, Alloy 7075-T6, aluminum alloy bars, rods and wire.

Post clips shall conform to current ASTM B 108, Alloy 356-T6, aluminum base alloy permanent mold castings.

Post clip bolts and stitch bolts shall conform to current ASTM B 211, Alloy 2024-T4, aluminum alloy bars, rods and wire. Bolts shall have an anodic coating and shall be chromate sealed in accordance with MIL-A-8625.

Nuts, ¼ inch (6 mm) top and under, and all bolts and machine screws shall be made from Alloy 2024-T4, ASTM B 211. Nuts 5/16 inch (8 mm) and over, shall be Alloy 6262-T9, ASTM B 211. All nuts, bolts and machine screws shall have an anodic coating with a chromate seal conforming to MIL-A-8625.

U-bolts shall be fabricated of 2024-T4 aluminum alloy conforming to ASTM B 211 and connecting clips shall be fabricated of 6061-T6 aluminum alloy conforming to ASTM B 221.

661.2.1.4-Demountable Copy: Demountable copy, including all items of legend and border, shall be fabricated of aluminum 0.040 inch (1 mm) thick sheet conforming to ASTM B 209, Alloy 5052 H38.

Demountable copy shall be coated with white type II high-intensity sheeting unless another color is specified on the Plans.

Demountable legend shall be in accordance with the current MUTCD. Combined upper and lower case alphabets shall be Series E modified by widening the stroke width to approximately one-fifth of the letter or numeral height of the upper case alphabet. Capital alphabets shall be Series D modified by widening the stroke width to approximately one-fifth of the letter or numeral height.

661.2.1.5-Rivets: All rivets used for the attachment of demountable copy shall be blind, dome head, self-plugging or pull through type mandrel, made of aluminum alloy that will not produce streaking or discoloring of the sign face. The manufacturer of the rivets shall determine the method of rivet application.

All rivets used for the attachment of delineators shall be blind, dome head, self-plugging or pull through type mandrel. The rivets shall be an aluminum alloy.

661.2.2-Steel: Hardware-Low carbon steel bolts and nuts shall be in accordance with ASTM A 307. Manufacturer's markings on A 307 bolts will not be required. High strength steel bolts, nuts, and washers shall be in accordance with ASTM A 325. Stainless steel bolting materials shall be in accordance with ASTM A 320 and shall be of the type recommended by the manufacturer of the material. Galvanizing, if required, should conform to ASTM A 153. Cadmium plating, if required, should conform to ASTM B 766, Class 12 (0.47 mils) (12° m).

Material used for banding and buckles, clamps, bolts, and lockwashers shall be stainless steel.

Steel clamps for attaching sign to tubular supports shall be of two types. Type I, a light duty clamp shall be capable of withstanding loads equivalent to a sign area of 20 square feet

(2 square m) and shall be fabricated from material meeting the requirements of ASTM A 575 of A 576, Grade 1020. Type II, a heavy duty clamp, shall be capable of withstanding the loads equivalent to a sign area of 80 square feet (7.5 square m) and shall be fabricated from material conforming to the requirements of ASTM A606, A607 or ASTM A242.

Steel shapes and plates used as mounting hardware or as sign framing shall be Grade 1020 conforming to ASTM A 575 or A 576.

Steel for delineator supporting brackets shall be commercial quality steel galvanized in accordance with ASTM A 123.

661.2.3-Enclosed Lens Reflective Sheeting: The reflective sheeting shall conform to 715.9.2.1.

661.2.4-Reflex Reflectors: The reflectors shall conform to 715.9.2.4.

661.2.5-Delineators: The soiled anchored plastic delineator post or guardrail mounted plastic delineator post installed shall be a model post from the latest approved products listing (APL) for such. The posts supplied shall also meet the requirements noted on the APL. Unless otherwise noted, color shall be either white with white on the front or yellow with fluorescent yellow sheeting on the front. All soil anchored, guardrail mounted, and xs delineators shall utilize either type ASTM IX or TYPE ASTM XI Reflective Sheeting. All B-1 delineators shall be 8" x 12" and utilize type ASTM III Sheeting.

Mounting hardware for guardrail mounted plastic delineator posts on steel posts – self tapping screws shall be pan head and shall be manufactured of 410 or 410C stainless steel with a square drive. The screws shall meet the dimensional requirements of SAE J78. The fender washers shall be manufactured using 18-8 stainless steel. Mounting hardware for guardrail mounted plastic delineator posts on wood posts – the lag screws and fender washers shall be manufactured using low carbon steel. The bolts shall be hot dip galvanized per ASTM F2329 or in accordance with Class C of ASTM A 153. The bolts shall meet the dimensional requirements of ASME B18.2.1. Galvanizing for the fender washers shall be Class 25, Type 1, per ASTM B695.

Anchors used for surface mounted tubular delineators to concrete surfaces shall be self threading anchors meeting the requirements described herein, and shall exhibit performance and durability equal to or greater than ITW Redhead LDT Anchors. Anchor bodies shall be made of hardened carbon steel, plated with zinc or equal corrosion resistant coating. The anchors shall have a finished hex washer head with anti-rotation serrations to prevent anchor back-out. The head of the anchor shall be stamped with a length identification code for easy inspection. The anchors shall be installed with carbide tipped hammer drill bits made in accordance with ANSI B212.15. The anchor diameter shall be based on the pre-drilled holes provided in the marker base. The overall anchor length shall be sufficient to provide a minimum embedment depth of two inches into the concrete. All other components shall be those supplied and recommended by the manufacturer.

661.2.6-Inks: Inks for reflective sheeting shall meet the requirements of Section 711.13.

661.2.7-Nylon Washers: Nylon washers shall be of commercial grade.

661.2.8-Route Markers for Guide Signs: Route marker shields to be mounted on guide signs shall be fabricated using aluminum alloy 6061-T6 or 5052-H38, ASTM B209. The minimum thickness of the aluminum sheet shall be 0.040 inches (1.02 mm). All shields shall be attached to the guide signs using approved rivets.

661.2.8.1-Reflective Guide Signs: U.S. and State route marker shields shall have white encapsulated lens, reflective sheeting background, with black nonreflective sheeting numerals.

Interstate shields shall have red and blue encapsulated lens, reflective sheeting background, with white numerals and border.

661.2.9-Nonreflective Sheeting: Nonreflective sheeting shall conform to the requirements of 715.9.2.2.

661.2.10-Encapsulated Lens Reflective Sheeting: The reflective sheeting shall conform to 715.9.2.3.

CONSTRUCTION METHODS

661.3-FABRICATION:

661.3.1-General: Fabrication of all sign parts shall be in accordance with the dimensions shown on the Plans and approved shop drawings. Work shall be done in a uniform workmanlike manner.

661.3.2-Shop Drawings: If not as shown on the Plans, the Contractor shall submit to the Engineer for approval scale drawings, eight copies, of those signs having variances, showing arrangement and spacing of all letters, symbols and borders for all signs having demountable legend, attachment of sign panels, and copies of all layout templates for silk screen signs.

If a method of attaching sign panels to supports is other than as shown on the Standard Drawings, the Contractor shall submit to the Engineer for approval detailed drawings, eight copies, showing the proposed method of attaching each type of sign panel to each type of support.

661.3.3-Metal Cutting and Refinishing: Panels one-half inch (13 mm) thick or less shall be cut by one of the following methods: sheared, blanked, sawed or milled. Panels over one-half inch (13 mm) thick shall be sawed or milled. Re-entrant cuts shall be filleted by drilling prior to cutting. No flame cutting will be permitted. Cut edges shall be refinished to present a true and smooth edge that is free from burrs and ragged breaks. Holes shall be made in such a manner as not to affect the finished surface.

661.3.4-Sign Panel Preparation: Prior to application of ink or reflective sheeting to the sign panels, they shall be given a chemical conversion treatment meeting the requirements of ASTM B449, Class 1 or 2.

All fabrication, including cutting, welding, riveting, and punching of holes other than mounting holes for demountable letters, numerals, symbols and borders, shall be completed

prior to surface preparation. However, it will be permissible to weld studs to panels after application of sheeting.

661.3.4.1-Handling: Sign panels shall not be handled, except by mechanical devices or clean canvas gloves, between all cleaning and etching operations and the application of reflective sheeting. There shall be no opportunity for metal to come in contact with grease, oils, or other contaminants after cleaning and etching and prior to the application of the background material.

661.3.5-Application of Reflective Sheeting: The application of reflective sheeting to the backing material shall be in full accordance with instructions of the manufacturer of the reflective sheeting used.

Reflective sheeting shall cover one entire side of the flat sheet blank, which side shall be the sign face. When applied to extruded sign panels, reflective sheeting shall be rolled over each edge of the extrusion $\frac{1}{4}$ inch (6.35 mm) (plus $\frac{1}{16}$ inch (1.6 mm), minus 0 inch (mm)) to prevent an opened surface on the sign face.

Reflective sheeting shall be applied mechanically in a manner specified by the manufacturers of the reflective sheeting.

Signs 48 inches (1.2 m) and less on the shorter side shall be covered by a single piece of reflective sheeting. On signs larger than 48 inches (1.2 m), adjacent pieces shall be carefully matched for color to provide uniform reflective quality. All seams shall be straight and the edges of adjustment pieces shall be overlapped a minimum of $\frac{3}{16}$ inch (5 mm) the length of the seam.

661.3.6-Application of Copy:

661.3.6.1-Demountable Copy: Each letter, symbol and border shall be supplied with mounting holes and shall be secured to the sign surface with approved rivets. The use of tape, glue or other substance to secure the copy to the sign face during fabrication or in its final form, other than approved rivets, will not be allowed.

Demountable letters, digits, borders and alphabet accessories shall be attached flush against sign faces after background material has been applied.

Spacing of all legends and borders shall be as specified with an allowable tolerance of plus or minus 2 percent on any individual measurement as shown on the Plans or approved shop drawings. A sufficient number of rivets shall be used to securely fasten demountable legends and borders to sign panels.

661.3.6.2-Screen Processing: All legends or borders on signs, except demountable letters or borders, shall be applied by screen processing, reverse screen processing, or cut out letters after the reflective sheeting is applied to the panels. All screening shall be done in a workmanlike manner and as recommended by the manufacturer of the reflective sheeting. The Contractor may apply legends and borders to signs having reflectorized backgrounds by equally effective methods after approval of the Engineer. All legends, borders and backgrounds shall be of the color specified and placed on the sign as shown on the Plans.

The screening shall be done in a manner which results in a uniform color and tone, with sharply defined edges of legend and border and without blemishes on the sign background.

Where screening is required, free hand painting will not be permitted. Proper size screen mesh shall be used in reverse screening to ascertain that the finished colors match the prescribed Standard Interstate Colors.

661.3.7-Sign Panels:

661.3.7.1-Flat Sheet: Flat sheet signs shall be fabricated of a single piece of sheet material without joints. The height or width of the sign shall be within plus or minus 5/8 inch (3 mm) tolerance of the dimensions indicated on the Plans. Corner radii shall be within plus or minus 1/16 inch (1.6 mm) tolerance of the dimensions shown on the Plans.

Panels shall have dimensions and corner radii in accordance with the Standard Details and shall be punched only with the holes necessary for proper mounting. Signs shall be free of buckles, warp, dents, and burrs prior to the application of reflective sheeting or other background material. Dimples or indentations shall not be noticeable from a distance of 10 feet (3 m) normal to the sign.

{ENGLISH}

	Thickness Based On	
Width (Inches)	Single Post Mounting (Inches)	Two Post Mounting (Inches)
Up to 30 Inclusive	0.080	----
31 to 37 Inclusive	0.100	----
38 to 47 Inclusive	0.100	0.800
48 to 60 Inclusive	0.100	0.100
61 to 72 Inclusive	0.100	0.100

{METRIC}

	Thickness Based On	
Width (mm)	Single Post Mounting (mm)	Two Post Mounting (mm)
Up to 750 Inclusive	2.03	----
751 to 925 Inclusive	2.54	----
926 to 1 175 Inclusive	2.54	2.032
1 176 to 1 500 Inclusive	2.54	2.54
1 501 to 1 800 Inclusive	2.54	2.54

Panels shall have dimensions and corner radii in accordance with the Standard Drawings and shall be punched only with the holes necessary for proper mounting. Signs shall be free of buckles, warp, dents, and burrs prior to the application of reflective sheeting or other background material. Dimples or indentations shall not be noticeable from a distance of 10 feet (3 m) normal to the sign.

661.3.7.2-Extruded Panels: Extruded panel signs shall consist of extruded aluminum channel sections, bolted together at the flanges, to form a surface of the length, width, and depth required, to which the legend, border, and background have been applied.

The panel sections shall be of the shape, dimensions, and weight shown on the Standard Drawings. This section as shown is nominal and an alternate extruded panel section of

equal or greater section modulus and having dimensions suitable to utilize hardware as shown on the Standard Drawings may be supplied by the Contractor upon receipt of the written approval of the Engineer. No splicing of sections will be permitted.

The sections shall be within the established commercial tolerances of the aluminum industry.

Each panel shall be flat and true within ¼ inch (6.35 mm) tolerance on an 8 feet (2.4 m) length, with proportionately greater allowance on longer lengths. Flatness across the face of each panel shall be limited to 0.004 inch per inch (100 µm per 25.4 mm) of width.

The panels shall be assembled in the shop and firmly bolted to form a sign of the length and width required. Before bolting, the webs of the panels shall be in the same plane to form a smooth and uniform surface and the ends shall be free from projections. Adjacent panels shall be color matched both day and night.

It is intended that the sign shall be fabricated as a single unit. If the largest signs cannot be shipped as a single unit, they may be sectionalized as approved by the Engineer. All signs must be completely shop assembled but if field joining of panels is permitted, legend and border units which overlap the joining must be removed and replaced in the field.

661.3.7.3-BLANK

661.3.7.4-Clear Coating and Edge Sealing: Signs to which reflective sheeting has been applied shall not be clear coated, except when it is recommended by the manufacturer of the sheeting. Edge sealer shall be applied to all splices and edges as recommended by the sheeting manufacturer.

661.3.7.5-Packaging: All signs shall be protected by packaging during shipment and storage. The packing shall be adequate to prevent damage to any part of the sign, including any demountable legends or borders. Before packaging, all signs shall be free of moisture and all paints shall be thoroughly dry. Adhesive tapes shall not be applied to any sign surfaces. All packaged signs shall be kept entirely dry.

Signs delivered for use on a project shall be stored off the ground and under cover in a manner meeting the approval of the Engineer.

Signs reflectorized with encapsulated lens sheeting shall be packaged and stored as specified, with careful consideration to avoid friction or rubbing between signs; shall be kept dry and at an ambient temperature not to exceed 150° F (66° C); and shall be stored on edge to prevent excessive pressure on the surface of the sheeting.

661.3.8-Application of Nonreflective Film: Nonreflective film shall be mechanically applied and processed in accordance with the recommendation of the film manufacturer.

Nonreflective sheeting shall be clear coated and force cured as recommended by the manufacturer of the sheeting.

661.4-ERECTION:

661.4.1-General: All signs and delineators shall be erected at the points designated on the Plans or by the Engineer in accordance with these Specifications and in reasonable close conformity to the locations, elevations and angles shown on the Plans or established by the Engineer.

Before starting the erection of signs, the Contractor shall establish the location of each sign in accordance with the Plans or as directed by the Engineer, and mark each sign site with construction stakes, having clearly indicated the sign number of the respective sign. The Contractor shall furnish stakes, paint, other materials and labor for performing the locating and staking as described. When the sites have been staked and are ready for inspection, the Contractor shall inform the Engineer, who will check and approve the site or make necessary changes. Centerline station information will be furnished to the Contractor by the Engineer.

The Contractor shall take full responsibility for checking all cross sections at approved sign locations to determine final support lengths. The supports shall not be fabricated until such time as the above measurements prove acceptable to the Engineer. Upon approval of location and support length, the Contractor shall erect the proper sign at the staked location and complete all work.

After installation of the signs, they shall be inspected at night by the Engineer. If specular reflection is apparent on any sign, its positioning shall be adjusted by the Contractor at his expense to correct this condition.

661.4.2-Location of Ground Mounted Signs: Signs shall be oriented to minimize or eliminate specular reflection.

Ground mounted signs longer than 48 inches (1.2 m) shall normally be mounted at 93 degrees away from the direction of, and facing, the traffic that they are intended to serve.

On curves, structural posts shall be located and erected so as to face the sign at an angle of 85 degrees from the line of sight. The line of sight is defined as the line between the center of the sign and the centerline of the traffic lane adjacent to the sign. Its length in feet is equal to 50 (meters is equal to 0.6) times the letter height, in inches (mm), of the smallest legend in the major line of copy. (Example: 50 by 12 inches letter equals 600 feet in the line of sight). (Example: 0.6 by 300 mm letter equals 180 meters in the line of sight).

Ground mounted signs shorter than 48 inches (1.2 m) shall normally be mounted approximately at right angles to the direction of, and facing, the traffic that they are intended to serve.

661.4.2.1-Multi-lane Roadways: Signs on the thru roadway and on ramp entrances and exits at the thru roadway shall have the following clearance from the roadway:

In ground installations, the signs shall be erected at a height, measured from the edge of the pavement to the bottom of the sign, as indicated in the following table, unless otherwise specified on the Plans. If, however, a secondary sign is mounted below a guide sign, the major sign shall be at least 8 feet (2.4 m) and the secondary sign at least 5 feet (1.5 m) above the level of the pavement edge unless otherwise specified on the Plans.

SIGNS	HEIGHT (Ft)(m)	MEASURED TO
Route Marker Assemblies	7 (2.1 m)	Bottom of Lowest Sign
Regulatory Signs	7 (2.1 m)	Bottom of Sign
Warning Signs	7 (2.1 m)	Bottom of Sign
Truck Weight Station Signs	7 (2.1 m)	Bottom of Sign
All other signs	7 (2.1 m)	Bottom of Sign

Overhead signs shall provide a clearance of not less than 17 feet (5.2) over the entire width of the pavement and shoulders.

For roadways with no curbs or mountable curbs, the minimum horizontal clearance to any roadside sign or overhead sign structure shall be 4 feet (1.2 m) beyond the edge of the paved roadway shoulder, to either the right or left. Where there is an unmountable curb or guardrail, the horizontal clearance shall be at least 2 feet (600 mm) beyond the face of the curb or guardrail.

Mileposts shall be located in line with delineators and at a height of 4 ½ feet (1.350 m), measured between the grade of the pavement and the bottom of the sign panel.

661.4.2.2-Other Roadways: Signs on frontage roads, roads or streets affording access to the multi-lane roadway, and on ramps (other than at the multi-lane roadway) shall have the following clearance from the roadway.

The bottom of the roadside signs shall be 7 feet (2.1 m) above the level of the roadway edge. If however, a secondary sign is mounted below the major sign, the secondary sign shall be at least 6 feet (2.1 m) above the level of the pavement edge.

When signs are placed over the pavement, a clearance of 17 feet (5.2) shall be provided between the surface of the pavement and the bottom of the lowest part of the sign structure.

Roadside signs and overhead structures shall be placed at the edge of the road shoulders and normally shall have a horizontal clearance of two to twelve feet (0.6 to 3.6 m) beyond the edge of the pavement or travelway, except where conditions do not permit, or where otherwise shown on the Plans. Where a raised curb, guardrail, or paved shoulder is present, a sign shall ordinarily be placed with its nearest edge at least 2 feet (0.6 m) outside such curb line, guardrail, or paved shoulder.

661.4.3-Location of Delineators: The reflective units of the delineators shall be positioned to be clearly visible for a distance of 1,000 feet (300 m) wherever possible during night time under normal weather and atmospheric conditions when illuminated by the upper beam of standard automobile headlights with the vehicle located in the right hand traffic lane approaching the delineator.

Reflective units shall be attached with aluminum rivets of suitable length as follows:

- i. One white unit shall be attached to posts or brackets located along the right side of the main roadway.
- ii. One white unit shall be attached to posts or brackets along the right of the main roadway through interchange areas and on the right side of the connecting roadways and ramps through the interchange area.
- iii. One amber unit shall be attached to posts or brackets along the left side of the connecting roadways and ramps as necessary through the interchange area.
- iv. Two white units shall be attached vertically to all posts along the right side on acceleration and deceleration lanes.
- v. Two amber units shall be attached vertically on each face of posts or brackets located in the center of dividers less than 8 feet (2.4 m) in width on ramps.

Post mounted delineators shall be supported by flanged channel bar posts of the material, design, and dimensions specified in 657.

When the required longitudinal spacing of posts falls on a structure, delineator brackets, Type A, Type B, or Type C shall be installed instead of a post as shown on the Standard Drawings. Bracket mounted delineators shall be supported on aluminum or steel brackets of the materials, design, and dimensions in accordance with these Specifications and the Standard Drawings. Type A delineator brackets shall be used on bridge railing with horizontal members having a round section. Type B delineator brackets shall be used on bridge railing with horizontal members having a rectangular section. Type C delineator brackets shall be used on bridges having no horizontal bridge rail members.

When the delineators are located above the top rail, the bracket shall be mounted on the fascia side of the railing. The required height of the top of the bracket shall be measured from the surface of the roadway at the edges of the traveled lane as projected from the adjacent fill sections, or as indicated by the pavement edge markings. Brackets shall be fastened to the member of the bridge rail by means of a stainless steel band and hardware as indicated on the Standard Drawings.

Delineators, three per unit or nine per unit, shall be attached as shown on the Standard Drawings to the post at the approach end of channelizing islands within the roadway or at other locations as designated by the Engineer.

661.4.4-Attaching Sign Panels:

- i. Flat sheet: Flat sheet signs shall be attached to supports, after the supports are erected, using a nylon washer and a flat steel washer between the sign face and bolt head, a lock washer between U channel posts and nuts as shown on the Standard Drawings. Bolts, nuts and flat and lock washers shall be cadmium plated.
- ii. Extruded Panel: After the supports are firmly set, the signs shall be mounted as shown on the Standard Drawings and Plans or as recommended by the manufacturer of the panels. All panels shall be horizontal, the faces shall be flush within commercial tolerances, and the face of the sign shall be flat. All hardware used in erection of the sign shall conform to the Standard Drawings and these Specifications. Any appreciable buckling, warping, or other defects in the panels shall be cause for rejection of the entire sign.

661.4.5-Final Clean Up: Before final inspection, the Contractor shall perform any touching up on paint finishes, cleaning of exposed sign and support surfaces, and leveling and repair of the site as may be deemed necessary by the Engineer to insure the effectiveness and neat appearance of the work.

661.5-METHOD OF MEASUREMENT:

661.5.1-Signs: Measurement for payment for all types of signs will be based on the area in square feet (meters) of the sign faces. Areas shall be calculated to the nearest 0.01 square foot (m) for each sign and to the nearest square foot (m) for the total quantity. The area of any sign shall be the area of the smallest rectangular, triangular or trapezoidal shape that will encompass the entire sign; except for extruded panel signs, which shall have an area equal to the smallest combination of rectangular, triangular, or trapezoidal shapes that constitute the sign.

661.5.2-Delineators: Measurement for payment for delineators will be based on the actual number of delineators necessary to complete the work.

661.5.3-Delineator Brackets: Measurement for payment for delineator brackets will be based on the actual number of delineator brackets necessary to complete the work.

661.5.4-Installation of Reusable Signs: Measurement for payment for installation of reusable signs will be based on the actual number of reusable signs that are designated on the Plans, and are necessary to complete the work. This quantity, shall be plan quantity, unless the Engineer determines the plan quantity to be in error and changes the quantity of reusable signs to be installed.

661.6-BASIS OF PAYMENT:

The quantities, determined as provided above, shall be paid for at the contract unit price for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all work prescribed in a workmanlike and acceptable manner, including all tools, equipment, supplies, and incidentals necessary to complete the work. All incidental work and materials for which no basis of payment is provided will be considered as completely covered by the prices bid for the items included in the Contract.

661.6.1-Signs: Payment will be made at the contract unit price per square foot (m) of sign for the appropriate type of sign. This price shall be full compensation for fabricating, furnishing, and attaching the sign or sign assembly to the post or posts as shown on the Plans or specified. It shall include the furnishing of the aluminum sign panels; all framing, bracing, attachment, and connections necessary to attach the signs to the supports; furnishing and applying the reflective sheeting, or other sign facing material; furnishing and applying the demountable copy or the process material and screens for screening the legend and border to the sign face as required by the Plans; furnishing all hardware required for the above; and all labor, equipment, tools, and incidentals necessary to complete the work. This item does not include posts.

661.6.2-Delineators: Payment will be made at the contract unit price per reflective unit for each color actually installed. The price shall include fabrication, furnishing and installing the reflective unit, suitable length aluminum rivets, aluminum rivet collar, and all other material, labor, equipment, and tools necessary to complete the installation. This item does not include the post or Type A, Type B, or Type C brackets.

Payment will be made at the contract unit price per installation for soil anchored plastic delineator post, guardrail mounted plastic delineator post, or surface mounted plastic delineator posts, hardware and labor. The construction details, material and labor will be in accordance with the applicable sections of standard specification sections 657 and 661, The Standard Details Book, Volume II-Signs, Signals, Lighting, and Marking (latest edition), and the Contract Plan Special Details.

661.6.3-Delineator Brackets: Payment will be made at the contract unit price per bracket for each type actually installed, which price shall include the fabrication, furnishing and

installing of the bracket, all necessary hardware and all other materials, equipment, labor and tools necessary to complete the installation.

661.6.4-Installation of Reusable Signs: Payment will be made at the contract unit price per installation of reusable sign. This price shall be full compensation for transporting the sign to the nearest possible location shown on the Plans and erection of the sign, including furnishing the necessary hardware and all other material, labor, equipment and tools necessary to complete the installation.

661.7-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
661001-*	“size” Flat Sheet Sign	Square Foot (Meter)
661002-*	Extruded Panel Sign	Square Foot (Meter)
661004-*	Delineator, Reflex Reflector, Single,	Each
661004-*	Delineator, Encapsulated Lens, Single,	Each
661006-*	Delineator, Nine Per Unit,	Unit
661007-*	Delineator, Three Per Unit,	Unit
661008-*	Delineator Bracket, Type “type”	Each
661011-*	Installation of Reusable Sign	Each
661013-*	Plastic Delineator Posts, “color, type”	Each

* Sequence number

SECTION 662 ROADWAY LIGHTING

662.1-DESCRIPTION:

This item shall consist of manufacturing, furnishing and installation of a lighting system in accordance with the requirements of the Plans and of these Specifications. All details not specified or not shown on the Plans shall conform to the details and requirements set forth in the following specifications and publications:

- i. *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, latest issue, *American Association of State Highway and Transportation Officials (AASHTO)*.
- ii. *National Electrical Code*
- iii. *American National Standards Institute*

In addition to the Plans, these Specifications and the above noted publications, any applicable local code shall apply.

662.2-MATERIALS:

Materials furnished by the Contractor shall be of new stock, shall be the product of the reputable manufacturers of lighting equipment, shall conform to Division of Highways' Specifications and shall meet the approval of the Engineer.

All materials shall conform to Division 700 of the Standard Specifications and specifically as follows, unless otherwise modified on the Plans. Reference specifications for materials shall be understood to be the latest available specification and revision at the time of award of the contract.

662.2.1-Concrete: All concrete shall conform to Standard Specifications, Section 601, Types B or K (Bridge Superstructure).

662.2.2-Reinforcing Steel Bars: Reinforcing steel bars shall conform to the applicable requirements of Section 602 of the Standard Specifications.

662.2.3-Electrical Conduit: Electrical Conduit shall meet the requirements of Section 715.42.10.

662.2.3.1-Type R (Rigid Steel Conduit): Type R (Rigid Steel Conduit) shall meet the requirements of Section 715.42.10.1.

662.2.3.2-Type F (Flexible, Liquid-Tight Conduit): Type F (Flexible, Liquid-Tight Conduit) shall meet the requirements of Section 715.42.10.2.

662.2.3.3-Type P (Polyvinyl Chloride Conduit): Type P (Polyvinyl Chloride Conduit) shall meet the requirements of Section 715.42.10.3.

662.2.4-Junction Boxes: The following Specifications shall set forth minimum design requirements for junction boxes for lighting cable and other electrical wiring. The type shall be noted on the Plans.

Junction boxes as shown on the Plans shall be installed where indicated. The Contractor may, with the approval of the Engineer and at his own expense, install additional junction boxes to facilitate the work of installing conduit and pulling cable.

662.2.4.1-Types A, B and C: Types A, B, and C shall meet the requirements of Section 715.42.11.4.

662.2.4.2-Type L (Light Duty): Type L (Light Duty) shall meet the requirements of Section 715.42.11.1.

662.2.4.3-Type H (Heavy Duty): Type H (Heavy Duty) shall meet the requirements of Section 715.42.11.2.

662.2.5-Manholes: Manholes shall be constructed to the dimensions shown in the Plans. Unless otherwise noted on the Plans, all units shall be completely equipped with the necessary cable racks, rack insulators, frames and covers, and all other appurtenances detailed on the Plans and approved by the Engineer.

Concrete manholes shall be monolithic construction and maybe either precast or cast in place.

662.2.5.1-Cable Rack: The cable rack assembly shall be a combination of Line Material Company Catalog Nos. DU17B2, DU581 or DU582, DE11U1, and WDU4M1, Joslyn Catalog Nos. J5124, J5131 or J5132, and J5122, or equal.

662.2.5.2-Pulling Iron: The pulling iron shall be Line Material Company Catalog # DU2T2, Joslyn Catalog # J8119, or equal.

662.2.5.3-Ground Connector: The ground connector shall be Burndy Company Type KC22B1, Dossert #DGN-5, or equal.

662.2.6-Ground Rods: Ground rods shall be copperclad steel, $\frac{3}{4}$ inches (19 mm) in diameter with a minimum length as noted on the plans and shall be one piece. Sectional or segmented ground rods are not permitted. The ground rods shall be complete with ground clamp and square head bolt.

662.2.7-Roadway Luminares: All castings shall be smooth, clean and free from cracks, blisters, pockets, voids, rough or chipped spots, or other similar defects.

The luminaire shall have a slipfitter capable of accepting mounting tenons made from 2 inches (50 mm) pipe and adjustable plus or minus three degrees about the tenon axis. No additional parts shall be required to accomplish the adjustment.

The luminaire shall have a terminal block prewired into the electrical system so that only two connections from the # 10 AWG tap wires need be made.

The ballast compartment shall be immediately accessible via a separate cover door such that the lamp area need not be opened to service the ballast.

The luminaire shall have a removable, parabolically formed aluminum reflector system with a finish as recommended by the manufacturer.

The luminaire shall have a porcelain mogul base socket capable of being adjusted along both the longitudinal and vertical axis of the lamp proper. A lamp grip shall also be provided at the socket.

The reflector-refractor chamber shall be gasketed with synthetic rubber or dacron felt gasket and filtered, when available for fixture type, with a replaceable activated charcoal or fiberglass filter such that the chamber shall be waterproof and dust-tight.

The refractor lens shall be cast for borosilicate glass or, when specified on the Plans, vandal resistant polycarbonate resin. It shall be temperature, shock and ultraviolet resistant and shall be free from visible cracks, blisters, bubbles, flashed or sharp flanges, or other similar defects.

The optical system shall produce the IES standard distribution patterns as specified and shall be capable of accepting internal, external, or internally molded-in shielding.

When so designated on the Plans, the luminaire shall be of a total cut-off type design, specially fabricated to recess the lamp and having a flat lens.

662.2.7.1-Luminaire Wattages: The luminaires shall be manufactured by General Electric, McGraw-Edison, Sylvania, American Electric or shall be approved equal.

The luminaires shall be designed to accommodate the appropriate lamps as called for on the Plans and Listed in 662.2.9.

662.2.7.2-Luminaire Ballasts: Luminaire ballasts shall be designed to rapidly restrike the lamp in the event of an outage and shall start the lamp at a minimum temperature of – 20° F (-29° C).

The ballasts for high pressure sodium lamps shall be of the high power-factor type (93 to 99 percent), similar to constant wattage type, and shall be rated to the circuit voltage and lamp wattage specified. The ballasts shall deliver rated lamp current at line-voltage variation of plus or minus 10 percent, with no more than plus or minus 5 percent of lamp wattage regulation. Starting aids shall be of the encapsulated type.

662.2.7.3-Area Luminaires: The luminaire requirements for "area" and "walkway" lighting shall be as called for in the Plans and in accordance with the latest edition of Special Provisions, Section 662, "Safety Rest Area Lighting" Subsection 662.11, Area Lighting Luminaires. Other portions of 662.2.7 above named shall not necessarily apply.

When incorporated as part of a Roadway Lighting project, the "area" or "walkway" type luminaire shall be Post Top Mounted on Type VII aluminum poles in accordance with 662.2.13.3. In this case, the "area" or "walkway" type luminaire shall be paid for under Item 662070-*, "Luminaires", per each.

662.2.8-Underpass Luminaires: The luminaire housing shall be die-cast aluminum and shall be gasketed to form a weatherproof and dusttight unit. All castings shall be smooth and clean and free from cracks, blisters, pockets, voids, rough or chipped spots, or other similar defects.

The assembly shall be prewired. The refractor shall meet the requirements set forth in 662.2.7, and the refractor holder shall be hinged to the housing and secured by stainless steel latches and safety chain. The reflector shall be anodic finished polished aluminum. The socket shall be an adjustable porcelain mogul-base type with lamp grip. The ballast shall meet the requirement set forth in 662.2.7.2.

The luminaire shall be manufactured by Guth, General Electric, Holophane or shall be approved equal. The luminaire shall be designed to accommodate the appropriate lamp as called for on the Plans and listed in 662.2.9.

662.2.9-Lamps: The high pressure sodium lamps shall be as manufactured by General Electric, Crouse-Hinds, Hollophane or approved equal. Any lamp shall be of the manufacturer's latest specification and shall meet the following minimum characteristics:

For the following chart: Life = minimum rated life hours; Initial Lumens = minimum initial lumens in horizontal position; Relamping Factor = estimated lamp lumen depreciation at the end of relamping period.

Type/Watts	Life-Hours	Initial Lumens	Relamping Factor
H.P.S./50-clear	24,000	4,000	0.73
H.P.S./70-clear	24,000	5,800	0.73
H.P.S./100-clear	24,000	9,500	0.73
H.P.S./150-clear	24,000	16,000	0.73
H.P.S./250-clear	24,000	30,000	0.73
H.P.S./400-clear	24,000	50,000	0.73
H.P.S./1000-clear	24,000	140,000	0.73

662.2.10-Wire and Cable: All wire and cable for feeder and branch circuits shall conform to the requirements of the current edition of the National Electric Code and shall meet all relevant ASTM Specifications. Conductors shall be coated softdrawn copper, unless otherwise noted on the Plans or in these Specifications. Insulation shall be type THWN or XHHW. Cable shall be UL approved.

Conductor sizes shall be standard American Wire Gauge sizes and shall be as noted on the Plans. All conductors shall be stranded. Stranded wire shall have a minimum of 19 strands.

The 15 KV wire and cable shall be single conductor G.E. Catalog # S1-58224, Anaconda AP-15315, Hatfield, Okonite, or approved equal. This cable shall have an approved stress cone at the terminating point.

All wire and cable shall have the size, voltage rating, type of insulation and manufacturer's name permanently marked on the outer covering at regular intervals. The manufacturer shall furnish to the Engineer and the Contractor all splicing or terminating information necessary for proper installation of the cable.

Color coding for the roadway lighting cables shall be permanent solid color as follows:

Single Phase		Three Phase	
Leg A	Black	Phase A	Black
Leg B	Red	Phase B	Red
Neutral	White or Gray	Phase C	Blue
Equipment Ground	Green	Equipment Ground	Green

Color coding of electrical conductors by use of phase tape or field paint is not acceptable. Conductors shall be manufacturer-colored, striped or ridge-marked.

Bare ground conductors shall be softdrawn copper.

662.2.10.1-Connectors: Cable connections in lighting support bases (except for Type IV and Type X) shall be made by means of connector kits, fused or nonfused, as indicated on the Plans. Underpass luminaires will be fused individually in the nearest accessible junction box.

Fused "Y" connectors shall be composed of a "Y" line side housing assembled with a load side and fuse terminal housing. The housings shall be formed from water-resistant synthetic rubber. Each housing shall provide a watertight seal around the cables and when fully assembled, shall form a watertight assembly. The cable size shall determine the connector size. Fuses shall be sized in accordance with nominally rated loads.

The line side housing shall contain a wye-tap having crimp or screwlug type connectors for the line wires and spring-loaded fuse contacts. The assembly shall have 90 percent minimum conductivity.

The load side housing shall contain a crimp-type connector for the load wire and spring loaded fused contacts. The assembly shall have 90 percent minimum conductivity.

When a load-side wire is pulled or jerked, the load-side housing and assembly, including the fuse and any protruding contacts, shall separate from the line-side housing and assembly, leaving no exposed contacts in the line-side housing.

All wire to wire connections shall be made by the use of connector kits. Unfused connectors shall be used on all neutral wire. All wire to wire connections must be made in accessible locations with workable wire slack as required. Accessible locations include manholes, junction boxes and bases.

662.2.10.1.1-Splices: In special cases, such as conductor sizes in excess of #1/0 AWG and with written approval of the Engineer, wire splicing may be permitted. As with connector kits, splicing shall be done only in accessible, workable areas. Electrical splicing, when approved, shall be used at specific locations only and the number of splices shall be kept at a minimum.

When connector kits are not used, the following splicing method shall be used. Splices on all wire and in all boxes shall be made mechanically and electrically secure by means of an approved split bolt connector only. It shall then be wrapped with layers of insulating tape and in opposite directions. Over the insulating tape, two layers of friction tape shall be applied, followed by several layers of jacket tape, two final layers of friction tape and two coats of an electrical waterproofing paint. The insulating tape shall be wrapped to a wall thickness equal to 12 times the wall thickness of the cable insulation. Similarly, the jacket tape shall be wrapped to a thickness equal to 12 times the thickness of the cable jacket.

662.2.10.2-Aerial Cable: Aerial cable shall be either aluminum NSD or lashed galvanized messenger construction. Cable assembly shall be self-supporting.

662.2.10.2.1-Conductors: Insulated conductors shall conform to the requirements noted in 662.2.10. Insulation shall be XLP.

662.2.10.2.2-Messenger Cable: Messenger for the aluminum N-SD cable shall be bare, stranded, steel reinforced aluminum.

Messenger for the lashed galvanized cable shall be extra high strength galvanized steel wire with a breaking strength of not less than 11,000 lb (49 kN). Lashing shall be stainless steel, ANSI 300 series.

662.2.11-Cable-in-Duct:

662.2.11.1-Description: The work under this item covers the installation of a system as described in the Plans and Special Provisions suitable for an installation buried directly in the earth.

662.2.11.2-Materials and Testing: The materials furnished and the testing necessary shall be as prescribed in the Plans.

662.2.12-Service and Control Stations:

662.2.12.1-General: The Contractor shall furnish and install service and control stations as noted on the Plans to serve the roadway lighting circuits. Service and control stations shall consist of cabinet (enclosure), all-weather padlock, control panel, conduit, cable, rock and earth excavation, backfill, concrete and steel reinforcement for the equipment pad, fencing and gate, transformer, grounding and all other incidentals for a complete and operable system as called for on the Plans.

Cabinets, electrical equipment, grounding and miscellaneous items shall conform to size, rating and description shown on the Plans and applicable NEMA and ANSI Standards as well as the usual practices of the local utility company and the National Electrical Code. Conductors shall be neatly arranged in a workmanlike manner and laced with nylon cable straps.

Cabinets (enclosures) shall be provided with nameplates and a wiring diagram of the circuits installed within the service and control station, sealed with a plastic cover and permanently attached to the inside of the door under a metal frame at a height of not less than one-half the door height.

Photoelectric controllers shall be the twistlock type, 120 volt, preset to "turn on" between 1.0 and 3.5 footcandles. "Turn off" shall be at least two times the "turn on" level; however, "turn off" must be greater than 3.0 and less than 15.0 footcandles. The unit shall meet all relevant NEMA Standards and shall be north oriented.

Transformers shall be built in accordance with the latest revision of the ANSI-NEMA standards for outdoor type distribution transformers, as manufactured by G.E., Westinghouse or shall be approved equal.

Two prints of shop drawings indicating the proposed dimensions and material specifications for the control center, cabinet (enclosure), and transformer, if required, shall be submitted for approval purposes within three weeks after the award of the Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved" or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Resubmission of drawings to obtain final approval by the Division shall not be considered as being just cause for delay in completion of any contract.

662.2.12.2-Ground Mounted Cabinets: The entire assembly shall meet the requirements of NEMA Type 4 Standards.

Framed overlapping doors shall be installed in the front of each cabinet for access to the panel interior, and they shall be hung on a substantial set of stainless steel hinges. The doors shall be provided with three-point and two-point, vault-type latch and padlock lugs. The cover joints shall have returned lips and shall be provided with gaskets which shall prevent water from entering the panels. A rain shield shall be provided over the doors.

Mounting plates and channels shall be provided within the cabinet for installing contractors, panelboards, auxiliary transformers, etc. The wiring shall be neatly arranged, laced and securely fastened in an approved manner.

Chain link fences shall conform to the requirements of 712.8 of the Specifications and shall contain at least four signs (one per center of each of the four sides) with the legend 'DANGER-HIGH VOLTAGE.'

Rock and earth excavation shall be in accordance with 207 of the Specifications, as revised and amended.

Adequate stainless steel screens and louvers shall be provided for the ventilation of internal equipment.

662.2.12.3-Pole Mounted Cabinets: The lighting circuit protector and disconnect switch shall have a NEMA Type 4 enclosure with operator capable of being locked in either position. Disconnect switch and fuse, or circuit breaker shall be rated and furnished with fuse or breaker size as shown on the Plans.

The framework steel and hardware used in the cabinet shall be stainless steel.

662.2.12.4-Service Poles: Service points shown on the Plans are approximate only. Final location of service poles shall be determined in the field. Materials and costs for the connections to the service point will be paid for by the Contractor. The Contractor shall conform to utility company requirements for this item. The service pole grounding system shall be installed as part of the pole in accordance with the requirements of the local power company.

All wiring on the poles shall be installed in steel conduits of sizes as shown on the Plans and shall be securely fastened to the service pole with pipe straps at not over four-foot (1.2 m) maximum spacing. All pole line hardware used in the service poles and control stations shall be hot-dipped galvanized.

662.2.13-Lighting Supports:

662.2.13.1-Lighting Pole Type I, II and III-Steel:

662.2.13.1.1-General Description: Each Lighting Pole, Type I, II and III shall consist of a pole shaft, removable pole top, luminaire support arm, base, support base (if required), anchor bolts, removable anchor bolt covers and any other accessories or hardware as required to make a complete installation as called for on the Plans or as directed by the Engineer. Spreads and mounting heights shall be as detailed on the Plans; tolerance for mounting heights shall be plus or minus 6 inches (150 mm). All wiring shall be concealed within the pole shaft and luminaire support arm.

Lighting Poles Type I, II, and III shall be certified to equal or exceed the requirements of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals", based on at least 90 mph (145 km/hr) wind loads, a luminaire weight of 50 lb. (22.7 kg) and a luminaire projected area of 1.1 sq ft (0.1 sq m).

The maximum allowable pole deflection from vertical at the top of the pole, due to the weight of the arm and luminaire, shall be two percent of the total shaft length. The pole deflection from vertical is defined as the horizontal distance between the pole top centerline when the pole alone is installed plumb and the pole top centerline after the arm and luminaire combination is installed on the previously plumb pole, the measurement to be made without additional shaft adjustment. The fabricator shall certify to the above and maintain results of computations or tests to document compliance, for each type of lighting pole supplied.

662.2.13.1.2-Pole Shaft: The pole shaft shall be an ASTM A 595 Grade A Tube or fabricated from weldable grade, hot-rolled, commercial quality steel, meeting the requirements of ASTM A 607, with a minimum yield strength of 55,000 psi (380 MPa) after fabrication. The round shaft shall be fabricated in one piece from not less than # 11 manufacturer's standard gauge steel and be continuously tapered at 0.14 or 0.10 inch per foot (3.04 mm/m). Two piece shafts, that assemble by telescoping the upper section over the lower section with a firm tapered fit, may be used for 40, 45, 50, 55 and 60 feet (11.7 or 8.33 mm per meter) mounting heights. Each pole shaft shall include a J-hook wire support welded inside near the top, a handhole with cover as noted on the plans (except for transformer bases), and a ground connector near the bottom. An opening shall be provided near the top of the shaft to provide a cable entrance from the shaft into the luminaire support arm.

662.2.13.1.3-Luminaire Support Arm Types I and II: Luminaire support arms for Lighting Poles Types I and II shall be of constant diameter and fabricated from 2 inches pipe, having a wall thickness equal to Schedule 40 pipe and meeting the requirements of ASTM A 501, or from 2-3/8 inches steel tubular members with a nominal wall thickness equal to Schedule 40 pipe and having a minimum yield strength equal to ASTM A36. For arm spreads 12 feet (3.6 m) and less, the fabrication of the lower member may be of 1½ in pipe, having a wall thickness equal to Schedule 40 pipe. For arm spreads over 18 feet (5.5 m), the fabrication may be of 2½ inches pipe, having a wall thickness equal to Schedule 40 pipe, or a combination of 2½ inches and 2 inches meeting the above requirements. The arm shall be attached to the pole so that it can transfer the full strength of the arm to the pole shaft.

The truss type arm (Type I) shall consist of an upper and lower member joined near the luminaire end of the arm and securely joined with vertical strut(s). The upper member shall be continuous and the wiring member. The vertical strut(s) shall be either oval, circular, rectangular or square in cross section and shall be made of steel meeting the physical requirements of ASTM A 36.

A 2 inches (50 mm) slip fitting arrangement shall be provided at the tip of all arms.

662.2.13.1.4-Luminaire Support Arm Type III: Luminaire support arms for Lighting Pole Type III shall be an ASTM A 595 Grade A Tube or fabricated from weldable grade, hot rolled, commercial quality steel, meeting the requirements of ASTM A 607, with a minimum yield strength of 55,000 psi (380 MPa) after fabrication. The arm shall be cylindrical in cross section and uniformly tapered from butt to tip at 0.14 or 0.10 inches per foot (11.67 or 8.33 mm per meter). The arm shall be fabricated in one piece from not

less than # 11 (3.04 mm) manufacturer's standard gage steel. The arm shall be attached to the pole so that it can transfer the full strength of the arm to the pole shaft.

Two-piece arms may be used for spreads greater than 34 feet (10.4 m). The outside luminaire support arm shall be a round tapered tubular member fabricated from material with a minimum yield strength of 36,000 psi (10.4 m) after fabrication. Two-piece arms shall assemble by a telescoping joint. The telescoping length of the joint shall not be less than 1½ times the diameter of the arm at the joint. The telescoping field joint shall not be welded but shall be keyed with a through bolt.

A 2 inches (50 mm) slip fitting arrangement shall be provided at the tip of all arms.

662.2.13.1.5-Bases: Anchor, support and approved breakaway bases shall be constructed of sufficient size and strength to fully develop the bending moment of the shaft. Each base shall be provided with four holes (slip base may have three) of sufficient size to accommodate the proper size anchor bolts to resist at yield stress, the bending moment of the shaft at its yield stress. All bases, except the transformer type, shall have the handhole centered approximately 18 inches (450 mm) above the bottom of the shaft located downstream of oncoming traffic.

Anchor bases shall be one-piece fabricated from material meeting ASTM A 27 Grade 65-35 or ASTM A 36 of sufficient cross section to fully develop the ultimate strength of the pole. Galvanizing shall be in accordance with ASTM A 123.

Breakaway bases (e.g. aluminum transformer, cast aluminum, fluted aluminum breakaway couplings, slip, etc.), if required, shall meet the dimensions and requirements as required by the Plans. All breakaway bases shall be certified for conformance to the AASHTO breakaway performance criteria.

The aluminum transformer bases shall be nominally 20 inches (500 mm) high with an access door secured in place by stainless steel locking screws. All bearing plates shall be hot-dipped galvanized in accordance with ASTM A 123. Washers shall be hot-dipped galvanized in accordance with ASTM A 153. A tapped hole shall be provided for grounding. When aluminum transformer bases are used with unpainted weathering steel poles and bases, both the bottom of the steel anchor base and the top of the aluminum transformer base shall be coated with a heavy film of zinc-rich paint.

662.2.13.1.6-Anchor Bolts: Anchor bolts shall be of sufficient size and strength to fully develop the bending moment of the shaft. Anchor bolts (unless otherwise directed on the Plans) shall be fabricated from ASTM F 1554, GRADE 55. Each bolt shall have the thread end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Each bolt shall be provided with a regular hex nut or heavy hex nut (anchor bases to have two hex nuts) that shall be hot dipped galvanized. Hex nuts shall be regular meeting ASTM A 563 Grade A for ¼ inch-1½ inches (6 through 38 mm) sizes and shall be heavy hex for sizes over 1½ inches to 4 inches (38 to 102 mm).

662.2.13.1.7-Galvanizing: The pole shaft, luminaire support arm, pole top, handhole cover, anchor base and slip base shall be galvanized in accordance with ASTM A 123. Galvanized coatings damaged for any reason shall be repaired by the application of a zinc rich paint conforming with 711.21 of the Specifications. The places to be painted shall be thoroughly cleaned before the paint is applied.

662.2.13.1.8-Marking: Each pole shall be identified by control station number (as applicable), circuit number (as applicable), wattage and pole number with adhesive labels applied 6 feet (1.8 m) above the grade line normal to the roadway. Adhesive labels shall be designed to be exposed to the weather. Legend shall be 3 inches (75 mm) black on white.

662.2.13.1.9-Drawings for Approval Purposes: Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved" or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved.

Resubmission of drawings to obtain final approval by the Division shall not be considered as being just cause for delay in the completion of any contract.

662.2.13.1.10-Mill Test Reports and Certification: Mill test reports or certifications of conformance to specifications for materials and design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

- i. Mill Test Reports (M.T.R.) for MAJOR structural items only, as noted in the following chart, shall include both physical and chemical descriptions of the material as supplied to the fabricator. When physical properties are altered during fabrication, the M.T.R. covering chemical composition will be supplemented by certified test reports indicating the physical properties of this material after fabrication.
- ii. Certification of Conformance to the Specifications for all remaining material not covered by M.T.R. as noted in the following chart.
- iii. Certification that all welding was performed by operators qualified as follows: steel welders to AWS and aluminum welders to ASME.
- iv. Certification of Conformance to the Specifications for the Design of all components not completely dimensioned and detailed on the Standard Drawing.

TABLE 662.2.13.1.10

COMPONENT MATERIALS	M.T.R.	CERTIFICATIONS
Tubes for arms and poles	X	
Base castings	X	
Anchor bolts	X	
Pole tops, misc. fittings and hardware		X
Fabricated or cast-type arm connections	X	
Galvanizing		
Welding Rod	X	

662.2.13.2-Lighting Pole Type IV-Wood:

662.2.13.2.1-General Description: Each Type IV Wood Pole shall consist of an upright shaft fitted with necessary hardware to make the installation complete as detailed on the contract Plans.

All wood poles shall meet the requirements of Section 710.8.

662.2.13.2.2-Luminaire Support Arms: Luminaire support arms for Type IV Lighting Poles shall be of constant diameter and fabricated from 2 inches pipe, having a wall thickness equal to Schedule 40 pipe and meeting the requirements of ASTM A 501, or from 2-3/8 inch OD steel tubular members with a nominal wall thickness equal to Schedule 40 pipe and having a minimum yield strength equal to ASTM A 36. For arm spreads over 18 feet (5.5 m), the fabrication may be of 2½ inches pipe having a wall thickness equal to Schedule 40 pipe, or a combination of 2 ½ inches and 2 inches, meeting the above requirements.

The method of attachment to the pole shall be that as suggested by the support arm manufacturer and approved by the Engineer.

A 2-in. (50 mm) slip fitting arrangement shall be provided at the tip of all arms.

662.2.13.3-Lighting Pole Type V and VII-Aluminum:

662.2.13.3.1-General Description: Each Lighting Pole Type V "Luminaire Support Arm Mounted" shall consist of a pole shaft, removable pole top, luminaire support arm, base, support base (if required), anchor bolts, removable anchor bolt covers and any other accessories or hardware as required to make a complete installation as called for on the Plans or as directed by the Engineer. Each Lighting Pole Type VII "Luminaire Post Top Mounted" shall consist of a pole shaft, base, anchor bolts, removable anchor bolt covers and any other accessories or hardware as required to make a complete installation as called for on the Plans or as directed by the Engineer. Spreads and mounting heights shall be as detailed on the Plans; tolerance for mounting heights shall be plus or minus 6 inches (150 mm). All wiring shall be concealed within the pole shaft and luminaire support arm.

Lighting Poles Type V and VII shall be certified to be equal or exceed the requirements of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals". Type V shall be based on at least 90 mph (145 km/hr) wind loads, a luminaire weight of 50 lb. (22.7 kg) and a luminaire projected area of 1.1 sq. feet (0.1 sq. m). Type VII shall be based on 90 mph (145 km/hr), ignore the weight and 2.5 sq. feet (0.232 sq. m).

The maximum allowable pole deflection from vertical at the top of the pole, due to the weight of the arm and luminaire, shall be two percent of the total shaft length. The pole deflection from vertical is defined as the horizontal distance between the pole top centerline after the arm and luminaire combination is installed on the previously plumb pole, and measurement to be made without additional shaft adjustment. The fabricator must certify to the above and maintain results of computations or tests to document compliance for each type of lighting pole supplied.

662.2.13.3.2-Pole Shaft: The pole shaft shall be one-piece, cylindrical, tapered seamless (or one continuous longitudinal weld) tubing which shall have mechanical properties not less than that listed for ASTM B221, B429, B241, Alloy 6061 T-6 or Alloy

6063-T6 after fabrication. Two-piece shafts that assemble by telescoping the upper section over the lower section with a firm tapered fit, may be used for 40, 45, and 50 ft. (12.13, 13.72, and 15.42 meter) mounting heights. Each pole shaft shall have a J-hook wire support inside near the top, a handhole with cover as noted on the Plans (except for transformer bases) and a ground connector near the bottom. Minimum wall thickness (unless otherwise approved by the Engineer) shall be 0.188 inch (4.775 mm) for Type V Poles and 0.125 inch (3.175 mm) for Type VII poles. The top of shaft OD for “Luminaire Post Tope Mounted” shall be 3 inches (75 mm) unless otherwise approved by the Engineer.

662.2.13.3.3-Luminaire Support Arm: The Luminaire Support Arm shall be aluminum pipe or tapered aluminum tubing which shall have the mechanical properties not less than that listed for ASTM B221, B429, B241 Alloy 6061 T-6 or Alloy 6063-T6 after fabrication. A 2 inch (50 mm) slip fitting arrangement shall be provided at the tip of all arms.

662.2.13.3.4-Bases: Anchor, support and approved breakaway bases shall be constructed of sufficient size and strength to fully develop the bending moment of the shaft. Each base shall be provided with four holes (three if approved by the Engineer) of sufficient size to accommodate the proper size anchor bolts to resist at yield stress, the bending moment of the shaft at its yield stress. All bases, except the transformer type, shall have a handhole centered approximately 18 inches (450 mm) above the bottom of the shaft located downstream of oncoming traffic.

Anchor bases shall be made from Alloy ASTM B108 as detailed on the Plans or as directed by the Engineer. Support bases shall be fabricated from steel conforming to ASTM A 36, with galvanizing in accordance with ASTM A 123. Aluminum transformer bases shall meet the requirements as identified in the fourth paragraph of 662.2.13.1.5.

Breakaway bases (e.g. aluminum transformer, cast aluminum, fluted aluminum breakaway couplings, slip etc.), if required, shall meet the dimensions and requirements as required by the Plans. All breakaway bases shall be certified for conformance to the latest AASHTO breakaway performance criteria.

662.2.13.3.5-Anchor Bolts: Anchor bolts shall be of sufficient size and strength to fully develop the bending moment of the shaft. Anchor bolts (unless otherwise directed on the Plans) shall be fabricated from ASTM F 1554, GRADE 55. Each bolt shall have the threaded end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Each bolt shall be provided with a regular hex nut or heavy hex nut (anchor bases to have two hex nuts) that shall be hot dipped galvanized. Hex nuts shall be regular meeting ASTM A 563 Grade A for ¼ inch (6 mm) to 1½ inches (38 mm) sizes and shall be heavy hex for sizes over 1 ½ inches to 4 inches (38 to 102 mm).

662.2.13.3.6-Marking: Each pole shall be identified as required in 662.2.13.1.8.

662.2.13.3.7-Drawings for Approval Purposes: Shop Drawings shall be submitted, approved and applied as required in 662.2.13.1.9.

662.2.13.3.8-Mill Test Reports and Certification: Mill test reports or certifications of conformance to specifications for materials and design shall be supplied as required in 662.2.13.1.10.

662.2.13.4-Lighting Pole Type X-Steel High Mast:

662.2.13.4.1-General Description: Each Lighting Pole Type X shall consist of pole shaft, anchor base, anchor bolts and nuts, lowering devices and any other accessories or hardware as required to make a complete installation as called for on the Plans or as directed by the Engineer. Mounting heights, number and type of luminaires shall be as detailed on the Plans. Tolerance for mounting heights shall be plus or minus 12 inches (300 mm). Any manufacturer's warranties, expressed or implied, shall become the property of the Division.

A complete service manual including instruction on installation, operation and maintenance shall be furnished for each lowering device, winch assembly and power drive system furnished on each project.

Lighting Poles Type X shall be certified to be equal or exceed the requirements of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals," based on the Final Deflected Pole Position Method and the following:

Wind Velocity	=	90 mph (144.8 km/hr)
Number of Luminaires	=	8
Weight of Luminaires	=	70 lbs. Each (560 lbs. total)
Area of Luminaires	=	2.0 sq. ft Each (16.0 sq. ft. total) (0.18 sq. meter each (1.472 sq. meters total)
Weight of Mounting Head	=	370 lbs. (167.8 kg)
Area of Mounting Head	=	3.5 sq. ft. (0.325 sq. meter)

662.2.13.4.2-Pole Shaft: The pole shaft shall be made from one to six continuously tapered circular or twelve sided sections which shall either telescope with each other or be shop butt welded by electric arc welding. Steel used in fabricating the shaft shall be either galvanized steel (hot-dipped according to ASTM A 123) or weathering steel with a minimum yield strength of 55,000 psi (380 MPa) after fabrication and shall have one or two longitudinal welds. Materials shall be galvanized steel unless otherwise indicated on the Plans as weathering steel. All poles on any one project shall be of the same type construction for pieces and sections. Straightness tolerance shall be ½ inch in 20 feet (2.08 mm per meter). The inside surface of the shaft shall be relatively smooth to provide a cable raceway. Projections on the inside of the pole (such as backup rings) shall not exceed 3/8 inch (9.5 mm) projection in the area between the handhole and the top flange.

Minor sections of galvanized coatings (of pole shaft, pole support assembly and circular luminaire ring assembly) damaged for any reason shall be repaired by the application of a zinc rich paint conforming with 711.21 of the Standard Specifications. The places to be painted shall be thoroughly cleaned before the paint is applied.

The lap joint produced by telescoping shall have a minimum length of one and one-half diameters of the shaft at the joint measured at the minimum diameter of the inner telescoping section. No transverse welding shall be permitted to secure the overlapping telescoping joints. Overlap areas on weathering steel poles shall be shop painted in

accordance with 688. The outside of the lower pole shall be coated so a minimum of 1 inch (25 mm) below the bottom edge of the upper pole is covered (after erection). The inside of the upper pole shall be coated so a minimum of 6 inches (150 mm) above the top edge of the lower pole is covered (after erection). In addition the intersection of each overlap joint on the outside shall be sealed with a commercial silicone building sealant such as Dow Corning 795. The numbering shall be applied in such fashion that the marks shall be unobtrusive after assembly.

In the bottom section of the shaft shall be an access door with stainless steel hinged door, neoprene door gasket and hasp (welded inside to the reinforcing frame, sleeve or plate) with an all-weather padlock. The door shall be sufficient size to allow the internal machinery (winch and gear box) to be disconnected from its mountings and removed through the door. An additional handhole may be provided for wiring access. All handholes or openings in the shaft shall be properly designed and fabricated to avoid stress risers by use of an internal reinforcing sleeve or a reinforcing frame with full penetration welds or other approved method.

Each pole shall be identified by control station number (as applicable), circuit number (as applicable), wattage and pole number with adhesive labels applied 8 feet (2.4 m) above the base plate normal to the nearest roadway. Adhesive labels shall be designed to be exposed to the weather. This legend shall be 5 inches (125 mm) black on white.

662.2.13.4.3-Anchor Base: The anchor base (cast or rolled steel) shall be constructed of ASTM A 36 minimum for galvanized steel or ASTM A 588 for weathering steel and shall be of sufficient size and strength to fully develop the bending moment of the shaft. It shall be welded to the shaft by a full penetration weld. The weld must be made with a backup ring, or other approved procedure, or be welded from both sides.

662.2.13.4.4-Anchor Bolts: Anchor bolts shall be of sufficient size and strength to fully develop the bending moment of the shaft. Anchor bolts shall be fabricated from ASTM A1554 Gr.55. Each bolt shall have the threaded end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Each bolt shall be provided with two heavy hex nuts and two heavy washers. Both nuts and washers shall be hotdipped galvanized. Detailed properties, dimensions, bolt circles and appropriate backup calculations for anchor bolts for each type pole supplied shall be submitted to and approved by the Division before fabrication.

662.2.13.4.5-Miscellaneous Hardware: Miscellaneous other hardware not covered by other specifications shall as a minimum comply with the following:

1. Galvanized steel structures:
2. Miscellaneous plates, bars and structural shapes shall be ASTM A 36. Pipe shall be ASTM A 501.
3. Weathering steel Structures:
4. Miscellaneous plates, bars and structural shapes shall be ASTM A 588. Pipe shall be Yolo high strength, low alloy steel or approved equal.

662.2.13.4.6-Welding: All welding shall conform to AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals",

Section 1.4.2 (A) through (D). Welding must be certified to performance by operators qualified as follows: Steel welders to AWS and aluminum welders to ASME. Longitudinal joints in the tapered sections of the pole shaft shall be made only by automatic electric arc welding. Transverse butt-welds may be used, but only under closely controlled shop conditions. Winch mount plate and emergency stop ring welds shall be fillet welds.

All welds in the shaft shall be tested and certified by close visual inspection or approved alternate methods (such as ultrasonic or magnetic particle). One hundred percent of the full penetration sections of longitudinal seam welds shall be radiographically inspected and a random ten percent of the partial penetration section of the longitudinal seam welds shall be inspected by the magnetic particle method.

662.2.13.4.7-Lowering Devices:

662.2.13.4.7.1-General Description: The integral luminaire lowering mechanism or devices shall be compatible with the pole design and shall consist of a head frame assembly, a luminaire ring assembly and a hoisting assembly. The system shall permit luminaire maintenance at ground level, provide for disconnection of the electrical service at the pole base, provide a convenient means of energizing the lighting assembly when it is at ground level, support eight 70 lb. (31.75 kg) luminaires in a symmetrical arrangement and include power cables and all miscellaneous electrical equipment in the pole necessary to provide a complete and workable device. All bolts and machine screws shall be secured in a manner that will preclude their becoming loosened by vibration. Star washers, jam nuts, self-locking nuts, locktite, etc., may be used to secure nuts and machine screws. Sheave pins shall be secured by means of washers and cotter keys or pins, not welded.

662.2.13.4.7.2-Head Frame Assembly: The head frame structure shall be galvanized steel, attached to the pole by a steel slipfitter and secured by the appropriate stainless steel setscrews. It shall consist of all necessary pulleys and rollers to guide the hoisting cables and electrical cable. The head frame shall support six, 6 inches (142.4 mm) diameter steel hoist cable sheaves or six, 5 inches (127.0 mm) diameter cast aluminum hoist cable sheaves with oil-impregnated, sintered bronze bushing with stainless steel shafts. The three hoisting cables shall be stainless steel 7 x 19 aircraft cord of 3/16 inch (4.7625 mm) diameter. The minimum tread diameter for the hoisting cable sheaves shall be 20 times the cable diameter for galvanized cable and 25 times the cable diameter for stainless steel cable. The hoisting cable sheave groove cross-section shall be semicircular with a radius of one-half the cable diameter plus 1/64 inch (396 μ m).

The power cable shall not be bent at a radius less than five times the cable diameter and the groove cross-section shall prevent the cable from rolling out of the groove if the cable is twisting. All power cable sheaves and rollers shall be suspended on stainless steel shafts fitted with self-lubricating bushings or be fabricated of self-lubricating material.

All head frame sheaves will have keepers to keep cables engaged during operation.

The head frame assembly shall be protected from the weather by an aluminum cover.

Positive latching devices shall be incorporated into the luminaire ring assembly. These devices shall be designed to prevent any movement of the luminaire ring assembly when it is latched to the top of the pole and tension is removed from the luminaire ring support cables. Latching shall be accomplished by the alternate raising and lowering of the luminaire ring assembly by the winch and hoisting assembly and there shall be no moving

latch parts or springs attached to the head frame assembly. Reflectors or flags shall be provided to indicate when the luminaire ring assembly is completely and securely latched to the head frame assembly. All moving parts of the latching mechanism shall be attached to the luminaire ring assembly and serviceable from the ground.

662.2.13.4.7.3-Luminaire Ring Assembly: The luminaire ring shall be fabricated of 6 inches (150 mm) steel channel, hot dipped galvanized with the appropriate number of 2 inches (50 mm) nominal galvanized steel pipe mounting arms. The luminaire ring shall be wired with Type S.O. power cable or equivalent and Type ST distribution cable with insulation suitable for at least 105 C.

All electrical cords shall be attached to the weathertight wiring chamber through weathertight cable connections. A prewired 600 volt terminal block and a secondary lightning arrester shall be provided in the weathertight chamber. A weathertight twistlock power inlet shall be provided on the chamber to allow testing of the luminaires while in the lower position.

Roller-contact, spring-loaded centering arms shall be provided to stabilize and center the luminaire ring during raising or lowering operations and to eliminate shock to the lamps from impact of the luminaire ring with the pole. The rollers for the centering arms shall be of a water-resistant, non-marking material with oil-impregnated sintered bronze bushings. All axle shafts for arms and rollers shall be stainless steel.

662.2.13.4.7.4-Housing Assembly (Winch Assembly): The winch shall have an ultimate strength of five times the lifted load with the number of layers of cable with which it will be used. The winch shall have a 30 to 1 worm gear reduction ratio and include an integral drag brake on the worm shaft to prevent free spooling of the winch. The winch shall be designed for at least intermittent power operation, but also have hand crank capability.

The winch shall be prewound with galvanized steel $\frac{1}{4}$ inch (6.35 mm), 7 x 19 aircraft cord of sufficient length to maintain at least four complete wraps on the drum after the device has been lowered to its lowest position. The drum shall be supported at both ends and keepers shall be provided to ensure that uncoiled cable will rewrap onto the drum.

A portable power unit is required (one per project). Its motor shall be the heavy-duty reversing type with a stalling torque at least twice that required to operate the device. The motor shall drive the winch through the torque limiter coupling to limit the lifting force. The hoisting rate shall be between 12 and 25 feet (3.6 and 7.5 m) per minute. The motor shall be controlled by a reversing switch connected by a 20 foot (6.1 m) remote cord. The portable power unit shall be provided with a portable enclosed and encapsulated transformer to stepdown the parent voltage to 120 volts to operate the power unit. All electrical connections from the transformer to the power cord and from the transformer to the power unit shall be twistlock caps and plugs.

662.2.13.4.8-Wire Rope:

662.2.13.4.8.1-Materials for the stainless steel cables shall conform to the Chemistry of ASTM A492 type 302 or 304.

The wire used in steel cable shall be cylindrical and smooth and of uniform high quality. The finished cable shall be uniform in construction and securely laid, free from kinks, loose

wires, loose strands, splits, cold shuts or other defects. A suitable type of friction-preventive compound having noncorrosive properties shall be impregnated into the wire rope. The individual wires and strands composing the wire rope shall be shaped into the exact helical position they will have in the finished wire rope, so that if the wire rope is cut or severed there is no tendency for the measured diameter of the wire rope at the unseized cut ends to increase by more than the amount specified in Table 662.2.13.4.8.

TABLE 662.2.13.4.8 {ENGLISH}

Construction, Physical Properties of Stainless Steel Wire Rope				
Nominal Diameter of Wire Rope (Inches)	Tolerance on Diameter (Plus Only) (Inches)	Allowable Increase of Diameter (Inches)	Nominal Break Strength Stainless Steel (Pounds)	Approximate Weight per 100 feet (Pounds)
5/32	.016	.017	2,400	4.50
3/16	.018	.019	3,700	6.50
7/32	.018	.020	5,000	8.60
1/4	.018	.021	6,400	11.00
5/16	.022	.024	9,000	17.30
3/8	.026	.027	12,000	24.30

TABLE 662.2.13.4.8 {METRIC}

Construction, Physical Properties Of Stainless Steel Wire Rope				
Nominal Diameter of Wire Rope (millimeters)	Tolerance on Diameter (Plus Only) (millimeters)	Allowable Increase of Diameter (millimeters)	Nominal Break Strength Stainless Steel (kilograms)	Approximate Weight per 30.48 meters (kilograms)
3.96	0.4064	0.4318	1090	0.16
4.762	0.4572	0.4826	1680	0.90
5.556	0.4572	0.5080	2270	1.19
6.350	0.4572	0.5334	2900	1.52
7.935	0.5588	0.6096	4080	2.39
9.525	0.6604	0.6858	5445	3.36

Flexible steel wire rope covered by this specification shall be of 7 x 19 construction. The type of construction for the respective diameters, the dimensional tolerances and the physical properties shall be as specified in Table 662.2.13.4.8. Wire rope shall be 7x19 aircraft cable.

662.2.13.4.8.2-Quality conformance testing shall consist of all the inspections such as workmanship and physical appearance previously specified. The sample wire rope shall pass the breaking strength test and stretch tests as specified below.

- i. Sampling-When conducting the tests, one sample shall be taken after any discard has been removed from the head or starting end of the first manufacturing reel for each lot of wire rope.

- ii. Lot-A lot shall consist of not more than 20,000 feet (6 100 meters) of wire rope of the same construction and diameter produced continuously by one machine or by one series of progressive processing machines.

662.2.13.4.8.3-Breaking Strength: The wire rope specimen shall be selected from the sample from each lot. The specimen shall be no less than 24 inches (600 mm) in length, and where necessary, swaged terminals conforming to MIL-T-781 (do not use ball end fitting) and accompanying hardware may be used to facilitate installation of the specimen in the jaws of the testing machine. The distance between the jaws of the testing machine with the sample shall be no less than 10 inches (250 mm). The breaking strength shall be determined by use of a tensile testing machine in accordance with applicable requirements of ASTM E 8. The breaking strength shall conform to the requirements of Table 662.2.13.4.8 for qualification.

662.2.13.4.8.4-Stretch Test: One specimen from each sample of wire rope selected as specified in 662.2.13.4.8.2 shall be tested to determine the percent stretch. The total length of the wire rope specimen to be tested shall not be less than 24 inches (600 mm). Where necessary, swaged terminals and accompanying hardware may be used to facilitate installation of the specimen in the jaws of the test machine. The amount of stretch shall be determined on a tension testing machine in accordance with ASTM E 8. The specimen shall be loaded to one percent nominal breaking strength shown in Table 662.2.13.4.8 to straighten the wire rope. While the specimen is under tension, an adequate gauge length shall be marked off the wire rope between the jaws of the testing machine. The specimen shall then be loaded to 60 percent of minimum breaking strength and measured to elongation under load. From this data the stretch shall not exceed 1.5 percent.

662.2.13.4.8.5-Certification: Upon request, the wire rope manufacturer shall furnish a certified test report showing that the wire rope manufacturer's product satisfactorily conforms to this Specification. The test report shall include, as a minimum, actual results of the tests specified.

662.2.13.4.9-Drawings for Approval Purposes: Two prints of shop drawings indicating the proposed dimensions and material specifications for the poles and lowering devices shall be submitted by the Contractor for approval purposes within three weeks after the award of the Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved" or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division shall not be considered as being just cause for delay in the completion of any contract.

662.2.13.4.10-Mill Test Reports and Certification: Mill test reports or certificates of conformance to specifications for materials and design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

- i. Mill Test Reports (M.T.R.) for MAJOR structural items only, as noted in the following chart, shall include both physical and chemical descriptions of the material as supplied to the fabricator. When physical properties are altered during fabrication, the M.T.R. covering chemical composition will be supplemented by certified test reports indicating the physical properties of this material after fabrication.
- ii. Certification of Conformance to the Specifications for all remaining material not covered by M.T.R. as noted in the following chart.
- iii. Certification of Conformance to the Specifications for the design of all components not completely dimensioned and detailed on the Standard drawing.

TABLE 662.2.13.4.10

COMPONENT MATERIALS	M.T.R.	CERTIFICATIONS
Tubes for poles	X	
Base Castings	X	
Anchor bolts	X	
Pole tops, lowering devices, cable, misc., fittings, and hardware		X
Galvanizing		X
Welding Rod	X	

662.2.14-Navigation Lighting System: The Contractor shall furnish and install a navigation lighting system as indicated on the Plans. The navigation lighting system shall consist of control center, enclosure, power service, conduit, cable, junction boxes, navigation light unit, photoelectric unit, electrical work, electrical tests and all other incidentals for a complete and operable system as called for on the Plans.

662.2.14.1-General: The installation, equipment, materials and workmanship, except as specifically modified, shall be in accordance with applicable provisions of the following publications, codes and regulations in effect on the date of the invitation for bids:

- National Electrical Code
- American National Standards Institute
- National Electrical Manufacturer's Association
- Insulated Power Cable Engineers Association
- U.S. Coast Guard Publication, "A Guide to Bridge Lighting"
- Enclosure 6 to COMDTINST M16590.5
- Federal Aviation Administration, "Obstruction Marking and Lighting" AC70/7460-1F
- Regulations of local power company

In the event of conflict in any requirements of the above standards, the Engineer will determine which authority is applicable.

Two prints of shop drawings indicating the proposed dimensions and material specifications for the control center, enclosure, transformer, if required, and navigation light unit shall be submitted for approval purposes within three weeks after the award of the Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved" or "Returned for Revisions as Noted".

Eight sets of drawings shall then be submitted for final approval. Resubmission of drawings to obtain final approval by the Division shall not be considered as being just cause for delay in completion of any contract.

After the installation is completed, the Contractor shall conduct a continuous 24-hour operating test for approval. In addition, final acceptance of any installation will not occur until 30 days of operation termed satisfactory by the Engineer.

662.2.14.2-Navigation Lighting (Surface):

662.2.14.2.1-General: Navigation lights shall be securely mounted to the bridge structure or substructure and shall show through a horizontal arc of 360° for green lights and show through a horizontal arc of 180° for red lights as specified or detailed in the Plans. They shall be pivot-swivel mounted or pedestal mounted as specified. The pivot mounted lights shall have a locking mechanism and service-retrieving chain made of corrosion-resistant non-plastic material.

The navigation lights shall have one or two lenses with one or two lamps as specified but unless otherwise noted, are to have one lens with one lamp.

The lamps shall be 100-W, 120-V, rated at 5-years. The lenses shall be fresnel glass eight inches (203 mm) (177 mm minimum I. D.). The signal housing shall be made of aluminum, silicon bronze or cast bronze and shall be watertight with weather-proof gaskets.

The hangar stem shall be 1½ inches (40 mm) minimum galvanized steel pipe or 1½ inches (40 mm) minimum stainless steel pipe. The mounting bracket and hangar housing shall be cast silicon bronze with stainless steel pivot and shall be watertight.

The cable shall be #16 S. O. minimum and all connections shall be watertight. Any other structural connections shall be watertight and of good quality non-corrosive construction.

The pedestal mounted light shall meet all of the aforementioned light, lamp, lens, signal housing, cable and structural connection requirements. The pedestal mounted stem itself shall be similar to and meet the requirement of the pivot mounted hangar stem requirements.

Navigation lights shall be provided with supports constructed of steel meeting ASTM A 36. Each fixture shall be individually protected by "in the line" fuses as manufactured by ESNA Corporation, Bussman Manufacturing Division of McGraw-Edison Company, HOMAC, or approved equal.

The photoelectric control for navigation lights shall provide automatic switching of circuits. The unit shall be oriented as nearly as possible to face the northern sky. Initial settings shall be 35 footcandles for "turn on" and 58 footcandles for "turn off". The unit shall be housed in a weatherproof enclosure of the twistlock type. The unit shall be "fail safe", i.e., failure of the electronic circuit will "turn on" the navigation lights. The unit shall be suitable for operation in three-wire, 120/240 Volt, 60 Hz. circuits.

662.2.14.2.2-Power Service: Power shall be received at a location noted on the Plans or as directed by the Engineer. Power will be 120/240 Volt single phase, 60 Hz., three-wire from the Power Company. Materials to be furnished and installed by the Contractor will be as designated on the Plans or as directed by the Engineer.

662.2.14.2.3-Cable: Cable shall be single conductor, stranded copper, 600 Volt, Type THW. Cable for the final connection to swivel mounted navigation lights shall be three or four conductor stranded copper, 600 V, Type S. O. Cable splicing will be permitted in junction boxes only.

CONSTRUCTION METHODS

662.3-GENERAL:

The Plans show, in general, the location of the roadway lighting systems and other incidental work to be performed. They are diagrammatic only, but shall be followed as closely as actual site conditions will permit.

Any alternate design or significant departure from the Plans proposed by the Contractor must be prepared by the Contractor in written or plan form, or both, and presented in writing to the Division for approval. The Division will not approve substitution of material or design detail changes which constitute a reduction in quality, workmanship, or strength of the materials involved.

662.4-CONCRETE:

Concrete shall be mixed and placed in accordance with Section 601 of the Standard Specifications.

662.5-CONDUIT:

Conduits shall be of the size and type noted on the Plans. Conduit shall be installed at a minimum depth of 18 inches (450 mm) and at a distance of at least 6 inches (150 mm) from any utility line. Conduit runs shall be continuous in size from terminal point to terminal point. No reducing coupling will be permitted. All unused conduits shall be threaded and capped. Unused conduits terminating underground shall also be marked with a concrete marker.

The threads on all steel pipe conduit shall be painted with rust preventative paint meeting Military Specification MIL-P-21035 before couplings are made. All couplings shall be tightened until the ends of conduits are brought together. Conduits stubs, caps, exposed threads, or damaged galvanized areas shall be painted with rust preventive paint meeting Military Specification MIL-P-21035.

Expansion deflection fittings shall be installed in metallic conduit runs in bridge structures and in retaining walls at all expansion joints and all stringer (stress) relief joints and all other locations as specified on the Plans. These fittings shall be bonded with approved flexible tinned copper bonding jumpers.

Conduit shall be placed under existing pavement by approved jacking or drilling methods. Pavement shall not be disturbed without permission of the Engineer. In the event obstructions are encountered, upon approval of the Engineer, small test holes may be cut in the pavement to locate obstructions. Jacking or drilling pits shall be kept 2 feet (600 mm) clear of the edge of any type of pavement wherever possible. Water jetting will not be permitted.

PVC conduit shall be made water tight by joining with solvent as per the manufacturer's recommendations. Ends terminating in junction boxes shall be terminated with end bells. Ends joining to metal conduit elbows at foundations shall be connected through expansion couplings and adapters.

Approximate lengths of conduit are shown on the Plans. It is the responsibility of the Contractor to determine exact lengths of conduit runs in the field.

A number 12 AWG (minimum) galvanized pull wire shall be installed in all conduits which are to receive future conductors. At least 2 feet (600 mm) of pull wire shall be doubled back into the conduit at each termination.

662.6-BACKFILL:

All excavations shall be backfilled with suitable random material in horizontal layers not to exceed 4 inches (100 mm) after compaction. Each lift shall be compacted to the satisfaction of the Engineer. Testing is not required. All surplus material shall be removed from the right-of-way and the backfill finished flush with surrounding natural ground, including replacement of any damaged facilities or appurtenances. The Contractor shall restore all areas disturbed by this excavation or other operations to their original conditions including grading, seeding, mulching and fertilizing as directed by the Engineer.

662.7-MANHOLES AND JUNCTION BOXES:

Boxes shall be located as shown on the Plans. Manholes and junction boxes shall be set so that the top of cover will be level with the surface without using an excessive amount of mortar for setting the metal frames.

Fill material for drainage shall be laid 12 inches (300 mm) minimum depth under the entire manhole or junction box. The aggregate used shall be stone or gravel of a grade approved by the Engineer and shall be by visual inspection a uniformly graded mixture of particles from 3/8 to 3/4 inch (10 to 20 mm) in nominal diameter.

The Contractor may, with the approval of the Engineer and at his own expense, install additional manholes or junction boxes to facilitate the work of installing conduit and pulling cable.

662.8-LUMINAIRES:

No luminaire shall be installed until the lamp socket position has been inspected and approved by the Engineer for conformance to the manufacturers recommended position for the specified distribution.

All luminaires shall be properly adjusted to produce the maximum illumination on the roadway surface, without disrupting the intended light distribution pattern.

The connection between the luminaire and connector kits shall be made with # 10 wires.

662.9-CABLES:

The Contractor shall provide adequate equipment for installation of cable, and shall pull all wires through conduits in such a manner as not to score, cut, twist or damage the protective covering or insulation. In the pulling of cables into conduits, where the strain on the cables is likely to prove excessive, the Contractor shall use soapstone powder as a lubricant. Where two or more cables are to occupy the same conduit, they shall be drawn in together and kept parallel to each other by the use of a pulling head.

Without exception, cables in manholes, junction boxes and bases shall be provided with an adequate amount of slack for subsequent connects and shall be arranged as ordered by the Engineer. After the cables have been installed and pending permanent connection, the end of each section of cable in manholes, junction boxes, bases and panel boxes shall be carefully sealed, using rubber tape, and painted with a sealing type of waterproof compound. Cables in manholes and junction boxes shall be placed on cable racks while waiting permanent connection. Ends of cable not connected to any device, which are to remain after completion of construction, shall be

insulated and sealed in a manner similar to a special splice. Cables in manholes and junction boxes shall be neatly arranged in a workmanlike manner and laced with nylon cable straps.

The Contractor, in connecting sockets, outlets and other similar equipment, shall ground the most accessible bare parts of each piece of equipment. In order ensure that this has been done, each piece of equipment shall be tested after installation, and under the supervision of the Engineer, with a test lamp, one leg of which has been connected to a definite ground, or by other approved means of testing.

All cable in junction boxes and lighting supports shall be tested for circuit connections which shall be in conformity with those indicated on the detail drawings. All cables in junction boxes, manholes and lighting supports/lighting support bases shall be provided with individual non-corrosive metal (minimum 1 ½ inch (40 mm) diameter) tags, die stamped with the control station (as applicable), circuit and phase designation. Similarly designed plastic tags shall be used in control stations. The tags shall be securely attached to the cables with nylon cord of 1/16 inch (2 mm) minimum diameter.

Upon completion of each wiring system, and before any connection is made to operating equipment, it shall be the responsibility of the Contractor to perform, in the presence of the Engineer, the following tests of each circuit to determine where the installations are in acceptable working order:

- Tests for continuity
- Tests for grounds
- Tests for insulation resistance between circuit wires and from circuit wires to ground

Upon completion of the electrical system, with fuses removed and before energizing, the insulation resistance shall be not less than five megohms.

662.10-CABLE-IN-DUCT:

At sign bridges where no sign lighting is contemplated under this contract, a sufficient length of cable shall be brought out of the ground or conduit system and extended up to the handhole or junction box of the sign bridge to permit future connections to sign lighting circuits without the need for splicing in additional underground cable.

Underground cable shall be installed at a depth of not less than 30 inches (750 mm) below finished grade or within the protection of galvanized metal conduit under roadways or in structures. Cable to be placed within the protection of conduit in structures may be installed without the polyethylene duct specified, provided that the duct originating from an underground location is continuous to the first junction box or other terminal connection on the structure. The general location of the cable is shown in the details of the Plans. However, the Contractor shall locate all underground cable in a manner that will preclude damage to cable resulting from subsequent construction operations. The conductor size indicated in the Plans is the minimum size permitted.

Cable placed in continuous conduit raceways shall be terminated with an appropriate splice connection at each junction box provided in the conduit system even though a lighting unit does not exist at that location, unless directed otherwise by the Engineer in the field.

A 5/8 inch by 8 feet (15.88 mm by 2.4 m) copper weld ground rod shall be installed at each ground mounted sign bridge. Installation and connections to units shall be as directed by the Engineer. The grounding conductor shall be connected to the grounding lug in each lighting support and sign bridge column.

The polyethylene ducts, where required, shall be continuous to within 6 inches (150 mm) of a terminal connection.

The Contractor shall exercise care in the installation of the cable-in-duct to insure that the completed duct raceway is smooth and free of sharp bends and that the cables inside the duct are free and are capable of being removed and replaced in the completed cable-in-duct assembly.

Connections and terminations of cable required at existing distribution centers including fuses, hardware and site restoration as required to make the lighting circuits complete and operable, and installation of ground rods to sign bridges shall be considered incidental to this item

662.11-LIGHTING SUPPORTS:

Lighting supports shall be located in accordance with the details shown on the Plans governing the spacings and set backs to provide continuously aligned lighting support installation, unless otherwise ordered by the Engineer. All anchor bolts shall be installed, tightened and tested in accordance with sections 658.5.1, 658.5.3, and 658.5.4.

662.11.1-Types I, II, III, IV, V and VII: Luminaire support arms shall be set normal to the roadway unless otherwise directed by the Plans or the Engineer. Each lighting support (except for twin arm poles and Type VII) shall be raked a horizontal distance from vertical at the top of the pole equal to the taper of the pole in inches per foot (millimeters per meter) times the height of the pole in feet (meters), unless otherwise directed by the Plans or the Engineer. Lighting support wiring shall consist of # 10 AWG single conductor, THWN insulated wire for both neutral and phase legs, and shall conform to the requirements for cables outlined in the preceding paragraphs.

When Type V lighting supports are to be erected on bridges, the entire assembly, including support arms and luminaires, shall be fully installed as a complete assembly at one time. When Types V or VII lighting supports are to be in contact with dissimilar materials: e.g., non-galvanized steel or concrete, the contacting parts shall be protected from corrosion by appropriate painting as noted in Section 1.5.4 of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals".

Aluminum surfaces that are to be in contact with concrete shall be given a heavy coat of alkali-resistant bituminous paint before installation.

The Contractor shall take full responsibility for checking all cross sections to determine final support lengths.

662.11.2-Type X: The loading, transporting, unloading and piling of structural materials shall be conducted so that the metal will be kept clean and free from injury in handling. Structural materials shall be stored above the ground upon platforms, skids, blocks or other supports. They shall be kept free from accumulation of dirt, oil, acids, or other foreign matter.

The manufacturer shall supply the Division with complete written instructions for the installation, operation and maintenance of the lighting supports and also complete parts lists for all items included by manufacturer and part number. The Contractor shall install the lighting supports strictly in accordance with the manufacturer's instructions. Extreme care should be exercised during lifting and plumbing. The manufacturer shall supply factory assistance in field assembly and installation when deemed necessary by Division. After the lighting support with all devices has been fully erected, the lowering devices shall be subjected to repetitive cycles of operation as a test.

662.12-FOUNDATIONS:

Footers shall conform to the sizes and shapes shown on the Plans, and shall be poured monolithically. The excavation shall conform to the neat lines of the footer. The top 12 inches (300 mm) and upper portion of the foundation shall be formed and floated and finished smooth on all sides. Castings may be used when deemed necessary by the Engineer to prevent caving of the soil. When casings are used, it is preferable that they be withdrawn as the shaft is filled with concrete. A concrete head of at least 2 feet (600 mm) should be maintained above the bottom of the casing. If any upward movement of the concrete or reinforcement cage occurs at the beginning of the casing pulling operation or at any time during casing pulling, removal should be stopped immediately and the casing left in place.

The conduit bends and anchor bolts shall be accurately set (by template) in the forms and rigidly held in position during concreting operations. No welding shall be permitted on anchor bolts, except at the bottom. Anchor bolts for Type X lighting supports shall be caged into a unit and shall include a steel template at the bottom for presetting. Reinforcement (vertical bars and hooping) shall be completely assembled and placed into position as a unit. The unit must be adequately supported in the excavation to insure centering for the entire length of the shaft.

662.13-GROUNDING:

662.13.1-General: The necessary conduit, conductors, bonding jumpers, clamps, connectors, ground rods, etc. for the grounding system shall be furnished, installed and connected by the Contractor. The grounding system shall be considered as an integral part of the system to which it belongs, e.g. conduit, manholes, junction boxes, luminaires, lighting supports, service and control stations, navigation lighting system, structures, etc. as appropriate.

In general, alternating current circuits, enclosures and frames of electrical apparatus, and conduit systems must be effectively and permanently grounded with a cross section as required by the National Electrical Code and of capacity sufficient to ensure continuity and continued effectiveness of the ground connections for fault current. Ground conductors must be as short and straight as possible, protected from mechanical injury and, where practicable, without splice or joint.

662.13.2-Codes and Approvals: All grounding work shall be done in accordance with the latest edition and revisions of the National Electrical Code and the regulations of State and local codes.

All connections in ground network shall be done of a type approved by NEC, Article 250.

662.13.3-Metal Conduits: All metal (rigid steel) conduit ends shall be bonded and grounded by means of a # 8 bare copper cable. The grounding shall be accomplished by driving ground rods as detailed on the Standard Drawings or the Plans. Grounding from the conduit to the ground rod in a junction box or manhole shall be accomplished by use of a # 8 bare copper cable. Grounding from the conduit to a lighting support shall be accomplished by use of an insulated (green) copper conductor equal in size to the largest adjoining phase wire except where otherwise called for on the Plans. The connection of the bonding cable to the junction box frames and to the shafts of the lighting supports shall be done by means of a grounding stud. The neutral conductor shall be grounded at the service and control station.

662.13.4-Lighting Supports on Bridges: The lighting supports installed on bridge structures shall be grounded by bonding the grounding bushings of the metal conduit terminating to the ground connector in the pole shaft or parapet bracket. The other end of this conduit, which terminates in a junction box, shall be bonded to the junction box frame and to an insulated ground conductor which shall be installed in the same conduit as the lighting circuit conductors. This ground conductor shall be continuous across each bridge, and it shall be attached to the ground rod in the junction box or lighting support adjacent to each end of a bridge.

662.13.5-Service and Control Stations: Grounding of all service and control stations shall be accomplished by means of a ground connector installed in the service cabinets where shown on the Plans and bonding all conduit ground bushings, metal casing of equipment, and neutral conductors by means of individual # 4 conductors, as elsewhere specified to the above mentioned ground connector. The other ends of these conduits shall be bonded together and connected to the ground rod in the adjacent concrete junction boxes.

662.14-TESTING:

The Contractor is advised that before proceeding with any work under this Contract, the Contractor shall conduct the necessary continuity and insulation tests to establish the integrity of cable runs already in place. The Contractor shall report any cable fault found to the Engineer. In case any fault is located while contract work is in progress, and which has not been reported by the Contractor as prescribed, then the Contractor shall be responsible for the correction of any such fault without any extra compensation.

Continuity and insulation tests shall also be performed in a manner satisfactory to the Engineer on cable runs to be placed under this contract. The Contractor shall be responsible for the correction of any fault discovered.

With all equipment connected to the wiring system, a functional test shall be performed by the Contractor in the presence of the Engineer to demonstrate that the system as a whole and all parts thereof function as specified or intended. Any defective materials or faulty or improper installation shall be permanently corrected by repairs or replacements to be made by the Contractor to the satisfaction of the Engineer at no additional cost.

Lighting circuits shall then be subjected to such other tests as may be required, including additional insulation resistance testing as detailed in 662.9, and shall be the responsibility of the Contractor to perform these tests in the presence of the Engineer or authorized representative. All tests shall be performed at the expense of the Contractor.

After the installation is completed, the Contractor shall conduct a continuous 24-hour operating test for approval. In addition, final acceptance of an installation will not occur until 30 days of operation termed satisfactory by the Engineer.

During the 30 days of operation, the Contractor shall be responsible for repairing or replacing any defective equipment within 24 hours after being notified by the Engineer. After any malfunctioning equipment has been repaired or replaced, the 30 day test shall begin anew.

The Contractor shall inspect and certify to the replacement of all damaged traffic signal loop conductors and to the proper functioning of the traffic signal, and that the junction boxes within the project limits comply with section 660.15. The inspection shall be performed before project completion and after all the work has been completed in the area of the traffic signal system and related components.

The Electrical Inspection shall be paid as item 662015-*, Electrical Test, per Lump Sum.

662.15-METHOD OF MEASUREMENT:

662.15.1-Conduit: Galvanized steel conduit and PVC conduit will be measured as a complete and operable conduit system on a lump sum basis per service.

662.15.2-Manholes: Manholes will be measured as a complete unit in place on a per each basis.

662.15.3-Junction Box: Junction Box Type A, B, C, H, or L will be measured as a complete unit in place on a per each basis.

662.15.4-Luminaires: Luminaires will be measured as a complete unit in place on a per each basis including lamp of wattage called for on the Plans.

662.15.5-Cable: Cable will be measured as a complete and operable cable system on a lump sum basis per service, including all connector kits necessary.

662.15.6-Cable-in-Duct: Cable-in-Duct will be measured as a complete and operable duct system on a lump sum basis per service.

662.15.7-Lighting Supports: Lighting supports will be measured per each per type furnished and installed, including support base and foundation as required for each support.

662.15.8-Service and Control Station: Service and control station will be measured as a complete and operable unit in place on a per lump sum per service basis.

662.15.9-Incidental Electrical Work: Incidental electrical work will be measured as a complete unit on a lump sum basis. Measurement of the unit will be based upon the amount of incidental work shown on the Plans and as necessary to complete the work.

662.15.10-Electrical Tests: Electrical tests will be measured as a complete unit on a lump sum basis per service, including all tests performed as required by the Plans and Specifications.

662.15.11-System Modification: System modification will be measured as a complete unit on a lump sum basis. Measurement of the unit will be based upon the actual amount of changes performed on previously installed systems as called for on the Plans and as necessary to complete the work.

662.15.12-Navigation Lighting System: Navigation lighting system will be measured as a complete and operable system in place on a lump sum per service basis. If the project requires temporary protection of any existing or new structure/substructure for an interim period of construction, all such temporary items/facilities shall be included in the pay item.

662.16-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which prices and payments shall be full compensation for furnishing all the materials and doing all work in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work. All incidental work and materials for which no basis of payment is provided will be considered as completely covered by the prices bid for the items included in the contract.

662.17-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
662002-*	Galvanized Steel Conduit	Lump Sum
662003-*	Polyvinylchloride Conduit	Lump Sum
662006-*	Junction Box , Type “type”	Each
662007-*	Luminaires	Each
662008-*	Cable	Lump Sum
662010-*	Lighting Support, Type “Type”	Each
662013-*	Service And Control Station	Lump Sum
662014-*	Incidental Electrical Work	Lump Sum
662015-*	Electrical Test	Lump Sum
662016-*	System Modification	Lump Sum
662020-*	Navigation Lighting System	Lump Sum

* Sequence number

SECTION 663 PAVEMENT MARKINGS

663.1-DESCRIPTION:

Pavement markings shall consist of furnishing and installing various types of markings. It shall include, but is not limited to, edge lines, lane lines, center lines, channelizing lines, intersection markings, stripes, curb markings, island markings, and raised markers, or combinations thereof, in accordance with Contract plans and the following specifications or as directed by the Engineer.

All details not specified or shown on the Plans shall conform to the details and requirements set forth in the following publications. These publications shall collectively be referred to as the “pavement marking standards” throughout the remainder of this Section:

1. The WVDOT Standard Details Book, Vol. II, Signing, Signals, Lighting, and Marking, latest issue date
2. The Manual on Uniform Traffic Control Devices for Streets and Highways, latest issue, as printed by the Federal Highway Administration, U.S. Department of Transportation. (Referred to as the MUTCD.)

663.2-MATERIALS:

Materials shall conform to the following Subsections of Division 700 of the Standard Specifications:

MATERIAL	SUBSECTION
Interim Pavement Markings, Type VIIA	715.40.3
Preformed Traffic Markings, Type V	715.40.2
Raised Pavement Markers	715.40.6
Temporary Pavement Marking Tape, Types VIIB and VIIC	715.40.4
Temporary White or Yellow Traffic Paint	711.40
White or Yellow Fast-Dry Traffic Paint, Type II	711.41

663.3-TYPES OF PAVEMENT MARKINGS:

663.3.1-Edge Lines: Edge lines shall be continuous or dashed, white or yellow beaded stripes, six (6) inches (100 mm) or eight (8) inches (150 mm) in width, as specified on the Plans or otherwise in the pavement marking standards. Color to be specified on the Plans. Center of stripe shall be located six (6) inches (150 mm) from the edge of the pavement or as otherwise specified on the Plans.

Dashed edge lines shall be applied in lengths of two (2) feet (0.6 m), separated by gaps of six (6) feet (1.8 m), or as otherwise specified on the Plans.

663.3.2-Lane Lines and Centerline: Lane lines and centerlines shall be lines between contiguous lanes of pavement. They shall be continuous, broken, or dashed, white or yellow beaded stripes six (6) inches (150mm) or eight (8) inches (200mm) in width, as specified on the Plans or otherwise in the pavement marking standards.

Lane lines and broken centerline lines shall be applied in lengths of ten (10) ft. (3m), separated by gaps of thirty (30) ft. (9m). Dashed lane lines shall be applied in lengths of two (2) ft. (0.6m) separated by gaps of thirteen (13) ft. (4m), or lengths of three (3) ft. (0.9m)

separated by gaps of nine (9) ft. (2.7m), as specified on the Plans or otherwise in the pavement marking standards.

When applied to bituminous surfaces, the center of single stripes shall be centered about the dividing line between the contiguous lanes. When applied to Portland cement concrete pavement, the near edge of single stripes shall be offset to the left and four (4) inches (100 mm) from the longitudinal joint. Double yellow centerlines shall be centered about the dividing line between the contiguous lanes, with the gap between the stripes being equal to the width of the stripes.

663.3.3-Railroad Crossing Marking: Railroad Crossing Markings shall be white beaded markings located as shown on the Plans or otherwise in the pavement marking standards. Dimensioning shall be in accordance with the pavement marking standards.

663.3.4-Channelizing Lines: Channelizing lines shall be continuous white beaded stripes, eight (8) inches (200mm) in width. The length of the line shall be as detailed on the Plans.

663.3.5-Stop and Crosswalk Lines: Stop lines shall be solid white beaded lines, twelve (12) inches (300 mm) or twenty-four (24) inches (600 mm) wide, as specified on the Plans or otherwise in the pavement marking standards. Crosswalk lines shall be solid white beaded lines, twelve (12) inches (300 mm) wide by six (6) feet (1.8 m) in length.

663.3.6-Stripes: These markings are transverse, diagonal or longitudinal white or yellow beaded lines, twelve (12) inches (300 mm) wide. They are used to increase the visibility of pedestrian crosswalk areas and to designate neutral traffic zones formed by channelizing lines or edge lines. Location, spacing and use of these stripes shall be shown on the Plans or otherwise in the pavement marking standards.

663.3.7-Curb and Island Markings: Where specified, exposed surfaces of curbs and paved islands shall be painted solid with yellow or white fast-dry traffic zone paint (Type II) and covered with glass beads. Color to be specified on the Plans.

663.3.8-Arrows: Arrows shall be white beaded markings located as shown on the Plans or otherwise in the pavement marking standards. Dimensioning shall be in accordance with the pavement marking standards. Arrows may be one of the following:

1. One Directional Lane Assignment Arrows
2. Multi Directional Lane Assignment Arrows
3. Ramp Wrong Way Arrows
4. Lane Drop Arrows

663.3.9-Lane Letters: Lane letters shall be white beaded markings located as shown on the Plans or otherwise in the pavement marking standards. Dimensioning shall be in accordance with the pavement marking standards.

663.3.10-Raised Pavement Markers (RPM's): RPM's include reflective Type P-2 markers and reflective Type R-4 markers. The type to be installed and general placement guidelines shall be as shown on the Plans or otherwise in the pavement marking standards.

663.3.11-Yield Triangles: Yield Triangles shall be white beaded markings located as shown on the Plans or otherwise in the pavement marking standards. Dimensioning shall be in accordance with the pavement marking standards.

663.3.12-Handicapped Symbols: Handicapped symbols shall be white beaded markings located as shown on the Plans or otherwise in the pavement marking standards. Dimensioning shall be in accordance with the pavement marking standards.

663.3.13-Bicycle Symbols: Bicycle symbols shall be white beaded markings located as shown on the Plans or otherwise in the pavement marking standards. Dimensioning shall be in accordance with the pavement marking standards.

CONSTRUCTION METHODS

663.4-PAVEMENT PREPARATION-PREMARKING, CODING:

The Contractor shall clean all debris from the surface to be marked by means of a power broom, compressed air or other mechanical means to the satisfaction of the Engineer. Markings and markers shall be applied only when the surface is clean and dry and when ambient and other roadway conditions are within any specified requirements herein.

If pavement markings are included in the contract, they shall be applied in a timely manner and in the patterns directed by the Plans or pavement marking standards.

All materials shall be applied as recommended by the material manufacturer. This shall include surface pre-treatment, if required.

All surface cleaning, surface pre-treatment and premarking shall be performed by the Contractor prior to the installation of the proposed markings, or markers, and shall be subject to approval by the Engineer.

Coding and premarking changes in traffic flow patterns, i.e., passing, no passing zones, is very critical and should always be approved by the Engineer.

663.5-APPLICATION:

663.5.1-General: The Contractor shall supply all of the marking material, equipment, and traffic control devices required for the completion of the project.

The Contractor shall provide and have approved by the Division a plan for traffic control and maintenance for all phases of the marking operations. The plan must be approved by the Division prior to the beginning of work. All traffic control plans shall be in conformance with provisions in the WVDOT publication "Manual on Temporary Traffic Control for Streets and Highways", latest Edition.

663.5.1.1-Interim Traffic Control, Temporary Marking, and Permanent Marking Placement Schedule: The Contractor shall adhere to specific guidelines provided herein for scheduling the placement of interim traffic control, temporary pavement markings, and permanent pavement markings. These guidelines are based on various factors such as facility type, ADT, and time of season. All interim, temporary, and permanent pavement markings shall be in conformance with specifications herein, the project Plans, or otherwise the pavement marking standards. The Contractor shall be responsible for maintaining both interim traffic control signs and temporary pavement markings until such time as the

permanent markings are placed or for the duration of the thirty (30) calendar day warranted performance period for the temporary markings, whichever is less. No separate payment will be made for maintenance of these items but shall be included in the applicable pay items for initial installation.

If it becomes necessary to open the roadway to traffic prior to the completion of the final paving course for longer than fourteen (14) calendar days, the Contractor shall install full compliance temporary pavement markings in conformance with Section 636 and the specifications herein.

663.5.1.1.1-Interim Traffic Control Placement Schedule: Interim Traffic Control includes interim pavement markings and may also include “Do Not Pass” regulatory signs. Interim markings are markings applied to freshly resurfaced roadways between lifts and after placement of the final lift prior to opening the portion of the roadway being resurfaced to traffic. These markings are intended to provide the minimum amount of delineation required for safe navigation of the roadway. Interim markings shall be Type VIIA material applied as described in Section 663.5.6 and shall meet the requirements of Material Section 715.40.3. All interim markings shall be installed by the end of the work day by placing the markings as the paving operation progresses within 1000 feet (300 meters) of the paver. Removal of interim markings shall not be required between lifts or after placement of the subsequent markings. Payment of interim markings shall be incidental to the Paving Items. The specific interim traffic control to be placed shall be in accordance with the following.

663.5.1.1.1.1-Two-Lane, Two-Way Roadways: Prior to any work which will cover the centerline, the Contractor shall install twenty-four (24) inch (600mm) x thirty (30) inch (750mm) “Do Not Pass” (R4-1) signs on permanent posts at the beginning of each no passing zone throughout the length of the project. These signs shall be placed at the beginning of each no passing zone and shall be repeated every 2,500 feet (762 m) as required. Payment shall be made under the “Traffic Control Devices” item.

To delineate the centerline of the roadway, the Contractor shall install yellow interim markings measuring four (4) inches (100mm) x four (4) inches (100mm) along the centerline of the roadway on twenty (20) foot (6 m) centers.

663.5.1.1.1.2-One-Way Multilane Roadways: On all one-way multilane roadways, the Contractor shall install white interim markings measuring four (4) inches (100mm) x forty-eight (48) inches (1200mm) along the lane line. Interim markings shall be placed on forty (40) foot (12 m) centers.

663.5.1.1.1.3-Two-Way Three-Lane Roadways: Prior to any work which will cover the centerline and/or lane lines, the Contractor shall install twenty-four (24) inch (600mm) x thirty (30) inch (750mm) “Do Not Pass” (R4-1) signs on permanent posts at the beginning of each no-passing zone throughout the length of the project as required. “Do Not Pass” signs in both directions will be required when the center lane is a two way left turn lane. These signs shall be placed at the beginning of each no-passing zone and shall be repeated every 2500 feet (762 m) as required. Payment shall be made under the “Traffic Control Devices” item.

The Contractor shall install interim markings measuring four (4) inches (100mm) x forty-eight (48) inches (1200mm). On such roadways having two thru lanes in one direction, the centerline shall be marked with two parallel yellow lines separated by a four (4) inch (100mm) space placed on forty (40) foot (12 m) centers. Lane lines shall be marked with white lines placed on forty (40) foot (12 m) centers. On such roadways having a two way left turn lane, the center lane shall be marked on both sides with two parallel yellow lines separated by a four (4) inch (100mm) space, and placed on forty (40) foot (12 m) centers.

663.5.1.1.4-Two-Way Four-Lane and Five-Lane Roadways: On all two-way four-lane and five-lane roadways, the Contractor shall install interim markings measuring four (4) inches (100mm) x forty-eight (48) inches (1200mm) along the lane line and centerline where required. Centerlines shall be marked with two parallel yellow lines separated by a four (4) inch (100mm) space placed on forty (40) foot (12 m) centers. On five-lane roadways these markings shall be placed on both sides of the two way left turn lane. Lane lines shall be marked with white lines placed at forty (40) foot (12 m) centers.

663.5.1.1.2-Temporary Pavement Marking Placement Schedule: Interim markings are to be succeeded by temporary markings within a three (3) to fourteen (14) day period, based on the type of roadway and ADT, as specified herein. Temporary markings are markings, typically short-lived in nature, which supplant interim markings. Temporary markings shall be applied as specified herein and in Section 636, and shall meet the requirements of Materials Section 711.40. Payment for Temporary pavement markings shall be made under the "Temporary Pavement Marking Paint" pay item.

Interim Markings shall be permitted only for a period of up to three (3) calendar days after completion of the final course. The only exception to this shall be for two-way, two-lane roadways having an ADT < 3,000, in which case fourteen (14) Calendar Days shall be permitted after completion of the final course.

Full compliance temporary centerline and edge lines in conformance with Section 636 and the specifications herein shall be installed on two-way, two-lane roadways within the time frame specified above. Two-way three-lane, two-way four-lane, and two-way five-lane roadways shall have full compliance temporary centerline, lane line, and edge lines installed in conformance with Section 636 and the specifications herein within the time frame specified above.

On one-way multilane roadways, the Contractor shall install a full compliance temporary yellow edge line after paving is first completed in the left lane and prior to the left lane being opened to traffic. Prior to the remaining lanes being opened to traffic, the Contractor shall install a full compliance temporary white lane lines and white edge line. These markings shall be installed in conformance with Section 636 and the specifications herein.

663.5.1.1.3-Permanent Pavement Marking Placement Schedule: Permanent markings are the final pavement marking application within a project. Permanent markings shall be placed as specified herein and shall meet the requirements of Materials Sections 711.41, 715.40.2, 715.40.6, and/or any other material specifications made part of the Contract.

The Contractor shall be required to place full compliance permanent pavement markings within sixty (60) calendar days after the placement of temporary pavement markings. In addition, there shall be a minimum thirty (30) calendar day period between the placement of temporary and permanent markings when the temporary markings are placed on or after April 15th and prior to November 1st. There shall be a minimum fifteen (15) calendar day period between the placement of temporary and permanent markings when the temporary markings are placed on or after November 1st and prior to April 15th of the following year. Full compliance markings shall consist of all centerline, lane line, channelizing line, edge line, and intersection markings.

663.5.2-Temporary and Permanent White or Yellow Traffic Zone Paint: Pavement marking lines shall be straight or of uniform curvature and shall conform to the tangents, curves, and transitions as specified in the Plans, the pavement marking standards, and/or as directed by the Engineer.

The finished lines shall have well-defined edges and be free of horizontal fluctuations. The lateral deviation shall not exceed 0.5 inch (13 mm) from the proposed location alignment as specified herein, on the Plans, in the pavement marking standards, and/or as directed by the Engineer.

When striping interchanges and intersections, material shall be applied for the full length of all ramps and the entire perimeter surrounding islands and gore areas. When striping at-grade intersections, yellow edge lines shall be placed completely around and shall be connected at the median ends.

The Contractor shall be responsible for removing all pavement marking materials spilled upon the roadway surface or adjoining area. The Contractor shall use methods acceptable to the Engineer for removing the spilled material.

Any pavement marking which is crossed by a vehicle and tracked shall be replaced and any subsequent marking made by the vehicle shall be removed by methods acceptable to the Engineer and at no additional cost to the Department.

Unless otherwise specified, the Contractor shall be responsible for coding and spotting per the Plans or otherwise the pavement marking standards. The Contractor's coding and spotting shall be reviewed and approved by the Engineer prior to application.

The Contractor will be responsible for cleaning any Raised Pavement Marker (RPM) lenses that are painted during this Contract. If the RPMs are not able to be cleaned, the Contractor shall replace the effected RPM lenses.

Permanent Traffic Paint shall be Type II, White or Yellow Fast- Dry Traffic Paint as described in Materials sections 711.41, unless otherwise specified in the Contract Plans. In regards to ambient air temperature, the Contractor shall utilize an appropriate pavement marking material such that the ambient air temperature at the time of application is within the recommended ambient air application temperatures specified by the material manufacturer. This requirement shall apply to both temporary and permanent traffic zone paint. The Contractor shall not be granted any time extensions to the requirements for the application of temporary or permanent markings, based on ambient air temperature, when the ambient air temperature is thirty-five (35) degrees Fahrenheit (1.7 degrees Celsius) or above. The Contractor shall not be paid any additional monies in order to provide materials suitable for cold weather application. Whenever temporary or permanent traffic zone paint is applied at an ambient air temperature below fifty (50) degrees Fahrenheit (10 degrees Celsius), the

Contractor shall provide, upon request by the WVDOH, a certification letter from the marking material manufacturer. This certification letter shall reference the project number, shall identify the marking material supplied for the project, and shall state the minimum acceptable ambient air temperature for application of the material.

Temporary traffic paint shall be applied at the same width as will be used for the permanent markings.

663.5.2.1-Approved Equipment and Personnel: The following provisions shall apply to the application of permanent traffic zone paint only:

The Contractor (prior to commencement of the project) shall submit to the Engineer a detailed list of all equipment and the resumes of all personnel within the confines of the project. The Contractor shall also provide certification from the binder manufacturer that the Contractor is qualified to apply the manufacturer's material in conformance with these specifications. Drivers and operators with less than one year of experience shall not be used on this project.

The Contractor's striper shall be equipped with electrical foot counters. The counters shall individually tabulate the amount of footage applied by each striping gun whether solid or dashed. The counters shall be six digit types with a reset feature. The Contractor shall determine the accuracy of the foot counters and establish an adjustment factor as required to determine the pay item quantities. The foot counters shall be periodically checked to assure accurate measurements. No paint shall be applied without the accurate operation of the foot counters. The Contractor shall provide the Engineer with a certified document on these calibrations.

The Contractor shall use an accurate dashing mechanism, capable of being adjusted to retrace existing lane or center line markings.

Glass beads applied to the surface of the completed marking material shall be applied by an automatic bead dispenser attached to the pavement marking equipment in such a manner that the beads are dispensed uniformly and almost instantly upon the marking as the marking is being applied to the road surface. The bead dispenser shall be equipped with an automatic cut-off control, synchronized with the cut-off of the pavement marking equipment.

663.5.2.2-Contractor's Warranty: The Contractor shall warranty the performance of temporary traffic zone paint for a period of thirty (30) Calendar Days after application, and shall warranty the performance of Type II permanent traffic zone paint through October 31st. If the Type II markings are placed on or after November 1st, the markings shall only be required to meet the initial performance requirements specified in the Materials Section. The required performance level of the markings are described in Section 711.41.

During the warranty periods, if any markings greater than 1000 feet (305 m) are found to be deficient for any reason, the Contractor will be given notification stating the locations and the type of deficiency. These notifications will be given at any time within the specified warranty periods for the markings. The Contractor shall completely replace the deficient markings, as directed by the Engineer, within twenty (20) calendar days of the written notification. Retroreflectivity and color may be checked after re-application of the pavement marking to ensure that segment meets the minimum values specified in Section 711.41.

If the Contractor does not complete the replacement of all of the deficient pavement markings by the end of the twenty (20) calendar day replacement period, and the Contract has not been finalized, the Contractor shall be subject to liquidated damages as described within Section 108.7 until replacement is completed. These liquidated damages shall not stop during the winter shut-down period. No direct payment shall be made for the replacement of any deficient pavement marking during the warranty period as such work shall be considered as incidental to the work as paid for by the various pavement marking items in the Contract.

663.5.3 through 663.5.4-BLANK

663.5.5-Type V Preformed Intersection Traffic Markings: Type V preformed intersection traffic markings shall be affixed to bituminous or Portland cement concrete pavements as specified in the Contract Plans, or as otherwise specified on the pavement marking details.

Care shall be taken by the Contractor to follow the installation recommendations of the material manufacturer. Preformed tapes used as Type V material are particularly sensitive to ambient air temperatures and road surface temperatures. Both preformed tapes and thermoplastics are highly sensitive to extraneous materials on the road surface and moisture contained on and within the road surface. Type V materials shall not be applied if the manufacturer's recommendations are not met.

The Contractor shall provide the Engineer with certification from the Manufacturer that they have been adequately trained through the Division of Highway's approved training seminar to apply this material. This certification shall be valid for a period of four (4) years after being issued, after which recertification shall be required.

663.5.5.1-Contractor's Warranty: If the material has been identified by the Division as having failed the skid resistance (when applicable), adherence, road presence, color, and/or retroreflectivity requirements described in Materials Section 715.40.2 prior to finalization of the Contract, the material shall be corrected by the Contractor in a manner acceptable to the Division and in accordance with the Manufacturer's recommendations at no additional cost to the Division if the failure is determined by the WVDOT to be caused by improper installation or defects in the manufacturer's materials.

If the material has been identified by the Division as having failed the skid resistance (when applicable), adherence, road presence, color, and/or retroreflectivity requirements described in Materials Section 715.40.2 after finalization of the Contract, and less than one (1) year from the date of application, the material shall be corrected by the Contractor in a manner acceptable to the Division and in accordance with the Manufacturer's recommendations at no additional cost to the Division if the failure is determined by the WVDOT to be caused by improper installation.

All warranty related work required shall be completed within sixty (60) calendar days of notification. In the event that the Contractor fails to meet this time requirement, liquidated damages will be charged for each Calendar Day in the amount of \$120 per day.

The Contractor may, but shall not be required to replace preformed thermoplastic Type V material between December 1st and March 1st of the following year. The Contractor may, but shall not be required to replace preformed marking tape Type V material between

October 1st and May 1st of the following year. Calendar Days falling within the time frames specified above will not be counted against the Contractor.

In addition to any liquidated damages, non-compliance with the warranty requirements specified above may result in the Division's temporary non-recognition of the Contractor's material application manufacturer certifications, as described in Section 663.5.5 and as they pertain to other ongoing and/or future Contracts, until the failed materials are corrected.

663.5.6-Interim Pavement Markings (Type VIIA Material): Interim Pavement Markings shall be Type VIIA Interim Pavement Marking Tape. Type VIIA Marking shall be installed in accordance with the manufacture's recommendations.

The Contractor shall remove all dirt, debris, and loose particles from the road surface application areas immediately prior to the installation of Interim markings.

While in place, Type VIIA pavement markings shall remain adhered to the pavement, and shall meet the color and retroreflectivity requirements described in Materials Section 715.40.3. Any material that fails to meet the above provisions shall be corrected by the Contractor in a manner acceptable to the Engineer at no additional cost to the Division. If necessary, the material shall be tested and evaluated for deficiencies, with the devices described in the Materials Section, based on an adequate sampling to be determined by the Engineer.

663.5.7-Temporary Pavement Marking Tape (Types VIIB and VIIC Material): Temporary Pavement Marking Tape shall be either Type VIIB or VIIC, as called for in the Contract plans, and shall be installed in accordance with the manufacturer's recommendations.

The pavement surface shall be dry at the time of pavement marking application. The Contractor shall remove all dirt, debris, loose particles and heavy oil residues from the road surface application areas immediately prior to installation of pavement markings.

Care shall be taken by the Contractor to follow the installation recommendations of the material manufacturer. The Contractor shall be responsible for determining if a surface primer is necessary. Type VIIB and VIIC temporary pavement marking film shall be applied with a mechanical applicator to provide pavement lines which are neat, accurate and uniform. The mechanical applicator shall be equipped with a film cut-off device. The pavement marking film shall be rolled or tamped to facilitate adhesion to road surface.

While in place, all temporary pavement markings shall remain adhered to the pavement and shall meet the color and retroreflectivity requirements described in Materials Section 715.40.4. These provisions shall also apply to Type VIIC materials in wet conditions, as described in the Materials Section. Any materials that fail to meet the above provisions shall be corrected by the Contractor in a manner acceptable to the Engineer at no additional cost to the Division. If necessary, the materials shall be tested and evaluated for deficiencies, with the devices described in the Materials Section, based on an adequate sampling to be determined by the Engineer.

Beginning on November 1st, the adherence, color, and retroreflectivity requirements referenced in the previous paragraph shall no longer apply to temporary tape materials which were installed prior to this date. In addition, the adherence, color, and retroreflectivity requirements shall at no point apply to temporary tapes placed on or after November 1st and prior to April 1st of the following calendar year.

When temporary pavement markings are no longer required as approved or determined by the Engineer, the plastic pavement marking film shall be neatly removed in its entirety. The cost for this work shall be included in the Contractor's bid price for installing the temporary markings.

663.5.8-BLANK

663.5.9-Raised Pavement Markers (RPM's): Unless otherwise directed by the Engineer, RPM's shall be placed as specified in the Plans or as otherwise specified in the pavement marking details. The proposed placement of all RPM's shall be reviewed and approved by the Engineer prior to proceeding.

In all cases, the reflective faces of RPM's shall be perpendicular to a line parallel to the roadway centerline.

Up until the time of installation, Type P-2 and R-4 markers should be stored indoors and should be protected from any source of moisture both during shipment to the jobsite and at the jobsite. The markers should be maintained at a high enough temperature as to preclude moisture condensation and, at the time of placement, both the markers and their containers shall be dry.

The color(s) of the lenses and bodies (Type R-4 only) of the markers shall be in accordance with the Plans or as otherwise specified in the pavement marking details.

Unless otherwise specified in the Plans, markers supplementing a broken line, such as a lane line, shall be placed in line with the pavement marking and within the gaps along the line at the appropriate spacing. Markers supplementing a solid line, such as a channelizing line, shall be installed immediately adjacent to the line with the edge of the marker against the edge of the line. If a Type R-4 marker is to be installed in line with the normal location of a solid line pavement marking, no painted or Type V pavement marking shall be installed at the locations where the R-4 markers are to be installed. R-4 markers shall not be placed on top of existing pavement markings.

The Contractor shall be responsible for the replacement of any markers having failed due to non-conformance with any portion of the specifications herein, and shall incur all associated costs. The Contractor shall also be responsible for the repair of any pavement surfaces damaged and requiring repair, as determined to be necessary by the Engineer and by a method approved by the Engineer, due to non-conformance with any portion of the specifications herein, and shall incur all associated costs.

663.5.9.1-Type P-2 Marker Installation: At the time of installation, the exposed surfaces of Type P-2 castings shall be free of scale, dirt, rust, oil, grease, or any other contaminant which may impair adhesion. If upon inspection the Engineer determines that one or more of the markers are not sufficiently in conformance with this requirement, the Contractor shall clean each contaminated holder by sand blasting or other means acceptable to the Engineer in order to remove all such foreign matter prior to installation.

The location of placement for each Type P-2 marker shall be of a constant slope longitudinally and laterally, and homogeneous. The location shall show no visible signs of distress or failure, such as cracking or delamination. All edges of the marker shall be placed a minimum of two (2) inches (50 mm) from any portion of the road surface showing such signs of distress or failure. Type P-2 markers shall be placed such that all edges are a

minimum of (2) inches (50 mm) from any lateral construction joint. In addition, Type P-2 RPM's shall not be placed within an intersection with a public street or highway where the placement of the marker creates a likelihood that the marker will be plowed in a direction other than that which the marker is designed for. If it is determined during pre-installation planning that a marker would be placed at a point with one of the aforementioned pavement surface defects, or at a lateral construction joint, or within the intersection of a public street or highway as a result of typical marker spacing, the affected marker may be relocated longitudinally a sufficient distance to be approved by the Engineer. The distance the marker may be relocated shall not exceed ten (10) % of the typical marker spacing. Where it would be necessary to relocate the marker a distance greater than ten (10) % of the typical marker spacing, the affected marker shall be deleted.

With the exception of markers installed to supplement yellow centerline markings along undivided roadways, all Type P-2 markers shall be installed such that the near edge of the casting is a minimum of two (2) inches (50 mm) from the nearest longitudinal construction joint. Individual markers may be shifted laterally up to two (2) inches (50 mm), and up to ten (10) % of the typical marker spacing longitudinally in order to meet this requirement. Where it would be necessary to shift the marker a greater distance laterally and/or longitudinally as allowed above, the affected marker shall be deleted.

The recesses for P-2 markers shall be machine cut fully in accordance with the marker manufacturer's specifications pertaining to, but not limited to, dimensions and blade configuration. All P-2 markers shall be installed within seven (7) days of cutting the recesses. All recesses shall be dry at the time of installation of the markers, and the pavement and ambient air temperature shall be a minimum of fifty (50) degrees Fahrenheit (10 degrees Celsius) and rising. Prior to installation of the markers, the recesses shall be brushed or blown clean of any loose material.

Epoxy adhesive recommended by the marker manufacturer and meeting the requirements of Materials Section 715.40.6 shall be used to adhere the Type P-2 marker castings in the recesses. Unless otherwise specified by the adhesive manufacturer, the epoxy adhesive shall be mixed by combining components A and B in a ratio of 1:1 by volume. The epoxy adhesive requires that the mixing operation and placing of the pavement markers be done rapidly. Any mixed batch that becomes so viscous that it cannot be readily extruded from under the casting under light pressure shall not be used. Unless otherwise specified or allowed by the adhesive manufacturer, the adhesive shall be maintained at 60 to 80 degrees Fahrenheit (15 to 27 degrees Celsius) before mixing, and shall not be heated above 120 degrees Fahrenheit (49 degrees Celsius) once mixing starts. Any heating of the epoxy shall be by the application of indirect heat. The Contractor shall insure that the epoxy is thoroughly mixed until it is one homogeneous color. The epoxy shall be placed fully in accordance with the epoxy manufacturer's specifications. Any requirements made by the adhesive manufacturer which are more stringent than those contained herein shall take precedence.

The Contractor shall install P-2 marker castings in the recesses using the epoxy adhesive fully in accordance with the marker manufacturer's specifications. Sufficient epoxy shall be placed in the recess to ensure that all voids beneath and around the casting are filled so as to create a watertight seal around the casting. The casting shall be hand placed into the recesses. The Contractor shall insure that each of the lugs on the sides of the casting are resting on the pavement and that the tips of the casting snowplow deflecting

surface(s) are below the pavement surface. The Contractor shall take reasonable steps to avoid buildup of epoxy on either the pavement surface or the casting lip in front of the lens as this buildup will affect the maximum visibility distance of the markers. There shall be no epoxy on the marker lens. If this occurs, the Contractor shall replace the marker lens in accordance with the manufacturer's recommendations and will incur all costs associated with this.

Newly installed P-2 markers shall not be exposed to traffic until the epoxy adhesive has sufficiently cured. The amount of cure time required is based on the ambient air temperature. The Contractor shall follow the recommendations of the adhesive manufacturer. In no case shall the newly installed markers be exposed to traffic within a time period less than that which is shown in the following table:

Ambient Air Temperature, °F (°C)	Minimum Protection Time (minutes)
100 (38)	15
90 (32)	20
80 (27)	25
70 (21)	30
60 (16)	35
50 (10)	45

663.5.9.3-Type R-4 Marker Installations: Type R-4 markers shall be placed such that all edges are a minimum of (2) inches (50 mm) from any lateral construction joint. If during pre-installation planning, it is determined that a marker would be placed at a lateral construction joint, the affected marker may be relocated longitudinally a sufficient distance to be approved by the project Engineer. The distance the marker may be relocated shall not exceed ten (10) % of the typical marker spacing. Where it would be necessary to relocate the marker a distance greater than ten (10) % of the typical marker spacing, the affected marker shall be deleted. In addition, Type R-4 markers shall not be installed spanning a longitudinal pavement joint. Affected markers may be shifted if necessary such the edge of the marker bodies are along the edge of the joint.

All applications shall be made on dry pavement surfaces free of extraneous materials such as, but not limited to, dirt, dust, grease, oils, existing pavement markings, and excessive remnants of previous delineation or channelization device adhesives. Extraneous materials shall be removed prior to placement by means approved by the Engineer, such as sweeping, high pressure air, scraping, or grinding. The Engineer shall make the final determination as to when the existing surface has been sufficiently cleaned for placement of the markers.

Type R-4 markers shall be applied to the asphalt or concrete surface fully in accordance with the manufacturer's recommendations using an adhesive recommended by the marker manufacturer. The adhesive shall be either 1) a rapid set epoxy adhesive, 2) a standard set epoxy adhesive, or 3) a bitumen adhesive, and shall meet any applicable requirements contained in Materials Section 715.40.6. The Contractor is cautioned in regards to the application of markers to new asphalt or concrete surfaces. If the markers are to be applied to a new asphalt surface, the Contractor shall consult with the adhesive manufacturer and follow all recommendations of the adhesive manufacturer in regards to special surface

preparation steps or recommended waiting periods between the completion of paving operations and adhesive application. In no case shall the markers be placed until the new asphalt surface has cured for a minimum period of fourteen (14) Calendar Days. If the markers are to be applied to a new concrete surface less than ninety (90) Calendar Days after concrete placement, any remaining curing compound on the application surface shall be removed by an Engineer approved method and procedures such as sandblasting, hydro-blasting, shot blasting, or grinding. Regardless of the type of adhesive used, type R-4 markers shall not be placed under the following conditions:

1. When either the pavement or air temperature is 32°F (0°C) or less when using rapid set epoxy, 50°F (10°C) or less when using standard set epoxy, or 40°F (4.4°C) or less when using bitumen adhesive.
2. If the relative humidity of the air is greater than 80 %
3. If the pavement is not surface dry or if there has been rainfall in the previous 24 hours

If the markers are to be applied using an epoxy adhesive, this requires that the mixing operation and placing of the markers be done rapidly. If standard set epoxy adhesive is used, the Contractor may mix this material by hand; however, not more than one (1) qt. (1 L) shall be mixed at one time and the markers shall be aligned and pressed into place within five (5) minutes after mixing operations are started. Any mixed batch which becomes so viscous that the adhesive cannot be readily extruded from under the marker on application of slight pressure shall not be used. Rapid set epoxy adhesive shall not be mixed by hand; it shall be mixed by a 2-component type automatic mixing and extrusion apparatus. Automatic mixing equipment for the epoxy adhesive shall use positive displacement pumps and shall properly meter the two components in the specified ratio. At any time requested by the Engineer, the ratio shall be checked by the Contractor in the presence of the Engineer. This check shall be made by disconnecting the mixing heads, or using suitable bypass valves, and filling two suitable containers with the unmixed components. The mixing head shall properly mix the two components so that there is no trace of black or white streaks in the mixed material. Voids in a cured, undisturbed sample of the mixed adhesive obtained from the extrusion nozzle should not exceed four (4) %.

When machine mixing standard or rapid set epoxy adhesives, the markers shall be placed within sixty (60) seconds after the adhesive has been mixed and extruded, and no further movement of the marker shall be allowed. No more than ninety (90) seconds shall be permitted between the time the adhesive is in place on the roadway and the marker is no longer subjected to further movement. The mixed adhesive should not remain in the mixing head for more than forty-five (45) seconds. Adhesive remaining in the mixing head longer than this period shall be wasted before resuming the operation.

When applying the markers with epoxy adhesive, the adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been lightly pressed in place. Ideally there will be approximately 0.060 in. (1.5 mm) adhesive between the marker and the pavement. Excess adhesive around the edge of the marker, excess adhesive on the pavement, and adhesive on the exposed surfaces of the markers shall be immediately removed. Soft rags moistened with mineral spirits in accordance with Federal Specification

TT-T-291 or kerosene may be used to remove adhesive from exposed faces of pavement markers. No other solvent shall be used. The markers should be protected against impact until the adhesive has hardened to a sufficient degree, as determined by the Engineer.

Bituminous adhesive shall be dispensed from a thermostatically controlled melter-applicator at a temperature of 375 to 425 degrees Fahrenheit (141 to 218 degrees Celsius). The material shall be stirred frequently to ensure even heating. The adhesive shall be dispensed in a puddle slightly larger than the bottom of the marker, and the marker shall be dropped onto the puddle as quickly as possible, preferably within five (5) seconds of adhesive placement. The marker shall then be pressed lightly onto the adhesive. The adhesive will set up in approximately two (2) minutes and typically no longer requires protection from traffic.

Any requirements made by the adhesive manufacturer which are more stringent than those contained herein shall take precedence.

663.6-METHOD OF MEASUREMENT:

Pavement markings shall be measured complete in place in the units designated below. Length measurements shall exclude gaps. Calibrated and verified odometer measurements will be acceptable as method of measurement on edge lines (mainline only), lane lines, and centerlines only for plan quantities in excess of 10,000 linear feet (3 000 m) or two linear miles (3.2 km).

Island marking will be measured by the square foot (meter) of island area painted.

Type P-2 markers, Type S markers, and Type R-4 markers shall be measured in units of each, completely installed as specified herein. Payment for the installation of Type P-2 and Type S markers shall include payment for the marker lens, regardless of whether the lens is factory or field installed.

Yield Triangle, Handicapped symbol, Bicycle Symbol, Arrow, Lane Letter, and Railroad Crossing Marking intersection markings shall be measured in units of each, completely installed as specified herein. One unit of the Railroad Crossing Marking shall consist of the large "X" and the two "R" letters necessary to install the complete marking in one direction.

663.7-BASIS OF PAYMENT:

663.7.1-General: The quantities, determined as provided above, will be paid for at the Contract unit prices less adjustments provided for in the Contract, which shall constitute full compensation for furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including the furnishing of all the auxiliary vehicles, labor, tools, equipment, supplies and incidentals necessary to complete the work.

The payment for Temporary Pavement Markings includes removal of the pavement marking film.

663.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
663001-*	Edge Line, Type “type”, “size” In, “color”	Linear Foot or Miles
663002-*	Lane Line, Type “type”, “size” In	Linear Foot or Miles
663002-*	Center Line, Type “type”, “size” In	Linear Foot or Miles
663004-*	Channelizing Line, Type “type”, “size” In	Linear Foot (Meter)
663005-*	Stop Line, Type V, “size” In	Linear Foot (Meter)
663006-*	Crosswalk Line, Ty V, 12 In x 6 Ft	Linear Foot (Meter)
663007-*	Stripe, Type V, 12 In, “color”	Linear Foot (Meter)
663008-*	Yield Triangle, Type V	Each
663009-*	Handicapped Symbol, Type V	Each
663009-*	Bicycle Symbol, Type V	Each
663010-*	One Direction Lane Arrow, Type V**	Each
663010-*	Multi Direction Lane Arrow, Type V***	Each
663010-*	Ramp Wrong Way Arrow, Type V	Each
663010-*	Lane Drop Arrow, Type V	Each
663011-*	Lane Letter, Type V	Each
663012-*	Raised Pavement Marker, Type “type”	Each
663015-*	Railroad Crossing Markings, Type V	Each

* Sequence number

** Single headed lane assignment arrow. Typically left or right turn

*** Multi-headed lane assignment arrow with two to three arrow heads

“type” Pavement marking type

“size” Pavement marking size or width

SECTION 664 TRAFFIC SAFETY DEVICES

664.1-DESCRIPTION:

This work shall consist of the furnishing and installing of various types of traffic safety devices in accordance with these Specifications and the Plans or as established by the Engineer. This work shall include, but not be limited to impact attenuating devices.

664.2-MATERIALS:

Materials shall conform to the requirements of the following subsections of Division 700.

MATERIALS	SUBSECTION
Crash Cushion Terminal Impact Attenuating Device (Type VI)	715.41.2
Quad Guard Terminal Device (Type VIII)	715.41.4
Reusable Energy Absorbing Crash Terminal Device (Type I)	715.41.5
Sand Barrel Impact Attenuating Device (Type V)	715.41.1
SCI Impact Attenuating Device (Type III)	715.41.7
TAU-II Impact Attenuating Device (Type IX)	715.41.8
Trinity Attenuating Crash Cushion (Type II)	715.41.6
Truck Mounted Attenuating Devices (Type VII)	715.41.3

Unless otherwise specified in the project plans, the appropriate model Type II, III, VIII, or IX device listed on the Division's APL may be utilized for any installation for which Bid Item Number 664001-016 is to be used for payment.

664.3-CONSTRUCTION METHODS:

664.3.1-Impact Attenuating Devices: Fabrication and installation of Impact Attenuating Devices shall be as detailed on the Plans or as directed by the Engineer. All work shall be done in a uniform, workmanlike manner.

The devices shall be located on a hard, flat surface, preferably concrete. The lateral slope of the installation site should be as level as possible and still provide adequate drainage.

The nose of the device shall have a XS-15 marker attached with alternating black and reflectorized yellow stripes in accordance with Section 3C-2 of the latest edition of the *Manual on Uniform Traffic Control Devices for Streets and Highways*. The width of the alternating stripes shall be 6 inches (152.4 mm). The stripes for construction zone attenuating devices shall be as above except the stripes shall be reflectorized white and reflectorized orange.

Type V devices shall be protected from freezing by mixing sodium chloride with the sand in a ratio of 1:10 by volume. Clean concrete on building sand with a moisture content of less than three percent shall be used. The sand shall weigh 100 ± 5 pounds per cubic foot ($1\ 270 \pm 60$ kg per cubic meter). Type V devices shall be winterized in accordance with 715.41.

664.3.1.1-Crash Cushion, Quad Guard Terminal Devices, Reusable Energy Absorbing Crash Terminal, Trinity Attenuating Crash Cushion, SCI Impact Attenuating, and TAU-II Impact Attenuating Devices: A backup structure accommodating the width of the impact cushion and providing adequate length for the cushion must be constructed or modified into the existing structure as shown on the plans.

The backup structure must be capable of resisting the imposed forces brought upon it by the unit.

664.3.1.2-Sand Barrel Devices (Type V): The assembly of all parts of the device, including filling with sand, shall be in the sequence and according to the recommendations of the manufacturer. The weight and location of each module and overall arrangement of each installation shall be as shown on the Plans. The figures within each circle on the Plans indicate the amount of sand, in pounds (kg), contained in each module. Leave one to 6 inches (24 to 150 mm) clearance between modules to facilitate lid installation. Each barrel location shall be painted on the pavement with a circle and the weight of sand in pounds (kg).

"Core-type" modules of 2,100 pound (953 kg) design require a sand seal to be placed on the bottom before the sand is added. "Wine glass-type" modules on structures require a stem block. If modules are preassembled before delivery to the site, the modules must be shipped upright on their bottom and not forced into an oval shape.

664.3.2-Rumble Strips: This work consists of furnishing a machine capable of cutting or milling rumble strips on the centerline or edge of roadways in accordance with the details and notes on the plans and as directed by the Engineer.

The Contractor shall pre-mark the location of the center of each cut, and the beginning and ending points of the sections, prior to the installation of the Rumble Strips. The Engineer shall review and approve the locations.

Rumble Strips shall not be installed on bridge decks, loop detector saw-cut locations, structures, approach slabs or in other areas identified by the Engineer.

The method and equipment for constructing ground-in indentations shall be selected by the Contractor and shall meet the requirements of 664.3.2.1.

Rumble Strips shall be constructed within two (2) inches of the required alignment.

Indentations shall not vary from the dimensions shown on the plans by more than 0.10 inch in depth and five percent (5%) in width.

Finished Rumble Strips not meeting the specified tolerances shall be brought within tolerance by either abrasive grinding, or removal and replacement. The corrective method will be selected by the Engineer. Ground surface areas shall be neat and uniform in appearance. The corrective work shall be at the Contractor's expense.

All removed material shall become the property of the Contractor and disposed of in conformance with provisions in Section 415, "Milling of Asphalt Surfaces" of the Standard Specifications or as approved by the Engineer.

664.3.2.1-Rumble Strip Equipment: The machine shall consist of a rotary type cutting head with a maximum outside diameter of 12 (twelve) inches (305mm). The cutting tool shall have the cutting head(s) arranged in such a pattern as to provide a relatively smooth cut per milled section without tearing or snagging and be equipped with guides to provide uniformity and consistency in alignment of each cut with respect to the roadway. The strips shall be cut in accordance with the dimensions as detailed on the Plans, and materials resulting from cutting the pavement shall be disposed of and the slots shall be properly cleaned.

664.4-METHOD OF MEASUREMENT:

664.4.1-Impact Attenuating Devices: This work shall be measured as a unit, complete and in place.

664.4.2-Rumble Strips: This work shall be measured for payment by the actual linear feet of rumble strips placed and accepted, without regard to the width of the strip. This distance shall be measured longitudinally along the centerline of pavement with deductions for bridge decks, drainage structures, raised pavement markers, loop detector saw-cut locations, and any other sections where Rumble Strips were not installed.

664.5-BASIS OF PAYMENT:

The quantities, determined as provided above, shall be paid for at the contract unit price for the items listed below, which prices and payment shall be full compensation for furnishing all the materials and doing all work prescribed in a workmanlike and acceptable manner, including all tools, equipment, supplies, and incidentals necessary to complete and, where required, winterize the items. All incidental work and materials for which no basis of payment is provided will be considered as completely covered by the prices bid for the items included in the contract.

The Contract unit price per foot for Rumble Strips will be paid for the pay items listed in Section 664.6. The price shall include furnishing all equipment, tools, labor, and work incidental thereto and also disposal of any waste material resulting from this operation.

664.6-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
664001-*	Impact Attenuating Device, Type "type"	Each
664002-*	Edge Line Rumble Strip, "pavement"	Linear Foot (Meter)
664003-*	Centerline Rumble Strip, "pavement"	Linear Foot (Meter)
664004-*	Rumble Strip, ADAB	Linear Foot (Meter)

* Sequence number

"pavement" Asphalt or Concrete

SECTION 665 PLUGGING GAS, OIL, AND DRILLED WATER WELLS

665.1-DESCRIPTION:

This work shall consist of plugging oil wells as designated on the Plans. This work shall also consist of plugging drilled water wells unless otherwise noted on the Plans.

665.2-MATERIALS:

665.2.1-Oil and Gas Wells: All materials used for plugging the oil wells and gas wells shall meet the requirements of the laws of the State of West Virginia.

665.2.2-Drilled Water Wells: Materials for plugging water wells shall meet the requirements of Division 700 as follows:

MATERIAL	SUBSECTION
Aggregate	703
Bentonite	715.45

Concrete shall be class D conforming to applicable requirements of 601 and may be with or without air entrainment at the option of the Contractor. The concrete shall be placed in accordance with current regulations of the Oil and Gas Division of the Department of Mines when a coal seam is involved.

CONSTRUCTION METHODS

665.3-GENERAL:

The Division will obtain all necessary permits, bonds and licenses required for this work.

665.4-PLUGGING GAS AND OIL WELLS:

The Contractor shall plug the gas well or oil well prior to starting any other construction in the vicinity of the well. The well shall be plugged using bentonite mud and neat cement as provided for by law, and the work shall be accomplished by a qualified service company meeting the approval of the Gas and Oil Division of West Virginia Department of Mines. All work pertaining to plugging the well must be performed under the supervision of the representative of the Division of Mines. The Contractor shall notify the Project Engineer and the Division of Mines at least 14 days in advance of the date on which the Contractor intends to begin work.

The Division will make available upon request copies of Sections 9 and 10, Article 4, Chapter 22 of the Gas and Oil Laws.

665.5-PLUGGING DRILLED WATER WELLS:

The Contractor shall plug all drilled water wells within the right-of-way limits prior to starting any other work in the vicinity of the wells. The wells shall be filled from the bottom with a mixture of aggregate and bentonite mud to within 20 feet (6 m) of the surface. The aggregate for each specific site may be any of the following AASHTO sizes: 7, 57, or 67. The bentonite shall be proportioned with fresh water as follows: eight percent bentonite by volume (minimum)

to 92 percent by volume fresh water (maximum). The final in-place product shall be a consistent mixture of bentonite mud and aggregate. The upper 20 feet (6 m) shall be plugged using Class D or other suitable concrete. All coal seams of 24 inches (600 mm) or more in thickness or a seam that is being mined that the well encounters or passes through shall have Class D concrete placed from 30 feet (9 m) below the seam, if the well passes through the coal, or from the base of the coal seam, if the well ends within the coal seam, to 20 feet (6 m) above the coal seam.

The Contractor at their option may plug all drilled water wells from the bottom of the well to the surface with Class D or other suitable concrete in lieu of the bentonite mud and aggregate.

665.6-METHOD OF MEASUREMENT:

Plugging gas wells, oil wells, and drilled water wells will be measured by the unit.

665.7-BASIS OF PAYMENT:

The quantity, determined as provided above, will be paid for as provided below, which price and payment shall constitute full compensation for furnishing all material, labor, tools, equipment and all incidentals necessary to complete this work.

665.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
665001-*	Plugging Gas Well	Each
665002-*	Plugging Oil Well	Each
665003-*	Plugging Drilled Water Well	Each

* Sequence number

SECTION 666 THROUGH SECTION 669-BLANK

SECTION 670 WATERLINE INSTALLATION

670.1-DESCRIPTION:

This work shall consist of the construction or relocation of waterlines, including installation of gate and valve boxes, casing pipe, fire hydrants, water meter, meter boxes, and in reasonably close conformity with lines, grades, dimensions and locations shown on the Plans or established by the Engineer.

670.2-MATERIALS:

The material shall meet the requirements of the following subsections.

MATERIAL	SUBSECTION
Casing Pipe (Steel)	718.12
Cement lining	718.1.1
Controlled Low Strength Material, Type A	219
Copper Service Line	718.9
Copper Service Line Fittings	718.9.1
Ductile Iron Pipe	718.1
Fire Hydrants	718.13
Fittings	718.1.2
Flanged Joints	718.1.4
Gate Valves	718.10
Mechanical Joints	718.1.3
Meters	718.14
Miscellaneous Steel	718.15
Plastic Pipe (Polyethylene)	718.7
Plastic Pipe (PVC)	718.5
Plastic Pipe Fittings	718.8
Push-On Joints	718.1.3
Valve Boxes	718.11

CONSTRUCTION METHODS

670.3-GENERAL:

The Contractor shall furnish all materials, perform all excavation and backfill, construct all necessary joints and connections, install all valves, construct all necessary joints and connections, construct all appurtenances, install all temporary lines and dispose of all surplus excavation and discarded material and perform all work as may be necessary to complete the water line relocations and installations as set forth in these Specifications and as shown on the Plans.

The Contractor shall assume all risk and bear any loss or injury to property or persons occasioned by neglect or accident during the progress of the work. The Contractor shall exercise special care during the water line relocation so as not to damage any existing utility line or appurtenances.

It is of prime importance that the Contractor, in the performance of their work, does not disrupt the operation of the existing water facilities in any manner or at any time without the express prior approval of the Engineer. Prior notice shall be given to the Engineer by the Contractor of their intention to begin any work that will disrupt or appreciably alter normal system operation so that ample opportunity may be given to the Engineer to notify the owner to prepare for emergency operation, if necessary. The Engineer, upon advice of the owner, will have the sole right of determining at what times and in what order the Contractor shall undertake work involving connections and modifications to the existing system.

The Contractor shall dig test pits as necessary to determine the size of fittings required for connections to existing lines. All material necessary for tie-ins shall be at the work site prior to any disruption of service. Once a connection is started, work shall be continuous until completion. The Contractor shall be responsible for the unloading, storing, hauling, and distribution of all materials and shall replace, at their own expense, all such material that is damaged, destroyed or lost during or after unloading. All pipe, pipe fittings, valves and accessories shall be handled in a manner in order to avoid shock and to protect the coating material. Material not needed for immediate construction shall be stored in a safe manner at places provided by the Contractor and approved by the Engineer.

If the Contractor should observe either proposed or existing sewers or water lines in close proximity the Contractor shall notify the Engineer. The Engineer will determine if the observed situation lacks conformity to the State Department of Health's Design Standards for Water Distribution Systems, its magnitude and the course of action. Additional costs necessitated by a modification in the plan of construction will be paid for in accordance with 109.4.

670.4-WATER PIPE:

670.4.1-Trench Excavation: Excavation of the trench may be done either by hand or by the use of suitable trenching equipment. The invert profile as shown on the Plans shall be followed except where changes are authorized in writing by the Engineer to avoid existing structures or to suit topography. The depth of trench shall be increased where necessary to procure a smoothly curved profile or to avoid existing structures. The trench shall be excavated in such a manner as to provide uniform and continuous bearing and support for the pipe and shall be excavated to the depth required to give a minimum of 42 inches (1050 mm) cover from finished grade to the top (outside) of the pipe barrel, except under roadways where minimum cover shall be 30 inches (750 mm) from subgrade to the top of the pipe barrel. The depth of cover may be modified at creek crossings or at other dips in the profile, when approved by the Engineer, providing it does not extend more than 100 feet (30 m) with a cover of less than 42 inches (1050 mm). In the event it is required to decrease the cover to less than 2 feet (600 mm), the pipe line shall be insulated for that distance.

Where stones, dry clay, hard pan, shale or cemented gravel are exposed at the bottom of the trench, the trench shall be excavated to at least 3 inches (75 mm) and not more than 6 inches (150 mm) below the specified grade. Where the bottom of the trench at grade is found to be unstable or include ashes, cinders, all types of refuse, vegetable or other organic material, the Contractor shall excavate and remove such unsuitable material to the width and depth ordered by the Engineer. The trench shall be backfilled to grade with approved material; replacement material shall consist of random material, as directed by the Engineer. Each layer shall not exceed 4 inches (200 mm) compacted depth and shall be compacted in accordance with

670.4.5. The bedding shall be finished by means of hand tools to provide a uniform and continuous bearing and support for the pipe.

Where the bottom of trench at grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer it cannot be removed and replaced with material suitable to support the pipe properly, the Contractor shall construct a foundation for the pipe, consisting of concrete, pilings, timber or other materials or as directed by the Engineer.

Where excavation is made in rock or boulders, the rock shall be removed to provide a clearance of at least 6 inches (150 mm) for pipe 24 inches (600 mm) in diameter or smaller and at least 9 inches (225 mm) for pipe larger than 24 inches (600 mm) in diameter, below and on each side of all pipe, valves and fittings. The trench shall be backfilled to grade with approved material in 4 inches (200 mm) layers loose depth. Each layer shall be thoroughly compacted in accordance with 670.4.5 and the bedding shall be finished by means of hand tools to provide a uniform and continuous bearing and support for the pipe. The width of the trench shall be ample to permit the pipe to be laid and jointed properly and to permit the backfill to be placed and compacted as specified. Trench widths shall be in accordance with Table 670.4.1. Excessive trench widths will not be permitted. Where necessary for protection of workers or to avoid undermining or otherwise damaging structures or property, the trench shall be properly and sufficiently shored and braced to prevent caving, slipping or cracking of the sides. Where bracing, sheeting or shoring are required or extra width is required for handling of specials, the trench shall be of such extra width to accommodate these items.

TABLE 670.4.1

Pipe Diameter Inches (mm)	Trench Width Inches (mm)	Pipe Diameter Inches (mm)	Trench Width Inches (mm)	Pipe Diameter Inches (mm)	Trench Width Inches (mm)
2 (50)	18-26 (450-650)	10 (250)	22-34 (550-850)	20 (500)	32-44 (800-1 100)
3 (75)	18-26 (450-650)	12 (300)	24-36 (600-900)	24 (600)	36-48 (900-1 200)
4 (100)	18-28 (450-700)	14 (350)	26-38 (650-950)	30 (750)	42-54 (1 050-1 350)
6 (150)	18-30 (450-750)	16 (400)	28-40 (700-1 000)		
8 (200)	20-32 (500-800)	18 (450)	30-42 (750-1 050)		

Blasting for excavation will be performed only after securing the approval of the Engineer and only when proper precautions are taken for the protection of persons or property. The hours of blasting will be fixed by the Engineer. Any damage caused by blasting shall be repaired by the Contractor at their expense. The Contractor's method of procedure relative to blasting shall conform to local and state laws.

The Contractor shall exercise reasonable care to avoid damage to trees and hedges; electric, telephone and gas lines and installations; sewer lines; buildings; roads and all appurtenances

thereto. Care shall be used to maintain driveways to permit free access to and from the different properties by the owners.

All excavated material shall be piled in a manner that will not endanger the work and will not obstruct sidewalks and driveways. Fire hydrants under pressure, valve boxes, service stop boxes, fire and police boxes or other utility controls shall be left unobstructed and accessible. Gutters shall be kept clear or other satisfactory provisions made for drainage, and natural watercourses shall not be obstructed. All trenches, material piles, equipment and pipe which may cause a hazard or serve as obstructions to either vehicular or pedestrian traffic shall be enclosed by fences or barricade, adequately lighted, to protect persons from injury and to avoid property damage. Where traffic must cross open trenches, the Contractor shall provide suitable bridges, which will be subject to approval by the Engineer. The Contractor shall furnish temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work.

670.4.2-Laying and Joining: Proper implements, tools and facilities satisfactory to the Engineer shall be provided and used for the safe and convenient prosecution of the work. All pipe, fittings, valves, specials, and fire hydrants shall be carefully lowered into the trench piece by piece by means of a derrick, ropes or other suitable tools or equipment in such a manner as to prevent damage to the water main materials and protective coating and linings. Under no circumstances shall water main materials be dropped or dumped into the trench.

All pipe and fittings shall be carefully examined for defects and no pieces shall be laid which are known to be defective. Any defective or damaged pipe will be rejected. If any defective piece shall be discovered after having been laid, it shall be removed and replaced at the Contractor's expense. All pipes and fittings shall be thoroughly cleaned before they are laid and shall be kept clean until accepted in the completed work. Pipe which has been contaminated by mud or soil shall be cleaned with a swab.

The pipe shall be supported its full length by the uniform grade of the trench. Pipe ends shall not be left open, such as at the end of a day's work or during temporary suspension of construction, but shall be securely covered to prevent the entry of foreign matter or small animals. Kinks or sharp bends giving excessive deflection or which put pipe joints in strain will not be permitted. Table 670.4.2 shows the Maximum permissible for various types of joints or pipe.

TABLE 670.4.2
MAXIMUM PERMISSIBLE DEFLECTION PER JOINT

A. "Push On" Type Joint Pipe:

Pipe Diameter in (mm)	*Maximum Deflection for 18-ft (5.5 m) Length in (mm)
4 (100) thru 12 (300)	19 (475)
14 (350) thru 24 (600)	11 (275)

* Permissible deflection per joint for lengths more or less than 18 feet (5.5 m) are proportional.

B. Mechanical Joint Pipe:

Pipe Diameter in (mm)	*Maximum Deflection for 18-ft (5.5 m) Length in (mm)	Pipe Diameter in (mm)	*Maximum Deflection for 18-ft (5.5 m) Length in (mm)
2 (50)	31 (775)	12 (300)	20 (500)
3 (75)	31 (775)	14 (350)	13.5 (340)
4 (100)	31 (775)	16 (400)	13.5 (340)
6 (150)	27 (675)	18 (450)	11 (275)
8 (200)	20 (500)	20 (500)	11 (275)
10 (250)	20 (500)	24 (600)	

* Permissible deflection per joint for lengths more or less than 18 feet (5.5 m) are proportional.

C. Flexible Joint Pipe:

The maximum permissible deflection per joint shall be in accordance with the manufacturer's recommendations

D. Plastic Pipe:

The maximum permissible deflection per joint shall be in accordance with the manufacturer's recommendations.

When cutting short lengths of copper pipe, a pipe cutter shall be used and care shall be taken to make the cut at right angles to the centerline of the pipe. In the case of "push on" pipe, the cut ends shall be tapered with a portable grinder or coarse file to match the manufactured taper.

Rigid plastic pipe such as acrylonitrile-butadiene-styrene or polyvinyl chloride shall be jointed and laid in accordance with the manufacturers' recommendations. Plastic pipe may be sawn. Thrust blocking, pads, straps and clamp and rod assemblies shall be provided at fittings, valves or specials at the location and in the manner set forth on the Plans.

Joints shall be as follows:

I. "Push on" Type Joint: "Push on" type joints such as "Bell Tight", "Tite On" or equal joints shall be prepared by removing all dirt or foreign material from the bell end of pipe and inserting the gasket. The spigot end of the pipe shall be prepared by cleaning and applying a thin coat of approved lubricant after which the spigot end shall be centered in the bell and jacked on by using a special jack and choker sling. The procedure in making up this joint shall be performed in accordance with the recommendations of the manufacturer.

II. Mechanical joint: When "making up" mechanical joints, the spigot end of each pipe shall be centered into the adjoining bell to within 5/8 inch of the total depth of the bell. The pipe shall be properly centered and have uniform space all around for reception of the packing material. The packing material, bolts, nuts and other accessories used in making mechanical or sleeve type joints shall be obtained from the manufacturer of the pipe and joint.

The surfaces of the spigot and bell shall be brushed thoroughly with a wire brush just prior to assembling. The spigot end shall be brushed with soapy water just prior to slipping the gasket on and entering into the bell.

When tightening bolts the gland shall be brought up toward the pipe flange evenly, maintaining approximately the same distance between the gland and the face of the flange at all points around the socket. This shall be done by partially tightening the bottom bolt first, then the top bolt, next two bolts at either side and last, the remaining bolts. This cycle shall be repeated until all bolts are within the range of the torques listed below:

Bolt size, Inches (mm)	Range of Torque, Pounds (Newton meters)
5/8 (16)	40 (54)-60 (81)
3/4 (20)	60 (81)-90 (122)
1 (24)	70 (95)-100 (140)
1 1/4 (30)	90 (122)-120 (165)

If the effect of sealing is not obtained at the maximum torques indicated above, the joint must be disassembled and reassembled after thorough cleaning. A calibrated torque wrench shall be furnished by the Contractor and made available to the Engineer.

IV. Flanged joint: When making up flanged joints, a gasket shall be put in place, the flanges butted together and the bolts tightened in the manner as prescribed for mechanical joints.

V. Flexible joint: Flexible joints shall be "made up" and installed in the manner prescribed by the manufacturer of the joint.

VI. Coupled joints: Coupled joints shall be constructed in accordance with the recommendations of the manufacturer.

VII. Plastic Pipe joints: Joints in plastic pipe formed of polyvinyl chloride may be cemented, threaded or "push on" type. Joints in pipe formed of flexible polyethylene shall be constructed utilizing a plastic, nylon or brass insert secured by stainless steel clamp may be butt fused or any other method recommended by the manufacture.

VIII. Copper Pipe joints: Copper pipe joints shall be made by use of copper flanged joint couplings or fittings unless otherwise specified in the Plans or in the Bill of Materials.

670.4.3-Thrust Blocking: Thrust blocks shall be constructed where called for and to the dimensions shown on the Plans. Concrete used for thrust blocking shall be Class C concrete; however, Class B concrete may be used with no increase in cost.

670.4.4-Nuts, Bolts, Washer, Rods, Straps and Clamps: Where the use of nuts, bolts, washers, rods, straps and clamps is required due to the peculiarities of the installation, these items shall be installed and be of the size and dimension shown on the Plans or recommended by the manufacture.

670.4.5-Backfilling: Backfill material shall consist of suitable random material or controlled low strength material, type A. All material shall be free of particles larger than 3 inches (75 mm) and free from cinders, ashes, refuse, vegetable or other organic material. Controlled low strength material shall meet the requirements of Section 219. Unless otherwise specified on the plans or by the utility, controlled low strength material can be used as a substitute for random material at the option of the contractor.

The backfill material shall be deposited in the trench for its maximum width in layers not exceeding 4 inches (100 mm) after compaction. Quality control testing and acceptance of the backfill material will be according to the applicable sections of 207 and 716 with the following exceptions: The lot size will be one day's production or 500 linear feet (150 m) whichever is less for a continuous section of conduit backfilled. The target percentage of dry density will be 95% for the backfill material and each lot shall have 5 density tests performed for quality control.

Backfill placed outside embankments and roadbed is to be compacted to or better than the average total dry density for the existing soil. An average total dry density will be determined from representative density tests conducted for each existing soil. Quality control testing will normally consist of one test per 500 linear feet (150 m) of conduit installed and lot evaluations are not required. The moisture tolerance is not applicable.

Backfilling shall not be done in freezing weather, except by permission of the Engineer, and frozen material shall not be used. No backfilling shall be made where the material already in the trench is frozen.

From the bottom of the trench to the centerline of the pipe, the backfill material shall be placed by hand and compacted by approved hand tamps. From the centerline of the pipe to a height of 1 foot (300 mm) above the pipe, the backfill shall be placed by hand and compacted by use of approved mechanical tampers. The Contractor shall use special care in placing this portion of the backfill to avoid damaging or moving the pipe. The remainder of the backfill in the trench shall be placed by hand or mechanical means and compacted by approved mechanical tampers. All pipe after being bedded and backfilled shall be adequately protected before heavy equipment is permitted to cross during construction of the roadway. The

Contractor will be held responsible for any damage to the pipe resulting from movement of equipment over the pipe. Prior to testing, the pipeline shall be backfilled in accordance with the Specifications.

The Contractor shall maintain the surface of the trench to the original ground surface until accepted by the Engineer. The job site shall be left in a neat and orderly condition to the satisfaction of the Engineer.

Excess material not needed for backfill and material unsuitable for backfill shall be removed from the site and disposed of as directed by the Engineer. Additional backfill material as required to make up deficiency or to replace unsuitable excavated material shall be furnished by the Contractor at no additional cost, from approved borrow pits or from excavations on the roadway.

670.4.6-Testing: Where any section of the main is provided with concrete thrust blocking, the hydrostatic pressure test shall not be made until at least the concrete has reached 2000 psi compressive strength.

Each completed section of pipe line relocation shall be plugged at both ends, and connected to the existing main by means of temporary 1 inch (25 mm) corporation stops and 1 inch (25 mm) copper service lines. After the main has been slowly filled with water in preparation for the hydrostatic pressure test, all air shall be expelled from the pipe. If fire hydrants or blowoffs are not available at high places, the Contractor shall make the necessary taps at points of highest elevation and insert the necessary corporation stops and copper service line in order that the air may be expelled. The main shall be subjected to the hydrostatic test pressure, indicated on the Plans for a period of time pressure shall be applied to the main by means of a hand pump for small lines or by use of a gasoline pump or fire engine for larger lines. During the duration of the test, the lines shall be thoroughly examined for leakage at the joints and elimination of leakage effected where necessary. "Make up" water shall be measured with a displacement meter. Any cracked or defective pipes, fittings, valves or fire hydrants discovered in consequence of the pressure test shall be removed and replaced by the Contractor at their own expense. After replacing or correcting cracked or defective pipe, fittings or valves discovered in the test or correcting any leakage, the Contractor shall retest the pipe. The allowable leakage for a period of one hour shall be as shown in Equation 670.4.6. In the event the pipe line is tested in sections and temporary thrust blocking is required, a temporary plug or cap shall be installed and blocked with a screw jack firmly braced against the end of the trench or against a heavy timber embedded into the side of the trench.

Where pipe line construction ties into existing lines, and where it is not practicable to make a hydrostatic test testing shall not be required. Any leakage discovered in these sections shall be immediately corrected by the Contractor.

Upon completion of the testing, the temporary corporation stops and lines shall remain in place until the pipeline is disinfected, after which they shall be removed and the line plugged.

Equation 670.4.6

$$\{\text{English}\} \quad L = \frac{ND\sqrt{P}}{7,400}$$

Where:

- L = allowable leakage, in gallons per hour
- N = number of joints in the length of pipeline tested
- D = nominal diameter of the pipe, in inches
- P = average test pressure during the leakage test, in pounds per square inch (gauge)

$$\{\text{Metric}\} \quad L_m = \frac{ND\sqrt{P}}{130,400}$$

Where:

- L_m = allowable leakage, in liters per hour
- N = number of joints in the length of pipeline tested
- D = nominal diameter of the pipe, in millimeters
- P = average test pressure during the leakage test, in kilovolts per ampere

670.4.7-Disinfection: The requirements for disinfection during construction and previous to placing the line in service shall be in compliance with the requirements of the Public Utility involved. In the event the Public Utility has no requirements for disinfection; the following requirements shall govern:

Each completed section of pipeline constructed shall be sterilized by the addition of one pound (kg) of calcium hypochlorite powder containing 70 percent available chlorine for each 1,600 gallon (10 000 L) of water treated. Table 670.4.7 shows the length of pipe that one pound (0.75 kg) of calcium hypochlorite powder will disinfect. This may be introduced by pumping a liquid solution into the main as it is being filled, or it may be introduced dry by measured amounts placed inside the pipe at each joint immediately before the joint is made. In the latter case the pipe line must be filled from the low point and at a rate not to exceed 20 gallons (75 L) per minute. Water treated with calcium hypochlorite shall remain in the pipeline for a period of 24 hours. After the treated water is retained for the required time, the chlorine residual at the pipe extremities and other representative points shall be at least 50 PPM. Following chlorination all treated water shall be thoroughly flushed from the newly laid lines until the replacement water throughout its length shall be comparable to the quality of water served from the existing system.

TABLE 670.4.7-DISINFECTION CHART

Pipe Diameter Inches(mm)	Pipe Length Feet (m)	Pipe Diameter Inches (mm)	Pipe Length Feet (m)
2 (50)	10,000 (6 700)	12 (300)	270 (180)
3 (75)	4,300(2 900)	14 (350)	200 (135)
4 (100)	2,500 (1 680)	16 (400)	150 (100)
6 (150)	1,100 (740)	18 (450)	120 (80)
8 (200)	600 (400)	20 (500)	100 (70)
10 (250)	400 (268)	24 (600)	70 (45)

* Length of pipe that one pound (kilogram) of calcium hypochlorite will disinfect.

In lieu of the liquid solution or dry application of calcium hypochlorite, a chlorine gas-water mixture may be introduced by means of a solution-feed chlorinating device or a dry gas may be fed directly through proper devices for regulating the rate of flow and providing diffusion of the gas into the water within the pipe treated. Devices for feeding the gas-water mixture or dry gas shall provide means for preventing backflow of water into the chlorine cylinder. The duration of treatment and chlorine residual shall be as previously stated.

The Contractor shall contact the County Health Department prior to public use of the drinking water so they may perform sampling and testing in accordance with Health Department requirements.

Disinfection and testing shall be accomplished by the Contractor prior to performing any work in connecting to the existing main.

Where connecting into existing mains and it is not practicable to include the connecting pieces, i.e.; pipe, fittings, valves in the normal disinfecting process, the connecting pieces shall be swabbed with a chlorine solution containing not less than 1% Hypochlorite solution prior to making the connection.

670.5-GATE VALVES AND VALVE BOXES:

Gate valves shall be installed in accordance with 670.4. The valve box shall be set in such manner that no shock or stress is transferred to the valve. The valve box shall be centered and plumbed over the wrench nut of the valve. The valve box cover shall be set flush with the finished surface.

670.6-CASING PIPE:

Construction methods shall be as described under 670.4, where open trench construction is feasible. In the event that boring and jacking methods are specified in the Contract or are otherwise necessary to complete the installation, the applicable provisions of 604.11 shall govern.

670.7-FIRE HYDRANTS:

The work shall be performed in accordance with the requirements of 670.4. When relocating hydrants, no work shall be started on removing a hydrant until the pressure on the hydrant has been shut off. Before relocating a hydrant, it shall be thoroughly cleaned of all dirt and foreign matter.

All hydrants shall be provided with a concrete thrust block or anchorage as shown on the Plans and care shall be taken that the concrete does not obstruct any hydrant drain openings. All

hydrants shall be set upon 0.5 cubic yard (meter) of AASHTO # 3 stone to provide drainage for the hydrant. The stone shall extend above the hydrant drain opening to prevent entrance of soil into the hydrant barrel. The thrust blocking and stone shall be placed as shown on the Plans.

670.8-METERS, METER BOXES, AND SPECIAL VALVES AND APPURTENANCES:

The construction method shall be as set forth in 670.4.

When removing and relocating a meter box and lid, the Contractor shall exercise care in order to avoid damaging the box. In the event the box or lid is damaged in performing the work, the Contractor shall furnish replacements in kind.

670.9-SPECIAL STRUCTURES:

Special structures for waterline appurtenances, such as meter pits, special valve pits, etc., shall be in accordance with the applicable provisions of 605.

670.10-HOUSE CONNECTION:

The work to be performed under this item shall consist of furnishing and installing all pipe, taps, couplings and fittings necessary to provide a connection from the relocated line to a point where the existing house connection is reconnected. Construction methods shall be as described in 670.4.

670.11-METHOD OF MEASUREMENT:

670.11.1-Water Pipe: Water pipe will be measured by the linear foot in place. The measurement will be made along the centerline of such pipeline, before backfilling, to or from the following described points:

- i At the centerline of the connection where work begins or ends and connection is made to an existing pipe or special.
- ii At the centerline of the special casting or connection that is part of the new pipeline.
- iii At the centerline of a fire hydrant or at the face of a dead plug, dead cap, flange, or spigot at the end of the new pipe line.
- iv At the ends of new inserted material, where connection is made by breaking and insertion in an existing pipeline. This inserted material, regardless of size, will be considered being of the same size as the connecting pipe and paid for as such.

No deduction in length will be made for valves or fittings.

670.11.2-Casing Pipe: Casing pipe will be measured by the foot (meter) in place. The measurement will be made along the centerline of each pipe installed.

670.11.3-Gate Valve and Valve Box, Fire Hydrants, Meters, Meter Valves and Appurtenances, and Special Structures: These items will be measured by the unit.

670.11.4-House Connections: House connections will be measured foot (meter) of pipe, measured along the centerline, complete in place including all taps and all couplings, goose necks, corporation stops, curb cocks, curb boxes or other material necessary to complete the work.

670.12-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit prices bid for the items listed in 670.13, which prices and payments shall be full compensation for excavation and backfill, except as otherwise provided, testing, disinfecting, thrust blocking, connecting to valves and fire hydrants, all branch connections, fittings, drains, blowoffs and service connections, reinforcing steel, manhole frame and cover, the repair and repaving of areas not otherwise provided for in the Plans, the removal of all surplus material and clean up, furnishing of all materials and doing all work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete the work.

When unsatisfactory foundation materials encountered at the bottom of the trench, there will be no additional compensation for such excavation and backfill, unless the required excavation and replacement exceeds 1 foot of depth. Excavation and replacement material in excess of 1 foot, and any special foundation not called for on the Plans will be paid for in accordance with 109.4.

When boring and jacking of casing pipe is specified in the Contract, the cost of the boring and jacking operations will not be paid for separately but shall be included in the unit price bid for the respective casing pipe pay items. If the Engineer determines that field conditions necessitate the boring and jacking of casing pipe not so specified, the casing pipe pay item as originally specified will be non-performed and the cost for such boring and jacking operations, including the cost of the casing pipe, will be paid for in accordance with 109.4.

670.13-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
670001-*	"size" Cast Iron Pipe Type, "type**", Class "class"	Linear Foot (Meter)
670004-*	"size" Ductile Iron Pipe, Type "type**", Class "class"	Linear Foot (Meter)
670007-*	"size" Plastic Pipe, Class "class"	Linear Foot (Meter)
670008-*	"size" Copper Service Pipe	Linear Foot (Meter)
670009-*	"size" Gate Valve And Valve Box	Each
670010-*	"size" Steel Casing Pipe, Thickness "thickness"	Linear Foot (Meter)
670013-*	"size" Fire Hydrant	Each
670014-*	Relocate Fire Hydrant	Each
670015-*	"size" Meter	Each
670016-*	Relocate Meter	Each
670017-*	Meter Box	Each
670018-*	Relocate Meter Box	Each
670019-*	Special Valve, Type "type"	Each
670020-*	Special Structure	Each
670021-*	"size" House Connection	Linear Foot (Meter)

* Sequence number

"type**" in accordance with the table below:

Type I-Push On Type Joint

Type II-Mechanical Joint

Type III-Bell And Spigot Joint

Type IV-Flanged Joint

Type V-Flexible Joint

SECTION 671 THROUGH SECTION 674-BLANK

SECTION 675 SANITARY SEWERS

675.1-DESCRIPTION:

This work shall consist of construction or reconstruction of sanitary sewers and appurtenances in accordance with these Specifications and in reasonable close conformity with the lines, grades, dimensions, and locations shown on the Plans or established by the Engineer.

675.2-MATERIALS:

The material shall meet the requirements of the following subsections.

MATERIAL	SUBSECTION
Bedding Material	718.21
Casing Pipe	718.12
Cement Lining	718.1.1
Concrete Brick and Block	715.17
Controlled Low Strength Material (CLSM)	219
Ductile Iron Pipe	718.1
Fine Aggregate	718.20
Fittings	718.1.2
Flanged joints	718.1.3
Manholes	605
Manholes, Frames and Grates	605
Mechanical joints	718.1.3
Plastic Pipe (PVC)	718.5
Plastic Pipe Fitting	718.8
Push-On Joints	718.1.3
Structural Concrete	601

Quality control testing of the bedding material is the responsibility of the Contractor as specified in 106.1.

In the event any material does not conform to the specified gradation requirements the contractor's written certification shall reflect said nonconformance with quantities thereof. The contractor's gradation data shall be evaluated in accordance with applicable sections of Section 307 except that Table 704.6.2 shall not apply. Gradation limits shall be in accordance with Table 703.4. The certification is to include the results of testing from samples obtained at a minimum frequency of one sample per day of aggregate production or stockpiling or one sample per placement day, sampling from the working face of an existing stockpile.

A revised unit price for calculation purposes will be established based on the delivered quantities and delivered aggregate cost.

CONSTRUCTION METHODS

675.3-GENERAL:

These Specifications shall apply to the furnishing and installation of all material necessary to complete sanitary sewer relocations and installations in accordance with the Plans.

The Contractor shall furnish all materials, perform all excavation and backfill, construct all necessary joints and connections, construct all appurtenances, install all temporary facilities and dispose of all surplus excavation and discarded material as may be necessary to complete the sanitary sewer relocations and installations.

If the Contractor should observe either proposed or existing sewers or water lines in close proximity the Contractor shall notify the Engineer. The Engineer will determine if the observed situation lacks conformity to the State Department of Health's Design Standards for Water Distribution Systems, its magnitude and the course of action. Additional costs necessitated by a modification in the plan of construction will be paid for in accordance with 109.4.

The Contractor shall also perform the work of permanently plugging existing sanitary sewers at the locations shown on the Plans or as required due to the field conditions at the time of construction. The plug shall consist of CLSM, type C, or concrete block or brick capped with CLSM, type C, and shall extend a minimum of 1 foot (300 mm) into the existing pipe. The plugging of sanitary sewers, except as provided in 675.16, shall be considered incidental work and its cost shall be included in the unit price bid for sanitary sewer pipe.

The Contractor shall assume all risk and bear any loss or injury to property or persons occasioned by neglect or accident during the progress of the work. The contractor shall make every effort to avoid damaging any existing utility lines or appurtenances.

In the performance of their work, it is of prime importance that the Contractor not disrupt the operation of the existing sanitary sewer facilities in any manner or at any time without the prior written approval of the Engineer. Prior notice shall be given to the Engineer by the Contractor of their intention to begin any work that will disrupt or appreciably alter normal system operation so that the Engineer will have ample opportunity to notify the owner to prepare for any emergency operations that may be required. The Engineer upon advice of the owner will have the sole right of determining at what times and in what order the Contractor shall undertake work involving connections and modifications to the existing system.

The Contractor shall excavate as necessary to determine the number and size of fittings and specials required for connections to existing lines. All material necessary for tie-ins shall be at the work site before discontinuing service. Once the work of connection is begun it shall be continuous until the connection is complete.

675.3.1-Maintenance of Local Services: The Contractor shall exercise utmost care to avoid damage to trees and hedges, electric, telephone, gas and water lines and other operating sewer lines, buildings, roads and all appurtenances thereto. The interruption of free access to streets, roads and driveways due to trench excavation shall be kept to a minimum. Where possible, a minimum opening of one lane shall be maintained at all times for these appurtenances. All excavated material shall be piled in a manner that will not endanger the work and will not obstruct access to sidewalks and driveways.

Fire hydrants under pressure, valve boxes, service stop boxes, fire and police boxes or other utility controls shall be left unobstructed and accessible throughout the duration of the work. Gutters shall be kept clear or other satisfactory provisions made for drainage. Natural water courses shall not be obstructed. All trenches, material piles, equipment and pipe which may cause a hazard or serve as obstructions to either vehicular or pedestrian traffic shall be enclosed by fences or barricades, adequately lighted, to protect persons from injury and to avoid property damage. Where traffic must cross open trenches, the Contractor shall provide suitable bridges, which will be subject to approval of the Engineer. The Contractor shall furnish

temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work.

675.3.2-Removal of Water: The Contractor shall at all times during construction provide proper and satisfactory means and devices for the removal of all water entering the excavated area, and the Contractor shall remove all such water as fast as it may collect to avoid interference with the prosecution of the work or the proper placing of masonry or other materials.

675.3.3-Hauling and Storing Materials: The Contractor shall be responsible for the unloading, storing, hauling and distribution of all material and shall replace at their expense all such material that is damaged, destroyed or lost. All pipe, pipe fittings and accessories shall be handled so as to avoid shock. Pipe having factory applied joint material shall be stacked and blocked to prevent damage to the joint material. Material not needed for immediate use shall be stored in a safe manner at places provided by the Contractor and approved by the Engineer.

675.4-TRENCH EXCAVATION:

675.4.1-General: Excavation of the trench may be done either by hand or by the use of suitable trenching equipment. Safety requirements for trenching shall comply with the West Virginia Safety Code, published by the West Virginia State Division of Labor.

675.4.2-Trench Width: The width of the trench shall be ample to permit the pipe to be laid and jointed properly, and to permit the backfill to be placed and compacted as specified. Excessive trench widths will not be permitted. Recommended maximum trench widths at top of pipe are given in Table 675.4.2. Where necessary for protection of workers or to avoid undermining or otherwise damaging structures or property, the trench shall be properly and sufficiently sheeted or braced to prevent caving, slipping or cracking of the sides in accordance with applicable provisions of the West Virginia Safety Code. Where bracing or sheeting is required or extra width is required for handling of specials, the trench shall be of such extra width to accommodate this work.

TABLE 675.4.2

Recommended Trench Widths At Top Of Pipe	
Pipe Diameter Inches (mm)	Trench Width Inches (mm)
6 (150)	21 (525)
8 (200)	24 (600)
10 (250)	27 (675)
12 (300)	30 (750)
15 (375)	33 (825)
18 (450)	36 (900)
21 (525)	42 (1 050)
24 (600)	45 (1 125)
27 (675)	48 (1 200)
30 (750)	54 (1 350)
33 (825)	57 (1 425)
36 (900)	60 (1 500)

675.4.3-Blasting: Blasting for excavation will be performed only after securing the approval of the Engineer and only when proper precautions are taken for the protection of persons or property. The Engineer will set the hours of blasting. The Contractor at his expense shall repair any damage caused by blasting. The Contractor's method of procedure relative to blasting shall conform to the West Virginia Safety Code.

675.5-BEDDING:

675.5.1-General: Bedding of the pipe shall conform to class 'B' as follows:

The trench shall be excavated to a depth that will provide a granular bed of at least 4 inches (100 mm) or the pipe diameter divided by four, whichever is greater, below the pipe in soil. The trench shall then be backfilled with bedding material. The granular bed shall be extended to the spring line of the pipe.

The pipe shall be bedded in an earth foundation of uniform density, carefully shaped by means of a template to fit the lower pipe exterior for at least 15 percent of the overall height of the pipe. Fine aggregate shall be used to level the foundation.

675.5.2-Unstable Foundation: Where the bottom of the trench at grade is found to be unstable or include ashes, cinders, all types of refuse, vegetable or other organic material, the Contractor shall excavate and remove such unsuitable material to the width and depth ordered by the Engineer. The trench shall be backfilled to the invert grade, in 6 inch (150 mm) loose layers, with suitable earth or granular material from unclassified excavation. Each layer shall be thoroughly compacted in accordance with 675.10, and the bedding shall be in accordance with 675.5.1.

There will be no additional compensation for such excavation and backfill, unless the

Required excavation and replacement exceeds 1 foot in depth. Excavation and replacement material in excess of 1 foot in depth will be paid for in accordance with 109.4.

Where the bottom of trench at grade is found to consist of material which is unstable to such a degree that, in the opinion of the Engineer, it cannot be removed and replaced with material suitable to support the pipe properly, the Contractor shall construct a foundation for the pipe, consisting of concrete, pilings, timber or other materials or as directed by the Engineer. A special foundation, if not called for on the Plans, will be paid for in accordance with 109.4.

675.5.3-Rock Foundation: Where rock (or boulders) is encountered, the rock shall be removed to provide a clearance, below and on each side of all pipe, fittings and appurtenances, of at least 6 inches (150 mm) for pipe 24 inches (600 mm) in diameter or smaller and at least 9 inches (225 mm) for pipe larger than 24 inches (600 mm) in diameter. The trench shall be backfilled to invert grade with bedding material in 4 inch (100 mm) loose layers. Each layer shall be thoroughly compacted in accordance with 675.10, and the bedding shall be in accordance with 675.5. 1.

675.6-PIPE LAYING:

Proper implements, tools and facilities satisfactory to the Engineer shall be provided and used for the safe and convenient prosecution of the work. Line and grade of the pipeline shall be maintained and checked by use of laser beam for relocation's less than 100 ft (30 m) batter boards, grade line and grade rods or methods of equivalent accuracy may be utilized. Batter boards for

gravity sewers shall be set at intervals of not greater than 25 feet Pipe shall be laid from the lowest point upgrade with the spigot or tongue ends pointing downgrade in the direction of flow.

All pipe, fittings and appurtenances shall be carefully lowered into the trench, piece by piece, by means of a derrick, ropes or other suitable tools or equipment in such a manner as to prevent damage to the sewer line materials, protective coating, and linings. Under no circumstances shall sewer line materials be dropped or dumped into the trench.

All pipe and fittings shall be carefully examined for defects and no pipe or fitting shall be laid which is known to be defective. Any defective, damaged or unsound pipe will be rejected. If any defective piece is discovered after laying, it shall be removed and replaced at the Contractor's expense. All pipes and fittings shall be cleaned before they are laid and shall be kept clean until accepted in the completed work.

The pipe shall be supported its full length by the uniform grade of the trench. Pipe ends shall not be left open at the end of a day's work or during temporary suspension of construction, but shall be securely covered to prevent the entry of foreign matter or animals.

When cutting short lengths of cast iron pipe, a pipe cutter shall be used and care shall be taken to make the cut at right angles to the centerline of the pipe. For "push-on" pipe, the cut ends shall be tapered with a portable grinder or coarse file to match the manufactured taper. Plastic and composite pipe may be sawed.

675.7-JOINTING:

Jointing of all pipes is to be preformed in accordance with the manufacturer's recommendations.

675.8-CASING PIPE:

Construction methods shall conform to the applicable requirements of the Specification, except that in the event that boring and jacking methods are specified in the Contract or are otherwise necessary to complete the installation, the applicable provisions of 604.11 shall govern.

Damaged coating on the outside of the pipe shall be repaired by hand brushing a thick coat of the same type as the original coating material when placed by open trench construction; outside repair coating is waived for casing pipe to be placed by boring and jacking operations. Inside coating damage shall be repaired, as specified above, for all pipe except as limited by inaccessibility to damage areas for small diameter casing pipe.

675.9-THRUST BLOCKING AND ANCHORAGE:

Thrust blocking or anchorage of sewer force main as shown on the Plans shall be constructed in accordance with 670.4.3 and 670.4.4.

675.10-BACKFILLING:

Backfilling shall be in accordance with 670.4.5

675.11-TESTING INSTALLATIONS:

Exfiltration or air tests shall be made on all sections of new gravity sewer extending from manhole to manhole. New installations that become a part of an existing line and testing is not practical then testing shall not be required. All pressure lines shall be subjected to a pressure test at the pressure shown on the Plans. An infiltration test shall be made only when called for on the Plans. All new manholes shall be tested.

In the event the allowable test rates are exceeded, the Contractor shall determine the location of the leaks and shall repair the sewer or manholes, or both, in a manner satisfactory to the Engineer. The sewer line shall be retested until the leakage in the sewer is within the allowable limits. The Contractor shall include in the unit bid price the cost of all bulkheads, plugs, pipe stoppers, pumps, water, weirs, labor, delay and any other items of cost necessary for the performance and completion of the required tests and for the cost of any repairs or adjustments which may be necessary to make the installations conform to the required allowable leakage rates.

All leakage tests shall be conducted under the supervision of the Engineer or representative.

675.11.1-Exfiltration Testing: In conducting the exfiltration test, the line shall be plugged in the lower manhole and filled with water until the water level in the upper manhole is 2 feet (600 mm) above the top of the pipe. The line shall then be left for a period of two hours to allow for absorption of water into pipes and structures, after which it shall be refilled to the specified height and the test begun. Readings shall be taken on the level of the water at one hour intervals, the manhole refilled to an elevation of 2 feet (600 mm) above the top of the pipe and the amount of replacement water recorded. Duration of the test shall be four hours, and the allowable exfiltration shall not exceed that shown in Formula 675.11.1.

Pressure tests for force mains (sewers under pressure) shall be performed in accordance with 670.4.6.

Formula 675.11.1 - Allowable Loss Rate

(Based on Loss Rate of 500 Gallons per Inch Diameter per One Mile per 24 Hours)

$$\text{Loss} = \frac{\{\text{English}\}}{0.00395 (D)L}$$

Where

$$\text{Loss} = \text{Gallons per Hour}$$

D = Nominal diameter of the pipe, in inches

L = Length of pipe in feet

$$\text{Loss} = \frac{\{\text{Metric}\}}{0.00193 (D)L}$$

Where

$$\text{Loss} = \text{Liters per Hour}$$

D = Nominal Diameter in Millimeters

L = Length of pipe in Meters

675.11.2-Infiltration Testing: The infiltration test shall be made by installing a weir or other measuring device approved by the Engineer in the lower end of the sewer section to be tested. The incoming sewer or sewers in the upper end of the test section shall be securely sealed. The quantity of ground water infiltration into the test section shall be measured and shall not exceed that shown in Equation 675.11.1

675.11.3-Low Pressure Air Testing: Low pressure air test conforming to these specifications shall be conducted between consecutive manholes. All Wye branches in the test section shall be plugged. The duration of the test shall be as shown in Table 675.11.3.

The drop in pressure during the prescribed test time shall not exceed 1.0 psi, from 3.5 psi to 2.5 psi testing pressure. A drop below 2.5 psi shall be indication of a failure in the section being tested.

Time required for pressure drop from 3.5 PSI (24.1 kPa) to 3.0 PSI (20.7 kPa).
The required test time shall be the minimum test time or test duration whichever is greater.

TABLE 675.11.3 - Air Test Table

Pipe Diameter inches (mm)	Minimum Test Time Min: Sec	{English} Test Duration L = Feet Sec	{Metric} Test Duration L = Meters Sec
4 (100)	1:53	0.190 L	0.623 L
6 (150)	2:50	0.427 L	1.401 L
8 (200)	3:47	0.760 L	2.493 L
10 (250)	4:43	1.187 L	3.894 L
12 (300)	5:40	1.709 L	5.607 L
15 (375)	7:05	2.671 L	8.763 L
18 (450)	8:30	3.846 L	12.618 L
21 (525)	9:55	5.235 L	17.175 L
24 (600)	11:20	6.837 L	22.431 L

675.11.3.1-Safety Precautions during Air Testing: The air test may be dangerous if a line is improperly prepared. It is extremely important that the various plugs be installed and braced in such a way as to prevent blowouts. Inasmuch as a force of 250 pounds (113.4 kg) is exerted on an 8-inch (200 mm) plug by an internal pipe pressure of 5 psi (34.5 kPa), it should be realized that sudden expulsion of a poorly installed plug or of a plug that is partially deflated before the pipe pressure is released can be dangerous.

As a safety precaution, pressurizing equipment should include a regulator set at 10 psi (69 kPa) to avoid over pressurizing and damaging an otherwise acceptable line. No one shall be allowed in the manhole during testing.

For sewers 30 inches (750 mm) and greater in diameter, joint testing is an acceptable method of testing. Joint testing shall be accomplished by isolating each joint and applying low pressure air. The line shall be acceptable if each joint passes the air test. The joint will be considered acceptable if the air pressure being applied to the joint drops less than 1 psi (7 kPa) in three minutes. The air pressure applied shall be 4 psi (27.6 kPa) over and above the groundwater back pressure. Groundwater shall be compensated by increasing the 4 psi (27.6 kPa) test pressure by 0.433 psi (9.8 kPa) for each foot (meter) of groundwater. It is the Contractor's responsibility to determine the groundwater level.

675.11.4-Manhole Testing: The test shall consist of plugging all inlets and outlets and filling the manhole with water to a height determined by the Engineer. Leakage in each manhole shall not exceed 0.2 gallons per hour per foot (2.48 liters per meter) of head above the invert. A manhole may be filled 24 hours prior to time of testing, if desired, to permit normal absorption into the pipe walls to take place. Repair all manholes that do not meet the leakage test, or are unsatisfactory from visual inspection, to conform to the requirements herein.

The Contractor may request to test manholes for leakage by the vacuum testing procedure developed by Perer A.Glazier and Associates of Worcester, Massachusetts, 01603. This test shall not be used until the Engineer has given written approval. The Engineer reserves the right to refuse to permit this procedure or to place any condition upon the procedure he deems appropriate.

675.12-RECONSTRUCTED SANITARY SEWER:

Sections of existing sanitary sewers so specified shall be removed and replaced in the same locations. The reconstructed sewer shall be of the type and size as shown on the Plans and shall be laid on a uniform grade between points of removal.

Construction methods shall conform to the applicable requirements of this Specification. Tests shall be performed as set forth in 675.11.

This work shall also include construction and maintenance of temporary lines, as required, to avoid disrupting operation of the existing sanitary sewer system. Temporary service may be maintained by use of pumps and hose lines or in any other manner satisfactory to the Engineer.

675.13-MANHOLE:

Construction of manholes shall conform to the applicable requirements of 605.

675.14-ABANDONING MANHOLES:

Upon completion of the new gravity sewer and placing it in service, or upon abandonment of an existing sewer line, the existing manholes to be abandoned shall be cut down to 2 feet (600 mm) below the proposed finished grade, the inlet and outlet ends of existing pipe plugged with CLSM, Type C, and the manhole backfilled to subgrade elevation with material from the unclassified excavation and compacted.

675.15-ADJUSTING MANHOLES:

Construction methods shall conform to the applicable requirements of Section 605.

675.16-CAPPING MANHOLES:

The existing manhole shall be removed to a minimum depth of 1.5 ft (450 mm) below the subgrade elevation. Permanent forms of sheet or corrugated sheet steel shall be used to form over the manhole opening. Side forms may be undisturbed earth. No form work shall be placed inside the manhole which will interfere with the flow of the existing sewer. Steel shall be set and the cap poured to Plan dimensions. No finish is required.

675.17-JUNCTION BOXES:

Construction methods for junction boxes shall conform to the applicable requirements of Section 605.

675.18-METHOD OF MEASUREMENT:

675.18.1-Sanitary Sewer Pipe: Pipe of the different types and sizes, both new and reconstructed, will be measured by the linear foot (meter) in place. Measurement will be made along the centerline of each pipe installed. Branch connections, valves, tees, wyes, and elbows will be measured along their centerlines and these lengths included in the total lengths of the appropriate conduit. Wyes, tees, and other branch connections will be measured along the centerlines to points of intersection. Pipe with sloped or skewed ends will be measured along the longitudinal axis through the center of the pipe. The portion of pipe extending through to the inside face of manholes, boxes, or other structures will be included in the measurement.

675.18.2-Manholes: Manholes will be measured as a complete unit in place, including frame, cover and cover castings.

675.18.3-Abandoning Manholes, Adjusting Manholes and Capping Manholes: "Abandoning Manhole", "Adjusting Manhole", and "Capping Manhole" will be measured as a complete unit in place.

675.18.4-Junction Boxes: "Junction Box" will be measured as a complete unit in place, including, if called for, manhole frame and cover casting (ring type).

675.18.5-Steel Casing Pipe: Steel casing pipe will be measured by the linear foot (meter) complete in place.

675.19-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below, which prices and payments shall be full compensation for excavation and bedding, except as otherwise provided. Backfilling, testing, construction and maintenance of temporary service when required, repair and repaving of areas not otherwise provided for in the contract, removal of surplus material and clean-up, furnishing all materials and doing all the work prescribed in a workmanlike and acceptable manner, including all labor, tools, equipment, supplies, and incidentals necessary to complete work.

When boring and jacking of casing pipe is specified in the Contract, the cost of the boring and jacking operations will not be paid for separately but shall be included in the unit price bid for the respective casing pipe pay items. If the Engineer determines that field conditions necessitate the boring and jacking of casing pipe not so specified, the casing pipe pay item as originally specified will be non-performed and the cost for such boring and jacking operations, including the cost of casing pipe, will be paid for in accordance with 109.4

675.20-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
675007-*	"size" Plastic Sewer Pipe	Linear Foot (Meter)
675008-*	"size" Ductile Iron Sewer Pipe, Type "type", Class "class"	Linear Foot (Meter)
675013-*	"size" Reconstructed Sanitary Sewer, Type "type"	Linear Foot (Meter)
675014-*	Manhole Complete, Including Casting	Each
675015-*	Drop Manhole Complete, Including Casting	Each
675016-*	Special Manhole Complete, Including Casting	Each
675017-*	Abandoning Manhole	Each
675018-*	Adjusting Manhole	Each
675019-*	Capping Manhole	Each
675020-*	Junction Box	Each
675021-*	"size" Steel Casing Pipe, Thickness "thickness"	Linear Foot (Meter)

* Sequence number

SECTION 676 THROUGH SECTION 678-BLANK

SECTION 679

OVERLAYING OF PORTLAND CEMENT CONCRETE BRIDGE DECKS

679.1-DESCRIPTION:

The work shall consist of furnishing and placing a specialized concrete overlay to a designated grade line. Unless otherwise indicated on the plans, the Contractor may place any one of the specialized overlays allowed by the terms of this specification. Only one type of overlay will be allowed on any one structure.

679.1.1-Other Work: The following work, as required by the contract plans, may also be performed under the terms of this section:

- a) Clean the bridge deck
- b) Bridge deck repair
- c) Clean exposed reinforcing steel
- d) Support and tie reinforcing steel
- e) Place slab reconstruction concrete
- f) Abutment backwalls and approach slabs repair (same as bridge deck or as shown in the plans.)
- g) Hydrodemolition of existing deck surface

679.1.2-Definitions:

679.1.2.1-Specialized Concrete Overlay: Two types of specialized concrete overlay are permitted as follows:

- 1) **Latex Modified Concrete:** A Portland cement concrete to which an approved styrene butadiene latex admixture has been added.
- 2) **Microsilica Concrete:** A Portland cement concrete to which an approved Microsilica admixture has been added.

679.1.2.2-Slab Reconstruction Concrete: Slab reconstruction concrete is that concrete placed completely around exposed reinforcing bars.

679.1.2.3-Curing Hour: A curing hour is any hour, beginning with the hour of placement, during which the temperature of the concrete surface remains at, or above, 50° F (10° C) as measured by a recording thermometer.

679.1.2.4-Curing Temperature: This is the air temperature at the concrete surface, or the air temperature between the concrete surface and its protective covering.

679.2-MATERIALS:

679.2.1-General: Materials used in the manufacture of specialized concrete overlays shall meet the requirements specified in Section 601.2 of the Specifications and as required herein.

679.2.1.1-Fine Aggregate: Fine aggregate shall be silica sand meeting the requirements of Sections 702.1.2 through 702.1.5 and 702.6 of the Specifications.

679.2.1.2-Coarse Aggregate: Coarse aggregate shall be AASHTO Size No. 8 crushed stone or gravel conforming to Section 703 of the Specifications.

679.2.1.3-Latex Admixture: Formulated latex modifier shall meet the requirements of Section 707.5 of the Standard Specifications.

679.2.1.4-Microsilica Admixture: Microsilica Admixture shall meet the requirements of Section 707.4.3 of the Standard Specifications.

679.2.1.5-Bonding Grout: Bonding Grout shall not be used on Reconstruction Projects. On New Construction Projects Bonding Grout shall consist of the actual modified concrete used with coarse aggregates removed. The consistency of the slurry shall be such that it can be applied to the prepared concrete surfaces with a stiff bristle broom in a thin, even coating that will not run or puddle. The bonding grout shall be applied using a stiff broom and worked into all areas of the slab. The rate of applying this coating shall be controlled so that the brushed material does not become dry before it is covered with additional material.

679.2.1.6-Class K Concrete: Class K Concrete shall meet the requirements of Section 601 of the Specifications except that coarse aggregate shall meet the requirements of 679.2.1.2.

679.2.1.7-Curing Materials:

Burlap: This shall meet the requirements of Section 707.7 of the Specifications.

Quilted Covers: These shall be clean and free of defects, providing a water retention blanket over the concrete. Acceptance will be based on visual inspection.

Polyethylene Curing Covers: These shall meet the requirements of Section 707.6 of the Specifications.

Plastic Coated Fiber Blankets: These shall be clean and free of defects, providing a water retention blanket over the concrete. Acceptance will be based on visual inspection.

679.2.1.8-Replacement Bars: Reinforcing bars shall be Grade 60 and shall meet the material requirements of Section 602 of the Specifications. Replacement bars shall be spliced to existing bars using either minimum 30-bar diameter lap splices or approved mechanical connectors.

679.2.2-Specialized Concrete Mix Design and Testing: Specialized concrete shall consist of a homogeneous mixture of cement, fine aggregate, coarse aggregate, latex or microsilica admixture, chemical admixtures and water.

The Contractor shall determine mixture proportions in general accordance with ACI 211.1, "Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete." Establishment of mixture proportions shall be coordinated with the manufacturer of the latex or microsilica admixture.

Prior to the start of construction, the Contractor shall design and submit to the Engineer for approval the proportion of materials, including admixtures, to be used which will result in a

workable concrete having the applicable properties enumerated below, including those of section 679.2.2.1 or 679.2.2.2. This mix design shall be prepared in accordance with MP 711.03.23.

Design mixture testing shall include air content, slump, and compressive strength results at 28 days and results of rapid chloride permeability tests. Compressive strength cylinders for microsilica concrete shall be cured in accordance with ASTM C 192 for 28 days, but compressive strength cylinders for latex modified concrete shall be moist cured in accordance with ASTM C 192 for 2 days then air cured in the lab at a temperature between 73.5 ± 3.5 °F (23 ± 2 °C) for 26 days. For establishment of mixture proportions, rapid chloride permeability tests for microsilica concrete shall be made on representative samples cured for 56 days in accordance with ASTM C 192, then allowed to air dry in the lab at a temperature of 73.5 ± 3.5 °F (23 ± 2 °C) until the time of test. These specimens shall be prepared and tested in accordance with AASHTO T277 at an age of 56 to 90 days. For establishment of mixture proportions, rapid chloride permeability tests for latex modified concrete shall be made on representative samples moist cured in accordance with ASTM C 192 for 2 days, air cured at in the lab at a temperature between 73.5 ± 3.5 °F (23 ± 2 °C) for 54 days, then prepared and tested in accordance with AASHTO T277 at an age of 56 to 90 days. The final rapid chloride permeability test result shall consist of the average of the two individual test results. This average shall not exceed 750 coulombs.

For establishment of mixture proportions, as an alternative to the curing methods for rapid chloride permeability testing outlined in the previous paragraph, microsilica concrete specimens may be moist cured for 7 days in accordance with ASTM C 192, then cured for 21 days in lime-saturated water at 100.0 ± 3.5 °F (38.0 ± 2.0 °C), then tested at an age of 28 days. For establishment of mixture proportions, as an alternative to the curing methods for rapid chloride permeability testing outlined in the previous paragraph, latex modified concrete specimens may be moist cured for 2 days in accordance with ASTM C 192, then cured for 26 days in air at 100.0 ± 3.5 °F (38.0 ± 2.0 °C) and a minimum of 50% relative humidity, then tested at an age of 28 days. These methods of curing shall be noted as the accelerated RCPT curing methods.

The 28-day compressive strength of the test mix that satisfies the 750 coulomb threshold shall be used as the basis for acceptance of the Specialized Concrete Overlay permeability requirements. Concrete for any slump test shall be deposited in a manner and location that excludes the effects of vibrations caused by traffic and concrete placement operations.

The total concrete constituents shall contribute less than 0.10% water soluble chloride ion by weight of cement. Use one brand and/or one source for any concrete constituent.

The Contractor shall obtain a written statement from the manufacturer of the latex or microsilica admixture that confirms the compatibility of the material combination and the sequence in which they are combined. The written statement, along with the results of all required tests, shall be furnished to the Engineer prior to the pre-construction meeting (refer to 679.2.2.3). Substantiating data showing compliance with the requirements of this specification shall also be submitted. This data shall also include the sources of coarse and fine aggregates as well as the brands of all admixtures to be used.

Contractor's Quality Control: Quality control of the specialized concrete is the responsibility of the Contractor as designated in MP 601.03.50. The Contractor shall maintain equipment and qualified personnel, including at least one certified Portland Cement Concrete

Technician who shall direct all field inspection, sampling, and testing necessary to determine the magnitude of the various properties of concrete governed by the Specifications and shall maintain these properties within the limits of this Specification. The Contactor's personnel who conduct the field sampling and testing shall be a certified Portland Cement Concrete Inspector. The quality control plan designated in MP 601.03.50 shall be submitted to the Engineer at the preconstruction conference. Work shall not begin until the plan is reviewed for conformance with the contract documents.

Compressive strength specimens shall be made and cured in accordance with AASHTO T 23 and MP 601.04.20 at the frequency required in MP 601.03.50 except that specimens for latex modified concrete shall be moist cured for 2 days and air cured at a temperature of 73.5 ± 3.5 °F (23 ± 2 °C) for 26 days.

During construction, a minimum of four specimens shall be fabricated for rapid chloride permeability testing in accordance with AASHTO T277 every time that a set of compressive strength specimens is fabricated.

If the 28-day compressive strength of the in-place concrete, obtained from specimens made as outlined in the previous paragraph, is less than or equal to eighty percent of the compressive strength of the approved test mix, these rapid chloride permeability test specimens shall be tested, as outlined in the following two paragraphs. Otherwise, testing of these specimens is not required.

When microsilica concrete is used, these specimens shall be moist cured for 56 days and then allowed to air dry at a temperature of 73.5 ± 3.5 °F (23 ± 2 °C) until the time of test. Two of these specimens shall be tested at an age of 90 days in accordance with AASHTO T277, and if necessary, the remaining two specimens shall be tested at an age of 180 days in accordance with AASHTO T277, and the average result of the two values from these specimens shall be reported as the result required in Note (a) in section 679.2.2.2.

When latex modified concrete is used these specimens shall be moist cured for 2 days and then air dried at a temperature of 73.5 ± 3.5 °F (23 ± 2 °C) until the time of test. Two of these specimens shall be tested at an age of 90 days in accordance with AASHTO T277, and the average result of the two values from these specimens shall be reported as the result required in Note (a) in section 679.2.2.1. If necessary, the remaining two specimens shall be tested at an age of 180 days in accordance with AASHTO T277, and the average result of the two values from these specimens shall be reported as the result required in Note (a) in section 679.2.2.1.

Gradation testing shall be performed in accordance with Section 601.3.2.4.

679.2.2.1-Latex Modified Concrete: The following test criteria must be met for all latex modified concrete pours placed at the structure. This testing shall be performed by the Contractor or his designated representative and certified results provided to the Engineer prior to final acceptance of the project.

Table 679.2.2.1

Chloride Permeability (a)	1000 coulombs @ 90 or 180 days, maximum (per AASHTO T277)
Compressive Strength (b)	not less than 80% of 28-day compressive strength of the approved test mix
Water/Cement Ratio (c)	0.40 by weight, maximum
Portland Cement Content	658 lb/cu. yd., minimum (390 kg/m ³ , minimum)
Latex Admixture Content (d)	24.5 gal/cu. yd., minimum (121 liters/m ³ , minimum)
Air Content (e)	6.5% maximum (Per AASHTO T152)
Slump	4.0 inches ± 2.0 inches (100 mm ± 50 mm)

- Note (a) When required, as outlined in the Contractor's Quality Control Section of Section 679.2.2, rapid chloride permeability tests shall be performed and the results tabulated and submitted to the Engineer. Chloride permeability of the in-place concrete shall be considered acceptable if the 28-day compressive strengths obtained in Section 679.2.2 are greater than eighty percent of the 28-day compressive strength of the approved test mix. If the compressive strength requirements noted in Table 679.2.2.1 are not satisfied, and the permeability value noted in the Table 679.2.2.1 is exceeded, then the concrete represented by these strength and permeability values may be removed and replaced by the Contractor. If the Contractor elects to leave the material in place, the Engineer shall evaluate it as to the adequacy for the use intended. All concrete evaluated as unsatisfactory for the use intended shall be removed and replaced by the Contractor. When the Engineer's evaluation indicates that the work may satisfactorily remain in place, the subject material shall be paid for at a reduced unit price based on Table 679.2.2.3.
- Note (b) The minimum compressive strength for the overlay concrete shall be 80% of the 28-day compressive strength of the approved test mix. However, the minimum 28-day compressive strength shall be 4,000 psi (28 Mpa). Overlay concrete with a compressive strength of less than this acceptance level may be removed and replaced at the contractor's expense.
- Note (c) The amount of added water shall be adjusted to provide slump at or below the prescribed limit. The water portion of all admixtures shall be included as part of the water/cement ratio.
- Note (d) Latex sampling shall be in accordance with 707.5.
- Note (e) The initial mix design shall be based on an expected air content range of 3% to 6%. The mixture proportions shall be determined using actual conditions for fineness modulus and bulk specific gravities (saturated surface dry for aggregates).

679.2.2.2-Microsilica Concrete: The following test criteria must be met for all microsilica concrete pours placed at the structure. This testing shall be performed by the Contractor or his designated representative and certified results provided to the Engineer prior to final acceptance of the project.

Table 679.2.2.2

Chloride Permeability (a)	1000 coulombs @ 90 days or 180 days, maximum (per AASHTO T277)
Compressive Strength,(b)	not less than 80% of 28-day compressive strength of the approved test mix
Water/(Cementitious Materials) Ratio (c)	0.37 by weight, maximum
Portland Cement Content (d)	680 lb/cu.yd., minimum (404 kg/m ³ , minimum)
Microsilica Content (e) (Dry Weight)	50 lb./cu. yd., minimum (30 kg/m ³ , minimum)
Air Content	7.0% (plus or minus 1.5%) (Per AASHTO T152)
Slump	6.5 inches ± 1.5 inches (165 mm ± 40 mm)
High Range Water Reducer(Superplasticizers) (f)	As needed for workability, slump and water/cementitious ratios

- Note (a) When required, as outlined in the Contractor's Quality Control Section of Section 679.2.2, rapid chloride permeability tests shall be performed and the results tabulated and submitted to the Engineer. Chloride permeability of the in-place concrete shall be considered acceptable if the 28-day compressive strengths obtained in Section 679.2.2 are greater than eighty percent of the 28-day compressive strength of the approved test mix. If the compressive strength requirements noted in Table 679.2.2.2 are not satisfied, and the permeability value noted in the Table 679.2.2.2 is exceeded, then the concrete represented by these strength and permeability values may be removed and replaced by the Contractor. If the Contractor elects to leave the material in place, the Engineer shall evaluate it as to the adequacy for the use intended. All concrete evaluated as unsatisfactory for the use intended shall be removed and replaced by the Contractor. When the Engineer's evaluation indicates that the work may satisfactorily remain in place, the subject material shall be paid for at a reduced unit price based on Table 679.2.2.3.
- Note (b) The minimum compressive strength for the overlay concrete shall be 80% of the 28-day compressive strength of the approved test mix. However, the minimum 28-day compressive strength shall be 4,000 psi (28 Mpa). Overlay concrete with a compressive strength of less than this acceptance level may be removed and replaced at the contractor's expense.
- Note (c) The amount of added water shall be adjusted to provide slump at or below the prescribed limit. The water portion of all admixtures shall be included as part of the water/cement ratio.
- Note (d) An equal volume of fly ash may be substituted for cement to a maximum of 1 ¼ bags per cubic yard. An equal volume of ground granulated blast furnace slag (GGBFS) may be substituted for cement to a maximum of 3 bags per cubic yard (meter). When fly ash or GGBFS are used, equivalent volumes of fly ash or GGBFS shall be considered as cement for purposes of determining the proportioning ratios.
- Note (e) Microsilica sampling shall be in accordance with 707.4.3.
- Note (f) A high range water-reducing admixture is required to improve workability. No more than two additions of the admixture shall be made, and the total quantity shall not exceed the manufacturer's maximum dosage rate. Each time high range water reducer is added, the concrete shall be mixed an additional minimum of 30 revolutions. The total number of revolutions shall not exceed 300.

Table 679.2.2.3

Permeability result obtained in Table 679.2.2.1 or 679.2.2.2. See Note (a) (values expressed in Coulombs)	Percent of unit bid price paid according to Section 679.6.3 which will be paid for material in question
>1,000 – 1,500	95%
>1,500 – 2,000	90%
>2,000 – 2,500	85%
>2,500 – 3,000	80%
>3,000 – 3,500	70%
>3,500 – 4,000	60%
>4,000	Remove and replace

679.2.2.3-Pre-Pour Meeting: The Contractor shall schedule a meeting prior to the start of the concrete work. The Engineer, Construction Manager, Prime Contractor, Concrete Contractor, Concrete Finisher, the Concrete Supplier and the Individual or Agency that will perform the quality control testing of the concrete shall attend. Topics of discussion shall include specialized concrete mixture proportions, batching, transporting, handling, placing, finishing and curing.

679.2.2.4-Test Slab Requirements: After obtaining the Engineer's approval of mixture proportions and at least one week before any slab reconstruction concreting or overlay is to be placed, the Contractor shall make one or more trial batches of the specialized concrete of the size to be hauled or mixed at the site. The trial shall simulate transportation and job site conditions, utilizing proposed material and methods of placing, finishing, and curing, including the application of bonding grout when required.

The test slab shall be constructed the same as the actual work (depth, reinforcing steel, etc.) and shall be at least one lane width wide and of a length to allow the use of the contractor's entire paving train from placement to finishing. The test slab location shall be as shown in the plans or as approved by the Engineer. The prime intent is to familiarize the concrete finishing crew with the handling, finishing and curing characteristics of the concrete. Batching, placement and texturing shall be in strict accordance with this specification. Additional reference test slabs may be constructed as necessary to provide an acceptable standard of reference. This standard of reference shall serve throughout the project construction period as the basis of acceptance of the actual as-built work. This Item may be deleted at the discretion of the Engineer.

679.2.3-Equipment: All equipment proposed for use shall have the Engineer's approval prior to its usage.

679.2.3.1-Cutting Equipment: Shall consist of a high pressure water jet (hydrodemolishing) system per the following requirements.

679.2.3.1.1-Hydrodemolishing Equipment: The hydrodemolishing system shall be self-propelled, completely programmable, designed for high production concrete removal,

and capable of removing precise depths of sound concrete. Hydrodemolishers shall be capable of removing concrete from around and below the steel reinforcement. Lances shall be of a type intended to remove rather than scarify concrete. Individuals certified by the equipment manufacturers shall operate the removal equipment.

All removal equipment shall be capable of operating at a noise level of less than 90 decibels at a distance of 50 feet (15 m) from the noise source. The Contractor shall monitor noise levels throughout the project to insure compliance, if required by the Engineer. No separate or additional payment will be made for monitoring -noise levels.

Potable or filtered water may be used. Filtered water shall have all visible solids and oils removed that could prevent a proper bonding with the remaining concrete. When filtered water is used, the Contractor shall wash the bridge deck with potable water in water blasting equipment as soon as all the concrete debris has been cleaned up. This water blasting shall be in addition to any other water blasting that may be required.

The Contractor shall shield his operations to prevent injury or damage from flying or falling debris. The Contractor shall provide a method for handling expected and unexpected blow-through of the deck. This method shall provide for the containment of runoff water and debris, and the protection of the area under the bridge deck. The Contractor shall be responsible for any injury or damage caused by his operations.

679.2.3.1.2-Hydrodemolishing Equipment Demonstration: Two trial areas will be designated by the Engineer to allow the Contractor to demonstrate that the equipment, personnel, and methods of operation can meet the requirements of this specification. The demonstration shall follow any roto-milling permitted by this specification. No separate or additional payment will be made for this demonstration.

The first trial area will consist of approximately 30 square feet (9 m²) of sound concrete. The hydrodemolisher shall be calibrated to remove sound concrete to the depth specified in the contract documents without damaging the underlying sound concrete. After removing the sound concrete in the first trial area, the hydrodemolisher shall be moved to the second trial area. This area will consist of deteriorated or defective concrete. This trial will determine whether this unsound concrete will be completely removed with the above calibration.

If the equipment is deemed inadequate for use, the Contractor shall obtain another hydrodemolisher for a subsequent demonstration. When satisfactory results are obtained, production removal may proceed. No adjustment in the completion date of the project will be considered due to delays in obtaining suitable equipment.

If concrete is not being adequately removed during production work, recalibration of the equipment will be required.

679.2.3.2-Blastcleaning Equipment: Blastcleaning Equipment shall be capable of removing rust from reinforcing bars, laitance, and small chips of partially loosened concrete. Certain qualities of rust are not necessary to be removed (refer to Section 679.3.3).

679.2.3.3-Proportioning and Mixing Equipment: Handling, Measuring, and Batching of materials shall conform to the requirements specified in 501.7.

Proportioning and Mixing Equipment shall consist of the following:

679.2.3.3.1-Latex Modified Concrete: Self-contained, continuous mixing and proportioning mobile units shall be used. A minimum of two units shall be supplied. The requirements of Sections 679.2.3.4 and 679.2.3.5 shall apply.

679.2.3.3.2-Microsilica Concrete: An approved concrete batch plant, mobile mixer or truck mixer shall supply all concrete. The requirements of Section 601 of the Specifications shall apply, except as modified herein.

When microsilica densified powder is used, the densified powder shall be weighed using an approved cement scale or supplied in bags, the weight of each bag shall be clearly marked on the bag. The densified powder shall be last in the weighing sequence and the tolerance for each material draw weight shall be based upon the total weight of cement plus densified powder. Batching tolerance for the cement plus densified powder shall be 1%.

679.2.3.4-Mobile Mixer Units: Each unit shall be self-propelled and shall be capable of carrying sufficient unmixed material to produce on site, no less than 6 cubic yards (4.5 cubic meters) of specialized concrete.

Volumetric mixers shall conform to the requirements of AASHTO M241, except as otherwise specified.

The Engineer will inspect each unit. A unit not functioning in a manner the Engineer considers acceptable shall be repaired. If repair is impractical, the unit shall be replaced. All costs associated with delays attributable to mobile mixer replacement shall be borne by the Contractor. No extension of time, for the purpose of replacing unacceptable mixers, will be granted. Conditions which will automatically designate a unit unacceptable are: hydrated cement deposits; broken, bent, loose or scalloped mixing paddles; mixing paddles worn 20% in any dimension; mixing paddles heavily caked with mortar; and admixture or water delivery system out of tolerance.

Proportioning devices shall deliver the materials within the following tolerances:

Coarse Aggregate	±2%
Fine Aggregate	±2%
Cement + fly ash	0% to +4%
Water	±1%
Cement + microsilica powder	1%
Latex Admixture	1%
Other Admixtures	3%

The unit shall be capable of positive measurement of cement being introduced into the mix.

There shall be positive control of the flow of water into the mixing chamber. Water flow shall be indicated by a flowmeter and readily adjustable to provide for minor variations in aggregate moisture. The system shall be equipped with a bypass valve, or hose, for determining proportioning accurately. Also, there shall be a positive control of the flow of admixture into the mixing chamber. The admixture discharge pipe shall be readily accessible for determining proportioning accuracy.

The units shall be capable of being calibrated to automatically proportion and blend all components of indicated composition on a continuous or intermittent basis as required by the

finishing operation, and shall discharge mixed material through a conventional chute directly in front of the finishing machine.

A sufficient number of self-propelled mixers shall be available at the job site to insure that not more than 30 minutes shall elapse between the placement of batches.

679.2.3.5-Mobile Mixer Unit Testing: The units shall be calibrated by the Contractor to accurately proportion the approved mix design prior to placing the mix. The Engineer may require recalibration of any mixer as deemed necessary. Yield tests shall be performed by the Contractor for each mixer for each day's operation and when there appears to be a change in the mix. Certification of the calibration by an approved testing authority will be accepted as evidence of this accuracy if the yield is shown to be true within a tolerance of 1.0% according to the following test:

With the cement yard set on zero and all controls set for the approved design mix, activate the mixer and discharge mixed material into a 0.25 cubic yard (meter) container 1 yard (meter) square by 9 inches (250 mm) tall. When the container is level-struck full, making provision for settling the material into all corners, the cement yard shall show the discharge for a 0.25 cubic yard (meter) pour within the tolerance specified (refer to 679.2.3.4). No calibration shall be performed while it is raining.

679.2.3.6-Placing and Finishing Equipment: This shall include adequate hand tools for the placement of plastic concrete and for working down to approximately the correct level for the auger strike-off. A self-propelled finishing machine will be required to place and finish all concrete, except in areas inaccessible to the machine.

The finishing machine shall be capable of forward and reverse motion under positive control. Provisions shall be made for raising the screeds to clear the screeded surface, if traveling in reverse.

The machine shall be capable of placing full width, in one operation, the pours shown in the plans. The finishing machine shall be equipped with a vibrating device to consolidate the concrete, a power driven strike-off auger, a power driven finishing roller, and a pan float. The vibrating device shall vibrate at a frequency between 50 Hz and 115 Hz. A sufficient number of suitable portable lightweight or wheeled work bridges shall be required and used behind the finishing operation for touch-up work, surface texturing and curing cover placement.

Approved manual type screeds, metal plates equipped with electric vibrators, or hand held vibrators shall be used to consolidate and finish small inaccessible areas and slab reconstruction concrete.

Supporting rails shall be required. Rails may be two inch by 2 inch (50 mm) perforated steel bar stock, 2 inch (50 mm) pipe rail, or approved equal. They shall exhibit no bends or kinks. Rail supports shall be fully adjustable (not shimmed) to obtain the correct profile. Rail supports are subject to the requirements of 679.3.7.2.

When placing concrete adjacent to a previously completed pour, the side of the finishing machine adjacent to the completed pour shall be equipped to travel on the completed lane on rail supports only.

The placing and finishing equipment shall be designed so that the elapsed time between depositing concrete and final finishing shall not exceed 10 minutes.

679.2.3.7-Recording Thermometer: The Contractor shall supply a continuous recording thermometer capable of recording temperatures in the 30 - 150 F (2° - 66° C) range. It shall likewise provide a recording capability over a 24-hour continuous period, minimum. The Contractor shall provide any ancillary equipment, supplies and labor necessary for calibration of this equipment.

679.2.3.8-Compressors Or Water Flushing Equipment: Equipment used for surface preparation shall be of such size and capacity to thoroughly remove all foreign material from the surface being prepared.

679.2.3.9-Saw Cutting Equipment: Only multi-bladed saw cutting equipment, using circular saw blades, will be permitted for final deck finish operations. The Engineer may allow the use of single blade circular saw equipment only where such equipment is necessary to complete the work as required.

679.2.3.10-Fogging Equipment: Fogging equipment shall be available for use in accordance with these specifications. The fogging nozzles shall produce an atomized mist. Fogging nozzles shall incorporate compressed air to create the mist. Hand held or hand operated equipment shall be permitted when the Contractor has demonstrated that his operator has been trained in its use.

679.3-CONSTRUCTION METHODS:

679.3.1-Removal of Existing Deck Surface: All asphaltic patches or bituminous overlays shall be removed by hydrodemolishing, roto-milling, or other approved methods. All debris from patch or overlay removal shall be legally disposed. Unless otherwise directed by the engineer, prior to concrete deck removal operations, the Contractor shall sound the deck using chain drags.

679.3.1.1-Removal of Existing Deck Surface Phase I: The Contractor shall determine the depth to the top mat of reinforcing steel using methods acceptable to the Engineer. The existing deck shall be removed down to the top mat of rebar by roto-milling, hydrodemolishing, or any means acceptable to the Engineer. When full depth removal of material is necessary, the forming shall be incidental to the cost of the concrete deck overlay.

After removal to the top mat of reinforcing steel, the Contractor shall sound the deck using chain drags and delineate remaining areas of delaminated and unsound concrete for removal subject to the approval of the Engineer. Aerosol spray paint for delineating shall be provided by the Contractor. Edges around these concrete removal areas shall be vertical or slightly undercut. Upon completion of removal, the Contractor shall provide a hydrodemolished surface on which to install the new concrete Overlay.

When full depth removal of material is necessary, the forming shall be performed in accordance with Sections 104.3 and 109.4 of the Specifications.

679.3.1.2-Removal of Existing Deck Surface Phase II: Unless waived by the Engineer, immediately prior to placement of new concrete overlay, the Contractor shall sound the deck using chain drags and delineate any additional areas that may have become delaminated or unsound. Edges around these concrete removal areas shall be vertical or slightly undercut. These areas shall be removed prior to placement of the new concrete overlay.

The Division is not responsible for delays caused by the concrete removal described here in 679.3.1.2.

When full depth removal of material is necessary, the forming shall be performed in accordance with Sections 104.3 and 109.4 of the Specifications.

679.3.1.2.1-Full Depth Removal of Material: When full depth removal of material is necessary it shall be handled in accordance with section 679.6.2.3.

679.3.1.3-Use of Chipping Hammers: When encountering locations of delaminated and unsound concrete that need to be removed but not easily accomplished or accessible as described in sections 679.3.1.1 and 679.3.1.2, chipping hammers may be used when permitted by the Engineer to remove concrete.

679.3.1.4-Disposal: Debris shall be removed directly following any concrete removal operations. Removal of debris shall be accomplished by hand and vacuum methods. All debris shall become the property of the Contractor and shall be legally disposed. The Contractor shall exercise care to avoid damage to the remaining concrete or exposed reinforcement.

The Contractor shall provide for the collection, treatment and/or disposal of all runoff water generated by the removal process. The Contractor will provide the Engineer with evidence and documentation of disposal means and/or that any discharge does not exceed water quality standards. No payment for item 679001 Concrete Deck Overlay will be made until the Engineer receives evidence of satisfactory disposal and/or treatment. Should the disposal and/or discharge of material occur within the State's Rights-Of-Way without satisfactory evidence of maintaining the current water quality standards, the Engineer will have the authority to suspend the work wholly or in part as described in section 105.9. The Contractor shall obtain all required permits and shall comply with applicable local, state, and federal regulations concerning such water disposal. The Contractor shall make provision for the safe handling of runoff water insofar as it may constitute a physical hazard on the adjacent or underlying traveled roadway surface.

Water will not be allowed to enter storm sewers, bridge drainage, downspouts, fingerdams, or any other drainage area of the deck surface. The Contractor shall exercise care to protect existing berm slopes from scouring by water jets or runoff water.

In addition to the requirements mentioned above, to temporarily discharge wastewater from activities associated with hydroblasting demolition of concrete on a bridge deck. The wastewater shall be treated prior to discharging to natural drainage.

The authorization being granted herein is contingent upon strict adherence to the following conditions.

1. The Contractor shall provide via email to the West Virginia Department of Environmental Protection (DEP)-with carbon copies to the WVDOH personnel as listed in the plan notes, the following information for review:
2. Project Name, Project Number, County, Route number, layman's description of location, Contractor's Name, description of work, description of discharge, a list of Best Management Practices to be used to protect water quality, and estimated start & stop dates of discharging activity.

The Contractor will allow the DEP seven (7) days to review the submitted information and respond.

- a) All materials and equipment required to perform the work shall be on site prior to the initiation of the work activities.
- b) The Contractor shall immediately implement the necessary procedures needed to mitigate any adverse impacts resultant to the temporary discharge occurrence.
- c) Collected solids shall be disposed of in a manner consistent with any, and all, appropriate laws and regulations.
- d) The work activities and temporary discharge shall be managed in a manner that will provide for the maximum alleviation of impact to, and maximum protection of, aquatic life and human health.
- e) The Contractor shall notify the applicable DEP's Environmental Enforcement's District field office, 24 hours prior to the initiation of any procedures. This will afford the DEP with an opportunity to have personnel available to observe the activities.
- f) The Contractor shall, further, notify the Emergency Response Spill Alert System at 1-800-642-3074 in the event of an accidental discharge that did not go through the appropriate devices.

679.3.1.5-Miscellaneous: The Contractor shall provide adequate lighting to allow for the safe conduct of night removal operations, and shall obtain the Engineer's approval for same, exercising care to avoid any hazardous glare in the direction of oncoming traffic.

679.3.2-Removal of Newly Placed Deck Surface: The finished deck surface shall be shotblasted in preparation for a mechanically bonded surface. Burlap shall be continuously wet for a period of 168 curing hours by means of automatic intermittent sprinkling or a continuous wetting system. This may require approximately 1/8 inch to 1/4 inch (3 to 6 mm) of the concrete to be removed. In all cases the surface laitance shall be removed to provide a solid profile on which to bond the overlay. The cost of shot-blasting of the concrete deck shall be considered incidental to the Specialized Concrete Overlay.

679.3.3-Preparation of Surface: Blastcleaning shall be performed to thoroughly clean all horizontal and vertical receiving surfaces. Surfaces, which will be in contact with the specialized concrete overlay, shall have laitance and partially loosened chips of concrete removed by blastcleaning, which shall produce a bright, clean appearance. The edge of previously placed pours shall be similarly treated to promote bond.

All reinforcing steel, or other steel, which is to be in contact with the new concrete, shall be cleaned of all grease, dirt, concrete mortar and injurious rust. Injurious rust is defined as all scale, loose rust deposits, or all rust not firmly bonded to steel. Rust and concrete deposits, which in the Engineer's opinion cannot be removed by blastcleaning, will be considered firmly bonded and may remain. Any portion of a reinforcing bar judged by the Engineer to have any more than 50% section loss shall be replaced at no additional cost to the Division. A light coating of orange colored rust that forms on the reinforcing steel after blast cleaning is not considered detrimental to bond and may remain unless the time limit that follows is exceeded, or if ordered to be removed by the Engineer.

All debris from the blastcleaning operation shall be removed. After removal, the exposed reinforcing steel shall be supported and tied. Rustproof chairs shall be provided. If a continuous length of 6 ft. (1.8 m) or more of reinforcing bar is exposed, the Engineer may require supports and positive tie-downs at a maximum spacing of 4 ft. (1.2 m). Positive tie-downs shall consist of anchors drilled into the structural slab and connected to the reinforcing bars. Replacement bars shall be spliced to existing bars using either minimum 30 bar diameter lap splices, approved mechanical connectors, or a welded splice as directed by the Engineer. Welded splices, if approved, shall be in accordance with ANSI/AWS Structural Welding Code - Reinforcing Steel D1.4. The Engineer shall be allowed sufficient time to inspect the work after the supporting and tying of the reinforcing steel has been completed.

Blastcleaning operations may be commenced in an area after necessary concrete removal, per Section 679.3.1 or Section 679.3.2, as applicable, has been completed. If more than 48 hours elapse from the termination of any blastcleaning operation to slab wetting, blastcleaning shall be repeated per the Engineers direction regardless of the apparent condition of the receiving surfaces.

679.3.4-Structural Slab Wetting: The structural slab surface and any other porous surface, which will be in contact with new concrete, shall be prewetted with water. All standing water in depressions or areas of concrete removal shall be blown out with oil-free compressed air. The surface shall be thoroughly wetted to a saturated surface dry condition and shall be visibly moist when placement begins.

679.3.5-Placement Preconditions: Slab reconstruction concrete, or overlay concrete, shall be placed only after all of the following preconditions are satisfied:

The Contractor has submitted to the Engineer, in writing, the proposed sequence of operations, equipment, number of personnel, and category of personnel to be used during the concrete placement.

- a) All concrete removal operations in the placement area are complete and approved.
- b) Deck drains have been cleaned of all debris and plugged.
- c) Blastcleaning has been completed on an area large enough to require one working day for concrete overlay placement. In no case shall this be less than one span long.
- d) Any additional blastcleaning, if required, has been completed and approved on an area large enough to require one working day for concrete overlay placement. In no case shall this be less than one span long.
- e) Slab temperature and wetting requirements are met.

679.3.6-Placing, Finishing and Curing Slab Reconstruction Concrete: Slab reconstruction concrete shall be placed separately from overlay concrete except when both of the following conditions are, in the opinion of the Engineer, present:

- a) Areas of exposed reinforcing steel do not exceed 5% of the total slab area ready to be overlaid.
- b) Individual areas of exposed reinforcing shall not exceed 25 square feet (7.5 m) in area.

When these two conditions are present, slab reconstruction concrete may be placed integrally with overlay concrete.

The Contractor has the following choices of concrete placed as slab reconstruction concrete:

Overlay Type	Slab Reconstruction Concrete
Latex Modified	Latex Modified or Class K
Microsilica	Microsilica or Class K

Slab reconstruction concrete placed integrally with overlay shall match the Specialized Concrete Overlay.

The horizontal and vertical surfaces on which the slab reconstruction concrete is being placed shall be in a saturated surface dry condition immediately prior to placing any concrete.

When Class K Concrete is used as reconstruction concrete, a self-contained mobile mixer meeting the requirements of 679.2.3.4 may be used to provide the concrete.

After blastcleaning is completed, the Contractor shall place slab reconstruction concrete in the locations where reinforcing bars have been exposed. The concrete shall be consolidated by internal vibration in accordance with Section 601.10.3 of the Specifications. It shall be finished to the level of the surrounding concrete, or to the middle of the reinforcing steel, whichever is higher. The surface of the new concrete shall be intentionally roughened to a raked finish. Placement of slab reconstruction concrete in accordance with this subsection shall not relieve the Contractor of the requirements to provide the minimum required thickness of overlay material.

679.3.6.1-Slab Reconstruction Concrete Curing Requirements: Curing shall be accomplished in the following manner:

Latex Modified Concrete. Curing shall be performed in accordance with 679.3.7.5.1.

Microsilica and Class K Concrete. Curing shall be by means of quilted covers, or plastic coated fiber blankets. Quilted covers, if used, shall be kept wet for the entire curing period in accordance with 679.3.7.5.2. The wet curing period shall be 72 curing hours.

The use of membrane curing compounds shall not be allowed.

679.3.6.2-Removal of Slab Reconstruction Concrete Surface: The slab reconstruction concrete surface shall be blastcleaned per the requirements of Section 679.3.3 prior to the placement of the overlay.

679.3.7-Placing and Finishing Specialized Concrete Overlay:

679.3.7.1-General: The following requirements shall apply for specialized concrete overlay placements:

- a) The normal overlay thickness shall be as shown on the plans. Under any circumstances, the overlay shall not be less than 1 ¼ inches (31 mm).
- b) The prepared surface of the structural slab shall be protected from contamination by any source and shall be in a saturated surface dry condition immediately prior to concrete placement.
- c) Concrete may be mixed at the point of deposition.
- d) When placing Specialized Concrete Overlays on a newly placed deck, the deck concrete shall be a minimum of 28 days old. The sidewalks, parapets, or curbs shall be a minimum of 7 days old.

679.3.7.2-Finishing Equipment: Supporting rails upon which the finishing machine travels shall be placed outside the area to be overlaid. Said rails shall be supported at spacings sufficient to prevent any deflections. If deflections occur, support spacings shall be reduced, or rails shall be replaced by more resistant rail material. Anchorage of supporting rails shall provide for horizontal and vertical stability. The Engineer may require positive anchorage. A hold-down device shot into the prepared surface, or new overlay, will not be permitted. Supporting rails shall not be treated with parting compounds or release agents to facilitate their removal.

Immediately prior to the beginning of overlay operations, the finishing machine shall be operated over the full length of the bridge segment to be overlaid. This test run shall be made with the screed adjustment set to its finishing position. While operating the finishing machine during the test, the screed rails shall be checked for deflection and the minimum overlay thickness confirmed. The clearance shall be checked with the use of 1¼ inches (31 mm) thick filler blocks attached to the bottom of the screed during the test run. All necessary corrections shall be made prior to any concrete placement.

679.3.7.3-Placement: The following requirements shall apply during placement of the Specialized Concrete Overlay:

No concrete shall be placed unless surface slab temperature requirements of 679.4.6 and 679.4.7 are met. So that the use of hand tools will be kept to a minimum, concrete shall be deposited as nearly as possible to its final position. Internal vibrators shall not be used for moving concrete into position.

- a) A pencil type vibrator shall be used along all construction joints and edges to further consolidate the concrete to prevent voids.
- b) The new concrete shall be placed slightly above final grade. It shall then be struck-off, screeded, and finished to final grade.
- c) The finished surface, before texturing, shall be uniformly smooth, dense and even. Variations in pavement surface in excess of 1/8 in. (3 mm) above, or below, the proper finished elevation, or surface irregularities of more than 1/8 in. in 10 feet (3 mm in 3 m), will not be accepted.

- d) At transverse and longitudinal construction joints, the overlay placement shall be continued beyond the joint location a distance at least equal to the placement depth, and shall be allowed to stand free or shall be formed. After the overlay has cured, the concrete shall be sawed to a depth of $\frac{3}{4}$ in. $\pm$ $\frac{1}{8}$ in. (19 mm $\pm$ 3 mm). The overlay material beyond the saw cut shall be chipped out to the level of the original prepared surface, or to the level of the reinforcing bars, whichever is higher. The chipped face of the construction joints shall not undercut the saw cut and shall have a slope of approximately 45°. Chipping hammers shall use only chisel bits.
- e) A construction dam, or bulkhead, shall be installed in case of a delay in the placement operations exceeding 30 minutes duration. During any delays of 30 minutes or less, the placement shall be protected from drying with several layers of wet burlap. If the concrete placement is stopped, or delayed, for 90 minutes or more, further placement shall be discontinued and may be resumed only upon the approval of the Engineer. When a placement delay greater than 90 minutes occurs, the Contractor shall saw and seal a control joint in the overlay.
- f) Adequate precautions shall be taken to protect freshly placed concrete from rainfall. All placement operations shall stop when it starts to rain. The Engineer may order removal and replacement of material damaged by rainfall in accordance with 679.4.9.
- g) The addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted.

679.3.7.4-Surface Texturing: The surface of the specialized concrete overlay shall be uniformly smooth, dense and even. The surface shall then be given a suitable texture with an approved burlap drag.

The Contractor shall texture in a transverse or longitudinal direction. Once begun, the direction of texturing shall not change. All texturing shall be performed prior to the beginning of curing operations. Only one pass of the drag over the finished area will be permitted. Texturing shall be in strict accordance with the time requirements of 679.3.7.5 for applying wet burlap.

If texturing is done in the transverse direction, the Contractor shall texture by hand methods as soon as practical after finishing machine passage.

If texturing is done in the longitudinal direction, the burlap drag shall be a seamless strip and shall be attached to the work bridge such that the surface of the concrete is textured as soon as practical after finishing machine passage. Small areas, inaccessible to the attached drag, may be textured by hand methods.

The finishing movement and resulting progress of the burlap drag shall be done in a manner so as to prevent ridges or gouges from forming in the concrete surface. The drag shall be weighted and the contact area changed as required to produce a texture acceptable to the Engineer. The drag shall be cleaned as required; to remove all hardened concrete particles.

Texture resulting from the drag shall stop within 1 ft. (300 mm) of curbs or parapets.

679.3.7.5-Curing: It is the nature of specialized concrete overlay material to quickly form a plastic film at the surface upon drying. This film is to be protected from drying and cracking by prompt covering with wet burlap. Regardless of the type of concrete placed, the use of membrane curing compounds will not be allowed. Floor drains shall be immediately unplugged to permit the deck to drain.

The overlay surface shall be completely covered with clean, wet burlap. The burlap shall be thoroughly saturated over its entire area, but shall be drained of excess water before application. Burlap shall be lapped a minimum of 1 ft. (300 mm) and shall lay flat. Failure to apply wet burlap within 30 minutes after discharge of the concrete from the truck and within 10 minutes of the completion of finishing operations shall be cause for rejection of the work as determined by the Engineer. Care shall be exercised to ensure that the burlap is well drained. Burlap shall be continuously wet for a period by means of automatic intermittent sprinkling or a continuous wetting system

679.3.7.5.1-Curing Latex Modified Concrete: A layer of 4-mil (0.1 mm) thick white polyethylene film shall be placed over the burlap as soon as possible. The overlay shall then be wet cured for 48 curing hours. Care shall be exercised to ensure the burlap remains saturated for the 48-hour cure period. Plastic coated fiber blankets may be substituted for the polyethylene film, but shall not replace the initial wet burlap. The film (or fiber blankets) shall be anchored along all edges and internally to prevent the loss of moisture and from being displaced. After the wet cure, the polyethylene film and burlap shall be removed and the concrete shall be air-cured for 48 hours.

679.3.7.5.2-Curing Microsilica Concrete: Care shall be exercised to ensure that the burlap is well drained. Burlap shall be continuously wet for a period of 168 curing hours by means of automatic intermittent sprinkling or a continuous wetting system.

679.4-CONSTRUCTION LIMITATIONS AND REQUIREMENTS:

679.4.1-Stockpiling Aggregates: All aggregates shall be stockpiled at the concrete mixing site or another location approved by the Engineer. No stockpiling shall be permitted on the bridge deck unless approved in writing by the Engineer.

Stockpiles shall be completely covered and no additions to approved stockpiles are permitted.

The free moisture content of each aggregate type, at the time of batching, shall not exceed 7% of the saturated-surface dry weight of the fine or coarse aggregate or 8% total for both aggregates.

Fine and coarse aggregates, which are stored in piles or bins, shall be kept entirely separated.

679.4.2-Storage and Handling of Cement: Suitable provisions shall be made to prevent the loss of cement during handling. Cement to be stored shall be kept in suitable weatherproof enclosures, which will protect the cement from dampness. Cement, which has developed lumps in storage, shall not be used.

679.4.3-Vehicular and Equipment Restrictions: The operation of vehicles and equipment on or over, the structural slab area where concrete removal operations have been started is subject to the following restrictions:

679.4.3.1-Vehicle Weight Limits: Vehicular traffic is limited to necessary construction equipment. No vehicle or construction equipment weighing in excess of 7000 lb., (3175 kg), shall be allowed to operate on, or over, any area of structural slab which exhibits unprotected, fully exposed reinforcing steel.

679.4.3.2-Runways: Properly supported runways shall be provided where concrete transporting devices operate over exposed reinforcing steel and expansion devices.

679.4.3.3-Reinforcing Steel Protection: Exposed reinforcing steel shall be protected from concrete transporting devices so that no debonding, loosening, bending, or breaking occurs. Reinforcement that is damaged by any of the Contractor's operations shall be removed and replaced to the satisfaction of the Engineer and at no additional cost to the Division.

679.4.3.4-Loading Limitations during Curing: No construction load shall be permitted on new concrete until the specified curing period(s) has been completed. No structural slab concrete removal work shall be performed on structural slab areas adjoining new concrete during the time the new concrete is curing and until the overlay concrete has attained a compressive strength of at least 4,000 psi (28 Mpa) as outlined below.

No newly placed concrete shall be opened to traffic until the overlay concrete has attained a compressive strength of at least 4,000 psi (28 Mpa). This strength shall be determined by an average of three compressive strength specimens which have been cured in conditions as similar as possible to the concrete which they represent.

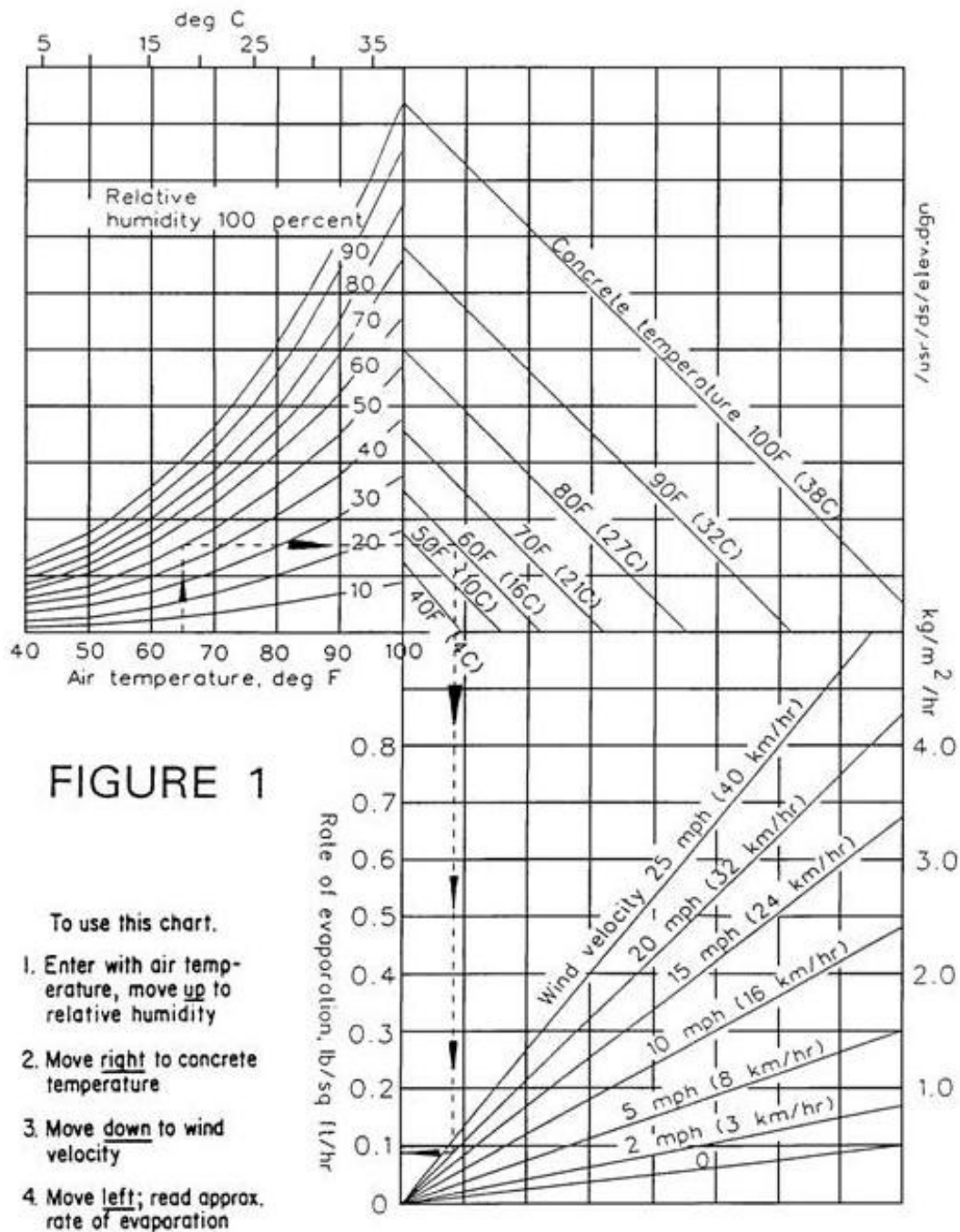
679.4.4-Concrete Placement Limitations: The temperature of the plastic concrete, as discharged from the mobile mixer or delivery unit, shall be at least 50°F (10°C) but not more than 85°F (30°C). If conditions are such that, in the opinion of the Engineer, these temperature requirements may not be met, the provisions of either Section 601.9.1 or 601.9.2 of the Specifications will apply. If the evaporation rate exceeds 0.05 lb./sq. ft. per hour (0.25 kg/sq. m per hour) (see Figure 1), the Contractor shall make provisions (i.e. wind breaks, fogging, etc.) to reduce the rate to 0.05 lb./sq. ft (0.25kg/sq.m) prior to placing concrete. These provisions shall be maintained during the placement of the concrete. If the evaporation rate obtained from Figure 1 is close enough to the maximum allowable value of 0.05 lb./sq. ft. per hour (0.25 kg/sq. m per hour) that there may a discrepancy in the exact numerical value, the equation listed below (EQ 679.4.4) shall be used to obtain a more accurate value. The Evaporation rate shall be checked every hour of placement and the results given to the Division.

Equation 679.4.4:

$$E = \left(Tc^{2.5} - (HTa^{2.5}) \right) * (1 + 0.4W)(10^{-6})$$

Where:

E	=	evaporation rate (lb/ft ² /h)
Tc	=	concrete temperature (°F)
Ta	=	air temperature (°F)
H	=	relative humidity % / 100
W	=	wind velocity (mph)



679.4.5-Concrete Pavement at Night: If placement of any concrete is to be made at night, a plan which provides adequate lighting for the work area shall be submitted at least 14 days before concrete is placed for the Engineer's approval.

679.4.6-Hot Weather Provisions: The requirements of section 601.9.2 and ACI 305R, Hot Weather Concreting shall apply except as modified in this section. No concrete shall be placed when the ambient air temperature or deck surface temperature, after prewet, is above

85° F (30° C). Concrete may be placed at an ambient air temperature of 85° F (30° C), if the deck temperature, after prewet, is no higher than 85° F (30° C), and falling temperatures are predicted, and then only if the prediction indicates a temperature of under of 85° F (30° C) for the placement period. The time limitations for the placement of wet burlap, as required by 679.3.7.5, shall also apply.

679.4.7-Cold Weather Provisions: The requirements of section 601.9.1 shall apply except as modified in this section. No concrete shall be placed if the ambient air temperature or deck surface temperature after prewet, is below 50° F (10° C), except as noted. Concrete may be placed at an ambient air temperature of 50° F (10° C) if the deck surface temperature, after prewet, is no less than 50° F (10° C) and rising air temperatures are predicted, and then only if the prediction indicates a temperature of over 50° F (10° C) for the eight hours immediately after placement. If air temperatures are such that the minimum temperature will not be met, the Contractor may place concrete if external heat is provided (refer to 679.4.8).

If the curing temperature, as defined in section 679.1.2.4, drops below 45° F (7° C) during the curing period, then the surface shall be enclosed and external heat shall be provided in accordance with the provisions of 679.4.8. The time required for tenting will not be counted as curing time. Once external heat provisions are required, they shall remain on the surface until curing is complete, regardless of the ambient air temperature.

If curing temperature falls below 32° F (0° C), at any time during the curing period, the concrete will be rejected.

Continuous wetting shall be replaced by wetting at regular intervals if, in the opinion of the Engineer, expected air temperatures could result in freezing of run-off water.

679.4.8-External Heat Provisions: The provisions of ACI 306, Cold Weather Concreting, and the following modifications shall apply:

- a. Temperature limits shall be maintained for 168 curing hours.
- b. If the concrete is latex modified concrete, then steam equipment shall not be used to supply external heat after the initial 48 curing hours.
- c. Enclosures for heat retention shall be properly vented to prevent surface disintegration from carbon dioxide gas.
- d. Continuous wetting will not be required, but the burlap shall be kept wet by wetting at regular intervals in a manner satisfactory to the Engineer for microsilica concrete.

679.4.9-Defective or Damaged Concrete: After the overlay has been cured, the Contractor in the presence of the Engineer shall sound the deck in order to detect delaminated areas. All defective or damaged concrete, as determined by the Engineer, shall be repaired or replaced at no additional cost to the Division. Defects shall include but not be limited to delaminations, cracking, tearing, damage or other imperfections. The Contractor shall propose repair methods for approval by the Engineer. All concrete requiring removal and replacement, as determined by the Engineer, shall be removed by sawcutting the perimeter to a depth of $\frac{3}{4}$ in. $\pm$ $\frac{1}{8}$ in. (19 mm $\pm$ 3 mm). Damaged concrete shall then be chipped out to the level of the original prepared surface. The chipped face shall not undercut the sawcut and shall have a slope of approximately 45°. Chipping hammers shall use only chisel bits. The prepared surface shall be blastcleaned prior to reapplying the overlay concrete.

679.5-FINAL BRIDGE DECK FINISH:

679.5.1-Straightedge Test: After defective or damaged concrete has been repaired and cured in accordance with 679.4.9 and before opening to traffic, the bridge deck shall be grooved perpendicular (or radial) to the centerline of the roadway. Prior to grooving, the entire deck shall be checked by the Contractor in the presence of the Engineer with an approved rolling straightedge as outlined in section 601.11.4.

679.5.2-Finished Deck Grooving: After corrective grinding and before opening to traffic, grooves shall be cut into the concrete using a mechanical saw. These grooves shall be 0.10 inch (2.5 mm) wide and 0.25 inch (6 mm) deep. Groove spacing shall be 1.5 inches (37 mm) center to center. No later than one week prior to grooving operations, the Contractor shall provide the Engineer with two accurate, easily readable gauges with which to verify groove dimensions. Groove depth and spacing tolerances are limited to $\pm 1/16$ inch (1.5 mm). Groove width tolerances are +0.02 inch (0.5 mm) and -0.0 inch (0 mm). Grooves shall be cut continuously across the deck to within 1 ft. (300 mm) of gutter lines or drainage structures. Grooves shall also be continuous across the full width of the deck surface including construction joints. Grooves shall terminate within 1 in. (25 mm) of any exposed metal component or elastomeric concrete of an expansion joint. When the deck is skewed and the contractor is using gang blades to saw the grooves, the maximum distance (measured perpendicular to the centerline of the expansion joint) from the last groove termination in the pass to the expansion joint shall be 1 ft., 8 inches (200 mm). Radial grooving shall be performed in increments limited to 12 ft. (3.6 m) of bridge length.

679.6-METHOD OF MEASUREMENT:

679.6.1-General: The quantity of work performed for Concrete Deck Overlay shall be measured in square yards (meters). This quantity includes the removal of the existing deck surface and delivery of newly installed deck surface.

679.6.2-Removal of Existing Surface:

679.6.2.1-The removal of the existing deck surface as described in section 679.3.1.1 shall be one half ($\frac{1}{2}$) the field measured deck area to be removed and paid at the unit bid price for Item 679001 Concrete Deck Overlay.

679.6.2.2-The removal of the existing deck surface as described in section 679.3.1.2 shall be the actual field measured areas in square yards (meters) of the locations and paid at the unit bid price for Item 679001 Concrete Deck Overlay.

679.6.2.3-Full Depth Removal: It is reasonably expected that full depth removal of material will be encountered on the project at various locations.

The Contractor will be required to fully repair such locations accounting for up to and including 2% (two percent) of the deck area for the individual bridge deck being overlaid at no additional cost to the Division.

As determined by the Engineer, when full depth repairs exceed 2% of the each bridge deck area being overlaid, the Contractor shall be paid \$200 per square yard (SY) for each square yard (or fraction thereof) in excess of the 2% described above.

For clarity, the phrase “each bridge deck being overlaid” is not a cumulative Project total bridge area, but instead refers to a single bridge’s total deck surface area. It is likely a project will contain multiple bridges to be overlaid. Expansion dam area locations shall not be included in the bridge deck surface area measured.

679.6.3-Newly Installed Deck Surface: The concrete and other materials used in the installation of the new deck surface once accepted by the Division shall be paid as one half (½) the field measured deck area as measured in section 679.6.2.1 and paid at the unit bid price for Item 679001 Concrete Deck Overlay

679.6.3.1-Blast Cleaning: During New Construction projects only where no removal of existing surface is required, Blastcleaning of the deck surface as described in section 679.3.3, shall be paid at the unit bid price for 679001 Concrete Deck Overlay. Measurement shall be in square yard (meters) at one half (½) the actual field measured area to be Blastcleaned.

679.6.4-Test Slab: will be measured on a lump sum basis complete in place. This shall include the complete execution of work required herein, regardless of the number of test slabs constructed. This item may be deleted at the discretion of the Engineer.

679.6.5-Slab Reconstruction Concrete: The quantity of work performed for Slab Reconstruction Concrete shall be incidental to Item 679001 Concrete Deck Overlay. Slab Reconstruction Concrete placed monolithic with the overlay shall be included in the overlay quantity.

679.7-BASIS OF PAYMENT:

The quantities, determined as provided above, will be paid for at the contract unit price bid for the items listed below. The price and payment shall be full compensation for all material removal and for furnishing and placing all the materials and doing all the work herein prescribed in an acceptable manner including materials and doing all the work herein prescribed in an acceptable manner including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

679.7.1-Rideability Price Adjustments: Section 601.15.2 of the Standard Specifications shall apply to the finish requirements of the specialized concrete overlay.

679.8-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
679001-*	Concrete Deck Overlay	Square Yard (Meter)
679006-*	Test Slab	Lump Sum

* Sequence number

SECTION 680-BLANK

SECTION 681 ASBESTOS ABATEMENT

681.1-GENERAL:

681.1.1-Description of Work: The work to be performed under this section of the specifications comprises the furnishing of all labor, materials and equipment for completion of all work as shown elsewhere within this Special Provision and/or the Contract Plans. This work includes handling and removal of asbestos containing materials, and the incidental procedures, materials and equipment required to protect workers and/or occupants of the structure and adjacent areas from contact with airborne asbestos containing materials.

All asbestos materials shall be disposed of in a landfill approved by the West Virginia Department of Environmental Protection, Division of Water and Waste Management, Solid Waste.

This work is to be performed by a *Certified/West Virginian Licensed Asbestos Abatement Contractor*.

681.1.2-Definitions: Except as specifically defined otherwise, the following definitions apply generally to the work of this section.

Abatement: Procedures to control fiber release from asbestos containing materials, including removal of asbestos containing material (ACM) as per this specification.

Air Monitoring: The process of measuring the fiber content of a specific volume of air in a stated period.

Amended Water: Water to which a surfactant has been added.

Asbestos: Fibrous silicates with a crystalline structure, including chrysotile, amosite, crocidolite, tremolite, anthophyllite and actinolite.

Asbestos Abatement Contractor: Certified/WV Licensed Asbestos Contractor.

Asbestos Fibers: Asbestos fibers having an aspect ratio of 3:1 and longer than five (5) micrometers.

Authorized Visitor: WVDOH personnel, Authorized Agent of the WVDOH or a representative of any regulatory agency having jurisdiction over the project.

Class I Project: A Class I project as defined in OSHA as being abatement of asbestos containing insulating, surfacing and/or thermal surfacing materials.

Class II Project: A Class II project as defined in OSHA as being the abatement of any asbestos containing material other than insulating, surfacing and/or thermal surfacing materials.

Clean Room: An uncontaminated area or room, which is part of the worker decontamination enclosure system, with provision for storage of workers street clothes and protective equipment.

Curtained Doorway: A device to allow ingress or egress from one room or area to another while permitting minimal air movement between the rooms or areas. This curtained doorway is typically constructed by placing two (2) overlapping sheets of plastic over an existing or temporarily framed doorway and securing each along the top of the doorway. Secure the vertical edge of one (1) sheet along the side of the doorway and secure the vertical edge of the other sheet along the opposite side of the doorway.

Decontamination Enclosure System: A series of connected rooms, with curtained doorways between adjacent rooms, for the decontamination of the workers, materials or equipment.

Equipment Decontamination Enclosure System: A decontamination enclosure system for materials and equipment, typically consisting of a designated area of the work area, a washroom, a holding area or an uncontaminated area.

Equipment Room: A contaminated area or room, which is part of the worker decontamination enclosure system, with provisions for storage of contaminated clothing and equipment.

HEPA Filter: A filter capable of trapping and retaining at least 99.97% of all mono-dispersed particles of 0.3 micrometers in diameter.

High Efficiency Particulate Air (HEPA) Vacuum Equipment: HEPA filtered vacuuming equipment.

Holding Area: A chamber between the washroom and an uncontaminated area in the equipment decontamination enclosure system.

Negative Pressure: A local exhaust system capable of maintaining a minimum pressure differential of minus 0.02 inches of water column relative to adjacent unsealed areas.

Removal: All herein specified procedures necessary to strip asbestos containing materials from the designated areas and to dispose of these materials at an acceptable site.

Shower Room: A room between the clean room and the equipment room in the work decontamination enclosure system, with hot and cold running water and suitably arranged for complete showering during decontamination.

Surfactant: A chemical wetting agent added to water to improve penetration, thus reducing the quantity of water required for a given operation or area.

Washroom: A room between the work area and the holding area in the equipment decontamination enclosure system to be used for personal decontamination.

Worker Decontamination Enclosure System: A decontamination enclosure system for workers, typically consisting of a clean room, a shower room and an equipment room.

Wet Cleaning: The process of eliminating asbestos contamination from building surfaces and objects by using cloths, mops or other cleaning tools which have been dampened with amended water and afterwards disposing of these cleaning tools as asbestos contaminated waste.

681.1.3-Applicable Regulation, Standards and Guidance Regulations: The Contractor shall comply with the following regulations. If conflicts occur between these regulations and specifications, the more stringent requirements shall apply.

- A. Title 29, Code of Federal Regulations, 1910.134 (Respiratory Protection), 1910.145 (Specifications for Accident Prevention Signs and Tags), Occupational Safety and Health Administration (OSHA), U.S. Department of Labor.
- B. Title 29, Code of Federal Regulations, Sections 1926.1101, Occupational Safety and Health Administration (OSHA), U.S. Department of Labor.
- C. Title 40, Code of Federal Regulations, Part 61, Subpart M, National Emission Standards for Hazardous Air Pollutants, U.S. Environmental Protection Agency (EPA), (NESHAPS) Asbestos Regulations.
- D. West Virginia Legislative Rule, 64 CSR 63 Department of Health, Asbestos Abatement Licensing Rule.
- E. All regulations related to environmental protection and pollution control relating to asbestos removal and disposition.

681.1.3.1-Guidance Documents: The following documents will supply guidance for the project and shall be utilized.

1. A Guidance for Controlling Asbestos Containing Material in Buildings: EPA Publication (560/5-85-004).
2. EPA Adequately Wet Guidance Document

681.1.4-Submittals, Notices and Documentation: Ten (10) working days prior to commencement of work (regardless of the presence of ACM), the Contractor shall notify in writing, with a copy to the Division, the following agencies:

Asbestos NESHAP Coordinator (3WC32) US EPA Region III 1650 Arch Street Philadelphia, PA 19103	West Virginia Department of Environmental Protection Division of Air Quality 601 57 th Street SE Charleston, West Virginia 25304-2345 ATTN: Asbestos Coordinator
West Virginia Department of Environmental Protection Division of Water & Waste Management, Solid Waste 601 57 th Street SE Charleston, West Virginia 25304-2345 ATTN: Asbestos Coordinator	West Virginia Department of Health & Human Resources Office of Environmental Health Services Radiation, Toxics and Indoor Air Division Capitol and Washington Streets One Davis Square, Suite 200 Charleston, WV 25301-1798

The Contractor shall maintain copies of all required notifications and of all the following documents at the job site:

1. Copies of air monitoring.
2. Copies of negative air pressure readings taken once per shift (on Class I projects).
3. Work schedule and updated progress chart depicting all phases of the work and completion dates.
4. A daily log of personnel having entered the work area.

681.1.5-Pre-Abatement Meeting: The Contractor and/or the Asbestos Abatement Contractor shall meet with the Engineer prior to beginning work to discuss in detail the asbestos plan, including work procedures and safety precautions. The plan must be approved, in detail, by the Engineer, prior to the start of any abatement.

The Contractor shall also submit to the Engineer the following information:

1. An Abatement Plan that complies with 64 CSR 63-8 which includes the location of regulated areas, decontamination system and layout, sequencing of asbestos related work, disposal plan, air monitoring plan, description of personal protective equipment to be used, and detailed description of all abatement methods to be used. A WV Licensed Asbestos Project Designer must sign this plan.
2. Copies of Training Certificates, a Photo I.D. and WV Licenses for each employee that will be involved with this project.

681.1.6-Personnel Protection: The Asbestos Abatement Contractor shall provide for all workers, supervisors, inspectors and monitoring technicians, disposable paper-type protective overalls plus head and shoe covers as required by OSHA regulations. Respiratory equipment selection shall be based on OSHA requirement in 1926.1101.

All persons entering a regulated area shall wear an approved respirator and protective clothing.

Eye protection and hard hats shall be available as required.

The Asbestos Abatement Contractor shall provide a minimum of one set of personal protective equipment for use by a Division authorized visitor(s).

681.1.7-Security: The Asbestos Abatement Contractor shall provide and post all required warning signs in accordance with OSHA regulations. The Contractor is responsible for securing the regulated area from unauthorized personnel.

681.1.8-Air Monitoring and Testing: All exposure air monitoring shall be conducted in accordance with 1926.1101 of OSHA Regulations. The analysis of all air samples shall be conducted by a certified and licensed independent testing laboratory that is not owned or financially related to the Asbestos Abatement Contractor. Air sample results shall be posted within 24 hours of the assessment.

For all Class I projects, the Asbestos Abatement Contractor shall be responsible for hiring a Testing Laboratory to conduct perimeter samples outside the regulated area. The Contractor shall send to the Engineer the results of all air monitoring tests conducted by the Asbestos Abatement Contractors testing laboratory. No Class I abatement shall be performed without the air-monitoring technician being notified.

681.1.9-Asbestos Contamination Limits: If activities create a visible escape of dust from the work area, the Asbestos Abatement Contractor shall immediately cease abatement work and further seal the work area and apply additional wetting agent.

If air test results from inside the work area or in the breathing zone of one of the employees exceeds the OSHA (TWA) Permissible limit, all workers inside the work area will be required to wear powered air purifying respirators until subsequent air tests show the asbestos levels have dropped below the permissible limit. At this time negative pressure half mask respirators may again be used.

If testing outside the work area indicates that the levels of asbestos exceed 0.01 fibers per cubic centimeter or above the background levels, then abatement work shall cease. The enclosure will be further sealed and additional wetting agents applied. Work shall resume only upon approval of the Engineer.

681.1.10-Contractor's Certification: The Contractor shall provide written certification to the Engineer that the abatement as shown in the contract plans has been completed according to OSHA, EPA and West Virginia 64 CSR 63.

681.2-EXECUTION:

681.2.1-General: Work Procedures: Perform asbestos related work in accordance with 29 CFR 1910.1001 and as specified within this provision. Use wet removal procedures. Personnel shall wear and utilize protective clothing and equipment as specified herein. Eating, smoking or drinking shall not be permitted in the asbestos work area. Personnel other than those engaged in the removal and demolition of asbestos shall not be exposed at any time to airborne concentrations of asbestos unless all the personnel protection provisions of this specification are complied with.

681.2.2-Preparation of Work Area: Establish a regulated area as required by 1926.1101. All Class I and Class II asbestos work shall be conducted in a properly demarcated regulated

area. Critical barriers shall be placed over all openings into the regulated area for all Class I and Class II projects. These critical barriers shall consist of one or more layers of plastic sheeting, portable partitions, temporary wood partitions or other enclosures and shall be used to prevent the escape of asbestos fibers.

Shut down and isolate heating, cooling and ventilation air systems in affected areas of the structure to prevent contamination and fiber dispersal to other areas. All air supply and return vents within the work areas shall be sealed with duct tape and two layers of plastic sheeting. In no case shall the structure ventilation system be used as a part of the local exhaust system for the asbestos work area, nor shall any fans or room ventilators be in operation during abatement work.

Remove all heating, ventilation and air conditioning system filters located in the work areas, spray with amended water and pack impermeable clear plastic bags (6-mil thickness minimum) with proper labeling for disposal in the approved waste site.

Pre-clean the regulated area prior to installing plastic sheeting over walls, floors and other stationary items is required if visible contamination exists. This cleaning shall be performed using HEPA filtered vacuum equipment or wet cleaning methods as appropriate. Methods that raise dust, such as dry sweeping or vacuuming with equipment not equipped with HEPA filters is prohibited.

For Class I work, cover floor and wall surfaces with plastic sheeting sealed with duct tape. Cover floors with two (2) layers of 6-mil plastic sheeting, extending the plastic 12 inches (304 mm) up the walls. Then cover the walls with one layer of 6 mil plastic sheeting to the floor level, overlapping the floor covering a minimum of 12 inches (304 mm) and seal with duct tape.

When tape is insufficient to support plastic sheeting or where existing finishes may be damaged by the application of plastic sheeting, the Asbestos Abatement Contractor shall construct temporary wood frame supports for the plastic sheeting. All remaining equipment and other items that will not be removed are to be covered with 6-mil plastic sheeting and sealed with duct tape.

Emergency and fire exits from the work areas are to be maintained.

681.2.3-Local Exhaust System (Negative Pressure): On Class I work the Asbestos Abatement Contractor must provide a local exhaust system in compliance with 29 CFR 1926.1101. Each exhaust unit must be equipped with pre-filters and a HEPA filter through which air from the work area is drawn and exhausted. The exhaust unit(s) shall be located opposite to and at the farthest side from the make-up air entrance to the work area, so the make-up air enters the work area through the decontamination facility and travels across the work area. The structure ventilation system shall not be used as any part of the local exhaust system for the asbestos control area, nor shall any fans or room ventilators be in operation during the abatement work. All supply and return air openings are to be closed and sealed.

Position the exhaust unit inside the work area and exhaust through the windows, door or other openings to the exterior of the structure through the use of flexible duct connections sealing around the ducts with plastic and tape. Exhaust into the construction area will be permitted only upon approval of the Engineer.

Local exhaust equipment shall be supplied in a sufficient quantity to produce a minimum of four (4) air changes per hour in each removal area. A spare unit shall be kept on site at all times to ensure continuous negative air operations. The exhaust units shall be started prior to

beginning removal operations and shall run continuously to maintain a constant negative pressure. Filters are to be replaced as required to maintain the efficiency of the system.

The Contractor shall provide a viewing window of 9 square feet (1 square meter) showing the enclosed work area.

681.2.4-Decontamination Enclosure Systems: The Contractor shall provide personal hygiene facilities in compliance with 1926.1101.

All Class I projects involving quantities of ACM greater than 100 square feet (30.5 square meters) require a decontamination system that includes a clean room, shower room and equipment room. (See Figure 1-Typical Decontamination Enclosure System)

Access between any two (2) rooms within the decontaminated enclosure systems shall be through a curtained doorway. Both the work decontamination system and the equipment decontamination enclosure system shall contain lighted emergency exit signs on the doors of the enclosures.

A worker decontamination enclosure system is to be constructed contiguous to the work area and consist of three (3) totally enclosed chambers. These chambers shall be:

- a. Clean Room: In this area a person can dress in clean disposable coveralls and store clean respiratory protection equipment. No asbestos contaminated items shall enter this room.
- b. Shower Room: This is a separate area used for showering upon leaving the work area. *This is a contaminated area.*
- c. Equipment Room: This is a change and storage area for people and equipment. *This is a contaminated area.*

The equipment room shall have a curtained doorway to the work area.

The shower room shall contain at least one (1) shower for every 10 workers and be equipped with hot and cold water with temperature controls. Careful attention shall be paid to the shower enclosure to insure against leakage of any kind. A supply of soap and shampoo is to be on hand at all times in the shower room.

Wastewater from the shower room shall pass through a 5-micron HEPA hydraulic filter before being allowed to enter the structures sanitary sewer system.

The equipment decontamination enclosure system for Class I projects shall consist of two (2) totally enclosed chambers as follows:

- a. A washroom used to remove contamination from bagged or wrapped ACM. Any wastewater from this washroom must be filtered or contained and disposed of as contaminated material as noted previously.
- b. A holding area with a curtained doorway to an uncontaminated area.

For Class II projects as well as Class I projects less 100 square feet (30.5 square meter), the contractor shall establish an equipment room consisting of a drop cloth adjacent to the regulated area. The area must be of sufficient size to accommodate cleaning of equipment and removing personal protective equipment without spreading contamination beyond this area. Personal protective clothing shall be cleaned with a HEPA vacuum before it is removed.

All barriers and plastic linings are to be effectively sealed and taped. Immediate repair of any damage or defects is to be completed upon discovery. A visual inspection of the enclosures is to be done at the beginning of each work shift.

681.2.5-Entry And Decontamination: All workers and visitors leaving the work area must follow the decontamination sequence. Contaminated respirators are to be worn into the shower and are not to be removed until they have been washed to remove any dust. Cartridges are to be removed and properly discarded. Respirators that have been thoroughly washed are to be stored in the clean room ready for reuse.

Work Entry Sequence: All persons are to be logged in as they enter. Non-employees must sign the attached wavier before entering. The sequence for entry shall be as follows:

For Class I projects, the worker enters the clean room and changes from street clothes into clean protective disposal clothing, including footwear, and don the appropriate respirator. A positive/negative pressure fit check is performed to insure proper fitting. When all required protective equipment has been donned, the worker proceeds into the work area.

For Class II projects, employees shall don personal protective equipment prior to entering the regulated area.

Work Exit Sequence: For Class I projects, the worker shall remove all gross contamination and debris from coveralls and footwear by wet wiping or HEPA vacuuming prior to entering the equipment room. The worker then proceeds to the equipment room. All clothing except for respiratory equipment is to be removed. Extra work clothing may be stored as contaminated materials in the equipment room. Disposable coveralls shall be placed in plastic bags for disposal with other contaminated material. The worker shall then proceed to the shower room and wash; removing the respirator last so as to prevent inhalation of fibers during decontamination.

After showering, the worker enters the clean room and dresses in new coveralls (if returning to the work area) or street clothing (if leaving).

For Class II projects, the worker shall step onto the drop cloth and HEPA vacuum the protective clothing prior to its removal. The respirator shall be thoroughly cleaned after doffing.

Filters in the respirators shall be removed when wet and shall be treated as contaminated waste. A new filter shall be placed in the respirator prior to reuse.

There shall be no smoking, eating or drinking in the regulated area or the decontamination area.

681.2.6-Asbestos Removal: Asbestos removal techniques used by the Asbestos Abatement Contractor shall comply with OSHA, EPA and West Virginia regulations. Unless prior written approval is received from EPA and the Engineer, amended water shall be used to adequately wet all ACM removed or disturbed by the Asbestos Abatement Contractor.

681.2.6.1-Class I Projects: The following procedures shall be used on all Class I project:

- a. The project shall be supervised by a competent person.
- b. Critical barriers shall be installed over all openings to the regulated area (inside projects only).
- c. All persons in the regulated area shall be equipped with respiratory protection.
- d. A negative pressure enclosure or glove bag shall be used
- e. ACM shall not be dropped more than 10 feet (3.5 meters).

681.2.6.2-Class II Projects: The following procedures shall be used on all Class II projects:

- a. All persons in the regulated area shall be equipped with respiratory protection and protective clothing.
- b. The project shall be supervised by a competent person
- c. Critical barriers shall be installed over all openings to the regulated area unless a negative exposure assessment has been produced or the project is conducted outside.
- d. Removal of asbestos containing flooring materials shall be conducted in accordance with 1926.1101
- e. Removal of asbestos containing roofing materials shall be conducted in accordance with 1926.1101
- f. Roofing ACM and cementitious asbestos containing siding and shingles or transite panels shall not be dropped to the ground. These materials shall be immediately lowered to the ground via covered dust-tight chute, crane or hoist, or placed in an impervious waste bag or wrapped in plastic sheeting and lowered to the ground no later than the end of the work shift.

681.2.7-Site Inspection: While performing work, the Asbestos Abatement Contractor may be subject to on-site inspections by a representative of the WVDOH, USEPA, WVDEP and/or WVDHHR, during the abatement process.

If the work is found to be in violation of this specification, the Engineer will be requested to issue a stop work order to be in effect immediately and until the violation is resolved. Standby time required resolving the violation shall be at the Contractors expense.

If at any time, the Engineer determines that work practices of the Contractor are violating pertinent regulations, endangering workers or not complying with these specifications; The Engineer will immediately notify in writing the Asbestos Abatement Contractor's on-site representative that operations are to cease until corrective actions are taken.

681.2.8-Cleanup: Throughout the abatement project, maintain surfaces in the work area free of accumulations of asbestos fibers, dust and debris. All visible accumulations of asbestos material and debris are to be removed by wet cleaning or HEPA vacuuming. Give special attention to restricting the spread of dust and debris. Prevent waste from being distributed over the general area.

Wet-clean all surfaces in the work area. Remove only the plastic sheets from floors and walls before work area is certified as asbestos free. Windows, doors and HVAC vents shall remain sealed and any HEPA filtered negative air pressure systems, air filtration and decontamination enclosure systems shall remain in service.

Clean all surfaces in the work area and any other contaminated areas with water and/or with HEPA filtered vacuum equipment. After cleaning the work area, wait 24 hours to allow for settlement of dust, and again wet clean or clean with a HEPA filtered vacuum all surfaces in the work area. After completion of the second cleaning operation, a complete visual inspection of the work area to ensure that the work area is free of visible debris is to be performed.

Sealed drums and all equipment used in the work area shall be included in the cleanup and shall be removed from work areas through the equipment decontamination enclosure system at the appropriate time in the cleaning sequence.

When the final inspection determines that the area is free of accumulations of visible debris and a final air test shows that the concentration of asbestos fibers is less than 0.01 fibers per cc (or the predetermined baseline), the decontamination enclosures system shall be removed, and the area thoroughly cleaned with HEPA filtered vacuum equipment then windows, doors and vents can be unsealed and material from these areas and the equipment and shower rooms disposed of as contaminated waste. The Engineer is to be notified before the regulated area has been deemed an unrestricted entry area.

681.2.9-Disposal: Collect asbestos waste, scrap, debris, bags, containers, equipment and asbestos contaminated clothing which may produce air borne concentrations of asbestos fibers and place them in sealed, clear impermeable bags. Each bag shall be labeled according to OSHA, EPA and DOT requirements. Dispose of waste asbestos material in accordance with Environmental Protection Agency (EPA) and West Virginia regulations at an approved landfill. For temporary storage, the sealed impermeable clear bags may be stored in asbestos waste drums or skids.

681.2.10-Forms: Sample forms located on the Divisions Specifications Website and specified are listed as follows and shall be submitted to the Engineer as required:

- a. Air Test Samples Sampling Data Sheet
- b. Ten Day Notice Form
- c. Asbestos Disposal Form
- d. Employee Release Form
- e. Asbestos Abatement Observer's Wavier and General Release
- f. Declaration of Witness

Specifications Website:

<http://www.transportation.wv.gov/highways/contractadmin/specifications/Pages/default.aspx>

681.3-METHOD OF MEASUREMENT:

The quantity of work done will be on a lump sum basis.

681.4-BASIS OF PAYMENT:

The quantities, determined as provided, will be paid for at the contract unit price for the items listed below. The prices and payment shall be full compensation for furnishing of material and performing all the work prescribed in a workmanlike and acceptable manner, including all tools, equipment, supplies and incidentals necessary to complete the work. All incidental work and materials for which no basis of payment is provided will be considered as completely covered by the prices bid for the items included in the Contract.

681.5-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
681001-*	Asbestos Abatement, Class I	Lump Sum
681002-*	Asbestos Abatement, Class II	Lump Sum

* Sequence number

SECTION 682 THROUGH SECTION 684-BLANK

SECTION 685 BRIDGE CLEANING

685.1 DESCRIPTION:

The cleaning work shall consist of three phases of cleaning. Phase-One will be a dry, pre-wash cleaning, followed by two-phase water cleaning. All dry, pre-wash cleaning shall be performed prior to any water cleaning, and all water cleaning shall be performed prior to surface preparation and painting operations. With approval of the Engineer, the Contractor may break this work up into sections or bays.

685.1.1-Phase One: This phase shall consist of cleaning by dry methods all loose dirt and debris from all areas as noted in the plans. This phase shall be completed prior to any washing operations. Collection may include the use of brooms, brushes, shovels, wheelbarrows, buckets, vacuums, or other suitable means.

685.1.2-Phase Two: This phase shall consist of washing completely with low pressure plain water the entire bridge deck, curbs, parapets, sidewalks and expansion joints, and any other areas as noted in the plans. All drains shall be thoroughly flushed and shall be free flowing. All debris and trash shall be removed from the drains. At the nozzle end, the washing equipment shall have a minimum pressure of 3000 PSI and a maximum pressure of 4500 PSI.

685.1.3-Phase Three: This phase shall consist of washing with a mixture of low pressure water and a solution of a commercial brand soluble salt remover, any areas as noted in the plans. This washing shall be accomplished with a low pressure washer at a minimum pressure of 3000 PSI and a maximum pressure of 4500 PSI, at the nozzle end with the nozzle 4" to 8" from the surface. Remove all surface abnormalities such as rust scale, peeling paint, or blistered paint that would prevent the soluble salt remover from coming into contact with the salt contamination. Typically, low pressure water washing is not capable of removing intact coating material. The nozzle type shall be a rotary nozzle. The contractor shall follow the Manufacturer's recommendations or specifications for method and rate of application of the soluble salt remover. Water shall be from an approved source of drinking water, and the soluble salt remover shall be chosen from West Virginia Division of Highways Approved Source List.

The contractor is to place special emphasis on the top surface of all flanges, connection plates, bearings, and excessively rusty or pitted areas. Any areas of the structure that exhibit mineral deposits of black iron oxide called "black rust" after any abrasive blasting shall be considered contaminated with chlorides and will need an additional washing with the soluble salt remover solution and another abrasive blasting.

685.2-TESTING OF STRUCTURAL STEEL:

The maximum level of chloride contamination shall be 5 micrograms/cm². Testing method shall be in accordance with The Society for Protective Coatings (SSPC) Technology Guide 15, Section 5.2.5, Latex Sleeve Methodology. In the first 150 sq. ft. of cleaning the contractor is to determine by sufficient testing of the most deteriorated areas (after rust has been removed), the rate of application, nozzle pressure, nozzle distance from surface, and dilution ratio of mixture to achieve the desired level of cleanliness. Thereafter, the contractor is to perform test in areas designated by the Engineer to insure that the entire structure has attained the specified level of cleanliness. The Engineer is to verify the degree of cleanliness. The Engineer's decision shall be final.

685.3-GENERAL CONTRACTOR RESPONSIBILITY:

The Contractor's washing sequence and plans shall not allow the possibility of recontamination of the structure before blast cleaning and/or painting operations are completed. No cleaning shall be performed when temperatures are such that freezing could occur or that it is anticipated that temperatures could drop to freezing while the structure is wet. Equipment, methods and materials shall meet the approval of the Engineer. All applicable sections of Section 107 of the Standard Specifications shall be followed when washing over the railroad, roadways, navigational waterways, parking lots etc.

All applicable sections of Section 107 of the Standard Specifications shall be followed regarding dirt and debris from cleaning, paint chips, and dirt and debris containing paint chips.

685.4-BASIS OF PAYMENT:

Payment for the above described work, including all material, equipment, labor and any other incidental work necessary to complete this item, will be considered completely covered by the contract unit price for the item below.

685.5-PAY ITEM:

ITEM	DESCRIPTION	UNIT
685001-*	Bridge Cleaning	Lump Sum

* Sequence number

SECTION 686-BLANK

SECTION 687

SHOP PAINTING METAL STRUCTURES

687.1-DESCRIPTION:

The shop painting (coating) of metal structures shall follow the provided requirements set forth in this specification unless otherwise noted in the Contract. This specification shall apply to surface preparation, coating application, contractor/fabricator responsibilities, environmental and worker protection, and waste handling/disposal.

687.2-GENERAL:

687.2.1-Surface Preparation: Shall meet the requirements of this section.

687.2.1.2-Blasting: The compressed air used for nozzle blasting shall be free of water or oil. The cleanliness of each compressed air system shall be verified at least once per shift using the blotter test in accordance with ASTM D4285, "Standard Test Method for Indicating Oil or Water in Compressed Air".

687.2.1.2.1-Commercial: Shall meet the requirements of SSPC-SP 6 prior to painting. The appearance of the steel surface after blast cleaning shall correspond to the applicable and current SP 6 pictorial standards of SSPC Vis 1.

687.2.1.2.2-Brush-Off Blast: Shall meet the requirements of SSPC-SP 7 prior to painting. The appearance of the steel surface after brush off blast cleaning shall correspond to the applicable and current SP 7 pictorial standards of SSPC Vis 1.

687.2.1.2.3-Near White: Shall meet the requirements of SSPC-SP 10 prior to painting. The appearance of the steel surface after blast cleaning shall correspond to the applicable and current SP 10 pictorial standards of SSPC Vis 1.

687.2.1.2.4-White Metal Blast: Shall meet the requirements of SSPC-SP 5 prior to painting. The appearance of the steel surface after blast cleaning shall correspond to the applicable and current SP 5 pictorial standards of SSPC Vis 1.

687.2.1.2.5-Blast Media: The abrasives used for all blasting shall meet the guidelines set forth in SSPC AB1 for mineral and slag abrasives, and AB3 for ferrous metallic abrasives. Any additive mixed with the abrasive shall be approved by the Division prior to use. The abrasives used shall produce a height of profile between 1.0 and 3.0 mils (25 µm and 75 µm). In addition, the container or bag of abrasive shall include the name of the abrasive, the name of the manufacturer, and the size of the abrasive. If any additive has been included with the abrasive, the name and the percentage of the additive shall be on the container or bag.

687.2.2-Post-Surface Preparation: Surface prep operations shall be performed in such a manner that no damage is done to partially or entirely completed portions of the work. After surface prep, any areas that are repaired by welding shall be prepped again.

Areas repaired by grinding or other means shall have the anchor pattern restored by abrasive blasting. Visible deposits of oil, grease, or other contaminants shall be removed according to SSPC-SP1 "Solvent Cleaning" prior to painting. Dust, loose residues, and the removal of abrasives from pockets and corners shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning. The prepped surface shall be checked for cleanliness by wiping a clean, dark cloth across the surface. If residue is present, the surface shall be cleaned again and rechecked. All blast cleaned surfaces shall be painted prior to any rust bloom or flash rust occurring or within 24 hours, whichever comes first. After blast cleaning, surface imperfections that remain (e.g., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers, etc.) shall be removed. Any damage to the surface profile resulting from the removal of surface imperfections shall be re-blasted.

687.3-PAINT APPLICATION REQUIREMENTS:

687.3.1-Weather Conditions: Painting shall not be done when the ambient temperature is below 40° F (5° C) or above 100° F (38° C), or the relative humidity above 90 percent. The temperature of the steel must be at least 5° F (3° C) above the dew point. Painting shall not be performed when the surface to be coated is sufficiently hot to cause blistering of the film or too rapid solvent release.

687.3.2-Paint Storage: Paint and thinners shall be stored in a temperature-controlled environment between 40° F (5° C) and 100° F (38° C). At no time will paint be used beyond the manufacturer's shelf life.

687.3.3-Paint Application: The blast cleaned surface shall be painted within 24 hours. In the event rust bloom or flash rusting occurs, the effected members shall be re-cleaned by blasting. The paint shall be applied by spray methods, except those areas inaccessible to spray application may be brushed. Brushes, when used, shall have sufficient body and length of bristle to spread a uniform coat. Small touch-up areas may be brushed, if approved by the Engineer.

Use of an agitated pot shall be mandatory in spray application of Zinc primer. The agitator or stirring rod shall reach within 1 inch (25 mm), of the bottom of the pot and shall be in motion at all times during paint application. Coatings shall be mixed in strict accordance with the coating manufacturer's written instructions. Under certain conditions, it may be necessary to thin or adjust the solvent balance of the paint. The type and amount of solvent to be used shall be that listed on the coating manufacturer's product data sheet for that material. Upon thinning, the dry film thickness requirement shall still be met. Application requirements and drying times between coats shall be in accordance with the manufacturer's written instructions. Dry film thickness requirements shall be specified in the contract documents. Exposed steel surfaces of expansion dams shall be painted as specified for structural steel. Spray guns must be equipped with the recommended size tip for the paint product being applied and shall be held perpendicular (90 degrees) to, and at, the proper distance from the receiving surface. Complete protection shall be provided by the fabricator against paint spatter, spillage, overspray, wind-blown paint, or similar releases. For the fully shop painted bridge, the entire top of the top flanges for the full length of the girders will only get primer at two mils (50 µm) dry.

For weathering steel bridges, the ends of the girders, to the length specified in the plans, are painted with the whole system, and the top of the top flange at the end of girders is primed only at two mils (50 µm) dry. The remaining lengths of the girders are left unpainted.

687.3.4-Painting Sequence: Shall be in accordance with the following:

687.3.4.1-Materials: The primer shall meet the requirements of 711.6 or 711.20. The fabricator responsible for the largest percentage of the painting will choose a Zinc Rich, Low VOC system. Primer coat shall have a maximum VOC of 3.5 lbs/gal (420 g/l). Intermediate and top coats shall have a maximum VOC of 2.8 lbs/gal (335g/l).

687.3.4.2-Paint systems:

3 COAT: Primer, Intermediate, Top Coat

2 COAT: Primer, Top Coat

1 COAT: Epoxy Mastic only

INORGANIC PRIME COAT:

All edges, corners, crevices, bolt heads and nuts, all rivet heads, edges of flanges and plates, welds, sharp edges, in general all edges, shall receive a dusting coat, by spray application, of the same primer as the Full Prime Coat. The dusting shall extend a minimum of one inch (2cm) from the edge. The full prime coat shall be applied immediately following the dusting coat. No dry film thickness is specified for this coat. Inorganic Zinc Primers are NOT to be tinted.

ORGANIC PRIME COAT:

All edges, corners, crevices, bolt heads and nuts, all rivet heads, edges of flanges and plates, welds, sharp edges, in general all edges, shall receive one stripe coat, by brush application, of the same primer as the Full Prime Coat. Striping shall extend a minimum of one inch (2cm) from the edge. The prime coat shall at a minimum, be set-to-touch before the stripe coat is applied. No dry film thickness is specified for this coat. This coat shall be tinted as allowed by the manufacturer to be in contrast to the full prime coat and intermediate coat. The tinting agent shall be the paint manufacturer's approved tinting agent.

FULL PRIME COAT:

The structure shall receive one coat of a primer meeting the requirements of Section 711 of the Standard Specifications. The primer used for the full prime coat shall be of the same type and shall be from the same manufacturer as the primer used for dusting and striping.

INTERMEDIATE COAT:

The structure shall receive one uniform coat of a paint meeting the requirements of Section 711 of the Standard Specifications. The color shall be in contrast to the prime and top coats. If tinting is required, the tinting agent shall be the paint manufacturer's approved tinting agent.

CAULKING:

Caulking shall be applied before the application of the topcoat. This includes all seams between diaphragm connections to stiffeners and splices; and seams between any connection that is riveted or bolted. Any welded connections that are not fully sealed by the weld shall be caulked with a paste type caulk. The caulk shall be pressed into the seams between the adjoining surfaces, by wetted finger or specialty tool, to insure bond and provide a smooth uniform surface. Caulking in a 3-coat system shall be applied after the intermediate coat has cured. Caulking on a 2-coat system shall be applied after prime coat has cured. The top coat shall not be applied until the caulking has fully cured in accordance with the manufacturer's recommendations. The caulking material shall be compatible with the paint system being applied and shall be by written recommendation of the paint manufacturer. The caulking material shall be tested for compatibility with the paint system at the same time that the paint is tested for intercoat compatibility. Caulking operations shall be performed only when weather conditions are within the parameters as specified in section 687.3.1.

TOP COAT:

The structure shall receive one uniform coat of paint as designated in the plans meeting the requirements of Section 711 of the Standard Specifications. The color shall be as designated in the plans and shall be in accordance with current Federal Standard 595.

NO TOP COAT SYSTEM:

Prime coated structures that will not be top coated in the field shall meet all the requirements of section 687.3, except the dry film thickness shall be a minimum of 4 mils (100 μ m). In addition, the Contractor shall provide the inspection access and surface protection required in section 688.2.4.1. The repair procedures of section 688.3.6 shall apply. In order to keep uniformity in the color of the structure, all paint applications will require the use of the same product formulation.

Erection weight and match marks shall be stenciled or painted on structural steel after the last shop coat is applied. Surfaces of steel within 2 inches (50 mm) of edges to be field welded shall not be painted in the shop.

687.3.4-Inspection of Applied Paint: If in the opinion of the Engineer the coating has flaws other than deficiencies in the prescribed dry film thickness, the material shall be repaired or shall be removed and replaced. Defects in the film, including but not limited to runs, sags, mud-cracking, lifting, overspray, dry spray, pinholes, and holidays shall be corrected until a continuous uniform film has been applied. Excessive film thickness shall be reduced and insufficient film thickness shall be increased. If the thickness of the finish coat is reduced, a thin coat of the finish shall be reapplied to seal the surface and to blend the area into the surrounding coating. Depending on the defect, total removal and replacement of the effected coating may be required. No unsightly runs or sags shall be visible. All "mud-cracking" and/or "dry overspray" in the paint film shall be removed. Excessive bubbles or pinholes shall not be visible in the coat after examination under a minimum of 8X magnification. Calibration of the thickness gage and dry film thickness measurements shall be in accordance with MP 708.40.00.

687.3.4.1-Access for Inspection: The Fabricator shall furnish suitable safe access and shall provide a time mutually agreed to for inspecting the structural steel prior to and after coating. The Division's inspector shall approve all repairs. When providing suitable safe access, rubber rollers or other protective devices shall be used. Metal rollers or clamps and other types of fastenings that will mar or damage freshly coated surfaces shall not be used. No temporary attachments, supports for access, or forms, shall damage the coating system (In particular, on the fascias where bracing is used, sufficient size support pads must be provided). Any damage that occurs from such devices shall be repaired.

687.3.5-Handling Coated Steel: Extreme care shall be exercised when handling the steel in the shop, during shipping, erection, and subsequent construction of the bridge. Painted steel shall not be moved or handled until sufficient cure time has elapsed to insure no damage is done to the fresh coating. The steel shall be insulated from the binding chains by softeners. Hooks and slings used to hoist steel shall be padded. To prevent damage to the coating, diaphragms and similar pieces shall be spaced in such a way that no rubbing will occur during shipment. Upon arrival at the project site, if weather conditions were such that deicing materials from the roadway were thrown onto the steel during shipment, the contractor shall be responsible for washing the entire surface of the steel with low-pressure water to remove chloride contamination. This also includes unpainted portions of weathering steel. Water shall be from an approved source of drinking water. The water is to be applied at minimum pressure of 3000 PSI (21 Mpa) to a maximum of 4500 PSI (31 Mpa) at the nozzle end, with the nozzle held at a distance of 4" (100 mm) to 8" (200 mm) from the surface. After the low-pressure wash, a minimum of one area on each piece is to be tested for chloride contamination. The testing shall be by the CHLOR*TEST (chloride test kit) method. The maximum chloride contamination shall be 5 micrograms/cm². If the degree of contamination is above the maximum level, the steel is to be re-washed, using a mixture of low-pressure water and a solution of a commercial brand of soluble salt remover, followed by additional testing for chloride contamination. The Soluble Salt Remover shall be CHLOR*RID or equal. The steel to be washed shall not be erected until it has been washed, tested and accepted. The testing also includes unpainted portions of weathering steel.

687.3.6-Shop Repair: The requirements specified herein for provisions for inspection, mixing, thinning, temperature and humidity, and application shall govern the coating of the repaired areas. All shop repairs to the coating shall be made in strict accordance with the coating manufacturer's recommendations except where the requirements listed in this specification are more stringent. The Engineer is to review and accept a repair plan before damaged areas are repainted. The repair primer shall be from the same manufacturer as the original primer. Surfaces that will be inaccessible for coating after erection shall be repaired and/or recoated prior to erection. In order to avoid abrupt changes in paint thickness, the area adjacent to repair areas shall transition from zero paint thickness to full system thickness within not less than 3 inches (75 mm) of the repair area by means of sanding the transition area. The requirements for the dry film thickness of the repair coats are the same as those specified for the paint system.

Blast cleaning and application of shop primer shall not be required for mechanically galvanized or zinc rich painted bolts, nuts and washers. All welds and surfaces from which the shop coat of paint has been damaged or is otherwise defective shall be blast cleaned and painted in accordance with sections 687.2.

687.4-SUBMITTALS:

Submittals shall be forwarded through the Prime Contractor and be accepted by the Engineer prior to commencement of the subject work. This is the responsibility of both the Fabricator and the Field Contractor. Electronical submittals will be accepted.

687.4.1-Quality Control Plan for Painting: Minimum requirements and document form are set forth in MP 688.02.20.

SECTION 688

FIELD PAINTING OF METAL STRUCTURES

688.1-DESCRIPTION:

The field painting (coating) of metal structures shall follow the provided requirements set forth in this specification unless otherwise noted in the Contract. This specification shall apply to surface preparation, coating application, contractor responsibilities, environmental and worker protection, and waste handling/disposal.

688.2-GENERAL:

688.2.1-Bridge Pre-Cleaning and Washing: All structures shall be pre-cleaned and washed in accordance with Section 685 of the Standard Specifications.

688.2.2-Surface Preparation:

688.2.2.1-Non-Blasting: When non-blast cleaning is specified in the contract documents, any one or any combination of the methods below shall be used. The surface and the surface profile after cleaning shall meet the requirements of the methods below. The amount of material, rust scale, and pack rust removed after non-blast cleaning, will meet the requirements of the SSPC methods listed:

1. Hand Tool Cleaning SSPC-SP 2
2. Power Tool Cleaning SSPC-SP 3
3. Commercial Grade Power Tool Cleaning SSPC-SP 15

688.2.2.2-Blasting: The abrasives used for all blasting shall meet the guidelines set forth in SSPC AB1 for mineral and slag abrasives, and AB3 for ferrous metallic abrasives. Any additive mixed with the abrasive shall be approved by the Division prior to use. The abrasives used shall produce a height of profile between 2.0 and 3.0 mils (50 μ m and 75 μ m).

In addition, the container or bag of abrasive shall include the name of the abrasive, the name of the manufacturer, and the size of the abrasive. If any additive has been included with the abrasive, the name and the percentage of the additive shall be on the container or bag.

The compressed air used for nozzle blasting shall be free of water and oil. The cleanliness of each compressed air system shall be verified at least once per shift using the blotter test in accordance with ASTM D4285, "Standard Test Method for Indicating Oil or Water in Compressed Air".

688.2.2.2.1-Commercial: Shall meet the requirements of SSPC-SP 6 prior to painting. The appearance of the steel surface after blast cleaning shall correspond to the applicable and current SP 6 pictorial standards of SSPC Vis 1.

688.2.2.2.2-Brush-Off Blast: Shall meet the requirements of SSPC-SP 7 prior to painting. The appearance of the steel surface after brush-off blast cleaning shall correspond to the applicable and current SP 7 pictorial standards of SSPC Vis 1.

688.2.2.2.3-Near White: Shall meet the requirements of SSPC-SP 10 prior to painting. The appearance of the steel surface after blast cleaning shall correspond to the applicable and current SP 10 pictorial standards of SSPC Vis 1.

688.2.2.3-Water Jetting: Shall meet the requirements of SSPC-SP 12, section 2.1.6 "Ultrahigh-Pressure Water Jetting" (UHP WJ), visual standard condition WJ-1, prior to painting.

688.2.2.4-Post-Surface Preparation: Surface prep operations shall be performed in such a manner that no damage is done to partially or entirely completed portions of the work. After surface prep, any areas that are repaired by welding shall be prepped again. Areas repaired by grinding or other means shall have the anchor pattern restored. Visible deposits of oil, grease, or other contaminants shall be removed according to SSPC-SP 1 "Solvent Cleaning" prior to painting. Dust, loose residues, and the removal of abrasives from pockets and corners shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning. The prepped surface shall be checked for cleanliness by wiping a clean, dark cloth across the surface. If residue is present, the surface shall be cleaned again and rechecked. All blast cleaned surfaces shall be painted prior to any rust bloom or flash rust occurring or within 24 hours, whichever comes first.

688.2.3-Paint Application Requirements:

688.2.3.1-Weather Conditions: Painting shall not be done when the ambient temperature is below 40° F (5° C) or above 100° F (38° C), or the relative humidity above 90 percent. The temperature of the steel must be at least 5° F (3° C) above the dew point. Painting shall not be performed when the surface to be coated is sufficiently hot to cause blistering of the film or too rapid solvent release. Painting will only be permitted between the dates of April 15th through October 15th. There will be no painting permitted to occur in a heated containment.

688.2.3.2-Paint Storage: Paint and thinners shall be stored in a temperature-controlled environment between 40° F (5° C) and 100° F (38° C). At no time will paint be used beyond the manufacturer's shelf life.

688.2.3.3-Paint Application: The blast cleaned surface shall be painted within 24 hours. In the event rust bloom or flash rusting occurs, the affected members shall be re-cleaned by blasting. The paint shall be applied by spray methods, except those areas inaccessible to spray application may be brushed or rolled. Brushes or rollers, when used, shall have sufficient body and length of bristle or roller nap to spread a uniform coat. Small touch-up areas may be brushed or rolled, if approved by the Engineer.

Use of an agitated pot shall be mandatory in spray application of zinc-rich primer. The agitator or stirring rod shall reach within 1 inch (25 mm), of the bottom of the pot and shall be in motion at all times during paint application. Coatings shall be mixed in strict accordance with the coating manufacturer's written instructions. Under certain conditions, it may be necessary to thin or adjust the solvent balance of the paint. The type and amount of solvent to be used shall be that listed on the coating manufacturer's product data sheet

for that material. Upon thinning, the dry film thickness requirement shall still be met by appropriately increasing the wet film thickness.

Application requirements and drying times between coats shall be in accordance with the manufacturer's recommendations. Exposed steel surfaces of expansion dams shall be painted as specified for structural steel.

Spray guns must be equipped with the recommended size tip for the paint product being applied and shall be held perpendicular (90 degrees) to, and at, the proper distance from the receiving surface. Complete protection shall be provided by the contractor against paint spatter, spillage, overspray, wind-blown paint, or similar releases.

Appropriate containment shall be placed around the work area to protect public and private property. Staging must be adequate to provide access to all areas being painted. Violation of these requirements causing excessive paint waste will be justification for the WVDOT Engineer to order the Contractor to cease all work on the project until corrective action has been taken. The method of cleaning and/or replacement shall be submitted to the Engineer in advance for approval.

688.2.3.3.1-Paint Systems:

3 COAT: Primer, Intermediate, Top Coat

2 COAT: Primer, Top Coat

1 COAT: Epoxy Mastic only

688.2.3.3.2-Painting over Galvanized Surfaces: Painting Galvanized surfaces shall be in accordance to the paint manufacturer's recommendations.

688.2.3.3.3-Damage to Galvanized Surfaces: The Contractor is to exercise care while cleaning and painting around expansion joints and galvanized surfaces. Any damage to the expansion joints or galvanized surfaces found by the Engineer, as a result of the cleaning and painting operation shall be repaired and/or replaced, to the satisfaction of the Engineer, at the Contractor's expense.

688.2.4-Inspection Requirements:

688.2.4.1-Inspection of Applied Paint: If in the opinion of the Engineer the coating has flaws other than deficiencies in the prescribed dry film thickness, the material shall be repaired or shall be removed and replaced. Defects in the film, including but not limited to runs, sags, mud-cracking, lifting, overspray, dry spray, pinholes, and holidays shall be corrected until a continuous uniform film has been applied.

Excessive film thickness shall be reduced and insufficient film thickness shall be increased. If the thickness of the finish coat is reduced, a thin coat of the finish shall be reapplied to seal the surface and to blend the area into the surrounding coating. Depending on the defect, total removal and replacement of the effected coating may be required. No unsightly runs or sags shall be visible. All "mud-cracking" and/or "dry overspray" in the paint film shall be removed. Excessive bubbles or pinholes shall not be visible in the coat after examination under 8X magnification. Calibration of the thickness gage and dry film thickness measurements shall be in accordance with MP 708.40.00.

688.2.4.2-Access for Inspection: The Contractor shall furnish suitable safe access and shall provide a time mutually agreed to for inspecting the structural steel prior to and after each coating. The Division's inspector shall approve all repairs. When providing suitable safe access, rubber rollers or other protective devices shall be used. Metal rollers or clamps and other types of fastenings that will mar or damage freshly coated surfaces shall not be used. No temporary attachments, supports for access, or forms, shall damage the coating system. In particular, on the fascias where bracing is used, sufficient size support pads must be provided. Any damage that occurs from such devices shall be repaired to the satisfaction of the Engineer at the Contractors expense.

688.2.4.3-Repair Procedures for Field Paint Deficiencies: All field repairs to the coating shall be made in strict accordance with the coating manufacturer's recommendations, except where the requirements listed in this specification are more stringent. Any products used during repairs to the coating deficiencies shall be from the same manufacturer as the coating being repaired. All welds from which the coating of paint has been damaged or is otherwise defective shall be cleaned and repaired. Surfaces that will be inaccessible for coating after erection shall be repaired and/or recoated prior to erection. The Engineer is to review and accept a repair plan before deficient areas are repaired. The requirements specified herein for provisions for inspection, mixing, thinning, temperature and humidity, and application shall govern the coating of the repaired areas. In order to avoid abrupt changes in paint thickness, the area adjacent to repair areas shall transition from zero paint thickness to full system thickness within not less than 3 inches (75 mm) of the repair area by means of sanding the transition area. The requirements for the dry film thickness of the repair coats are the same as those specified for the paint system.

688.2.5-Submittals: Submittals shall be forwarded through the Prime Contractor and be accepted by the Engineer prior to commencement of the subject work. This is the responsibility of both the Fabricator and the Field Contractor. Electronic submittals will be accepted.

688.2.5.1-Quality Control Plan for Painting: Minimum requirements and document form are set forth in MP 688.02.20.

688.2.5.2-Containment/Disposal Control Plan for Existing Steel Structures: Minimum requirements and document form are set forth in MP 688.03.20.

688.3-COMPLETE PAINTING OF EXISTING STRUCTURES:

688.3.1-General: The field coats (total system) of paint shall meet the requirements of Section 711. The applicable sections of 711, the dry film thickness and the color shall be as specified in the contract documents. Each coat shall be a contrasting color to the one previously applied.

688.3.2-Surface Preparation: All structural steel shall undergo a near-white blast cleaning in accordance with SSPC SP 10. All structural steel is to include 100% of the girders, stringers, diaphragms, floor beams, upper and lower chord members, drains, bearing devices, etc. In general, all accessible steel surfaces not galvanized, aluminum, or weathering steel shall be blast cleaned. All laminar and stratified rust that has formed on the existing steel

surfaces shall be removed. Pack rust formed along the perimeter of mating surfaces of connected plates or shapes shall be removed to the extent feasible without mechanically detaching the mating surface. The Contractor is to exercise care while cleaning and painting around expansion joints, weathering steel, and galvanized surfaces. Any damage to these surfaces found by the Engineer as a result of the cleaning and painting operation shall be repaired and/or replaced, to the satisfaction of the Engineer, at the Contractor's expense.

688.3.3-Paint Application Requirements: Painting shall be in accordance with Section 688.2.3.3.

688.3.4-Painting Sequence:

FULL PRIME COAT:

The structure shall receive one coat of a primer meeting the requirements of Section 711 of the Standard Specifications. The full prime coat shall be applied before the stripe prime coat. The primer used for the full prime coat and the stripe prime coat shall be of the same type and shall be from the same manufacturer. Dry film thickness requirements shall be as specified by the manufacturer's recommendations, or as specified in the contract documents.

STRIPE PRIME COAT:

All edges, outside corners, seams, bolt heads and nuts, all rivet heads, edges of flanges and plates, welds, sharp edges, in general all edges, shall receive one stripe coat, by brush or roller application, of the same primer as the Full Prime Coat. Striping shall extend a minimum of one inch (2cm) from the edge. The prime coat shall at a minimum, be set-to-touch before the stripe coat is applied. No dry film thickness is specified for this coat. This coat shall be tinted as allowed by the manufacturer to be in contrast to the full prime coat and intermediate coat. The tinting agent shall be the paint manufacturer's approved tinting agent.

INTERMEDIATE COAT:

The structure shall receive one uniform coat of a paint meeting the requirements of Section 711 of the Standard Specifications. The color shall be in contrast to the prime and top coats. If tinting is required, the tinting agent shall be the paint manufacturer's approved tinting agent. The intermediate coat shall not be applied until the primer and stripe coat have fully cured according to the manufacturer's recommendations. Dry film thickness requirements shall be as specified by the manufacturer's recommendations, or as specified in the contract documents.

CAULKING:

Caulking shall be applied before the application of the topcoat. This includes all seams between diaphragm connections to stiffeners and splices; and seams between any connection that is riveted or bolted. Any welded connections that are not fully sealed by the weld shall be caulked with a paste type caulk. The caulk shall be pressed into the seams between the adjoining surfaces, by wetted finger or specialty tool, to

insure bond and provide a smooth uniform surface. Bottom seams shall not be caulked on vertical surfaces.

Caulking in a 3-coat system shall be applied after the intermediate coat has cured. Caulking on a 2-coat system shall be applied after prime coat has cured. The top coat shall not be applied until the caulking has fully cured in accordance with the manufacturer's recommendations.

The caulking material shall be compatible with the paint system being applied and shall be by written recommendation of the paint manufacturer. The caulking material shall be tested for compatibility with the paint system at the same time that the paint is tested for intercoat compatibility. Caulking operations shall be performed only when weather conditions are within the parameters as specified in section 688.2.3.1.

TOP COAT:

The structure shall receive one uniform coat of paint as designated in the plans meeting the requirements of Section 711 of the Standard Specifications. The color shall be as designated in the plans and shall be in accordance with current Federal Standard 595. Dry film thickness requirements shall be as specified by the manufacturer's recommendations, or as specified in the contract documents.

688.3.5-Vegetation: Vegetation may need to be trimmed or removed in order to accomplish the cleaning or painting of the structure. If allowed by the Contract Documents, the Contractor may waste vegetation within the Right-of-Way. Otherwise, any such vegetation cut, shall be removed from the site by the contractor. No direct payment will be made for this work, but shall be included in the contract price for the item in connections with which it is used.

688.3.6-Utilities: Shall be in accordance with Section 107.17, Contractor Responsibility for Utility Property and Services or any other applicable sections of Section 107.

688.3.7-Paint Designation Label:

688.3.7.1-Description: The bridge paint designation label shall consist of painting on the fascia web of the exterior girder with the following information; the paint system, contractor, and the month-year the project was completed. This paint designation label will only be utilized during the complete removal and painting of existing or new structures. The acronyms and details for the paint designation label will be assigned to the Contractor by the Materials Control, Soils and Testing Division when the Quality Control Plan for Painting is approved.

688.3.7.1-Location: The paint designation label will be located at abutment number one on the fascia web of the exterior girder with a southern or eastern orientation, and paint color shall be a semi-gloss black paint compatible with the topcoat material.

688.3.7.2-General: All work performed regarding the paint designation label shall be considered incidental to the painting of the structure.

688.4-ZONE PAINTING OF EXISTING STRUCTURES:

688.4.1-General: The field coats (total system) of paint shall meet the requirements of Section 711. The applicable sections of 711, the dry film thickness shall be in accordance with the manufacturer's recommendations and the color shall be as specified in the contract documents. Each coat shall be a contrasting color to the one previously applied. The contract documents shall specify the areas to be prepared and zone painted.

688.4.2-Surface Preparation: The surface shall be prepared as specified in the contract documents. Specific instructions will be given on the amount of surface required to be cleaned in accordance with the specific standards identified in 688.2.2. All laminar and stratified rust that has formed on the existing steel surfaces shall be removed. Pack rust formed along the perimeter of mating surfaces of connected plates or shapes shall be removed to the extent feasible without mechanically detaching the mating surface. Any rust remaining after cleaning shall be tight and intact when examined using a dull putty knife. The tools used to remove these corrosion products shall be identified in the submittals and accepted by the Engineer. If the surface preparation or removal of rust results in nicks or gouges, the work shall be suspended, and the damaged areas repaired to the satisfaction of the Engineer, at the Contractor's expense. The Contractor is to exercise care while cleaning and painting around expansion joints and galvanized surfaces. Any damage to the expansion joints or galvanized surfaces found by the Engineer, as a result of the cleaning and painting operation shall be repaired and/or replaced, to the satisfaction of the Engineer, at the Contractor's expense.

688.4.3-Paint Application Requirements: Painting shall be in accordance with Section 688.2.3.3.

688.4.4-Painting Sequence: Painting shall be in accordance with Section 688.3.4.

688.4.5-Vegetation: - Shall be in accordance with Section 688.3.5

688.4.6-Utilities: Shall be in accordance with Section 107.17, Contractor Responsibility for Utility Property and Services or any other applicable sections of Section 107.

688.5-FIELD PAINTING OF SHOP PRIME-COATED STEEL:

688.5.1-General: Field painting of new shop prime coated structures: Shall include, unless otherwise specified in the contract, the preparation of the primed surface for painting, the procurement of all materials to meet the necessary specifications and the application of the coatings. In addition, the Contractor shall protect pedestrian, vehicular, and other traffic on or underneath the structure from splattering, splashing, or dripping paint. Railings, curbs and all other superstructure and substructure shall be protected against spatters, splashes, and the like.

688.5.2-Sheer Studs: When shear studs are applied in the field, repair to the Prime Coat shall be completed to the satisfaction of the Engineer and prior to any and adjoining concrete work.

688.5.3-Materials: The field coats (Intermediate and/or Top Coats) of paint shall meet the requirements of 711.22.3 and 711.22.4. Dry film thickness requirements shall be as specified by the manufacturer's recommendations, or as specified in the contract documents. Each coat

shall be a contrasting color to the previous coat. In addition, the field intercoat adhesion shall be at least 3A when tested in accordance with MP 711.00.20.

688.5.4-Surface Preparation: Prior to field coats, surface contamination such as rust, dirt, mud, oil, concrete, loose zinc, salts, or other foreign matter shall be removed. The shop primed structural steel shall be pressure washed, with a soluble salt remover from the division's approved product list, at 2000 – 3000 psi (13800 – 20700 kpa). Touch up of the primer shall be in accordance with section 688.2.3.3.

688.5.5-Paint Application Requirements: Painting shall be in accordance with Section 688.2.3.

688.5.6-Paint Sequence: Painting shall be in accordance with Section 688.3.4, with the exception of the Full Prime Coat and Stripe Coat. Paint containment shall be a minimum of Class 3P as specified in the current edition of SSPC Guide 6.

688.6-ENVIRONMENTAL, WORKER PROTECTION, AND WASTE HANDLING:

688.6.1-General: Environmental protection shall be used when cleaning, painting, welding or cutting an existing bridge. The containment class, emission assessment methods and levels as defined by the current revision of SSPC Guide 6 shall be as stated in the contract documents. The specific pollution control system which is proposed for the complete capture, containment, collection, and disposal of the “spent material” generated by the work shall be included in the plan.

688.6.2-Permits for Disposal of “Spent Material”: Shall be in accordance with Section 107.2, Permits, Licenses, and Taxes or any other applicable sections of Section 107. The “spent material” shall not be disposed of until authorized by the Engineer and in no case shall “spent material” be allowed to accumulate longer than 90 days prior to transport.

688.6.2.1-“Spent Material”: This shall include material generated by surface preparation operations and shall be sampled and tested in accordance with the current revision of SSPC Guide 7. The Contractor shall, at the Contractor's expense, select a laboratory that will sample and analyze the “spent materials”. The laboratory must be certified by the WVDEP, EPA or by another state's DEP-equivalent. Certification will be provided to the Engineer prior to the beginning of work. The waste transporter for both hazardous and non-hazardous waste will be listed on the Contractor's Containment/Disposal Control Plan.

688.6.3-Additional requirements for all classes of containment: Contractor will provide ground covers beneath the containment area and all equipment where spills are possible to capture inadvertent spills or leaks of debris. Extend the covers a minimum of 5 feet beyond the area to be covered. Debris shall be removed from the covers at least once per shift, or as directed by the Engineer. If the ground beneath the structure serves as the base of the containment, install and maintain air and dust impenetrable materials such as solid plywood panels or flexible materials such as tarpaulins. Provide explosion-proof lighting inside containment for all paint application. Maintain a minimum of 10 foot-candles for surface

preparation and painting, and a minimum of 30 foot-candles for inspection. Water booms shall be used to contain inadvertent releases of debris unless prohibited by navigation lanes. In these cases, a boat with a skimmer shall be available to collect fugitive materials. Remove all project-related debris from the surface of the water or from the stream sediment at the end of each working day at a minimum unless directed otherwise by the Engineer.

688.6.4-Temporary Waste Storage: The Division (WVDOH) will obtain a provisional (temporary) EPA waste generator number for the project prior to the beginning of the work. The location of the temporary waste storage site at the project shall be noted in the Contractor's Containment/Disposal Control Plan. This location must be approved by the Division prior to beginning work.

688.6.5-Worker Protection: Shall be in accordance with Section 107.7, Public Convenience and Safety, or any other applicable sections of Section 107. The Contractor shall have a Certified Industrial Hygienist (CIH) develop, review and approve their written compliance plan. The CIH shall be certified by the American Board of Industrial Hygiene. The CIH, or a technician working under the direction of the CIH, shall be present during the first three days of work and at least twice a month thereafter. The CIH shall certify in writing during the first week of work and at the end of the work that the worker protection plan fully complied with all regulations and that the plans were fully implanted. Daily inspections of the work area shall be made by the project "competent person". The Contractor shall have identified the "competent person" by name in both the CIH's written compliance plan and the Contractor's Containment/Disposal Control Plan. The compliance plan shall also include the "competent person's" qualifications and the frequency of inspections to be taken. The CIH requirements will not apply to those zone painting projects where only SP 2 and SP 3 surface preparation is being done.

688.6.6-Division Employee Worker Protection: The Contractor shall provide respiratory protection and protective clothing and other necessary equipment for up to 2 Division employees at each site.

688.7-METHOD OF MEASUREMENT:

The unit of measurement for "Clean and Paint Existing Steel Bridges", "Containment and Disposal of Spent Material", "Field Painting of Shop Primed Steel" shall be lump sum. The unit of measurement for "Zone Cleaning and Painting Steel Bridges" shall be square foot.

688.8-BASIS OF PAYMENT:

Basis of Payment for "Clean and Paint Existing Steel Bridges", "Containment and Disposal of Spent Material", "Field Painting of Shop Primed Steel" shall be lump sum price bid. "Zone Cleaning and Painting Steel Bridge" shall be square foot price bid. The cost for the items listed below, which price and payment shall be full compensation for furnishing all the materials and doing all the work herein prescribed in workmanlike and acceptable manner, including all labor, tools, equipment, supplies and incidentals necessary to complete the work.

688.9-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
688001-*	Clean and Paint Existing Steel Bridge	Lump Sum
688003-*	Containment and Disposal of Spent Material	Lump Sum
688005-*	Zone Cleaning and Painting Steel Bridge	Square Foot (Meter)
688007-*	Field Painting of Shop Primed Steel	Lump Sum

* Sequence number

SECTION 689 METALIZING STEEL

689.1-DESCRIPTION:

This specification covers the requirements for thermal spray metallic coatings, with or without sealers or top coats, as a means to prevent corrosion of steel surfaces.

All work shall be done at the steel fabrication shop unless otherwise specified.

The requirements outlined in the Society of Protective Coatings Guide for “Thermal Spray Metallic Coating Systems” (SSPC CS-Guide 23.00) shall be followed and considered as part of this specification.

689.2-MINIMUM REQUIREMENTS:

All metalizing work shall be performed by a company with at least three years of experience in coating steel. Any company which is new to metalizing and does not have three years experience shall, prior to starting any work, submit written documentation of successful structural steel metalizing projects. This shall include the name of the owner of previous projects, number and location of jobs completed, and number of years experience. This document will be reviewed, verified, and approved by the Engineer prior to beginning any work. The company shall possess knowledge and experience in all areas of surface preparation and metalizing work.

Each spray operator shall be qualified to metalize in conformance with the latest edition of ANSI/AWS C2.18. Spray operators not having evidence of qualification shall be prohibited from spraying.

689.3-MATERIAL:

Unless otherwise specified, the metallic coating to be applied shall be pure zinc, conforming to the requirements of ASTM B6.

The manufacturer shall furnish a Certificate of Analysis for each lot of material supplied. Each container or coil reel shall be properly labeled to identify component type, supplier, size, and wire lot number.

The size of wire material shall conform to the manufacturer’s recommendations for the Arc Sprayed method.

The metalizing material shall satisfy the requirements for at least a Class B slip coefficient and creep resistant per Appendix A of the “Specification for Structural Joints Using ASTM A 325 or A 490 Bolts” by the Research Council on Structural Connections. The test results shall be provided to the Engineer by the contractor prior to the start of work.

689.4-APPLICATION OF METALLIC COATING:

The metalizing unit shall be an arc type gun manufactured by an established domestic company. The equipment shall be used in conformance with the manufacturer’s recommendations. No surface shall be sprayed which shows any signs of rust, scale or moisture. All metalizing shall be applied at 8 - 14 mils (200 - 350 μm) with no individual reading less than 6 mils (150 μm) nor more than 16 mils (400 μm). Field and/or shop bolted contact surfaces shall have the coating applied in the range of 2 to 5 mils (25-125 μm) dry film thickness. At least one layer of coating shall be applied within four hours after blasting and the final thickness within a maximum of eight hours of the blasting. The steel shall be cleaned with sharp, angular grit, to at least a near white finish meeting SSPC-SP-10. No shot will be allowed as the blasting abrasive. The profile of the anchor pattern shall be 2-4 mils (50-100 μm).

The top flange which will require shear studs shall have the metalizing applied at a minimum of 2 mils (50 µm) in order to prevent rusting. If applied in the shop, the studs shall be installed prior to metalizing. Metalizing of the studs is not required. If installed in the field, the shop applied metalizing on the top of the top flange shall be removed at the stud locations to bare metal prior to installation of the studs.

The contractor shall provide facilities to protect the finished metalized surface from damage during the blasting and thermal spraying work operations on adjacent areas. All damaged coated areas shall be properly repaired and remetalized at no additional cost to the Division.

Surfaces not intended to be metalized shall be suitably protected from the effects of the metalizing operations.

689.5-SEALERS AND TOP COATS:

The Division has the option of requiring a sealer and/or top coats over the metalizing. When this option is chosen, the requirements will be specified in the contract documents.

689.6-SHIPPING AND HANDLING:

All fully coated and cured assemblies shall be protected from handling and shipping damage with the prudent use of padded slings, dunnage, separators and tie downs. Loading procedures and sequences shall be designed to protect all coated surfaces. Any damaged areas shall be repaired in conformance with the manufacturer's recommendations or as directed by the Engineer.

689.7-FIELD TOUCH UP:

All touch up for metalizing shall be in conformance with the coater's recommendations.

689.8-METHOD OF MEASUREMENT:

The unit of measurement for "Metalizing Steel" shall be lump sum.

689.9-BASIS OF PAYMENT:

Basis of payment for "Metalizing Steel" shall be lump sum. Payment shall be full compensation for furnishing all the labor, tools, equipment, supplies, and incidentals necessary to complete the work herein prescribed.

689.10-PAY ITEMS:

ITEM	DESCRIPTION	UNIT
689001-*	Metalizing Steel	Lump Sum
689002-*	Metalizing Steel With Sealer	Lump Sum
689003-*	Metalizing Steel With Sealer And Top Coats	Lump Sum

* Sequence number

SECTION 690

SURFACE PREPARATION AND POWDER COATING OF NEW GALVANIZED STEEL FOR HIGHWAY SIGNING AND LIGHTING STRUCTURES

690.1-GENERAL:

690.1.1-Purpose and Scope: This Specification provides the material and workmanship requirements for the surface preparation and powder coating of new galvanized steel surfaces. The work consists of surface preparation and application of the powder coating system.

690.1.2-Reference Standards: The latest edition of the following standards and regulations form a part of this specification.

- A. American Society for Testing and Materials (ASTM)
 - 1. ASTM A123/A123M, Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
 - 2. ASTM A153/A153M, Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
 - 3. ASTM A780, Standard Practice for Repair of Hot-Dip Galvanized Coatings
 - 4. ASTM B201, Standard Test Method for Testing Chromate Coatings on Zinc and Cadmium Surfaces
 - 5. ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air
 - 6. ASTM D4414, Standard Practice for Measurement of Wet Film Thickness by Notch Gages
 - 7. ASTM E376 Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods
- B.
 - 1. MP 708.40.00-Procedure for the Determination of Structural Painting Film Thickness.
 - 2. MP 688.02.20-Guide for Contractor's and Fabricator's Quality Control Plan for Painting Structural Steel.
- C. The Society for Protective Coatings
 - 1. SSPC-SP 1, Solvent Cleaning
 - 2. SSPC-SP 2, Hand Tool Cleaning
 - 3. SSPC-SP 3, Power Tool Cleaning
 - 4. SSPC-SP 7, Brush-Off Blast Cleaning
- D. Equipment, and Coating Manufacturers Published Instructions.

690.2-PRODUCTS:

690.2.1-Hot-Dip Galvanized Materials: Material to be powder coated is required to be Hot-Dip galvanized as described in ASTM A123/A123 M and A153/A153 M.

690.2.2-Hot-Dip Galvanizing Requirements: Water quenching or chromate conversion coating shall be avoided as these processes interfere with paint adhesion and surface preparation. Testing for the presence of chromate coatings in accordance with ASTM B201 can be conducted if necessary.

690.3-SURFACE PREPARATION AND POWDER COATING:

Cleaning and powder coating shall be done in accordance with WVDOH Standards and Specifications, Section 688. Preparation of the galvanized surface, prior to powder coating shall conform to written recommendations from the powder coating manufacturer, or at a minimum, in accordance with subsection 690.3.B. This recommendation will then become part of the Paint Quality Control Plan (QC Plan).

A. Weld Spatter and Sharp Edges:

1. The fabricator shall remove slag, flux deposits, weld spatter and grind any resulting burrs smooth, and shall round sharp edges such as those created by flame cutting and shearing.
2. The rolled edges of angles, channels, and wide flange beams do not require further rounding unless specifically directed by the Engineer.

B. Galvanized Surfaces:

1. Remove surface contamination and oils (if any) from the finished galvanized surface by SSPC-SP1, Solvent Cleaning.
2. Remove zinc oxide prior to powder coating. Any zinc or other metal oxide that remains on the surface of the galvanized steel can potentially retain air or moisture. This may cause the powder coating to blister or create voids. Likewise, the galvanized coat may also release gas.
3. Remove surface oxidation with a light sweep blast, SSPC- SP 7, Brush-Off Blast Cleaning. This process will also promote good adhesion between galvanized surface of steel and powder coating.
4. Degassing any entrapped air or water within the galvanized coating is achieved by the process known as pre-baking. This is done in a drying oven operated at higher temperatures than the curing temperature. This temperature is typically 55° F higher than the recommended curing temperature. In no instance the temperature should exceed 535° F.
5. Chemical cleaning is not allowed.*
6. Cleaned material shall be stored in a controlled environment and shall be coated immediately after the preparation.

* Chemical cleaning leaves a film in the material surface that may create the effect of bond breaker between the base material and the powder coating.

690.4-ENVIRONMENTAL CONDITIONS:

1. All powder coatings shall be done in a climate controlled self-contained shop.
2. Do not apply materials when surface and ambient temperatures are outside the temperature and/or relative humidity ranges required by the powder coating manufacturer.
3. It is recommended to have room temperature between 65 to 85 degrees F and relative humidity between 40 to 60%.
4. Coordinate the shop work with field installation and other appurtenances.

690.5-POWDER COATING:

Except as otherwise specified, powder coating materials shall meet the following requirements:

i. Gloss @60°	ASTM D-523	5 - 70 Low Gloss 60 - 80 Semi-Gloss 70- 100 High Gloss

ii. Adhesion	ASTM D-3359	100% (5B)
iii. Hardness	ASTM D-3363	H-2H Pencil
iv. Conical Mandrel	ASTM D-522	1/8" Mandrel
v. Impact Resistance	ASTM D -2794	80-160 In-lbs. Direct No Cracking
vi. Salt Spray	ASTM B-117	1,000 Hrs. <1/8" Scribe Creep -No Blisters
vii. Humidity	ASTM D-1735	1,000 Hrs. <1/16 " Scribe Creep No Blister
viii. All powder products shall be ready mixes from the manufacturer. No mixing is to be done in the applicator shop.		

690.6-POWDER COATING APPLICATION:

Prior to any powder coating application, any area that is not to be coated (threads, tight fit holes, friction bolted connections, etc.) will be masked.

All powder coatings shall be applied at a minimum of three (3) mils (75 µm) dry film thickness.

Prior to application of powder coating, determine the average thickness of the bare Galvanized layer. Subtract the average galvanized thickness from total measured dry film thickness in order to determine the actual powder coating film thickness.

Verify that the coating thickness of each coat is in accordance to the coating manufacturer's requirement or plan's notes.

690.7-REPAIR OF DAMAGED COATING:

All shop and field repairs to the powder coating shall be made in accordance with WVDOH Standards and Specifications 688.3.6 and the powder coating manufacturer's recommendations. In addition, the powder coating applicators shall include touch up paint with the Shipment of finished products to the job site.

690.8-INSPECTION:

- A. The Engineer may inspect any or all phases of the work to verify that it is in accordance with the requirements of this Specification. The Contractor shall facilitate this inspection as required, including allowing ample time for the inspections and access to the work. Inspections may include, but are not limited to, surface preparation, pre-painting cleanliness, paint application, dry film thickness, film appearance, and adhesion.
- B. The presence or activity of Engineer inspections in no way relieves the Contractor of the responsibility to comply with all provisions of this Specification and to provide adequate inspections of its own.
- C. Furnish, until final acceptance of the powder coating system, all equipment and instrumentation needed to inspect all phases of the work.

690.9-BASIS OF PAYMENT:

The basis of payment for the "Surface Preparation and Powder Coating" shall be incidental to highway signing, signal, and lighting structures required to be powder coated.

DIVISION 700

MATERIALS DETAILS

SECTION 701 HYDRAULIC CEMENT

The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which for any reason has become partially set or which contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

701.1-PORTLAND CEMENT:

Portland cement shall conform to the requirements of ASTM C 150, Type I.

701.2-BLANK

701.3-BLENDED HYDRAULIC CEMENTS:

Blended hydraulic cement shall conform to the requirements of ASTM C595 for Portland blast-furnace slag cement, Type IS, or Portland-pozzolan cement, Type IP, or Portland-limestone cement, Type IL.

701.4-MASONRY CEMENT:

Masonry Cement shall conform to the requirements of ASTM C 91.

SECTION 702 FINE AGGREGATE

702.1-FINE AGGREGATE FOR PORTLAND CEMENT CONCRETE:

702.1.1-General Requirements: Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof, conforming to the requirements of these Specifications.

702.1.2-Deleterious Substances: The Maximum percentages of deleterious substances shall not exceed the limits below.

MATERIAL	PERCENT BY WEIGHT
Amount finer than No. 200 (75 µm) sieve for manufactured fine aggregate (determined by AASHTO T 11 and T 27). A manufactured fine aggregate is one which has been reduced in particle size by crushing	5.0
Amount finer than No. 200 (75 µm) sieve for all other sands (determined by AASHTO T 11 and T 27)	3.0
Coal and other lightweight deleterious material (determined by MP 702.01.20)	2
Friable particles (determined by MP 703.01.20)	1

Larger percentages passing the No. 200 (75 µm) sieve in the fine aggregate fraction will be permitted if the percent passing the No. 200 (75 µm) sieve in the coarse aggregate fraction (703.4) is less than the specified maximum. In no event, however, shall the percent passing the No. 200 (75 µm) sieve in the total concrete aggregate be greater than an amount which would exist if both aggregate fractions contained their specified maximum percentage passing the No. 200 (75 µm) sieve.

702.1.3-Soundness (Determined by MP 703.00.22): When the fine aggregate is subjected to five alternations of the sodium sulphate soundness test, the weighted loss shall not exceed 10 percent by weight.

702.1.4-Organic Impurities (Determined by AASHTO T21): When the fine aggregate is subjected to the organic impurities test, the color shall not be darker than the standard. In the event a color darker than the standard is produced, the acceptability of the material will be determined as specified in 702.1.5.

702.1.5-Mortar Strength (Determined by AASHTO T71): Fine aggregate failing the organic impurities test shall be subjected to the test for mortar making properties. The fine aggregate shall develop a compressive strength at the age of seven days when using Type I or II cement, or at three days when using Type III cement, of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded Ottawa sand having a fineness modulus of 2.4 plus or minus 0.10.

702.1.6-Grading: The fine aggregate used for developing a concrete mix design shall have an $\bar{A}$ of 6.1 plus or minus 0.4.

The $\bar{A}$ value shall be determined by adding the cumulative percentages by weight of material passing each of U.S. Standard Sieve Nos. 1½ in. (37.5 mm), ¾ in. (19 mm), 3/8 in. (9.5 mm), 4 (4.75 mm), 8 (2.36 mm), 16 (1.18 mm), 30 (600 µm), 50 (300 µm), 100 (150 µm), and 200 (75 µm) and dividing by 100.

The gradation shall be determined in accordance with AASHTO T 27 and T 11.

702.1.7-Uniformity of Grading: The gradation limits given in 702.1.6 represent the extreme limits which shall determine suitability of material from all sources of supply. The gradation of material from any one source, however, shall be reasonably uniform.

702.2-MORTAR SAND:

Sand (natural or manufactured) shall meet the requirements of AASHTO M 45, except delete 4.1 through 4.4 and substitute the following:

Aggregate for use in masonry mortar shall be graded within the following limits:

SIEVE SIZE	PERCENT PASSING
No. 4 (4.75 mm)	100
No. 8 (2.36 mm)	90-100
No. 100 (150 µm)	0-30
No. 200 (75 µm)	0-10

For joints thicker than ½ in. (13 mm), sand meeting the requirements of 702.1.1 through 702.1.5 and 702.6 will be permitted.

702.3-FINE AGGREGATE FOR ASPHALT MIXTURES:

Fine aggregate for asphalt mixtures shall meet the requirements of ASTM D 1073, except that the gradation requirements will be waived.

702.4-MINERAL FILLER FOR ASPHALT MIXTURES:

Mineral filler for asphalt mixtures shall meet the requirements of ASTM D 242, modified as follows: Mineral filler shall be free from harmful organic impurities. Gradation requirements will be waived.

702.5-LIGHTWEIGHT FINE AGGREGATE FOR STRUCTURAL CONCRETE:

Lightweight fine aggregate for structural concrete shall meet the requirements of ASTM C 330.

702.6-ALTERNATE GRADING:

Fine aggregate shall be well graded from coarse to fine and shall conform to the following requirements:

SIEVE SIZE	PERCENT PASSING BY WEIGHT
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 16 (1.18 mm)	45-80
No. 50 (300 µm)	10-30
No. 100 (150 µm)	2-10

SECTION 703 COARSE AGGREGATE

Coarse aggregate shall consist of crushed stone, washed gravel (crushed or uncrushed), crushed slag, or any combination thereof, conforming to the requirements of these Specifications.

703.1-CRUSHED STONE:

703.1.1-General Requirements: Crushed stone shall consist of particles of clean, hard, tough, durable rock free from adherent coatings.

703.1.2-Deleterious Substances: Deleterious substances shall not exceed the limits set forth below:

MATERIAL	PERCENT BY WEIGHT
Thin or elongated pieces (determined by MP 703.00.25)	5
Shale (determined by MP 703.00.27)	1
Coal and other lightweight deleterious material (determined by MP 702.01.20)	1.5
Friable particles (determined by MP 703.01.20)	0.25

703.1.3-Percentage of Wear (AASHTO T 96 or ASTM C 535): Crushed stone shall have a percentage of wear not to exceed 40.

703.1.4-Soundness (Determined by MP 703.00.22): When subjected to five cycles of the sodium sulphate test, the weighted percentage of loss shall be not more than twelve.

703.1.5-Limestone Anti-Skid Aggregates:

703.1.5.1 Limestone: When produced for anti-skid, limestone shall be sampled from the stockpile by the Division. The stockpile shall meet the requirements for Section 703.1, with the addition of MP 703.00.29. Limestone shall contain a minimum of 10% quartz retained on the #200 (75µm) sieve.

703.1.5.2-Dolomite Limestone: When produced for anti-skid, shall be sampled from the stockpile by the Division. The stockpile shall meet the requirements for Section 703.1, with the addition of ASTM C1271 and ASTM C1301. Dolomite shall contain a minimum of 10% elemental magnesium.

703.2-GRAVEL:

703.2.1-General Requirements: Gravel shall be composed of particles of hard, durable rock, thoroughly clean and well graded in size. Gravel shall meet the requirements of 703.1.2, 703.1.3 and 703.1.4.

703.2.2-Crushed Particles: The following minimum requirements for percent of crushed particles (determined by MP 703.00.21) for the type of construction indicated shall govern:

	Crushed Particles Minimum Percent by Weight of the Gravel or Blends Retained on No. 4 (4.75 mm) Sieve	
	Fracture	
Type Of Construction	One Face	Two Face
Bituminous Concrete Base 1	80	0
Bituminous Concrete Wearing, Patching and Leveling. Base 2, Prime, Tack, Surface Treatments, Winter Grade Patching Mixtures and aggregates No. 7 and smaller in penetration macadam and Road Mix Bituminous Pavements	-----	80
Bituminous Concrete Surfaces or Wearing Courses on all projects requiring specific skid resistant qualities	-----	80

703.2.3-Pea Gravel: Pea gravel shall consist of clean uncrushed river gravel conforming to the requirements of 703.1.3, 703.1.4, total deleterious substances shall not be greater than five percent, and shall meet the following grading requirements for percent passing:

<u>½ in. (12.5 mm)</u>	<u>No. 16 (1.18 mm)</u>
100	0-5

703.3-SLAG:

Slag shall be air cooled blast-furnace slag, reasonably uniform in density and quality, and free from dirt and other objectionable matter. When tested in accordance with AASHTO T 19 and when standard sizes are combined in the proportions used in the job mix formula, the slag shall not weigh less than 70 lb. per cu. ft. (1 Mg per cubic meter) when used in Portland cement concrete or hot-laid bituminous concrete surface courses, and not less than 60 lb. per cu. ft. (960 kg per cubic meter) when used in other applications. Blast furnace slag shall meet the requirements of 703.1.2 and 703.1.4. In addition to air cooled blast furnace slag, other slags which meet the applicable physical requirements may be used with the approval of the Engineer. All other slag shall meet the requirements of 703.1.2, 703.1.3 and 703.1.4.

703.3.1-Steel Slag: Steel slag, from the production of steel, includes open hearth, electric furnace, and basic oxygen furnace slag. Steel slag is differentiated from air cooled blast-furnace slag which is from the production of iron.

For items where steel slag is used, it must be crushed to its intended item gradation, maintained in a constant wet condition for a period of at least 6 months, and must be rendered sufficiently inert to minimize potential expansion and the discharge of deleterious effluent. The aging period shall begin at the completion of stockpiling and shall be strictly monitored by the supplier. The stockpile shall be isolated with no additional material being added during the aging period. Should additional material be added, the aging period shall start over from

the date of the addition. When aging, stockpiles should be kept at a maximum height of 10 feet to allow adequate moisture penetration throughout the pile.

To evaluate the effectiveness of the aging process expansion tests shall be conducted at the end of the 6-month aging period. The selection of samples for expansion testing shall be on a stratified random basis vertically with at least one sample from each top one-third, middle one-third, and bottom one-third of the stockpile. Samples shall be obtained in accordance with MP 700.00.06, *Aggregate Sampling Procedures*. Expansion values shall not be greater than 0.50 percent at seven days when tested in accordance with applicable portions of ASTM D4792. If one or more of the samples do not meet the 0.50 percent expansion limit after the 6 month aging period, the stockpile shall be kept moist and aged an additional two months, after which expansion tests shall again be conducted in the manner described above. This process shall continue prior to use until the steel slag conforms to the expansion limit. When the stockpile has shown compliance to the expansion test requirements, it may be used in items as directed by the Engineer.

When steel slag is to be used in Hot-Mix Asphalt (HMA), the expansion tests shall be waived. Steel slag, when used in HMA, shall not exceed 50 percent by weight of the coarse fraction of the mix, and in no case shall steel slag be used as a coarse aggregate fraction and a fine aggregate fraction within a single mix.

When steel slag is to be used in items where thickness and quantities are limited and the slag is not confined, such as aggregate shoulders, road stabilization, snow and ice control, etc., the expansion tests may be waived as directed by the Engineer.

In addition to other requirements specified elsewhere in the Contract Documents, for the particular item, acceptance of the material shall be on the basis of the Division's evaluation of the supplier's written certification that the aforementioned aging, moisture, and expansion requirements (where applicable) have been accomplished, and that the level or degree of expansion exhibited meets the expansion criteria. The certification shall include all test data when applicable.

Steel slag shall not be used in any item where expansion might be detrimental. Such items include, but not necessarily limited to, the following: aggregate for Portland cement concrete, backfill around drainage structures, piers, abutments, walls, etc.

703.3.1.1-Wearing III (Sand Mix): When fine aggregate steel slag is used in a sand mix all the requirements specified in Section 703.3.1 for coarse aggregate steel slag when used in HMA shall apply with the following exceptions: fine aggregate steel slag shall meet the quality requirements of 702.1.2 and 702.1.3, and shall not exceed 25 percent by weight of the total fine aggregate used in the mix.

703.3.2-Electrometallurgical Slag: Electrometallurgical slag is from the production of metal alloys as differentiated from the production of steel. Electrometallurgical slag may not be used as a Portland cement concrete aggregate.

When electrometallurgical slag is used as an aggregate in bituminous construction and payment is on a tonnage (megagram) basis, proper allowance will be made for the difference in weight per cubic foot (meter).

703.3.3-Power Plant Slag: Power plant slag consists of Wet Bottom Boiler Slag (shiny, black, glassy material) formed when molten ash from the burning of coal drops into water and shatters at the bottom of the boiler, and Bottom Ash formed when ash particles from the burning of pulverized coal is allowed to air cool at the bottom of the furnace. Power plant slag may not be used as a Portland cement concrete aggregate.

703.4-GRADING OF COARSE AGGREGATES:

Coarse aggregate shall be uniformly graded to conform to the requirements of Table 703.4. The gradation of coarse aggregates in the production of concrete shall be controlled by the $\bar{A}$ value as specified in 501.3 and 601.3. In addition, coarse aggregates to be used in Portland cement concrete shall have no more than one percent by weight passing the No. 200 (75 μm) sieve, except that this percentage may be increased to 1.5 in the case of crushed aggregate if the material finer than the No. 200 (75 μm) sieve consists of the dust of fracture, essentially free from clay or shale. The gradation shall be determined in accordance with AASHTO T 27 and T 11.

When the coarse aggregate is to be used in Portland cement concrete, larger percentages passing the No. 200 (75 μm) sieve in the coarse aggregate fraction will be permitted if the percent passing the No. 200 (75 μm) sieve in the fine aggregate fraction (702.1) is less than the specified maximum. In no event, however, shall the percent passing the No. 200 (75 μm) sieve in the total concrete aggregate be greater than an amount which would exist if both aggregate fractions contained their specified maximum percentage passing the No. 200 (75 μm) sieve.

Table 703.4 shows the gradations for coarse aggregates required by AASHTO M 43 (Note that the specification current at the time of advertisement of bid shall govern).

703.5-LIGHTWEIGHT COARSE AGGREGATE FOR STRUCTURAL CONCRETE:

Lightweight coarse aggregate for structural concrete shall meet the requirements of ASTM C 330.

TABLE 703.4
STANDARD SIZES OF COARSE AGGREGATES (AASHTO M 43)

Size No.	Nominal Size Square Openings ⁽¹⁾	Amounts Finer Than Each Laboratory Sieve (Square Openings), Percent By Weight														
		4 in 100 mm	3½ in 90 mm	3 in 75 mm	2½ in 63 mm	2 in. 50 mm	1½ in 37.5 mm	1 in 25.0 mm	¾ in 19.0 mm	½ in 12.5 mm	3/8 in 9.5 mm	No. 4 4.75 mm	No. 8 2.36 mm	No. 16 1.18 mm	No. 50 300 µm	No. 100 150 µm
1	3½ to 1½ in 90 to 37.5 mm	100	90 to 100		25 to 60		0 to 15		0 to 5							
2	2½ to 1½ in 63 to 37.5 mm			100	90 to 100	35 to 70	0 to 15		0 to 5							
24	2½ to ¾ in 63 to 19.0 mm			100	90 to 100		25 to 60		0 to 10	0 to 5						
3	2 to 1 in 50 to 25.0 mm				100	90 to 100	35 to 70	0 to 15		0 to 5						
357	2 in to No. 4 50 to 4.75 mm				100	95 to 100		35 to 70		10 to 30		0 to 5				
4	1½ to ¾ in 37.5 to 19.0 mm					100	90 to 100	20 to 55	0 to 15		0 to 5					
467	1½ in to No 4 37.5 to 4.75 mm					100	95 to 100		35 to 70		10 to 30	0 to 5				
5	1 to 1/2 in 25.0 to 12.5 mm						100	90 to 100	20 to 55	0 to 10	0 to 5					
56	1 to 3/8 in 25.0 to 9.5 mm						100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5				
57	1 in. to No 4 25.0 to 4.75 mm						100	95 to 100		25 to 60		0 to 10	0 to 5			
6	¾ to 3/8 in 19.0 to 9.5 mm							100	90 to 100	20 to 55	0 to 15	0 to 5				
67	¾ in to No 4 19.0 to 4.75 mm							100	90 to 100		20 to 55	0 to 10	0 to 5			
68	¾ in to No 8 19.0 to 2.36 mm							100	90 to 100		30 to 65	5 to 25	0 to 10	0 to 5		
7	½ in to No 4 12.5 to 4.75 mm								100	90 to 100	40 to 70	0 to 15	0 to 5			
78	½ in to No 8 12.5 to 2.36 mm								100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5		
8	3/8 in to No 8 9.5 to 2.36 mm									100	85 to 100	10 to 30	0 to 10	0 to 5		
89	3/8 in to No 16 9.5 to 1.18 mm									100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	
9	No. 4 to No. 16 4.75 to 1.18 mm										100	85 to 100	10 to 40	0 to 10	0 to 5	
10	No. 4 to 0 ⁽²⁾ 4.75 mm to 0 ⁽²⁾										100	85 to 100				10 to 30

⁽¹⁾ In inches, except where otherwise indicated. Numbered sieves are those of the United States Standard Sieve Series

⁽²⁾ Screenings

Where standard size of coarse aggregate designated by two or three digit numbers are specified, obtain the specified gradation by combining the appropriate single digit standard size aggregates by a suitable proportioning device where has a separate compartment for each coarse aggregate combined. Performed the blending as directed by the Laboratory.

SECTION 704

STONE AND CRUSHED AGGREGATE

704.1-STONE FOR MASONRY:

Stone for coursed masonry shall be tough, sound and durable, resistant to weathering action, reasonably fine grained, uniform in color, and free from seams, cracks, pyrite inclusions or other structural defects. The stone shall have a compressive strength of not less than 5,000 psi (34.5 MPa). Stone shall be of such character that it can be truly wrought to such lines and surfaces as may be required.

704.2-STONE FOR RIPRAP:

Stone of riprap shall consist of field stone or rough unhewn quarry stone as nearly rectangular in section as is practicable. The material shall have a maximum weighted loss of 30 percent when subjected to five cycles of sodium sulfate soundness test, MP 703.00.22.

704.3-STONE FOR GABIONS:

Material for gabions shall consist of rock, field stone, unhewn quarry stone or river bed stone. The dimensions of the rock or stone fillings shall be such as to prevent loss of material through mesh openings and accomplish a mass with a minimum amount of voids. The material shall have a maximum weighted loss of 30 percent when subjected to five cycles of sodium sulfate soundness test, MP 703.00.22.

704.4-DUMPED ROCK GUTTER:

The material for dumped rock gutter shall be rock containing a combined total of not more than 15 percent other suitable material, as determined by visual inspection.

Visual inspection shall be used to determine that the rock will conform to the following weight requirements:

Thickness of Gutter Feet (mm)	70 Percent of the Weight of Material Shall Consist of Stones Weighing Between the Following Limits:
1 (300 mm)	50-100 lb. (20-45 kg)
1.5 (450 mm)	60-150 lb. (25-70 kg)
2.0 (600 mm)	75-200 lb. (30-90 kg)
2.5 (750 mm)	100-250 (45-115 kg)

704.5-SPECIAL ROCK FILL:

Special rock fill shall be limestone or sandstone having a maximum weighted loss of 30 percent when subjected to five cycles of sodium sulfate soundness test, MP 703.00.22. Metallurgical slag or broken concrete, from a source approved by the Engineer, may be furnished.

The rock shall have the dimensions in accordance with the Contract Documents. Thin Slab-like pieces shall not be used.

704.6-AGGREGATE FOR BASE OR SUBBASE COURSE:

704.6.1-General: The material shall consist of gravel, crushed gravel, crushed stone, crushed slag, or any combination of these materials uniformly blended to conform to the requirements of 704.6.2, with the following exception: Los Angeles abrasion is not required

for blast furnace slag. Natural or manufactured sand may be used as a component of the blend. Crushed slag shall meet the requirements of 703.3 with the exception of the third and fifth sentences. When gravel is to be used in stabilized (treated) base or subbase construction, it need not be crushed. When used in an unstabilized base or subbase construction, the gravel shall be crushed as specified.

When the Contractor elects to blend materials, each component of the blend shall meet the quality requirements of 704.6.2. Blade or road mixing will not be allowed.

When shoulders are specified, natural sand may not be used as a shoulder component.

704.6.2-Gradation, Quality, and Crushed Particle Requirements: Material shall be sampled in accordance with MP 700.00.06, Aggregate Sampling Procedures.

When gravel is used in an unstabilized condition and in combination with other types of aggregate, it shall produce a combined material having a minimum of 80 percent one-face fracture as determined by weight of particles retained on the No. 4 (4.75 mm) sieve. When gravel is used in an unstabilized condition and alone, it shall have a minimum of 80 percent one-face fracture as determined by weight of particles retained on the No. 4 (4.75 mm) sieve.

704.6.3-Sampling, Testing and Acceptance Procedure: Material shall be sampled in accordance with MP 700.00.06 Aggregate Sampling procedures. Frequency of sampling and testing and plotting of gradation test data will be in accordance with established Division procedures.

Material failing to comply with the Specification requirements when sampled, tested, and evaluated in accordance with the above Division procedures shall be removed and replaced at the Contractor's expense, or, at the option of the Engineer, may be left in place with reduced payment.

TABLE 704.6.2A-GRADATION REQUIREMENTS

Gradation Amounts Finer Than Each Laboratory Sieve (Square Openings), % By Weight										
Aggr. class	8" (200)	2½" (63)	2" (50)	1½" (37.5)	1" (25)	¾" (19)	#4 (4.75)	#40 (425 µm)	#100 (150 µm)	#200 (75 µm)
1				100		50-90	20-50	5-20		0-7.0
2				100		80-100	35-75	10-30		0-10.0
3				100		50-90	20-50	5-20		4.0-12.0
4				100		50-95	20-60	5-35		
5			100				30-90			0-25.0
6				100		50-100	25-70	10-45	3-28	
7	90-100		0-5	with intermediate sizes between 6" (150 mm) and 4" (100 mm) represented						
8				100		80-100	35-75	10-40		4.0-14.0
9		100		80-95		50-70	20-40			0-8.0
10 *					100	70-100	30-75	8-40		4.0-20.0

* Crusher Run Material Only

TABLE 704.6.2B-QUALITY REQUIREMENTS

Aggr. class	Los Angeles Abrasion, Percent Max.	Sodium Sulfate Soundness, Percent Max.	Liquid Limit Max.	Plasticity Index Max.	Deleterious Material, Percent Max.
1	50	12	25	6	5
2	50	12	25	6	5
3	50	12	25	6	5
4	Note 1		25	6	5
5			25	6	5
6			25	6	5
7		30			10 (by visual observation)
8	50	12	25	6	5
9	50	12	25	6	5
10	50	12	25	6	5

Note 1: The Los Angeles Abrasion value of aggregate comprising the base course shall be treated in the manner hereinafter set forth to determine the specification requirement for the item:

Los Angeles Abrasion Value Assigned to the Base Course Aggregate	LA≤50	None
	50<LA≤65	Top 4 inches (100 mm)
	65<LA≤80	Top 6 inches (150 mm)
	80<LA	Top 8 inches (200 mm)

Stabilization shall be accomplished with bituminous material or Portland cement in accordance with the applicable sections of these Specifications. When the depth indicated above exceeds the Plan depth for the item, the depth to be stabilized shall be the Plan depth. In the event the Contractor elects to stabilize the material, no separate payment will be made for the cost of such stabilization.

If aggregates are blended to produce the base course material, the Los Angeles Abrasion Value used to determine the stabilization requirements shall be the highest value obtained from testing the individual components of the blend.

704.6.4-Test Methods:

Deleterious Materials	ASTM C 295, MP 703.01.20, MP 702.01.20, MP 703.00.27
Gradation	AASHTO T 11 and T 27
Liquid Limit	AASHTO T 89
Los Angeles Abrasion	AASHTO T 96, ASTM 535
Plasticity Index	AASHTO T 90
Soundness (Sodium Sulphate, 5 cycles)	MP 703.00.22

704.7-FILTER MATERIAL:

Filter material shall consist of sand, other approved inert material, or a combination thereof, having hard, strong, durable particles. The material shall contain no more than a total of five percent coal, clay lumps, shale, soft fragments, organic matter, and other local deleterious substances.

The material shall conform to the following gradation:

U.S. Standard Sieve Size	Percent Passing, by Weight
2 in. (50 mm)	100
No. 4 (4.75 μ m)	65-100
No. 40(4.25 μ m)	25-50
No. 200 (75 μ m)	0-25

704.8-SHOT ROCK:

Shot rock shall be limestone, sandstone, or other inorganic material acceptable to the Division, having dimensions similar to that which exists after final blasting at the quarry site and prior to crushing. It shall contain material that would generally be retained on a 6 inch (150 mm) sieve, and not larger than that which could be tailgated from a single axle 8 to 10 ton (7 to 9 Mg) dump truck. In addition, some 10 inch to 12 inch (250 to 300 mm) material shall be represented as an intermediate size. Shot rock shall have a maximum weighted loss of 30 percent when subjected to five cycles of the Sodium Sulfate Soundness test, MP 703.00.22.

Acceptance for gradation shall be on the basis of a letter of certification from the Producer verifying that the sizes specified are represented.

SECTION 705 ASPHALT MATERIALS

Asphalts shall be made by refining of petroleum and shall be free from tar or tar products. The respective types and grades shall meet the specification requirements.

Asphalts shall be sampled in accordance with AASHTO T40. When asphalt material is furnished by a supplier who is not certified under provisions of MP 401.02.25, the supplier shall be required to have each batch or lot of material, to be furnished to the Division, sampled by a Division-approved inspection agency, in accordance with MP 700.00.01 and shall have the samples tested for compliance with the governing Specification in a Division-approved laboratory.

The correct application temperature for the material shall be used as directed by the material manufacturer. Measurement of the volume of asphalt materials however, shall be based on the volume of the materials at 60° F (15.5° C). Volumes measured at higher or lower temperatures shall be corrected to the volumes of the material at 60° F (15.5° C) using the coefficients of expansion given below:

Temperature Conversion Factors

Material	Coefficient for °F (°C)
Asphalt Emulsion	0.00025 (0.00045)
Performance Graded Binder	0.00035 (0.00062)
Cut-back Emulsified Asphalt	0.0004 (0.0007)

705.1-WINTER GRADE CUT-BACK ASPHALT:

This material shall conform to Cut-back asphalts as per section 705.2, 705.3, or 705.4

705.2-LIQUID ASPHALT (RAPID CURING TYPE):

Rapid curing liquid asphalt shall conform to the requirements of AASHTO M 81.

705.3-LIQUID ASPHALT (MEDIUM CURING TYPE):

Medium curing liquid asphalt shall conform to the requirements of AASHTO M 82 and in addition shall meet the requirements of AASHTO T 182

705.4-ASPHALT EMULSION:

Anionic emulsified asphalts shall conform to the requirements of AASHTO M 140.

705.5-PERFORMANCE GRADED BINDERS:

Performance graded binders shall conform to the requirements of AASHTO M-322, Table 1. Manufacturers are not required to perform Direct Tension Testing, AASHTO T-314. The naming convention for asphalt binder grades will be as followed:

Old binder Grade Designations	New Binder Grade Designations
PG 58 – 28	PG 58S – 28
PG 64 – 22	PG 64S – 22
PG 70 – 22	PG 64H – 22
PG 76 – 22	PG 64E – 22 ^{Note 1}

Note 1: The indication of elastic response for binders tested in accordance with AASHTO T-350 shall be determined using the appendix X1-INDICATIONS OF ELASTIC RESPONSE in AASHTO M 332.

705.6-BLANK

705.7-ASPHALT FOR DAMPPROOFING AND WATER-PROOFING:

Materials shall conform to the requirements of ASTM D449. Unless otherwise specified, Type-II shall be used.

705.8-PRIMER FOR USE WITH ASPHALT IN DAMPPROOFING AND WATERPROOFING:

Materials shall conform to the requirements of ASTM D41.

705.9 through 705.10-BLANK

705.11-CATIONIC EMULSIFIED ASPHALT:

Cationic emulsified asphalt shall conform to the requirements of AASHTO M 208.

705.12-POLYMER-MODIFIED CATIONIC EMULSIFIED ASPHALT:

Polymer-modified cationic emulsified asphalt shall conform to the requirements of AASHTO M 316.

705.13-NONSTANDARD ASPHALT MATERIALS:

All asphalt materials that are not standard AASHTO or ASTM grades shall meet the recommended requirements specified by the Division. After Division approval, materials will be listed on the MCS&T web page under Division Approved Source/Product Listing for bituminous materials.

SECTION 706-BLANK

SECTION 707

CONCRETE ADMIXTURES, CURING AND COATING MATERIALS

707.1-AIR-ENTRAINING ADMIXTURES FOR CONCRETE:

707.1.1-Acceptance Requirements for Air-Entraining Admixtures:

707.1.1.1-In the event that the Contractor elects to use an air-entraining admixture, evidence based on tests made in a recognized laboratory shall be submitted to show that the material conforms to the requirements of AASHTO M 154 for 7-day and 28-day compressive and flexural strengths and resistance to freezing and thawing, except as provided in 707.1.1.2. Tests for bleeding, bond strength and volume change will not be required unless specifically called for in the Plans. A "recognized" laboratory is any Division, Federal Highway Administration or cement and concrete laboratory regularly inspected by the Cement and Concrete Reference Laboratory of the National Bureau of Standards. Tests may be made upon samples taken from a quantity submitted by the Contractor for use on the project or upon samples submitted and certified by the manufacturer as representative of the admixture to be supplied.

707.1.1.2-An exception to the requirements in the preceding paragraph is the case of air-entraining admixtures which are manufactured by neutralizing Vinsol resin with caustic soda (sodium hydroxide). When the Contractor proposes to use such an admixture, the Contractor shall submit a certificate concerning the admixture is the following form:

"This is to certify that the product (trade name) as manufactured and sold by the (company) is an aqueous solution of Vinsol resin that has been neutralized with sodium hydroxide. The ratio of sodium hydroxide to Vinsol resin is one part of sodium hydroxide to (number) parts of Vinsol resin. The percentage of solids based on the residue dried at 221° F (105° C) is (number). No other additive or chemical agent is present in this solution."

707.1.1.3-When the Contractor proposes to use a air-entraining admixture which has been previously approved, the Contractor shall submit a certification stating that the admixture is the same as that previously approved. If an admixture offered for use is essentially the same (with only minor differences in concentration) as another previously approved material, a certification will be required stating that the product is essentially the same as the approved admixture and that no other admixture or chemical agent is present.

707.1.2-Optional Acceptance Requirements for Air-Entraining Admixtures:

707.1.2.1-The Division may elect to approve air-entraining admixtures as satisfactorily meeting acceptance requirements as outlined. If the Division chooses to exercise this option, then the acceptance requirements specified in 707.1.1 above shall be modified as noted.

707.1.2.2-The Division may develop a spectroscopic standard for an air-entraining admixture if such air-entraining admixture has previously been approved by the Division as satisfactorily meeting all the specification requirements as set forth in 707.1.1.

707.1.2.3-When a Contractor proposes to use an air-entraining admixture for which a spectroscopic standard has been developed, then the air-entraining admixture may be approved without further certification being made if a special analysis made on a representative sample of the admixture proposed for use on the project compares satisfactorily with the standard related thereto.

707.1.3-Additional Test Requirements for Air-Entraining Admixtures (Optional):

707.1.3.1-Either prior to or at any time during construction, the Engineer may require that the admixture selected by the Contractor be further tested to determine its effect upon the strength of the concrete. When so tested, the seven-day compressive strength of concrete made with the cement and aggregates in the proportions to be used in the work and containing the admixture under test is an amount sufficient to produce from four to seven percent entrained air in the plastic concrete shall be not less than 88 percent of the strength of concrete made with the same materials and with the same cement content and consistency but without the admixture.

707.1.3.2-The percentage reduction in strength shall be calculated from the average strength of at least five standard 6 by 12-in. (150 by 300 mm) cylinders of each type of concrete. Specimens shall be made and cured in the laboratory in accordance with the requirements of ASTM C 192 and shall be tested in accordance with the requirements of ASTM C 39. The percentage of entrained air shall be determined in accordance with the requirements of ASTM C 231.

707.1.3.3-Admixtures failing to meet the above requirements will be rejected.

707.2-WATER-REDUCING AND RETARDING ADMIXTURES FOR CONCRETE:

707.2.1-Acceptance Requirements for Approval of Retarders: Water reducing and retarding admixtures for concrete shall conform to the requirements of AASHTO M 194, Type D or Type G.

707.2.2-Performance Requirements for Concrete Retarders:

707.2.2.1-The retarding effect caused by water-reducing and retarding admixtures may vary widely with different types of cement, cement from different mills, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore, no retarder shall be used until the concrete of the specified class, designed in accordance with the Specifications and made with the ingredients proposed for use by the Contractor, including Type D or Type G admixtures as specified or permitted under this specification, is shown to meet the requirements of AASHTO M 194 for water reduction and compressive strength increases at ages 3, 7 and 28 days.

When a Type G admixture is used for the sole purpose of increasing the slump of the subject concrete mix (no water is removed when this admixture is added), the requirements of AASHTO M 194 for water reduction and compressive strength increases will be waived.

When a Type G admixture is used for the sole purpose of increasing the slump of the subject concrete mix (no water is removed when this admixture is added), the requirements of AASHTO M 194 for water reduction and compressive strength increases will be waived.

707.2.2.2-The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.2.3-Optional Performance Requirements for Concrete Retarders:

707.2.3.1-The Division may elect to approve water-reducing and retarding admixtures as satisfactorily meeting performance requirements as outlined. If the Division chooses to exercise this option, then the performance tests specified in 707.2.2 will be waived.

707.2.3.2-The Division's testing laboratory may design concrete mixes in which various types and gradings of aggregates and various types of cements are used and in which water-reducing and retarding admixtures are used, the admixtures first having met the acceptance requirements for approval of concrete retarders as specified in 707.2.1. The water-reducing and retarding admixtures used in laboratory design mixes may be subjected to a spectral analysis, and a spectroscopic standard or a standard spectrograph may be developed if the admixture in combination with the particular type and grading of aggregate and the particular type of cement has met the performance requirements for water-reducing admixtures as specified in 707.2.2.

707.2.3.3-When a Contractor proposes to use a water-reducing and retarding admixture with a type of grading of aggregate and a type of cement which was previously used in a laboratory design mix and for which a special standard is available, the retarder may be approved on the basis of a spectral analysis made on a representative sample of the admixture proposed for use on the project if:

- i. The spectral analysis compares satisfactorily with the standard related thereto, and
- ii. The admixture met performance requirements in previous tests conducted in the Division's laboratory as outlined in 707.2.3.2.

707.2.4-Certification of Water-Reducing and Retarding Admixtures: When a Contractor proposes to use an approved water-reducing and retarding admixture, the Contractor shall submit a certificate stating that the admixture is identical in composition with the sample that was used for the acceptance tests. If the admixture varies in concentration from the acceptance sample, a certificate will be required stating that the product is essentially the same for chemical ingredients as the approved admixture, and that no other admixture or chemical has been added.

707.2.5-Additional Test Requirements for Water-Reducing and Retarding Admixtures (Optional): Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested further to determine its effect on the strength of the concrete. When so tested the retarder shall meet the requirements specified in 707.2.2.

707.3-WATER-REDUCING ADMIXTURES FOR CONCRETE:

707.3.1-Acceptance Requirements for Approval of Water-Reducers: Water-reducing admixtures for concrete shall conform to the requirements of AASHTO M 194, Type A or Type F.

707.3.2-Performance Requirements for Concrete Water-Reducers:

707.3.2.1-The effects of using water-reducing admixtures may vary widely with different types of cement, cement from different mills, aggregate proportions, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore, no water-reducer shall be used until the concrete of the specified class, designed in accordance with these Specifications and made with the ingredients proposed for use by the Contractor, including Type A or Type F admixtures as specified or permitted under this Specification, is shown to meet the requirements of AASHTO M 194 for water reduction and compressive strength increases at ages 3, 7 and 28 days.

When a Type F admixture is used for the sole purpose of increasing the slump of the subject concrete mix (no water is removed when this admixture is added), the requirements of AASHTO M 194 for water reduction and compressive strength increases will be waived.

707.3.2.2-The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.3.3-Optional Performance Requirements for Concrete Water-Reducers:

707.3.3.1-The Division may elect to approve water-reducing admixtures as satisfactorily meeting performance requirements as outlined. If the Division chooses to exercise this option, then the performance tests specified in 707.3.2 will be waived.

707.3.3.2-The Division's testing laboratory may design concrete mixes in which various types and gradings of aggregates and various types of cement are used and in which water-reducing admixtures are used, the admixture first having met the acceptance requirements for approval of concrete water-reducers as specified in 707.3.1. The water-reducing admixture used in laboratory design mixes may be subjected to a special analysis, and a spectroscopic standard or a standard spectrograph may be developed if the admixture in combination with the particular type and grading of aggregate and the particular type of cement has met the performance requirements for water-reducing admixtures as specified in 707.3.2.

707.3.3.3-When a Contractor proposes to use a water-reducing admixture with a type and grading of aggregate and a type of cement which was previously used in a laboratory design mix and for which a spectral standard is available, the water-reducer may be approved on the basis of a spectral analysis made on a representative sample of the admixture proposed for use on the project if:

- i. The spectral analysis compares satisfactorily with the standard related thereto, and
- ii. The admixture met performance requirements in previous tests conducted in the Division's laboratory as outlined in 707.3.3.2.

707.3.4-Certification of Water-Reducing Admixtures: When a Contractor proposes to use an approved water-reducing admixture, the procedure set forth in 707.2.4 shall apply.

707.3.5-Additional Test Requirements for Water-Reducing Admixtures (Optional): Either prior to or at any time during construction, the Engineer may require the selected

admixture to be tested further to determine its effect on the strength of the concrete. When so tested the water-reducer shall meet the requirements specified in 707.3.2.

707.4-POZZOLANIC ADDITIVES FOR USE IN PORTLAND CEMENT CONCRETE:

707.4.1-Fly ash shall conform to the following requirements of ASTM C618, Class F or C when sampled and tested in accordance with the applicable Section of ASTM C311

Fineness	Class F (ASTM C618)	Class C (ASTM C618)
Amount Retained on No. 325 (45 μ m) Sieve	34% Max.	34% Max.
Loss on Ignition:	6% Max.	6% Max.
SiO ₂ +Al ₂ O ₃ +Fe ₂ O ₃	70% Min.	50% Min

707.4.2-Ground granulated blast furnace slag shall conform to the requirements of AASHTO M302.

707.4.3-Microsilica Admixture: Microsilica shall be supplied in the densified powder form and shall meet the requirements of AASHTO M 307.

707.4.4-Natural pozzolans shall conform to the requirements of ASTM C618, Class N.

707.5-LATEX ADMIXTURE:

Formulated latex modifier shall be Dow Modifier A, Tylac 97-314 (Thermoflex 8002), BASF Latex 1186 or Deco-Ray 4776. The manufacturer of these products shall certify that the latex being supplied is of equal formulation to that supplied to the FHWA Turner-Fairbank Highway Research Station for initial approval. Other Styrene-Butadiene latex modifiers may be used provided they have been tested in accordance with and meet the acceptance criteria of the testing program outlined in Report No. FHWA-RD-78-35 of the Federal Highway Administration. The manufacturer shall certify that the latex being supplied meets the acceptance criteria used in the testing program. Only one brand shall be supplied. Samples taken at the job site shall contain a minimum of 46% solids in the latex when tested in accordance with MP 679.03.00.

The latex admixture shall be agitated as necessary to prevent separation of the emulsion. It shall be maintained in storage within the temperature range of 35° F (2° C) to 85° F (29° C). Admixture obtaining temperatures outside the foregoing limits shall be removed and replaced at no additional cost to the Division.

707.6-POLYETHYLENE COATED BURLAP FOR CURING CONCRETE:

This material shall consist of burlap impregnated on one side with white opaque plastic film. The plastic film shall be securely bonded to the burlap. The film shall be clean and free of imperfections. Acceptance will be based on visual inspection.

707.7-BURLAP CLOTH MADE FROM JUTE OR KENAF FOR CURING CONCRETE:

The burlap cover shall be clean and free of defects. The cover shall provide a water retention blanket over the concrete. Acceptance will be based on visual inspection.

707.8-WATERPROOF PAPER FOR CURING CONCRETE:

Waterproof paper shall consist of two sheets of kraft paper cemented together with bituminous material and reinforced with fiber. The top surface shall be white. Acceptance will be based on visual inspection.

707.9-LIQUID MEMBRANE-FORMING COMPOUNDS FOR CURING CONCRETE:

Curing compounds shall conform to the requirements of ASTM C309, Type 2, Class A.

707.10-WHITE POLYETHYLENE SHEETING (FILM) FOR CURING CONCRETE:

The sheeting shall be opaque white plastic film. The film shall be clean and free of imperfections. Acceptance will be based on visual inspection.

707.11-EPOXY RESIN PROTECTIVE COATING:

The material shall conform to the requirements of ASTM C881, Type III, Grades 1 or 2, Class B or C. Pigmentation shall be required in the system so the cured coating shall conform to Federal Color Standard 595, No. 16357.

707.12-CONCRETE SEALER:

707.12.1-General: The material shall be a one component, water repellant penetrating sealer, meeting the criteria listed in section 707.12.2. The material shall be capable of meeting the criteria with a single coat and shall not alter the color of the treated surfaces.

707.12.2-Acceptance: The Contractor shall furnish certified laboratory test data showing the material meets the following performance requirements:

1. Absorption-ASTM C642 (non-air entrained concrete). Concrete should be proportioned and mixed in accordance with ASTM C672. Sealed concrete, under total immersion, will not exceed 1.0% absorption after 48 hours or 2.0% absorption after 50 days.
2. Scaling Resistance-ASTM C672. A rating of "No Scaling" after 100 cycles on the sealed concrete (non-air entrained concrete) as compared to "Severe Scaling" on untreated concrete.
3. NCHRP 244, Series II-Cube Test
 - 3.1 Weight Gain-not to exceed 25% of untreated cube.
 - 3.2 Absorbed Chloride-not to exceed 25% of untreated cube.
4. NCHRP 244, Series IV-Southern Exposure
 - 4.1 Absorbed Chloride-not to exceed 10% of untreated concrete.

707.13-ACCELERATING ADMIXTURES FOR CONCRETE:

707.13.1-Acceptance Requirements for Approval of Accelerators: Accelerating admixtures for concrete shall be non-chloride and shall conform to the requirements of AASHTO M 194, Type C.

707.13.2-Performance Requirements for Concrete Accelerators:

707.13.2.1-The effects of using accelerating admixtures may vary widely with different types of cement, cement from different mills, aggregate proportions, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore,

no accelerator shall be used until the concrete of the specified class, designed in accordance with these Specifications and made with the ingredients proposed for use by the Contractor, including Type C admixtures as specified or permitted under this Specification, is shown to meet the requirements of AASHTO M 194 for compressive strength at ages 3, 7, and 28 days.

707.13.2.2-The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.13.3-Certification of Accelerating Admixtures: When a Contractor proposes to use an approved accelerating admixture, the procedure set forth in 707.2.4 shall apply.

707.13.4-Additional Test Requirements for Accelerating Admixtures (Optional): Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested further to determine its effect on the strength of the concrete. When so tested, the accelerator shall meet the requirements specified in 707.13.2.

707.14-WATER-REDUCING AND ACCELERATING ADMIXTURES FOR CONCRETE:

707.14.1-Acceptance Requirements for Approval of Water-Reducing and Accelerating Admixtures: Water-reducing and accelerating admixtures for concrete shall be non-chloride and shall conform to the requirements of AASHTO M 194, Type E.

707.14.2-Performance Requirements for Concrete Water-Reducing and Accelerating Admixtures:

707.14.2.1-The effects of using water-reducing and accelerating admixtures may vary widely with different types of cement, cement from different mills, aggregate proportions, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore, no water-reducing accelerator shall be used until the concrete of the specified class, designed in accordance with these Specifications and made with the ingredients proposed for use by the Contractor, including Type E admixtures as specified or permitted under this Specification, is shown to meet the requirements of AASHTO M 194 for water reduction and compressive strength increases at ages 3, 7, and 28 days.

707.14.2.2-The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.14.3-Certification of Water-Reducing and Accelerating Admixtures: When a Contractor proposes to use an approved water-reducing and accelerating admixture, the procedure set forth in 707.2.4 shall apply.

707.14.4-Additional Test Requirements for Water-Reducing and Accelerating Admixtures (Optional): Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested further to determine its effect on the strength of the concrete. When so tested, the water-reducing accelerator shall meet the requirements specified in 707.14.2.

707.15-HYDRATION CONTROL STABILIZING ADMIXTURES FOR CONCRETE:

707.15.1-Acceptance Requirements for Approval of Hydration Control Stabilizing Admixtures: Hydration control stabilizing admixtures for concrete shall conform to the requirements of AASHTO M 194, Type B or D.

707.15.2-Performance Requirements for Concrete Hydration Control Stabilizing Admixtures:

707.15.2.1-The effects of using hydration control stabilizing admixtures may vary widely with different types of cement, cement from different mills, aggregate proportions, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore, no hydration control stabilizing admixture shall be used until the concrete of the specified class, designed in accordance with these Specifications and made with the ingredients proposed for use by the Contractor, including hydration control stabilizing admixtures as specified or permitted under this Specification, is shown to meet the requirements of AASHTO M 194 for water reduction and compressive strength increases at ages 3, 7, and 28 days.

Upon completion of mixing of this trial batch, air content and slump tests in accordance with section 601.4.1 shall be performed on the plastic concrete containing the hydration control stabilizing admixture. A test to establish the initial and final times of setting of the concrete mix shall also be performed in accordance with ASTM C403. The air content and slump tests shall then be repeated at 45-minute intervals until a period of 3-hours after the completion of mixing has elapsed.

The value obtained by any of the air content tests during the 3-hour period shall not vary from the value obtained by the initial air content test by more than 2.5 percentage points.

The value obtained by any of the slump tests during the 3-hour period shall not vary from the value obtained by the initial slump test by more than 1.75 inches (445 mm).

707.15.2.2-The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.15.3-Certification of Hydration Control Stabilizing Admixtures: When a Contractor proposes to use an approved hydration control stabilizing admixture, the procedure set forth in 707.2.4 shall apply.

707.15.4-Additional Test Requirements for Hydration Control Stabilizing Admixtures (Optional): Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested further to determine its effect on the strength of the concrete. When so tested, the hydration control stabilizing admixture shall meet the requirements specified in 707.15.2.

707.16-CONCRETE PROTECTIVE COATING MATERIALS:

707.16.1-Acceptance: For initial approval, the manufacturer shall submit representative samples, colors chip(s) and certified laboratory test data along with the Material Data Sheets on the batch of material that is going to be used on WVDOT's projects to the Division of Materials for review, approval and placing on the Department's List of Approved Materials. In addition, the Materials Division may require that a representative from the manufacturer of

the product be present at the project site during the application of the concrete protective coating to provide guidance on the mixing (if any), application of the product, and surface preparation.

If a representative from the manufacturer of the product is required, the cost will be incidental to Item 601020-001 Concrete Protective Coating Representative.

If the initially accepted product has not been used on a WVDOH's project for a period of two consecutive years, the product shall be removed from the Department's List of Approved Materials. Any re-approval of a removed product shall comply with Subsection 707.16.1

Subsequent approval of an initially accepted product shall be based on the manufacturer's submittal of a certification to the Materials Division on each batch of the product that is going to be used on WVDOH's projects. Such a certification shall be stating that the said product passes the laboratory test requirements listed in this subsection. Tests listed herein are the minimum testing requirements to be met. When requested in writing, the Engineer may accept materials based on conformance to the same type of test but differing on minor procedural points. Attach copies of test procedures which differ from those stated herein. In addition to the material, provide brochures or booklets containing detailed instructions and explanatory remarks about surface preparation, application procedures, and operations.

- A. **Freeze-Thaw Test.** Cast and cure three concrete specimens no less than 4 by 6 by 6 inches (100 by 150 by 150 mm). Moist cure specimens for 14 days and then dry in room air at 60° to 80°F (15° to 27°C) for three hours and remove.
 - 1.) Immerse in water at room temperature 60° to 80°F (15° to 27°C) for three hours and remove.
 - 2.) Place in cold storage at 5°F (-15°C) for one hour and remove.
 - 3.) Thaw at room temperature 60° to 80°F (15° to 27°C) for one hour.
 - 4.) Repeat steps 1, 2, and 3 to complete a total of 50 cycles. At the end of 50 cycles of the Freeze/Thaw Test, ensure that the coated specimens show no visible defects.
- B. **Accelerated Weathering.** Test according to ASTM G153. Apply at an application rate of 50 ± 10 ft²/gal (1.75 ± 0.35 m²/L). Test for 5,000 hours in an Enclosed Carbon Arc Weatherometer. Perform the test in 120 minutes cycles consisting of 102 minutes of light and 18 minutes of light and demineralized water. At the end of the exposure test, ensure that there are no checking, cracking, or loss of film integrity, and no other firm defects. The color difference after 5,000 hours shall be no more than five ΔE units.
- C. **Salt Spray Resistance.** Apply the masonry coating to concrete at a rate of 50 ± 10 ft²/gal (1.75 ± 0.35 m²/L), and test the coating according to ASTM B 117. Expose the coating to a five percent sodium coating chloride (salt) solution for 300 hours, and maintain it at 95°F (35°C) during the period of exposure. Ensure that it shows no loss of adhesion or deterioration at the end of the 300 hours.
- D. **Fungus Growth Resistance.** Ensure that the protective coatings pass a fungus resistance test as described by the ASTM D 3273. At the end of four weeks exposure there shall be no growth on the coatings.

707.17-SPECIFIC PERFORMANCE ADMIXTURES FOR CONCRETE:

707.17.1-Acceptance Requirements for Approval of Specific Performance Admixtures: Specific performance admixtures for concrete shall conform to the requirements of AASHTO M 194, Type S.

707.17.2-Performance Requirements for Concrete Accelerators:

707.17.2.1-The effects of using specific performance admixtures may vary widely with different types of cement, cement from different mills, aggregate proportions, aggregates from different sources and of different gradation, and changes in water-cement ratio. Therefore, no specific performance admixture shall be used until the concrete of the specified class, designed in accordance with these Specifications and made with the ingredients proposed for use by the Contractor, including Type S admixtures as specified or permitted under this Specification, is shown to meet the requirements of AASHTO M 194 for compressive strength at ages 3, 7, and 28 days.

707.17.2.2-The mix shall contain the quantity of admixture recommended by the manufacturer at the prevailing temperature.

707.17.3-Certification of Specific Performance Admixtures: When a Contractor proposes to use an approved specific performance admixture, the procedure set forth in 707.2.4 shall apply.

707.17.4-Additional Test Requirements for Accelerating Admixtures (Optional): Either prior to or at any time during construction, the Engineer may require the selected admixture to be tested further to determine its effect on the strength of the concrete. When so tested, the accelerator shall meet the requirements specified in 707.17.2.

SECTION 708 JOINT MATERIALS

708.1-PREFORMED EXPANSION JOINT FILLER FOR CONCRETE:

708.1.1-Nonextruding and Resilient Nonbituminous Type: The material shall conform to the requirements of AASHTO M 153. The sampling frequency shall be on the basis of one sample per each day of a manufacturers production for each thickness.

708.1.2-Nonextruding and Resilient Bituminous Type: The material shall conform to the requirements of AASHTO M 213. The sampling frequency shall be on the basis of one sample per each day of a manufacturers production for each thickness.

708.2-PREFORMED ELASTOMERIC JOINT SEALS; LUBRICANT-ADHESIVES:

708.2.1-Joint Seals for Concrete Pavements: This material shall meet the requirements of AASHTO M 220. The lubricant-adhesive shall be of the type recommended by the seal manufacturer.

708.2.2-Joint Seals for Bridges: Multiple web design and strip seals shall meet the requirements of AASHTO M 297. The compression-deflection and recovery tests for strip seals are deleted. The lubricant-adhesive shall be of the type recommended by the seal manufacturer.

The strip seal gland shall be delivered to the jobsite in lengths suitable for continuous one piece installation for each individual expansion joint. Field splicing of a strip seal gland is not permitted. Special conditions such as doglegs, tees, and crosses shall be shop fabricated in a mold under heat and pressure.

708.3-JOINT SEALANT, HOT-POURED FOR CONCRETE AND ASPHALT PAVEMENTS:

This material shall meet the requirements of ASTM D6690. Unless otherwise specified, Type II sealant shall be used.

708.4-SILICONE JOINT SEALANT; JOINT BACK-UP MATERIAL:

708.4.1-Silicone Joint Sealant:

708.4.1.1-General Requirements: Silicone sealant shall be furnished in a one part formulation. The compound shall be compatible with the surface to which it is applied. Acid cure sealants are not acceptable for use on concrete.

Silicone sealants shall be of the following types:

Type I-A low modulus non-sag silicone for use in sealing horizontal and sloping joints in Portland cement concrete pavements. Tooling is required.

Type II-A very low modulus self-leveling silicone used to seal horizontal joints in Portland cement concrete pavements.

Type III-An ultra-low modulus self-leveling silicone used to seal horizontal joints in Portland cement concrete pavements. It can also be used to seal joints between Portland cement concrete pavement and asphalt concrete shoulders.

708.4.1.2-Test Requirements: The sealant shall meet the following requirements.

Test Method	Test	Type I	Type II	Type III
ASTM D2202	Flow	0.3 In (7.6 mm) Max	Self-Leveling	Self-Leveling
ASTM C679	Tack Free Time	1.5 Hours Max		
Manufacturer Note 1	Skin Over Time		2 Hours Max	2 Hours Max
ASTM D412 Die C Notes 2 & 3	Modulus @ 150% Elongation	45 PSI (310 kPa) Max	40 PSI (276 kPa) Max	15 PSI (103 kPa) Max
ASTM D412 Die C Notes 2 & 3	Elongation	500% Min	500% Min	500% Min
ASTM D3583 Notes 2, 3, 4, 5	Adhesion to Concrete	No Failures @ 200% Elongation Min	No Failures @ 200% Elongation Min	No Failures @ 200% Elongation Min
ASTM C719 Note 6	Movement Capability 10 Cycles @ $\pm 50\%$	No Adhesive or Cohesive Failures	No Adhesive or Cohesive Failures	No Adhesive or Cohesive Failures
ASTM C793 Notes 2 & 3	Accelerated Weathering 5,000 Hours	No Cracking	No Cracking	No Cracking

Note 1: The manufacturer shall verify that the sealant will have a skin over time within the time limitations under field conditions.

Note 2: Cure Temperature $77^{\circ} \pm 3^{\circ} \text{ F}$ ($25 \pm 2^{\circ} \text{ C}$) at $50 \pm 5\%$ Relative Humidity.

Note 3: Cure Time 21 Days Maximum.

Note 4: Specimens shall be 0.5 in. x 0.5 in. x 2.0 in (13 mm x 13 mm x 50 mm).

Note 5: Type III material shall also demonstrate adhesion to asphalt blocks.

Note 6: Type I material shall have movement capability 10 cycles @ $+100 -50\%$.

708.4.1.3-Acceptance: Manufacturers of silicone joint sealants shall submit certified test data during the first calendar quarter of each year. The testing shall be performed by an independent testing laboratory. The test data must demonstrate that all requirements of the specifications are met. Only those sealants which have been evaluated and appear on the Division's approved list can be used on a project. Manufacturers are responsible for quality control of their product and the submission of test data in a timely manner in order to be considered for and/or continue to have their product on the approved list.

708.4.2-Joint Back-Up Material: Joint back-up material shall be compatible with the sealant. The material shall be the correct size to fit tightly in the joint to resist movement and to prevent the sealant from moving past the back-up material to the bottom of the joint.

708.5-VITRIFIED CLAY PIPE JOINTS HAVING RESILIENT PROPERTIES:

This material shall conform to the requirements of ASTM C 425.

708.6-HOT POUR MINERAL FILLED JOINT SEALER FOR SEWER AND CULVERT PIPE:

Hot pour mineral filled sealing compound shall conform to the requirements of Federal Specifications SS-S-169.

708.7-JOINTS FOR CIRCULAR CONCRETE SEWER AND CULVERT PIPE USING FLEXIBLE WATERTIGHT GASKETS:

Joints for circular concrete sewer and culvert pipe shall conform to the requirements of AASHTO M 198.

708.8-JOINT MORTAR:

Joint mortar shall consist of one part cement and two parts sand, with water as necessary to obtain the required consistency. Sand shall conform to the requirements of 702.2. Cement shall conform to the requirements of 701.4 for masonry construction. For other uses cement shall conform to the requirements of 701.1 or 701.3.

Mortar shall be used within 30 minutes after its preparation.

708.9-ASPHALT PLASTIC CEMENT:

708.9.1-General Requirement: Asphalt plastic cement is intended for use as a joint sealer for concrete and masonry. It shall consist of an asphalt base, volatile petroleum solvents, and mineral stabilizers, mixed to a smooth, uniform consistency, suitable for trowel application.

708.9.2-Composition:

	Minimum	Maximum
Nonvolatile Matter, %	70	
Mineral Matter (Ash), %	15	45

708.9.3-Physical Requirements: Uniformity-A thoroughly stirred sample shall show no separation of solvent or setting that cannot be overcome by moderate stirring after standing for 6 hours at room temperature in a closed container.

Workability-The asphalt plastic cement shall spread readily without drawing or pulling when applied to a metal test panel and spread to a thickness of approximately 1/8 inch (3 mm).

Behavior at 60° C (140° F)-A sample cured at room temperature for one hour, and heated in a (60° ± 2° C) oven for five hours shall show no blistering and not more than 1/4 inch (6 mm) sagging or slipping.

Behavior at 0° C (32° F)-After completion of the 60° C behavior test, the sample shall be cooled to 0 ± 2° C for one hour. Immediately after this exposure, the sample shall be bent around a 1 inch (25 mm) diameter mandrel. The sample shall show no cracking of the asphalt or separation of the asphalt from the panel.

708.9.4-Test Methods: Nonvolatile matter-Test in accordance with ASTM D 2822.

Ash-Transfer approximately 5 grams of the sample (weighed to the nearest 0.01g) to a crucible and heat at a low temperature (not above a dull red heat) until all carbon is consumed. Cool in a desiccator, weigh and calculate the percentage of ash.

708.10-WATERSTOPS (ELASTOMER MATERIAL):

All waterstops shall be produced by a molded or extrusion process such that, as supplied for use, they will be dense, homogenous, and free from holes and other imperfections. The cross section of the waterstop shall be uniform along the length and shall be symmetrical transversely so that the thickness at any given distance from either edge of the waterstop will be uniform. One three foot (meter) sample shall be furnished for each 1,000 ft. (300 meters), or fraction thereof, of each size of waterstop material.

The waterstops shall conform to the requirements in Table 708.10.1 for the polyvinylchloride waterstops and Table 708.10.2 for rubber waterstops.

TABLE 708.10.1

Polyvinylchloride Waterstops		
Property	Value	Test Method
Tensile Strength, Die "C", psi (Mpa)	1,400 (9.6) min.	ASTM D 412
Ultimate Elongation, Die "C", percent	280 min.	ASTM 412
Cold Bend Test	No Cracking	**

** The cold bend test shall be made by subjecting three full-width, one-inch long sample specimens to a temperature of 20°F for two hours. The specimen shall then be bent 180° around a ½ inch mandrel.

TABLE 708.10.2

Rubber Waterstops		
Property	Value	Test Method
Tensile Strength, Die "C", psi (Mpa)	2,000 (14) min.	ASTM D 412
Ultimate Elongation, Die "C", percent	360 min.	ASTM 412
Shore Durometer Hardness, Type A	60-85	ASTM D 2240
Absorption of Water, by Weight, percent	5 max.	ASTM D 570
Weight per linear ft.	0.67 lb. (0.3 kg) min.	-----

SECTION 709 METALS

709.1-STEEL BARS FOR CONCRETE REINFORCEMENT:

All bar reinforcement, whether deformed or plain, shall meet the requirements of AASHTO M31 or AASHTO MP18 and be NTPEP certified where applicable. All reinforcement for use in structures shall be labeled to correspond with marks on the plans before being shipped to the job site.

When reinforcing steel material is furnished by a supplier who is not certified under provisions of MP 709.01.50, with either epoxy coated or plain bar, the supplier shall at their expense be required to have each heat or lot of material to be furnished to the Division sampled by a Division approved inspection agency in accordance with MP 700.00.01 and shall have the samples tested for compliance with the governing specification by a Division approved laboratory. The test and inspection information shall be furnished in the Division approved computer acceptable format.

Epoxy coated reinforcing steel shall meet the requirements of ASTM A775, except that Section 12.1 of ASTM A775 shall be deleted and replaced with the following. The Contractor shall repair any damage to epoxy coating of reinforcing steel that occurs during shipment, storage and installation of the steel. The sum of all damage areas in each one foot (300 mm) length of bar shall not exceed two percent of the bar area. The total bar surface area covered by patching material shall not exceed five percent. All field handling and patching requirements shall conform to ASTM D3963.

709.2-PRESTRESSING REINFORCEMENT:

Prestressing reinforcement shall be high-tensile steel wire conforming to AASHTO M 204, high-tensile wire strand conforming to AASHTO M 203, or high-tensile-strength steel bars conforming to AASHTO M 275.

709.3-HOOK EXPANSION BOLTS FOR FASTENING WIRE MESH IN SHOTCRETE APPLICATIONS:

Hook fasteners for wire mesh reinforcement used in shotcrete applications shall meet the requirements of American Iron and Steel Institute (AISI) C1010 through C1018.

709.4-WELDED WIRE FABRIC FOR CONCRETE REINFORCEMENT:

Welded wire fabric for concrete reinforcement shall conform to the requirements of AASHTO M 55, except as modified.

Fabric reinforcement for pavement shall be not less than 5 feet (1.5 meters) in width and shall be shipped in sheets and not in rolls. Fabric for slope protection, gutters and miscellaneous items may be shipped in rolls. Sheets shall be bent in the shop as shown on the Plans. Epoxy coated welded wire fabric for concrete reinforcement shall meet the requirements of ASTM A 884/A 884M.

709.5-EXPANDED METAL PAVEMENT REINFORCEMENT:

Expanded metal pavement reinforcement shall be made from open-hearth mild steel plates by a cutting and drawing process to form a uniform diamond shape mesh. The weight per 100 sq. ft. (10 square) and size of the meshes shall be as specified on the Plans. The strands or members

shall be clean cut, straight and uniform in size. A bend test specimen cut from the furnished fabric shall withstand bending cold through 180 degrees flat upon itself without cracking on the outside of the bent portion. A tensile specimen cut from the furnished material shall have a minimum tensile strength of 55,000 psi (380 MPa). The chemical composition of the steel shall conform to SAE Standard No. 1010.

709.6-FABRICATED BAR OR ROD MATS FOR CONCRETE REINFORCEMENT:

Fabricated steel bar or rod mats shall conform to the requirements of AASHTO M 54.

709.7-JOINT TIE BOLT ASSEMBLY:

Joint tie bolt assemblies shall conform to the applicable details of the Standard Detail Book, Volume I. The bar used shall conform to the requirements of ASTM F432, Grade 55. The tensile strength of the assembly shall be not less than 15,000 lb. (65 kN) The coupling or shank of the hook bolt shall provide a positive stop to prevent the shank of the hook bolt from being threaded beyond the center of the coupling. The tie bolt assemblies shall be equipped with an approved fastener for installation of the assembly in the steel pavement form. The fastener shall hold the assembly in the designated position during the placing and finishing of the concrete and subsequent removal of the pavement forms without damage to the concrete or the tie bolt assembly.

709.8-HIGH STRENGTH LOW ALLOY STRUCTURAL METAL:

High-strength structural steel for bridges shall conform to AASHTO M270, grades 50, 50W, or HPS 70W. High-strength steel for all other applications shall conform to AASHTO M222 (weathering) or AASHTO M223.

709.9-BLANK

709.10-GRAY IRON, MALLEABLE IRON AND DUCTILE IRON CASTINGS:

Gray iron castings shall conform to the requirements of AASHTO M 105, Class No. 30.

Malleable iron castings shall conform to the requirements of ASTM A 47, Grade 32510. Castings shall be boldly filleted at angles, and the arrises shall be sharp and perfect.

Malleable iron castings for railings posts shall be Grade No. 32510 and shall be galvanized with hot-dipped zinc coating in accordance with AASHTO M 232.

Ductile iron castings shall conform to the requirements of ASTM A-536, Grade 80-55-6, 65-45-12 or 60-40-18.

The dimension tolerance for gray iron castings is $\pm 1/16$ inch per foot (5.2 mm per meter) and the weight tolerance is $\pm 5\%$.

All castings shall contain a manufacturer's heat number, lot number, or cast date. This identification shall be cast into the material at the time of manufacturer.

709.11-HP BEAMS, WIDE FLANGE BEAMS (WHALERS) AND SHEET PILING:

All HP beams and wide flange beams (whalers) used for structural piling systems shall be hot rolled, new and unused and conform to ASTM A572 Grade 50. All steel sheet piling shall conform to AASHTO M202/ASTM A328 Grade 50 unless otherwise directed on project plans.

709.12-STRUCTURAL AND EYEBAR STEEL:

All structural steel for bridges shall conform to the applicable grade of AASHTO M270 that is specified in the Plans. When no specific grade is called for, AASHTO M270, Grade 36 shall

be used. Non-designated structural steel in all other sections of the Specifications shall conform to ASTM A36.

709.13-STEEL FORGINGS AND STEEL SHAFTING:

709.13.1-Steel Forgings: Steel forgings shall conform to AASHTO M 102, Class E. They shall be bored as specified in 615.4.9.2. A record of the annealing or normalizing changes shall be furnished showing the forgings in such charge, the melt or melts from which they were secured and the treatment they received.

709.13.2-Steel Shafting: Cold finished carbon steel shafting shall conform to AASHTO M169 Grades 1016 through 1030, inclusive, unless otherwise specified.

709.14-STEEL CASTINGS:

Steel castings shall conform to the requirements of AASHTO M 103, except steel produced by the converter process shall not be used. All steel castings shall be grade 65-35 (450-240). Sharp unfilleted angles or corners shall not be permitted.

709.15-COATED DOWEL BARS & DOWEL BASKET ASSEMBLIES:

Coated dowel bars shall meet the requirements of AASHTO M254 except that the steel used to make the dowel bars shall meet the requirements of Section 709.1. Additionally, the coating applicator shall meet the requirements of Section 709.1.2 and the saw cut ends of the coated dowel bars shall be touched-up with a coating material in accordance with the requirements of Section 602.6.2.

709.16-BLANK

709.17-WELDED AND SEAMLESS STEEL PIPE:

Black and galvanized steel pipe shall meet the requirements of ASTM A 53. When used for other than pressure pipe, the hydrostatic test will be waived. Pipe for ferrous metal railing shall be galvanized after fabrication in accordance with AASHTO M 111.

709.18-COPPER ALLOY CASTINGS FOR BEARING, EXPANSION, AND NAME PLATES FOR BRIDGES:

709.18.1-Copper Alloy Castings for Bearing and Expansion Plates for Bridges: The copper alloy castings for bearing and expansion plates for bridges shall be bronze conforming to the requirements of AASHTO M 107, Copper Alloy UNS Number C91100.

709.18.2-Copper Alloy Castings for Name Plates for Bridges: The copper alloy for name plates shall meet the requirements of ASTM B584, alloy C83600, C83450, C83800, C92200, or C92210. The mechanical requirements of the specification are waived

709.19-ROLLED COPPER-ALLOY BEARING AND EXPANSION PLATES FOR BRIDGES:

The rolled plates shall conform to the requirements of AASHTO M 108, Alloy C51000 or C51100.

709.20-FLASHING FOR CONSTRUCTION AND EXPANSION JOINTS:

709.20.1-Copper: Copper shall conform to the requirements of AASHTO M 138. Any type cold finished, suitable for the purpose intended, may be used. The sheet shall withstand being bent cold through 180°, flat upon itself, without fracture on the outside of the bent portion. Unless otherwise specified, thickness of the sheet shall be 0.022 in. (approximately 16 oz. per sq. ft.) (550 µm (approximately 4.88 kg per square meter)) with a tolerance of ±0.002 in (50 µm).

709.20.2-Nickel-Copper Alloy: Nickel-copper alloy sheeting for flashing shall conform to the requirements of ASTM B 127. It shall be cold rolled, deep drawing and spinning quality. The thickness shall be as specified on the plans.

709.21-PIPES FOR FLOOR DRAINS AND DOWN-SPOUTS:

Cast iron pipe for floor drains and down-spouts shall conform to the requirements of ASTM A 74.

709.22-BLANK

709.23-STEEL BOLTS AND NUTS:

Material shall meet the requirements of ASTM A 307.

709.24-HIGH-STRENGTH BOLTS FOR STRUCTURAL STEEL JOINTS, INCLUDING SUITABLE NUTS AND HARDENED WASHERS:

709.24.1-Bolts, Nuts and Washers: All bolts, nuts and washers shall bear the manufacturer's markings and all markings specified in the applicable AASHTO specifications. All bolts, nuts and washers supplied shall be domestic, as defined in 106.1.1.1, and the manufacturer and identification marks shall be registered in the Industrial Fastener Institute's Technical Information Report IFI-122.

709.24.2-High-Strength Bolts: High-Strength bolts, black, galvanized or zinc rich coated, shall meet the requirements of AASHTO M 164 with the following exceptions. Zinc rich coated fasteners shall also meet the requirements of 709.24.10.

709.24.2.1-BLANK

709.24.2.2: Proof load tests (ASTM F606, Method #1) are required for all bolts except as excluded in Section 6.2 of AASHTO M 164. Minimum frequency of tests shall be as specified in AASHTO M 164, paragraph 9.5.1.

709.24.2.3: Wedge tests on full size bolts (ASTM F606, paragraph 3.5) are required. If bolts are to be galvanized or zinc rich coated, tests shall be performed after galvanizing or coating. Minimum frequency of tests shall be specified in AASHTO M 164, paragraph 9.5.1.

709.24.2.4: If galvanized or zinc rich coated bolts are supplied, the thickness of the zinc coating shall be measured. Measurements shall be taken on the wrench flats or top of bolt head.

709.24.3-Nuts: Nuts plain, galvanized or zinc rich coated shall meet the following requirements.

709.24.3.1: Nuts to be galvanized (hot-dip or mechanically galvanized), or to be zinc rich coated shall be grade DH or DH3 meeting AASHTO M 291 or shall be grade 2H meeting AASHTO M 292.

709.24.3.2: Plain (black) nuts shall be grade C, D or C3 meeting AASHTO M 291 or shall be grade 2 meeting AASHTO M 292 and shall have a minimum Rockwell hardness of 89 HRB (or Brinell hardness 180 HB). Plain nuts may also be supplied to grades listed in paragraph 709.24.3.1 above.

709.24.3.3: Nuts that are to be galvanized shall be tapped oversize the minimum amount required for proper assembly. The amount of overlap in the nut shall be such that the nut will assemble freely on the bolt in the coated condition and shall meet the mechanical requirements of the applicable AASHTO specification listed above and shall meet the requirements of the rotational-capacity test specified (the overtapping requirements of AASHTO M 291, paragraph 7.4 shall be considered maximum values instead of minimum, as currently shown).

709.24.3.4: Galvanized and zinc rich coated nuts shall be coated with a lubricant containing a dye of any color that contrasts with the color of the coating.

709.24.3.5: Proof load tests (ASTM F606, paragraph 4.2) are required for all nuts. Minimum frequency of tests shall be as specified in AASHTO M 291, paragraph 9.3 or AASHTO M 292, paragraph 7.1.2.1. If nuts are to be galvanized or zinc rich coated, tests shall be performed after coating, overtapping and lubricating.

709.24.3.6: If galvanized or zinc rich coated nuts are supplied, the thickness of the coating shall be measured. Measurements shall be taken on the wrench flats.

709.24.4-Hardened Washers: Hardened washers, plain, galvanized or zinc rich coated shall meet the requirements of AASHTO M 293 and the following:

709.24.4.1: If galvanized or zinc rich coated washers are supplied, hardness testing shall be performed after coating. (Coating shall be removed prior to taking hardness measurements).

709.24.4.2: If galvanized or zinc rich coated washers are supplied, the thickness of the coating shall be measured.

709.24.5-Rotational Capacity Testing: Rotational-capacity tests are required and shall be performed on all black (plain), galvanized (after galvanizing) bolt, nut and washer assemblies by the manufacturer or distributor prior to shipping. Washers are required as a part of the test. The following shall apply:

709.24.5.1: Except as modified, the rotational-capacity test shall be performed in accordance with the requirements of AASHTO M 164.

709.24.5.2: Each combination of bolt production lot, nut lot and washer lot shall be tested as an assembly.

709.24.5.3: A rotational-capacity lot number shall be assigned to each combination of lots tested.

709.24.5.4: The minimum frequency of testing shall be two assemblies per rotational-capacity lot.

709.24.5.5: The bolt, nut and washer assembly shall be assembled in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device. For short bolts which are too short to be assembled in the Skidmore-Wilhelm Calibrator see Section 709.24.5.9.

709.24.5.6: The minimum rotation, from an initial condition (10% of the specified bolt proof load), shall be:

240° (2/3 turn) for bolt lengths up to and including 4 diameters.

360° (1 turn) for bolt lengths over 4 diameters up to and including 8 diameters.

480° (1-1/3 turn) for bolt lengths over 8 diameters.

709.24.5.7: The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test are shown below:

ENGLISH

Diameter (Inches)	5/8	3/4	1/2	1	1 1/8	1 1/4	1 1/2
Required Installation Tension (kips)	19	28	39	51	56	71	103
Turn Test Tension (kips)	22	32	45	59	64	82	118

METRIC

Diameter (mm)	16	20	22	24	27	30	36
Required Installation Tension (kN)	91	142	176	205	276	326	475
Turn Test Tension (kN)	105	163	202	236	317	375	546

709.24.5.8: After the required installation tension listed above has been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following:

$$\text{Torque (T)} \leq 0.25 \text{ PD}$$

Where:

Torque (T) = measured torque (foot-pounds) (kN•m)

P = measured bolt tension (pounds) (kN)

C = Contractor's total overhead for contract period

D = bolt diameter (feet) (m)

709.24.5.9: Bolts that are too short to test in a Skidmore-Wilhelm Calibrator may be tested in a steel joint. The tension requirement of Section 709.24.5.7 need not apply. The

maximum torque requirement of Section 709.24.5.8 shall be computed using a value P equal to the turn test tension shown in the Table in Section 709.24.5.7.

709.24.6-Reporting of Test Results:

709.24.6.1: The results of all tests (including zinc coating thickness) required and in the appropriate AASHTO specifications shall be recorded on an appropriate document.

709.24.6.2: Location where tests are performed and date of tests shall be reported on the appropriate document.

709.24.7-Witnessing of Tests: The tests need not be witnessed by an independent inspection agency. However, the manufacturer or distributor that performs the test shall certify that the results recorded are accurate. Independent of the above, the Engineer reserves the right to witness any and all tests as the Engineer deems necessary. The manufacturer or distributor will notify the Engineer prior to conducting any tests.

709.24.8-Documentation:

709.24.8.1: Mill Test Report(s) (MTR) shall be furnished for all mill steel used in the manufacture of the bolts, nuts and washers. MTR shall indicate the place where the material was melted and manufactured.

709.24.8.2: Manufacturer Certified Test Report(s) (MCTR): The manufacturer of the bolts, nuts and washers shall furnish test reports (MCTR) for the items furnished. Each MCTR shall show the relevant information required in accordance with Section 709.24.6. The manufacturer performing the rotational-capacity test shall include on the MCTR:

- a. The lot number of each of the items tested.
- b. The rotational-capacity lot number as required in Section 709.24.5.3.
- c. The results of the tests required in Section 709.24.5.
- d. The pertinent information required in Section 709.24.6.2.
- e. A statement that MCTR for the items are in conformance to this specification and the appropriate AASHTO specification.
- f. The location where the bolt assembly components were manufactured.

709.24.8.3-Distributor Certified Test Report(s) (DCTR): The DCTR shall include MCTR above for the various bolt assembly components. The rotational-capacity test may be performed by a distributor (in lieu of a manufacturer) and reported on the DCTR. The DCTR shall show the results of tests required in Section 709.24.5; shall show the pertinent information required in Section 709.24.6.2 and shall show the rotational-capacity lot number as required in Section 709.24.5.3. The DCTR shall certify that the MCTR are in conformance to this specification and the appropriate AASHTO specifications.

709.24.9-Shipping:

709.24.9.1: Bolts, nuts and washers from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be watertight and shall be permanently marked with a shipping label on the container lid

and on the side of the container. The labels shall contain, as a minimum, the following information: quantity and description of contents, manufacturer's lot number for each item and the rotational-capacity lot number.

709.24.9.2: The appropriate MTR, MCTR or DCTR shall be supplied to the Engineer or representative prior to installation of any fasteners.

709.24.10-Zinc Rich Coated Fasteners:

709.24.10.1: Fastener components shall be vapor degreased, blast cleaned to Steel Structures Painting Council (SSPC) condition SSPC-10 (near white) and spray coated with a high ratio water-based inorganic zinc rich primer meeting the requirements of Section 711.20.2 of the Standard Specifications. The primer utilized shall be included on the Division of Highways Approved List of Zinc Primers. Copies of the Approval List are available from WVDOH District Materials Officers or from the Materials Division in Charleston, WV.

709.24.10.2: Dry film thickness of the zinc rich primer shall be 2 mils (50 μ m) minimum and 4 mils (100 μ m) maximum.

709.25-STEEL SHELLS OR CASINGS (DRIVEN WITHOUT MANDREL) FOR CAST-IN-PLACE PILES:

Steel shells or casings shall be composed of basic open hearth steel having a tensile strength of not less than 50,000 psi (345 MPa). The thickness of metal shall be as indicated on the Plans. The tips (small end) shall be equipped with a steel driving point securely fastened to the shell and the entire shell shall form one integral water-tight unit. Shells shall be tapered or step-tapered from top to bottom.

Any shell proposed for use shall be approved by the Engineer before driving.

709.26 through 709.28-BLANK

709.29-ZINC COATED STEEL SHEETS FOR USE IN MANUFACTURING TRAFFIC SIGNS:

The zinc coated steel sheets shall be 16 gage (USS) and shall conform to the requirements of ASTM A 525.

The sheets shall be resquared. They shall be furnished with a galvanized coating, Class 2.00.

The surface of the sheets shall be clean, free of oil, soot, dirt, scale, and other foreign material. They shall be protected in transit and shall be suitable for painting without cleaning or processing in any manner upon receipt by the Division.

709.30-CAST IRON SOIL PIPE AND FITTINGS:

Cast iron soil pipe and fittings shall conform to the requirements of ASTM A 74.

709.31-ALUMINUM ALLOY EXTRUSIONS AND ALUMINUM ALLOY EXTRUDED TUBE:

Aluminum alloy extrusions and extruded tube shall conform to ASTM B 221, alloy 6061, temper condition T6.

709.32-ALUMINUM ALLOY STANDARD STRUCTURAL SHAPES:

Aluminum alloy standard structural shapes, rolled or extruded, shall conform to ASTM B 308, alloy 6061, temper condition T6.

709.33-ALUMINUM ALLOY DRAWN TUBE:

Aluminum alloy drawn tube shall conform to ASTM B 210, alloy 6061, temper condition T6.

709.34-ALUMINUM ALLOY PIPES:

Aluminum alloy pipe shall conform to ASTM B 241, alloy 6061, temper condition T6.

709.35-ALUMINUM ALLOY RIVETS:

Aluminum alloy rivets shall conform to Military Specifications MIL-R-5674; grade and head style shall be as specified by the Engineer.

709.36-ALUMINUM ALLOY BOLTS, NUTS AND SET SCREWS:

Aluminum alloy bolts and set screws shall be made from rod conforming to ASTM B 211, alloy 2024, temper condition T4. The aluminum alloy nuts shall be made from rod conforming to either ASTM B 221, alloy 6061, temper condition T6 or ASTM B 211, alloy 6061, temper condition T6.

Bolt head and nuts shall conform to the American Standard Regular Hexagon, ASA Specifications B 18.2 with the following modification: the width across the flats and the width across the corners may exceed the maximum given in the specification tables by an amount no greater than 20 percent of the difference between the maximum and minimum values given in the tables.

Threads shall conform to American Standard Coarse Thread Class 2. The finished product shall be in the fully heat-treated and aged condition. Anchor bolts shall be given a clear anodic coating at least 0.0002 in (5 μ m) thick. Exposed nuts and washers need not be given as anodic coating.

709.37-ALUMINUM ALLOY WASHERS:

Aluminum alloy washers shall be made from sheet conforming to ASTM B 209, Alclad 2024, temper condition T3 or T4 depending upon the thickness supplied.

709.38-BLANK

709.39-ALUMINUM ALLOY SAND CASTINGS:

Aluminum alloy sand castings shall conform to Table 658.4.3.

709.40-ALUMINUM ALLOY SHIM MATERIAL:

Aluminum alloy shims shall be made from sheet or plate conforming to ASTM B 209, alloy 1100, temper condition 0.

709.41-ALUMINUM FILLER METAL FOR WELDING:

Aluminum filler metal for welding shall conform to ASTM B 285, alloy ER 4043.

709.42-GALVANIZED PIPE OR TUBING FOR HORIZONTAL DRAINS:

709.42.1-General: Horizontal drains may be of galvanized welded or seamless steel pipe, or galvanized tubing, conforming to the requirements prescribed.

The outside diameter shall be a nominal diameter of 2 inches (50 mm) or greater, and the wall thickness shall be a minimum of 0.043 in. (1 mm). The material shall be perforated. Perforations shall consist of two rows of 3/16 in. $\pm$ 1/32 in. (5 mm $\pm$ 1 mm) diameter holes along the length of the pipe or tubing. The holes in each row shall be on 2 inches $\pm$ 1/4 in. (50 mm $\pm$ 6 mm) centers. The row shall be 110 deg apart.

The material may be furnished in random or regular lengths.

709.42.2-Galvanized Welded or Seamless Steel Pipe: Galvanized welded or seamless steel pipe shall conform to the requirements of ASTM A 53. The hydrostatic test will be waived.

709.42.3-Galvanized Tubing: Galvanized tubing shall be circular in cross section with a welded seam. The base metal shall conform to the requirements of Table 1, AASHTO M 218M. The outside surface of the weld shall be metalized.

709.43 through 709.44-BLANK**709.45-GALVANIZED STEEL GUARDRAIL POSTS:**

Steel guardrail posts shall be fabricated from steel meeting the requirements of ASTM A36 or fabricated in accordance with ASTM A 769, Grade 40. They shall be of a section, length and weight as specified on the Plans. The weight shall not be less than 97.5 percent of that specified.

Galvanizing shall be in accordance with AASHTO M 111, with a minimum of 2 oz. per square foot (600 grams per square meter).

709.46-STEEL POSTS, POST BRACES AND GATE FRAMES FOR RIGHT-OF-WAY FENCE:

Unless otherwise specified, all right-of-way fence posts, post braces and grate frames shall meet the requirements of AASHTO M 181. Either Grade 1 or Grade 2 may be used unless one is specifically called for in the contract. Pipe members shall have the dimensions and weights called for on the plans.

Studded tee posts used as line posts for farm-field fence shall conform to the requirements of either AASHTO M281/ASTM A702 or ASTM A499 and coated to meet the requirements of AASHTO M111 unless otherwise directed on project plans.

709.47-BLANK**709.48-CADMIUM COATED MATERIALS:**

Cadmium coated (electrodeposited) steel articles, steel hardware, nuts, bolts, etc. shall meet the requirements of ASTM B766.

709.49-SHEET LEAD:

Sheet lead shall conform to the requirements of ASTM B 29.

709.50-STEEL PILE POINTS:

Steel pile points may be either ASTM A27 Grade 65/35 cast steel or ASTM A148 Grade 90/60. Pile points will be approved by the Materials Control, Soil and Testing Division.

709.51-U-CHANNEL BREAKAWAY MOUNTING DEVICES:

709.51.1-General Description and Requirements: The device shall be NCHRP-350 approved up to Test Level III for use with 2# per foot and 3# per foot-u-channel supports on installations with up to three (3) supports in a seven (7) foot lateral width. The device shall be designed to withstand cyclic loading (allowing for bending beyond 12%), yet break away safely on impact. The device shall be designed to not fail due to wind loading prior to failure of the sign support.

709.51.2-General Design and Functionality: The objective of the device shall be to ensure a signpost with release from an anchor upon impact from a motor vehicle. The device shall include a driven subgrade anchor, a receiver for the channel support, and a breakaway coupling connecting the receiver to the anchor,

Vehicle damage shall be minimized, as shall the risk to pedestrians after the post has been impacted. As a minimum, the device shall incorporate the following features:

1. The breakaway coupler shall be designed to shear or yield at any angle of incidence (360) degrees), with a constant amount of force, irrespective of vehicle velocity.
2. The breakaway coupler shall function effectively and independent of the sequence in which the fasteners are tightened. The sole function of the fasteners shall be to secure the sign post to the receiver and the coupler to the subgrade anchor. The receiver for the sign support shall be integral to the upper end of the coupler, eliminating the need for connection hardware.
3. Upon impact, no shards of metal shall be left above the top of the subgrade anchor, which shall be designed to be driven to grade. The anchor shall be automatically plugged to prevent any foreign matter or debris from entering, and to ensure protection from a pedestrian trip or fall accident.
4. No special tools such as torque wrenches or the like shall be required for effective installation or replacement of the receiver and breakaway coupler.
5. The receiver and breakaway coupler design shall enable the sign installer to fully reattach a signpost to the anchor within a five-minute period after a knock down.
6. When damaged by a direct wheel impact or vehicle under carriage, the design of the breakaway coupler shall facilitate reuse of the anchor.

709.51.3-Individual Component Features:

709.51.3.1-Breakaway Coupler: The breakaway coupler shall incorporate a hollow biconical or other similarly shaped shear section facilitating reliable true 360 degree functionality and enabling the post and receiver to separate cleanly from the anchor. To prevent trip or fall hazards, the coupler shall break cleanly and reliably at grade without leaving any sharp pieces of metal above grade. The coupler material shall provide for a minimum bending (elongation) of 12% prior to fracture. Upon impact the anchor shall remain undamaged with the inside of the anchor plugged by the remaining portion of the coupler. The bottom end of the coupler shall attach to the anchor by slidably fitting inside with the breakaway portion of the coupler being slightly above the anchor. The coupler shall incorporate a locking feature which applies equal and opposite force directly to a

minimum of two opposing side walls of the anchor through the tightening of one externally accessible fastener prior to or after installation of the sign support.

709.51.3.2-Anchor: The breakaway coupler shall attach to a square 2½“ x 2½” (min.) heavy duty anchor. The length of the anchor shall be 8” min. for concrete applications and 12” min. for asphalt applications. The anchor shall incorporate a tab completely around the top end such that the tab will sit flush on the road surface when completely driven, and will aid to seal the pre-driven hole from moisture and debris.

The anchor may be designed to allow a square 2”x2” ¼ “ wall (min.), 80 KSI min. yield strength seamless extension to slide into the end in order to meet the 12” length requirement in asphalt. The anchor a minimum of 4”. The anchor shall use a taper lock feature which is designed to ensure the joining of the anchor and the extension.

The anchor shall incorporate an inside plug or barrier, below the designed elevation of the bottom of the coupler after being inserted, to prevent moisture or soil from the bottom of the anchor to come into contact with the coupler.

709.51.3.3-Receiver: The receiver for the sign support shall be cast, and shall facilitate a snug male (sign support) to female (receiver) connection. The support shall be securely fastened to the receiver through the use of a maximum of two fasteners.

709.51.4-Component Materials and Coatings: The coupler and receiver components of the device shall be manufactured using material meeting the requirements of ASTM A536 (65-45-12 min). These components shall be coating with an exterior grade (UV protected) powder coating.

The subgrade anchor shall be manufactured from steel meeting the requirements of ASTM C1018. The entire anchor shall be covered with a rust inhibiting exterior grade epoxy coating.

SECTION 710 WOOD MATERIALS

710.1-STRUCTURAL MATERIALS:

Timber, lumber, piles, posts, and blocks shall meet the requirements of AASHTO M168 and AASHTO M133. Preservation and Treatment plants shall meet the requirements of the Book of Standards of the American Wood Protection Association (AWPA). All preservatives and treated wood products shall comply with US EPA regulations.

710.2-SPECIES AND GRADE:

710.2.1-Structural softwood shall meet the requirements of the Southern Pine Inspection Bureau (SPIB) grading rules. All wood for structural use shall be visually or mechanically graded for the requirements shown on the Plans or specified in the contract.

710.2.2-Structural hardwood shall meet the requirements of AASHTO M168 or the Northeastern Lumber Manufacturers Association (NeLMA) structural grades. The grade and species required shall be as shown on the Plans or specified in the contract.

710.2.3-Hardwood used for bridge decking shall meet the Standards of the National Hardwood Lumber Association (NHLA) for sound square edge, be rough sawn and sized by being processed through a hit or miss surfacer.

710.2.4-All graded material may either carry the appropriate grade stamp, or be inspected by an independent inspection agency approved by the Division.

710.3-PRESERVATIVE TREATMENT:

All wood products and preservative treatments used for highway and commercial use shall meet the requirements of AWPA Standard U1 and AASHTO M133.

The quantity of preservative shall be as required above, unless modified by the Plans or purchase order.

710.4-TREATMENT PLANTS:

Material treated with preservative may be purchased from certified or noncertified plants. Both types of plants shall adhere to the quality control procedures of AWPA M2.

710.4.1-Certified Plants: The Division's procedure for plant certification is defined in MP 710.01.40.

710.4.2-Noncertified Plants: Material purchased from noncertified plants will be tested on a lot by lot basis. The inspection shall be performed by a Division approved inspection agency. The cost of the inspection will be paid by the supplier. Shipments from noncertified plants shall be documented as described in MP 710.01.40.

710.5-WOOD POSTS:

Wood posts shall meet the requirements of AASHTO M168 and AASHTO M133 except round posts may be used for guardrail.

710.5.1-Round posts for guardrail shall meet the requirements of Section 5 "Material Requirements" of ANSI 05.1. Round posts for guardrail shall be from the major or minor species of Southern Pine.

710.5.2-Rectangular posts for guardrail shall be No. 1 major or minor species of Southern Pine as defined in Section 400 of the SPIB grading rules.

710.5.3-Dimensions of all guardrail posts except as noted on the Plans shall be as follows:

Round Guardrail Posts

Diameter: 7" $\pm \frac{1}{4}$ " (177 mm $\pm$ 6 mm) throughout the length except as noted on Plans.

Length: 6' $\pm \frac{1}{2}$ " (1 828 mm $\pm$ 13 mm)

Rectangular Guardrail Posts

Size: 6" $\pm \frac{1}{4}$ " X 8" $\pm \frac{1}{4}$ " (152 mm $\pm$ 6 mm by 203 mm $\pm$ 6 mm) throughout the length except as noted on Plans

Length: 6' $\pm \frac{1}{2}$ " (1 828 mm $\pm$ 13 mm)

710.5.4-Dimensions of wood posts for fence and signs shall be as shown on the Plans.

710.6-PLYWOOD:

710.6.1-Plywood shall meet the requirements of Product Standard PS-1 of U.S. Department of Commerce. All plywood shall be identified with the mark of a qualified inspection and testing agency. The identification shall include:

710.6.1.1-Species group classification, or class number, or span rating, depending on grade.

710.6.1.2-Either interior or exterior.

710.6.1.3-Grade name or grade of face and back veneers.

710.6.1.4-The symbol PS-1 signifying conformance with the standard.

710.6.2-Exterior plywood shall be bonded with exterior glue and the veneers used in manufacture cannot be less than grade C as defined in PS-1.

710.7-COMMON LUMBER:

710.7.1-Common lumber is untreated and suitable for general construction and utility purposes. Common lumber is from 2 inches (50 mm) to, but not including, 5 inches (125 mm) thick and is 2 inches (50 mm) or more in width. Common lumber shall be grade 2 or better, unless otherwise specified in the plans, when graded by the Board of Review of the American Lumber Standards Committee.

710.8-SERVICE AND LIGHTING POLES:

710.8.1: Wood Service or lighting poles shall be ANSI Class 5, or larger, or as called for on the contract plans. Lighting poles shall be southern yellow pine and service poles shall be either southern yellow pine or Douglas fir. The poles shall be pressure-treated to meet the requirements of AWWA U1 (Commodities Specification D: Poles).

SECTION 711

PAINTS, COATINGS, OILS, AND INKS

Paints shall consist of pigments and vehicles conforming to the general requirements of these specifications, proportioned and treated to produce materials possessing the detailed composition and physical properties.

General Requirements: The finished products shall not settle excessively nor cake in the container, shall be readily mixed with a paddle to a smooth uniform paint of specified consistency and working properties. The product shall not thicken, liver, skin, or curdle. The paint shall have a storage life of at least 12 months. No product may have VOC's in excess of 3.5 lbs /gal (420 g/l).

All ready mixed paints shall be furnished in containers holding not more than five gallons (20 liters), unless authorized by the Engineer. Shop paints may be furnished in larger containers providing approved mechanical agitation is available.

Each container shall bear a label with the following information: Name and address of the manufacturer, trade name or trade mark, type of paint, reference to the Division's Standard Specification Number, number of gallons (liters), lot or batch number, date of manufacture, and flash point. The label of two component systems shall include mixing instructions.

Sampling and testing shall be in accordance with MP 711.00.20. Quantities of 50 gallons (200 liters) or less may be accepted on manufacturer's certification.

711.1-BLANK

711.2-BOILED LINSEED OIL:

Boiled linseed oil shall conform to the requirements of ASTM C1315.

711.3 through 711.4-BLANK

711.5-MINERAL SPIRITS:

Mineral spirits shall conform to the requirements of ASTM D 235.

711.6-ORGANIC ZINC PRIMER:

711.6.1-General: This primer may be used in the shop on new steel or in the field on existing steel. When used as a shop primer, the material shall have a minimum slip coefficient of 0.50 (Class B) when tested in accordance with "Test Method to Determine the Slip Coefficient for Coatings used in Bolted Joints" as adapted by the Research Council on Structural Connections. Acceptance for field use shall be based on batch testing on materials that do not meet the minimum of 0.50 (Class B) slip coefficient. Initial approval of all material will be based on complete testing to assure specification compliance. The steel shall be capable of being blast cleaned to a near-white finish, SSPC-SP-10, for new steel, and to a commercial finish, SSPC-SP-6, for existing steel. The primer may be top coated with materials meeting the requirements of Subsections 711.22.3 and 711.22.4. The dry film thickness requirement for this material is three mils (75 µm) minimum unless specified otherwise.

711.6.2-Vehicle: The organic vehicles may include phenoxies, catalyzed epoxies, urethanes, chlorinated rubbers, styrenes, silicones, vinyls, and other suitable resinous binders.

They may be chemically cured or may dry by solvent evaporation. Under certain conditions, as approved by the Engineer, heat may be used to facilitate or accelerate hardening.

711.6.3-Physical Requirements:

	Minimum	Maximum	ASTM
i. Total Solids - % by weight of paint	70		D2369
<i>Variance shall be within $\pm 2\%$ of the percent solids by weight of the previously qualified paint.</i>			
ii. Pigment - % by weight of total solids	83		D2371
iii. Total zinc dust - % by weight of pigment	93		D521
iv. Total zinc dust - % by weight of total solids	77		
v. Mudcracking - The coating when applied to a five to six mil (125-150 μm) dry film thickness shall show no mudcracking when viewed under 8X magnification.			
vi. Adhesion - Shall be no less than 4B when evaluated in accordance with MP 711.00.20.			
vii. Salt Spray - Testing shall be in accordance with ASTM B117. After 1000 hours of continuous exposure, there shall be no evidence of checking, cracking, rusting, or blistering.			
viii. Viscosity of the mixed paint shall be in accordance with ASTM D 562. Variance shall be within ± 10 Krebs Units of the viscosity of the previously qualified paint.			
ix. Weight per gallon of the mixed paint shall be in accordance with ASTM D 1475. Variance shall be within ± 0.5 pounds (225 g) of the weight per gallon of the previously qualified paint.			

711.7 through 711.11-BLANK

711.12-EPOXY MASTIC MAINTENANCE COATING:

711.12.1-General: This specification provides the requirements for a two component, modified epoxy coating for use as a spot primer or a one coat system for use on poorly prepared surfaces on most existing structures. All ingredients are not specified, however, the finished product shall comply with the requirements prescribed.

The coating may be used as a primer over steel that has been cleaned to a minimum of a commercial finish meeting SSPC-SP-6. If it is used as a primer, it may then be coated with the manufacturer's recommended intermediate and top coat from the Division's approved list of Zinc Rich Low Voc Systems (711.22).

This coating shall also be suitable for use over zinc rich primers.

711.12.2-Composition: The pigment shall be flake metallic aluminum. The vehicle shall be modified epoxy resin and curing agent. The vehicle shall be formulated to permit trouble free application during normal humidity conditions.

711.12.3-Physical Requirements:

- i. **Dry to touch @ 5 mils, (125 μ m) dry, 24 Hours Maximum**
- ii. **Dry hard @ 5 mils, (125 μ m) dry, 72 Hours Maximum**
- iii. **Weight per gallon, 10.5 Lbs. Minimum**
- iv. **Corrosion resistance:** Steel panels meeting the requirements of MP 711.00.20, Section 5.2 shall be sandblasted to a white metal blast finish in accordance with SSPC-SP-5, exposed to the atmosphere for 30 days so uniform rusting occurs, and then hand cleaned with a wire brush in accordance with SSPC-SP-2. The panel shall then be spray applied with epoxy-mastic according to manufacturers' recommendations.
- v. **Fresh Water Resistance:** The coated panels shall be scribed to the base metal with an X of at least two inch (50 mm) legs and shall be immersed in fresh tap water at $75 \pm 5^\circ \text{ F}$ ($24^\circ \pm 3^\circ \text{ C}$). Upon examination after 30 days immersion, the panels shall be unaffected except for discolorations of the epoxy-mastic coating. There shall be no blistering, softening, or visible rusting beyond 1/16 inch (2mm) from the edge of the scribe mark.
- vi. **Salt Water Resistance:** Panels shall be scribed to the base metal with an X of at least two inch (50 mm) legs and shall be immersed in five percent sodium chloride solution at $75 \pm 5^\circ \text{ F}$ ($24^\circ \text{ C} \pm 3^\circ \text{ C}$). The panels shall be unaffected except for discoloration of the epoxy-mastic coating upon inspection after 30 days. There shall be no blistering, softening or visible rusting beyond 1/16 inch (2 mm) from the center of the scribe mark. The sodium chloride solution shall be replenished with fresh solution each week.
- vii. **Weathering Resistance:** Panels shall be tested in accordance with ASTM G 53. After 1,000 hours exposure, the coating shall show no rusting, blistering, or loss of adhesion to the test panel.
- viii. **Salt Fog Resistance:** Panels shall be scribed to the base metal with an X of at least two inch (50 mm) legs. The test panels shall then be tested in accordance with ASTM B 117. After 1,000 hours of continuous exposure, the coating shall show no loss of bond, nor shall it show rusting or blistering beyond 1/16 inch (2 mm) from the center of the scribe mark.
- ix. **Flexibility:** A steel panel that is No. 20 gage (0.0375 in. or 0.952 mil), but in no case, no thinner than No. 24 gage (0.025 in. or 0.635 mil) shall be blasted to a white finish meeting SSPC-SP-5, coated and cured for 14 days at $75^\circ \pm 5^\circ \text{ F}$ ($24^\circ \text{ C} \pm 3^\circ \text{ C}$). The epoxy mastic coating shall be applied at a minimum of 5 mils (125 μ m) dry film thickness. The coating shall display no sign of cracking or loss of adhesion when the panel is uniformly bent 180° around a $\frac{3}{4}$ inch (19 mm) diameter mandrel.
- x. **Application Properties:** The mixed paint, when thinned in accordance with manufacturer's recommendations, shall be capable of being sprayed in one coat at a 10 mils (250 μ m) wet film thickness without runs or sags. The properly thinned paint shall be capable of brush and roller application. The manufacturer's current printed instructions for application of epoxy-mastic coating shall be submitted to the Division for review and approval prior to application.

711.12.4-Packaging and Labeling: The epoxy-mastic coating shall be packaged in two containers, labeled Part A and Part B. Each container shall bear a label on which shall be clearly shown the manufacturer and brand name of paint, the lot number, and the date of manufacture.

The label on the containers shall also include complete instructions for the use of this paint. The inside of the container shall be coated, if necessary, to prevent attack by the paint components.

711.12.5-Acceptance Procedure: The Division will develop an approved list of products meeting this specification. This list will be placed on the Division's website.

The list shall be based upon testing performed by the Division. Upon approval by the Division, further testing will not be required unless random samples tested by the Division show non-compliance with any of the specification requirements.

The manufacturer shall supply the Materials Division the following for each product:

- i. One two gallon kit of the product
- ii. One gallon thinner
- iii. Instructions for mixing, thinning and application
- iv. Materials Safety Data Sheet for both the paint and thinner
- v. Product data sheet

711.12.6-Colored epoxy-mastic shall meet the above requirements with the following changes:

The metallic aluminum pigment shall be replaced by other pigments and coloring agent necessary to provide the specified color. The color choices permissible are from Federal Standard 595. The color difference, ΔE , of the acceptance samples shall not be more than 5 ΔE units from the standards listed below:

Federal Standard Numbers - 14062, 14223, 14241, 20062, 26373

- i. Gloss @ 60° shall be 30-50 for semi-gloss and 51 or greater for gloss finishes. Flat finishes shall have a gloss of 29 or less.

711.13-INKS:

Inks for use on reflective sheeting shall be as recommended by the manufacturer of the reflective sheeting.

711.13.1-Transparent Ink:

711.13.1.1-Color: The color shall meet the requirements of Table 1 and be tested in accordance with Section 7.1 of AASHTO M 268.

711.13.1.2-Black Ink: Black Ink shall be opaque process ink made with synthetic resin.

711.13.2-Clear Transparent Ink: Clear transparent ink for application as a final protective coat shall be as recommended by the manufacturer of the reflective sheeting.

711.14-OVERCOAT SYSTEMS:

711.14.1-General: This specification provides paint systems which may be used with minimal surface preparation.

711.14.2-Cleaning and Painting: Surface preparation will be limited to Hand or Power Tool Cleaning or Power Tool Cleaning to Bare Metal meeting SSPC-SP-2, SSPC-SP-3, or SSPC-SP-11. Application of the paint system shall be in accordance with the manufacturer's recommendations.

711.14.3-Acceptance: The Division will maintain an approved list of overcoat systems.

711.15 through 711.19-BLANK

711.20-INORGANIC ZINC RICH PRIMER:

711.20.1-General: This specification provides the requirements for an inorganic zinc rich primer. The primer is to be shop applied over a near white blasted surface, SSPC – SP-10.

711.20.2-Physical Requirements: This primer shall meet the requirements set forth in MP 711.20.59 and AASHTO M 300 with the following exceptions:

- a. Delete X-ray diffraction
- b. Delete accelerated weathering
- c. Delete bullet hole immersion test
- d. Delete humidity test
- e. Delete primer field performance requirement
- f. Delete infrared spectrum
- g. The VOC shall not exceed 3.5 lbs /gal (420 g / l).
- h. The adhesion shall be a minimum of 3B when tested in accordance with MP 711.00.20.
- i. The primer shall have a minimum slip coefficient of 0.50 (Class B) when tested in accordance with "Test Method to Determine the Slip Coefficient for Coatings used in Bolted Joints" as adapted by the Research Council on Structural Connections.

711.20.3- Acceptance Procedure: The Division will develop an approved list of products meeting this specification. This list will be placed on the Division's web –site.

The list shall be based upon testing performed by the Division. Upon approval by the Division, further testing will not be required unless random samples tested by the Division show non-compliance with any of the specification requirements.

711.21-REPAIR OF DAMAGED GALVANIZED SURFACES:

Repair of damaged galvanized surfaces will be done using a primer meeting the requirements Section 711.6.

711.22- ZINC RICH LOW VOC SYSTEM:

711.22.1-General: Initial approval of the system will be based on complete testing for specification compliance. Each product in the system shall be from the same paint manufacturer. Each coat shall be a contrasting color to the one previously applied. An intermediate coat meeting 711.22.3 may be needed to tie the primer and the top coat together. The use of the intermediate coat shall be at the option of the paint manufacturer. In either case, the adhesion of the system shall be at least 3A when testing in accordance with MP 711.00.20. Also see MP 711.22.22 for additional requirements.

The adhesion test shall be conducted approximately 14 days after application of the top coat.

All products are to have a VOC of 2.8 lbs / gallon (336 g/l) - Max. except the primer, which can go to 3.5 lbs / gallon (420 g/l) - Max.

The prime fabricator is responsible for choosing the paint system when shop applied.

711.22.2-Primer: The primer shall meet the requirements of 711.6 or 711.20.

711.22.3-Intermediate Coat: This material shall meet the manufacturer's specification and shall be compatible with a primer (711.6 or 711.20) and the top coat (711.22.4). See MP 711.20.60 for additional requirements.

711.22.4-Top Coat: This material shall meet the manufacturer's specification and shall meet the requirements of 711.22.4.1. All topcoat material shall be batch tested. Tinting of batches shall not be allowed unless as stated below. When the quantity of material is 50 gallons (200 liters) or less, the Division may elect to accept the material based on certified test data from the manufacturer. For projects requiring less than 25 gallons of topcoat, the topcoat may be tinted with prior approval by the Division.

711.22.4.1-Requirements:

- i. **Dry Hard** - 24 Hours Maximum
- ii. **Color** – The color choices permissible are from Federal Standard 595. The color difference, ΔE , of the acceptance samples shall not be more than five units from the Standards listed below:

Federal Standard Numbers - 14062, 14223, 14241, 20062, 26373

- iii. **Gloss @ 60°** shall be 30-50 for semi-gloss and 51 or greater for gloss finishes. Flat finishes shall have a gloss of 29 or less.

711.22.5-System: The system shall be composed of a primer (711.6 or 711.20) and topcoat. The primer shall be applied at a minimum of 3 mils (75 μm) dry. The intermediate coat shall be applied at a minimum of one mil (25 μm) dry. The top coat shall be applied at a minimum of 3 mils (75 μm) dry. The total coating over the primer shall be a minimum of 4 mils (100 μm) dry.

711.22.5.1-System Requirements:

Intercoat Adhesion-After all tests, the intercoat adhesion shall be at least 3A when tested in accordance with MP 711.00.20.

Accelerated Weathering-After cycling 1000 hours there shall be no evidence of checking, cracking, rusting, or blistering. The degree of chalking shall not be less than No. 6 when tested according to the ASTM G 154. The color difference after 1000 hours shall be no more than five ΔE units.

Salt Spray-Testing shall be in accordance with the ASTM B117. After 1000 hours of continuous exposure, there shall be no evidence of checking, cracking, rusting, or blistering.

Flexibility-(1/2 in. (13 mm) mandrel) – No failure

Chemical Resistance-The top coat shall show no visual deterioration, other than minor discolorations, after seven days exposure to:

- a) Ten percent sulfuric acid solution
- b) Ten percent sodium hydroxide solution

711.23 through 711.39-BLANK

711.40-TEMPORARY WHITE OR YELLOW TRAFFIC ZONE PAINT:

Temporary Traffic Zone Paint shall be any commercially available white or yellow paint designed for use on highways. The paint shall be applied with glass beads, designed by the manufacturer to be compatible with the paint.

711.40.1-Color and Retroreflectivity Requirements: The Contractor may retest any areas or sections reported as being deficient, in the presence of a project inspector, in order to verify the deficiency of the areas or sections. However, the final decision in regards to requiring re-striping shall be at the Project Engineers discretion.

COLOR: After the application of the glass beads or other retroreflective elements, each color installed shall fall within the boundaries created by the following CIE Chromaticity Coordinate Limits within three (3) and up to thirty (30) days after application:

COLOR	CIE CHROMATICITY COORDINATE LIMITS							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

RETROREFLECTIVITY: The markings shall be visibly retroreflective, under both dry conditions and conditions of moderate rainfall, within three (3) and up to thirty (30) days after application. The markings shall be readily visible when viewed with automobile headlights at night. Markings not meeting the above visual criteria shall be subject to replacement by the Contractor at no additional charge to the Division.

If necessary, retroreflectivity readings representing an adequate sampling, to be determined by the Project Engineer, may be performed by Division personnel. Readings shall be taken with an LTL 2000, or approved equal, hand held Retroreflectometer. The markings shall have a minimum retroreflective reading of 150 mc/lx/m² within three (3) and up to thirty (30) days after application. A 5% tolerance with the stated minimum required retroreflectivity values shall be allowed when tested with a hand held retroreflectometer.

711.40.2-MAP-21 Section 1504 Requirements: Reflective elements that are manufactured using glass and that are applied to temporary traffic zone paint shall meet all applicable state and federal requirements pertaining to materials content. Specifically, such elements shall meet the requirements of Section 1504 of MAP-21. Prior to application of the markings, the Contractor shall provide certifications of compliance with Section 1504 of MAP-21 for all applicable reflective elements. These certifications shall be from each supplier of applicable reflective elements to be used on the project, and shall identify the reflective elements being used on the project by stating the identifier used by the supplier(s), such as the product name(s) or product code number(s). Each supplier's certification shall be accompanied by a certification(s) from an independent testing laboratory. The lab certification(s) shall certify that a representative sample of the supplier's product(s) has been tested, and that the product(s) meets the requirements of Section 1504 of MAP-21. The lab certification(s) shall provide clear indication that the products tested include the product(s) specified by the supplier(s) in their certification letter(s), and shall indicate the date(s) that the testing was performed. The date of testing for each product shall be one (1) year or less prior to the letting date of the Contract. The representative sample(s) tested are not required to be from the same batch or lot number assigned to the reflective elements used on the project.

711.41-WHITE OR YELLOW FAST-DRY TRAFFIC PAINT (TYPE II):

711.41.1-General: The pavement marking material shall be formulated as a medium-life pavement marking system capable of providing a minimum of one year of continuous performance. Solvent born paint, methyl methacrylate, chlorinated rubber, or other short duration products will be not approved.

The composition of the paint shall be left to the discretion of the pavement marking manufacturer. The Contractor shall provide a pavement marking system to meet the performance requirements specified herein.

During the pavement marking warranty period, the pavement marking materials furnished and installed shall show no loss greater than five (5) percent due to tracking, chipping, spalling, poor adhesion to the pavement, and damage from traffic and normal wear. Loss due to pavement failure, unless caused by the marking material, will not be considered as a material failure and will not be included in the loss calculations and/or retroreflectivity readings.

There shall be no materials testing associated with the application of warranted pavement marking. However, the binder, bead type(s), application rate, and all other particulars shall be provided to the Engineer.

The pavement marking material shall be mixed uniformly throughout and shall have a homogeneous dispersement of color and beads when applied to the pavement. The material shall have a uniformly thick cross-section through its entire length.

An appropriate pavement marking material shall be used such that the ambient air temperature at the time of application is within the recommended ambient air application temperatures specified by the material manufacturer. Section 663 specifies that the Contractor shall be required to apply an appropriate Type II material at temperatures as low as thirty-five (35) degrees Fahrenheit (1.7 degrees Celsius).

The warranty and performance criteria of this specification shall apply to Type II markings placed on or after April 15th and prior to November 1st. Markings placed prior to April 15th, and on or after November 1st shall be required to meet the specified warranty performance requirements at the time of application only.

711.41.2-Color and Retroreflectivity Requirements: The Contractor may retest any areas or sections reported as being deficient, in the presence of a project inspector, in order to verify the deficiency of the areas or sections. However, the final decision in regards to requiring re-stripping shall be at the Project Engineers discretion.

COLOR: After the application of the glass beads or other retroreflective elements, each color installed shall fall within the boundaries created by the following:

COLOR	CIE CHROMATICITY COORDINATE LIMITS							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

The color shall show no appreciable discoloration due to aging during the warranty period of this pavement marking. Pavement markings shall be visually checked by the Engineer at any time during the warranty period of this pavement marking.

Additionally, the Engineer may at any time during the warranty period of this marking use a portable colorimeter to determine if the markings have faded or darkened beyond the above described CIE Chromaticity Coordinate Limits. The Colormeter used shall be a LTL-Y or other hand held colormeter device approved by the Division.

RETROREFLECTIVITY: Markings installed on or after April 15th and prior to November 1st shall maintain a minimum retroreflectivity value of 200 mcd/m²/lx for white pavement markings and 150 mcd/m²/lx for yellow pavement markings through October 31st.

Readings shall be taken with a LTL-X, or Traffic Engineering Division approved equal, 30 meter geometry retroreflectometer. A 5% tolerance with the stated minimum required retroreflectivity values shall be allowed when tested with a hand held retroreflectometer. A 15% tolerance with the stated minimum required retroreflectivity values shall be allowed when tested with a mobile retroreflectometer.

711.41.3-Sampling and Testing Procedures for Performance Samples: The Division may conduct periodic pavement marking reviews throughout the warranty period of the markings. These reviews will occur at any time up to one (1) year after the markings have been placed. These reviews will evaluate the pavement marking material within the project limits for either day and night acceptability considering all requirements listed above. The following method will be used to measure the retroreflectivity and color acceptance of the pavement marking material:

1. Locate and identify the starting point for measuring retroreflectivity of pavement markings for a roadway. Obtain five readings per line over a 1000 foot length of each line and calculate the average reading. Repeat this procedure at each mile point in the project, taking 5 readings per line over a 1000 foot section (500 feet on either side of the mile point), and averaging. Samples should be spaced out evenly over the entire 1000 foot section.

2. From each failed mile point, obtain an additional five readings for each failed line at a point 1/2 mile in each direction from the original failure point. Obtain five readings per line over a 1000 foot length of each line and calculate the average reading.
3. If the readings at either 1/2 mile point from the original failure point fail, the Contractor shall be required to re-stripe the entire 1/2 mile section between the original failure point and the failed 1/2 mile point.
4. If the readings at either 1/2 mile point from the original failed point pass, the Contractor shall be required to re-stripe a distance of 1/4 mile from the original failed point in the direction of the passing 1/2 mile point.
5. No readings shall be required to be taken between successive failing mile points and successive passing mile points. The Contractor shall be required to re-stripe the entire 1-mile section between successive failing mile points.
6. If a project is less than one-mile in length, but longer than 1/2 mile, 20 readings shall be taken for each line, spaced out evenly over the length of the project, and averaged to determine if each line is required to be re-striped. If a project is 1/2 mile or less in length, 10 readings shall be taken for each line, spaced out evenly over the length of the project, and averaged to determine if each line is required to be re-striped.

711.41.4-MAP-21 Section 1504 Requirements: Reflective elements that are manufactured using glass and that are applied to Type II traffic paint shall meet all applicable state and federal requirements pertaining to materials content. Specifically, such elements shall meet the requirements of Section 1504 of MAP-21. Prior to application of the markings, the Contractor shall provide certifications of compliance with Section 1504 of MAP-21 for all applicable reflective elements. These certifications shall be from each supplier of applicable reflective elements to be used on the project, and shall identify the reflective elements being used on the project by stating the identifier used by the supplier(s), such as the product name(s) or product code number(s). Each supplier's certification shall be accompanied by a certification(s) from an independent testing laboratory. The lab certification(s) shall certify that a representative sample of the supplier's product(s) has been tested, and that the product(s) meets the requirements of Section 1504 of MAP-21. The lab certification(s) shall provide clear indication that the products tested include the product(s) specified by the supplier(s) in their certification letter(s), and shall indicate the date(s) that the testing was performed. The date of testing for each product shall be one (1) year or less prior to the letting date of the Contract. The representative sample(s) tested are not required to be from the same batch or lot number assigned to the reflective elements used on the project.

SECTION 712 GUARDRAIL AND FENCE

712.1 through 712.3-BLANK

712.4-GALVANIZED STEEL DEEP BEAM GUARDRAIL, FASTENERS AND ANCHOR BOLTS:

Galvanized steel deep beam guardrail, fasteners and anchor bolts shall conform to AASHTO M180, Type II, Class A.

712.5 through 712.7-BLANK

712.8-CHAIN-LINK FENCE:

Chain-link fence shall conform to the requirements of AASHTO M 181. Fence height, gage and details shall be as specified on the Plans.

712.9-ZINC-COATED (GALVANIZED) IRON OR STEEL FARM-FIELD AND RAILROAD RIGHT-OF-WAY WIRE FENCING:

This fencing shall meet the requirements of AASHTO M 279 and details shown on the Plans. Either of the following styles and coating classes may be used.

1. Style 1047-6-9 with Class 1 coating
2. Style 1047-6-11 with Class 3 coating

Zinc coating for miscellaneous steel fittings and hardware shall conform to the requirements of AASHTO M 232. Zinc coating for clips used for securing fence or wire shall conform to AASHTO M 279, Class 1 coating.

712.10-COATED STEEL BARBED WIRE:

Barbed wire shall meet the requirements of AASHTO M 280, Class 1 or AASHTO M 305, Type I.

712.11-SAFETY FENCE:

Safety Fence shall be orange in color, commercially manufactured from UV stabilized high-density polyethylene or a suitable substitute approved by the Engineer.

SECTION 713 METAL PIPE

713.1-BLANK

713.2-METALLIC COATED CORRUGATED STEEL PIPE AND PIPE ARCH:

Metallic coated corrugated steel pipe and pipe arch shall conform to the requirements of AASHTO M 36 for Type I and Type II pipe.

Special sections, such as elbows, for these conduits shall be of the same gage as the conduit to which they are jointed, and shall conform to the applicable requirements of AASHTO M 36.

713.3-BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCH:

Bituminous coated corrugated steel pipe, pipe arches, coupling bands, elbows, and other special sections shall conform to the requirements of AASHTO M 190. Coating and invert paving shall be of the type specified.

713.4-FULL BITUMINOUS COATED AND FULL PAVED CORRUGATED STEEL PIPE:

The pipe shall conform to the applicable requirements of AASHTO M 190 and in addition thereto, when riveted corrugated steel pipe is used, the rivets shall be placed on the outside crests of corrugations. Bituminous coating shall be in accordance with the requirements for Type A; the paving shall be in accordance with the requirements for Type B except that the pavement shall be formed on the inside for the entire circumference of the pipe. Smooth lined pipe over 30 inches (750 mm) in diameter shall have lifting lugs attached to each section when manufactured.

713.5-FIBER BONDED FULL BITUMINOUS COATED CORRUGATED STEEL PIPE AND PIPE ARCH:

713.5.1-Type A, Fiber Bonded Full Bituminous Coated: Fiber bonded full bituminous coated conduits shall comply with the requirements of AASHTO M 36 for base metal, and fabrication where applicable. The conduit shall be formed from sheets which have been coated on both sides with a layer of aramid fibers, applied in a sheet form by pressing them into a molten metallic bonding medium. Immediately after the metallic bond has solidified, the fibers shall be thoroughly saturated with a bituminous saturant. The finished sheets shall be of first class commercial quality, free from blisters and unsaturated spots. In addition, the conduit shall be coated inside and out with a bituminous material complying with the requirements of AASHTO M 190, Type A.

713.5.2-Type C, Fiber Bonded Full Bituminous Coated and Paved Invert: Fiber bonded full bituminous coated and paved conduits shall comply with all the requirements of 713.5.1 and shall be paved to conform with the requirements in AASHTO M 190, Type C.

713.6-FIBER BONDED FULL BITUMINOUS COATED AND FULL PAVED CORRUGATED STEEL SEWER PIPE:

Fiber bonded full bituminous coated and full paved steel sewer pipe shall comply with the requirements of 713.5.1, where applicable, and in addition thereto, the rivets shall be placed on the outside crests of the corrugations and the inside of the pipe shall be paved so that a smooth surface

will be formed filling the corrugations of the pipe with a minimum thickness of 1/8 in. (3 mm) over the crests of the corrugations. Smooth lined pipe over 30 inches (750 mm) in diameter shall be provided with lifting lugs for each section when manufactured.

713.7-CORRUGATED STAINLESS STEEL CULVERTS AND UNDERDRAINS:

Corrugated stainless steel culverts and underdrains shall comply with the requirements of zinc coated (galvanized) corrugated iron or steel culverts and underdrains, AASHTO M 36, with the following exceptions (Numbers refer to Subsections in AASHTO M 36):

1. SCOPE:

- 1.1 This specification covers corrugated stainless steel culverts and underdrains.

3. IRON OR STEEL SHEETS:

- 3.1 The stainless steel sheets shall conform with the requirements of SAE Standard J-405B, Alloy Grade SAE 51409.

6. SHEET MANUFACTURER'S GUARANTEE:

- 6.1 The manufacturer of the sheets shall submit with the certified analysis a guarantee providing that all metal furnished conforms with the Specification requirements, shall bear a suitable identification brand or mark, and shall be replaced without cost to the purchaser when not in conformity with the specified analysis and sheet thickness; and the guarantee shall be so worded as to remain in effect as long as the manufacturer continues to furnish material.

7. RIVETS:

- 7.1 Rivets shall conform to the requirements of SAE Standard J-405B, Alloy Grade SAE 51430, or ASTM A 276, Type 430.

10. CORRUGATIONS:

Corrugations shall be annular, spiral or a combination of annular and spiral.

12. RIVETED SEAMS:

- 12.2 For pipe with 1 in. (25 mm) deep corrugations, ½ in. (12 m) diameter bolts and nuts conforming to the requirements of ASTM A 276. Type 430, may be used in lieu of rivets or spot welds on a one-for-one replacement ratio.

In Table 2, substitute sheet thickness as follows:

.048 (1.2 mm)	.105 (2.7 mm)
.060 (1.5 mm)	.135 (3.4 mm)
.075 (1.9 mm)	.164 (4.2 mm)

15. RESISTANCE SPOT WELDED SEAMS:

- 15.1.2 The welding shall be performed in such a manner that (1) the exterior surfaces of 90 percent or more of the spot welds on a length of pipe shall show no evidence of burning of the metal. Discoloration of the spot weld surfaces will not be cause for rejection.

15.3.5 In Table 3, substitute sheet thickness as follows:

Inches (mm) (Approx.)	Pounds (Mg)
.048 (1.2 mm)	3,100 (1.40)
.060 (1.5 mm)	4,100 (1.85)
.075 (1.9 mm)	5,200 (2.36)
.105 (2.7 mm)	7,000 (3.17)
.135 (3.4 mm)	8,500 (3.85)
.164 (4.2 mm)	10,000 (4.52)

19. TYPE III PIPE:

19.1 Culverts furnished under this type shall consist of stainless steel corrugated metal pipe to be used in underdrains. Unless otherwise specified the pipe shall be perforated.

21. COUPLING BANDS:

21.1 Revise third sentence as follows: The coupling bands shall be made of base metal conforming to SAE Specification J-405B, Alloy Grade 51409.

23. WORKMANSHIP:

23.1.10 Delete this Subsection.

24. REPAIR OR DAMAGED SPECTER COATING:

Delete this Subsection.

25. Add the following notation: This Section applies only with reference to those factors applicable to a stainless steel sheet.

713.8-STRUCTURAL PLATE FOR PIPE, PIPE ARCH, AND ARCHES:

These conduits, and bolts and nuts for connecting plates, shall conform to the requirements of AASHTO M 167.

713.9-FULL BITUMINOUS COATED STRUCTURAL PLATE PIPE, PIPE ARCH, AND ARCHES:

These conduits shall conform to the requirements of AASHTO M 167 and shall be coated with bituminous material. When the coating can be applied in the shop it shall conform to the requirements of AASHTO M 190, Type A Coating. When the coating must be applied in the field the coating shall conform to the requirements of AASHTO M 243. The bituminous coating shall coat the entire inside and outside of the pipe and is not required between the metal sheets at the splices.

713.10-STAINLESS STEEL STRUCTURAL PLATE PIPE:

Stainless steel structural plate pipe shall comply with the applicable requirements of structural plate pipe, AASHTO M 167, with the following exceptions (Numbers refer to Subsections in AASHTO M 167):

1. SCOPE:

This specification covers stainless steel structural plate pipe.

2. BASE METAL:

The stainless steel sheets shall conform with the requirements of SAE Standard J-405B, Alloy Grade SAE 51409.

4. GAGE DETERMINATIONS AND TOLERANCE:

In Table II substitute as follows:

Gage	Sheet Thickness (Inches)	Tolerance Under
1	.276 (7 mm)	.012 (300 µm)
3	.245 (6.2 mm)	.012 (300 µm)
5	.215 (5.5 mm)	.012 (300 µm)
7	.184 (4.7 mm)	.012 (300 µm)
8	.164 (4.2 mm)	.012 (300 µm)
10	.135 (3.5 mm)	.012 (300 µm)
12	.105 (2.7 mm)	.012 (300 µm)

8. CERTIFIED ANALYSIS AND GUARANTEE:

The manufacturer of the sheets shall submit with the certified analysis a guarantee providing that all metal furnished conforms with the specification requirements, shall bear a suitable identification brand or mark, and shall be replaced without cost to the purchaser when not in conformity with the specified analysis and sheet thickness; and the guarantee shall be so worded as to remain in effect as long as the manufacturer continues to furnish material.

10. BOLTS AND NUTS FOR CONNECTING PLATES:

Material for bolts and nuts shall conform to the chemical and mechanical requirements of ASTM A 276, Type 431, Condition T. Size and geometric configuration shall conform to the applicable requirements of ASTM A 325, Paragraph 5.

713.11-METALLIC COATED CORRUGATED STEEL UNDERDRAIN PIPE:

Metallic coated corrugated steel underdrain pipe shall conform with the requirements of AASHTO M 36 Type III.

713.12-BITUMINOUS COATED CORRUGATED STEEL UNDERDRAIN PIPE:

This pipe shall conform to the requirements of AASHTO M 36, Type III, and shall be coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating, except that the minimum coating thickness, shall be 0.03 in. (750 µm) Coupling bands shall be fully coated. The specified minimum diameter of perforations shall apply after coating.

713.13-BLANK

713.14-CORRUGATED ALUMINUM ALLOY PIPE AND PIPE ARCHES:

Corrugated aluminum alloy pipe and pipe arches shall conform to the requirements of AASHTO M 196, Type I and II. Helically corrugated aluminum alloy culvert pipe shall conform to the requirements of AASHTO M 211.

Certification from the manufacturer will be the basis of acceptance for band material and rivets used in the fabrication.

713.15-BITUMINOUS COATED CORRUGATED ALUMINUM ALLOY PIPE AND PIPE ARCHES:

Bituminous coated corrugated aluminum alloy pipe, pipe arches, coupling bands, elbows, and other special sections shall conform to the requirements of AASHTO M 190. Coating and invert paving shall be of the type specified.

713.16-CORRUGATED ALUMINUM ALLOY PIPE UNDERDRAIN:

Corrugated aluminum alloy pipe underdrain shall conform to the requirements of AASHTO M 196, Type III.

713.17-BITUMINOUS COATED CORRUGATED ALUMINUM ALLOY PIPE UNDERDRAIN:

This pipe shall conform to the requirements of AASHTO M 196, Type III, and shall be coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating, except the minimum coating thickness shall be 0.03 in. (750 μ m) Coupling bands shall be fully coated. The specified minimum diameter of perforations shall apply after coating.

713.18-ALUMINUM ALLOY STRUCTURAL PLATE FOR PIPE, PIPE ARCH, AND ARCHES:

These conduits and the bolts and nuts for connecting plates shall conform to the requirements of AASHTO M 219.

713.19-FULL BITUMINOUS COATED ALUMINUM ALLOY STRUCTURAL PLATE PIPE, PIPE ARCH, AND ARCHES:

These conduits shall conform to the requirements of AASHTO M 219 and shall be coated with bituminous material conforming to the requirements of AASHTO M 190, Type A coating.

713.20-END SECTIONS FOR CORRUGATED STEEL PIPE AND PIPE ARCHES:

End sections for corrugated iron or steel pipe and pipe arches shall be of the thickness recommended by the manufacturer, and they shall conform to the applicable requirements of AASHTO M 36 and the details shown on the Plans.

713.21-END SECTIONS FOR CORRUGATED ALUMINUM ALLOY PIPE AND PIPE ARCHES:

End sections for corrugated aluminum alloy pipe and pipe arches shall be of the thickness recommended by the manufacturer and they shall conform to the applicable requirements of AASHTO M 196 or M 211 and the details shown on the Plans.

713.22-BLANK

713.23-PRECOATED, METALLIC COATED STEEL PIPE AND UNDERDRAIN:

Precoated sheets shall have a Type B coating conforming with the requirements of AASHTO M 246. The minimum thickness shall be 10 mils (250 μm) on the inside and 3 mils (75 μm) on the outside of the pipe.

Precoated, metallic coated steel pipe and underdrain shall conform to the requirements of AASHTO M 245 with the following exceptions (numbers refer to subsections of AASHTO M 245).

- 19.1 Coupling bands, conforming to the requirements of AASHTO M 218, will not require organic coating.
- 22.1.1 Damaged areas of spelter coating shall be painted in this sequence:
 - 1. Zinc rich primer conforming to Section 711.21.
 - 2. Red oxide lacquer primer.
 - 3. Lacquer.
- 22.1.2 Areas of damaged polymeric coating only shall be painted in this sequence after the areas are rubbed with commercially available acetic acid (such as vinegar) and dried:
 - 1. Red oxide lacquer primer.
 - 2. Lacquer.

The primer and lacquer as specified above must be mutually compatible when applied and compatible with the polymeric coating. The red oxide primer and lacquer, which are commercially available, shall be allowed to completely dry between coats and before handling and backfilling. If the lacquer is applied from a spray can, a minimum of two coats is required. The first coat should provide a light covering, and the second coat should be applied heavily just to the point of running.

713.24-ALUMINUM COATED CORRUGATED STEEL PIPE AND PIPE ARCH:

These conduits shall conform to AASHTO M 36 requirements for aluminum coated or aluminum-zinc coated corrugated steel pipe and pipe arch.

SECTION 714 CONCRETE, CLAY, FIBER AND PLASTIC PIPE

714.1-NONREINFORCED CONCRETE PIPE:

This pipe shall conform to the requirements of AASHTO M 86 or ASTM C 14.

714.2-REINFORCED CONCRETE CULVERT, STORM DRAIN AND SEWER PIPE:

This pipe shall conform to the requirements of AASHTO M 170 or ASTM C 76 and MP 711.03.30.

714.3-REINFORCED CONCRETE ARCH CULVERT, STORM DRAIN AND SEWER PIPE:

This pipe shall conform to the requirements of AASHTO M 206 or ASTM C 506.

714.4-REINFORCED CONCRETE ELLIPTICAL CULVERT, STORM DRAIN AND SEWER PIPE:

This pipe shall conform to the requirements of AASHTO M 207 or ASTM C 507.

714.5-PERFORATED CONCRETE PIPE:

This pipe shall conform to the requirements of AASHTO M 175 or ASTM C 444.

714.6-POROUS CONCRETE PIPE:

This pipe shall conform to the requirements of AASHTO M 176.

714.7-CONCRETE DRAIN TILE:

This pipe shall conform to the requirements of AASHTO M 178 or ASTM C 412.

714.8-CLAY DRAIN TILE:

Drain Tile shall conform to the requirements of AASHTO M 179 or ASTM C 4.

714.9-VITRIFIED CLAY-LINED REINFORCED CONCRETE PIPE:

Designs for fully lined or half lined pipe of the specified strength classes shall be submitted for approval. The applicable requirements of AASHTO M 170 and AASHTO M 65 or ASTM C 479 shall govern. Liner or liner elements shall be clay of first quality, sound, thoroughly and perfectly burned, without warps, cracks, or other imperfections, and they shall be fully and smoothly glazed.

714.10-CLAY PIPE:

This pipe shall conform to the requirements of AASHTO M 65 or ASTM C 700. Extra strength clay pipe may be substituted for standard strength.

714.11 through 714.12-BLANK

714.13-PERFORATED ASBESTOS CEMENT PIPE FOR UNDERDRAINAGE:

The pipe shall conform to the requirements of AASHTO M 189 or ASTM C 508.

714.14-BITUMINIZED FIBER PIPE FOR UNDERDRAINAGE:

This pipe shall conform to the requirements of ASTM D 1861 or ASTM D 1862.

714.15-PERFORATED BITUMINIZED FIBER PIPE FOR UNDER-DRAINAGE:

This pipe and fittings shall conform to the requirements of ASTM D 2311.

714.16-FIBERGLASS-REINFORCED (FRP) PIPE:

This pipe shall conform to ASTM D 2996 or ASTM D 2997. Fittings shall be those recommended by the manufacturer.

714.17-REINFORCED PLASTIC MORTAR (RPMP) PIPE:

This pipe shall conform to ASTM D 3262. Fittings shall be those recommended by the manufacturer.

714.18-REINFORCED CONCRETE END SECTIONS:

Precast reinforced concrete end sections shall conform to the requirements of the cited Specifications for the conduit to the extent to which they apply and to the details shown on the Plans.

714.19-CORRUGATED POLYETHYLENE PIPE:

For nominal pipe sizes of 3 to 6 inches (75 to 150 mm) when perforations are required the pipe shall meet the requirements of AASHTO M 252 with class 2 perforations.

For nominal pipe sizes of 3 to 10 inches (75 to 250 mm) when perforations are not required the pipe shall meet the requirements of AASHTO M 252 type "S" only.

For nominal pipe sizes of 12 to 60 inches (300 to 1 500 mm) the pipe shall meet the requirements of AASHTO M 294 type "S" or type "D" only.

714.20-PERFORATED PLASTIC SEMICIRCULAR PIPE:

Perforated plastic semicircular pipe shall be extruded or molded using a high density, flexible plastic.

The pipe shall have a smooth or corrugated top and a smooth semicircular bottom, averaging 4-5/8 inches (116 mm) in diameter, with perforations uniformly distributed along the top of the semicircular section. The perforations shall be not less than 1/4 inch (6 mm) nor more than 3/8 inch (10 mm) in diameter, and shall provide a minimum intake area of one square inch per linear foot (2100 sq. mm per m). Minimum material thickness shall be 1/8 in. (3 mm). The top flange shall extend a minimum of 1/2 in. (13 mm) beyond the top of the semi-circular section.

A one foot (300 mm) section of pipe shall deflect no more than 1 1/2 at an applied load of 900 lb. (38 mm), using the Parallel Plate Load Test of ASTM D 2412. Fifteen minutes after removal of the load, the pipe section shall have recovered not less than 50 percent of its deflection at 900 lb. (4 kN).

714.21-ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PIPE:

This pipe and fittings shall conform to AASHTO M 264, ASTM D 2680 or ASTM D 2751.

714.22-POLYVINYL CHLORIDE (PVC) PIPE:

The pipe and fittings shall conform to the requirements of AASHTO M278, ASTM D3034 or ASTM F949.

714.23-PRECAST REINFORCED CONCRETE BOX CULVERTS:

Precast reinforced concrete box culverts shall conform to the requirements of AASHTO M259 where depth of cover is 2 feet (600 mm) or more and AASHTO M273 where depth of cover is less than 2 feet (600 mm). Interstate live load design shall be provided for Interstate highway facilities; and HS20 live load design shall be provided for other locations.

All fabricators of precast reinforced concrete box culverts shall maintain an adequate level of quality control. Plant certification by NPCA (National Precast Concrete Association), ACPA (American Concrete Pipe Association) plant certification for box culverts, or other approved equal certification program will be required to verify this level of quality control. Plant approval must be obtained prior to the start of fabrication. All Fabricators shall then submit evidence of Plant approval to the MCS&T Division on an annual basis.

All box culverts shall be cured in accordance with section 601.12 except that curing may be discontinued once 70% of the design strength is achieved.

714.24-NON-ASBESTOS FIBER-CEMENT STORM DRAIN PIPE:

This pipe shall conform to the requirements of ASTM C 1450, and the water used in the fabrication of this pipe shall meet the requirements of section 715.7.

SECTION 715 MISCELLANEOUS MATERIALS

715.1-CALCIUM CHLORIDE:

The material shall conform to the requirements of ASTM D 98.

715.2-SODIUM CHLORIDE:

The material shall conform to the requirements of ASTM D 632.

715.3-BLANK

715.4-CONCRETE REPAIR MATERIALS:

715.4.1-Cementitious Materials for Concrete Repairs: Material to be used in concrete repair applications that will not be subjected to any type of loading for a minimum of 24 hours shall meet the minimum requirements of ASTM C 928 with the exception of the requirements for consistency listed in Table 1.

715.4.2-Non-Cementitious Materials for Concrete Repairs: This includes materials such as methyl methacrylate, polymer concrete, and other polymer/epoxy based materials used for concrete repairs. These materials will be evaluated and approved on a case-by-case basis. Follow preparation, mixing, and application procedures as prescribed in the specific material supplier's instructions.

715.5-PACKAGED DRY, HYDRAULIC-CEMENT GROUT (NON-SHRINK):

The material shall conform to the requirements of ASTM C1107.

715.6-HYDRATED LIME:

715.6.1-General Use: The material shall conform to the requirements of ASTM C206.

715.6.2-Soil Stabilization or Pavement Preservation Purposes: The material used in for soil stabilization purposes or pavement preservation purposes shall conform to the requirements of ASTM C977.

715.7-WATER FOR USE WITH HYDRAULIC CEMENT:

Water from sources other than treated public water systems shall conform to the requirements of MP 715.07.20.

715.8-WATERPROOFING FABRIC:

The material shall conform to the requirements of ASTM D173.

715.9-WARNING DEVICES:

715.9.1-General: Warning devices shall include, but shall not be limited to, signs, barricades, auxiliary barriers, channelizing devices, hazard warning lights, flares, and reflectors. Unless otherwise indicated such devices shall conform to the standard, "Manual on Temporary Traffic Control for Streets and Highways ", published by the Division. The

Contractor shall exhibit evidence that the warning devices furnished meet the requirements detailed.

715.9.2-Signs: Sign blank material shall be either 0.080 in. flat sheet aluminum, 0.040 in. flat sheet aluminum (guide sign demountable shields, legend, & border only), or extruded panel as specified in Section 661. Retroreflection shall be required and shall be accomplished by using approved retroreflective sheeting as specified in Section 661 and meeting the requirements specified herein.

All references herein to ASTM specification D4956 shall be interpreted as referencing version D4956 – 11a. Any portion of this specification which is in contradiction to ASTM D4956 shall supersede ASTM D4956. All references herein to AASHTO (American Association of State Highway and Transportation Officials) specification M268 shall be interpreted as referencing version M 268-10. Any portion of this specification which is in contradiction to AASHTO M268 shall supersede AASHTO M268. All AASHTO-NTPEP references herein shall be interpreted as referring to the AASHTO National Transportation Product Evaluation Program (NTPEP). All retroreflectivity values referenced herein shall be in units of $\text{cd}/\text{fc}/\text{ft}^2$ ($\text{cd} \cdot \text{lx}^{-1} \cdot \text{m}^{-2}$). All “matched component” references herein shall be interpreted as referencing the retroreflective sheeting manufacturer’s recommended inks and overlay films to be used for manufacturing purposes with the manufacturer’s sheeting. All APL references herein shall be interpreted as referring to the Division’s Approved Products List (APL) for Retroreflective Sheeting. All CSS references herein shall be interpreted as referring to the Division’s Central Sign Shop (CSS) internal sign manufacturing facility in Charleston, WV.

715.9.2.1-Retroreflective Sheeting, Type ASTM-I: A retroreflective sheeting referred to as “engineering grade” that is typically an enclosed lens glass-bead sheeting.

715.9.2.1.1- Type ASTM-I Sheeting Requirements:

715.9.2.1.1.1-Coefficient of Retroreflection: New sheeting shall meet the Minimum Coefficient of Retroreflection requirements in ASTM specification D4956 for Type I material, as defined in ASTM D4956.

For transparent ink printed or transparent film covered areas over white sheeting, the Minimum Coefficient of Retroreflection requirements shall be seventy (70) % of the values specified in ASTM D4956 for sheeting of the same color as the ink or film.

All testing shall be conducted in accordance with ASTM D4956.

715.9.2.1.1.2-Color: New sheeting shall meet the Daytime Color & Nighttime Color requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. These requirements shall also apply to transparent ink and transparent film covered areas over white sheeting.

715.9.2.1.1.3-Daytime Luminance Factor: New sheeting shall meet the Daytime Luminance Factor requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. These requirements shall also apply to transparent ink and transparent film covered areas over white sheeting.

715.9.2.1.1.4- Adhesion: New sheeting with a pressure sensitive backing shall meet the adhesion requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.1.1.5-Shrinkage: New sheeting shall meet the shrinkage requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.1.1.6-Flexibility: New sheeting shall meet the flexibility requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.1.1.7-Liner Removal: New sheeting shall meet the liner removability requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.1.1.8-Impact Resistance: New sheeting shall meet the impact resistance requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.1.1.9-Rotational Sensitivity: New sheeting shall meet the applicable requirements of AASHTO M268 in order for the sheeting to be considered rotationally insensitive. Testing shall be conducted at the viewing geometry of 0.5/-4 as recommended in AASHTO M268, and the results of retroreflectivity readings at rotation angles of 0, 45, 90, and 120 degrees shall be compared as recommended in AASHTO M268. If the sheeting does not meet these requirements, it shall be noted on the APL that the material is rotationally sensitive.

715.9.2.1.1.10-Shelf Life: Any Type ASTM-I material to be considered for listing on the Division's APL shall have a minimum one (1) year shelf life. The same provisions shall apply to the manufacturer recommended matched components. Reasonable conditional requirements pertaining to storage, such as temperature and relative humidity, shall be permitted.

715.9.2.1.1.11-Backing Class: Type ASTM-I sheeting shall have a Class 1 adhesive backing, as defined in ASTM D4956.

715.9.2.1.1.12-Durability: The durability requirements of finished products manufactured using Type ASTM-I sheeting are specified within Section 715.9.2.7.

715.9.2.1.2-Approval Process: The WVDOH approval process for Type ASTM-I sheeting products is specified within Section 715.9.2.9.

715.9.2.2-Retroreflective Sheeting, Type ASTM-IV: A retroreflective sheeting referred to as "high-intensity" that is typically an unmetalized microprismatic retroreflective element material.

715.9.2.2.1-Type ASTM-IV Sheeting Requirements:

715.9.2.2.1.1-Coefficient of Retroreflection: New material shall meet the Minimum Coefficient of Retroreflection requirements in ASTM D4956 for Type IV material, as defined in ASTM D4956.

For transparent ink printed or transparent film covered areas over white sheeting, the Minimum Coefficient of Retroreflection requirements shall be seventy (70) % of the values specified in ASTM D4956 for sheeting of the same color as the ink or film.

All testing shall be conducted in accordance with ASTM D4956.

715.9.2.2.1.2-Color: New sheeting shall meet the Daytime Color & Nighttime Color requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. These requirements shall also apply to transparent ink and transparent film covered areas over white sheeting.

715.9.2.2.1.3-Daytime Luminance Factor: New sheeting shall meet the Daytime Luminance Factor requirements in specification D4956 when tested in accordance with ASTM specification D4956. These requirements shall also apply to transparent ink and transparent film covered areas over white sheeting.

715.9.2.2.1.4-Adhesion: New sheeting shall meet the adhesion requirements in specification D4956 when tested in accordance with ASTM specification D4956. If the material is marketed as a reboundable material, the supplementary adhesion requirements in ASTM D4956 for reboundable materials shall apply.

715.9.2.2.1.5-Shrinkage: New sheeting shall meet the shrinkage requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.2.1.6-Flexibility: New sheeting shall meet the flexibility requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. If the material is marketed as a reboundable material, the supplementary flexibility requirements in ASTM D4956 for reboundable materials shall apply.

715.9.2.2.1.7-Liner Removal: New sheeting shall meet the liner removability requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.2.1.8-Impact Resistance: New sheeting shall meet the impact resistance requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. If the material is marketed as a reboundable material, the supplementary impact resistance requirements in ASTM D4956 for reboundable materials shall apply.

715.9.2.2.1.9-Rotational Sensitivity: New sheeting materials, with exceptions noted herein, shall meet the applicable requirements of AASHTO M268 in order for the sheeting to be considered rotationally insensitive. Testing shall be conducted at the viewing geometry of 0.5/-4 as recommended in AASHTO M268, and the results of retroreflectivity

readings at rotation angles of 0, 45, 90, and 120 degrees shall be compared as recommended in AASHTO M268. If the sheeting does not meet these requirements, it shall be noted on the APL that the material is rotationally sensitive. With the exception of fluorescent-orange materials intended for application to rigid substrate signs, “work zone” materials as defined herein shall not be subject to rotational sensitivity testing.

715.9.2.2.1.10-Shelf Life: A minimum shelf life shall not be required for the sheeting to be listed on the APL. However, in order for the sheeting to be approved for manufacturing purposes within the Division’s CSS, a minimum (1) year shelf life shall be required. The same provisions shall apply to the manufacturer recommended matched components. Reasonable conditional requirements pertaining to storage, such as temperature and relative humidity, shall be permitted.

715.9.2.2.1.11-Backing Class: All Type ASTM-IV material supplied to the Division for manufacturing purposes within the CSS shall have a Class 1 adhesive backing, as defined in ASTM D4956. The adhesive backing on all Type ASTM-IV material supplied to manufacturers providing finished products to the Division or to Contractors performing work on Division Contracts shall have the most appropriate ASTM D4956 defined adhesive backing for the materials intended purpose, as determined by the manufacturer.

715.9.2.2.1.12-Durability: Durability requirements of finished products manufactured using Type ASTM-IV to be warranted by the sheeting manufacturer are specified within Section 715.9.2.7.

715.9.2.2.2-Approval Process: The WVDOH approval process for Type ASTM-IV sheeting products is specified within Section 715.9.2.9.

715.9.2.3-Retroreflective Sheeting, Type ASTM-VI: An elastomeric retroreflective sheeting without adhesive. This sheeting is typically a vinyl microprismatic retroreflective material.

715.9.2.3.1-Type ASTM-VI Sheeting Requirements:

715.9.2.3.1.1-Coefficient of Retroreflection: New sheeting shall meet the Minimum Coefficient of Retroreflection requirements as specified in Table 715.9.2.3.1.1-I below.

Table 715.9.2.3.1.1-I

Observation Angle	Entrance Angle	Color	
		White	Florescent-Orange
0.2	-4	300	200
0.2	+30	180	120
0.2	+45	100	60
0.5	-4	200	120
0.5	+30	75	50
0.5	+45	60	30

For transparent ink printed areas over white sheeting, the Minimum Coefficient of Retroreflection requirements shall be as shown in Table 715.9.2.3.1.1-II below.

Table 715.9.2.3.1.1-II

Observation Angle	Entrance Angle	Color				
		Green	Blue	Red	Yellow	Brown
0.2	-4	21	9.5	29	147	6.1

All testing shall be conducted in accordance with ASTM D4956.

715.9.2.3.1.2- Color: New sheeting shall meet the Daytime Color & Nighttime Color requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. These same requirements shall apply to transparent ink covered areas over white sheeting.

715.9.2.3.1.3-Daytime Luminance Factor: New sheeting shall meet the Daytime Luminance Factor requirements of ASTM specification D4956 when tested in accordance with ASTM specification D4956. These requirements shall also apply to transparent ink covered areas over white sheeting.

715.9.2.3.1.4-Shrinkage: New sheeting shall meet the shrinkage requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.3.1.5-Flexibility: New sheeting shall meet the flexibility requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.3.1.6-Impact Resistance: New sheeting shall meet the impact resistance requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.3.1.7-BLANK

715.9.2.3.1.8-Backing Class: All Type ASTM-VI material shall have a Class 5 backing, as defined in ASTM D4956.

715.9.2.3.1.9-Durability: Durability requirements of finished products manufactured using Type ASTM-VI material to be warranted by the sheeting manufacturer are specified within Section 715.9.2.7.

715.9.2.3.2-Approval Process: The WVDOH approval process for Type ASTM-VI sheeting products is specified within Section 715.9.2.9.

715.9.2.4-Retroreflective Sheeting, Type ASTM-XI: A retroreflective sheeting typically manufactured as an unmetallized cube corner microprismatic retroreflective element material.

715.9.2.4.1-Type ASTM-XI Sheeting Requirements:

715.9.2.4.1.1- Coefficient of Retroreflection: New sheeting shall meet the Minimum Coefficient of Retroreflection requirements in ASTM specification D4956 for Type XI material, as defined in ASTM D4956.

For transparent ink printed or transparent film covered areas over white sheeting, the Minimum Coefficient of Retroreflection requirements shall be seventy (70) % of the values specified in ASTM D4956 for sheeting of the same color as the ink or film.

All testing shall be conducted in accordance with ASTM D4956.

715.9.2.4.1.2- Color: New sheeting shall meet the Daytime Color & Nighttime Color requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. These same requirements shall apply to transparent ink and transparent film covered areas over white sheeting.

715.9.2.4.1.3-Daytime Luminance Factor: New sheeting shall meet the Daytime Luminance Factor requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. These same requirements shall apply to transparent ink and transparent film covered areas over white sheeting.

715.9.2.4.1.4-Adhesion: New sheeting shall meet the adhesion requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. If the material is marketed as a reboundable material, the supplementary adhesion requirements in ASTM D4956 for reboundable materials shall apply.

715.9.2.4.1.5-Shrinkage: New sheeting shall meet the shrinkage requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.4.1.6-Flexibility: New sheeting shall meet the flexibility requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. If the material is marketed as a reboundable material, the supplementary flexibility requirements in ASTM D4956 for reboundable materials shall apply.

715.9.2.4.1.7-Liner Removal: New sheeting shall meet the liner removability requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956.

715.9.2.4.1.8-Impact Resistance: New sheeting shall meet the impact resistance requirements in ASTM specification D4956 when tested in accordance with ASTM specification D4956. If the material is marketed as a reboundable material, the supplementary impact resistance requirements in ASTM D4956 for reboundable materials shall apply.

715.9.2.4.1.9-Rotational Sensitivity: New sheeting materials, with exceptions noted herein, shall meet the applicable requirements of AASHTO M268 in order for the sheeting to be considered rotationally insensitive. Testing shall be conducted at the viewing geometry of 0.5/-4 as recommended in AASHTO M268, and the results of retroreflectivity

readings at rotation angles of 0, 45, 90, and 120 degrees shall be compared as recommended in AASHTO M268. If the sheeting does not meet these requirements, it shall be noted on the APL that the material is rotationally sensitive. With the exception of fluorescent-orange materials intended for application to rigid substrate signs, “work zone” materials as defined herein shall not be subject to rotational sensitivity testing.

715.9.2.4.1.10-Shelf Life: A minimum shelf life shall not be required for the sheeting to be listed on the APL. However, in order for the sheeting to be approved for manufacturing purposes within the Division’s CSS, a minimum (1) year shelf life shall be required. The same provisions shall apply to the manufacturer recommended matched components. Reasonable conditional requirements pertaining to storage, such as temperature and relative humidity, shall be permitted.

715.9.2.4.1.11-Backing Class: All Type ASTM-XI material supplied to the Division for manufacturing purposes within the CSS shall have a Class 1 adhesive backing, as defined in ASTM D4956. The adhesive backing on all Type ASTM-XI material supplied to manufacturers providing finished products to the Division or to Contractors performing work on Division Contracts shall have the most appropriate ASTM D4956 adhesive backing for the materials intended purpose.

715.9.2.4.1.12-Durability: Durability requirements of finished products manufactured using Type ASTM-XI material to be warranted by the sheeting manufacturer are specified within Section 715.9.2.7.

715.9.2.4.2-Approval Process: The WVDOH approval process for Type ASTM-XI sheeting products is specified within Section 715.9.2.9.

715.9.2.5-Transfer Film: Transfer film for premasking or applying prespaced legends using transparent or opaque films.

715.9.2.5.1-Transfer Film Requirements:

715.9.2.5.1.1-Transparency: Transfer films shall be transparent.

715.9.2.5.2-Approval Process: The WVDOH approval process for Transfer Film is specified within Section 715.9.2.9.

715.9.2.6-Matched Components:

715.9.2.6.1-Black Opaque Overlay Film: A black, opaque, typically vinyl or acrylic pressure-sensitive film designed for permanent graphics that may be prespaced and electronically cut. These films have a synthetic liner that resists moisture absorption and static buildup.

715.9.2.6.1.1-Black Opaque Overlay Film Requirements:

715.9.2.6.1.1.1-Adhesive: This material shall utilize a pressure sensitive adhesive.

715.9.2.6.1.1.2-Chemical Resistance: This material shall resist mild alkalis, mild acids, and salt. The material shall exhibit excellent resistance to water, with exception to cases of submersion.

715.9.2.6.1.1.3-Shrinkage: After application, this material shall not exhibit shrinkage in excess of 0.010 inches.

715.9.2.6.1.1.4-Durability: Durability requirements of black opaque overlay films, depending on the Type sheeting the material is to be utilized with and the intended application, are specified in Sections 715.9.2.1 through 715.9.2.4.

715.9.2.6.1.1.5-Shelf Life: A minimum shelf life shall not be required for the film to be approved for use with the manufacturer's sheeting products. However, in order for the film to be approved for manufacturing purposes within the Division's CSS, a minimum (1) year shelf life shall be required. Reasonable conditional requirements pertaining to storage, such as temperature and relative humidity, shall be permitted.

715.9.2.6.1.1.6-CSS Requirements: In addition to, but not limited to, any other requirements stated herein, all black opaque overlay film to be approved for manufacturing purposes within the CSS shall be a vinyl material. In addition, this material shall have sufficient strength so that it can be handled, processed, and applied according to the recommendations of the manufacturer without appreciable stretching, tearing, or other damage. The material shall permit cutting and application at temperatures of 40 to 100°F (4 to 38°C).

715.9.2.6.1.2-Approval Process: The WVDOH approval process for Black Opaque Overlay Film is specified within Section 715.9.2.9.

715.9.2.6.2-Transparent Overlay Films: A colored, transparent, typically acrylic, transparent pressure-sensitive film designed for permanent graphics that may be prespaced and electronically cut. These films have a synthetic liner that resists moisture absorption and static buildup.

715.9.2.6.2.1-Transparent Overlay Film Requirements:

715.9.2.6.2.1.1-Adhesive: This material shall utilize a transparent pressure sensitive adhesive.

715.9.2.6.2.1.2-Chemical Resistance: This material shall resist mild alkalis, mild acids, and salt. The material shall exhibit excellent resistance to water, with exception to cases of submersion.

715.9.2.6.2.1.3-Color Standards: Transparent overlay films applied to the manufacturer's approved white sheeting shall produce colors meeting the daytime and nighttime color requirements of ASTM D4956 for like colored sheeting. Testing shall be conducted in accordance with ASTM D4956.

715.9.2.6.2.1.4-Transparency: After application over the manufacturer's white sheeting, the film's level of transparency shall result in a minimum retroreflectivity level of seventy (70) % of the minimum required retroreflectivity level, as specified herein, of the like colored sheeting of the same grade as the white sheeting. Testing shall be conducted in accordance with ASTM D4956.

715.9.2.6.2.1.5-Durability: Durability requirements of transparent overlay films, depending on the Type sheeting the material is to be utilized with and the intended application, are specified in Sections 715.9.2.1 through 715.9.2.4.

715.9.2.6.2.1.6-Shelf Life: A minimum shelf life shall not be required for the film to be approved for use with the manufacturer's sheeting products. However, in order for the film to be approved for manufacturing purposes within the Division's CSS, a minimum (1) year shelf life shall be required. Reasonable conditional requirements pertaining to storage, such as temperature and relative humidity, shall be permitted.

715.9.2.6.2.1.7-CSS Requirements: In addition to, but not limited to, any other requirements stated herein, all transparent overlay film to be approved for manufacturing purposes within the CSS shall be an acrylic material and shall be supplied on a clear liner. In addition, this material shall have sufficient strength so that it can be handled, processed, and applied according to the recommendations of the manufacturer without appreciable stretching, tearing, or other damage. The material shall permit cutting and application at temperatures of 40 to 100°F (4 to 38°C).

715.9.2.6.2.2-Approval Process: The WVDOH approval process for Transparent Overlay Film is specified within Section 715.9.2.9.

715.9.2.6.3-Opaque and Transparent Inks: Weather resistant, quick drying inks designed for use in traffic sign screen printing processes.

715.9.2.6.3.1-Opaque and Transparent Ink Requirements:

715.9.2.6.3.1.1-Chemical Resistance: This material shall resist mild alkalis, mild acids, and salt. The material shall exhibit excellent resistance to water, with exception to cases of submersion.

715.9.2.6.3.1.2-Color Standards: Transparent inks applied to the manufacturer's approved white sheeting shall produce colors meeting the daytime and nighttime color requirements of ASTM D4956 for like colored sheeting. Testing shall be conducted in accordance with ASTM D4956.

715.9.2.6.3.1.3-Transparency: After application over the manufacturer's white sheeting, the level of transparency of the transparent ink shall result in a minimum retroreflectivity level of seventy (70) % of the minimum required retroreflectivity level, as specified herein, of the like colored sheeting of the same grade as the white sheeting. Testing shall be conducted in accordance with ASTM D4956.

715.9.2.6.3.1.4-Durability: Durability requirements of opaque & transparent inks, depending on the Type sheeting the material is to be utilized with and the intended application, are specified in Sections 715.9.2.1 through 715.9.2.4.

715.9.2.6.3.1.5-Shelf Life: A minimum shelf life shall not be required for the ink to be approved for use with the manufacturer's sheeting products. However, in order for the ink to be approved for manufacturing purposes within the Division's CSS, a minimum (1) year shelf life shall be required. Reasonable conditional requirements pertaining to storage, such as temperature and relative humidity, shall be permitted.

715.9.2.6.3.2-Approval Process: The WVDOH approval process for Opaque and Transparent Ink is specified within Section 715.9.2.9.

715.9.2.7-Durability Requirements: The durability requirements of the various type sheeting materials described herein and their matched components are specified in this Section. The sheeting manufacturer's obligations in the event that the manufacturer's material(s) fails to meet the durability requirements specified herein, as applicable, are specified within Section 715.9.2.8. All warranty requirements, and sheeting manufacturer obligations specified in Section 715.9.2.8 for materials failing to meet these requirements, are intended for installed devices remaining in place and becoming the property of the WVDOH after completion of the project, and for devices purchased or manufactured by the WVDOH. In all cases, the obligations of the sheeting manufacturer for failure of the materials to meet the established warranty requirements are to the WVDOH. The warranty requirements and sheeting manufacturer obligations specified herein shall not be construed as establishing mandatory warranty terms and obligations that the sheeting manufacturer is required to provide to Contractors, device manufacturers, fabricators, vendors, or other third parties performing work for or providing materials or finished products to the WVDOH.

715.9.2.7.1-Non Work Zone Applications:

715.9.2.7.1.1-Type ASTM-I Sheeting: Finished signs manufactured using Type ASTM-I sheeting shall exhibit the minimum level of performance described herein for a period of seven (7) years after field installation.

The retroreflectivity levels maintained by the sheeting placed on the signs shall be a minimum of fifty (50) % of the required values for new sheeting of the same color, per 715.9.2.1.1.1. For transparent ink and film covered areas over white sheeting, the retroreflectivity levels maintained by these areas of the signs shall be a minimum of thirty-five (35) % [seventy (70) % of the fifty (50) % value specified above] of the required values for new sheeting of the same color as the ink or film, per 715.9.2.1.1.1.

The colors and luminance factors of all areas of finished signs shall be such that the sign remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

All retroreflectivity testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.7.1.2-Type ASTM-IV Sheeting: Finished signs manufactured using Type ASTM-IV sheeting shall exhibit the minimum level of performance described herein for a period of ten (10) years after field installation.

The retroreflectivity levels maintained by the sheeting placed on the signs shall be a minimum of eighty (80) % of the required values for new sheeting of the same color, per 715.9.2.2.1.1. For transparent ink and transparent film covered areas over white sheeting, the retroreflectivity levels maintained by these areas of the signs shall be a minimum of fifty-six (56) % [seventy (70) % of the eighty (80) % value specified above] of the required values for new sheeting of the same color as the ink or film, per 715.9.2.2.1.1.

The colors and luminance factors of all areas of finished signs shall be such that the sign remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

All retroreflectivity testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.7.1.3-Type ASTM-XI Sheeting:

715.9.2.7.1.3.1-Non Fluorescent Materials: Finished signs manufactured using Type ASTM-XI non-fluorescent sheeting shall exhibit the minimum level of performance described herein for a period of twelve (12) years after field installation.

The retroreflectivity levels maintained by the sheeting placed on the signs shall be a minimum of eighty (80) % of the required values for new sheeting of the same color, per 715.9.2.4.1.1. For transparent ink and film covered areas over white sheeting, the retroreflectivity levels maintained by these areas of the signs shall be a minimum of fifty-six (56) % [seventy (70) % of the eighty (80) % value specified above] of the required values for new sheeting of the same color as the ink or film, per 715.9.2.4.1.1.

The colors and luminance factors of all areas of finished signs shall be such that the sign remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

All retroreflectivity testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.7.1.3.2-Fluorescent Materials: Finished signs manufactured using Type ASTM-XI fluorescent sheeting shall exhibit the minimum level of performance described herein for a period of ten (10) years after installation.

The retroreflectivity levels maintained by the sheeting placed on the signs shall be a minimum of eighty (80) % of the required values for new sheeting of the same color, per 715.9.2.4.1.1.

The colors of all areas of finished signs shall be such that the sign remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

The daytime luminance factor of all areas of finished signs shall be in conformance with the daytime luminance factor requirements referenced in Section 715.9.2.4.1.3.

All testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.7.2-Work Zone Applications:

715.9.2.7.2.1-Type ASTM-IV Sheeting:

715.9.2.7.2.1.1-Channelization & Delineation Devices:

Products in this category include but may not be limited to plastic posts, tubes, barricades, drums, cones, and channelizer cones, including “permanently” installed plastic posts and tubes. Applicable colors are orange, white, yellow, blue, and red. The sheeting placed on finished products of this type shall have its’ performance warranted for a period of three (3) years after application on the finished product.

The Minimum Coefficient of Retroreflection shall be fifty (50) % of the values specified in Section 715.9.2.2.1.1 for sheeting of the same color.

The colors and luminance factors of the applied sheeting shall be such that the sheeting remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

All retroreflectivity testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.7.2.2-Type ASTM-VI Sheeting:

715.9.2.7.2.2.1-Roll-Up Signs:

Finished roll-up signs manufactured using Type ASTM-VI sheeting shall have their performance warranted for a period of three (3) years after manufacturing.

The retroreflectivity levels maintained by the white or fluorescent-orange areas of the finished signs shall be a minimum of fifty (50) % of the required values for new sheeting of the same color, per Table 715.9.2.3.1.1-I. For transparent ink covered areas over white sheeting, the retroreflectivity levels maintained by these areas of the signs shall be a minimum of fifty (50) % of the required values for like colored screen printed areas over new sheeting (50% of the values in Table 715.9.2.3.1.1-II).

The colors and luminance factors of all areas of finished signs shall be such that the sign remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

The daytime luminance factor of fluorescent-orange finished signs shall be in conformance with the daytime luminance factor requirements referenced in Section 715.9.2.3.1.3.

All testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.7.2.3-Type ASTM-XI Sheeting:

715.9.2.7.2.3.1-Signs:

Finished work zone signs manufactured using fluorescent-orange Type ASTM-XI material shall have their performance warranted for a period of three (3) years after manufacturing.

The retroreflectivity levels maintained by the sheeting placed on the signs shall be a minimum of fifty (50) % of the required values for new fluorescent-orange sheeting, per 715.9.2.4.1.1.

The colors of all areas of finished signs shall be such that the sign remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

The daytime luminance factor of all areas of finished signs shall be in conformance with the daytime luminance factor requirements referenced in Section 715.9.2.4.1.3 for fluorescent-orange.

All testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.7.2.3.2-Channelization & Delineation Devices: Products in this category include but may not be limited to plastic posts, tubes, barricades, drums, cones, and channelizer cones, including “permanently” installed plastic posts and tubes. Applicable colors are orange, white, yellow, blue, and red. The sheeting placed on finished products of this type shall have its’ performance warranted for a period of three (3) years after application on the finished product.

The Minimum Coefficient of Retroreflection shall be fifty (50) % of the values specified in Section 715.9.2.4.1.1 for sheeting of the same color.

The colors and luminance factors of the applied sheeting shall be such that the sheeting remains effective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision.

The daytime luminance factor of fluorescent-yellow sheeting shall be in conformance with the daytime luminance factor requirements referenced in Section 715.9.2.4.1.3.

All testing shall be done in accordance with ASTM D4956. All retroreflectivity testing shall be done at the set observation angle / entrance angle geometry of 0.2/-4.

715.9.2.8-Warranty Claims: The sheeting manufacturer’s obligations in the event that the manufacturer’s material(s) fails to meet the warranty requirements specified herein are specified within this Section. The retroreflective sheeting and/or matched components used to manufacture finished signs, channelization devices, & delineation devices shall be considered to be in non-compliance with these specifications where it can be shown that during the specified warranty period the finished product has deteriorated due to natural causes to the extent that is in non-compliance with the quantitative requirements contained herein related to retroreflectivity or luminance factor, as applicable, or is otherwise determined to be ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by drivers with normal vision. Under such circumstances, the sheeting manufacturer’s warranty obligations shall be as outlined as described herein. The retroreflectivity, color, & luminance factor durability requirements of the various type sheeting materials described herein and their matched components, as well as the required warranty periods, are specified within Section 715.9.2.7.

Warranty claims shall be based on failures which occur as a result of design or manufacturing defects in the manufacturer’s sheeting and/or matched components and not of outside causes such as improper fabrication, handling, maintenance, or installation; use of non-manufacturer recommended inks, thinners, coatings, or overlay films for the sheeting being used; use of application equipment not recommended by the manufacturer; failure of sign substrate; exposure to chemicals, abrasion, or damage from fasteners used to mount the sign; snow burial; collisions, vandalism, or malicious mischief. It shall be the sheeting manufacturer’s responsibility to investigate and demonstrate that the recommendations contained in their product bulletins, information folders, and technical memos have not been followed in cases where the manufacturer chooses to contest the

warranty claim.

Replacement sheeting shall carry the unexpired warranty of the sheeting it replaces.

715.9.2.8.1-Non Work Zone Applications:

715.9.2.8.1.1-Signs:

715.9.2.8.1.1.1-Non Fluorescent Type ASTM-IV and Type ASTM-XI Sheeting: If the failure occurs within the first seven (7) years from the date of field installation, the sheeting manufacturer shall, at its expense, restore the sign surface to its original effectiveness. The Division will be responsible for no labor, equipment, or material costs in this case.

If the failure occurs after seven (7) years from the date of field installation, but less than ten (10) years from the date of field installation for Type ASTM-IV material or less than twelve (12) years from the date of field installation for Type ASTM-XI material, the manufacturer shall furnish the necessary amount of sheeting to restore the sign surface to its original effectiveness.

715.9.2.8.1.1.2-Fluorescent Type ASTM-XI Sheeting: If the failure occurs within the first seven (7) years from the date of field installation, the sheeting manufacturer shall, at its expense, restore the sign surface to its original effectiveness. The Division will be responsible for no labor, equipment, or material costs in this case.

If the failure occurs after seven (7) years from the date of field installation, but less than ten (10) years from the date of field installation, the manufacturer shall furnish the necessary amount of sheeting to restore the sign surface to its original effectiveness.

715.9.2.8.2-Work Zone Applications:

715.9.2.8.2.1-Signs:

715.9.2.8.2.1.1-Type ASTM-VI and Type ASTM-XI Sheeting: If the failure occurs within one (1) year from the date of manufacturing, the sheeting manufacturer will, at its expense, provide all required sheeting to restore the effected sign(s) to their original effectiveness.

If failure occurs after one (1) year from the date of manufacturing, but less than two (2) years from the date of manufacturing, the sheeting manufacturer will, at its expense, provide two-thirds (2/3) of the required sheeting to restore the effected sign(s) to their original effectiveness.

If failure occurs after two (2) years from the date of manufacturing, but less than three (3) years from the date of manufacturing, the sheeting manufacturer will, at its expense, provide one-third (1/3) of the required sheeting to restore the effected sign(s) to their original effectiveness.

715.9.2.8.2.2-Channelization & Delineation Devices:

715.9.2.8.2.2.1-Type ASTM-IV and Type ASTM-XI Sheeting: If the failure occurs within one (1) year from the date of manufacturing, the sheeting manufacturer will, at its expense, provide all required sheeting to restore the effected device(s) to their original effectiveness.

If failure occurs after one (1) year from the date of manufacturing, but less than two (2) years from the date of manufacturing, the sheeting manufacturer will, at its expense,

provide two-thirds (2/3) of the required sheeting to restore the effected device(s) to their original effectiveness.

If failure occurs after two (2) years from the date of manufacturing, but less than three (3) years from the date of manufacturing, the sheeting manufacturer will, at its expense, provide one-third (1/3) of the required sheeting to restore the effected device(s) to their original effectiveness.

715.9.2.9-Approval Processes: The WVDOH processes for review and approval of the various material types described in Sections 715.9.2.1 through 715.9.2.6 are described within this Section.

Retroreflective sheeting materials of the Types described herein, manufacturer recommended matched components for use with the sheeting materials, and transfer films to be considered for inclusion on the WVDOH APL shall be submitted to the Materials Division following the current procedures specified by the Materials Division. The manufacturer may contact the Traffic Engineering Division for verification. The manufacturer should include all relevant documentation and information with their submittal, including but not limited to Product Data Sheets, Product Flyers, Manufacturer Product Specifications, Product Bulletins, and any required independent test results described herein.

In addition to the above described documentation and information, the manufacturer shall submit a letter of certification prior to approval. This letter shall include the following:

1. Certification that the material(s) submitted for approval will meet all applicable requirements contained within Section 715 of the WVDOH Standard Specifications. The applicable material Type designation, as defined in this specification, should also be referenced. If the material is a Type ASTM-I, IV, or XI material and not intended solely for application to work zone devices as defined herein, or is a fluorescent-orange material intended for application to rigid substrate signs, and does not meet the requirements of this specification to be considered rotationally insensitive, the manufacturer should note this exception in the certification letter. Classification of the material as being rotationally sensitive will not prevent approval of the material.
2. Certification that the manufacturer agrees to warranty the performance of the material(s) in accordance with Section 715 of the WVDOH Standard Specifications.
3. Certification that the material(s) have a minimum one (1) year shelf life, when stored as recommended by the manufacturer, if the manufacturer is seeking approval of the material(s) for manufacturing purposes within the CSS.

All submitted information will be forwarded to the WVDOH Traffic Engineering Division, which will in turn contact and work directly with the manufacturer during the evaluation process. The Traffic Engineering Division will evaluate all submitted literature and documentation for compliance with the specified requirements as well as satisfactory independent testing results, as applicable. The Traffic Engineering Division will also arrange for the manufacturer to furnish test samples for evaluation of the materials suitability for use within the CSS, as applicable. After the evaluation is complete, the Traffic Engineering Division will inform the Materials Division in writing of the outcome of its evaluation.

The WVDOH reserves the right to conduct testing, whether internally or through an independent testing agency of its choice, on any material submitted for approval in order to verify that the material meets any of the material specifications herein. This testing may be conducted prior to or any time after approval is issued. Any such testing shall be conducted in accordance with the testing requirements of the applicable standardization body, such as ASTM or AASHTO.

715.9.2.9.1-Retroreflective Sheeting Materials & Matched Components:

715.9.2.9.1.1-Independent Test Results: In order for the material to be evaluated and considered for approval, independent test results must be supplied by the manufacturer demonstrating the sheeting material's conformance with the requirements specified within the applicable Section 715.9.2.1, 715.9.2.2, 715.9.2.3, or 715.9.2.4, with the exception of the requirements specified in the "Shelf Life", "Backing Class", and "Durability" subsections. The independent test results shall include accelerated outdoor weathering test results conducted in conformance with ASTM D4956. Artificial accelerated lab weathering shall not be accepted except for materials intended for work zone applications. Materials intended for work zone applications shall include all Type ASTM-VI materials and shall include, but may not be limited to, other "Type" materials intended for use on plastic posts, tubes, barricades, drums, cones, and channelizer cones, including "permanently" installed plastic posts and tubes. However, any approval granted based on the results of artificial accelerated lab weathering shall be provisional in nature and noted as such on the APL. As a condition of the acceptance of artificial accelerated lab weathering results in lieu of accelerated outdoor weathering results, the accelerated outdoor weathering process shall be ongoing at the time of issuance of the provisional approval. In addition, the material manufacturer shall submit the standard outdoor weathering test results to the WVDOH within nine (9) months after the effective date of the provisional approval for Type ASTM-VI materials, and within fifteen (15) months after the effective date of the provisional approval for all other material "Types". AASHTO-NTPEP results shall be considered acceptable for meeting the accelerated outdoor weathering test results requirement.

Rotational sensitivity testing is not required for sheeting materials intended solely for application to work zone devices, as defined herein, with the exception of fluorescent-orange materials intended for application to rigid substrate signs. Otherwise, if a material submitted for approval does not meet the rotational sensitivity requirements herein, rotational sensitivity testing may be omitted from the independent test results provided that the manufacturer notes that the material does not meet the rotational sensitivity requirement in their required certification letter described in Section 715.9.2.9.

715.9.2.9.1.1.1-Accelerated Weathering Test Results: The duration of testing required shall be based on the sheeting material Type, as defined by this specification, and the intended application of the material. All Type ASTM-I sheeting materials shall be subjected to two (2) years of accelerated outdoor weathering. Type ASTM-IV and Type ASTM-XI materials intended for non-work zone applications shall be subjected to three (3) years of accelerated outdoor weathering. Type ASTM-IV and Type ASTM-XI materials intended for work zone applications shall be subjected to one (1) year of accelerated outdoor weathering. Type ASTM-VI materials shall be subjected to six (6) months of accelerated outdoor weathering.

After completion of the accelerated outdoor weathering, all materials shall be in conformance with the general durability requirements related to cracking, scaling, pitting, blistering, edge lifting, curling, shrinkage, and expansion specified in ASTM D4956.

The retroreflectivity level of the sheeting material after completion of the accelerated outdoor weathering, when tested in accordance with ASTM D4956, shall be in conformance with the requirements of ASTM D4956. ASTM D4956 specifies the level of retroreflectivity to be maintained by the material as a percentage of the initial required retroreflectivity level specified in ASTM D4956. An exception to this shall apply to Type ASTM-VI materials. In this case, the percentage specified in ASTM D4956 shall be applied to the applicable initial required retroreflectivity levels specified in Section 715.9.2.3.1.1 rather than the initial values specified in ASTM D4956.

After completion of the accelerated weathering, the sheeting material shall be in conformance with the requirements specified in the “Color” (daytime) and “Luminance Factor” subsections within the applicable Section 715.9.2.1, 715.9.2.2, 715.9.2.3, or 715.9.2.4 when tested in accordance with ASTM D4956.

The manufacturer recommended matched components for use with the sheeting material must also be subjected to accelerated outdoor weathering in order for approval to be given for the manufacturing of signs requiring the use of these matched components. The duration of accelerated outdoor weathering required for the matched components shall be the same as the applicable duration required for the sheeting.

The retroreflectivity level of the areas of all signs processed with transparent inks or transparent films after completion of the accelerated outdoor weathering, when tested in accordance with ASTM D4956, shall be a minimum of seventy (70) % of the retroreflectivity values required for like colored sheeting of the same material Type upon completion of the accelerated outdoor weathering.

After completion of the accelerated outdoor weathering, the areas of all signs processed with transparent inks or transparent films shall be in conformance with the requirements specified in the “Color” (daytime) and “Luminance Factor” subsections within the applicable Section 715.9.2.1, 715.9.2.2, 715.9.2.3, or 715.9.2.4 when tested in accordance with ASTM D4956.

If artificial accelerated lab weathering is conducted in order to obtain provisional approval for a material intended for work zone applications, per Section 715.9.2.9.1.1, the weathering process shall be done in accordance with the ASTM D4956 specifications. The performance requirements for the results of the testing shall be the same as described herein for accelerated outdoor weathering.

715.9.2.9.1.2--CSS Evaluation: Material Types and their matched components that are typically used in manufacturing processes within the CSS are subject to evaluation by WVDOH personnel for their suitability for use within the Division’s CSS. This evaluation is primarily focused on the compatibility, workability, and general “user friendliness” of the materials when used for production purposes within the CSS using the equipment in place at the CSS, as well as the characteristics of the materials in these regards relative to other materials which have already been approved. The suitability of the materials in these regards shall be based solely on the judgment of the Division. The un-acceptance of the manufacturer’s sheeting material and/or matched components based on this evaluation shall not prevent the listing of these materials on the APL and the use of these materials by

private fabricators supplying finished products to the WVDOH or to Contractors performing Contracts for the WVDOH.

In order for a sheeting material to be eligible for bidding on any Division raw material supply Contract, particular Section(s) of the Contract may require that only the sheeting material be determined to be suitable for use within the CSS. Other Section(s) may require that one or more of the matched components also be determined to be suitable for use within the CSS. These requirements shall be indicated in the raw material supply Contract.

In addition to any other requirements specified herein, in order to be accepted for manufacturing purposes within the CSS all sheeting materials shall permit application to aluminum blanks and shall permit processing with compatible matched components at temperatures between 60 to 100°F (16 to 38°C) and relative humidity at 20% to 80 % when performed in accordance with the manufacturer's recommendations. In addition, the sheeting and the matched component inks shall allow oven accelerated curing, providing that the manufacturer's recommendations are followed.

Any restrictions on the use of the material or any of the matched components within the CSS shall be noted on the APL.

In addition to the information provided above, note the following:

1. Type ASTM-I material is not specified for any applications on WVDOH advertised construction projects. The specifications and approval process described herein for Type ASTM-I material are in place solely for the purpose of establishing requirements for the placement of Type ASTM-I materials on the Division's APL. A listing of approved Type ASTM-I materials is maintained in order to establish a list of materials approved for bidding on Division raw material supply Contracts. Therefore, no Type ASTM-I material that is not accepted by the Division for manufacturing purposes within the CSS shall be placed on the APL.
2. Type ASTM-IV sheeting materials and their matched components intended for work zone (as described herein) applications only are not required to be evaluated for use within the CSS.
3. Type ASTM-VI sheeting materials and their matched components are not required to be evaluated for use within the CSS.
4. With the exception of fluorescent-orange material and its' applicable matched components intended for use in manufacturing temporary work zone signs, Type ASTM-XI sheeting materials and their matched components intended for work zone (as described herein) applications only are not required to be evaluated for use within the CSS.

715.9.2.9.2-Transfer Films: The transfer film section of the APL is solely for the purpose of establishing an approved list of transfer tapes for bidding on Division raw material supply Contracts. Private fabricators are not required to utilize transfer tapes listed on the APL. This shall be noted on the APL. Therefore, no transfer film that is not accepted by the Division for manufacturing purposes within the CSS shall be placed on the APL.

All transfer films submitted for approval shall be transparent. No other specific requirements are listed herein. However, transfer films shall be thoroughly evaluated by personnel within the Division's CSS. The CSS evaluation is primarily focused on the compatibility, workability, and general "user friendliness" of the material when used for production purposes within the CSS using the equipment in place at the CSS, as well as

the characteristics of the material in these regards relative to other transfer films which have already been approved. The suitability of the material in this regard shall be based solely on the judgment of the Division.

715.9.3-Channelizing Devices and Auxiliary Barriers: Traffic cone markers shall be constructed of rubber or other flexible material acceptable to the Engineer, shall have a height of 28 to 36 in. (700 to 900 mm) and a base of approximately 14 in. by 14 in. (350 by 350 mm), and shall be predominantly orange in color. If the cones are required to be in place during periods of darkness, they shall be reflectorized.

Barricades shall be fabricated in accordance with details shown on the plans and shall not be constructed with sufficient strength to stop any vehicle which collides with them, but shall be so constructed as to do a minimum amount of damage to a vehicle colliding with them.

Traffic control drums shall be flexible plastic and appear basically cylindrical viewed from any direction. Drums shall have a minimum profile width of 18 inches (450 mm) regardless of orientation. The drum shall be 36 inches (900 mm) in height and orange in color.

The markings on the drum shall be horizontal, circumferential, orange and white reflectorized stripes 6 inches (152.4 mm) minimum width fabricated from Type I or Type IV sheeting. There shall be two orange and two white stripes uniformly spaced on each drum.

The drum shall be designed to securely attach a Type A or C warning light to the top of the drum. The drum shall contain a removable base not to exceed 5 inches (127 mm) in height.

715.9.3.1-Channelizer Cones: The Channelizer Cone utilized shall be manufactured using a lightweight, reboundable plastic material, such as Low Density Polyethylene. The material used to manufacture the Channelizer Cone shall be colored bright orange throughout, and shall include UV stabilizers. The Channelizer Cone shall utilize a detachable low profile rubber base for ballast. Two different categories of bases shall be recognized.

Each Channelizer Cone shall utilize retroreflective sheeting for nighttime visibility. The Channelizer Cone cross-section shall be round where the Retroreflective sheeting is to be applied. The Retroreflective sheeting utilized shall be 2 each 6-inch (150 mm) wide bands of orange Type ASTM-III sheeting, and 2 each 6-inch (150 mm) wide bands of white Type ASTM-III sheeting. The top band of sheeting shall be orange and shall be placed such that the top edge of the band is approximately 43 inches (1050 mm) above the bottom of the Channelizer Cone. The remaining white and orange bands shall be alternated down the Channelizer Cone, with each band separated by approximately 0.5 edge inches (12 mm) (+/-0.5 inch (12 mm)). The diameter of the Channelizer Cone at the top of the edge of the top band of sheeting shall be approximately 4 inches (100 mm). The diameter approximately 5½ inches (137 mm). The Channelizer Cone may be constructed such that the diameter of the of the Channelizer Cone transitions from the top to the bottom uniformly, or the Channelizer Cone may utilize a tiered construction such that the section of the Channelizer Cone that each band of sheeting is attached to is of a different constant diameter, with each tier going down the Channelizer Cone being a larger diameter than the one above it.

Two different categories of bases shall be recognized, as described below.

715.9.3.1.1-55 MPH or Less Channelizer Cone Bases: Bases for use only on roadways with a normal (non work zone) posted speed limit of 55 MPH or less shall weight a minimum of 15 pounds (6.8 kg.). These bases may be a symmetrical or non-symmetrical shape of the manufacturer's choosing, but shall not be round. The square or rectangular effective footprint defined by the outer extremes of the base shall meet the following guidelines:

- If the footprint is square, the overall footprint shall not exceed 20" x 20" (500 mm x 500 mm)
- If the footprint is rectangular, the measurement in one direction shall not exceed 24" (600 mm) in one direction, and 18" (450 mm) in the other direction.

715.9.3.1.2-60 MPH or Greater Channelizer Cone Bases: Bases for use on roadways with a normal (non-work zone) posted speed limit of 60 MPH or greater shall weigh a minimum of 20 pounds (9.1 kg.). These bases shall be rectangular in shape in order to provide maximum tipping resistance when the long side of the base is installed parallel to traffic. The long dimension of the base shall be a minimum of 24 inches (600 mm) in length. The short dimension of the base shall be a minimum of 12 inches (300 mm), and a maximum of 20 inches (500 mm) in length. All bases should be manufactured within the parameters described in a manner to provide stability similar to other industry standard Channelizer Cones, and will be subject to review and testing by WVDOH personnel for approval. Note, bases meeting the requirements described above may also be used in work zones with a normal (non-work zone) posted speed of 55 MPH or less.

715.9.3.1.3-Approved Products: The Channelizer Cone utilized shall be a model off the Division's current Approved Products Listing (APL). A list of qualified devices and their manufacturers may be obtained by contacting the Materials Division at the following address:

West Virginia Division of Highways
Material Controls, Soils, and Testing
190 Dry Branch Road
Charleston, West Virginia 25306

715.9.4-BLANK

715.9.5-Warning Lights: The purpose of this specification is to provide minimum requirements for light-emitting warning lights used for warning purposes in roadway work zones.

715.9.5.1-Types of Warning Lights: Types of warning lights include any device which emits light, either in a flashing or steady burn mode, using any power source (electrical, solar, etc.). The lights include, among others, incandescent lamps, light emitting diodes (LED), neon, and halogen lamps. Types of warning lights are categorized as follows:

- Type A: low intensity flashing warning lights
- Type B: high intensity flashing warning lights
- Type C: steady burn warning lights
- Type D: 360-degree steady burn warning lights

715.9.5.2-General Requirements:

715.9.5.2.1-Internal and External Illumination: The warning lights shall be internally illuminated by means of a light source behind a lens and, for Type A and C devices, shall be externally illuminated by retroreflective elements built into the lens to enable warning lights to be seen by retro-reflection of the light from the headlights of oncoming vehicles. The type B device may have a retro-reflective ring of prismatic tape or built in elements that meet the requirements of Section 715.9.5.10.

715.9.5.2.2-Battery Operation and Battery Protection: When the device is to be operated by battery, the battery must be entirely enclosed in a weatherproof case that is constructed of steel or any other material such as high-impact plastics suitable for use along roadway work zones. The case shall be secured by a locking device. The battery may be replaceable or rechargeable using, for example, solar collectors or an AC power source.

715.9.5.2.3-AC power Operation: When the device is to be operated by a 120-volt, 60Hz power supply, the unit shall be supplied with a separate ground wire and shall be protected with suitable fuses. At no time shall the effective intensity of the light have a value greater than 500 candelas. The connections and equipment used shall be in accordance with the pertinent current standards of the Institute of Electrical and Electronics Engineers, the American Society for Testing Materials, and the National Board of Fire Underwriters. In those areas where there are pertinent local ordinances and requirements, the wiring, material, and installation procedures shall comply with the local requirements.

715.9.5.3-Flash Requirements:

715.9.5.3.1-Flash Rate: The light from Type A and Type B devices shall have a flash rate of 65 (+/- 10) flashes per minute for temperatures between -29 deg C to 66 deg C (-20 deg F to 150 deg F) regardless of the power source.

715.9.5.3.2-ON-time:

- a) Definition: ON-time is defined as the period of the flash where instantaneous intensity is equal to or greater than the effective intensity as specified in Section 715.9.5.4.1.2.
- b) Type A: The light shall have an ON-time of not less than 10 percent of the flash cycle.
- c) Type B: The light shall have an On-time of not less than 8 percent of the flash cycle.
- d) Maximum allowable ON-time for either Type A or Type B lights shall be 50 percent.

715.9.5.4-Optical Requirements:

715.9.5.4.1-Photometry:

715.9.5.4.1.1-Light Distribution: The light distribution for Types A, B and C shall have a minimum lateral width of 9 degrees and a minimum vertical height of 5 degrees from the optical axis of the system. Within these confines, minimum candela requirements, as specified in Sections 715.9.5.4.1.2.1 through 715.9.5.4.1.2.3, shall be met.

The light distribution for Type D shall be 360 degrees in the horizontal plane and shall be a minimum of 5 degrees vertical from the horizontal plane. Within these confines, minimum candela requirements, as specified in Section 715.9.5.4.1.2.4, shall be met.

715.9.5.4.1.2-Minimum Candela Requirements:

715.9.5.4.1.2.1-Type A: For Type A the effective luminous intensity shall not drop below 4.0 candelas within the area specified in Section 715.9.5.4.1.1, during the first 336 hours of continuous flashing.

715.9.5.4.1.2.2-Type B: For Type B the effective luminous intensity shall not drop below 35 candelas within the area specified in Section 715.9.5.4.1.1 during the first 168 hours of continuous flashing. During the hours of darkness, the effective intensity may be reduced by a maximum of 50 percent.

715.9.5.4.1.2.3-Type C: For Type C the luminous intensity shall not drop below 2.0 candelas within the area specified in Section 715.9.5.4.1.1 during the first 168 hours of continuous burning.

715.9.5.4.1.2.4-Type D: For Type D the luminous intensity on a horizontal plane shall not drop below 1.0 candelas. At 5 degrees vertical from the horizontal plane, the luminous intensity shall not drop below 0.5 candelas. This performance shall be met throughout the first 168 hours of continuous burning. Type D steady burn warning lights shall be visible on a clear night from a distance of 3,000 feet.

715.9.5.4.2-Testing Procedures:

715.9.5.4.2.1-Type A and Type B Effective Intensity: The effective intensity of Type A and Type B lights shall be calculated using the “Guide for Calculating the Effective Intensity of Flashing Signal Lights,” published in the November 1964 edition of Illuminating Engineering magazine, by the Illuminating Engineering Society of North America, or latest revision.

715.9.5.4.2.2-Type C and Type D Effective Intensity: The intensity of the Type C and Type D lights shall be tested as set forth in the current edition of SAE Standard J575 (Society of Automotive Engineers, Inc., Lighting Equipment and Photometric Tests).

715.9.5.4.2.3-Retro-reflection: Retro-reflection shall be tested in accordance with the current edition of SAE Standard J594.

715.9.5.4.2.4-ATSSA Test T-101: Warning devices furnished or approved under this specification shall be tested in accordance with the current edition of ATSSA Test Procedure T-101 (American Traffic Safety Services Association).

715.9.5.4.2.5-Disabling of Solar Collectors: If the device uses a solar collector, the collector shall be disabled by either covering the collector or disconnecting it for the entire test period.

715.9.5.5-Lens Requirements: The following section applies to devices that use a lens.

715.9.5.5.1-Lens Sizes:

715.9.5.5.1.1-Types A, B, and C: Type A, B and C device lenses shall not be less than 177 mm (7 in) in diameter, including a retro-reflector ring of 12 mm (1.2 in) width around a minimum of 300 degrees of the lens periphery.

715.9.5.5.1.2-Type D: A Type D device lens shall be 360 degrees circular in the horizontal plane, with a minimum outside diameter of 75 mm (3 in) and a minimum height of 75 mm (3 in), including mounting flanges.

715.9.5.5.2-Lens Directionalities:

715.9.5.5.2.1-Types A and C: Type A and Type C device lenses shall be either bi-directional or unidirectional.

715.9.5.5.2.2-Type B: A Type B device lens shall be unidirectional.

715.9.5.5.2.3-Type D: A Type D device shall have a 360 degree dome lens.

715.9.5.5.3-Lens Chromaticity: The chromaticity of the lens colors and retro-reflective colors shall be tested using a light source with a color temperature ranging between 2600 deg K and 2856 deg K. The chromaticity of lenses and the emitted light from both yellow and red warning lights, and of both yellow and red retro-reflectors, shall conform to the chromaticity requirements of Section 8.04 and Figure 1 of the ITE Vehicle Traffic Control Signal Head standard. The wavelength spectra distribution of the light source shall be within the range of 500 nm to 650 nm.

715.9.5.5.4-Lens Retroreflector Performance: The specific intensity of the retro-reflector, when provided, shall meet the requirements as specified in Section 715.9.5.10.

715.9.5.5.5-Lens Material: The lens shall be of one-piece construction. The lens shall be manufactured using materials such as plastic capable of meeting the chromaticity requirements of this specification. The lens material shall meet the test requirements set forth in the most recent edition of SAE Standard J576 (Society of Automotive Engineers, Inc., Lighting Equipment and Photometric Test). For the purposes of this specification, the exposure time and conditions of paragraph 3.4.3, SAE Standard J576, shall be for one year (365 calendar days).

715.9.5.6-Head and Housing Requirements:

715.9.5.6.1-Swivel Heads: If swivel capabilities as described in this Section are not incorporated in the device used to mount a Type A or Type C light to any channelizing device, barrier, or a sign, the head shall be mounted on the housing in a manner permitting it to be swiveled through a minimum 90 degree arc in a horizontal plane. If swiveling is to be accomplished by rotating the head, the design of the device head and its construction shall be such that rotating the head will not result in damaging any circuitry or wiring. If

the lens assembly rotates around the light source, the photometrics shall meet the requirements of Section 715.9.5.9.

715.9.5.6.2-Housing:

715.9.5.6.2.1-Definition: Housing is defined as the case containing the battery and may contain the circuitry.

715.9.5.6.2.2-Material: The housing, when constructed of steel, shall be constructed of No. 18 U.S. Standard Gauge Steel. The housing may be made of any other material such as high-impact plastics suitable for use along roadway work zones.

715.9.5.6.3-Painting: The housing and the lens frame, if constructed using corrodible metal, shall be properly cleaned, degreased and pretreated to promote adhesion. It shall be given one or more coats of enamel which, when dry, shall completely obscure the metal substrate. The enamel coating shall be of such quality that when the coated case is struck a light blow with a sharp tool, the paint shall not chip or crack, and if scratched with a knife shall not powder.

715.9.5.6.4-Weatherproofing: The case shall be constructed and closed as to exclude moisture that would affect the specified operation of the light. The case shall have a weep hole to allow the escape of moisture.

715.9.5.6.5-Sun Shield Visor: All Type B Warning Lights shall incorporate a sun shield visor for the purpose of enhancing visibility during daylight conditions. The visor shall encircle a minimum of 77-1/2 degrees of the face of the lens in each direction from a datum point at the top of the lens face. At the datum point, the lens shall extend a minimum of 4-3/4" out from the face of the lens. At the ends of the visor, as measured in degrees in each direction from the above described datum point, the visor shall extend a minimum of 1-1/2" out from the face of the lens.

715.9.5.7-Photoelectric Controls: Photoelectric controls, when provided, shall keep the device operating whenever the ambient light level falls below 215 lux.

715.9.5.8-Testing and Certification, Quality, and Marking:

715.9.5.8.1-Testing and Certification of New Warning Lights: Warning lights furnished or approved for use under this specification shall be statistically represented by units that have been tested and approved as to conformance to these specifications by an independent accredited testing organization. Certification as to conformance to these specifications shall be provided upon request and will be furnished by the manufacturer as substantiated by testing results from an independent accredited testing laboratory or organization. Warning lights tested and approved as described above shall be retested for compliance and recertification when required or when the supplier makes changes to any aspect of the light-emitting warning devices covered by this specification. For example, whenever any changes are made in the lens, light source, or circuitry.

715.9.5.8.2-Quality: All electrical components, the quality of the materials used, and the workmanship of all warning lights furnished for use and certified as to the conformance to this specification shall be the same as that of models approved under this specification.

715.9.5.8.2-Marking: Each device shall be plainly marked as to type (A, B, C or D), the manufacturer's or customer's name, model number or name, and label or marking stating it meets the requirements of the Institute of Traffic Engineers "Purchase Specification for Flashing and Steady Burn Warning Lights". The location of the label or marking may be internal or external to the housing, and may be placed on the outside of the circuit and/or lamp holder assembly.

715.9.5.9-Summary Information:

	Type A	Type B	Type C	Type D
	Low Intensity	High Intensity	Steady Burn	Steady Burn
Lens Directional Faces	1 or 2	1	1 or 2	360 ⁰
Flash Rate Per Minute	55 to 75	55-75	NA	NA
Minimum On-Time	10%	8%	NA	NA
Minimum Effective Luminous Intensity*	4.0 Candelas (yellow); 1.0 Candelas (Red)	35 Candelas** (yellow) 12 Candelas** (red)	NA	NA
Minimum Luminous Intensity*	NA	NA	2.0 Candelas	1.0 to 0.5 Candelas
Hours of Required Operation*	Dusk to dawn	24 hours/day	Dusk to dawn	Dusk to dawn

* These values shall be maintained within the areas as specified in Section 715.9.5.4.1

* During hours of darkness, the effective intensity may be reduced by a maximum of 50%

715.9.5.10-Retroreflector Requirements:

Observation Angle	Entrance Angle	Yellow Luminous Intensity (Candelas/lux)	Red Luminous Intensity (Candelas/lux)
0.2	20 degrees left	0.9	0.23
0.2	10 degrees left	1.31	0.33
0.2	0 degrees	1.67	0.42
0.2	10 degrees right	1.31	0.33
0.2	20 degrees right	0.9	0.23

715.9.5.11-Approved Products Listing: Warning Lights utilized as part of WVDOH Construction projects must be included on the WVDOH Approved Products Listing (APL) for Warning Lights. A list of approved products and their code numbers may be obtained by contacting:

West Virginia Division of Highways
Material Controls, Soil and Testing Division
190 Dry Branch Road
Charleston, WV 25306

715.10-PREFABRICATED DRAINAGE SYSTEMS:

715.10.1-Prefabricated Pavement Edge Drain:

715.10.1.1-General: Prefabricated pavement edge drain shall be a flexible rectangular hollow mat consisting of a supporting polymeric drainage core encased in an engineering fabric envelope and having sufficient flexibility to withstand installation bending and handling without damage.

715.10.1.2-Core: The drainage core shall be constructed from a polymeric material, have a minimum thickness of $\frac{3}{4}$ inch (19 mm) and a minimum compressive strength of 3,000 pounds per square foot (145 kPa) with a maximum deflection of 20 percent determined by ASTM D 1621, except the sample size may be increased to a maximum of 12 in. by 12 in. (300 mm by 300 mm) The edge drain shall permit inflow on both sides of the drain and produce a minimum flow rate of 10 gal/minute/ft (123 liters/minute/meter) of width as determined by ASTM D 4716. Flow rates shall be based on a hydraulic gradient of 0.1 and a confining pressure of 10 psi (69 kPa) using a closed-cell foam rubber layer on both sides. The height of the edge drain shall be as shown on the Plans.

715.10.1.3-Fabric: The fabric shall be suitable for subsurface drainage applications and shall meet the requirements of 715.11 except the minimum tensile strength shall be 90 lbs. (400 N). The fabric shall be bonded to or stretched tightly over the core support contact points.

715.10.1.4-Fittings: All fittings shall be in accordance with the manufacturer's published specifications.

715.10.1.5-Outlet Pipe: The outlet pipe shall be a smooth inner wall unperforated pipe meeting the requirements of 714.19 (AASHTO M252, Type S only) or 714.22

715.10.1.6-Acceptance: All components of the edge drain shall be approved before use. The Contractor shall furnish certified test data with the material supplied for each project. Tests for all required properties shall be performed in accordance with the procedures specified. Compliance of this data with the requirements specified will be the basis of acceptance.

715.11-ENGINEERING FABRIC:

715.11.1-General: Engineering fabric shall meet the applicable requirements of AASHTO M 288.

715.11.2-Acceptance: All engineering fabric shall be approved before use. When using a fabric not on the Division's approved list, the Contractor shall furnish certified test data with each shipment of fabric. Compliance of this data with the requirements of the specific application will be the basis of acceptance.

The test results submitted shall be derived from testing samples representing the fabric contained in each shipment. Tests for all required properties shall be performed in accordance with the procedures specified. Each roll shipped shall be identified so as to show its relationship to the test data submitted.

715.11.3-Maintenance and Repairs: Any fabric damaged or displaced shall be replaced or repaired at the Contractor's expense. Any fabric, other than that used for silt fence, not covered within 14 days after installation shall be removed and replaced at no expense to the Division. Minor tears or ruptures in the fabric may be repaired by sewing or by placing another piece of fabric over the damaged area so that the overlap is at least 2 feet (600 mm) in each direction or as directed by the Engineer.

715.11.4-Engineering Fabric for Subsurface Drainage: Engineering fabric for subsurface drainage shall meet the applicable requirements of AASHTO M 288, Section 7, Class 2. Additionally, the permittivity shall be a minimum of 0.2 sec^{-1} and the apparent opening size shall be no larger than No. 60 (250 μm) sieve.

715.11.5-Engineering Fabric for Sediment Control (Silt Fence): Engineering fabric for sediment control shall meet the applicable requirements of AASHTO M 288, Section 8.

715.11.6-Engineering Fabric for Erosion Control: Engineering fabric for erosion control shall meet the applicable requirements of AASHTO M 288, Section 7, Class 1.

715.11.7-Engineering Fabric for Paving: Engineering fabric for paving shall meet the applicable requirements of AASHTO M 288, Section 9.

715.11.8-Engineering Fabric for Separation: Engineering fabric for separation shall meet the applicable requirements of AASHTO M 288, Section 7, Class 2.

715.11.9-Engineering Fabric for Stabilization: Engineering fabric for stabilization shall meet the applicable requirements of AASHTO M 288, Section 7, Class 1.

715.11.10-Engineering Fabric for Pumped Sediment and Erosion Control (Dewatering Device): Each standard Dewatering Device shall have a fill spout large enough to accommodate a 4 inch (100 mm) discharge hose with attached straps to secure the hose and prevent pumped water from escaping without being filtered. The device must be able to accommodate a minimum flow rate of 1000 gal per minute (4 546 liters per minute) for the application for which it is to be used and a minimum size of 100 square feet (9 square meters).

The Dewatering Device shall be a nonwoven bag, which is sewn with a double needle stitching using a high strength thread.

The Dewatering Device seams shall have an average wide width strength per ASTM D 4884 of 100 LB/IN (1.15 kg/meter).

The geotextile fabric shall be nonwoven fabric with the following properties:

PROPERTIES	TEST METHOD	ENGLISH	METRIC
Grab Tensile	ASTM D-4632	250 Lbs.	113 kg
Puncture	ASTM D-4833	165 Lbs.	75 kg
Flow Rate	ASTM D-4491	70 Gal/ Min/Square Foot	25 Liters/Min/Square Meter
Permittivity	ASTM D-4491	1.3 Sec.-1	1.3 Sec.-1
Mullen Burst	ASTM D-3786	550 lbs. /Square Inch	3.79 MPa
UV Resistant	ASTM D-4355	70 %	70 %
AOS % Retained	ASTM D-4751	100 %	100 %

* All properties are minimum average roll value.

715.12-CONCRETE FOR MISCELLANEOUS USES:

Concrete specified in this Section is intended for such uses as cast-in-place footers for right-of-way fence and footers for guardrail breakaway cable terminals and special trailing end terminals. The concrete may be mixed with or without air entrainment at the option of the Contractor. Batching and mixing may be by hand, by portable mixer, or by a commercial plant. At the time of placement, the concrete shall be of a workable consistency which can be consolidated satisfactorily by spading or vibrating. Indications of initial set in the concrete to such an extent as to adversely affect the workability of the concrete during placement shall be cause for rejection. The concrete shall be in accordance with one of the following:

- i. Concrete produced for other construction items under an approved mix design.
- ii. Concrete produced from premixed ingredients sold commercially in acceptable sacks, such as "Sacrete", or "Quickrete", "Handicrete" or approved equal. Premixed commercial preparations shall be mixed in accordance with the manufacturer's instructions.
- iii. Concrete produced from separate components proportioned by volume in the ratio of one part Portland cement to two parts sand to three parts coarse aggregate. Sand and coarse aggregate shall be visually inspected for deleterious substances, and such matter shall be removed prior to mixing.

715.13-PREFORMED FABRIC PADS:

Material shall conform to the requirements of the AASHTO Standard Specifications for Highway Bridges, Division II, Section 18.4.10.1.

A certified copy of test reports showing compliance with the above requirements shall be furnished the Division's Shop Inspector, or to other representatives of the Division as may be designated, for each shipment.

715.14-ELASTOMERIC BEARING PADS:

Bearing pads shall meet the requirements of the AASHTO Standard Specifications for Highway Bridges, except for sampling frequency.

715.14.1-Sampling Frequency for Elastomeric Bearing Pads: The sampling rate shall be one bearing pad per lot, per nominal dimensional size. (A change in nominal dimensional size is any change in the designed length, width or height of the bearing pad.)

715.15-ELASTOMERIC BEARING PADS FOR BRIDGE RAILING POSTS:

Elastomeric bearing pads for bridge railing posts shall have a thickness of 1/8 inch (3 mm) unless modified by the project plans.

The pads shall have a minimum tensile strength of 1,000 psi (7 MPa) when tested in accordance with ASTM D 412. The pads shall have a durometer hardness of 55 to 75 when tested in accordance with D2240.

715.16-CLAY OR SHALE BRICK:

Brick shall conform to the requirements of one of the following Specifications:

Sewer Brick.....AASHTO M 91, Grade SM or MM

Sewer Brick.....ASTM C 32, Grade SM or MM

Building Brick.....AASHTO M 114, Grade SW

Building Brick.....ASTM C 62, Grade SW

715.17-CONCRETE BRICK:

Concrete brick shall conform to the requirements of ASTM C 55; the grade shall be as specified on the Plans.

715.18-CONCRETE MASONRY UNITS:

Hollow load-bearing concrete masonry units shall conform to the requirements of ASTM C 90. The type and grade shall be as shown on the Plans.

Solid precast segmental concrete masonry units for construction of catch basins and manholes shall conform to the requirements of ASTM C 139.

715.19-PRECAST CONCRETE UNITS FOR MANHOLES AND INLETS:

Precast concrete units for manholes shall conform to the requirements in AASHTO M 199. In addition, air entrainment in the concrete shall be seven percent plus or minus two percent.

Portland cement concrete for precast inlets shall be in accordance with the applicable portions of the "Materials", "Manufacture" and "Physical Requirements" sections of AASHTO M 199, with the additional statement regarding compression tests to be included in the "Physical Requirements" section: "If no design strength is specified for precast concrete inlets, the minimum 28-day compressive strength shall be considered to be the 3,200 psi (20 MPa) minimum cylinder strength."

Also, for precast inlets, air entrainment in the concrete shall be seven percent plus or minus two percent. Surface finish for precast inlets is not required, except, if resultant exposed surfaces have unsightly voids, flaking or other surface defects present, those imperfections shall be repaired in accordance with the requirements of 601.11.1 for Class 1, Ordinary Surface Finish.

715.20-PRECAST CONCRETE TRAFFIC DIVIDERS:**715.20.1-Materials:**

715.20.1.1-Cement: The cement used shall conform to the requirements of 701.1 or 701.3. It shall, in addition, be manufactured to conform to the whiteness of Atlas or Medusa brands of white Portland cement.

715.20.1.2-Water: Water shall conform to the requirements of 715.7.

715.20.1.3-Aggregates: Fine aggregate shall be white silica sand conforming to the requirements of 702.1.1, 702.1.2, 702.1.4 and 702.1.5. Coarse aggregate shall be marble, 3/4 in. (9.5 mm) nominal top size. Fine and coarse aggregates shall meet the soundness requirements in 715.20.1.4.

715.20.1.4-Acceptance Tests: When tested in accordance with ASTM C 88 using sodium sulphate, the weighted average loss in five cycles shall not exceed five percent. If materials are blended to produce the aggregate, each component of the blend shall meet the soundness requirements specified above.

A sample of concrete made with the materials proposed for use in the item, combined in the proportions specified in 715.20.2, shall be submitted to the Engineer for inspection and approval of color. The sample size shall not be less than a two-inch (50 mm) cube.

Certified test reports from the manufacturer for all materials used in manufacturing the dividers shall be furnished.

715.20.2-Proportioning: Concrete shall be proportioned to meet the following requirements:

- i. The sand-aggregate ratio shall be in the range of 30 to 45 percent.
- ii. The maximum allowable slump shall be 1 in. (25 mm).
- iii. The maximum water content shall be five gallons per sack (0.44 liters per kg) of cement.
- iv. The minimum cement factor shall be eight sacks per cubic yard (446 kg per cubic meter) of concrete.
- v. The amount of entrained air in the plastic concrete shall be seven plus or minus two percent.

715.20.3-Placing and Curing: Concrete shall be placed in forms designed to conform to the lengths, shapes and other details of the traffic divider shown on the Plans. Curing shall be in accordance with the applicable requirements in 601.

715.21-BLANK

715.22-PRECAST CONCRETE MEDIAN BARRIERS (PERMANENT):

715.22.1-Description: Precast median barriers shall conform to the shape and dimensions shown on the Plans and shall meet the following requirements:

715.22.2-Materials: Materials shall meet the requirements specified in the following Subsections of Division 700:

MATERIAL	SUBSECTION
Air Entraining Admixture	707.1
Cement	701.1
Coarse Aggregate	703.1, 703.2, or 703.3
Expansion Joint Filler Preformed	708.1
Fine Aggregate	702.1
Joint Sealing Material	708.3
Reinforcing Steel	709.1 and 709.4
Water	715.7

Sampling and testing of materials shall be in accordance with the minimum frequency stated in Table 2 of MP 711.03.30.

715.22.3-Proportioning: Concrete shall be in proportion to meet the following requirements:

- i. The minimum cement factor shall be seven sacks (6.58 cwt) per cubic yard (390 kg per cubic meter) of concrete.
- ii. The maximum water content shall be five gallons per sack (0.94 cwt) (0.44 liters per kg) of cement.
- iii. The amount of entrained air in the plastic concrete shall be seven plus or minus two percentage points.
- iv. The consistency shall be such as to allow proper placement, consolidation, and finishing.

715.22.4-Placing and Curing: Concrete shall be placed in forms designed to conform to the lengths, shapes and other details of the median barrier shown on the Plans. Curing shall be in accordance with the applicable requirements of 601.

715.22.5-Finishing: The surface of the barrier shall be smooth and free from air bubble pockets, depressions, and honeycombs.

When the barriers are removed from the forms, any surface imperfections present shall be repaired in accordance with the requirements of 601.11.1-Class I, Ordinary Surface Finish.

715.23-GABIONS:

Welded wire fabric gabions shall conform to ASTM A974 and non-welded (twisted) wire mesh gabions shall conform to ASTM A975. Additionally, the use of fastener rings in the assembly of the gabion baskets may be permitted by the Engineer, providing the rings have at least the same tensile strength, zinc coating, and size as the wire used in the body of the gabion.

715.24-MATTING FOR EROSION CONTROL:

715.24.1-General: Matting for erosion control shall be commercially designed and manufactured especially for the prevention of soil erosion.

The matting used shall be recommended by the technical representative for a manufacturer and approved by the Engineer after an evaluation of the site conditions has been made. The manufacturer shall provide installation instructions and attest that the proposed matting is well suited to the particular site to be protected.

The matting shall be stabilized or manufactured in such a way that the physical integrity of the product is maintained throughout the intended life expectancy. The matting shall not effect the germination of seed nor inhibit plant growth. Temporary matting shall gradually deteriorate with no adverse environmental effects.

715.24.2-Permanent Erosion Matting: The matting shall consist of a machine produced mat of 100% ultraviolet stabilized polymeric or other suitable fibers resistant to degradation and having uniform thickness and mass per unit area throughout. The matting shall conform to the following:

Property ¹	Test Method	Type A	Type B	Type C
Minimum Mat Thickness	ASTM D1777	0.35 in. (9 mm)	0.50 in. (13 mm)	0.50 in (13 mm)
Minimum (Wide Width) Tensile Strength	ASTM D4595	145 x 110 lb/ft (2.16 x 1.6 kN/m)	170 x 130 lb/ft (2.5 x 1.5 kN/m)	3100 x 2000 lb/ft (45 x 29 kN/m)
Maximum Elongation	ASTM D4595	50%	50%	50%
Minimum Porosity (Calculated)		95%	95%	95%
Resiliency	ASTM D1777	80%	80%	80%
Ultraviolet Stability	ASTM D4355	80%	80%	80%

¹ Property values are reported as minimum average roll values (MARV)

Tractive Force (Shear Stress) Performance Specification:

Type A Matting shall have the ability to prevent soil loss where the maximum channel shear stress ranges from 0-4 lb/ft² (0-20 kg/m²) in a vegetated state, @ 0.5 hours peak flow duration.

Type B Matting shall have the ability to prevent soil loss where the maximum channel shear stress ranges from 0-6 lb/ft² (0-29 kg/m²) in a vegetated state, @ 0.5 hours peak flow duration.

Type C Matting shall have the ability to prevent soil loss where the maximum channel shear stress ranges from 0-8 lb/ft² (0-39 kg/m²) in a vegetated state, @ .5 hours peak flow duration.

715.24.3-Acceptance: Acceptance of temporary erosion control matting shall be based upon the manufacturer's written certification that the erosion control mat used is well suited to the particular site to be protected and upon the Division's visual inspection of the material. Acceptance of permanent erosion control matting shall be based upon certified test data with each shipment of matting. Compliance of this data with the requirements specified will be the basis of acceptance.

715.25-GROUND AGRICULTURAL LIMESTONE:

Ground agricultural limestone shall consist of high calcitic or dolomitic limestone containing not less than 85% of total calcium and magnesium carbonates, ground to such fineness

and clearly labeled in accordance with the requirements of the West Virginia Department of Agriculture. Ground agricultural limestone shall be furnished and used in accordance with State Laws. Suppliers must be registered with the West Virginia Department of Agriculture.

715.26-FERTILIZERS:

Commercial fertilizers shall be supplied separately or in mixtures containing the specified percentages of total nitrogen, available phosphoric acid, and water soluble potash. Fertilizer shall be furnished in standard containers with weight, name of plant nutrients and guaranteed percentages, clearly marked, all in accordance with governing State and Federal laws. Brands must be registered with the West Virginia State Department of Agriculture.

715.26.1-Fertilizer for Seeding: Fertilizer for seeding shall consist of any type with a 1-2-1 ratio providing the minimum nutrient equivalent specified. Urea formaldehyde fertilizer shall contain a minimum of 38 percent slowly available nitrogen.

Commercial fertilizer for seeding may be supplied in any of the following forms, subject to the approval of the Engineer.

- i. A dry, free flowing fertilizer that may be applied by ordinary agricultural spreaders.
- ii. A fertilizer which is water soluble or one which will permit complete suspension of insoluble particles in water, applicable to hydraulic methods of application.

715.26.2-Fertilizer for Landscape Planting: The fertilizer shall be a co-granulated magnesium ammonium phosphate and magnesium potassium phosphate, controlled release, inorganic fertilizer compound (coarse grade). It shall have a guaranteed minimum analysis of:

	Percent
Nitrogen	7
Maximum water soluble ammoniacal nitrogen.....	2
Minimum water insoluble ammoniacal nitrogen	5
Phosphoric acid (available P ₂ O ₅).....	40
Potash(K ₂ O)	6

715.27-MULCH MATERIAL:

715.27.1-Mulch Material for Seeding:

715.27.1.1-Straw Mulch: Straw mulch for seeding shall include baled wheat or oats straw, or baled grass hay. Alfalfa, clover and salt grass hay are not acceptable. Straw mulch shall be dry and reasonably free from weeds, sticks, or other foreign material.

Acceptance shall be based on the Division's visual inspection of the material.

715.27.1.2-Wood Cellulose Mulch: Mulch for use with the hydraulic application of grass seed shall consist of wood cellulose fiber. It shall contain no growth or germination inhibiting factors and shall be dyed green. When the material is agitated in slurry tanks with fertilizers, grass seed, water and other approved additives, the fibers shall become uniformly suspended to form a homogeneous slurry. The hydraulically sprayed slurry shall form a blotter-like ground cover impregnated with grass seed. The ground cover shall permit the absorption of water and allow rainfall or mechanically applied water to percolate to the underlying soil.

The wood cellulose fiber mulch shall conform to the following requirements:

Length of fibers	10 mm. maximum
Thickness of Fibers	1 mm. maximum
Net Dry Weight Content*	Minimum stated on bag
pH*	4.0-8.5
Water Holding Capability*	90% Minimum

* Test Procedure-MP 715.27.20

The mulch shall be delivered in packages not to exceed 100 lbs. (45 kg). The package shall bear the name of the manufacturer, the net weight and a supplemental statement of the net dry weight.

The material must be approved prior to being used. Acceptance will be based on sampling and testing by the Division for conformance to specifications.

715.27.1.3-Chemical Mulch Binder: A chemical mulch binder shall consist of a polymer synthetic resin, polypectate, or other material which can readily be removed and will give similar adhesive properties as asphalt when sprayed on straw or other fiber mulches.

715.27.2-Mulch Materials for Landscape Plantings: Acceptable materials for mulching shall be shredded bark, buckwheat hulls, wood chips or other organic materials approved by the Engineer.

Certain inorganic materials such as calcined clay, crushed rock or coarse gravel will be acceptable when designated on the Plans.

715.28-SEED:

The varieties of grass and legume seeds to be furnished to the project shall bear a tag on each bag of each species showing the lot number, the seedman's name, the percent of purity, the percent of germination and the weed seed content, in accordance with governing State and Federal laws.

All seeds shall be free from noxious weed seeds as set forth in the West Virginia State seed law and in no event shall the total weed content of any lot of seed or seed mixture exceed one-half percent by weight. The minimum percent purity and germination for the various seeds shall be as shown in Table 715.28.

Seed	Purity Minimum %	Germination	
		Total Minimum (%)	Minimum Quick Sprouts (%)
Crown Vetch	99	*70	35
Kentucky Bluegrass	85	75	
Kentucky 31 Fescue	98	85	
Marion Bluegrass	90	75	
Perennial Ryegrass	95	85	
Red Fescue	98	85	
White Dutch Clover	98	*85	55

Crown vetch seed shall be inoculated according to the supplier's recommendations. However, when seeding with the hydroseeder the inoculant shall be increased to five times the recommended rate.

If test results indicate noncompliance with the above germination or purity requirements, or both, additional seed may be added to give the equivalent germination or purity, or both.

The Division reserves the right to test, reject or approve all seed after delivery on the project.

715.29-INOCULATING BACTERIA:

This material shall be used to treat all leguminous seed and shall be a pure culture of nitrogen fixing bacteria selected for maximum vitality and ability to transform nitrogen from the air into soluble nitrates and deposit them in the soil. It shall not be more than one year old.

715.30 through 715.32-BLANK

715.33-VINES AND GROUND COVER PLANTS:

This material shall have a healthy, well-formed root system, free from disease. All transported stock is subject to inspection by the State Agriculture Department for insect or plant pests, and subject to rejection if found lacking in any of the above requirements. All plants shall be nursery grown, two years or older, and of the quality and size designated on the Plans, subject to approval both at the nursery and on the planting site. All vines and ground cover plants shall meet the requirements of U.S.A. Standard for Nursery Stock, AAN. The 1969 edition shall govern unless a more recent issue is in effect at the time of advertisement of bids.

For vines and ground cover plants, a listing by standard names in effect on any date is on file with the Division and is available on request.

715.34-SEEDLING PLANTS:

This material shall have a healthy, well-formed root system, free from disease. All transported stock is subject to inspection by the State Agriculture Department for insect or plant pests, and subject to rejection if found lacking in any of the above requirements.

All plants shall be nursery grown, two years or older, and of the quality and size designated on the Plans, subject to approval both at the nursery and on the planning site. All seedling plants shall meet the requirements of U.S.A. Standard for Nursery Stock, AAN. The 1969 edition shall govern unless a more recent issue is in effect at the time of advertisement of bids.

For seedling plants, a listing of standard names in effect on any date is on file with the Division and is available on request.

715.35-TREES AND SHRUBS:

Plants shall be healthy with well-developed root systems and top growth for the species and shall be free of injury from disease, insects or other causes. All plants shall be true to type and name in accordance with "Standardized Plant Names" where applicable. Plants shall conform to the requirements of U.S.A. Standard for Nursery Stock, AAN. The 1969 edition shall govern unless a more recent issue is in effect at the time of advertisement of bids.

Collected plants shall be native or naturalized trees or shrubs growing in soils favorable for digging. The soil shall be of such character as to be readily retained on the roots of transplanted trees and shrubs.

The minimum root spread of bare-root collected plants shall be at least one third greater than that for nursery grown bare-root plants. Nursery grown stock, balled and burlapped for shipment, shall have ball sizes conforming to an AAN Standards. In the case of collected plants, ball sizes shall be at least 10 percent greater in diameter than those specified for nursery grown stock and shall be of sufficient depth to include the greater portion of the root system.

For ornamental flowering trees, deciduous and evergreen trees, and deciduous and evergreen shrubs, a listing by standard names in effect on any date is on file with the Division and is available on request.

Wherever balled and burlapped material is mentioned in these Specifications, the Contractor may with the approval of the Engineer, substitute container stock for balled and burlapped stock of small trees and shrubs. The container grown plants shall conform to the AAN Standards.

Plantable type pots can be used in lieu of burlapping balled plants; however, a firm ball must be placed in the pot, and the hole dug with the same care and to the same size as for balled and burlapped plants. Plants with balls which have been manufactured on bare-root dug material or bare-root material that has only recently been potted will be rejected. These improperly potted plants will not be considered equal to balled and burlapped or container grown plants.

715.36-ASPHALTUM BASE PAINT FOR TREE SURGERY:

Paint for tree wounds shall be antiseptic and waterproof, black in color and with an asphaltic base. It shall contain no coal-tar creosote, oils, kerosene, turpentine or other material harmful to the living tissue of trees.

715.37-MISCELLANEOUS ITEMS FOR LANDSCAPE PLANTINGS:

715.37.1-Tree Stakes: Stakes used for guying or supporting newly planted trees shall be made from rough sawed oak, or other approved material, free from unsound or loose knots that impair its strength. The stakes shall be two inch (50 mm) by two inch (50 mm) square and of a length in proportion to the height of the tree. The following lengths for stakes shall be used as a guide:

Approximate Tree Height Feet (m)	Stake Length Feet (m)
3 to 6 (1 to 2)	5 (1.5)
6 to 9 (2 to 3)	6 (2.0)
9 to 14 (3 to 5)	7 (2.5)

Larger size trees shall be guyed or supported by stakes as shown on the Plans.

715.37.2-Wire: The wire used for guying and staking plants shall be galvanized steel wire, free from bends and kinks. Trees less than 3 inches (75 mm) in diameter shall be guyed with No. 14 gage (1.9 mm) wire, and trees 3 inches (75 mm) and larger shall be guyed with No. 12 gage (2.7 mm) wire.

715.37.3-Hose: The hose used for staking and guying plants shall be new 3/8 to 5/8 in. (10 to 16 mm) nominal I.D. rubber garden hose or equal. The walls of the hose shall be of sufficient thickness to prevent wire damage to the plans.

715.37.4-Twine: The material used for tying wrapped tree trunks shall be binder twine not less than two-ply strength.

715.37.5-Tree Wrap: The material shall be four-inch (100 mm) wide waterproof sisal paper manufactured especially for wrapping trunks of trees.

715.37.6-Anti-Desiccant: Anti-desiccant shall be an emulsion which provides a protective film over plant surfaces, permeable enough to permit transpiration. It shall be delivered in the manufacturer's containers and shall be mixed according to the manufacturer's directions.

715.38-REINFORCED PLASTIC OR REINFORCED CORROSION-RESISTANT RUBBER MANHOLE STEPS:

715.38.1-General: Steps shall be composed of a steel reinforcing bar encased in plastic or rubber, pressure-molded to the steel; steps shall have a minimum cross-sectional dimension of 1 in. (25 mm). Reinforcing shall be continuous through the entire length of the legs and tread. Steps shall have a depressed tread or a ½ inch (12 mm) minimum height cleat at tread ends, and a top surface configuration such that it will prevent or minimize slippage during ascent or descent.

715.38.2-Steel Reinforcing: Steel shall be a deformed reinforcing bar; either No. 3, Grade 60, or No. 4, Grade 40 or 60 (Metric No. 10, Grade 300 or Grade 400); meeting the requirement of AASHTO M 31.

715.38.3-Plastic: Plastic shall be a grade of propylene copolymer which meets the requirements of ASTM D4101.

715.38.4-Corrosion-Resistant Rubber: The rubber compound shall meet the physical requirements of ASTM C443 except the durometer, Shore A, hardness shall be 70 plus or minus five.

715.38.5-Acceptance: Steps which have been evaluated by the Division and appear on the Division's list of approved sources will be accepted. If the Contractor proposes to use a step not previously approved, a complete step and certified test data conforming to the above stated requirements shall be submitted for evaluation.

715.39-ELASTOMERIC GASKET AND SEALING MATERIAL:

These Specifications cover those elastomeric materials intended for use as, but not restricted to, such noncritical applications as gaskets, sealing materials, miscellaneous drainage items, etc. The elastomeric material shall meet the following requirements:

Tensile Strength, minimum psi (MPa), ASTM D 412	1,200 (8.3)
Elongation at Break, minimum percent, ASTM D 412	350
Shore Durometer Hardness, ASTM D 2440	
Minimum	35
Maximum	65
Compression Set, max percent, ASTM D 395,	
Method B	25
Accelerated Aging, ASTM D 573 (96 hr. at 70EC):	
Decreased Tensile Strength, maximum percent	15
Decreased Elongation, maximum percent	20
Water Absorption by Weight, maximum percent, ASTM D 471	10

715.40-PAVEMENT MARKING MATERIAL:

This material includes all pavement marking material exclusive of White or Yellow Fast-Dry Traffic Zone Paint (Types II or IX).

Certification from the manufacturer that the material supplied meets the applicable requirements of these Specifications is required. The certification shall include the name and address of the manufacturer, the trademark or trade name, kind of material, reference to the Division's Standard Specification (Subsection Number), quantities, lot number and date of manufacture.

The supplier shall have equipment and qualified personnel to conduct all of the tests that are required by these specifications.

715.40.1-BLANK

715.40.2-Preformed Intersection Traffic Markings (Type V Material): The markings described are preformed, retroreflective pavement markings conforming in color, size and shape to the WVDOT Standard Details Book, Vol. II, and to the Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD)

Preformed thermoplastic traffic markings shall be fabricated to a uniform thickness of not less than 125 mils, including retroreflective beads. Preformed pavement marking tapes, applied as Type V material, shall be fabricated such that no portion of the material profile is less than 60 mils, including adhesive and retroreflective beads.

As a minimum, preformed thermoplastic traffic markings shall be capable of being applied to clean road surfaces at minimum road surface and ambient air temperatures of 35 degrees Fahrenheit (2 degrees Celsius), with a surface primer if necessary, providing moisture has been sufficiently removed from the application surface.

As a minimum, preformed pavement marking tapes applied as Type V material shall be capable of being applied to clean road surfaces, with a surface primer if necessary, when the following conditions are met:

1. Road surface is dry
2. Ambient air temperature 60 degrees Fahrenheit (16 degrees Celsius) and rising
3. Road surface temperature 70 degrees Fahrenheit (21 degrees Celsius) and rising
4. No rainfall 24 hours prior to application
5. Minimum air temperature overnight prior to application 40 degrees Fahrenheit (4 degrees Celsius)

715.40.2.1-Enhanced Skid Resistant Preformed Thermoplastic Traffic Markings: Specific markings, as identified on the Plans or otherwise on the applicable sheets in the WVDOH Standard Details Book, Vol. II, shall be applied only with preformed thermoplastic markings with enhanced skid resistant properties. The enhanced skid resistance of this material shall be achieved by utilizing surface applied abrasives with a minimum hardness of 7 (Mohs scale). The material, after application, shall have a minimum skid resistant value of 60 BPN when tested in accordance with ASTM specification E303, and shall not fall below this value for the warranty period specified in 715.40.2.2.

715.40.2.2-Adherence, Retroreflectivity, Color, Road Presence, and Skid Resistance Warranty Requirements: Section 663 requires the Contractor to correct any markings not meeting the warranty requirements specified herein up to the finalization date of the contract, if the cause of non-conformance with the performance requirements herein is due to either improper application or material defect(s), and requires the Contractor to correct any markings not meeting the warranty requirements specified herein for the balance of the one (1) year period from the date of installation when the failure is determined by the WVDOH to be caused by improper application. Warranty of the performance of the material for the balance of the warranty periods specified herein shall be provided directly to the WVDOH by the material manufacturer, and shall apply only to non-conformance with the performance requirements herein determined by the WVDOH to be caused by material defects.

Transverse markings shall be warranted to adhere to both asphalt and concrete, maintain road presence, and meet the retroreflectivity and color requirements described herein, for a minimum of three (3) years when applied according to the Manufacturer's recommendations. Transverse markings shall include stop bars, yield triangle markings, legend, symbols such as lane assignment arrows and lane drop arrows, railroad crossing markings, crosswalk markings, stripes inside lane shunts and gore areas, and other similar markings. When Enhanced Skid Resistant Preformed Thermoplastic material is specified, the marking shall meet the skid resistance requirement specified in 715.40.2.1 for the three year warranty period.

Longitudinal lines shall be warranted to adhere to both asphalt and concrete, maintain road presence, and to meet the retroreflectivity and color requirements described herein, for a minimum of four (4) years when applied according to the Manufacturer's recommendations. Longitudinal lines shall include lane lines, channelizing lines, edge lines, center lines, and other similar markings. When Enhanced Skid Resistant Preformed Thermoplastic material is specified, the marking shall meet the skid resistance requirement specified in 715.40.2.1 for the four year warranty period.

RETROREFLECTIVITY: Both white and yellow markings shall be warranted to maintain a minimum retroreflectivity level of 150 millicandelas, with beads applied, for the applicable warranty period described above.

All retroreflectivity measurements will be taken with a LTL-X or other Traffic Engineering Division approved 30-meter geometry retroreflectometer. A 5% tolerance with the stated minimum required retroreflectivity value shall be allowed when tested with a hand held retroreflectometer. Average retroreflectivity values shall be determined by following an adequate sampling plan to be determined by the Division.

Generally, conformance of markings with the retroreflectivity requirement shall be based on a well dispersed sampling, to be determined by the Division, of the retroreflectivity over the whole marking. Retroreflectivity sampling may be concentrated on a specific area of the marking that appears to be in non-compliance with the Road Presence requirement for the purpose of determining non-compliance with quantitative data.

COLOR: Each color installed shall be warranted to fall within the boundaries created by the following CIE Chromaticity Coordinate Limits, with beads applied, for the applicable warranty period described above:

COLOR	CIE CHROMATICITY COORDINATE LIMITS							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

The colormeter used shall be a LTL-Y, or other hand-held colormeter device approved by the Division. Average color coordinate values shall be determined by following an adequate sampling plan to be determined by the Division.

Generally, conformance of markings with the color requirements shall be based on a well dispersed sampling, to be determined by the Division, of the color values over the whole marking. Color sampling may be concentrated on a specific area of the marking that appears to be in non-compliance with the Road Presence requirement for the purpose of determining non-compliance with quantitative data.

ADHERENCE AND ROAD PRESENCE: Both white and yellow markings shall be warranted to maintain adherence and road presence for the applicable warranty period described above.

The Adherence and Road Presence requirement shall apply to materials worn uniformly, from the surface down, by normal traffic and snow-plowing. In addition, these requirements shall apply to materials at intersections subject to turning movements by normal traffic. However, these requirements shall not apply in cases of damage attributable to snow-plowing such as chiseling, cutting, chipping, or in cases of material removal from the roadway (other than removal from the surface down due to normal wearing as described above) when it can be shown that the material removal is due to snow-plowing rather than material adhesion failure. Loss due to pavement failure, unless caused by the marking material, will not be considered as a material failure.

715.40.2.3-Approved Products Listing: Material approvals are based on results from AASHTO's NTPEP testing program and/or WVDOH field evaluation tests. Approvals may also be granted or rescinded based on actual performance on WVDOH projects. A list of approved materials, code numbers, and approved Contractor personnel may be obtained by contacting:

Materials Control, Soils, & Testing Division
190 Dry Branch Drive
Charleston, West Virginia 25306

715.40.3-Interim Pavement Markings (Type VIIA Interim Pavement Marking Tape)

715.40.3.1-Interim Pavement Markings (Type VIIA): This specification describes an interim pavement marking tape, to be placed immediately after paving operations are completed, and prior to the opening of the roadway to traffic, as described in Section 401.11. The material shall be designed to be inlaid and used in place of centerlines and lane lines until temporary edge lines, centerlines, and lane lines are placed as described in Section 636.8, within the time period specified in Section 401.11.

715.40.3.1.1-Requirements-Any material not meeting the following requirements shall not be placed by the Contractor. If placed, the material shall be removed and replaced by the Contractor:

- i. **Composition:** This material shall consist of a white or yellow weather and traffic resistant reflective film on a conformable backing precoated with a pressure sensitive adhesive.
- ii. **Color:** The marking material shall be white or yellow color, as specified, and shall fall within the boundaries created by the following CIE Chromaticity Coordinate Limits until temporary markings are placed:

COLOR	CIE CHROMATICITY COORDINATE LIMITS							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

The Colormeter used shall be a LTL-Y, or other hand-held colormeter device approved by the Division. Average color coordinate values shall be determined by following an adequate sampling plan to be determined by the Division.

- iii. **Retroreflection:** The marking material shall be visibly retroreflective, under both dry conditions and conditions of moderate rainfall, when inlaid on bituminous concrete surfaces. The markings shall be readily visible, through the interim period prior to the placement of temporary markings, when viewed with automobile headlights at night.
- iv. **Adhesive:** The marking material shall have a precoated pressure sensitive adhesive and require no activation (primer). If necessary, the adhesive shall be protected prior to application with a removable liner to prevent contamination during processing, cutting, and handling. The liner shall release from the adhesive easily, without splitting or tearing, and shall not shrink or prematurely release from adhesive during processing, storage, or handling.
- v. **Storage Life:** The material shall not be used after being stored beyond the manufacturer's recommended storage life. The material shall have a minimum storage life of one (1) year.
- vi. **General:** The pavement marking material as supplied shall be of good appearance, and free from cracks. Edges shall be true, straight, and unbroken.
- vii. **Approved Suppliers:** The material must perform successfully in the Division's field evaluation test. The Division reserves the right to remove products from the

approved list based on actual field performance. A list of approved suppliers and their code numbers may be obtained by contacting:

West Virginia Division of Highways
Material Controls, Soil and Testing Division
190 Dry Branch Drive
Charleston, WV 25306

715.40.4-Temporary Pavement Marking Tape (Types VIIB and VIIC)

715.40.4.1-BLANK

715.40.4.2-Temporary Pavement Markings (Type VIIB): This specification describes a removable pavement marking consisting of a film designed to be used as temporary lines. The temporary pavement markings shall be white or yellow as denoted on the Plans or required by the MUTCD.

715.40.4.2.1-Requirements: Any material not meeting the following requirements shall not be placed by the Contractor. If placed, the material shall be removed and replaced by the Contractor:

- i. Composition: The removable preformed plastic pavement marking film shall consist of a mixture of polymeric materials, pigments, nonmetallic reinforcing medium to facilitate removal, and reflective beads or elements.
- ii. Color: Color pigments shall be thoroughly blended to provide a plastic marking film that maintains uniform color under both daylight and night lighting conditions throughout the expected life of the film. Each color installed shall fall within the boundaries created by the following CIE Chromaticity Coordinate Limits, with beads applied, while in place for any time period from April 1st to November 1st:

COLOR	CIE CHROMATICITY COORDINATE LIMITS							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

The Colormeter used shall be a LTL-Y, or other hand-held colormeter device approved by the Division. Average color coordinate values shall be determined by following an adequate sampling plan to be determined by the Division.

- i. Application Requirements: As a minimum, Type VIIB materials shall be capable of being applied to clean road surfaces, with a surface primer if necessary, when the following conditions are met:
 1. Road surface is dry
 2. Ambient air temperature 50 degrees Fahrenheit and rising
 3. Road surface temperature 50 degrees Fahrenheit and rising
 4. No rainfall 24 hours prior to application
 5. Minimum air temperature overnight prior to application 40 degrees Fahrenheit

- ii. **Adhesive:** The removable preformed plastic pavement marking film shall be pre-coated with a pressure sensitive adhesive capable of being affixed to bituminous concrete and Portland cement concrete pavement surfaces without the use of heat. An additional adhesive primer or activator is allowable and may be required under certain weather conditions, per the manufacturer's recommendations. The adhesive shall exhibit excellent shear characteristics and minimal tensile characteristics. The adhesive shall not require a protective liner when the preformed plastic pavement marking film is in rolled form for shipment.
- iii. **Storage Life:** The material shall not be used after being stored beyond the manufacturer's recommended storage life. The material shall have a minimum storage life of one (1) year.
- iv. **Thickness:** The removable plastic marking film shall be manufactured such that no portion of the material profile is less than 30 mils, including adhesive and retroreflective beads.
- v. **Skid Resistance:** The surface for the retroreflective preformed plastic pavement marking film shall provide a minimum skid resistance value of 50 BPN when tested in accordance with ASTM E 303.
- vi. **Removability:** While in place for any time period from April 1st to November 1st, the preformed plastic pavement marking film shall be removable from bituminous concrete and Portland cement concrete in its entirety, either manually or by a mechanical roll-up device, at temperatures above 40 degrees Fahrenheit (ambient and road surface temperature), and without the use of heat, solvents, grinding, or blasting.
- vii. **Retroreflectivity:** The markings shall be capable of maintaining a minimum average retroreflective performance level of 150/ mcd/m²/lx, while in place for any time period from April 1st to November 1st, when installed according to the manufacturer's recommendations. All retroreflectivity measurements will be taken with a LTL 2000, or other Traffic Engineering Division approved 30-meter geometry retroreflectometer. Average retroreflectance values shall be determined by following an adequate sampling plan to be determined by the Division.
- viii. **General:** The pavement marking material as supplied shall be of good appearance, and free from cracks. Edges shall be true, straight, and unbroken.
- ix. **Approved Products Listing (APL):** Approvals are based on results from AASHTO's NTPEP testing program and/or WVDOH field evaluation tests. Approvals may also be granted or rescinded based on actual performance on WVDOH projects. A list of approved suppliers and their code numbers may be obtained by contacting:

West Virginia Division of Highways
Material Controls, Soil and Testing Division
190 Dry Branch Drive
Charleston, WV 25306

715.40.4.3-Temporary Pavement Markings (Type VIIC): This specification describes a removable pavement marking consisting of a film designed to be used for temporary lines. The temporary marking retroreflective performance level shall not be

affected in a “wet” condition, as defined in this specification. The temporary markings shall be white or yellow as denoted on the plans or required by the MUTCD.

715.40.4.3.1-Requirements: Any material not meeting the following requirements shall not be placed by the Contractor. If placed, the material shall be removed and replaced by the Contractor:

- i. Composition: The removable preformed plastic pavement marking film shall consist of a mixture of polymeric materials, pigments, nonmetallic reinforcing medium to facilitate removal, a thin, flexible, conformable backing, and reflective beads or elements.
- ii. Color: Each color installed shall fall within the boundaries created by the following CIE Chromaticity Coordinate Limits, with beads applied, while in place for any time period from April 1st to November 1st:

COLOR	CIE CHROMATICITY COORDINATE LIMITS							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

The Colormeter used shall be a LTL-Y, or other hand-held colormeter device approved by the Division. Average color coordinate values shall be determined by following an adequate sampling plan to be determined by the Division.

- iii. Application Requirements: As a minimum, Type VIIC materials shall be capable of being applied to clean road surfaces, with a surface primer if necessary, when the following conditions are met:
 1. Road surface is dry
 2. Ambient air temperature 50 degrees Fahrenheit and rising
 3. Road surface temperature 50 degrees Fahrenheit and rising
 4. No rainfall 24 hours prior to application
 5. Minimum air temperature overnight prior to application 40 degrees Fahrenheit
- iv. Adhesive: The removable preformed plastic pavement marking film shall be pre-coated with a pressure sensitive adhesive capable of being affixed to bituminous concrete and Portland cement concrete pavement surfaces without the use of heat. An additional adhesive primer or activator is allowable and may be required under certain weather conditions, per the manufacturer’s recommendations. The adhesive shall exhibit excellent shear characteristics and minimal tensile characteristics. The adhesive shall not require a protective liner when the preformed plastic pavement marking film is in rolled form for shipment.
- v. Storage Life: The material shall not be used after being stored beyond the manufacturer’s recommended storage life. The material shall have a minimum storage life of one (1) year.
- vi. Thickness: The removable plastic marking film shall be manufactured such that no portion of the material profile is less than 30 mils, including adhesive and retroreflective beads.

- vii. Skid Resistance: The surface of the marking shall provide a minimum skid resistance value of 50 BPN when tested in accordance with ASTM E 303.
- viii. Removability: While in place for any time period from April 1st to November 1st, the preformed plastic pavement marking film shall be removable from bituminous concrete and Portland cement concrete in its entirety, either manually or by a mechanical roll-up device, at temperatures above 40 degrees Fahrenheit (ambient and road surface temperature), and without the use of heat, solvents, grinding, or blasting.
- ix. Wet Reflective Performance: The visual performance of the marking in wet and dry conditions shall be nearly identical. For visual evaluation purposes, the marking material shall be considered to be in a “wet” condition when a layer of water completely covers the top surface of the material. The layer of water shall measure a minimum of ¼ inch from the highest profile point of the material to the top surface of the water layer.
- x. Retroreflectivity: The markings shall be capable of maintaining a minimum average retroreflective performance level of 200/ mcd/m²/lx, while in place for any time period from April 1st to November 1st, in both dry and wet conditions when installed according to the manufacturer’s recommendations. Retroreflectance shall be measured in accordance with ASTM specifications E 2176 and/or E 2177 to determine the markings retroreflectivity in wet conditions. Average retroreflectance values shall be determined by following an adequate sampling plan to be determined by the Division. All retroreflectivity measurements will be taken with a LTL 2000 (dry condition), LTL-X (wet conditions), or other Traffic Engineering Division approved 30-meter geometry retroreflectometer.
- xi. General: The pavement marking material as supplied shall be of good appearance, and free from cracks. Edges shall be true, straight, and unbroken.
- xii. Approved Products Listing (APL): Approvals are based on results from AASHTO’s NTPEP testing program and/or WVDOH field evaluation tests. Approvals may also be granted or rescinded based on actual performance on WVDOH projects. A list of approved suppliers and their code numbers may be obtained by contacting:

West Virginia Division of Highways
Material Controls, Soil and Testing Division
190 Dry Branch Drive
Charleston, WV 25306

715.40.5-BLANK

715.40.6-Raised Pavement Markers (RPM’s): RPM’s include Type P-2 markers, Type R-4 markers, and Temporary markers.

715.40.6.1-Type P-2 Markers: This specification covers Type P-2 markers, a type of plowable, retroreflective, RPM for lane marking and delineation.

All references to ASTM specification D 4383 herein shall be taken as referencing the D 4383 – 05 version of this specification.

715.40.6.1.1-Casting Requirements: The metal castings of Type P-2 markers shall meet the following requirements:

- a. When tested in accordance with the methods and procedures specified in ASTM D4383, the castings shall meet the Compressive Strength performance requirements of ASTM D4383.
- b. When tested in accordance with the methods and procedures specified in ASTM D4383, the “ramps” of the castings shall meet the Hardness performance requirements of ASTM D4383.
- c. The installed height of the casting shall not exceed 0.25 in. (6.4 mm) above the road surface.
- d. The casting shall be manufactured of material specified in ASTM D4383, and shall be hardened to the level specified in ASTM D4383. The castings shall be capable of demonstrating that this hardness level has been achieved when tested in accordance with the methods and procedures specified in ASTM D4383.
- e. The plow blade deflecting ramps of the casting shall be angled not more than six (6) degrees to the surface of the road.
- f. The ramps of the castings shall be designed such that there shall be no vertical surfaces above the road level that can be contacted by the plow blade moving in the normal travel direction.
- g. In new condition, the surfaces of the casting shall be free of scale, dirt, rust, oil, grease, or any other contaminant which may reduce its bond to the adhesive with which the casting is installed or with which the lens is mounted.
- h. The casting shall be designed to be partially recessed below the pavement surface to withstand plow impact. It shall have means for indexing the pavement surface, such as tabs.
- i. Castings with center rails shall not be allowed.
- j. Castings shall have fully completed testing on the American Association of State and Highway Transportation Officials -National Transportation Product Evaluation Program (AASHTO-NTPEP) test deck in a location having a similar climate to West Virginia. Upon review, the performance of the castings on the test deck shall meet or exceed the historical performance of other industry standard castings approved by the WVDOH. This determination shall be made solely by the WVDOH.
- k. Castings shall have been tested by an independent testing facility to the applicable ASTM D4383 specification requirements referenced herein. The castings shall have been sampled as specified in ASTM D4383 and shall meet the applicable specification requirements, as demonstrated by test results certified and made available by the testing facility. The applicable ASTM D4383 specification requirements referenced herein shall be considered to be parts a), b), and d) of this Section.

715.40.6.1.2-Lens Requirements: The retroreflective lenses of Type P-2 markers shall meet the following requirements:

- a. The coefficient of luminous intensity (RI) of the lenses in new condition shall be not less than the values specified in ASTM D4383 when measured in accordance with the procedures and methods specified in ASTM D4383. Coefficient of luminous intensity shall be defined as the ratio of the luminous intensity (I) of the retroreflector in the direction of observation to the illuminance (E) at the retroreflector on a plane perpendicular to the direction of the incident light, expressed in candelas per lux (cd/lx).
- b. After abrading the lenses in accordance with the procedures and methods specified in ASTM D4383, the coefficient of luminous intensity of the lenses at zero (0) degrees entrance angle shall be not less than the values specified in ASTM D4383 when measured in accordance with the procedures and methods specified in ASTM D4383. This requirement shall not apply to red faces of lenses.
- c. When illuminated in accordance with ASTM D4383, the color of the lenses shall meet the color requirements of ASTM D4383 when measured in accordance with the procedures and methods specified in ASTM D4383.
- d. When impacted in accordance with the methods and procedures specified in ASTM D4383, the lenses shall meet the Lens Impact Strength performance requirements of ASTM D4383.
- e. When subjected to temperature cycling in accordance with the methods and procedures specified in ASTM D4383, the lenses shall meet the Temperature Cycling performance requirements of ASTM D4383.
- f. The lens shall be comprised of materials with adequate chemical, water, and UV resistance for the intended use.
- g. The lens width shall be approximately four (4) in. (102 mm).
- h. The angle between the face of the lens and the base shall be no greater than forty-five (45) degrees.
- i. The base of the marker shall be flat within 0.05 in. (1.3 mm). If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 0.05 in. (1.3 mm) from a flat surface.
- j. The lens shell, or body, shall be a solid polymer with no fill material. The retroreflective face(s) of the lens shall not be required to be integral with the shell.
- k. The retroreflective face(s) of the lens shall be subdivided into multiple “cells” which shall allow undamaged cells to continue to perform unaffected when one or more cells are damaged.
- l. The retroreflective technologies incorporated into the retroreflective face(s) of the lens shall be designed such that the lens will provide retroreflectivity when wet.
- m. Lenses shall have fully completed testing on the American Association of State and Highway Transportation Officials -National Transportation Product Evaluation Program (AASHTO-NTPEP) test deck in a location having a similar climate to West Virginia. Upon review, the performance of the lenses on the test deck shall meet or exceed the historical performance of other industry standard lenses approved by the WVDOH. This determination shall be made solely by the WVDOH.

- n. Lenses shall have been tested by an independent testing facility to the applicable ASTM D4383 specification requirements referenced herein. The lenses shall have been sampled as specified in ASTM D4383 and shall meet the applicable specification requirements, as demonstrated by test results published and certified by the testing facility. The applicable ASTM D4383 specification requirements referenced herein shall be considered to be parts a), b), c), d), and e) of this Section.

715.40.6.1.3-Adhesive Requirements: Epoxy adhesive shall be used for applying Type P-2 markers to the pavement surface. The specific adhesive used shall be an adhesive recommended by the P-2 marker manufacturer and meeting the requirements of ASTM D4383.

The adhesive used for adhering the Type P-2 marker lenses in the castings shall be an adhesive recommended by the P-2 marker manufacturer.

715.40.6.1.4-Product Submission and Approval: Type P-2 marker castings and/or lenses to be considered for inclusion on the WVDOH Approved Products List (APL) shall be submitted to the Materials Division following the current procedures specified by the Materials Division. The manufacturer may contact the Traffic Engineering Division for verification. The manufacturer should include all relevant documentation and information with this form, including but not limited to Product Data Sheets, Product Flyers, Manufacturer Product Specifications, Product Bulletins, Engineering Drawings, AASHTO-NTPEP test results, and the independent testing facility test results described herein.

In addition to the above, the WVDOH may also require that the casting and/or lens product(s) submitted for evaluation be field tested in one or more locations in West Virginia in order to validate the acceptable performance of the product(s). This field testing shall typically be a minimum of six months to one year in duration including a full winter season. Specific details related to this testing, such as locations and quantities, shall be determined by the WVDOH.

All submitted information will be forwarded to the WVDOH Traffic Engineering Division, which will in turn contact and work directly with the manufacturer during the evaluation process. The Traffic Engineering Division will evaluate all submitted literature and documentation for compliance with the specified requirements as well as satisfactory performance on the AASHTO-NTPEP test deck. The Traffic Engineering Division may also arrange for the manufacturer to furnish test samples and arrange for the product to be installed for field testing as previously described. After the evaluation is complete, the Traffic Engineering Division will inform the Materials Division in writing of the outcome of its evaluation.

715.40.6.2-Type R-4 Markers: This specification covers Type R-4 markers, a type of nonplowable, retroreflective RPM for nighttime lane marking and delineation. Note, due to the fact that snow plowing operations are necessary throughout the state of West Virginia, Type R-4 markers are not placed such that they will be subjected to direct plowing; rather, the RPM's are installed in limited locations in conjunction with surface mounted tubular markers in order to be shielded from plowing. All references to ASTM specification D 4280 herein shall be taken as referencing the D 4280 – 08 version of this specification.

Type R-4 markers shall meet the following requirements:

- a. When tested in accordance with the methods and procedures specified in ASTM D4280, the markers shall meet the Flexural Strength performance requirements of ASTM D4280.
- b. When tested in accordance with the methods and procedures specified in ASTM D4280, the markers shall meet the Compressive Strength performance requirements of ASTM D4280.
- c. The markers shall be comprised of materials with adequate chemical, water, and UV resistance for the intended use.
- d. The color of the marker shell shall match the color of the lens of the marker that is not red.
- e. The marker height shall not exceed 0.80 in. (20.3 mm).
- f. The marker width shall not exceed 5.1 in. (130 mm).
- g. The base of the marker shall be substantially free from gloss or substances that may reduce its bond to adhesive.
- h. The base of the marker shall be flat within 0.05 in. (1.3 mm). If the bottom of the marker is configured, the protruding faces of the configurations shall not deviate more than 0.05 in. (1.3 mm) from a plane.
- i. The coefficient of luminous intensity (RI) of the marker lenses in new condition shall be not less than the values specified in ASTM D4280 when measured in accordance with the procedures and methods specified in ASTM D4280. Coefficient of luminous intensity shall be defined as the ratio of the luminous intensity (I) of the retroreflector in the direction of observation to the illuminance (E) at the retroreflector on a plane perpendicular to the direction of the incident light, expressed in candelas per lux (cd/lx).
- j. After abrading the marker lenses in accordance with the procedures and methods specified in ASTM D4280, the coefficient of luminous intensity of the lenses at zero (0) degree entrance angle shall be not less than the values specified in ASTM D4280 when measured in accordance with the procedures and methods specified in ASTM D4280. This requirement shall not apply to red faces of lenses.
- k. When illuminated in accordance with ASTM D4280, the color of the marker lenses shall meet the color requirements of ASTM D4280 when measured in accordance with the procedures and methods specified in ASTM D4280.
- l. When impacted in accordance with the methods and procedures specified in ASTM D4280, the marker lenses shall meet the Lens Impact Strength performance requirements of ASTM D4280.

- m. When subjected to temperature cycling in accordance with the methods and procedures specified in ASTM D4280, the marker lenses shall meet the Temperature Cycling performance requirements of ASTM D4280.
- n. The retroreflective face(s) of the lens shall be subdivided into multiple “cells” which shall allow undamaged cells to continue to perform unaffected when one or more cells are damaged.
- o. The retroreflective technologies incorporated into the retroreflective face(s) of the lens shall be designed such that the lens will provide retroreflectivity when wet.
- p. The angle between the face of the marker lens and the base shall be no greater than forty-five (45) degrees.
- q. The markers shall have fully completed testing on the American Association of State and Highway Transportation Officials -National Transportation Product Evaluation Program (AASHTO-NTPEP) test deck. Upon review, the performance of the markers on the test deck shall meet or exceed the historical performance of other industry standard Type R-4 markers approved by the WVDOH. This determination shall be made solely by the WVDOH.
- r. The markers shall have been tested by an independent testing facility to the applicable ASTM D4280 specification requirements referenced herein. The markers shall have been sampled as specified in ASTM D4280 and shall meet the applicable specification requirements, as demonstrated by test results certified and made available by the testing facility. The applicable ASTM D4280 specification requirements referenced herein shall be considered to be parts a), b), i), j), k), l), and m) of this Section.

715.40.6.2.1-Adhesive Requirements: Standard set epoxy adhesive, rapid set epoxy adhesive, or bituminous adhesive may be used for applying Type R-4 markers to the pavement surface. The specific adhesive used shall be an adhesive recommended by the R-4 marker manufacturer and meeting the requirements of ASTM D4280 for one of the adhesive types described above.

715.40.6.2.2-Product Submission and Approval: Type R-4 markers to be considered for inclusion on the WVDOH Approved Products List (APL) shall be submitted to the Materials Division following the current procedures specified by the Materials Division. The manufacturer may contact the Traffic Engineering Division for verification. The manufacturer should include all relevant documentation and information with this form, including but not limited to Product Data Sheets, Product Flyers, Manufacturer Product Specifications, Product Bulletins, Engineering Drawings, AASHTO-NTPEP test results, and the independent testing facility test results described herein.

In addition to the above, the WVDOH may also require that the markers submitted for evaluation be field tested in one or more locations in West Virginia in order to validate the acceptable performance of the product(s). This field testing shall typically be a minimum of six months to one year in duration including a full winter season. Specific details related to this testing, such as locations and quantities, shall be determined by the WVDOH.

All submitted information will be forwarded to the WVDOH Traffic Engineering Division, which will in turn contact and work directly with the manufacturer during the evaluation process. The Traffic Engineering Division will evaluate all submitted literature

and documentation for compliance with the specified requirements as well as satisfactory performance on the AASHTO-NTPEP test deck. The Traffic Engineering Division may also arrange for the manufacturer to furnish test samples and arrange for the product to be installed for field testing as previously described. After the evaluation is complete, the Traffic Engineering Division will inform the Materials Division in writing of the outcome of its evaluation.

715.40.6.3-Temporary Markers: Temporary markers shall meet the same requirements as permanent Type R-4 markers, as described in Section 715.40.6.2, with the exception of requirements q) and r).

The adhesive used to apply the markers shall meet the requirements of Section 715.40.6.2.1 or, in lieu of adhesives of this type, the Contractor may utilize markers supplied by the manufacturer with a “peel and stick” pressure sensitive adhesive pad pre-applied to the marker, provided that the surface upon which the marker is to be placed is within the manufacturer’s recommendations for markers incorporating a pre-applied adhesive pad. Markers supplied for temporary application to newly placed asphalt final wearing course surfaces or newly placed concrete surfaces shall be placed using a pre-applied pressure sensitive adhesive pad.

Temporary markers are not required to be submitted for review, approval, and placement on an Approved Products List (APL). No APL shall be maintained for temporary markers. When requested, the Contractor shall submit to the project Engineer a letter of certification from the marker manufacturer certifying that the markers supplied meet the current WVDOH Standard Specifications.

715.41-TRAFFIC SAFETY DEVICES:

Traffic Safety Devices shall meet the requirements of the AASHTO Roadside Design Criteria and the National Cooperative Highway Research Program Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances.

The Manufacturer of the Safety Device shall provide certified crash test data that indicates the product meets the requirements noted above.

The manufacturer shall submit to Traffic Engineering Division 8 copies of their design (installation) drawings for the specific device. This drawing will be reviewed, if approved, it will be stamped and one copy returned to the manufacturer. Multiple devices of the same design for the same project or purchase order will require one set of drawings, not one set for each device. In addition, one design and one installation manual shall be shipped with each safety device.

All safety devices shall be manufactured and fabricated using the same components as crash tested. Any changes in design or compound shall be requested in writing by the supplier. The Engineer's concurrence is required prior to any change.

715.41.1-Sand Barrel Impact Attenuating Device (Type V):

715.41.1.1-Description: The unit shall have cylindrical containers capable of holding various amounts of sand. The amount of sand capable of being held shall include at least 2, 4, 7, 14, or 21 cubic feet (0.056, 0.112, 0.196, 0.393 or 0.588 cubic meters).

715.41.1.2-Performance: The unit shall be constructed so as to shatter upon impact to permit dispersion of the sand mass contained within. The center of gravity of each module shall be at a height which will control the attitude of the vehicle. The manufacturer shall certify that the units shall not crack, split, or color fade within five years of installation.

715.41.2-Crash Cushion Terminal Impact Attenuating Device (Type VI):

715.41.2.1-Description: The unit shall consist of a cable anchored system using slotted standard depth guardrail with breakaway wooden posts.

715.41.2.2-Performance: The unit shall be capable of redirecting 1,800 to 4,500 pounds (815 to 1 900 kg) vehicles at speeds up to 60 mph. (100 km/hr) which impacts the side of the unit at angles up to 15 degrees for the 1,800 pound (815 kg) vehicle and 25 degrees for the 4,500 pound (1 900 kg) vehicle.

715.41.3-Truck Mounted Impact Attenuating Device (Type VII):

715.41.3.1-Description: The unit shall consist of a crushable cartridge, a backup and a backup support structure for attaching the backup to the shadow vehicle. The unit shall have a standard trailer lighting system, including brake lights, taillights, turn signals and ICC bar lights. The back of the unit shall have a device attached with alternative diagonal black and reflectorized yellow stripes, 6 inches (150 mm) wide, similar to an XS-15 marker and in accordance with Section 3C-2 of the latest edition of the Manual on Uniform Traffic Control Devices for Streets and Highways.

715.41.3.2-Performance: The unit when attached to a standard truck weighing between 10,000 lb. and 24,000 lb. (4 530 kg and 10 872 kg) GVW, shall be capable of yielding according to the requirements of National Cooperative Highway Research Program Report 350. During the tests the truck shall have the brake set, transmission in gear, and engine off.

715.41.4-Quad Guard Impact Attenuating Device (Type VIII):

715.41.4.1-Description: The unit shall consist of crushable cartridges surrounded by a framework of steel Quad-beam guardrail which can telescope rearward during head-on impacts. The quad Guard System shall have a center monorail which will resist lateral movement during side angle impacts. The nose shall consist of a formed plastic or metal nose wrap.

715.41.4.2-Performance: The unit shall be capable of redirecting 1,800 to 4,500 pounds (815 to 1 900 kg) vehicles which impact the side of the system at speeds up to 60 mph. (100 km/hr) at angles up to 20 degrees for both right way and wrong way impacts (angles measured from systems longitudinal centerline). The unit shall be constructed so that there is no solid debris which can create a hazard on the roadway after impact.

715.41.5-Reusable Energy Absorbing Crash Terminal Device (Type I):

715.41.5.1-Description: The unit shall consist of high-density polyethylene cylinders, which will compress and absorb energy. In addition, these cylinders under most

circumstances will recover their shape, position, and absorption capabilities sufficiently enough, after being impacted by a vehicle, to withstand another impact by a vehicle. Each cylinder shall be 24" (611 mm) to 36" (908 mm) in outside diameter and 32" (813 mm) to 48" (1 220 mm) high. Cylinder color shall be black. Cylinder Units shall have a cover. The unit shall have a restraining cable system of heavy steel galvanized wire rope on each side of the row of cylinders.

715.41.5.2-Performance: The unit shall be capable of attenuating head-on hits and redirecting 1800 lbs. (820 Kg) to 4409 lbs. (2 000 kg) vehicles which impact the unit of speeds up to 55 MPH (88 KPH). The device shall meet all evaluation criteria specified by NCHRP 350, including occupant risk, structural integrity, and post-impact trajectory.

715.41.6-Trinity Attenuating Crash Cushion (Type II):

715.41.6.1-Description: The unit shall consist of a pair of guidance tracks, an impact "sled," intermediate steel frames, and 10 gauge W-Beam fender panels. The overall width should be 24 inches (610 mm). The guidance tracks are made from two C-channels formed into a box section by variable lengths and thicknesses of metal rip plates bolted to the outside flanges of the channels. The sled, or impact face, of the TRACC is positioned over the upstream end of the guidance tracks and contains a hardened steel blade which cuts the metal plates on the sides of the guidance tracks as it is forced backwards in an end hit. The intermediate frames support the W-beam fender panels and are free to slide backwards when the TRACC is hit on the end, but lock onto the guidance tracks to provide redirection for side impacts.

The fender panels are bolted to the intermediate frames with a design that locks the inside panels in place while allowing the outer panels to slide back freely as the system telescopes rearward.

715.41.6.2-Performance: The unit shall be capable of attenuating head-on hits redirecting 1,800 lbs. (820 kg) to 4,409 lbs. (2 000 kg) vehicles which impact the unit of speeds up to 62 MPH (100 KPH). The device shall meet all evaluation criteria specified by NCHRP 350.

715.41.7-SCI Impact Attenuating Device (Type III):

715.41.7.1-Description: The unit shall consist of a flat galvanized steel base plate, to be attached to the support surface with chemical anchor bolts, with welded galvanized steel reinforcing support gussets and two welded galvanized steel channel beams running the length of the unit.

The internal area of the unit shall be supported laterally by a framework consisting of a welded up galvanized steel box shaped "sled" at the front of the unit, followed by successive welded galvanized steel support diaphragms to which the left and right sides of the unit are to be connected. The sled and diaphragms shall be locked into and held in position laterally by, and shall be capable of sliding longitudinally along, the channel beams included as part of the base.

Each side of the unit shall provide a surface to capture and redirect impacting vehicles by using successive galvanized steel 10 ga. quad beam side panels, overlapped from the rear to the front of the unit, with the beginning of the front side panels attached to the front

sled, and the underlying panels at each overlap to be attached to an internal support diaphragm.

The kinetic energy dissipating system employed by the unit for front impacts shall consist of a round, non-rotating, steel sheave assembly at the front of the unit with the ability to slide longitudinally along the unit; two round, non-rotating, steel sheave assemblies at the rear of the unit connected by an energy dissipating hydraulic piston; and a galvanized steel cable interconnecting the sheaves. During front end impacts, the entire device shall telescope rearward. Energy shall be dissipated variably, dependent on the vehicle momentum, by the hydraulic piston as it is compressed by the two rear sheave assemblies as tension is induced in the cable.

For protection of the components, the unit shall be designed such that the tops of the sheave assemblies and piston sit below the top level of the base plate channel beams. In addition, the unit shall be designed such that when fully collapsed, all of the sheave assemblies and piston shall remain behind the front sled.

The total outside to outside width of the unit along its' entire length shall be approximately 36". The length of the unit from the front to rear of the support base shall be approximately 21-1/2 feet.

715.41.7.2-Performance: When installed in accordance with the manufacturer's recommendations, the device shall be acknowledged by the Federal Highway Administration (FHWA) to meet the structural adequacy, occupant risk, and vehicle trajectory criteria set forth in National Cooperative Highway Research Program Report 350 (NCHRP-350) for redirective, non-gating crash cushions. The device shall be acknowledged as meeting these criteria for all NCHRP-350 required impact tests, demonstrated by performance of the tests, unless specific tests are not required to be performed based on the results of other tests as acknowledged by the FHWA.

In regards to impact capacity, the device shall be available in two different basic versions; one designed to meet the requirements of NCHRP-350 Test Level 2 and one designed to meet the requirements of NCHRP-350 Test Level 3, with each to be clearly acknowledged by the FHWA as meeting the NCHRP-350 requirements at the applicable Test level.

715.41.8-TAU-II Impact Attenuating Device (Type IX):

715.41.8.1-Description: The device shall accommodate a wide range of hazard widths up to 8-1/2 ft (2.6 m) in six (6) inch (150 mm) increments. The device shall be available in various impact speed capacities, achievable by different combinations of number of bays and placement of the two different types of energy absorbing cartridges described herein within the bays. The device shall utilize non-proprietary transition components and hardware for transitioning to a wide range of proprietary and non-proprietary barrier systems. The system shall be made up of independent collapsible bays that are guided and supported by high strength galvanized steel cables. The system's energy dissipating capacity shall be achieved using energy absorbing cartridges. All length/width configurations shall be constructible using the same basic parts.

The foundation system shall consist of two cables, a back support, and front cable anchors of various designs for different specific site conditions. The back support and cable anchors shall be manufactured using ASTM A36 steel and shall be galvanized per ASTM

A123. The fasteners for these components shall be Class 5.8 (Grade 2) or greater and shall be galvanized per ASTM 153. All washers shall be hardened. The cables shall be one (1) inch (25 mm) in diameter, minimum, and shall be galvanized per ASTM A603.

Bays shall be separated by Front Supports, Middle Supports, and Bulkheads of various widths as required. The Supports, Bulkheads, and cable guides shall incorporate modular bolted on cable guides for the steel cables. The Supports and Bulkheads shall be manufactured using ASTM A36 steel and shall be galvanized per ASTM A123. The fasteners for these components shall be Class 5.8 (Grade 2) or greater and shall be galvanized per ASTM 153. All washers shall be hardened.

Each bay shall be enclosed on each side by steel three-beam shaped Sliding Panels. The panels shall be bolted to the Supports and Bulkheads using sliding bolts. End Panels shall be used at the rear end of the device. The End Panels shall be attached to the back support and the last bay's Sliding Panel through Pipe Panel Mounts which provide mounting points for transition components. The Pipe Panel Mounts shall be bolted to the Back Support. Sliding and End Panels shall be fabricated from steel conforming to AASHTO M180 Class B. Sliding Bolts shall be cast from ASTM 1045 HT steel and shall be galvanized per ASTM A123. Pipe Panel Mounts shall be fabricated from steel conforming to ASTM A513, Type 5. The fasteners for these components shall be Class 5.8 (Grade 2) or greater and shall be galvanized per ASTM 153. All washers shall be hardened.

The system shall incorporate a nose piece and flexible front support legs mounted to the front support. The front support legs shall be manufactured from either synthetic or natural rubber or polyurethane. The nose piece shall be fabricated from polyurethane. The fasteners for these components shall be Class 5.8 (Grade 2) or greater and shall be galvanized per ASTM 153. All washers shall be hardened.

The system shall utilize two types of energy absorbing cartridges. The cartridges shall be cylindrical shaped and shall measure approximately 30-1/2 in (775 mm) in length and 25 in (635 mm) in diameter. Each cartridge shall weight approximately 35 lb (16 kg). The cartridges shall be manufactured using a specially formulated High Density Cross-linked polyethylene.

The device shall be attached to a foundation. Foundation and attachment specifications and details shall be provided by the manufacturer. The anchor design shall achieve a pull out strength of 25,000 lb (12,000 kg) and shear strength of 19,000 lb (8,500 kg).

715.41.8.2-Performance: When installed in accordance with the manufacturer's recommendations, the device shall be acknowledged by the Federal Highway Administration (FHWA) to meet the structural adequacy, occupant risk, and vehicle trajectory criteria set forth in National Cooperative Highway Research Program Report 350 (NCHRP-350) for redirective, non-gating crash cushions. The device shall be acknowledged as meeting these criteria for all NCHRP-350 required impact tests, demonstrated by performance of the tests, unless specific tests are not required to be performed based on the results of other tests as acknowledged by the FHWA.

In regards to impact capacity, the device shall be available in two different basic versions; one designed to meet the requirements of NCHRP-350 Test Level 2 and one designed to meet the requirements of NCHRP-350 Test Level 3, with each to be clearly acknowledged by the FHWA as meeting the NCHRP-350 requirements at the applicable Test level.

715.41.9-Acceptance: Acceptance shall be based upon review and approval of the certified crash test data by the Division. Materials Control, Soils, and Testing Division shall develop an approved list of Traffic Safety Devices.

715.42-TRAFFIC SIGNAL MATERIALS AND EQUIPMENT:

715.42.1-Pre-timed Fixed Cycle Traffic Signal Controllers:

715.42.1.1-Definition of Terms: Following are definitions of terms used by the Division for pre-timed fixed cycle traffic signal controllers:

Cabinet: A dustproof and weatherproof enclosure for housing the controller and associated equipment.

Circuit Contact Cam Shaft: A device to operate the circuit contacts to provide the desired interval sequence.

Controller: A complete electrical mechanism for controlling the operation of traffic control signals, including the timer and all necessary auxiliary apparatus mounted in a cabinet.

Local Controller: A controller for operating traffic control signals at an intersection which may be isolated or included in an interconnected traffic control signal system.

Master Controller: An automatic device for supervising a system of controllers, maintaining definite time inter-relationship, selecting among alternate available modes of operation or accomplishing other supervisory functions.

Pedestrian Actuated Controller: An automatic controller in which part of the intervals or groups of intervals, particularly pedestrian WALK and clearance intervals, are initiated by actuation of a pedestrian detector.

Pre-timed Controller: A controller for the operation of traffic signals with predetermined:

- i. Fixed cycle length(s).
- ii. Fixed interval duration(s)
- iii. Interval sequence(s)

Synchronous Controller: An automatic controller operated by a synchronous motor which will keep in step with the frequency of the power supply circuit.

Emergency Feature: A mercury contact bus bar relay installed in a controller, which when energized from a manual switch, remote point, discontinues the normal signal operation and displays special signal indications for the movement of high speed fire apparatus, etc.

Field Terminals: Devices mounted on a panel board for connecting all wires entering the controller cabinet.

Flashing Feature: A mercury contact bus bar relay installed in a controller which, when energized from a manual switch, remote point or by automatic time switch, discontinues normal signal operation and causes the flashing of any predetermined combination of signal lights.

Interval: The part or parts of the signal cycle during which signal indications do not change.

Interval Sequence: The order of appearance of signal indications during successive intervals of a cycle.

Jack Mounted Relay: A relay which may be removed or replaced without the use of tools and without disturbing any wiring.

Manual Operation: The operation of a controller assembly by means of a hand-operated device(s); (i.e., push-button).

Offset: The number of seconds or percent of the cycle length that a defined time-reference point (normally the start of major street green) at a traffic signal occurs after the time-reference point of a master controller or of an adjacent traffic signal.

Offset Control Switch: A device which when operated stops the timing of the cycle length and intervals in order to manually adjust the offset.

Offset Dial: A calibrated dial on an automatic timer equipped with adjusting devices by means of which it is possible to set any desired offset of the beginning of the green traffic control signal indication.

Offset Interrupter: A device which will distribute over two or more cycles the time required for large offset changes.

Panel: A panel board within the controller cabinet upon which are mounted fuse receptacles, circuit breakers, contactors, terminals, relays, and electrically operated switches and other equipment, all suitable insulated.

Pedestrian Phase (Pedestrian Movement): A traffic phase or traffic movement allocated exclusively to pedestrian traffic.

Radio Interference Suppressor: A device inserted in the power line in the controller assembly (cabinet) than minimizes the radio interference transmitted back into the power supply line, which interference may be generated by the controller or other mechanisms in the cabinet.

Relay Jack: A set of clips, plugs or receptacles in a controller or cabinet by means of which a relay may be mounted or connected to the circuit.

Reset: An adjustment mechanism applied to an automatic controller providing for the setting up of the timing arrangement of the start of the green traffic control signal indication.

Automatic Reset: A reset by means of which the offset or beginning of the green is checked automatically and adjusted, if necessary, once each time cycle.

Double Automatic Reset: A reset by means of which it is possible to automatically select any one of two automatic resets.

Triple Automatic Reset: A reset by means of which it is possible to automatically select any one of three automatic resets.

Manual Reset: A reset by means of which it is possible to manually adjust the offset or beginning of the green.

Reset Interrupter: A device which will automatically distribute the time lag resulting from a particular resetting over a period of time varying from one to several cycle lengths.

Shutdown Feature: A mercury contact bus bar relay installed in a controller which, when energized from a manual switch, remote point or by an automatic time switch, discontinues normal traffic control signal operation and turns the signal indications off.

Shutdown Switch: A switch in a controller which may be operated by hand to discontinue the operation of traffic control signals.

Signal Circuit Contact: A device arranged to energize or de-energize signal light circuits during a specified interval.

Signal Indication: The illumination of a traffic signal lens, or equivalent device, or of a combination of several lenses or equivalent devices at the same time.

Split: A division of the cycle length allocated to each of the various phases (normally expressed in percent).

Time Cycle: The number of seconds required for one complete revolution of the timing dial or complete sequence of signal indications.

Time Cycle Indicator: An indicating device applied to an automatic timer for indicating the time cycle in seconds.

Timing Dial: A calibrated dial on an automatic timer equipped with adjusting devices by means of which it is possible to divide the time cycle into the required number of intervals and set up the offset and interlock.

Timer: An automatic timing unit in a controller, including all dials, dial transfer relays, switching and circuit contacts, motors, gears, camshaft, etc.

Time Switch: A device for the automatic selection of modes of operation of traffic signals in a manner prescribed by a predetermined time schedule.

Traffic Phase: Those right-of-way and clearance intervals in a cycle assigned to any independent movement(s) of traffic.

Yellow-Red Flash Terminals: Addition terminals installed in a traffic signal controller so wired that by an interchange of jumpers, flashing operation may be arranged to give either yellow or red on the main or cross streets.

715.42.1.2-General Design Requirements: The following are minimum design and operating requirements for all pre-timed, fixed cycle traffic signal controllers and associated equipment described in these specifications.

The signal time cycle shall be constant and accurate, regulated by the power line frequency. Neither cycle length variations nor interval timing variations shall occur if voltage of the power line varies between the limits of 10 percent above and 10 percent below 120 volts, 60 Hz AC standard service voltage. Similarly, neither cycle length variations nor interval timing variations shall occur if outside cabinet temperatures change to any value between -30° F (-34° C) and plus 122° F (50° C). Maximum inside cabinet temperature for above operation is plus 165° F (74° C).

It shall be possible to accurately set or adjust the cycle lengths between the limits of 30 and 130 seconds with accurate and definite settings within this range in five-second steps up to 100 seconds, and in ten-second steps above 100 seconds. This adjustment shall be accomplished by a change of marked gears requiring no more than the use of simple tools. Gear and gear shaft shall be designed to prevent slippage. Gear meshing pressure must be adjustable. The cycle length in operation shall automatically be indicated on a scale visible on the front of the dial unit.

All pre-timed controllers shall contain three timing dials and be capable of being interconnected into a three-dial, three-offset system and shall include all the necessary keys, contacts, rider arms, etc.

The signal color sequence period adjustments and offset adjustments shall be made on the same timing dial without the aid of any tools. The timing dial shall be calibrated for the signal color period in steps of one percent from 1 to 99 percent. The offset calibration

shall be in reverse order of the signal color sequence period. Each offset key shall be clearly identifiable as to its function and distinguishable from the color period keys. All keys for a given function shall be identical and each key having a specialized function shall be appropriately colored or otherwise identifiable to provide a visual indication of such function.

Any changes in operation of traffic control signal lights caused by turning the signal lights off, or turning them on flashing operation, shall not interfere with the continued in-time operation of the timer motor presently operating in each controller. A transfer from such special operation back to normal automatic operation shall immediately establish the normal time cycle and subsequently the in-time relation. The dial transfer mechanism shall be so designed that not more than one dial may operate at any one time. Dial No. 1 shall operate in absence of call for dial No. 2 or dial No. 3 or when there is a conflict on dial calls.

Each controller shall be furnished with three service manuals complete with all necessary instructions and diagrams for the installation and maintenance of the equipment supplied. Each controller shall be supplied with three complete sets of wiring diagrams. These wiring diagrams shall identify the color code or wire tagging used in all connections.

715.42.1.2.1-Interval Sequence: The controller shall provide consecutive divisions of the time cycle termed "intervals," during which time the combination of signal indications do not change. Each controller shall be provided with 12 or 16 interval cams. The cams shall be programmed so that a minimum number of dial unit keys are required for the plan specified phasing. If phasing is not specified, the cam lobes are not to be broken out.

715.42.1.2.2-Interval Adjustment: The controller shall provide for the setting of each interval of the cycle by means of a positive setting on each calibrated dial. The setting shall at all times show a visual indication of the amount of time allocated to each interval, in units of percent of the cycle length. When the controller is operating within a specified voltage and temperature limits, the time duration of each interval shall be within plus or minus 500 milliseconds of the time indicated by the setting of that interval, and timing of successive intervals shall be without cumulative errors that would affect the accuracy of the cycle length.

Each dial unit shall be provided with a scale calibrated in steps of one percent of the cycle length or one second, and shall provide for the accurate setting of any interval within the range of adjustment from 2 percent to 90 percent of the cycle length or from one second to 99 seconds.

The minimum time for any interval is not required to be less than one second whenever that is greater than two percent of the cycle length, nor is the minimum time for any interval required to be less than two percent of the cycle length when that is greater than one second.

The timing controls shall be on the front of the controller unit, easily identifiable, and it shall not be necessary to remove or change wires or contacts or to use any tools in making interval adjustments.

The three controller dial units specified shall provide for separate programs of interval timing. The dial units shall be readily identifiable and a change of one dial shall not affect

or alter the other two dials. Dial transfer shall be accomplished at the beginning of main-street green.

The cam-shaft dial synchronization key (commonly called the camswitch release key, interlock, drum release or release key) shall terminate the main-street green interval. No more than two cycle lengths shall be required to effect a dial transfer.

715.42.1.2.3-Mechanism: The controller components shall be of unitized design and readily interchangeable.

All mechanisms, motors, operating coils, bearings, contacts, relays, flashers and similar components shall be sufficiently large, rugged and accessible to insure reliability and minimum maintenance. All equipment shall be neatly and systematically arranged and mounted to allow thorough inspection while the controller is operating normally, and to permit easy removal of removable components without interfering with other portions of the controller. Components shall be securely fastened in place to prevent accidental contact with moving parts or electrical power and to permit the cabinet door to be opened and closed without interference or damage to the controller and wiring. Component accessibility shall permit easy access for any needed lubrication.

A 30 ampere, mercury contact-type bus bar relay shall be provided for opening the bus bar circuit for signal shutdown, flashing operation or any other type of controller preemption.

All relays associated with the control system shall be of the electromechanical type and designed for heavy, continuous operation. Except for the mercury contactors, all relays shall be mounted on a plug-in base with plug-in mounting. Dial transfer relays shall be jack or plug mounted within the timer unit chassis.

Solid state circuitry shall not be used in the dial transfer, offset or split functions. Point to point wiring must be used on all circuitry. Copper or other track board circuitry is not permitted.

The controller dial motors shall be designed for synchronous self-starting operation on 120 volts, 60 Hz, single-phase alternating current. The motors shall have ample torque for all requirements of controller operation. Motor and reduction gearing shall be a completely enclosed unit containing a lifetime supply of lubricant. This unit shall not be an integral part of the timer but shall be arranged for easy removal. A maximum of one connector of the screw or bolt type shall be used to hold the timing dial firmly in position.

The complete dial unit assembly shall be mounted in a manner which allows it to slide or hinge out of the timer chassis for complete access for inspection and maintenance.

Each dial unit shall be furnished with an assembly of five gears (15 per controller). Gears for cycle lengths of 50, 60, 70, 80 and 90 seconds shall be provided per dial, unless otherwise specified.

Only one contact (movable) shall be provided per controller circuit. Line side power for these circuits shall be by direct mechanical connection.

All make and break contacts shall be of fine silver or a superior alternate material and shall be capable of breaking a current of 15 amperes of tungsten lamp at 120 volts, 60 Hz AC, one half million times without breaking physically or failing to conduct current to the tungsten load when operated 360 times an hour. All signal contacts shall be readily accessible and easily inspected. The movable contacts shall be designed to eliminate the possibility of accidental cross connection between adjacent contacts. The contact assembly

shall be designed so that the contacts can be arranged or rearranged to cause any signal light circuit to be energized or de-energized during any one of the intervals. All contacts shall be easily replaceable by the use of simple tools.

The controller signal common and signal circuit bus shall have an ampacity of not less than 30 amperes.

The controller shall provide terminals, wiring, cams and contacts for 18 circuits complete.

Cam sequence switching shall be so designed that it shall not be possible to display a noticeable "dark out" interval at any time following any control function transfer, transfer to flash or any preempt transfer. In addition, the closing or opening of signal load contacts shall be positive, without objectionable dark intervals, flickering of lights or conflicting signal indications.

Cam shaft advance shall be shaded pole motor or electromagnetic coil and return by gravity assisted spring. The cam rotor mechanism shall provide ample torque to break all bus contact loads, as long as the contacts remain in operational condition. Cam shaft advance impulse shall be actuated by the timer dial unit, or when specified in the Plans by manual actuation.

All relays, coils, solenoids and motor windings shall be sufficiently large to insure reliability and minimum maintenance.

715.42.1.2.4-Electrical Connectors: All electrical connections to and from the timer unit to the controller back panel shall be made through a 47 pin MS screw-type connector and wiring harness. Each wiring harness shall be at least 48 in. (1.2 meters) long or of the standard length specified by the manufacturer for that controller type. The harness shall have color-coded leads of labeled sleeves or labeled wires. The harness connections on the controller shall be such that the timer unit may be replaced with a similar unit, without the necessity of disconnecting and reconnecting individual wires therefrom.

Seven circuits in this connector shall be capable of handling No. 12 AWG wire and a maximum of 30 amperes each. Connector pins for these circuits shall be rated at 41 amperes. All other connector circuits shall be rated at 15 amperes (No. 16 AWG) with connector pins rated at 22 amperes.

715.42.1.2.5-Controller Wiring Panel: A controller panel shall be installed on the back wall of the controller cabinet on which all relays, contactors, breaker receptacles, electrically operated switching devices and other auxiliary controller equipment, not an integral part of the timer unit assembly, shall be mounted. The panel shall be easily demountable in order that the entire control system can be removed, inspected and replaced as a unit. There shall be a minimum of 3 inches (75 mm) clearance between the bottom of the panel and the bottom of the cabinet.

All terminals, except the interconnect system terminals, shall be mounted on the controller panel. Interconnect terminals shall be mounted on the side of the controller cabinet, unless otherwise specified. All panel wiring shall be neat and firm. The back panel shall contain at least the following:

- i. Terminals with circuit breakers for power supply.
- ii. Terminals unfused for neutral side of power supply.
- iii. One terminal for each outgoing signal circuit and one or more terminals for the

common conductors.

- iv. A neutral bus with a minimum of six terminals to accommodate No. 10 wire.
- v. Terminals for pedestrian or any other type actuation.
- vi. Terminals for manual control of color sequence.
- vii. Terminals for red and yellow flash circuits.
- viii. Controller mode switch.

The controller mode switch shall provide for selection of timing dial and offset or system operation as a minimum. A manual sequence mode position shall be provided if manual operation is specified.

All outgoing circuit terminals shall be suitably identified and shall be of the same polarity as the line side of the power supply. The ground side of the power supply shall be grounded to the controller in an approved manner.

Power service breakers shall be provided to terminate the No. 8 AWG service conductor circuits on the controller back panel. Breaker No. 1 shall provide overcurrent protection for the controller circuits and No. 2 protection for the flasher and associated circuitry.

715.42.1.2.6-Flashing Operation: Means shall be provided for the substituting of flashing vehicular signal indications for the normal specified interval sequence. The flashing operation of the controller shall be as specified on the Plans.

Flashing of vehicular and pedestrian signal indications shall be obtained from one or more flashers, each of which is a self-contained device designed to plug into a socket mounted on the back panel of the cabinet.

Each controller shall be equipped with additional terminals which are so wired that, by an interchange of jumpers, flashing operation may be arranged to display either flashing yellow or flashing red on each of the vehicular signals.

Each controller shall be provided with a flash control switch for activating the flashing of vehicular signals. The controller shall be constructed so that the flashing operation can be obtained by operating the flash control switch even if the controller unit malfunctions or is removed from the cabinet. During flashing operation, the controller timer unit shall be de-energized.

The substitution of flashing vehicular signal indications for the normal specified interval sequence shall be obtainable by time switch as well as by the flash control switch.

The controller shall be so designed that an "open" in power service breaker No. 1 shall automatically switch the signal to flashing operation (see 715.42.1.2.5).

715.42.1.2.7-Manual Operation: All controllers shall be designed capable of manual signal sequencing. When manual operation is specified on the Plans it shall be accomplished with the addition of standard components.

715.42.1.2.8-Pedestrian Actuation: When called for on the Plans, non-concurrent, exclusive pedestrian actuated phases shall subtract the WALK interval time from the lead phase "green" interval and DON'T WALK time from the following phase "green" intervals.

Manual operation of interval timing shall provide the same interval sequence as when the controller is operating automatically. Manual interval timing shall be obtainable by

means of weather-resisting manual push-button mounted on a flexible weather proof extension cord. The transfer of manual to automatic operation, or vice versa, shall be accomplished by an automanual switch. It shall not be necessary, when switching from manual to automatic operation, or vice versa, to do so at any certain time or to make any time adjustments.

715.42.1.2.9-Signal Shutdown: Each controller shall be provided with a signal shutdown switch for turning off the signals at the intersection. This switch shall affect the power to the signals only and no other part of the controller.

715.42.1.2.10-Warranties and Guarantees: The Contractor or supplier is required to turn over to the Division any guarantee or warranties which are given by the manufacturer as a normal policy. The Contractor or supplier shall furnish the Division with three copies of complete drawings, diagrams and manufacturer's instructions for installing and maintaining the equipment and any assistance as required for timing and operation of the equipment. Any component called for by the circuit design which has special unique characteristics which would limit that component to certain manufacturers or suppliers shall be so indicated in the manufacturer's instructions.

The Contractor or supplier shall make available to the Division, at no cost, engineering data, diagrams, etc. on any later changes or improvements which would increase the performance of the equipment purchased.

The Division reserves the right to withhold any payments which may be due, should it be discovered that the equipment does not meet the Specifications.

715.42.1.3-Pre-Timed Fixed Cycle Traffic Signal Controller (Type FT-3): The purpose of this section is to set forth specific functional specifications and design requirements for the pre-timed fixed cycle traffic signal controller (local).

The general design requirements in 715.42.1.2 shall apply, except when the specific requirements exceed those in that section.

715.42.1.3.1-Interconnection: Type FT-3 controllers shall be furnished capable of interconnection with a master controller and other local controllers in signal system. A fused, interconnect terminal panel shall be furnished for mounting on the controller cabinet side wall. As a minimum, functional terminals for offset No. 1, offset No. 2, offset No. 3, dial No. 2, dial No. 3 and flashing operation shall be provided.

715.42.1.3.2-Isolation: The FT-3 controller shall also be furnished capable of operating as an isolated controller, functionally programmed by time clocks, master controller or other command device.

715.42.1.4-Pre-Timed Cycle Traffic Signal Master Controller (Type FT-3M): The purpose of this section is to set forth specific functional specifications and design requirements for a pre-timed fixed cycle master traffic signal controller (master).

The general design requirements in 715.42.1.2 shall apply, except when the specific requirements herein exceed those in that section.

715.42.1.4.1-System Supervision: Type FT-3M controllers shall be furnished capable of providing system supervision for local controllers (FT-3) or local coordinating units (LCU), or both. All equipment and apparatus necessary to provide this supervision shall be furnished in the controller.

The following supervisory functions shall be furnished in the controller as a minimum:

- i. Means for automatically establishing offset time relations for a system of interconnected FT-3 or LCU units.
- ii. An offset interrupter for decreasing the disruption to interval timing caused by large offset changes.
Offset power shall be routed through an interrupter that is independent of the controller. The interruption interval shall be power on-line for 21 seconds, power off 2 seconds (23 second cycle). The interrupter shall be on breaker circuit No. 2 (flasher circuit).
- iii. Manual switch for transfer of all system controllers to flashing operation.
- iv. Manual switch for selecting dial No. 1, dial No. 2 or dial No. 3 at all interconnected FT-3 or LCU units, or both.
- v. Manual switch for selecting offset No. 1, offset No. 2 or offset No. 3 at all interconnected FT-3 or LCU units, or both.
- vi. Manual switch for transfer to emergency feature operation at all system controllers.

Back panel mode switching shall be furnished to accomplish manual operations.

The following supervisory functions shall also be controllable by the use of time clocks or other command devices:

- i. Selection of offset mode.
- ii. Selection of timing dial unit.
- iii. Selection of system flashing operation.
- iv. Selection of system emergency feature operation.

715.42.2-Solid State Traffic Actuated Signal Controllers:

715.42.2.1-Definition of Terms:

Actuated: Identifies the type of signal control which responds to calling signals generated by action of vehicle or pedestrian.

Actuation: The operation of any type of detector.

Auxiliary Equipment: Separate devices used to add supplementary features to a controller assembly.

Cabinet: An outdoor enclosure for housing the controller unit and associated equipment.

Call: (Vehicle or Pedestrian) The result of a detector actuation indicating the presence of a vehicle or pedestrian requesting right-of-way.

Chassis: The traffic signal controller and housing, complete with power supply, internal wiring, harness pin connector and module bays to accommodate the number and type of phase modules specified.

Check: An outgoing circuit that indicates the existence of unanswered call.

Clearance Interval: A specific interval of time which follows after the termination of right-of-way to vehicles or pedestrians.

Controller: A complete electrical mechanism, including timer for controlling the operation of traffic signals.

Coordination: The terms applied to the interrelation between two or more intersection controllers.

Cycle: The total time required to complete one sequence of signal operation around an intersection.

Detector: An electrical device which when actuated signifies the passing or presence of a vehicle or pedestrian desiring the right-of-way.

Digital Timing: Pertaining to a method of timing that operates by counting discrete units.

Dual Max: A controller feature which provides two possible maximum time settings for cycle or right-of-way interval total time before termination.

Extension Unit: The timing interval during the extensible portion which is resettable by each detector actuation. The green right-of-way of the phase may terminate on expiration of the unit extension time.

Extension Limit: The maximum time of the extensible portion for which actuations on any traffic phase may retain the right-of-way after actuation on an opposing traffic phase.

Fail Safe: A controller feature that prevents conflicting phase indications when power or equipment malfunctions occur.

Flasher: A complete electrical mechanism for flashing a traffic signal or beacon.

Force Off: A command that will force the termination of the right-of-way.

Full Actuated: An intersection signal controller with detector input capability in all phases.

Gap Reduction: A feature where the "unit extension" or allowed time spacing between successive vehicle actuations on the phase displaying the green in the extensible portion of the interval is reduced.

Hold: A command that retains the existing right-of-way.

Initial: (Green) Minimum or guaranteed green time allotted the timing phase before which termination can begin.

Interface: A relay or electronic device(s) which isolates and matches one portion of a system to another.

Interval: Any one of the several divisions of the time cycle during which signal indications do not change.

Interval Sequence: The order of appearance of signal indications during successive intervals of a time cycle.

Main Frame: A definitive single chassis unit within the controller cabinet that contains all signal timing and control logic. This does not include back panels, load switching devices, flashers, breakers, detectors and other peripheral equipment inside the controller cabinet.

Manual Control: A control to permit authorized personnel in the option of terminating an active phase and initiating the next sequence in the signalization cycle.

Maximum: A time limit applied to traffic actuated controls to terminate and recall the timing phase after a predetermined time.

Major Street: The roadway approach or approaches at an intersection normally carrying the major volume of vehicular traffic.

Memory: Holds as recall a momentary vehicle actuation in the phase timer until the proper signal sequence can be displayed to release the vehicle.

Minor Street: The roadway approach or approaches at an intersection normally carrying the minor volume of vehicular traffic.

Modular Design: A design concept such that functions are sectioned into plug-ins units which can be readily exchanged with similar units.

Monitor, Signal Conflict: A device used to continually check for the presence of conflicting signal indications and too provide an output in response to conflict.

Nonlocking Memory: A mode of actuated-controller-unit operation which does not require detector memory.

Overlap: A right-of-way indication that allows traffic movement when the right-of-way is being assigned to two or more traffic phases.

Panel: A panel within the controller cabinet upon which are mounted fuse receptacles, terminals, relays and electrically operated switches and other equipment, all suitably insulated.

Passage Period: The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic.

Pedestrian-Actuated Controller: An automatic controller in which part of the intervals or groups of intervals, particularly pedestrian WALK and clearance intervals, are initiated by the actuation of a pedestrian detector.

Pedestrian Detector: A detector, usually of the push-button type installed near the roadway and capable of being operated by hand.

Pedestrian Phase: (Pedestrian Movement) A traffic phase allocated exclusively to pedestrian traffic.

Power Line Switch: A manual switch for discontinuing the operation of both traffic controller and traffic control signals.

Power Supply: As used, a fused regulated DC power source for operation of control equipment where necessary. It must be an integral part of the controller chassis.

Pre-emption: The transfer of the control of the signals from any phase or controller mode to a pre-emption timing unit to provide right-of-way for emergency vehicles or trains.

Presence: Term applied to the detection pulse produced by a passing vehicle to be used by the control for other than count purposes. True presence indicates that the pulse duration is equal to the actual time the vehicle remains in the detector field of influence.

Radio Interference Suppressor: A device inserted in the power line in the controller assembly (cabinet) that minimizes the radio interference transmitted back into the power supply line, which interference may be generated by the controller or other mechanisms in the cabinet.

Recall: A manual switch which will cause the automatic return of the right-of-way to a street, regardless of the absence of actuation on that street.

Rest: The interval portion of a phase when present timing requirements have been completed.

Semi-Actuated: A type of traffic actuated controller in which means are provided for traffic actuation on one or more, but not all, approaches to the intersection.

Sequence: The order in which signal intervals are displayed around an intersection when there are calls on all phases of an intersection.

Signal Indication: The illumination of a traffic signal lens or equivalent device, or of a combination of several lenses or equivalent devices, at the same time.

Skip Phase: A feature of actuated intersection control which omits the right-of-way signal indication for a phase or movement that does not have vehicle or pedestrian calls.

Solid State: Circuitry using semi-conductor devices exclusively in contrast to electronic (electron tubes) and electro/mechanical devices (relays, motors, etc.).

Split: The division of time within the signal cycle between adjacent phases in the sequence.

Stop Timing: Refers to the feature of a signal controller by which the application of an external signal or voltage will stop any one or all interval timers from timing further.

Terminate: Applies most frequently to the end of a timing interval. Termination of right-of-way begins in an active phase when a call is received from an inactive phase in a full-actuated control; right-of-way termination must always include adequate clearance intervals.

Time Cycle: The number of seconds required for one complete revolution of the timing dial or complete sequence of signal indications.

Traffic Adjusted: Term used in master supervisory systems where vehicle actuations and other data are fed to the master for effecting signalization changes at several intersections rather than at each intersection independently.

Uniform Manual: (MANUAL OR MUTCD) *Manual on Uniform Traffic Control Devices for Streets and Highways*, published by the Department of Transportation, Federal Highway Administration.

Vehicle: A mobile inanimate object which legally must use roadways and is subject to traffic control by signalization.

Volume: Numerical count of vehicle traversing a roadway and passing over a detector in the roadway.

Wiring Harness: The multi-terminal (M or F) connector and associated wiring through which all electrical connections into and out of the controller chassis are made. All wiring harnesses shall be at least 48 in. (1.2 meters) long.

Yield: A command which permits the transfer of the right-of-way.

The above list of definitions may not be complete for all terms used. Final interpretation of all terms is the responsibility of the Engineer (See West Virginia Standard Specifications, Sections 101). Where applicable and as approved by the Engineer, definitions as published by the National Electrical Manufacturer's Association, Traffic Control Systems Standards may be applicable.

715.42.2.2-General Design Requirements: The following are minimum design and operating requirements for all types of solid state traffic-actuated signal controllers and associated equipment described in these Specifications.

These controllers shall be phase-modular and completely programmed for the phase and interval sequence specified for that chassis type. Phase, interval sequence and phase sequence functions and associated circuitry shall be assembled on removal plug-in modules. A separate, independent phase module shall be provided for each phase.

Controller timing shall be by digital timing, utilizing power line frequency as a base, and be constant and accurate. The length of any interval, portion, period or unit extension as determined by the interval timing setting or any other programmed controller function shall not change due to power supply voltage variations between the limits of 95 to 135 volts AC. The nominal voltage shall be 120 volts AC. The controller and all associated equipment shall be designed to operate from a 120 volt, 60 Hz, AC supply (plus or minus 3.0 Hz).

Specifically, the environmental and operating limits specified in the latest Traffic Control Systems Standards Publication by the National Electrical Manufacturer's Association, designated as NEMA, must be adhered to.

A regulated fused power supply shall be an integral part of the controller chassis and it shall provide the DC voltages required for the operation of all equipment when necessary. This power supply shall provide the internal and external voltages and power requirements for normal operation of the signal equipment.

A dust resistant metal enclosure, or main frame chassis, suitable protected against corrosion shall be provided to enclose all electrical parts of the controller. The control devices, indicator lights, fuse holders, switches, input/output connectors and other components required for the operation and adjustment of the controller shall be mounted on the front panel(s). All component parts and terminals shall be readily accessible when the controller modules are removed from the enclosure for adjustments, testing or service. Circuit board extender cards or cable may be employed to facilitate testing. The controller shall be designed for placement on a shelf. Maximum main frame sizes shall be as designated by NEMA for each controller chassis type.

The front panel(s) of the controller shall be permanently marked to indicate the module positions, and to identify the fuses, indicator lamps, switches, controls, etc. so that the operation of the controller shall be readily apparent.

The main frame chassis shall be completely equipped and wired for a full complement of modules as required for that chassis type. No additional hardware or wiring shall be required whether or not the main frame is used with the maximum possible number of modules.

All modules shall be removable from the front of the controller and those of unlike function shall be mechanically keyed or electrically inter-locked to prevent insertion into the wrong opening causing controller unit malfunction. Modules of the same type shall be interchangeable between chassis. All modules shall be provide with controls as necessary to meet the functional requirements. In addition, all control logic for interval and startup sequence, overlap functions, coordination and all other specified controller functions must be an integral part of the main frame chassis.

Each module and associated controller bay shall be identified as to phase or function. To facilitate interchangeability, a guide or track shall be provided for each module assembly in the controller chassis. All modules shall be mechanically secured in the controller so as to retain the assemblies in their proper position under conditions of shock and vibration.

Each grouping of controller components as printed circuit assembly shall have a mean time to failure of three years. Printed circuits shall be of epoxy glass with an extra heavy (two ounces or more) copper track or a superior alternate or as otherwise specified by

NEMA standards. Circuit reference symbols for all component parts shall be clearly marked on the circuit boards.

All switching functions internal to the controller shall be accomplished through the use of solid state circuitry. No electrical-mechanical devices, such as camshafts, rotary, stepping or line switches shall be used for switching functions.

All controllers shall be equipped so that they may be coordinated with other controllers or supervised by a master system. This shall be possible by the simple addition of accessory equipment external to the controller.

715.42.2.2.1-Phase Sequence Unit: The phase sequence unit must be an integral part of the controller main frame and shall establish the order and operation of the Phase Timing in accordance with vehicle and pedestrian detector calls.

In the absence of recall or detector actuation, the right-of-way shall remain on the traffic phase upon which the last actuation occurred. The actuation of any detector during the extendible portion of a traffic phase having the right-of-way shall cause the retention of right-of-way by that traffic phase for one unit extension from the time of actuation. One unit extension interval of time shall be guaranteed for each vehicle actuation registered during the extendible period. Each actuation shall cancel the remainder of the previous unit extension interval in effect and initiate a complete new unit extension interval, timed from the instant of actuation. The actuation of a detector on another phase shall cause the right-of-way to transfer to that phase if during the extendible portion of the timing phase there have been no actuations for more than one full unit extension interval of time.

An actuation during the clearance period for a traffic phase shall cause the right-of-way to return to that phase in the same manner. Also, when the right-of-way is transferred by operation of the extension limit, the terminated phase shall again receive the right-of-way in the above manner without further detector actuations.

The controller shall be equipped with provision for skipping any phase when there is no call for that particular phase. Exact phase sequence when there are calls on three or more traffic phases shall be as specified for each controller chassis type.

The term "Phase A" as used shall in all cases refer to the artery or mainline phase. It shall be the first phase in the sequence of phases. Other phases such as B, C etc. shall follow Phase A in alphabetical sequence with right-of-way assigned in accordance with the above, or specified sequence logic.

715.42.2.2.2-Interval Sequence Unit: The interval sequence unit must be an integral part of the main frame and shall determine the order and control of the various intervals of each phase. The rotation shall be Green, Yellow, All Red and Red for vehicle movements and Steady Walk, Flashing Don't Walk and Steady Don't Walk for pedestrian movements.

The transfer of the right-of-way from any traffic movement shall take place only after a proper clearance period.

The clearance period for each vehicular phase shall consist of a vehicle change (Yellow) and an All Red Clearance interval. Each shall be timed separately and the second clearance interval of any phase may be omitted by a simple timing adjustment.

The clearance period for a pedestrian movement shall be a Flashing Don't Walk.

715.42.2.2.3-Interval Settings and Adjustments: The controller shall provide a positive means of setting signal timing intervals. The settings for each interval shall be in seconds or divisions of a second and the controller shall provide a clear visual display of the length of each interval or period. The interval settings shall be color coded, easily identifiable and shall be made by means of dials or thumbwheels. Settings shall be provided for each phase interval and shall be mounted on the front of the associated main frame phase module. It shall not be necessary to use punched data cards, remove or change wires, pins or contacts, or to use tools of any kind in making interval adjustments. All dials shall be on the front of the controller and easily accessible.

The minimum green interval shall be equal to either initial and one unit extension, walk plus pedestrian clearance, or walk plus pedestrian clearance plus one extension.

The timing of the extension limit shall commence with the first actuation or other registration of traffic demand for the right-of-way on any traffic phase not having the right-of-way, and should begin after the initial period has expired.

In the event the controller reverts to the start-up sequence, the signal operation shall be initiated in the Phase A green interval and at least one initial and one unit extension (or vehicle interval) period shall be timed while in that sequence. As part of the initialization routine, vehicle calls shall be placed on all phases.

All phases shall be provided with at least the following intervals and minimum range of interval settings:

i. Initial Interval	0 to 99 Seconds
ii. Vehicle Interval (Extension)	0 to 9 Seconds
iii. Yellow Interval	0 to 9 Seconds
iv. Maximum Extension	10 to 99 Seconds
v. All Red Clearance	0 to 9 Seconds

Time spans and actuation limits specified are minimum and may be expanded.

Each phase shall be provided with recall and memory control. Capability to initiate the maximum or single unit extension recall shall be provided for each phase. In addition, phase memory of vehicle actuations during any interval shall be provided. There shall also be a "Memory Off" control for each phase to delete the memory feature when it is not required.

The controller shall be provided with a vehicle call indicator light for each phase. The indicator light shall respond to each vehicle call on its phase. The indicator light shall go off at the end of the initial portion of the green interval and indicate each actuation momentarily during the extendible portion of the green interval. Sufficient monitoring lights must be provided on the controller to visually indicate what part of the controller is timing and what function will follow. The monitoring lights shall be an integral part of the controller and must be a standard rather than an optional feature.

The front panel of the modules shall be engraved, silk screened or otherwise permanently marked to indicate module type and identify indicator lamps, switches, controls, etc. so that the functions of the module are readily apparent.

715.42.2.2.4-Flashing Operation: For use during periods of low traffic volume or emergency conditions, a flasher unit shall be provided to flash all signal indications displayed during any specified yellow-red or all-red sequence.

Upon resumption of controller operation of the signal indications, Flashing Red indications must be followed by the Steady Red or Steady Green interval of that sequence and Flashing Yellow must be followed by the Steady Green interval. This logic must be built into each controller main frame chassis.

The controller shall be designed such that a fuse failure (open) on the controller side of the power supply will automatically switch the signal to flashing operation.

715.42.2.2.5-Manual Control Feature: The controller shall be so designed that by wiring external to the controller, manual control of signal sequence timing may be assumed. The manual control function may be assumed with the application of the Stop Timing command. The operator may sequence the controller by applying input signals with a Manual Advance Switch.

715.42.2.2.6-Uninterrupted Timing: Normal traffic-actuated operation shall be resumed automatically after Manual, Flashing Pre-emption or any other special operation has been utilized.

715.42.2.2.7-Stop Timing: Means shall be provided so that on call, timing may be stopped on any one of all interval timers in the control system. This is provided for the purpose of adding extra intervals or auxiliary equipment, or both. Upon resumption of timing, the interrupted interval shall be timed in its entirety.

715.42.2.2.8-Auxiliary Equipment: The controller shall be so designed that all standard auxiliary equipment may be added without internal controller modifications. Railroad or fire station pre-emption equipment shall be constructed and wired so as to transfer control of the signals from either the controller or the flasher unit to the preemption timing unit. Installation of the pre-emption equipment shall not alter the internal wiring of the controller chassis normally furnished by the manufacturer. In addition, the controller shall be furnished capable, by the addition of standard accessories external to the controller, of the following functions:

- i. Actuated pedestrian timing associated with each phase.
- ii. Minor movements associated with each phase.
- iii. Overlaps as required.

715.42.2.2.9-Check Circuit: All controllers must be provided with a check circuit to indicate the presence or absence of an actuation on any of the phases which do not have the right-of-way so that a pedestrian interval timer may be added to any phase without additional equipment, other than the pedestrian timer.

715.42.2.2.10-Connectors and Wiring Harness: All electrical connections to and from the controller shall be made through MIL-C-26482 series pin connectors and wiring harness. Each wiring harness shall be at least 4 feet (1.2 m) long or of the standard length specified by the manufacturer for that controller chassis type. The harness end opposite the connector shall have color-coded leads or labeled sleeves. The harness connections shall be mounted on the front of the controller unit in accordance with the following:

Connector A shall intermate with an MS3116()-22-55S.

Connector B shall intermate with an MS3116()-22-55P.

Connector C shall intermate with an MS3116()-24-61P.

The wiring harness, harness terminal functions and the MS connectors shall be identical for each connector type.

Terminals shall be provided for the signal light cable. One terminal for each signal circuit and one or more terminals for the common conductors are required. All field wiring shall be color coded and the terminals labeled.

The outgoing signal circuits shall be of the same polarity as the line side of the power supply and the common return shall be of the same polarity as the ground side of the power supply.

A double pole, low-voltage lighting arrestor with mounting bracket shall be mounted on the back panel and wiring between the power supply and the fuse.

All terminals except the interconnect system shall be mounted on the controller panel. The interconnect terminals shall be mounted on the side of the controller cabinet unless otherwise specified.

715.42.2.2.11-Controller Terminal Functions Required: All controller functions shall be available at the MS connector terminals on the controller chassis. These functions shall be as specified in the latest NEMA standard-identification of input/output pin connector termination.

In addition, the controller shall be provided with all terminal functions necessary for plan phasing and to meet the specification requirements. All functions shall be standard controller features and shall be available at the external controller terminal points.

715.42.2.2.12-Per Phase Load Switching Devices: Solid-state, heavy-duty, jack mounted, per phase load switching units shall be used for opening and closing the signal light circuits. Each switching circuit shall have a minimum rating of 10 amperes for a tungsten-lamp or gas-tubing transformer load over a voltage range of 95 to 135 volts at 60 Hz. No more than one circuit shall be energized at any one time unless the combined load on the energized circuits does not exceed a 10 ampere load. This, power handling capability shall not be derated for operation over the operating ambient temperature range described in the NEMA standards.

Covers or cover plates on all switching devices shall be so designed as to be easily removed and replaced by means of set screws or similar replaceable securing devices.

All load switches shall intermate with a Cinch-Jones socket S-2412-SB, or the equivalent. Physical and electrical characteristics of the switches and load racks must conform to the latest NEMA standards.

Signal load switches for use with the controller, but for mounting external to the controller units specified, shall be used for switching signal light circuits.

715.42.2.2.13-Fail Safe: Insofar as possible, all phase and interval sequence logic internal to the controller shall be such that conflicting signal indications are not possible even during power failures or equipment malfunction. If "failsafe" signal monitoring devices are required external to the controller, it must be clearly stated in the manufacturer's instructions.

In the same manner, combinations of signal indications expressly prohibited in the Manual on Uniform Traffic Control Devices shall not be possible.

715.42.2.2.14-Warranties and Guarantees: The Contractor or supplier is required to turn over to the Division any guarantee or warranties which are given by the manufacturer as a normal policy. The Contractor or supplier shall furnish the Division with two copies of complete drawings, diagrams and manufacturer's instructions for installing and maintaining the equipment and any assistance as required for timing and operation of the equipment. Any component called for by the circuit design which has special or unique characteristics which would limit that component to certain manufacturers or suppliers shall be so indicated in the manufacturer's instructions.

The Contractor or supplier shall make available to the Division at no cost, engineering data, diagrams, etc. on any later changes or improvements which would increase the performance of the equipment purchased.

The Division reserves the right to withhold any payments which may be due, should it be discovered that the equipment does not meet the Specifications.

All components specified shall be amply derated with regard to heat dissipating capacity and rated voltage so that, with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values shall not occur.

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715.42.2.5-Solid State Traffic-Actuated Signal Controller (Type C) (Two through Eight-Phase NEMA-Microprocessor Based-KeyBoard Entry): The purpose of this section is to set forth functional specifications for a microprocessor based, fully traffic-actuated dual-ring, functional modular controller unit capable of providing up to eight phase signal operation. Timing and per phase functions shall be programmable by main frame single keyboard entry; per-phase modular entry is not acceptable. Single entry timing mode shall be provided.

In addition to the above named, the Controller must provide a true MENU format for data entry. As a minimum, a forty (40) character by four (4) line, alpha-numeric liquid crystal data display screen must be provided on the front of the controller. The display must be easily visible in both full daylight and at night. Back lighting the display is required.

The general design requirement of 715.42.2.2, as well as the NEMA standards, shall apply except when the specific requirements exceed those in that section of the standards.

Phase designation and sequencing shall be as outlined in 715.42.2 of these Specifications.

The Controller must be capable of storing timings and other control parameters in an internal data memory. This data must then be accessible for display and/or alteration by means of front panel keyboard control and display. Coded memory access or other approved entry control must be provided.

Power requirements and recovery from power interruption shall be as specified in current NEMA standards for solid-state signal controllers. Internal backup battery power to maintain the controller memory for up to one year in the absence of A/C power input must be provided in the controller.

Full volume density operation per phase with walk must be an integral part of the controller logic, including variable initial and gap reduction. MUTCD flash operation, overlap programming, multiple phase configurations, partial or full entry capability, last car passage per phase and extended dual ring status display must also be provided in the controller.

All inputs, outputs, interface voltage and interface common returns shall be through front panel pin connectors. These connectors shall be as specified in 715.42.2.2.10. I/O pin functions shall be in accordance with current NEMA standards.

715.42.3-BLANK

715.42.4-Local Coordinating Units:

715.42.4.1-General Design Requirements: The following are minimum design and operating requirements for all types of local coordinating units. The general design requirements apply to master coordinating units and secondary coordinating units; both dial, electromechanical (LCU-EM) and digital, full solid state (LCU-DS). Local coordinating units provided for an interconnected signal system shall be completely compatible with the master controller and all local controllers in that system.

The coordinating units described shall be used in conjunction with solid state traffic actuated signal controllers and traffic adjusted master controllers. The coordinators shall inhibit the internal extension limit in the local controllers and provide external maximum control. Background cycle lengths, splits, system offsets and other coordination functions as required shall be called in by a master controller or coordinator. These functions may also be called in by local or master override or time switches.

For definition purposes, traffic phases shall be considered as running in sequence, such as A-B-C-D, etc. Also, any of these phases may consist of two separate auxiliary movements which must begin simultaneously but may end at different times, as long as the following phase is the auxiliary's associated thru-phase.

All coordinating units shall be furnished capable of at least the following:

- i. Three background time cycles.
- ii. A separate split associated with each time cycle.
- iii. Three offsets associated with each time cycle.
- iv. A variable permissive period for yielding to minor phases (B,C, etc.).
- v. External maximum limits (force offs) as required for all associated phases.
- vi. System offset interruption, unless provided for in the system master controller.
- vii. Capability of generating cycle lengths of at least 60, 70, 80, 90, 100 and 120 in association with each split and each offset.
- viii. Master-intersection control and supervision of other coordinating units as required.

- ix. Free operation when called for by the system master, time switch or manual override.
- x. A minimum of eleven independent in and out functions shall be provided per dial with associated circuitry to provide yield, force off, free operation, system sync, dial transfer, etc.

It shall be possible to set offset, splits and all synchronization functions from the front of the coordinating unit. It shall be possible to make these settings in at least one percent steps to any percentage of the associated cycle length and all such settings shall be clearly indicated.

Each coordinating unit shall be plug-connected, and it shall be possible to remove a unit and replace it with a similar unit without shutting off the power to the controller or signals. Removal of the coordinating unit and insertion of the coordinating unit harness receptacle into a shorting plug, which shall be mounted on the cabinet wall, shall cause the local controller to go to free operation.

In addition, each coordinating unit shall be provided with a switch on the front panel for selection of free or coordinated operation and at least the selection of one of three cycle lengths. Synchronization shall only be in effect in the coordinated position.

Switch indicator lights shall be provided at the local coordinating units to indicate the synchronization period in effect.

Absence or conflict of offset or cycle information on the interconnect shall place the coordinating unit in cycle number one, offset number one (average offset) or a pre-set standby cycle.

When the controller is working in coordinated operation, the internal maximum of the controller for Phase A shall be disabled. At all other times, the internal maximum of the controller shall remain operable.

Cycle change and transfer from free to coordinated operation shall take place at the first yield point (end of Phase A), unless otherwise specified.

When required in the coordinating unit, system offset interruption shall be adjustable in the range of at least 0 to 40 seconds. When the local coordinating unit, for any reason, gets out of synchronization with the master system, the length of the dwell in any one cycle shall be limited to the time allowed by the offset interrupter. Timing shall start at the beginning of the dwell. A switch shall be provided to eliminate the offset interrupter from the interconnected system.

Any changes in the operation of traffic control signal lights caused by turning the signal lights off, or transfer to flashing or preempt operation shall not interfere with the continued in-time operation of the coordination timer. A transfer from such special operation back to normal automatic operation shall immediately establish the normal time cycle and subsequently the in-time relation.

Each coordinating unit shall be furnished with two service manuals complete with all necessary instructions and diagrams for the installation and maintenance of the equipment supplied and two complete wiring diagrams. These wiring diagrams shall identify the color code or wire tagging used in all connections.

715.42.4.2-BLANK

715.42.4.3-Time Base Coordinating Units (Type TBC): The purpose of this section is to set forth functional specifications and design requirements for signal coordinating units that do not require communications interconnect or synchronous motors to maintain a signal system time base. These units will be designated as Time Base Coordinating Units or TBC.

The general functional requirements in 715.42.4.1 for "hardwire" coordinating units shall apply to the TBC except where otherwise noted. All units shall be capable of the coordination of two (2) through eight (8) signal phases per controller.

TBC units are to be used in conjunction with solid state traffic actuated signal controllers.

The coordinating unit circuitry shall be of the latest solid state digital design. The units shall be completely self-contained and designed to be shelf mounted as auxiliary equipment in standard traffic signal controller cabinets. The units shall operate normally on 115 VAC, 60 Hz line power and shall provide immediate standby battery power for the clock and programmable memory upon interruption of on-line power. Time base timing accuracy for normal (non-battery) operation shall be ± 1 second/month of continuous operation. Line voltage tolerance for specified operation shall be up to 135 VAC and down to 95 VAC. NEMA specified transient protection shall also be provided with each unit. Operating temperature, humidity and all other environmental tolerances specified in current NEMA standards shall be met.

Battery power for standby operation shall be of the rechargeable type and provide at least 100 consecutive hours of standby operation after 48 hours of normal operation with a minimum 3-year life. Standby clock accuracy shall be at least 0.005% in 48 hours.

The following programmable functions shall be available to the user via front of unit keyboard entry.

- Minimum 100 time of day (TOD) program events per day of week
- Four (4) cycle lengths
- Three (3) offsets per cycle
- Two (2) daylight savings time changes
- Free operation selection
- Four (4) synchronization reference times (1 per cycle)

At least eight (8) outputs associated with the above functions shall be provided. Outputs must be provided for synchronization, yield, force-off, phase omit (etc.); in addition, a minimum of three (3) auxiliary outputs shall be available to operate controller functions such as flash, MAX II, change of phase sequence, switching of detectors (etc.). The outputs shall be of the voltage required by the system configuration.

All program entries shall be available upon demand on a front panel display that is easily readable when shaded from direct sunlight. Output status shall also be available on the unit front panel display. In addition, the unit shall give positive feedback to the programmer that a keyboard entry was made and recognized. This also must be displayed on the front panel by readily discernible means.

Program transfer capability via data transfer port and cable must be provided on each unit. Standard interconnecting cable for this function must be provided with each unit.

715.42.5-Traffic Detectors:

715.42.5.1-General Design Requirements: The following are minimum design and operating requirements for all types of traffic detector units. The general design requirements apply to both the loop detectors and the magnetic probe detectors. Detector units within a traffic-actuated system shall be completely compatible with the control units in that system.

The detector units described shall be used in conjunction with pre-timed fixed cycle traffic signal controllers, solid-state traffic actuated signal controllers and traffic adjusted master system signal controllers.

The detector circuitry shall be solid state and all component parts shall be of high quality meeting the maximum acceptable standards of good engineering practices. All components shall be amply derated with regard to heat dissipating capacity and rated voltage so that, with maximum ambient temperature and maximum applied voltage, material shortening of life or shift in values shall not occur. Any component called for by the circuit design which has special or unique characteristics which would limit that component to certain manufacturers or suppliers shall be so indicated in the manufacturer's installation, operation and service instructions.

The detectors shall be capable of sensing both passage and presence of vehicles and shall not be affected by rain or other weather conditions. It shall be possible to change from passage to presence detection by a selector switch mounted on the outside of the detector unit case. The passage or presence of a vehicle over a road sensor shall activate an output relay.

The pulse detection mode shall provide a short output signal for each vehicle entering the roadway sensor zone of detection.

The presence detection mode shall provide a vehicle presence output signal for as long as a vehicle is stopped in the roadway sensor zone or as otherwise specified.

The detectors shall be designed "fail safe." In case of power failure, the output relay shall remain in the closed position.

All detector units shall be designed to operate from a 120 volt (plus or minus 10 percent), 60 Hz, AC power line service.

The detector units shall be completely self-contained and shall include an integral, fused power supply. The detector chassis shall be enclosed in a removable, sturdy aluminum or other non-corrosive metal case. The case shall furnish the chassis protection from moisture and other ambient conditions. The detector shall be of such a size as to readily fit into a cabinet with the signal controller when so required. All electrical connections to and from the detector unit shall be made through a multiterminal, quick disconnect, plug-type connector and wiring harness. Each wiring harness shall be at least 36 in. (900 mm) long. The harness end opposite the connector shall have color-coded leads or labeled sleeves. The harness connection shall be such that the detector may be replaced with a similar unit, without the necessity of disconnecting and reconnecting individual wires leading therefrom.

If the detector is mounted in the same cabinet with signal control equipment, all harness connections except power supply and vehicle call to controller shall be made on a separate terminal strip mounted in the controller cabinet for that purpose. Power supply connection and a vehicle call to controller may be connected to terminals on the controller back-panel.

A front panel light, clearly visible under full daylight conditions, shall be provided to indicate when a vehicle is in the detection area.

An instruction manual and an internal wiring schematic drawing shall be provided with each detector to facilitate installation, operation and service of the units.

The Contractor or equipment supplier shall turn over to the Division any guarantee or warranties which are given by the equipment manufacturer as a normal policy.

NOTE: The above general design requirements do not apply to pedestrian detectors. Pedestrian push buttons are covered in 715.42.5.4.

715.42.5.2-Loop Traffic Detectors (LPS):

The purpose of this section is to set forth functional specifications and design requirements for a solid state digital, automatically tuned and completely self-contained, shelf-mounted unit for detecting the passage or presence of vehicles when connected to a wire loop embedded in the roadway surface.

The general design requirements in 715.42.5.1 and NEMA standards shall apply except when the specific requirements exceed those in 715.42.5.1 and NEMA.

The detector shall respond only to vehicles either stopped in or passing over any portion of the roadway loop. The unit shall be capable of driving loops of various sizes and configurations within a range of 30-1,000 microhenries. It shall be capable of tuning loops of up to 50 feet (15 m) in length with up to 1,000 feet (300 m) of lead-in wire. The detector shall be capable of detecting vehicles traveling at any speed between zero and 100 mph. (0 and 160 km/hr.).

Individual sensor-detector assemblies shall operate satisfactorily under conditions where adjacent sensors are located within 6 feet (1.8 m) of each other.

The following minimum controls or equivalent shall be provided on the front panel of the detector.

- i. Frequency..... High, median and low
- ii. Sensitivity As specified below
- iii. Presence As specified below

Sensitivity-Three selections of minimum thresholds that will detect changes in total loop inductance as low as (1) 0.02%, (2) 0.08% and (3) 0.32%.

Presence-Three selections of presence time modes (1) long-3.5 minutes (minimum), (2) medium-20 seconds (minimum), (3) pulse – 125 ± 25 milliseconds pulse per vehicle.

All electrical connections to the detector shall be made through a single front-mounted, 11 pin, amphenol connector. The connection mounted on the detector shall be male-type and shall be protected and rigidly fixed.

A mating female receptacle with appropriate cable clamps and at least 4 feet (1.2 m) of connecting harness cable shall be provided with each detector. The other end of the cable shall have color-coded leads, or labeled sleeves, each of which shall be fitted with positive grip, and crimp spade terminals for field connections.

The 11 pin connector on the detector shall have the following pin assignments: (Adapter harnesses will not be acceptable.)

PIN NUMBER	CIRCUIT
1	Fused side of 120 volt AC line
2	Neutral side of 120 volt AC line
3	Not Used
4	Earth
5	Relay common contact
6	Relay, normally open, contact
7	Loop
8	Loop
9	Relay, normally closed, contact
10	Not Used
11	Not Used

Detector loopwire and detector feeder cable shall be as specified in 715.42.13. Loop layout and configuration shall be specified in the plans, or as directed by the Engineer.

Output interfacing shall be by means of relay circuitry. All components shall meet the latest requirements of the NEMA Standards.

Type LPS SD detectors shall meet all the requirements of the specifications for 715.42.5.2-Loop Traffic Detectors (LPS), but in addition, must have separate built-in stretch and delay timers with 0 to 15, 0 to 30, and 0 to 60 seconds timing ranges.

715.42.6-Adjustable Face Signal Heads:

715.42.6.1-Definition of Terms:

Lane Control Signal Head: An assembly containing one or more signal faces having indications used to permit or prohibit the use of specific lanes of a street or highway.

Lens: That part of the optical unit which redirects the light coming directly from the lamp and its reflector.

Optically Programmed Signal Head: An assembly containing one or more signal faces which may be designated accordingly as one-way, two-way, etc., permitting the visibility zone of the indication to be determined optically.

Optical Unit: An assembly of redirecting cover glass or lens, reflector, lamp and lamp socket with the necessity supporting parts to be used for providing a single signal indication.

Pedestrian Control Signal: A traffic control signal, manually, electrically or mechanically operated which is erected for the exclusive purpose of directing pedestrian traffic at signalized locations.

Signal Face: That part of a signal head provided for controlling traffic in a single direction. Turning indications may be included in a signal head.

Signal Head: An assembly containing one or more signal faces which may be designated accordingly as one-way, two-way etc.

Signal Indication: The illumination of a traffic signal lens or equivalent device or a combination of several lenses or equivalent devices at the same time.

Traffic Control Signal: Any device, whether manually, electrically or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed.

NOTE: The above list of definitions may not be complete for all terms used. Final interpretations of all terms is the responsibility of the Engineer (see West Virginia Standard Specifications, Section 101).

715.42.6.2-Traffic Control Signal Heads: Each signal shall be of the adjustable, colored light, vertical type with the number and type of sections described and shown on the Plans. Each head shall have an indication in one direction only and shall be adjustable through 360 degrees about a vertical axis.

All new signal heads at any one intersection shall be of the same make and type.

Position of Signal Indications:

All signal indications shall be in a straight line and shall be in the following order although all indications shown need not be included in all cases. In vertical signals, Position 1 shall be at the top, the Position 8 at the bottom. In horizontal signals, Position 1 shall be at the left (facing the signal), and position 6 at the right.

POSITION		SIGNAL INDICATION
Vertical	Horizontal	
1	1	Red
2	2	Yellow
3	4	Green
4	5	Straight Thru Arrow
5	3	Left Turn Arrow
6	6	Right Turn Arrow
7		Don't Walk Symbol
8		Walk Symbol

Pedestrian signal indication shall be mounted separately below the conventional post mounted signal to allow for separate directional facing for these indications and to obtain definition of the signal by spacing. At no time will a pedestrian signal indication be allowed to hang below an overhead-mounted signal.

Assembly:

Each head shall consist of an assembly of individual interchangeable sections securely bolted together to form a unit. There shall be no tie rods used in the assembly. The finished assembly shall present a clean, neat appearance. Each individual section shall house a complete optical unit. It shall be possible to assembly any combination of 8 in. and 12 in. (203 mm and 305 mm) heads without the use of special adapters.

The top and bottom of each section shall have an opening to accommodate standard 1½ in. (DN40) pipe brackets. The opening shall be in line vertically. The assembly shall be capable of being rotated between standard waterproof supporting brackets or trunnions and thus aimed in any direction in the horizontal plane. The portion of each section adjacent to the bracket openings and the portion used for connecting sections shall be properly reinforced to provide sufficient strength to resist shock, vibration and impact damage.

Each section shall have lugs for the mounting of at least one six-position, twelve-terminal, barrier-type terminal block.

Each section shall have lugs or pads such that backplates may be mounted without drilling or tapping the section.

The housing door shall be a one-piece square casting, having two hinge locations on the left side and at least one latch location on the right side. The hinges shall have stainless steel pins at least 3/16 inch (5 mm) in diameter. The latch shall consist (1) a latch jaw on the door and a stainless steel latch screw, wing nut, and washer securely affixed to the housing, or (2) a captive wing nut, washer, and screw assembly on the door and a captive nut in the housing. It shall be possible to open and remove the door without the use of any tools.

The door shall have a gasketed opening that shall provide a visible lens diameter of 7 3/4 to 8 in. (197 to 203 mm) for a nominal 8 in. (203 mm) lens and 11 1/2 to 12 in. (292 to 305 mm) for a nominal 12 in. (305 mm) lens. All lenses shall be as described in 715.42.6.4.

The door shall have four equally spaced visor attachment points around the lens opening.

Visors shall be at least 7 inches (175 mm) long for an 8-inch (203 mm) lens and at least 9 1/2 inches (241 mm) long for a 12-inch lens (305 mm). Visors shall be described as cutaway, tunnel, or full circle. All heads shall be supplied with tunnel visors, unless otherwise noted on the Plans or unless prior permission from the Division has been received. All new replacement signal heads at any one intersection shall have the same type as the existing visors supplied, unless otherwise specified on the Plans.

Visors shall be designed with a downward tilt between 3 1/2 degrees and 5 degrees, shall eliminate the escape of light from one indication to another, and with the optical unit, shall eliminate the return of outside rays entering the unit from above the horizontal (known as sun phantom).

The Signal Sections, all brackets, trunions and suspension devices shall be painted in accordance with ITE (Institute Transportation Engineers) Specifications. The inside of the signal section visors shall be flat black enamel to eliminate objectionable reflections. Non-Metallic signal sections must have a color impregnated finish and be the same color as the enameled sections. The inside of non-metallic visors must also be painted with a permanent flat black enamel or use other means to prevent reflections.

The optical unit shall consist of the lamp, lampholder, reflector, lens gasket and lens, and shall be so designed that all light emitted by the unit passes through the lens and so that any possibility of false indications is eliminated.

The lampholder shall be of heat resisting material designed to properly position a medium screw base traffic signal lamp, with means to accommodate a lamp having light center 2-7/16 inches (60 mm) in length for the 60-watt and 100-watt series and 3 inches (75 mm) in length for the 150-watt series. The lampholder shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lampholder or the reflector holder to permit rotation of the lamp so that the lead-in wires are up and the lamp shall be retained securely in that position, but no change in position of the socket with respect to the optical center of the reflector shall occur. The metal portion of the lampholder shall be compatible with brass or copper.

Each lampholder shall be provided with two coded No. 18 or larger lead wires, type TEW, 600-watt, AWM fixture with 2/64 in. (0.8 mm), 221° F (105° C) rating thermoplastic

insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with the holder or door fully open. The thermoplastic insulation shall at minus 30°F (-34° C) be capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage. A suitable terminal block or blocks shall be provided in the second section from the top or in each section of one-section heads. The terminal block shall have at least one section for each signal head section plus at least two additional sections per block. Terminal blocks shall be standard commercially available units.

Reflectors shall be specular aluminum in accordance with the latest ITE Specifications and shall be mounted in a reflector holder. The reflector holder shall provide a rigid reflector mounting to assure proper alignment between the lens and the reflector with the door closed. The reflector shall have a lampholder opening in the back. The reflector shall have a bead or flange on the outer edge to stiffen the reflector and insure its dimensional stability. The reflecting surface shall be totally free from flaws, scratches, defacements and mechanical distortion.

The lens gasket shall be a slotted circular neoprene gasket specifically designed to exclude moisture, dust and road film. The optical unit shall be sealed to exclude moisture and dust. This may be accomplished in one of two ways:

- i. If the open door contains the complete optical unit, the reflector/door and the reflector/lampholder interfaces shall be equipped with specially designed neoprene seals to completely seal the optical unit. The section must not accumulate water.
- ii. If the reflector and lampholder remain in the section when the door is opened, the entire section shall be made watertight and dust tight by a weatherproof neoprene gasket contained in a gasket groove in the door. The gasket shall seal against a raised bead in the section to provide the proper seal.

The lighted signal shall appear to be illuminated over the entire visible lens surface without shadows when viewed from any angle up to 30 degrees each side of the optical axis horizontally and up to 45 degrees below the optical axis vertically.

The required appearance, light distribution and candle power intensity from the complete assembled section shall meet latest revision of the ITE Specification. "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads."

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control signal heads shall be entirely weathertight without the use of externally applied sealants or caulking. The trunnions, brackets and suspensions shall be the same manufacturer as the signal heads.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under all normal wind conditions.

The lower support or connection between signal heads in a spanwire or mast-arm mounted signal may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for mast-arm or span-wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

Non-metallic trunnions, brackets and suspension parts previously approved by the Division may be supplied. Such parts must be capable of mounting both metallic and non-metallic signal heads and must have metallic reinforcement at points of anticipated wear.

Reinforcing metal must be compatible with aluminum, steel and galvanized steel.

Backplates:

All signal head assemblies so indicated on the Plans shall be provided with backplates designed to fit the combination of sections for each signal face.

These backplates shall be fabricated from non-ferrous metal of gage to withstand distortion in 60 mph. (100 km/hr) winds and shall be firmly attached to each signal face in such a manner as to withstand the above wind load and to permit the opening of any signal independent from the other doors in the signal face.

Overhead signal heads shall have backplates with a 5 inch (125 mm) border.

Pedestal mounted signals shall have backplates with an eight inch (200 mm) border.

The backplates shall be finished with the best quality, oven-baked black enamel and shall comply with Federal Specifications TT-E-489.

715.42.6.3-Metallic Signal Heads: Each head of this type shall be constructed primarily of aluminum and aluminum castings and stainless steel, and shall meet all requirements in 715.42.6.2, and shall accept lenses and lamps as described in 715.42.6.4.

The section and door shall be one-piece, corrosion-resistant aluminum alloy die castings. Visors and reflectors shall be made from sheet aluminum or die castings.

All cast metal parts shall have a tensile strength of not less than 17,000 psi. (117 MPa) All castings shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections. The castings shall conform to ASTM B 85 alloys SC84A, SC84B, SG100A, SG100B, S12A or S12B.

Sheet aluminum parts shall be manufactured from corrosion-resistant aluminum sheet having a tensile strength of at least 20,000 psi (138 MPa), except that reflectors shall be manufactured from the aluminum alloy suggested by the manufacturer.

All hinge pins and latch parts shall be Type 304, stainless steel.

Miscellaneous parts and hardware shall be made of non-corrosive materials.

All parts shall have sufficient strength to show minimal damage under severe loading conditions. Visors shall be not less than 0.05 in. (1.31 mm) thick. Reflectors shall be spun or drawn from aluminum not less than 0.025 in. (0.64 mm) thick.

715.42.6.4-Non-Metallic Signal Heads: Each head of this type shall be constructed primarily of a non-metallic material, aluminum and stainless steel, shall meet all requirements of 715.42.6.2 and shall accept lenses and lamps as described below. The non-metallic material used shall be durable and resistant to marring, scratching, discoloration, weather, temperature change, shock and color change from weather or photochemical action. The thickness of the non-metallic material shall be sufficient to provide at least the strength of the cast aluminum product of the same manufacturer at any location tested.

In addition, the finished section shall pass the following test for strength: A completely wired three-section head without lamps or visors shall be securely fastened between two brackets. A one-pound (450 gram) weight with a spherical tip 2 inches (50 mm) in diameter shall be impacted into the center section on any surface including the door with an impact of 70 ft-lb. No part of any section, except the lens, shall be dented, cracked, crazed, chipped, punctured or otherwise visibly damaged.

The test shall be conducted at 0°F, 70°F and 120°F (at -18° C, 21° C and 49° C) ambient temperatures after the head has been kept at the test temperature for 12 hours. Immediately after the test, lamps shall be installed and the head shall be shown to function normally.

The non-metallic material, resin and reinforcement fibers, where used, shall be die-cast to produce a smooth glossy surface to which water, dirt and diesel oil will not readily adhere. Colors shall be cast integrally in the material. The finished product shall be free from all visible casting defects, including color variances. All hinge pins and latch parts shall be Type 304 stainless steel.

Miscellaneous parts and hardware shall be made of a non-corrosive material.

Visors shall be at least as strong as aluminum sheet with a tensile strength of 20,000 psi (138 MPa) and a thickness of 0.05 in. (1.3 mm)

All parts shall have sufficient strength to show minimal damage under severe loading conditions.

Lamps and Lenses:

Lamps: The lamps supplied with the traffic signal heads shall have the filament adequately supported to withstand the vibration induced from truck traffic and heavy winds. The light center length (LCL) is the dimension, in inches (mm), from the center of the filament to the tip of the base. All traffic signal lamps shall have a brass, standard, medium screw base, a clear glass envelope and shall be in conformance with the following design requirements:

- i. All 8 in. or 12 in. (203 or 305 mm) traffic signal indications shall have a lamp rating of between 110 and 120 watts, a light center length (LCL) of 2-7/16 in. (60 mm), with a minimum initial lumen value of 1,260 and a rated life of at least 6,000 hours.
- ii. All 8 in. or 12 in. (203 or 305 mm) traffic signal indications, used exclusively for flashing operation shall have a lamp rating of between 60 and 70 watts, a light center length (LCL) of 2-7/16 in. (60 mm), with a minimum initial lumen value of 665 and a rated life of at least 6,000 hours.

The glass envelope of the lamps shall be etched to show the manufacturers insignia or trademark, the voltage rating, the rated wattage and the rated life hours.

Lenses: The lens shall be standard prismatic red, yellow or green and shall be durable on prolonged exposure to weather. Each lens shall be of clear colored glass or polycarbonate resin, free from bubbles and flaws and shall be annealed to relieve internal stresses. Flashed lenses will not be accepted.

Lenses shall conform to the ITE Specification, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," and any revisions to the latest edition.

The luminous transmission for traffic signal lenses and the limits of chromaticity for traffic signal colors shall be as follows:

RED	The minimum relative luminous transmittance shall be 0.095; the value of y shall not be greater than 0.308 nor less than 0.998 minus x
YELLOW	The minimum relative luminous transmittance shall be 0.440; the value of y shall not be less than 0.411 nor less than 0.995 minus x nor greater than 0.452
GREEN	The minimum relative luminous transmittance shall be 0.200; the value of y shall not be less than 0.506 minus 0.519x nor less than 0.150 plus 1.068x nor greater than 0.730 minus x

Each lens shall be furnished with a label which shall indicate that the lens meets the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," January 2, 1966, and any revisions thereof.

All lenses, except arrows, shall have pressed on its flange the word "TOP" to indicate the proper positioning of the lens in the door for obtaining the light distribution required, together with the diameter and other designations, including the name or trademark of the manufacturer needed for proper application and help in purchasing replacements.

The nominal 8 in. (203 mm) lens shall have an outside diameter of from 8-5/16 in. to 8-3/8 in. (211 to 213 mm) The nominal 12 in. (305 mm) lens shall have an outside diameter of from 11-15/16 in. to 12-1/32 in. (303 to 306 mm) (These dimensions do not apply to the visible indication area of the optically programmed head.) Each lens shall fit into a specifically designed slotted circular neoprene lens gasket designed to fit the housing door in such a manner so as to exclude moisture, dust and road film.

Arrow Lenses:

Arrow lenses shall meet the ITE Specification, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," January 22, 1966, and any revisions thereof, and all other specifications above. The lens shall be of approved color specified above. All lenses shall be covered, except for the arrow with the light from a 200 watt lamp placed behind it. The enamel shall be baked or fired into the lens. The enamel shall be hard and durable and shall not peel or flake when subjected to the heat of a signal lamp when the lens is in use, or when the lens is washed. The arrow shall be the only illuminated portion of the lens.

715.42.6.5-Pedestrian Control Signal Heads (Incandescent): These Specifications cover symbolic pedestrian signal assemblies to be illuminated by incandescent lamps mounted behind two lenses (one for each symbol), having translucent symbols.

General Design Requirements:

The nominal size of the lenses shall be 12 by 12 in. (305 by 305 mm).

Housing:

The housing shall be constructed of cast or sheet corrosion resistant, non-ferrous metal or plastic, or of a combination of these materials.

All cast metal parts shall have tensile strength of not less than 17,000 psi. (117 MPa) Sheet metal shall have a tensile strength of 27,000 psi. (186 MPa) All parts shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections.

If the housing and doors of the signal heads are made of aluminum alloy, they shall have one of the following compositions:

- i. If die castings are furnished, the alloys shall be in accordance with ASTM B 85 60T or the latest revision thereof, and the physical characteristics and chemical content of the alloy used shall be within the combined limits established by allows S-12A, S-12B, SC-84A, SC-84B, SG-100A and SG-100B of the ASTM Specification.
- ii. If sand castings are furnished, the alloys shall be in accordance with ASTM B 26 60T or the latest revision thereof, and physical characteristics and chemical content of the alloy used shall be within the combined limits established by alloys S-5A and CS-72A of the ASTM Specification.
- iii. If permanent mold castings are furnished, the alloys shall be in accordance with ASTM B 108 60T or the latest revision thereof, and the physical characteristics and chemical content of the alloy used shall be within the combined limits established by alloys S-5A and CS-72A of the ASTM Specification.
- iv. If sheets are furnished, the alloys shall be in accordance with ASTM 209 58T or the latest revision thereof, and the physical characteristics and chemical content of the alloy used shall be M1A of the ASTM Specification.

When required, the successful bidder shall furnish satisfactory evidence that materials comply with the foregoing requirements.

The housing shall be of unitized sectional construction and shall consist of as many sections as there may be optical unit levels. All sections shall be rigidly and securely fastened together into one weathertight signal face assembly.

Each housing shall be arranged with round openings in the top and bottom so that it may be rotated between waterproof supporting brackets on trunnions and thus be capable of being directed at any angle to the horizontal plane. The openings shall be provided with a serrated ring which shall permit indexing and locking of the signal head in five-degree increments throughout the entire 360 degrees of rotation possible. The portion of the housing adjacent to the bracket shall be properly reinforced so as to have sufficient strength against breakage from shock.

The housing door of each signal section shall be a one-piece, corrosion resistant aluminum alloy die casting. Two hinge lugs shall be cast on the one side of the door and latch jaws shall be cast on the opposite side of the door.

The door shall be attached to the housing by means of two solid stainless steel hinge pins of not less than 1/4 in. (6 mm) diameter.

A stainless steel latch screw, wing nut and washer on the latch jaw side of the housing shall provide for opening and closing the signal door without the use of any special tools.

A gasket groove on the inside of the door shall accommodate a weatherproof and dustproof seal.

The outer face of the door shall have tapped holes equally spaced about the perimeter of the housing to accommodate screws for securing the signal head visors.

Latch screws, hinge pins, wing nuts and washers shall be Type 304 stainless steel.

The housing door shall be finished with the best quality, oven-baked yellow enamel and shall comply with Federal Specifications TT-E-489.

The housing, when properly mounted using 1½ in. (DN40) pipe brackets, shall be able to withstand a concentrated load of 50 lbs. (23 kg) placed 6 inches (150 mm) from the centerline of the mounting brackets on either side of the opening or on both sides of the opening simultaneously. Such loading shall not produce sufficient deformation to cause the material to fail or to take a permanent set that would interfere with opening the door, rotation about the brackets, or loss of the weathertight integrity of the unit.

Visors:

Each signal head shall have a visor for each signal indication. The visor shall be designed to fit tightly against the door and shall not permit any perceptible filtration of light between door and the visor. The visor shall be 8 inches (203 mm) minimum in depth and inclined downward approximately 32 degrees with complete enclosure at the top and sides. The visor shall be of sheet construction and shall be of corrosion resistant, non-ferrous metal not less than 0.05 in. (No. 18 US gage) in thickness. The outside of the visor shall be of the same yellow enamel as the housing and door. The inside of the visors shall be painted a dull nonreflective black.

Pedestrian Signal Lenses:

Each lens shall be clear colored glass or plastic free from bubbles and flaws, and shall be annealed to relieve internal stresses. Flashed lenses will not be accepted.

Lenses shall conform to the ITE Specifications, "Adjustable Face Pedestrian Signal Standard," and revisions thereof, where applicable.

The luminous transmission for pedestrian lenses and the limits of chromaticity for signal colors shall be as follows:

Portland Orange-Don't Walk Symbol-The luminous transmittance shall be not less than 0.300; the value of y shall not be greater than 0.390 nor less than 0.997 minus x.

Lunar White-Walk Symbol-The luminous transmittance shall not be less than 0.290; the value of x shall not be greater than 0.420 nor less than 0.329. The value of y shall not be greater than 0.510x plus 0.186 nor less than 0.510 plus 0.170.

Each lens shall have pressed on its flange such designation and trademark of manufacturer to facilitate proper application and to help in purchase of replacements.

The nominal 12 in. (305 mm) lens shall have minimum overall dimensions of 12 in. by 12 in. (305 by 305 mm) with a visible area of 11 in. by 11 in. (280 by 280 mm).

Message:

The Walk-Don't Walk symbols shall be according to the Standard Highway Signs Booklet, published by the Federal Highway Administration.

The surface of the lens, except for the symbol, shall be covered by opaque enamel of sufficient thickness to totally obscure the light of a 150-watt lamp when placed 12 in. (305 mm) behind the lens. The enamel shall be baked or fired into the glass and shall not peel or flake during normal use.

Reflectors:

Reflectors shall be specular Alzak finished aluminum and be designed for a 10 year service life.

Reflectors shall be mounted in a cast aluminum reflector support attached to the housing, or shall be an integral reflector and support of formed sheet aluminum.

The reflector assembly shall be pivoted to the housing and shall be designed so that it can be swung out or easily removed without the use of any tools.

The method of mounting and fastening reflectors shall be sufficiently rigid to secure proper alignment between the lens and reflector when the door is closed.

The construction of the signal head and its components shall be such that the fit between the reflector and the lens will eliminate all possibility of false indications.

Reflectors shall have an opening in the back for the lamp socket.

Pedestrian signal reflectors shall be of specular aluminum, the thickness of the anodic coating shall be a minimum of 0.0001 in. (2.5 µm) or its equivalent, spun or drawn from metal not less than 0.025 in. (0.64 mm) thick, equipped with a bead or flange on the outer edge to stiffen the reflector and insure its being held true to shape.

The reflecting surface shall be totally free of flaws, scratches, defacements or mechanical distortion.

Light Distribution:

The lighted signal shall appear to be uniformly illuminated over the entire message surface, without shadows when viewed from usual angles encountered in service. Distribution of light through the letters shall be uniform and free from halation or other uncontrolled scattering which may reduce legibility of the message.

The pedestrian indications should attract the attention of, and be readable to, the pedestrian (both day and night) at all distances from 10 ft. (3 m) to the full width of the area to be crossed. When not illuminated, the WALK and DON'T WALK symbols shall not appear to be illuminated by external light sources when viewed from the far end of the crosswalk they control.

Lamps:

Lamps supplied with the pedestrian signal heads shall have the filament adequately supported to withstand the vibration induced from truck traffic and heavy winds. All pedestrian signal lamps shall have a brass, standard, medium screw base and clear glass envelope. The light center length (LCL), or the dimension, in inches (mm), from the center of the filament to the top of the base, shall be in conformance with the following design requirements:

All pedestrian signal lamps for use in 12 in. (305 mm) pedestrian signal heads shall have a light center length of 3 inches (75 mm).

Pedestrian signal lamps shall conform to the following standards:

TWELVE-INCH PEDESTRIAN SIGNAL		
Nominal Wattage	Rated Life Hours	Min. Initial Lumens
150 watt series	6,000	1,950

The glass envelope of the lamps shall be etched to show the manufacturer's insignia or trademark, the voltage rating, the rated wattage, and the rated life hours.

Lamp Receptacle:

The lamp receptacle shall be heat resisting material designed to properly position a medium screw base pedestrian signal lamp with means to accommodate a lamp having light center 3 inches (75 mm) in length for the 150-watt series. The receptacle shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lamp receptacle or the reflector holder to permit rotation of the lamp so that the lead-in wires are up, and a secure fastening for the retention of the lamp in that position, but shall not permit any change in position of the socket with respect to the optical center of the reflector. The metal portion of the lamp receptacle shall be compatible with brass or copper.

Wiring:

Each lamp receptacle shall be provided with two coded No. 18 or larger lead wires, Type TEW, 600 volt, AWM fixture wire with 1/32 in. (0.8 mm), 221° F (105° C) rating thermoplastic insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with the reflector fully open. The thermoplastic insulation shall at minus 30° F (-35° C) be capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage. A suitable terminal block signal housing shall be provided.

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control sign heads shall be entirely weather-tight without the use of externally applied sealants or caulking. The trunnions, brackets and suspensions shall be the same manufacturer as the signal heads.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under all normal wind conditions.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

715.42.6.6-Optically Programmed Traffic Signal Heads: The purpose of this section is to set forth the minimum specifications for all optically programmed traffic signal heads and associated equipment.

Signal Heads:

All signal heads shall be the nominal 12 in. (305 mm) type and shall be adjustable through 360 degrees about a vertical axis, with each individual section being adjustable plus or minus nine degrees about a horizontal axis, maintaining a vertical centerline through couplers and conduit. Each section shall be equipped with a sun visor.

All die cast aluminum parts shall conform to the following specifications or the latest revision thereof; Die casting SC-84A, SC-84B, SG-100A, SG-100B or S-12B of ASTM Specifications B 85. All stainless steel shall be of Type 304.

All surfaces outside of the signal heads (except the underside of the visors) shall be finished with the best quality, oven-baked yellow enamel and shall comply with Federal Specifications TT-E-489.

The signal head housing shall consist of an assembly of separate interchangeable sections, expandable type for vertical mounting without tie rods, substantially secured together in a watertight manner to form a unit. Each section shall house an individual optical unit. The top and bottom of the signal housing shall have an opening to accommodate standard 12 in. (DN40) pipe brackets.

The optical system shall consist of a lamp, a circlet reflector, an optical limiter-diffuser combination and an objective lens. The lamp shall be nominal 150 watt, 120 volt AC, three prong, sealed beam having an integral reflector and an average rated life of 6,000 hours. A circlet reflector with a specular inter surface shall mate the lamp to the diffusing element. The optical limiter-diffuser combination shall provide an imaging surface, at focus on the optical axis for objects 900 to 1,200 ft. distance and permit an effective veiling system to be variously applied as determined by the desired visibility zone. The optical limiter-diffuser shall be provided with positive indexing means and composed of heat resistant glass. The objective lens shall be a high resolution planar incremental lens hermetically sealed with a flat laminate of weather-resistant acrylic. The lens shall be symmetrical in outline and may be rotated to any 90 degree orientation about the optical axis. Lens colors shall conform to the specifications of the Institute of Traffic Engineers, 1966, and any revisions thereof.

Each signal head shall be equipped with a dimming mechanism that will gradually reduce the candlepower for nighttime operation to approximately 15 percent of that for daytime operation.

The lamp fixture shall comprise a separately accessible housing and integral lamp support, ceramic socket and self-aligning, quick release lamp retainer. Electrical connection between case and lampholder shall be accomplished with an interlock assembly which disconnects the lampholder when open. Coded No. 16 lead wires shall be used of a length sufficient to permit solderless connection to line wires external to the signal.

All signal indications shall be in a straight line and shall be in the following order, although all indications shown need not be included in all cases. In vertical signals, Position 1 shall be at the top, and Position 8 at the bottom. In horizontal signals, position 1 shall be at the left (facing the signal), and Position 6 at the right.

POSITION		SIGNAL INDICATION
Vertical	Horizontal	
1	1	Red
2	2	Yellow
3	4	Green
4	5	Straight Thru Arrow
5	3	Left Turn Arrow
6	6	Right Turn Arrow
7		Don't Walk Symbol
8		Walk Symbol

Each signal head shall be equipped with a suitably designed visor. The underside of the visor shall be flat black paint.

Hardware:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control signal faces shall be entirely weathertight.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under design wind conditions.

The lower support or connection between signal heads in multi-way span wire or mast arm mounted signals may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for mast arm or span wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

715.42.6.7-Lane Control Signal Heads (Single Lamp):

General Design Requirements:

Each signal head shall be of the adjustable, colored-light type with the number and type of sections described and as shown on the Plans. Single indication heads shall be mounted on a vertical axis. Each head shall have an indication in one direction only and shall be adjustable through 360 degrees about a vertical axis for single indication heads, or about a horizontal axis for multi-indication heads.

All lane control signal heads at any one intersection shall be of the same make and type.

Position of Signal Indications:

All signal indications shall be in a straight horizontal line and shall be in the following order although all indications shown need not be included in all cases. Position 1 shall be at the left (facing the signal), and Position 3 at the right.

POSITION	SIGNAL INDICATION
1	Red X
2	Yellow X
3	Green Arrow

Assembly:

Each head shall consist of an assembly of individual interchangeable sections securely bolted together to form a unit. Sections shall be capable of being oriented horizontally or vertically without the use of additional parts. There shall be no tie rods used in the assembly. The finished assembly shall present a clean, neat appearance. Each individual section shall house a complete optical unit.

The ends of each section shall have an opening to accommodate standard 1½ in. (DN40) pipe brackets. The openings shall be in line. The assembly shall be capable of being rotated between standard waterproof supporting brackets or trunnions and thus aimed

in any direction in the specified plane. The portion of each section adjacent to the bracket openings and the portion used for connecting sections shall be properly reinforced to provide sufficient strength to resist shock, vibration and impact damage.

Each section shall have lugs for the mounting of at least one six-position, twelve-terminal, barrier-type terminal block.

The housing door shall be a one-piece casting having two hinge locations and at least one latch location. The hinges shall have stainless steel pins at least 3/16 in. (5 mm) diameter. The latch shall consist of (1) a latch jaw on the door and a stainless steel latch screw, wing nut and washer securely affixed to the housing; or (2) a captive wing nut, washer and screw assembly on the door and a captive nut in the housing. It shall be possible to open and remove the door without the use of any tools.

The door shall have a gasketed opening that shall provide a visible lens area of 120 sq. in. (0.077 sq. m) for a nominal 12 in. (305 mm) lens and 289 sq. in. (0.185 sq. m) for a nominal 18 in. (455 mm) lens. All lenses shall be as described in 715.42.6.7.1.

The door shall have a gasketed opening that shall provide a visible lens area of 120 sq. in. (0.077 sq. m) for a nominal 12 in. (305 mm) lens and 289 sq. in. (0.185 sq. m) for a nominal 18 in. (455 mm) lens. All lenses shall be as described in 715.42.6.7.1.

The door shall have four equally spaced visor attachment points around the lens opening.

Visors shall be at least 10 in. (254 mm) long for a 12 in. (305 mm) lens and at least 12 in. (305 mm) long for an 18 in. (455 mm) lens. Heads shall be supplied with standard visors, unless otherwise noted on the Plans. All new signal heads at any one intersection shall have the same type visors supplied, unless otherwise specified on the Plans.

Visors shall be designed with a downward tilt between 3½ degrees and 5 degrees, shall eliminate the escape of light from one indication to another and, with the optical unit, shall eliminate the return of outside rays entering the unit from above the horizontal (known as sun phantom).

The section and all brackets, trunnions and suspensions shall be finished with yellow enamel. The door and the outside of the visor shall be finished with either yellow or black enamel. The inside of the visor shall be finished with a flat black enamel. All enamel shall be best quality, oven-baked meeting Federal Specifications TT-E-489.

The optical unit shall consist of the lamp, lampholder, reflector, lens gasket and lens, and shall be so designed that all light emitted by the unit passes through the lens and so that any possibility of false indications is eliminated.

The lampholder shall be of heat resisting material designed to properly position a medium screw base traffic signal lamp, with means to accommodate a lamp having light center 3 inches (75 mm) in length for the 116-watt series and 6 inches (150 mm) in length for the 200-watt series. The lampholder shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lampholder or the reflector holder to permit rotation of the lamp so that the lead-in wires are up, and the lamp shall be retained securely in that position, but no change in position of the socket with respect to the optical center of the reflector shall occur. The metal portion of the lampholder shall be compatible with brass or copper.

Each lampholder shall be provided with two coded No. 18 AWG or larger lead wire, Type TEW 600-watt fixture wire 2/64 in. (0.8 mm), 105° C rating thermoplastic insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with

the holder or door fully open. The thermoplastic insulation shall be at minus 30° F (-34° C) capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage. A suitable terminal block or blocks shall be provided in the second section from the left or in each section of one-section heads. The terminal block shall have at least one section for each signal head section plus at least two additional sections per block. Terminal blocks shall be standard commercially available units.

Reflectors shall be specular aluminum in accordance with the latest ITE Specifications and shall be mounted in a reflector holder. The reflector holder shall provide a rigid reflector mounting to assure proper alignment between the lens and the reflector with the door closed. The reflector shall have a lampholder opening in the back. The reflector shall have a head or flange on the outer edge to stiffen the reflector and insure its dimensional stability. The reflecting surface shall be totally free from flaws, scratches, defacements and mechanical distortion.

The lens gasket shall be a slotted neoprene gasket specifically designed to exclude moisture, dust and road film. The optical unit shall be sealed to exclude moisture and dust. This may be accomplished in one of two ways:

- i. If the door contains the complete optical unit, the reflector/door and the reflector/lampholder interfaces shall be equipped with specially designed neoprene seals to completely seal the optical unit. The section must not accumulate water.
- ii. If the reflector and lampholder remain in the section when the door is open, the entire section shall be made watertight and dusttight by a weatherproof neoprene gasket contained in a gasket groove in the door. The gasket shall seal against a raised bead in the section to provide the proper seal.

The lighted signal shall appear to be illuminated over the entire visible lens surface without shadows when viewed from any angle up to 39 degrees each side of the optical axis horizontally and up to 45 degrees below the optical axis vertically.

The required appearance, light distribution and candlepower intensity from the complete assembled section shall meet latest revision of the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads."

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for pedestrian signal heads shall be entirely weathertight without the use of externally applied sealants or caulking. The trunnions, brackets and suspensions shall be of the same manufacturer as the signal heads.

All tubular parts shall be 1½ in. IPS (DN40) pipe. When hollow cast brackets or trunnions are used, they shall be of sufficient strength to support the maximum load imposed by the signal heads under all normal wind conditions.

The lower support or connection between signal heads in a span-wire or mast-arm mounted signal may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding, and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for mast-arm or span-wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

Non-metallic trunnions, brackets and suspension parts previously approved by the Division may be supplied. Such parts must be capable of mounting both metallic and non-metallic signal heads and must be compatible with aluminum, steel and galvanized steel.

Metallic Lane Control Signal Heads:

Each head of this type shall be constructed primarily of aluminum and aluminum castings and stainless steel, shall meet all requirements of 715.42.6.7 and shall accept lenses and lamps as described in 715.41.6.7.1.

The section and door shall be one-piece, corrosion-resistant aluminum alloy die castings. Visors and deflectors shall be made from sheet aluminum or die castings.

All cast metal parts shall have a tensile strength of not less than 17,000- psi. (117 MPa). All castings shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections. The castings shall conform to ASTM B 85 alloys SC-84A, SC-84B, SG-100A, SG-100B, S-12A or S-12B.

Sheet aluminum parts shall be manufactured from corrosion-resistant aluminum sheet having a tensile strength of at least 20,000 psi (138 MPa), except that reflectors shall be manufactured from the aluminum alloy suggested by the manufacturer.

All hinge pins and latch parts shall be Type 304, stainless steel.

Miscellaneous parts and hardware shall be made of non-corrosive materials.

All parts shall have sufficient strength to show minimal damage under severe loading conditions. Visors shall be not less than 0.05 in. (1.3 mm) thick. Reflectors shall be spun or drawn from aluminum not less than 0.025 in. (0.064 mm) thick.

715.42.6.7.1-Lamps and Lenses for Lane Control Signal Heads:

Lamps:

Lamps supplied with the lane control signal heads shall have the filament adequately supported to withstand the vibration induced from truck traffic and heavy winds. The light center length (LCL), is the dimension, in inches (mm), from the center of the filament to the tip of the base. All lane control signal lamps shall have a brass, standard, medium screw base and a clear glass envelope and shall be in conformance with the following design requirements:

Head Size	Wattage Series	LCL	Minimum Rated Life	Minimum Initial Lumens
12	116	3 in. (75 mm)	6,000 hours	1,260
18	200	6 in. (150 mm)	6,000 hours	

The glass envelope of the lamps shall be etched to show: the manufacturer's insignia or trademark, the voltage rating, the rated wattage and the rated life hours.

Lenses:

The lens shall be standard prismatic red, yellow or green and shall be durable on prolonged exposure to weather. Each lens shall be of clear colored glass or polycarbonate resin free from bubbles and flaws and shall be annealed to relieve internal stresses. Flashed lenses will be accepted.

Lenses shall conform to the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads," January 22, 1966, and any revisions thereof. The luminous transmission for traffic signal lenses and the limits of chromaticity for traffic signal colors shall be as follows:

RED	The minimum relative luminous transmittance shall be 0.095; the value of y shall not be greater than 0.308 nor less than 0.998 minus X .
YELLOW	The minimum relative luminous transmittance shall be 0.440; the value of y shall be not less than 0.411 nor less than 0.995 minus X nor greater than 0.452.
GREEN	The minimum relative luminous transmittance shall be 0.200; the value of y shall not be less than 0.506 minus 0.519 X nor less than 0.150 plus 1.068 X nor greater than 0.730 minus X .

Each lens shall be furnished with a label which shall indicate that the lens meets the latest revision of the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable face Vehicle Traffic Control Signal Heads."

All lenses shall have pressed on the flange the work "TOP" to indicate the proper positioning of the lens in the door for obtaining the light distribution required, together with the size and other designations, including the name or trademark of the manufacturer needed for proper application and help in purchasing replacements. Each lens shall fit the housing door in such a manner so as to exclude moisture, dust and road film. All lenses shall be covered except for the X or the arrow with a dull or dark gray enamel of thickness sufficient to totally hide the light from a 200-watt lamp placed behind it. The enamel shall be baked or fired into the lens. The enamel shall be hard and durable and shall not peel or flake when subjected to the heat of a signal lamp when the lens is in use, or when the lens is washed. The X or the arrow shall be the only illuminated portion of the lens.

715.42.7-Auxiliary Traffic Signal Equipment: The purpose of this section is to set forth the minimum design and functional requirements for all types of optional auxiliary equipment which are described in this section.

All auxiliary equipment shall operate on 120 volts, 60Hz, AC power supply. The equipment operation shall not be affected by supply voltage variations between the limits of 10 percent above and 10 percent below 120 volts standard service. Similarly, the equipment operation shall not be affected by any change in temperature between the limits of plus 122°F (plus 50°C) and minus 30°F (minus 34°C) without the necessity of any heater element.

The Contractor shall furnish manufacturer's instructions for installing, maintaining and placing into operation the auxiliary equipment, along with engineering data, diagrams, etc. or any later changes or improvements which may increase the performance of the equipment purchased.

The Contractor is required to turn over to the Division any guarantees or warranties which are given by a manufacturer.

The Division reserves the right to withhold any payment which may be due for equipment which does not meet Specifications.

Solid state flashers meeting current NEMA TS standards and capable of the above specified outputs and circuit ratings are an acceptable alternate to motor driven units.

715.42.7.1-Flasher Units: The purpose of this subsection is to set forth minimum specifications and design requirements for flasher units to perform the flashing combinations as specified on the Plans.

The signal flasher unit shall be a motor-driven switching device for flashing beacons or traffic signal indications at signalized intersections. It shall be designed for back-panel mounting in a flasher or traffic signal controller cabinet and shall be complete with jack-mounting subbase. The unit shall be capable of flashing two non-simultaneous signal circuits at a rate of not less than 50 nor more than 60 flashes per minute per circuit, with approximately 50 percent on and 50 percent off periods.

Each flashing circuit contact shall be rated at 15 amperes, 120 VAC, 60 Hz under continuous make and break duty. The closing and opening of the flashing circuit contacts shall be accomplished in such a manner as to avoid undue pitting and burning. The flasher contacts shall be equipped with adequate integral radio interference filters.

The flasher motor shall be durable and provide a constant flash rate. It shall be designed for synchronous operation on 120 VAC, 60 Hz and shall have lifetime lubrication.

715.42.7.2-Time Clocks: The purpose of this subsection is to describe the 24-hour electric programmable time clocks to be used in pretimed and traffic-actuated signal controllers.

The clock motors shall be designed for synchronous operation on 120 volts, 60 Hz, single phase alternating current. The clocks shall be programmable for circuit on-off operation at 15-minute intervals of the day. In addition, the clocks must be capable of skip-a-day operation. Each clock dial shall provide from one to 48 on-off operations per day minimum in 15-minute settings. Each clock shall be capable of operating in a "power-off" condition for a minimum of ten hours. Drive for the clock when electric power is off shall be provided by a reserve spring which is wound automatically during "power-on" periods. All time clocks must be easily accessible and demountable and fit within the controller cabinet.

715.42.7.3-Offset Interrupter: The purpose of this subsection is to set forth functional specifications and design requirements for a system offset interrupter.

The offset interrupter shall provide system offset interruption in the range of at least 0 to 40 seconds in one-second increments. No tools or additional timing gears shall be required to change the interruption interval. The interval shall be set by use of a calibrated dial on the front of the unit. The interruption period shall be of sufficient duration to release all dial or coordination units in the system, or both.

A switch shall be provided to eliminate the function of the offset interruption.

715.42.7.4-Preemption: Preemption equipment shall be constructed and wired so as to transfer control of the signals from the controller to the preemption unit when actuated by the method specified and shall provide the color sequence specified. The preemption shall cause a clearance interval to be timed prior to the preemption sequence if actuated during a "green" or "flashing yellow" interval, unless otherwise specified.

Pedestrian WALK-DON'T WALK signals shall be placed on DON'T WALK during the preemption clearance interval and shall be turned off during the preemption sequence, unless otherwise specified.

Installation of the preemption equipment shall not alter the internal wiring of the controller unit normally furnished by the manufacturer.

After release of the preemption, normal controller operation shall be automatically resumed at the beginning of the "green" interval specified on the Plans and on actuated controllers, calls shall be placed on all phase in order for the controller to complete one cycle before resuming normal actuated operation.

Two sets of complete wiring diagrams shall be provided showing the physical layout of all relays and other components of the preemption unit.

715.42.7.4.1-Implementation: When included in the plans, the priority control system shall provide advance signal control per intersection approach. The systems consist of an emitter, detector, confirmation light and a card rack mounted signal interface unit.

Priority control shall be measured as a complete unit in place per intersection or control location. This item shall consist of a complete electrical mechanism and all intrinsic items necessary for controlling preemptive functions at each intersection.

When accepted as complete, the quantities determined and as provided below will be paid for at the contract unit price compensation for furnishing all materials and doing all work prescribed in a workmanlike manner and for furnishing all labor, equipment, tools and incidentals to complete the necessary work per intersection.

The emitter shall be mounted on the priority vehicle and transmit a shaped, optical pattern of infrared light to a detector at the prioritized intersection approach. The interface unit will then input a call to the controller for a pre-programmed preemption routine. The transmit/receive distance for each intersection approach must be user programmable and will be the responsibility of the Division of Highways to determine and set. A means of adjustment for the transmit/receive distance per approach must be provided with the system. See I/S phasing and estimate of quantities.

715.42.7.4.1.1-Optical Emitter: The Optical Emitter (OE) must be a single pulsed infrared light source capable of delivering sufficient optical energy to activate compatible O.C.S. detectors up to 2500 feet. Emissions must be precisely timed pulses of high intensity light. The O.E. must be available in 10HZ and 14HZ (+/- 1 HZ) modules for use as low and high priority vehicles.

The range of activation of preemption at signalized intersections must be a function of the P.C.S. hardware.

715.42.7.4.1.2-Detector: The Detector unit must be responsive to the optical emitter at a distance of up to 2500 feet. The unit must be totally compatible with all features of the emitter and be capable of priority distinction without the addition of special detectors. The Detector shall have a minimum reception angle of 35 degrees.

715.42.7.4.1.3-Card Rack Mounted Interface Unit: Each interface card must provide a two (2) to four (4) channels per card for a total of (8) eight pre-empt outputs for use by the local traffic signal controller.

715.42.7.4.1.4-Control Equipment: Preemption control must be applicable to NEMA TS1 standards.

715.42.7.4.1.5-System Requirements: Preemption control equipment must be compatible and completely interchangeable with existing preemption systems (as it relates to these special revisions and the WVDOT APL). All P.C.S. equipment for this system must be on the WVDOT Approved Products List (APL). Fixed card racks with integral power supplies and capacities to accommodate required P.C.S. features must be in the controller cabinet with priority control.

715.42.7.4.1.6-Warranty: all electronic components except the optical emitter strobe and confirmation light, shall be warranted for a minimum of three (3) years.

715.42.7.4.1.7-Codes and Basis of Payment: When accepted as complete, the quantities determined as provided above will be paid for at the contract unit price bid for the items listed below which the prices and payment shall be full compensation for furnishing all materials and doing all work prescribed in a workmanlike manner and for furnishing all labor, equipment, tools and incidentals necessary to complete the work.

Unit bid prices shall be submitted as indicated on the plans per code unit.

(OE) – OPTICAL EMITTER

(D1) – DETECTOR – one detector per intersection

(D2) – DETECTOR – two detector per intersection

(D3) – DETECTOR – three detector per intersection

(D4) – DETECTOR – four detector per intersection

715.42.7.5-Electronic Time Switch: The purpose of this subsection is to describe the seven-day programmable time switch to be used in pretimed and traffic-actuated signal controllers.

The time switch shall be microprocessor-based and capable of SPDT switching of at least three (3) independent five-amp loads at 120 VAC. The entire unit shall be solid state and capable of at least 15 on or off time sets per day or week. Automatic battery backup providing a minimum of 48 hours of memory protection shall also be provided. The timer shall be entirely self-contained in a unit that can be readily mounted inside a signal controller cabinet.

715.42.7.6-Electronic Time Switch (Type DST): Specification requirements for this time switch are the same as outlined in 715.42.7.5, with the exception that automatic Daylight Savings Time compensation can be programmed into this unit for an indefinite future period.

715.42.8-Cabinets: The following are minimum design requirements for all types of weatherproof traffic control equipment cabinets:

The terminal facilities shall be furnished in either a basemount NEMA type 5 ("P") cabinet or a pole mountable NEMA type 4 ("M") cabinet as called for on plans. The cabinet shall be UL listed and have a UL approval label installed on the inside of the main cabinet door. The cabinet shall also have labeling indicating date of manufacturer, part number, and drawing identification number. Base-mount cabinets shall be supplied with a minimum of four 1.0"

(25 mm) by 2.0" (50 mm) slotted holes for anchor bolt entry on the interior of the cabinet. Anchor bolt centers shall be 40.75" (1035 mm) wide by 18.50"(470 mm) deep. Four anchor bolts shall be supplied with the cabinet. The pole-mounted cabinet shall be mounted with the standard pole mounting brackets as shown on TES Standard Detail Sheets.

The cabinet shall be constructed of 0.125 inch (3 mm) thick 5052-H32 aluminum with the following minimum exterior dimensions: (Unless otherwise shown on the Plans)

	Base Mount	Pole Mount
Height	54 inches (1370 mm)	49 inches (1245 mm)
Width	44 inches (1115 mm)	30 inches (760 mm)
Depth	26 inches (660 mm)	17 inches (30 mm)

No cabinet shall exceed any of these dimensions by a maximum of 2 inches (50 mm).

All exterior seams of the cabinet shall be continuously welded for the entire length of the seam of the interior of the cabinet. Tack welding of seams and sealing with application of silicon or other sealers are not acceptable. Unless otherwise specified, the cabinet interior and exterior shall be furnished as natural (unpainted) aluminum. All surfaces shall be clean and free of oil, weld marks, etc. No holes for mounting rails or other main cabinet interior hardware shall be drilled through the cabinet walls. The conduit entry hole in the cabinet bottom must be field drilled to fit the location and the size of conduit required. The conduit entry hole must be placed as close as possible to the cabinet back wall when drilled.

715.42.8.1-Cabinet Doors: A stainless steel main door handle shall be supplied which is capable of being padlocked in the closed (locked) position. The cabinet handle shall operate a door strike plate assembly via a minimum 0.5" (13 mm) square (or round) solid stainless steel rod. The handle shall be oriented in such a way that it rotates inward when operated to the open position. The main door lock must be a keyed tumbler lock.

The main door shall be secured with a three-point latch assembly. The three-point latch assembly shall consist of a stainless steel strike plate located directly behind the handle in the approximate vertical center of the door that secures the center of the door. The strike plate shall operate two plated steel or stainless steel latch rods. The end of each rod shall be fitted with a minimum 0.75" (19 mm) diameter nylon roller complete with ball bearings to insure a smooth positive seal of the upper and lower main cabinet door. The main cabinet door shall be of essentially the same area as the front of the cabinet, and shall be provided with a #2 tumbler key lock and two keys.

The main door handle and all of its components shall be removable for replacement in the field. No parts shall be welded or permanently attached to the cabinet in any way that would restrict or prohibit replacement in the field with the use of simple tools.

The main door shall have a close cell neoprene gasket installed at its outer edge to form a watertight seal between the cabinet and main door. The gasket shall be a minimum of 1.0" (25 mm) by 0.5" (13 mm) thick and shall be secured between the edge of the door and an "L" shaped bracket welded to the inside of the door. This bracket shall extend virtually the full length of the gasket around the door. The gasket shall mate against the main door opening, which shall be formed as a double flange around the entire doorframe. The flange shall be bent in such a manner as to apply increasing pressure against the gasket as the

main door handle is rotated to the locked position. An automatic doorstop shall be provided on both pole and base mount and shall be located on the bottom of the door.

The main door for base mount shall be attached by four stainless steel butt hinges and for a pole mount using only three stainless steel hinges-all which have minimum 0.25" (6 mm) diameter stainless steel pins. They shall be attached to the body of the cabinet and the door with 1/4-20 stainless steel carriage bolts and stainless steel nylon insert lockouts. The hinges shall be mounted in such a way that the pins are recessed and not removable with the main door closed.

715.42.8.2-Mounting Rails: In a base mounted cabinet, four Unistrut rails shall be installed on each side of the cabinet and two on the back of the cabinet. For pole mounted cabinets, two Unistrut rails shall be installed on each side of the cabinet and two on the back of the cabinet. Each side rail shall extend from within 6" (150 mm) of the top of the cabinet to 6" (150 mm) from the bottom of the cabinet.

715.42.8.3-Shelves: A minimum of two shelves the width of the cabinet with a minimum depth of 10.50" (265 mm) mounted toward the rear of the cabinet shall be supplied with each cabinet. Shelves shall be aluminum and shall have sufficient strength to support the controller unit and accessory equipment. Shelves longer than 36" (915 mm) shall be reinforced with an angle on the underside. Unless otherwise specified, the controller unit and conflict monitor shall be positioned on the top shelf. The shelves shall be attached with spring loaded Unistrut type nuts and stainless steel bolts.

715.42.8.4-Ventilation: A motor-driven fan shall be mounted on a plenum in the top of the cabinet. It shall utilize roller (ball) bearings and be rated at 100 cubic feet per minute (45 liters/sec.). A finger guard shall be provided to cover the fan. The fan shall have an RC-network and V160LA20 MOV in parallel across the AC line to protect the controller unit from electrical noise generated by the fan.

The fan shall be controlled by a variable thermostat located on the plenum in close proximity to the fan. The thermostat shall have a minimum adjustable turn and range of 80 to 130 degrees F (27 to 55 degrees C).

A filtered, weatherproof opening shall be provided on the main door near the bottom, a filter 12"x 16" x 1" (305 mm X 405 mm X 25 mm) shall fit smoothly and conveniently over this opening. The filter shall be the aluminum metal EX clean type and shall be reusable by blowing out dust particles. A positive filter retainer shall be supplied as a part of the main door assembly to firmly hold the filter against the opening. A fine mesh screen shall be provided between the filter and louvered opening to prohibit the entry of small insects. The screen shall be either aluminum or brass and fastened to the door permanently.

The exhaust for the fan shall occur above the main door under the top of the cabinet and shall be located to prevent entry of water into the cabinet. A perforated aluminum panel or screen shall be installed over the exhaust openings to prevent entry of small insects.

715.42.8.5-Police Panel: A second hinged door (police panel), shall be located near the top of the main door for base mounted and near the bottom section of pole mounted cabinets. The police panel box shall be continuously welded to the main door. A gasket

shall be provided on the inside of the police panel door for the full width of the door opening to insure a watertight seal. The police panel door shall be attached with a stainless steel hinge with a stainless steel hinge pin. The hinge shall be attached with tamper proof (one way) stainless steel screws and lockouts.

The police door shall be provided with a conventional police lock and key.

The police panel shall provide access to the following controls:

Manual Control/Auto Switch-Which shall be wired to the police panel terminal, but no switch will be provided unless called for on plans. Manual Control Coiled Cord and Button (only if called for on plans). Signal Auto/Flash Switch-On and Off (Flash transfer shall be accomplished thru de-energization of the flash transfer relays. Upon restoration to Signal Auto position from Flash, a momentary external start pulse shall be generated and applied to the controller unit to initiate the programmed start up sequence. AC power shall not be removed from the controller unit during flashing operation).

715.42.8.6-Technicians Panel: A technician switch panel shall be installed on the back cover of the police panel inside the controller cabinet. The following switches shall be supplied:

Detector Test Switches-Detector test push-button shall be installed in the cabinet so that calls can be placed on each vehicle and pedestrian phase. A push-button switch shall be provided and wired for each vehicle and each pedestrian phase (12 switches). Each switch shall mount in a 0.5" (13 mm) diameter hole and shall have a minimum 0.375" (10 mm) actuator.

Controller Unit Power Switch-A switch shall be installed so that power to the controller unit and conflict monitor timer can be turned off. This switch shall not remove power from the detector rack.

Signals ON-OFF Switch-The signal on-off switch, when in the off position, shall extinguish all signal indications for normal and flashing modes without interrupting the controller unit, conflict monitor and associated equipment power.

Emergency Flash Switch-This switch shall initiate cabinet flash by de-energizing the flash transfer relays. Transfer into out of emergency flash via this switch shall be immediate and shall not restart the controller unit when returned to the normal operating position.

Wiring Diagram Holder-A 9.5" x 12" (240 mm X 25 mm) or larger plastic holder shall be mounted to the inside of the cabinet door for convenient keeping of wiring diagrams, installations layout, and timing records.

715.42.8.7-Technician Accessories: Convenience Outlet -A duplex convenience outlet shall be mounted on the inside right sidewall of the cabinet. The outlet shall be ground fault protected and shall be connected to the load side of the 20 amp circuit breaker that protects only the outlet, lamp, and fan.

Cabinet Light-A minimum 18" (455 mm) 15 watt fluorescent cabinet light shall be mounted on the inside of the cabinet above the door opening. The cabinet light shall have an RC-network and V150LA20 MOV in parallel across the AC line to protect the controller unit from noise. The door shall activate the cabinet light switch when the door is opened.

All hardware utilized in the cabinet assembly shall be aluminum, copper, nylon, brass, nickel plated brass or stainless steel.

715.42.8.8-Terminal Facilities: Various panels shall be installed in the cabinet to mount the necessary terminal facilities required for the controller, coordination, preemption, detectors, and signal circuits required for a full eight phase cabinet and controller unit. **A Fully Wired NEMA "C" Connector Must Be Provided.** All terminal facility panels shall be fabricated from minimum 0.125" (3 mm) thick aluminum. The terminals shall be provided on thermoplastic or Bakelite blocks with stainless steel or nickel-plated brass machine screws. Signal light field terminals shall utilize minimum 10-32 screws, detector terminals shall utilize minimum 8-32 screws except other terminals shall utilize minimum six 6-32 screws except as otherwise noted in this specification. All terminals including terminal stripe, sockets, and other mounting shall be made with stainless steel machine screws and nuts. No "Pop" rivets or other non-removable fasteners shall be permitted. Every terminal shall be silk-screened with a number and, when possible, the terminal function mnemonic. Panels that utilize feed-thru connections shall be silk screened with numbers and function mnemonics on both sides. No rub-on pressure sensitive or adhesive labels shall be permitted in the cabinet assembly. Special name plates, switch or relay identifications or other labels affixed in the cabinet or on the panels shall be made of white over black plastic that is engraved with the appropriate legend. These labels shall be permanently mounted to the cabinet or panel as applicable.

Terminal facilities shall be located on the back and sides of the cabinet and below the shelves wherever possible. All terminal strips and exposed electrical connections shall be no less than 6 inches (150 mm) from the floor of the base mount cabinet and no less than 3 inches (75 mm) for a pole mount cabinet. The lower right cabinet sidewall shall contain the power panel and its related components. The lower left cabinet sidewall shall contain the detector panel with the detector terminals, preemption terminals, system communication terminals and the MS D interface panel.

All wiring within the cabinet shall utilize stranded copper conductors. Conductors shall be properly sized for the operating ampacity. Insulation shall conform to MIL standards for Type BN conductors, clear nylon jacket over color-coded PVC insulation. Where wire size exceeds #18 AWG, Type TFFN or THHN insulation may be substituted for Type BN insulation.

All wiring within the cabinet shall be properly terminated at all points. Harness connections and all other connections made on the back of the backpanel shall be terminated by soldering individual wires directly to the terminal strips. Slip on or fast-on type terminals or insulation displacement methods shall not be utilized on the back of any panel for any purpose. Where terminal screws are provided, a suitable spade type terminal lug shall be attached to the end of the wire. Any crimp connection to terminals shall be made only with a controlled cycle, ratchet type tool approved for use on the specific terminal being installed. In addition, no more than three wires may be connected under any terminal screw. Connections to the field terminal blocks for the conflict monitor conductors shall be made with the use of ring type terminals which require removal of the screw in order to disconnect the terminal. Right terminals shall not be used at any other location in the cabinet. Any stranded wire connection made to a compression type terminal (ground bar, neutral bar, etc.) shall require tinning of the strands with solder before insertion into the compression lug. Connections to circular connectors shall be made by soldering or machine applied crimp connections. Hand applied crimp connectors are not acceptable.

The following color code shall be utilized throughout the cabinet:

120 VAC	Black
120 VAC Neutral	White
Chassis Ground	Green
Logic Ground	Gray
+24 VDC	Red

These colors shall not be utilized for any purpose other than that so specified anywhere in the cabinet.

All harnesses shall be covered with "Expando" sleeving. Nylon cable ties, tape, etc. are unsuitable for use on harnesses.

All inductive loads shall be suppressed with a series R/C network consisting of a 0.1 uf 600 V capacitor and a 100 ohm 1/2 watt resistor connected in parallel with the load. In addition, a V150LA20 MOV shall be connected in parallel with the R/C network. The MOV and the R/C network shall also be provided on the duplex receptacle, fan, and fluorescent lamp. All DC inductive loads shall be suppressed with a reverse biased diode wired in parallel with the inductive load.

715.42.8.9-Power Panel: Each cabinet shall be furnished with a power panel mounted on the lower right cabinet sidewall. This panel shall provide terminals for the incoming 120 VAC power line capable of accepting up to a #2 AWG conductors for line, neutral, and ground. In addition, the power panel shall provide mounting for circuit breakers 1 through 3, the surge arrester, line filter, mercury contactor, neutral bus bar, and ground bus bar. The circuit breakers shall be located on the panel closest to the main door opening. All wiring on the power panel shall be properly sized for its application. Main power wiring between circuit breakers, surge arrester, line filter and mercury contactor shall be a minimum of #8 AWG conductor for line, neutral and ground functions. The power panel shall be furnished with a clear lexan safety cover to prevent accidental contact with the power panel components. The safety cover shall have a cutout area for access to the circuit breakers and shall be secured with thumbscrews for easy removal.

Three circuit breakers shall be provided for the incoming power distribution, Circuit breaker #1 shall be rated 30 amps and shall control the signal bus, detectors and control equipment. Circuit breaker #2 shall be rated 20 amps and shall power only the flasher and any related flash circuits. Circuit breaker #3 shall be rated 20 amps and shall power the fan, fluorescent lamp and duplex receptacle circuits.

A line filter shall be supplied to reduce any outgoing noise into the AC power line, minimum rating of the line filter shall be 60 amps.

A mercury relay-contactor shall be provided for control of power to the loadswitches (signal bus). This mercury shall be of a type specially designed to switch tungsten loads and shall incorporate a sealed type filled with nitrogen to eliminate "wicking" of the mercury to the electrodes under light load conditions. Minimum acceptable rating of the mercury relay for signal bus control shall be 50 amps.

A main power lightning arrester shall be provided in the cabinet. The arrester shall consist of a primary and secondary stage. The primary stage shall be connected in parallel across the incoming AC line, neutral and ground. The line connections shall be made from

the load side of circuit breaker #1. The neutral connection shall be made from the neutral power lug. The ground connection shall be made from the ground lug. Each of these connections shall be short and direct. No other connections shall be made for line, neutral or ground before the lightning arrester (except circuit breaker #1). The second state of the lightning arrester shall be high-speed silicon protector intended to protect the controller unit, detector rack power supply, pedestrian call isolator and emergency vehicle preemption cards. The main power lightning arrester shall be an EDCO Model SHP 300-10. No substitutes shall be allowed without prior acceptance.

715.42.8.10-Backpanel: Each cabinet assembly shall be furnished with a backpanel located on the lower center rear of the cabinet. The backpanel shall mount the loadswitches, flasher, flash transfer relays and controller unit input/output terminals. A base mounted cabinet shall have a 16 position backpanel (capable of terminating 16 loadswitches) and shall be provided. Further, 6 flash transfer relay bases shall be provided with terminals for flash color programming for loadswitches 1 through 12 (vehicle phases 1 through 8 and overlaps 1 through 4). The backpanel shall be mounted in such a way that it shall be possible to lower it for access to tall terminals on the rear with the use of simple hand tools. A pole-mounted cabinet shall have a 12 position backpanel (capable of terminating 12 loadswitches) and shall be provided. Further, 4 flash transfer relay bases shall be provided with terminals for flash color programming. Each backpanel shall be provided complete with all flash transfer relays. Per phase loadswitches shall be furnished as required for each intersection plus two spares.

Wiring on the back of the backpanel and all harnesses shall be color-coded for ease of troubleshooting. In addition, loadswitch input and output groups shall be color-coded orange for red, yellow for yellow and blue for green. Loadswitch outputs shall be wired with #16 AWG conductors. Harnesses shall be #22 AWG 19 strand and color coded* as follows:

MS A Harness	Blue
MS B Harness	Purple
MS C Harness	Pink
CM A Harness	Orange
CM B Harness	Yellow

* If The Color Coding Is Different, It Must Be Shown On The Cabinet Net Wire Diagrams.

715.42.8.11-Detector Panel: Each cabinet shall be furnished with a detector field panel mounted on the lower left cabinet sidewall. This panel shall provide field terminals for the detector loops, pedestrian push-buttons, emergency vehicle preemption detectors, system communication conductors and railroad preemption circuits. The detector panel shall provide the interface between the field conductors, the detector rack, the MS D interface panel and the backpanel. In addition to the field conductors, terminals shall be provided for the 8 vehicle detector inputs, 4 pedestrian detector inputs, 8 logic level phase green outputs, (diode isolated), per channel detector rack outputs, per channel pedestrian isolation outputs and per channel emergency vehicle preemption outputs. This arrangement shall permit full programming of detector and pedestrian call phase

assignments as well as phase green delay inhibit functions without having to provide additional wiring to the backpanel or soldering of additional wires on the detector rack.

715.42.8.12-MS D Interface Panel: A panel shall be provided on the upper left sidewall to provide an interface for MS D harnesses for different brands of NEMA controller units. The panel shall mount a circular plastic connector to provide a universal interface for the MS D functions listed below. All functions from the MS D panel shall be at logic ground levels. Each controller unit furnished shall be supplied with a MS D adapter cable 3 feet (900 mm) in length. This adapter cable shall mate with the circular plastic connector on the MS D interface panel and whatever connectors are provided on the specific controller unit. If a particular model of controller unit provided requires a different logic level, coding of functions, etc., the adapter harness shall be equipped with a logic unit to perform the necessary conversions.

The MS D Interface Panel shall be provided with a 120 VAC relay to provide electrical isolation for a railroad preemption circuit. This relay shall be wired with one side of the coil connected to a continuous, 1 amp fused source of 120 VAC. The other side of the coil shall be connected to a terminal. An adjacent terminal shall be provided with AC Neutral. These terminals shall be the connection point for the railroad circuit. The relay shall be maintained in a normally energized state with no train present. When a train is detected, the railroad circuit shall open and the relay shall de-energize and initiate the preempt sequence. A test switch shall be provided to open the coil circuit of the relay. A red LED shall also be provided next to the test switch to be illuminated whenever the relay is in its de-energized (preempt active) state. A V150LA20 MOV and R/C network shall be installed across the coil of the relay.

The MS D Interface Panel shall be provided with a 120 VAC relay to provide electrical isolation for the flash sensing circuit. This relay shall be connected to the coil of the mercury contactor and shall be energized under normal signal operating conditions. This relay shall de-energize if the cabinet flash transfer relays de-energize or if the signal power is de-energized. The output of this relay shall be connected to the controller unit for reporting of flash conditions to a central monitor. A V150LA20 MOV and R/C network shall be installed across the coil of the relay.

A door switch shall be provided and connected to the MS D Interface Panel to indicate cabinet door open status. This switch shall provide a logic ground input whenever the main cabinet door is open.

The following pin connections shall be utilized for the MS D Interface Panel circular plastic connector. The connector shall be AMP part number 206438-1.

PIN	FUNCTION	PIN	FUNCTION
1	Offset 1 In	30	System Detector 6 In
2	Offset 2 In	31	System Detector 7 In
3	Offset 3 In	32	System Detector 8 In
4	Reserved	33	Preempt 1 Out
5	Reserved	34	Preempt 2 Out
6	Offset 1 Out	35	Preempt 3 Out
7	Offset 2 Out	36	Preempt 4 Out
8	Offset 3 Out	37	Railroad Preempt Out
9	Reserved	38	Cabinet Flash Monitor
10	Reserved	39	Flash Command
11	Transmit (Controller to Master)	40	Flash Out
12	Transmit (Controller to Master)	41	Dial 2 In
13	Receive (Controller to Master)	42	Dial 3 In
14	Receive (Controller to Master)	43	Dial 2 Out
15	Online	44	Dial 3 Out
16	System Enable	45	Split 2 In
17	Free/Coord In	46	Split 3 In
18	Free/Coord Out	47	Split 2 Out
19	Preempt 1 In	48	Out
20	Preempt 2 In	49	Conflict Status
21	Preempt 3 In	50	Local Special Function 1 Out
22	Preempt 4 In	51	Special Function 2 Out
23	Railroad Preempt In	52	Local Special Function 3 Out
24	Enable Dimming	53	+24 VDC
25	System Detector 1 In	54	Logic Ground
26	System Detector 2 In	55	Chassis Ground
27	System Detector 3 In	56	AC Neutral
28	System Detector 4 In	57	120 VAC
29	System Detector 5 In		

715.42.8.13-Detector Racks: A shelf detector rack shall be furnished fully wired to the detector panel. The detector rack shall be fully wired for all functions even though some functions may not be used at the present time. This includes a call output for each vehicle, pedestrian, a delay inhibit input for each vehicle channel, a common reset input for all vehicle channels and all necessary power conductors. The detector rack shall be a sturdy aluminum frame designed to mount card guides and edge connectors for all of the cards contained in the rack. All racks must be configured as shown on the following special sheet labeled Dual Ring/Card Rack Mounted Detectors.

All card edge connectors shall utilize gold plated mating surfaces and shall be of the solder type. No crisp connections of any type will be allowed for attachment of loop lead-in conductors.

All loop lead-in wiring from the detector panel to the detector rack shall utilize tightly twisted conductors to eliminate coupling. Tightly twisted means a minimum of thirty-six

twists per foot. Loop lead-in twisted pairs shall utilize a white/black stripe conductor for color-coding.

All cabinets must be provided with a minimum of eight (8) position NEMA racks, fully wired. Each position must be wired for two (2) channel detectors or P.C.S. as indicated. Rack Position assignments are as follows:

POSITIONS

	1	2	3	4	5	6	7	8
Channel 1	PH1	PH2	PH2	PH3	PH4	PCS	PCS	PCS
Channel 2	PH6	PH5	PH6	PH8	PH7	PH8	PCS	PCS

PH# = Phase Number

PCS = Priority Control System

NOTE: System detectors when required are to be clearly marked and placed in unused position slots. In no case should system detectors (sampling stations) be assigned to a channel with a phase detector in the same position.

715.42.8.14-Documentation: Each cabinet assembly shall be provided with four complete and accurate wiring diagrams. The wiring diagrams shall contain an identification number which is also attached to the cabinet on an engraved nameplate. This number shall identify the prints for specific cabinet assembly. In addition to the wiring diagrams, a 3.5" disk shall be supplied with the cabinet containing the cabinet wiring diagrams in a ".DWG" format suitable for use with Autocad Version 12 (Windows version). The cabinet assembly will not be considered complete without the required documentation.

715.42.8.15-Cabinet Submittal for Approval: One of each type of cabinet to be furnished for this project must be shipped for approval the Signal And Lighting Maintenance Shop in Charleston, West Virginia. These must be approved prior to shipping any cabinets to the project site for installation. All items covered in this subsection must be included with the representative cabinets.

715.42.9-Signal Supports: Signal supports shall be certified to be equal or exceed the requirements of "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals", including revisions, of the American Association of State Highway and Transportation Officials (AASHTO).

715.42.9.1-Mast Arm Signal Supports (Type A1, A1L, A2, A2L, B1 and B1L):

715.42.9.1.1-General Description: Mast arm supports Types A1, A2 and B1 shall consist of one two traffic signal mast arms (as designated on the Plans), an upright pole with anchor base and any other accessories or hardware as required to make a complete installation. They shall be designed to suspend traffic signals from a structural assembly similar in appearance and construction to that shown on the standard drawing which is part of the contract.

Mast arm supports Types A1L, A2L and B1L shall be identical to Types A1, A2 and B1 described above, except for the upright pole which shall be lengthened and provided with one or more street lighting luminaire arms as called for on the Plans. The upright pole

length shall be governed by the mounting height specified for the luminaire and the rise provided in the luminaire arm. The luminaire arm, unless otherwise noted, shall be as similar as possible in style to that shown on the standard drawing and shall have the spread noted on the Plans.

All upright poles and all mast arms shall be made of one continuous piece, cylindrical in cross section, and they shall be uniformly tapered from butt to tip approximately 1 in. in diameter for each seven linear feet in length (0.14 in. per foot)(11.7 mm in diameter for each meter in length).

The shaft length and diameter of the upright pole and mast arm shall be as described on the Plans.

715.42.9.1.2-Mast Arm: All mast arms shall include a removable end cap, grommets wire outlets, signal hanger assemblies of the type and quantity shown on the Plans, and a flange plate welded to the butt end to provide a rigid connection to the upright pole. The rigid connection to the upright pole shall be constructed so that it develops and transfers the full strength of the mast arm to the upright pole. The flange plate shall have four holes for the flange bolts which shall match the four tapped holes in the mounting plate on the upright pole. The entire assembly shall be constructed so that all wiring can be concealed internally. It shall be as similar, as possible in appearance and construction detail to that shown on the standard drawing. The use of guy rods of any type, or trussed-type arms, will not be permitted (except when noted for luminaire arms on the Plans).

Mast arms shall be connected to the upright pole at a height necessary to provide 17 ft-0 in. (5.2 m) clearance under the signals. The mast arm and upright pole shall be constructed so that the mast arm at any point along its length (measured from the flange plate connection), will fall within a tolerance of 0 to 5 percent of that length, above the true horizontal position, after loading as called for on the Plans. The fabricator must certify to the above and maintain results of computations or tests to document the certification for each type of mast-arm pole supplied. On Types B1 and B1L this requirement will only apply to the outboard end of the mast arm. Any deviations from this requirement due to sizes or loads listed on the Plans shall be brought to the Division's attention for appropriate corrective action prior to fabrication.

715.42.9.1.3-Upright Pole: Each pole shall consist of an upright shaft with a steel anchor base, a removable pole top, a J-hook wire support welded inside near the top, a handhole with reinforced frame and cover, anchor bolts and nuts, one flange plate assembly to match that welded to the butt end of each mast arm, and any other accessories or hardware as required to make a complete installation. Flange plates shall have a deburred wiring hole and four tapped holes for flange bolts. The handhole assembly shall be welded into the shaft near the base. The handhole reinforcing frame shall have a tapped hole to accommodate a grounding lug and contain a keeper chain. The keeper chain shall be secured by pop rivets or stainless steel screws. The cover shall be secured to the frame by at least two stainless steel screws. Each pole shall have a one-piece anchor base welded to the butt end. This base shall be designed to secure the pole assembly to a concrete foundation by means of four standard anchor bolts, each fitted with removable anchor bolt covers.

All construction details shall be as similar as possible to that shown on the standard drawing.

715.42.9.1.4-Materials Incorporated into the Support: The structures described above shall be fabricated from steel. The only exceptions permitted will be where the Contractor may prefer to use a cast aluminum pole top or aluminum anchor bolt covers, or both, on a galvanized steel pole.

All steel tubes for arms and poles shall be fabricated from ASTM A595, Grade A or A1011, Grade 55, Class 2 or A572, Grade 55.

Miscellaneous steel materials required for fabrication of other structural components shall be of a weldable quality and shall be covered physically and chemically by an applicable ASTM Specification. This includes welding rod, plate and bar stock (for flanges, signal hangers, etc.) and casting for anchor bases.

Anchor bolts shall be fabricated from steel meeting the requirements of ASTM F 1554, Grade 55. Each bolt shall be provided with two regular nuts or heavy hex nuts that shall be hot dipped galvanized. Hex nuts shall be regular hex meeting ASTM A-563 Grade A for ¼" to 1½" (6.35 to 38.1 mm) sizes and shall be heavy hex for sizes 1½" to 4" (38.1 to 101.6 mm).

All mast-arm signal supports shall be provided with a one-piece, anchor-type base. The base shall be fabricated from material meeting ASTM A 27, Grade 65-35, or ASTM A 36 of sufficient cross section to fully develop the ultimate strength of the pole. The base shall be fastened to the pole by means of a welded connection and shall develop the full strength of the pole. The base shall be provided with four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting at yield strength stress, the bending moment of the shaft at its yield strength stress. Four removable anchor bolt covers shall be provided.

All steel components shall be galvanized after fabrication in accordance with ASTM A 123 or A 153. Galvanized coatings damaged for any reason shall be repaired by the application of a zinc-rich paint, conforming with 711.21 of the Standard Specifications. The places to be painted shall be thoroughly cleaned before the paint is applied.

All nuts, bolts or screws used to connect any aluminum components shall be passivated stainless steel meeting the requirements of AISI 300 series, commercial grade.

All nuts, bolts (except anchor bolts), or screws used to connect steel components shall meet the following requirements:

- i. Less than 5/8 in. (16 mm) diameter shall be ASTM A 307 and plated in accordance with ASTM B 633, or stainless steel. An exception to this will be the two screws fastening the handhole cover, which shall be stainless steel in accordance with the description above.
- ii. For 5/8 in. (16 mm) diameter and over, any ASTM physical and chemical qualification that is acceptable to the Division on the basis of structural design requirements and hot-dipped galvanized in accordance with ASTM A 153.

715.42.9.1.5-Drawings for Approval Purposes: Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of the Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for

Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.1.6-Mill Test Reports and Certification: Mill test reports or certifications of conformance to specifications for materials and design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

715.42.9.1.6.1: Mill test reports (MTR) for major structural items only, as noted in the following chart, shall include both physical and chemical descriptions of the materials as supplied to the fabricator. When physical properties are altered during fabrication, the MTR covering chemical composition shall be supplemented by certified test reports indicating the physical properties of this material after fabrication.

715.42.9.1.6.2: Certification of conformance to the specifications for all remaining material not covered by MTR as noted in the following chart.

See 715.42.9.1.6.1		See 715.42.9.1.6.2	
Component Materials		MTR	CERTIFICATIONS
Tubes for arms and poles		X	
Base castings		X	
Anchor bolts		X	
Pole tops, misc. fittings and hardware			X
Fabricated or cast-type arm connections		X	
Galvanizing Welding rod			X

715.42.9.1.6.3: Certification of conformance to the specifications for the design of all components not completely dimensioned and detailed on the standard drawings.

715.42.9.1.6.4: Certification that all welding was performed by operators qualified as follows: steel welders to AWS and aluminum welders to ASME.

715.42.9.2-Strain Pole Signal Supports (Types C1, C1L, C2 and C2L):

715.42.9.2.1-General Description: Each strain pole support Type C1 and C2 shall consist of an upright shaft with steel anchor base, a removable pole top, a J-hook wire support welded inside near the top, a 45 degree wire inlet near the top, a handhole with reinforced frame and cover, anchor bolts and nuts and any other accessories or hardware as required to make a complete installation. The pole and all its component parts shall be designed to support free-swinging traffic signals suspended from a span wire assembly. It shall be as similar as possible in appearance and construction detail to that shown on the standard drawing which is part of the contract.

Each strain pole support Type C1L and C2L shall be identical to the type C1 and C2 described above, except that the upright pole shall be lengthened and provided with one or more street lighting luminaire arms as called for on the Plans. The shaft length of the Type C1L and C2L pole shall be governed by the mounting height specified for the luminaire and the rise provided in the luminaire arm. The luminaire arm, unless otherwise noted, shall be as similar as possible in style to that shown on the standard drawing and shall have the spread noted on the Plans.

The upright shaft shall be made in one continuous piece, cylindrical in cross section and shall be uniformly tapered from butt to tip approximately 1 in. in diameter for each seven linear feet in length (0.14 in. per ft) (11.7 mm per m). The diameter shall be measured outside to outside of the cylinder. No horizontal joints of any type will be permitted.

The shaft length and diameter of the Type C1, C1L, C2 and C2L poles shall be as described on the Plans. The signal clearance will be set for a minimum of 17 ft. in. (5.2 m) The span wire will be fastened from 12 in. (305 mm) to 18 in. (455 mm) from the top of the pole, except for the Type C1L and C2L poles, where the span wire height shall be as specified on the Plans.

715.42.9.2.2-Materials Incorporated into the Support: The entire strain pole assembly shall be made from steel. The only exceptions permitted will be where the Contractor may prefer to use a cast aluminum pole cover or aluminum anchor bolt covers, or both, on a galvanized steel pole.

The upright shaft shall be fabricated from ASTM A595, Grade A or A1011, Grade 55, Class 2 or A572, Grade 55. The minimum wall thickness shall be 0.1793 in. (7 gage) (4.55 mm).

Miscellaneous steel material required for fabrication of other structural components shall be of a weldable quality and shall be covered physically and chemically by an applicable ASTM Specification. This includes welding rod, plate or bar stock (for span wire clamps, etc.) and castings for anchor bases.

Anchor bolts shall be fabricated from steel meeting the requirement of ASTM F 1554, Grade 55. Each bolt shall have the threaded end galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Each bolt shall be provided for two regular nuts or heavy hex nuts that shall be hot dipped galvanized. Hex nuts shall be regular hex meeting ASTM A-563 Grade A for ¼" to 1½" (6.35 to 38.1 mm) sizes and shall be heavy hex for sizes over 1½" to 4" (38.1 to 101.6 mm).

All strain pole signal supports shall be provided with a one-piece anchor type base. The base shall be fabricated from material meeting ASTM A 27, Grade 65-35 or ASTM A 36 of sufficient cross section to fully develop the ultimate strength of the pole. The base shall be fastened to the pole by means of a welded connection and shall develop the full strength of the pole. The base shall be provided with four holes of sufficient size to accommodate the proper size anchor bolts that are capable of resisting at yield strength stress, the bending movement of the shaft at its yield strength stress. Four removable anchor bolt covers shall be provided.

All steel components shall be galvanized after fabrication in accordance with ASTM A 123 or A 153. Galvanized coatings damaged for any reason shall be repaired by the

application of a zinc-rich paint conforming with 711.21 of the Standard Specifications. The places to be painted shall be thoroughly cleaned before the paint is applied.

All nuts, bolts (except anchor bolts), or screws used to connect steel components shall meet the following requirements:

- i. Less than $\frac{5}{8}$ in. (16 mm) diameter shall be ASTM A 307 and plated in accordance with ASTM B 633, or stainless steel. An exception to this will be the two screws fastening the handhold cover which shall be stainless steel.
- ii. For $\frac{5}{8}$ in. (16 mm) diameter and over, any ASTM physical and chemical qualification that is acceptable to the Division on the basis of structural design requirements and hot-dipped galvanized in accordance with ASTM A 153.

715.42.9.2.3-Drawings for Approval Purposes: Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.2.4-Mill Test Reports and Certification: Mill test reports or certifications of conformance to specifications for materials and design will be required for all materials incorporated into the work. The following shall be supplied by the Contractor prior to acceptance of the structures:

715.42.9.2.4.1: Mill test reports (MTR) for major structural items only, as noted in the following chart, shall include both physical and chemical descriptions of the materials supplied to the fabricator. When physical properties are altered during fabrication, the MTR covering chemical composition shall be supplemented by certified test reports indicating the physical properties of this material after fabrication.

715.42.9.2.4.2: Certification of conformance to the specifications for all remaining material not covered by MTR as noted in the following chart.

See 715.42.9.2.4.1	See 715.42.9.2.4.2
COMPONENT MATERIALS	MTR CERTIFICATIONS
Tubes for upright shafts	X
Base castings	X
Anchor bolts	X
Pole tops, misc. fittings and hardware	X
Fabricated or cast-type arm connections	X
Galvanizing Welding rod	X

715.42.9.2.4.3: Certification of conformance to the specifications for the design of all components not completely dimensioned and detailed on the standard drawings.

715.42.9.2.4.4: Certification that all welding was performed by operators qualified as follows: steel welders to AWS and aluminum welders to ASME.

715.42.9.3-Wood Pole Signal Supports (Type D):

715.42.9.3.1-General Description: Each Type D wood pole shall consist of an upright shaft fitted with necessary hardware to make the installation complete.

The shaft length and diameter of the poles shall be as described on the Plans. The signal clearance will be set for minimum of 17 ft-0 in. (5.2 meters). The poles shall be of sufficient length to provide the luminaire mounting height when described on the Plans.

Maximum allowable span wire sag between supports is 5 percent of the pole to pole span. Maximum sag is measured at the point of the greatest offset of the span wire from a line in the plane of the support poles drawn through the span wire suspension points.

Spans supporting two signal heads or less shall not require tubular piping between the span wire mounting devices and the signal heads.

715.42.9.3.2-Material: Poles shall not have more than 180 degree twist in grain over the full length and the sweep shall be no more than 4 inches (100 mm).

715.42.9.3.3-Treatments: Poles shall be pressure treated in accordance with Section 710 of the Specifications.

715.42.9.4-Pedestal Pole Signal Supports (Types E1, E2, and E3):

715.42.9.4.1-Type E1: The pole shall consist of a cast aluminum base and tapered shaft. The shaft shall be spun from one piece of seamless tubing. Aluminum Association Alloy 6063 (ASTM B 221), having a nominal 0.125 in. (3.18 mm) wall thickness and 6 in. (152 mm) diameter at the base tapering to 42 in. (114 mm) diameter at the top which, after fabrication, shall have a mechanical strength of not less than T6 temper. The shaft shall have no longitudinal welds and no circumferential welds, except those joining the shaft to the base. A handhole shall be provided near the base.

The base shall be one-piece aluminum casting, Aluminum Association T-6 Temper (ASTM B 26). The base of adequate strength, shape, size and having a scalloped top flange, shall be secured to the lower end of the shaft by two continuous welds made by the metallic-arc-consumable-electrode-inert-gas-shielded process. The base shall telescope the shaft and one weld shall be on the inside of the base at the end of the shaft, while the other weld shall be on the outside at the top of the base. The two welds shall be not less than 2 inches (50 mm) apart and the welded connection shall develop the design strength of the pole assembly. The base shall be provided with four holes to receive the anchor bolts and eight tapped holes for attaching the ornamental covers. Four removable bolt covers shall be provided with each base and each cover shall attach to the upright portion of the body of the base by means of two hex-head cap screws.

Anchor bolts shall be fabricated from steel meeting the requirement of ASTM F 1554, Grade 55. The threaded end of each anchor bolt shall be galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Four galvanized nuts

and washers or clips as required shall be furnished with each pole. The anchor bolts shall be capable of resisting, at yield strength stress, the bending moment of the shaft at its yield strength stress. Bolts, nuts and washers or clips shall be galvanized to meet ASTM A 153.

The shaft shall have a uniform polished finish. Each shaft shall be tire-wrapped with a heavy water-resistant paper for protection during shipment and installation.

Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.4.2-Type E2: The pole shall consist of a base with anchor bolts and nuts and pipe shaft. The shaft shall be standard 4 in. Schedule 40 (DN100) pipe conforming to the requirements of ASTM A 501 and shall be welded to the steel base. A handhole shall be provided near the base.

The base shall be a one-piece cast steel anchor base, ASTM A 27, Grade 65-35, of adequate strength, shape and size secured to the lower end of the pipe shaft by two continuous electric arc welds. The base shall telescope the shaft and the one weld shall be on the inside of the base at the end of the shaft, while the other weld shall be on the outside at the top of the base. The design shall be such that the welded connection and base shall develop the calculated yield strength of the adjacent shaft section to resist bending action.

Anchor bolts shall be fabricated from steel meeting the requirements of ASTM F 1554, Grade 55. The threaded end of each anchor bolt shall be galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Four galvanized nuts and washers or clips, as required, shall be furnished with each pole. The anchor bolts shall be capable of resisting, at yield strength stress, the bending moment of the shaft at its yield strength stress. Bolts, nuts and washers or clips shall be galvanized to meet ASTM A 153. Each anchor bolt shall be furnished with one cap nut (acorn).

Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes with three weeks after the award of contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.4.3-Type E3: The pole shall consist of a base with anchor bolts and nuts and a tubing shaft. The shaft shall be fabricated from United States Standard 13 Ga. (0.095 in.) (2.41 mm) weldable grade commercial quality carbon steel meeting ASTM A 607 Gr. 45 after fabrication. A handhole shall be provided near the base.

The base shall be fabricated from structural quality hot-rolled carbon steel plate with a guaranteed minimum yield strength of 36,000 psi. (248 MPa) The base plate shall telescope the shaft and be circumferentially welded top and bottom. The design shall be such that the welded connection and base shall develop the calculated yield strength of the adjacent shaft section to resist bending action.

Anchor bolts shall be fabricated from steel meeting the requirements of ASTM F 1554, Grade 55. The threaded end of each anchor bolt shall be galvanized for a length sufficient to extend down through the grout and into the concrete foundation. Four galvanized nuts and washers or clips as required shall be furnished with each pole. The anchor bolts shall be capable of resisting, at yield strength stress, the bending moment of the shaft at its yield strength stress. Bolts, nuts and washers or clips shall be galvanized to meet ASTM A 153. Each anchor bolt shall be furnished with one cap nut (acorn).

The finish for all exposed parts shall be hot-dipped galvanizing in accordance with ASTM A 123.

Two prints of shop drawings indicating the proposed dimensions and material specifications for each of the components involved shall be submitted by the Contractor for approval purposes within three weeks after the award of the Contract. These drawings will be reviewed by the Division at the earliest possible date and one print will be returned marked "Approved," or "Returned for Revisions as Noted." Eight sets of drawings shall then be submitted for final approval. Appropriate action shall be taken by the Contractor after final approval to insure that the earliest possible erection of these items can be achieved. Resubmission of drawings to obtain final approval by the Division will not be considered as being just cause for delay in the completion of any contract.

715.42.9.4.4-Mill Test Reports and Certification: Mill test reports or certifications of conformance to Specifications for materials and design shall be supplied for pedestal pole signal supports (Types E1, E2 and E3) as required in 715.42.9.1.6.

715.42.10-Electrical Conduit: Following are minimum design requirements for underground conduit housing signal control cable and other electrical wiring.

Unless otherwise specified on the Plans, all conduit shall be 2 inches (50 mm) in diameter. The Plans will call for type of conduit to be used.

Approximate lengths of conduit are shown on the Plans. It is the responsibility of the Contractor to determine exact lengths of conduit runs in the field.

715.42.10.1-Type R (Rigid Steel Conduit): The steel conduit shall conform to American Standard Specification for rigid steel conduit, zinc-coated ASA C80-1 and current amendments.

Each length of conduit shall be furnished with one coupling.

Running threads shall not be used on conduit for connection and coupling.

All cut ends of conduit shall be reamed to remove rough edges.

Bends of rigid conduit shall be so made that the conduit will not be injured and the internal diameter of the conduit will not be effectively reduced.

715.42.10.2-Type F-(Flexible, Liquid-tight Conduit): Conduit shall be approved by Underwriters Laboratories.

Conduit shall have galvanized steel core over which is extruded a polyvinyl chloride cover.

Standard liquid-tight connectors shall be used for conduit connection.

Conduit shall protect electrical conductors from moisture, oil, grease, dirt, chemicals, corrosives, fumes, abrasion, etc.

715.42.10.3-Type P (Polyvinyl Chloride Conduit): Type P (Polyvinyl Chloride Conduit) shall be made of polyvinyl chloride plastic using polyvinyl chloride fillers where fillers are used. The conduit shall meet all requirements of EPC-40-PVC as contained in NEMA Standards Publication TC2, shall be Underwriters' Laboratories approved, and shall be suitable for direct burial.

715.42.11-Junction Boxes: Following are minimum design requirements for junction boxes for signal cable and other electrical wiring. The type will be noted on the Plans.

Junction boxes as shown on the Plans shall be installed where indicated. The Contractor may, with the approval of the Engineer and at their own expense, install additional junction boxes to facilitate the work of installing conduit and pulling signal control cable.

715.42.11.1-Type L- (Light Duty): The box shall meet the requirements of Standard Drawing TES-50.

715.42.11.2-Type H-(Heavy Duty): The junction box shall consist of a concrete box with a cast iron frame and either a cast iron or ductile iron cover. The box shall meet the requirements of Standard Drawing TES-50 for the 10" x 10" (255 mm x 255 mm) size or TEL-43 for the 18" x 18" (460 mm x 460 mm) size.

The walls and floor of the concrete box shall be either precast or cast in place.

If cast in place in a paved area, the interior shall be formed and the exterior wall and floor may be poured directly against a smooth, well-trimmed hole in the pavement and ground.

If cast in place in other than a paved area, the interior and top 3 inches (75 mm) of the exterior shall be formed to provide the size and shape shown on the standard drawing.

The Type H (10x10) (255 x 255 mm) junction box cover and frame shall have a minimum weight of 90 pounds (40 kg). Type H (10x10) (255 x 255 mm) cover frame shall be cast integral with the concrete box.

715.42.11.3-Type M (Magnetic Probe Box): The box shall have a minimum inside dimension of 4 in. by 4 in. by 4 in (100 x 100 x 100 mm).

The junction box and lid shall be of copper-free aluminum meeting Federal Specifications W-C-583b.

The cover shall be attached to the box by monel or stainless steel screws. The cover shall also contain a neoprene gasket of sufficient size to make it watertight.

The wall thickness on the boxes shall not be less than 1/4 in. (6.35 mm).

The lid shall have a checkered non-slip surface.

715.42.11.4-Types A, B, and C: Junction boxes Types A, B, and C shall meet the dimensions and requirements as shown on the Plans. Type A and B boxes shall be

fabricated from steel conforming to ASTM A 36 with galvanizing in accordance with ASTM A 123. Wall thickness shall be 3 in. (6.35 mm) for Types A and B and not less than 14 gauge for Type C.

715.42.12-Messenger Cable: The messenger cable shall be of the diameter specified on the signalization plan and shall be fabricated on seven steel wires, double galvanized and twisted into a single concentric strand to conform to the following:

Diameter Inches (mm)	Size Of Wire (No.)	Tensile Strength Pounds (kg)
½ (12.7)	8	12,100 (5490)
7/16 (11.1)	9.5	9,350 (4240)
3/8 (9.5)	11	6,950 (3150)
5/16 (7.9)	12	5,350 (2425)
¼ (6.4)	14	3,150 (1430)
3/16 (4.7)	16	1,900 (860)

The Contractor shall, when requested by the Division, furnish in suitable form a certified report of the cable to show compliance with this Specification.

715.42.13-Conductors: All conductors used for traffic signal control and external circuitry shall be solid or stranded copper wire as required, unless otherwise specified. Wire sizes shall be based on American Wire Gage (AWG). The copper wire shall conform to the requirements of ASTM B 3 and B 8, latest revision. IMSA specification numbers refer to the International Municipal Signal Associations, Inc., latest revisions on wire and cable specifications.

All single conductors shall have clear, distinctive and permanent markings on the outer surfaces throughout the entire length, showing the manufacturer's name or trademark, insulation type-letter designation, conductor size and voltage rating.

Conductors for traffic signal and supplemental flasher installations shall be rated for 600-volt operation. The insulation shall be a minimum TW Grade or as specified.

All conductors subject to flexing, such as opening and closing of the cabinet doors or on removal of equipment from the cabinet, shall be stranded. Conductors No. 14 AWG through No. 10 AWG, inclusive, shall be 19-strand and conductors No. 16 AWG shall be 26-strand.

Conductors in traffic actuated controller cabinets between the power service terminals and the "AC+" terminals on the external signal load switching devices shall have an ampacity of 20 amperes at 160° F (71° C). This ampacity shall include all switching devices and connections to switching devices in this circuit as well as signal light neutrals and interference suppressors.

Conductors in pre-timed controller cabinets between the power service terminals and the controller bus to the signal light circuits shall have an ampacity of 20 amperes at 160° F (71° C). This ampacity shall include all switching devices and connections to switching devices in this circuit as well as signal light neutrals and interference suppressors.

All other conductors in the signal light circuits (both traffic actuated and pre-timed system) shall be No. 14 AWG solid conductor cable meeting IMSA Specification No. 19-1 or 20-1.

Five-conductor signal light cable shall be used as a minimum per signal conductor run (see 660.16).

Power service conductors to the breakers (fuse) in all controller cabinets shall be No. 8 AWG service wire.

Conductors between the power service terminals, the "AC+" on all flasher units and the duplex receptacle shall have ampacity of 20 amperes at 160° F (71° C). This ampacity shall include all switching devices and connections to switching devices in this circuit as well as signal light neutrals and interference suppressors.

Conductors for traffic loops shall be continuous No. 14 THWN stranded wire to the detector terminals or the feeder cable junction box or conduit.

Detector feeder cable from the loop wire terminals to the detector terminals shall be two-conductor cable, No. 14 AWG-THW, meeting IMSA Specification 19-2, 20-2 or 50-2. The two conductor pair for each feeder shall be twisted together with approximately two turns per foot (6.5 turns per meter).

All other multi-conductor detector wiring, unless otherwise specified, shall be No. 14 AWG cable meeting IMSA Specifications No. 19-1 or 20-1. Single conductor detector wiring shall be No. 14 AWG-THWN stranded, unless otherwise specified.

Interconnect cable shall be No. 14 AWG cable meeting IMSA Specification No. 19-1 or 20-1.

All conductors used in the signal controller cabinets shall be No. 22 AWG, or larger. Conductors smaller than No. 14 AWG shall conform to Military Specification: MIL-W-16878D, Type B, Vinyl-Nylon Jacket, 600-volt, 105° C. Conductors No. 14 AWG and larger shall be as specified.

715.42.14-Supplemental Flashing Beacons and Mountings:

715.42.14.1-Flashing Signal Heads: The signal head shall provide an indication in one direction only and shall be adjustable through 360 degrees about a vertical axis.

Housing:

Each head shall be constructed primarily of aluminum and aluminum castings and stainless steel, shall meet all requirements in 715.42.14.1 and shall accept lenses and lamps as described in the paragraph on Optical Unit.

The signal head housing shall be one piece, corrosion-resistant aluminum alloy die casting complete with integrally cast top, bottom, and sides. All cast metal parts shall have a tensile strength of not less than 17,000 psi. (117 MPa) All parts shall be clean, smooth and free from flaws, cracks, blowholes and other imperfections.

The die cast aluminum housing, door and cast visor of the signal heads shall comply with the following specifications or latest revision thereof: Die Castings SC-84A, SC-84B, SG-100A, SG-100B, S-12A or S-12B of ASTM B 85.

When required by the Engineer, the successful bidder shall furnish satisfactory evidence that the materials comply with the foregoing requirements.

The top and bottom of the signal housing shall have round openings to accommodate standard 1½ in waterproof pipe brackets or trunnions. The portion of the housing adjacent to the bracket shall be properly reinforced so as to have sufficient strength to resist shock, vibration and impact damage.

Each signal head shall have lugs for the mounting of at least one six-position, twelve-terminal barrier type terminal block.

Each signal head shall have lugs or pads such that backplates may be mounted without drilling or tapping the head housing.

The housing door shall be a one-piece square casting having two hinge locations on the left side and at least one latch location on the right side. The hinges shall have stainless steel pins at least 3/16 inch (5 mm) in diameter. The latch shall consist of (1) a latch jaw on the door and a stainless steel latch screw, wing nut and washer securely affixed to the housing or (2) a captive wing nut, washer and screw assembly on the door and a captive nut in the housing. It shall be possible to open and remove the door without the use of any tools.

The door shall have a gasketed opening that shall provide a visible lens diameter of 7-3/4 in. to 8 in. (197 to 203 mm) for a nominal 8 in. (203 mm) lens. All lenses shall be as described in Optical Unit. The door shall have four equally spaced visor attachment points around the lens opening.

The section and door shall be one-piece, corrosion-resistant aluminum alloy die castings. Visors and reflections shall be made from sheet aluminum or die castings.

Sheet aluminum parts shall be manufactured from corrosion-resistant aluminum sheet having a tensile strength of at least 20,000 psi (138 MPa) except that reflectors shall be manufactured from the aluminum alloy suggested by the manufacturer.

All hinge pins and latch parts shall be Type 304, stainless steel.

Miscellaneous parts and hardware shall be made of non-corrosive materials.

All parts shall have sufficient strength to show minimal damage under severe loading conditions.

Visors shall be at least 7 inches (178 mm) long and shall be described as standard (cut-away), tunnel, or full circle. Heads shall be supplied with standard visors unless otherwise noted on the plans or unless prior permission from the Division has been received.

Visors shall be designed with a downward tilt between 32 and 5 degrees to eliminate the return of outside rays entering the unit from above the horizontal (known as sun phantom). Visors shall be not less than 0.05 in. (1.3 mm) thick.

All mounting brackets, trunnions, and suspensions shall be finished with yellow enamel. The door and the outside of the visor shall also be finished with yellow enamel. The inside of the visor shall be finished with flat black enamel. All enamel shall be best quality, over baked meeting Federal Specifications TT-E489.

Optical Unit:

The optical unit shall consist of the lamp, lampholder, reflector, lens gasket and lens, shall be so designed that all light emitted by the unit passes through the lens and so that any possibility of false indications is eliminated.

The lampholder shall be of heat resisting material designed to properly position a medium screw base traffic signal lamp, with means to accommodate a lamp having light center 2-7/16 in. (60 mm) in length for the 60-watt series. The lampholder shall be provided with a lamp grip to prevent the lamp from working loose due to vibration. Provision shall be made on either the lampholder or the reflector holder to permit rotation of the lamp so that lead-in wires are up, and the lamp shall be retained securely in that position, but no change in position of the socket with respect to the optical center of the

reflector shall occur. The metal portion of the lampholder shall be compatible with brass or copper.

Each lampholder shall be provided with two code No. 18 or larger lead wires, Type TEW, 600-watt, AWM fixture wire with 2/64 in. (0.8 mm), 105° C rating thermoplastic insulation, securely fastened to the socket, and with sufficient length to reach the terminal block with the holder door fully open. The thermoplastic insulation shall at minus 30° F (-34° C) be capable of being bent six times around a 1 in. (25 mm) mandrel without damage to its insulating properties at rated voltage.

Reflectors shall be specular aluminum in accordance with the latest ITE specifications and shall be mounted in a reflector holder. The reflector holder shall provide a rigid reflector mounting to assure proper alignment between the lens and the reflector with the door closed. The reflector shall have a lampholder opening in the back. The reflector shall have a hood or flange on the outer edge to stiffen the reflector and insure its dimensional stability.

The reflecting surface shall be totally free from flaws, scratches, defacements and mechanical distortion. Reflectors shall be spun or drawn from aluminum not less than 0.025 in. (0.64 mm) thick.

The lens gasket shall be a slotted circular neoprene gasket specifically designed to exclude moisture, dust and road film. The optical unit shall be sealed to exclude moisture and dust. This may be accomplished in one of two ways:

- i. If the open door contains the complete optical unit, the reflector/lampholder interfaces shall be equipped with specially designed neoprene seals to completely seal the optical unit. The section must not accumulate water.
- ii. If the reflector and lampholder remain in the section when the door is opened, the entire section shall be made watertight and dusttight by a weatherproof neoprene gasket contained in a gasket groove in the door. The gasket shall seal against a raised bead in the section to provide the proper seal.

The lighted signal shall appear to be illuminated over the entire visible lens surface without shadows when viewed from any angle up to 50 degrees each side of the optical axis horizontally and up to 45 degrees below the optical axis vertically.

The required appearance, light distribution and candlepower intensity from the complete assembled section shall meet the latest revision of the specifications of the Institute of Traffic Engineers, "A Standard for Adjustable Face Vehicle Traffic Control Signal Heads".

Trunnions, Brackets and Suspensions:

All trunnions, brackets and suspensions used for assembling and mounting vehicle traffic control signal faces shall be entirely weathertight.

All tubular parts shall be 1½ in. IPS (DN40) pipe.

The lower support or connection between signal heads in a span wire or mast arm mounted signal may be an aluminum casting or stamping of suitable strength.

Wire raceway areas within brackets, trunnions and suspensions shall be of adequate size to carry all necessary wires without crowding and raceway surfaces shall be free of sharp edges or protrusions which might damage insulation on wires.

Suspensions for the mast arm or span wire mounting shall include a device to permit adjustment for proper vertical alignment of the signal head.

Non-metallic trunnions, brackets and suspension parts previously approved by the Division may be supplied. Such parts must be capable of mounting metallic signal heads and must have metallic reinforcement at points of anticipated wear.

All reinforcing metal must be compatible with aluminum, steel and galvanized steel.

715.42.14.2-Flashing Mechanism: The signal head shall flash at a rate of not less than 50 not more than 60 flashes per minute with each lamp being lighted 50 percent of the time. The closing and opening of the flashing contacts shall be accomplished in such a manner as to avoid undue pitting and burning at 10 amps, 115 volts, A/C, continuous make and break duty. The flasher shall be equipped with adequate radio interference filter and protected by a fuse or circuit breaker.

Solid state flashers meeting current NEMA TS Standards and capable of the above specified outputs and circuit ratings are acceptable.

715.42.14.3-Time Clocks: The clock motors shall be designed for synchronous operation on 115 volts, 60 cycle, single phase alternating current.

The clocks shall be programmable for circuit on-off operation at 15 minute intervals of the day. In addition, the clocks must be capable of skip-a-day operation. Each clock dial shall provide from one to 48 operations per day, minimum 15-minute settings.

Each clock shall be capable of operating in a "power off" condition for a minimum of 10 hours. Drive for the clock when electric power is off shall be provided by a reserve spring which is wound automatically during "power-on" periods.

All time clocks must be easily accessible and demountable and fit within the controller cabinet.

Electronic time switches as specified under Auxiliary Traffic Signal Equipment are an acceptable alternate to the above time clock.

715.42.14.4-Flasher Cabinet: Flasher cabinets shall conform to the requirements of 715.42.8.3.

The cabinet shall be provided with the necessary opening and attachments for mounting and connecting in the manner specified by one of the following options as indicated on the plans.

715.42.14.4.1-(Optional): Mounting to wooden poles by means of lag screws.

715.42.14.4.2-(Optional): Mounting to steel poles using pole attachment clamps.

715.42.14.4.3-(Optional): The flasher mechanism may be located within one of the signal heads when the head is of special design to permit this mounting without hindering the functioning of the flasher.

715.42.14.4.4-(Optional): The timing mechanism may be located within a building and housed in a non-weatherproof cabinet.

715.42.14.5-Mounting: The mounting of the sign must conform to one of the following types:

715.42.14.5.1-Post Mounted: The post mounted sign shall be located so that the nearest edge of the sign is not less than 6 feet (1.8 m) not more than 12 feet (3.6 m) from the edge of the traveled way or a minimum of 2 feet (0.6 m) and a maximum of 6 feet (1.8 m) outside an unmountable curb.

The bottom of the sign shall be a minimum of 8 feet (2.4 m) and not more than 15 feet (4.5 m) above the pavement grade at the center of the highway.

715.42.14.5.2-Pedestal Mounted: Use the same criteria as for 715.42.14.5.1-Post Mounted.

715.42.14.5.3-Span Wire: The sign shall be located over the center of the lane that it faces on a two-lane roadway and in the center of the lanes it faces on a multi-lane roadway.

The span wire mounting shall be such that a minimum of 17-foot (2.4 m) and a maximum of 19-foot (4.5 m) clearance is maintained from the pavement to the bottom of the sign.

The span wire shall have a maximum sag of five percent of the span.

715.42.14.5.4-Mast Arm: The mast arm mounted sign shall be located so that the center of the sign is located over the lane or lanes to be controlled by the signs.

The mast arm mounting shall be such that a minimum of 17-foot (2.4 m) and a maximum of 19-foot (4.5 m) clearance is maintained from the pavement to the bottom of the sign.

715.42.14.6-Warranties and Guarantees: Any and all equipment shall be covered by manufacturer's written guarantee or warranty for a period of 12 months with respect to parts, workmanship and performance of product.

The department reserves the right to withhold any payments which may be due, should it be discovered that the equipment does not meet the Specifications.

The manufacturer shall make available, at no cost, engineering data, diagrams, etc., on any later changes or improvements which would increase the performance of the equipment purchased.

The manufacturer shall furnish instructions for installing and maintaining the equipment and assistance as required for timing and operation of the equipment.

715.42.14.7-Construction Methods: The materials furnished and used shall be new, except as may be specified on the Plans. All workmanship for electric work shall be in accordance with the details shown on the plans, the above Specifications, Special Provisions for 715.42 (Traffic Signals) as applicable, the Standard Drawing TES-36 and the requirements of the current National Electrical Code in addition to any local codes.

715.43 through 715.44-BLANK

715.45-BENTONITE:

Bentonite shall meet the requirements of Section 3 of American Petroleum Institute Standard 13A and Supplements.

SECTION 716

EMBANKMENT AND SUBGRADE MATERIAL

716.1-GENERAL:

Material for embankment shall be suitable soil, granular material, shale, rock, random material, or borrow material. The material shall have dimension limitations in accordance with the contract documents.

Material for subgrade shall be granular material free of particles larger than 3 inches (75 mm).

716.1.1-Random Material: Random material shall be considered as a mixture of any or all of soil, granular material, or soft shale as described which are permitted by the Engineer to be used in embankment. These are materials that can be incorporated in a 6 inch (150 mm) compacted layer.

716.1.1.1-Soil: Soil material shall be considered as layers or deposits of disintegrated rock, lying on or near the surface of the earth; which has resulted from natural processes, such as weathering, decay or chemical action or a combination of these processes. Material shall be considered as soil when more than 25 percent by weight of the grains or particles pass the No. 200 (75 μ m) sieve.

716.1.1.2-Granular Material: Granular material shall be considered as natural or synthetic mineral aggregate, such as broken or crushed rock, gravel, sand, or slag. Shale or fly ash shall not be considered granular material. Granular material shall have not more than 25 percent by weight of grains or particles passing the No. 200 (75 μ m) sieve (determined by AASHTO T-27) and the plasticity index shall not be more than 6 (determined by AASHTO T-90).

716.1.1.3-Softshale: Soft shale shall be considered as any of the shales, weak sandstone, weak limestone, claystones or siltstones that break down using the following roller test. Rock which break down under three complete coverages with a steel drum roller, meeting the following requirement, shall be classified as soft shale to be placed as specified in 207.7.3.2.1. Smooth drum rollers shall provide a minimum 1.5 tons per linear foot of roller width and drum rollers with any type of feet (sheep's foot, tamping foot, and etc.) shall provide the same minimum of 1.5 tons per linear foot of roller drum width. This criteria applies to single and multiple drum rollers as well as vibratory rollers with the vibration set to maximum. This criteria shall be calculated for each roller and test combination by dividing the operating weight of the roller in tons by the total measured width of the drum in feet, or the total of all drums if more than one drum. This calculation shall be provided to the Engineer in writing prior to the test. The contractor shall provide the roller or rollers and any other necessary equipment for this test without additional compensation.

716.1.2-Rock: Rock is defined as sandstone, limestone, or concrete that cannot be incorporated in a 6 inch (150 mm) compacted lift and shall be medium hard or harder.

716.1.3-Hard Shale: Material that meets the description of shale in 716.1.1.3 except that is does not break down under the hardness test shall be considered as hard shale and placed as specified in 207.7.3.2.2 when used as embankment material.

716.1.4-Borrow Material: Borrow shall consist of approved material required for the construction of embankments and other portions of the work and shall be subject to the applicable provisions of 211.

716.2-TEST METHODS:

Plastic Limit	AASHTO T 90 or ASTM D 424
Grain Size Analysis	AASHTO T 88 or ASTM D 422
Sieve analysis of fine and coarse aggregate	AASHTO T 27
Amount of material finer than 200 sieve (0.075 mm) in aggregate	AASHTO T 11
Specific Gravity of Soils	AASHTO T 100 or ASTM D854
Specific Gravity and Absorption of Coarse Aggregate	AASHTO T 85 or ASTM C 127
Organic Content	AASHTO T 267
Moisture and density of soil and material having less than 40 percent of particles by weight retained on the $\frac{3}{4}$ inch (19 mm) sieve	MP 207.07.20
Moisture and density of material having 40 percent or more of the particles by weight retained on the $\frac{3}{4}$ inch (19 mm) sieve and that are relatively uniform in gradation and can be incorporated in a 12 inch (300 mm) lift or less, and granular subgrade	MP 700.00.24 (See MP 717.04.21, Table 2.2.3.1)
Liquid Limit	AASHTO T 89 or ASTM D 423

716.3-MOISTURE AND DENSITY REQUIREMENTS:

716.3.1-Embankment Moisture: Embankment soil and material having less than 40 percent by weight of particles retained on the $\frac{3}{4}$ inch (19 mm) sieve shall be moistened or dried to a tolerance of plus three percentage points or minus four percentage points from optimum at the time compactive effort is applied. However, soils which evidence pronounced elasticity as the result of compactive effort shall be dried to optimum moisture content, if necessary to achieve stability.

716.3.2-Embankment and Subgrade Density:

716.3.2.1-Soil and material having less than 40 percent by weight of particles retained on the $\frac{3}{4}$ inch (19 mm) sieve shall be compacted within the moisture tolerance to a target percentage of dry density (Note 1) specified in Table 716.3.2.2. The maximum required dry density and the in-place dry density of the soil layers placed and compacted shall be determined by MP 207.07.20.

716.3.2.2- Soil and material having 40 percent or more by weight of particles retained on the $\frac{3}{4}$ inch (19 mm) sieve that are relatively uniform in gradation and can be incorporated in a 12 inch (300 mm) lift or less, shall be compacted to the target percentage of dry density (Note 1) specified in Table 716.3.2.2. The maximum required dry density shall be determined by Part 1 of MP 700.00.24. The in-place dry density of the soil layers placed and compacted shall be determined in accordance with Part II of MP 700.00.24.

TABLE 716.3.2.2

Type of Construction	Target % of Dry Density (Note 1) of Material Having Less Than 40% by Weight Retained on mm) the $\frac{3}{4}$ in. (19 mm) Sieve	Target % of Dry Density (Note 1) of Material Having 40% or More By Weight Retained on the $\frac{3}{4}$ in.(19 mm) Sieve and Granular Subgrade
Embankment	95	95
Subgrade	95	95

Note 1-Target percentage of density shall be the percentage of density by which the decision of acceptance is based. The percentage of dry density for each test shall be determined by comparing the in-place dry density with required maximum dry density.

716.3.2.3-Material, as outlined in MP 717.04.21, Table 2.2.3.1, shall be proof rolled with a pneumatic tire roller having an effective weight of 50 tons (45.5 Mg). Alternate proof rollers, acceptable to the Engineer, may be used in lieu of a 50 ton (45.5 Mg) pneumatic tired roller provided the weight per tire and tire pressure is maintained so that a minimum of 1315 pounds per inch (9.067 KN/mm) width of tire is maintained. The roller shall be operated at a speed of not more than five miles per hour (8 km/hr.). The designated areas to be proof rolled shall have two or more passes and the entire area shall be systematically covered with the proof rolling. During the proof rolling and after the proof rolling is completed, the area shall be checked for unstable areas or soft spots disclosed by the operation of the proof roller. These unstable areas or soft spots shall be corrected prior to placement of the overlying lifts of material. The Contractor may propose an alternate approach for small areas that are impractical to roll with the proof roller.

716.4-EMBANKMENT ORGANIC CONTENT:

The organic content of the embankment material shall not exceed 7.5 percent by weight as determined by AASHTO T 267.

716.5-ACCEPTANCE OF EMBANKMENT AND SUBGRADE:

The density of the embankment and subgrade will be accepted by the Division on a lot to lot basis provided the lot conforms to the specifications. A lot shall contain five approximately equal sublots. A sublot shall consist of not more than 2,500 cu. yd. (1900 cubic meters) for embankment and 400 linear ft. (120 m) per working width for subgrade. The Contractor's quality control testing shall include one nuclear moisture and density measurement made at a random

location within each of the sublots. Each lot shall be presented to the Engineer for acceptance. When a lot consists of more than one lift, the Contractor's quality control testing shall normally include testing on each lift. Testing for density shall be in accordance with 716.3.2.1, or 716.3.2.2, whichever is applicable. The random locations shall be determined in accordance with MP 712.21.26. The Contractor's quality control testing will be evaluated for each lot and acceptance of the lot may be based either upon the Contractor's quality control testing or by independent testing performed by the Division. The acceptance decision will be made as soon as practicable after the Contractor has informed the Engineer that the lot is ready for acceptance.

If the results of density tests on a lot indicate that at least 80 percent of the material, in accordance with 106.3.1 (West Virginia APA), has been compacted to the specified target percentage of dry density, the lot will be accepted. If less than 80 percent of the material has been compacted to the specified target percentage of dry density, no additional material shall be placed on the lot until it has been reworked to meet the specified requirements.

Lots failing to meet the quality requirements shall be reworked by the Contractor at their expense and be resubmitted for acceptance. Evaluation of the reworked lots, when the testing is performed by the Division, shall be at the expense of the Contractor at the unit cost specified in 109.2.2. The quality requirements of this Subsection shall apply to the reworked lots.

SECTION 717

COMPACTION CONTROL OF BASE COURSE MATERIAL

717.1-GENERAL:

The Contractor shall notify the Engineer prior to construction of the test strips as set forth in MP 700.00.24. The Contractor shall perform quality control compaction tests and record the data on the forms as set forth in the Materials Procedures (MPs). The test data shall be available to the Engineer at the time of testing or as indicated in the Contractor's quality control plan.

717.2-TEST METHODS:

Maximum density, quality control density and acceptance density for crushed aggregate base course and aggregate subbase shall be determined in accordance with MP 700.00.24.

717.3-DENSITY:

The crushed aggregate base course and aggregate subbase shall be compacted to the target percentage of dry density of 95%. The maximum required dry density shall be determined in accordance with MP 700.00.24 Part I on a control test strip having a compacted thickness of 6 inches (150 mm) or less. The in-place dry density of each base course layer shall be determined in accordance with MP 700.00.24 Part II. The maximum layer thickness, other than the test strip(s), shall not exceed 12 in. (300 mm) or as specified in the project documents. The density of layers with thickness that differ from the thickness of the control test strip(s) shall be subject to the density requirements determined by the control test strip.

SECTION 718 SEWER AND WATERLINE MATERIAL

718.1-IRON PIPE:

Ductile iron pipe for waterline applications shall conform to AWWA C151.

718.1.1: Cement lining shall conform to AWWA C104.

718.1.2: Fittings shall conform to AWWA C110 or C153.

718.1.3: Joints shall conform to AWWA C111. Flanged joints shall conform to C115.
Joints shall conform to AWWA C111. Flanged joints shall conform to C115.

718.2 through 718.4-BLANK

718.5-PLASTIC PIPE (PVC):

Plastic Pipe shall conform to the following requirements unless otherwise specified by the Utility responsible for its operation:

Pipe Size	Pressure Applications	Non-Pressure Applications
Less than 4 in (100 mm)	ASTM D2241, SDR 21	ASTM D3034
4 in (100 mm) to 12 in (300 mm)	AWWA C900, DR 14	ASTM D3034
14 in (350 mm) to 16 in (400 mm)	AWWA C905, DR 14	ASTM D3034
Joint Requirements	ASTM D3139	ASTM D3212

718.6-BLANK

718.7-PLASTIC PIPE (POLYETHYLENE):

Plastic pipe (polyethylene) shall conform to ASTM D2239 “PE3408”. Additionally, when used for potable water, polyethylene pipe shall be approved by the National Sanitation Foundation for use in transmitting liquids for human consumption.

718.9-COPPER SERVICE LINE:

Copper Service Line shall conform to ASTM B88. Fitting shall be industrial quality and conform to AWWA C800.

718.10-GATE VALVES:

Gate valves shall conform to AWWA C500 or C509.

718.11-VALVE BOXES:

Valve Boxes shall be as specified on the plans.

718.12-CASING-PIPE (STEEL):

Casing Pipe (Steel) shall conform to the following:”ASTM A53, Grade B, ASTM A139, Grade B or ASTM A252, Graded 2 for both waterline and sewer line applications. Hydrostatic test requirements under ASTM A53 or ASTM A139 are waived.”

718.13-FIRE HYDRANTS:

Fire Hydrants shall conform to AWWA C502. See plans for specific details.

718.14-METERS:

Meters shall conform to AWWA C700, type as required by the plans.

718.15-MISCELLANEOUS STEEL (CLAMPS, RODS, ETC.):

Miscellaneous Steel (Clamps, Rods, Etc.) shall be industrial quality.

718.16 through 718.19-BLANK

718.20-FINE AGGREGATE:

Fine aggregate used to level the bedding material shall consist of crushed or uncrushed mineral aggregate which has no particles larger than 3/8 in. (9.5 mm) as determined by visual inspection. The project Engineer/Supervisor may obtain samples on questionable materials for testing prior to use.

718.21-BEDDING MATERIAL:

Bedding Material shall conform to 703 and meet gradation for #67.

INDEX

Index

This index is not intended to be a complete concordance, but is intended to provide a general reference of where a Section or Subsection can be found. The entire book is available online and may be searched extensively and specifically for particular words and phrases.

Approach Slabs, 250

- Basis of Payment, 251
- Curbs, 251
- Description, 250
- Forms, 250
- Joints, 250
- Materials, 250
- Method of Measurement, 251
- Pay Item, 251
- Placing, 250

Asbestos Abatement, 760

- Basis of Payment, 769
- Execution, 764
- General, 760
- Method of Measurement, 769
- Pay Items, 769

Asphalt Base and Wearing Courses, Percent Within Limits (PWL), 194

- Acceptance Testing, 199
- Basis of Payment, 209
- Composition of Mixtures, 195
- Contractors Quality Control, 199
- Description, 194
- Equipment, 204
- General, 195
- Materials, 194
- Method of Measurement, 209
- Paving Operations, 208
- Pay Items, 212
- Protection of Pavement and Traffic Control, 208
- Testing, 198

Asphalt Base, Wearing, and Patching and Leveling Courses, 163

- Acceptance Testing, 168
- Basis of Payment, 178
- Composition of Mixtures, 164
- Contractors Quality Control, 167
- Description
- Equipment, 172
- General, 163
- Materials, 163
- Method of Measurement, 178
- Paving Operations, 176
- Pay Items, 178
- Protection of Pavement and Traffic Control, 178
- Testing, 167
- Weather Restrictions, 172

Asphalt Materials, 805

- Asphalt Emulsion, 805
- Asphalt for Dampproofing and Water-Proofing, 806
- Cationic Emulsified Asphalt, 806
- Liquid Asphalt (Medium Curing Type), 805
- Liquid Asphalt (Rapid Curing Type), 805
- Nonstandard Asphalt Materials, 806

- Performance Graded Binders, 805
- Polymer-Modified Cationic Emulsified Asphalt, 806
- Primer for use with Asphalt in Dampproofing and Waterproofing, 806
- Winter Grade Cut-Back Asphalt, 805

Asphalt Skid Resistant Pavement, 181

- Description, 181
- Fine Aggregate, 182
- Materials, 181
- Mixing, 182
- Pay Item, 182

Award and Execution of Contract, 15

- Award of Contract, 15
- Cancellation of Award, 16
- Consideration of Proposals, 15
- Execution of Contract, 18
- Failure to Execute Contract, 18
- Insurance Requirements, 17
- Preconstruction Conference, 18
- Requirement of Contract Bond, 16
- Return of Proposal Guaranty, 16
- Special Bonds and Insurance, 18

Base Course Reinforcement Geogrid, 107

- Construction, 110
- Description, 107
- Geogrid Material, 107
- Manufacturing Quality Control, 109
- Measurement/Payment, 111
- Pay Item, 111
- Reference Documents, 107
- Transportation, Handling and Storage, 110

Bidding Requirements and Conditions, 10

- Combination Proposals, 13
- Contents of Proposal Forms, 10
- Delivery of Proposals, 12
- Disqualification of Bidders, 13
- Examination of Plans, Specifications, and Site of Work, 11
- Free competitive Bidding Affidavit, 13
- Insurance of Proposal Forms, 10
- Interpretation of Approximate Estimates, 11
- Irregular Proposals, 11
- Material Guaranty, 13
- Pre-Construction Data, 13
- Preparation of Proposal, 11
- Prequalification of Bidders, 10
- Proposal Guaranty, 12
- Public Reading of Proposals, 13
- Withdrawal of Proposals, 12

Bituminous Underseal for Concrete**Pavement, 254**

Basis of Payment, 255
Description, 254
General, 254
Materials, 254
Method of Measurement, 255
Pay Items, 255

Borrow Excavation, 128

Basis of Payment, 132
Description, 128
General, 128
Materials, 128
Method of Measurement, 131
Pay Items, 132
Rock Borrow Excavation, 130
Select Borrow Excavation, 130
Unclassified Borrow Excavation, 130

Bridge Cleaning, 770

Description, 770
Testing of Structural Steel, 771
General Contractor Responsibility, 771
Basis of Payment, 771
Pay Item, 771

Building Demolition, Well and Septic Tank**Abandonment, 99**

Basis of Payment, 102
Buildings, 99
Description, 99
Disposal of Materials, 99
Method of Measurement, 102
Pay Items, 103
Septic Tanks, 102
Utilities, 99
Wells, 101

Cast Bronze and Rolled Copper-Alloy Expansion**Plates, 464**

Basis of Payment, 465
Cast Bronze Plates, 464
Description, 464
General, 464
Materials, 464
Method of Measurement, 464
Pay Items, 465
Rolled Copper-Alloy Expansion Plates, 464

Cleaning Culverts, Inlets, and Manholes, 152

Basis of Payment, 152
Construction Methods, 152
Description, 152
Materials, 152
Method of Measurement, 152
Pay Items, 152

Clearing and Grubbing, 95

Basis of Payment, 98
Clearing, 95
Description, 95
Disposal, 97
General, 95
Grubbing, 96
Materials, 95
Method of Measurement, 98

Pay Item, 98

Selective Clearing and Thinning, 96

Coarse Aggregate, 796

Crushed Stone, 796
Grading of Coarse Aggregates, 799
Gravel, 796
Lightweight Coarse Aggregate for Structural Concrete, 799
Slag, 797

Compaction Control of Base Course Material, 982

Density, 982
General, 982
Test Methods, 982

Concrete Admixtures, Curing and Coating Materials, 807

Accelerating Admixtures for Concrete, 812
Air-Entraining Admixtures for Concrete, 807
Burlap Cloth Made from Jute or Kenaf for Curing, 811
Concrete Protective Coating Materials, 814
Concrete Sealer, 812
Epoxy Resin Protective Coating, 812
Latex Admixture, 811
Liquid Membrane-Forming Compound for Curing Concrete, 812
Polyethylene Coated Burlap for Curing Concrete, 811
Pozzolanic Additives for use in Portland Cement Concrete, 811
Waterproof Paper for Curing Concrete, 812
Water-Reducing Admixtures for Concrete, 809
Water-Reducing and Accelerating Admixtures for Concrete, 813
Water-Reducing and Retarding Admixtures for Concrete, 808
White Polyethylene Sheeting (Film) for Curing Concrete, 812

Concrete Cribbing, 536

Basis of Payment, 537
Description, 536
Filling Crib, 536
Materials, 536
Method of Measurement, 537
Pay Item, 537
Placing Crib Members, 536

Concrete Gutter, Invert Pipe Gutter, or Dumped**Rock Gutter, 533**

Basis of Payment, 535
Concrete Gutter, 533
Description, 533
Dumped Rock Gutter, 534
General, 533
Invert Pipe Gutter, 534
Materials, 533
Method of Measurement, 535
Pay Items, 535

Concrete Pavement Cross Stitching, 278

- Basis of Payment, 281
- Construction Methods, 278
- Description, 278
- Equipment and Tools, 278
- Materials, 278
- Method of Measurement, 281
- Opening to Traffic, 280
- Pay Item, 281

Concrete Pavement Repair, 256

- Basis of Payment, 261
- Construction Methods, 257
- Description, 256
- Equipment and Tools, 257
- Materials, 256
- Method of Measurement, 261
- Pay Items, 262
- Proportioning, 256
- Ride Acceptance, 261
- Testing, 257

Concrete Slab Stabilization, 275

- Basis of Payment, 277
- Construction Methods, 276
- Description, 275
- Equipment, 275
- Materials, 275
- Method of Measurement, 277
- Opening to Traffic, 277
- Pay Items, 277
- Proportioning, 275

Concrete, Clay, Fiber and Plastic Pipe, 852

- Acrylonitrile-Butadiene-Styrene (ABS) Pipe, 853
- Bituminized Fiber Pipe for Underdrainage, 853
- Clay Drain Tile, 852
- Clay Pipe, 852
- Concrete Drain Tile, 852
- Corrugated Polyethylene Pipe, 853
- Fiberglass-Reinforced (FRP) Pipe, 853
- Non-Asbestos Fiber-Cement Storm Drain Pipe, 854
- Nonreinforced Concrete Pipe, 852
- Perforated Asbestos Cement Pipe for Underdrainage, 852
- Perforated Bituminized Fiber Pipe for Underdrainage, 853
- Perforated Concrete Pipe, 852
- Perforated Plastic Semicircular Pipe, 853
- Polyvinyl Chloride (PVC) Pipe, 853
- Porous Concrete Pipe, 852
- Precast Reinforced Concrete Box Culverts, 854
- Reinforced Concrete Arch Culvert Storm Drain, 852
- Reinforced Concrete Culvert Storm Drain and Sewer Pipe, 852
- Reinforced Concrete Elliptical Culvert Storm Drain and Sewer Pipe, 852
- Reinforced Concrete End Sections, 853
- Reinforced Plastic Mortar (RPMP) Pipe, 853
- Vitrified Clay Lined Reinforced Concrete Pipe, 852

Construction Surveying, 561

- As-Built Utility Survey, 562
- Basis of Payment, 564
- Construction Layout Stakes, 561
- Description, 561

- Materials, 561
- Method of Measurement, 564
- Pay Items, 564

Control of Materials, 39

- Division-Furnished Materials, 44
- Handling Materials, 43
- Local Material Sources, 41
- Plant Inspection, 42
- Samples, Tests, Cited Specifications, 41
- Silence of Specifications, 44
- Source of Supply and Quality Requirements, 39
- Storage of Materials, 43
- Unacceptable Materials, 43

Control of Work, 27

- Acceptance, 36
- Authority and Duties of the Inspector, 34
- Authority and Duties of the Project Engineer or Project Supervisor, 34
- Authority of the Engineer, 27
- Claims for Adjustment and Disputes, 36
- Construction Stakes, Lines and Grades, 33
- Cooperation Between Contractors, 33
- Cooperation by Contractor, 31
- Cooperation with Utilities, 32
- Coordination of Plans, Specifications, Supplemental Specifications, and Special Provisions, 31
- Failure to Maintain Roadway or Structure, 36
- Inspection of Work and Materials, 34
- Load Restrictions, 35
- Maintenance During Construction, 35
- Plans and Working Drawings, 27
- Removal of Unacceptable and Unauthorized Work, 35

Controlled Low-Strength Material, 146

- Construction Methods, 147
- Description, 146
- Materials, 146
- Pay Item, 148
- Properties, 146

Crack and Pothole Repair, 263

- Basis of Payment, 263
- Construction Methods, 263
- Description, 263
- Materials, 263
- Method of Measurement, 263
- Pay Items, 263

Crushed Aggregate Base Course, 153

- Basis of Payment, 158
- Compacting, 156
- Description, 153
- Equipment, 155
- Maintenance, 156
- Materials, 153
- Method of Measurement, 157
- Pay Items, 158
- Placing, 155
- Tolerance, 156

Curbs, Combination Curbs and Gutters and Medians, 418

Asphalt Curbing, 421
Basis of Payment, 423
Description, 418
Materials, 418
Medians, 422
Method of Measurement, 423
Pay Items, 423
Plain Concrete Curbing, Integral Concrete Curbing, and Combination Concrete Curb and Gutter, 420
Reflecting Concrete Curbing, 421
Resetting Curb, 422

Definition of Terms, 1

Abbreviations, 1
Definitions, 2
Interpretations, 9

Diamond Grinding, 264

Basis of Payment, 266
Construction, 264
Description, 264
Equipment, 264
Final Surface Finish, 264
Method of Measurement, 266
Pay Item, 266
Slurry Removal, 265
Smoothness, 266
Smoothness Requirements, 265

Dismantling Structures, 104

Basis of Payment, 105
Construction Methods, 104
Description, 104
Materials, 104
Method of Measurement, 105
Pay Item, 105

Dowel Bar Retrofit, 269

Basis of Payment, 274
Construction Methods, 270
Description, 269
Dowel Bar Alignment Assurance, 273
Materials, 269
Method of Measurement, 274
Opening to Traffic, 273
Pay Item, 274
Test Section, 274

Drilled Caisson Foundations, 500

Basis of Payment, 510
Construction, 504
Description, 500
Dimensional Requirements, 503
Inspection of Sockets, 509
Materials, 504
Method of Measurement, 509
Pay Items, 510
Tests and Submittals, 500

Electrical Work, 529

Basis of Payment, 529
Construction Methods, 529
Description, 529
Materials, 529
Method of Measurement, 529

Pay Item, 529

Embankment and Subgrade Material, 978

Acceptance of Embankment and Subgrade, 980
Embankment Organic Content, 980
General, 978
Moisture and Density Requirements, 979
Test Methods, 979

Excavation and Embankment, 112

Basis of Payment, 127
Benches, 114
Description, 112
Disposal of Material, 115
Ditches, 115
Drainage, 124
Finishing Earth Roads, 123
Forming and Compacting Embankment, 118
Materials, 112
Method of Measurement, 125
Pay Items, 127
Protection of Curtain Walls, 125
Roadway, 113
Shoulders, 124
Slides and Slipouts, 125
Subgrade, 123
Temporary Surcharge, 125

Field Office and Storage Building, 565

Alternate for Office Building, 567
Basis of Payment, 568
Description, 565
Field Office, 565
Liability for Property in Office/Storage Structures, 567
Location and Time of Erection, 565
Maintenance, 567
Materials, 565
Method of Measurement, 568
Pay Items, 569
Removal, 567
Storage Building, 566

Fine Aggregate, 794

Alternate Grading, 795
Fine Aggregate for Asphalt Mixtures, 795
Fine Aggregate for Portland Cement Concrete, 794
Lightweight Fine Aggregate for Structural Concrete, 795
Mineral Filler for Asphalt Mixtures, 795
Mortar Sand, 795

Furnishing and Placing Topsoil, 587

Basis of Payment, 588
Description, 587
Materials, 587
Method of Measurement, 588
Pay Items, 588
Placing and Manipulating, 587
Stripping Topsoil, 587
Transporting, 587

Guardrail, 391

- Basis of Payment, 403
- Description, 391
- Erecting Rail Elements, 393
- Guardrail Removed and Rebuilt or Stored, 394
- Materials, 391
- Method of Measurement, 394
- Pay Items, 404
- Setting Posts and Placing Footers, 392

Guardrail and Fence, 845

- Chain-Link Fence, 845
- Coated Steel Barbed Wire, 845
- Galvanized Steel Deep Beam Guardrail, Fasteners and Anchor Bolts, 845
- Safety Fence, 845
- Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-Of-Way, 845

Horizontal Drains, 530

- Basis of Payment, 532
- Collector Pipe Installation, 531
- Description, 530
- Drilling, 530
- General, 530
- Installation of Horizontal Drain Pipe, 531
- Materials, 530
- Method of Measurement, 531
- Pay Items, 532
- Terminal Chamber Installation, 531

Hydraulic Cement, 793

- Masonry Cement, 793
- Portland Cement, 793

Joint Materials, 817

- Asphalt Plastic Cement, 819
- Hot Pour Mineral Filled Joint Sealer for Sewer and Culvert Pipe, 819
- Silicone Joint Sealant, 817
- Joint Mortar, 819
- Joint Sealant, Hot-Poured for Concrete and Asphalt Pavements, 817
- Joints for Circular Concrete Sewer and Culvert Materials, 819
- Preformed Elastomeric Joint Seals, 817
- Preformed Expansion Joint Filler for Concrete, 817
- Vitrified Clay Pipe Joints Having Resilient Properties, 818
- Waterstops (Elastomer Materials), 820

Legal Relations and Responsibility to Public, 45

- Air Pollution Control, 56
- Barricades and Warning Signs, 51
- Bridges Over Navigable Waters, 51
- Clean Water Act/Wetlands, 57
- Construction Access and Environmental Permits, 58
- Contractor's Responsibility for Utility Property, 54
- Contractor's Responsibility for Work, 53
- Federal-Aid Provisions, 46
- Forest Protection, 52
- Furnishing Right-Of-Way, 54
- Laws to be Observed, 45
- Lead Exposure in Construction, 57
- No Waiver of Legal Rights, 54, 55

- Notification of Abatement Demolition or Renovation, 57
- Opening Sections of Project to Traffic, 53
- Patented Devices, Materials, and Processes, 45
- Permits, Licenses and Taxes, 45
- Personal Liability of Public Officials, 54
- Plant Pest Regulations, 56
- Protection and Restoration of Property and Landscape, 52
- Public Convenience and Safety, 46
- Railway, 47
- Restoration of Surfaces Opened by Permit, 45
- Sanitary Provisions, 46
- Use of Explosives, 52

Maintaining Traffic, 540

- Aggregates and Dust Palliatives, 542
- Basis of Payment, 555
- Channelizer Cones, 546
- Cleaning of Traffic Control Devices, 545
- Control of Traffic Through Work Areas, 540
- Description, 540
- Electric Arrow, 548
- Eradication of Pavement Markings, 542
- Flagger-Traffic Director, 545
- Materials, 540
- Method of Measurement, 550
- Pay Items, 555
- Pilot Truck and Driver or Shadow Vehicle, 542
- Portable Message Signs, 548
- Removing and Resetting Temporary Guardrail Barrier, 547
- Temporary Guardrail, 547
- Temporary Pavement Markings and Raised Pavement Markers, 543
- Temporary Pipe for Maintaining Traffic, 550
- Temporary Structures, 542
- Temporary Traffic Signal(s) or Temporary Lighting, 550
- Traffic Control Devices, 543
- Warning Lights, 550

Manholes and Inlets, 380

- Basis of Payment, 381
- Construction Methods, 380
- Description, 380
- Materials, 380
- Method of Measurement, 381
- Pay Items, 382

Matting for Erosion Control, 604

- Basis of Payment, 604
- Description, 604
- Maintenance and Repairs, 604
- Materials, 604
- Method of Measurement, 604
- Pay Items, 604
- Placing, 604

Measurement and Payment, 78

- Acceptance and Final Payment, 87
- Compensation for Altered Quantities, 81
- Eliminated Item, 85
- Force Account Work, 81
- Load Limit Violations and Weigh Tickets, 91
- Measurement of Quantities, 78
- Partial Payments, 85
- Payment for Material on Hand, 86
- Price Adjustment of Asphalt Binder, 89
- Price Adjustment of Fuels, 87
- Scope of Payment, 80

Metal Cribbing, 538

- Basis of Payment, 538
- Description, 538
- Filling Crib, 538
- Materials, 538
- Method of Measurement, 538
- Pay Item, 539
- Placing Crib Members, 538

Metal Pipe, 846

- Aluminum Alloy Structural Plate for Pipe, Pipe Arch, and Arches, 850
- Aluminum Coated Corrugated Steel Pipe and Pipe Arch, 851
- Bituminous Coated Corrugated Aluminum Alloy Pipe and Pipe Arches, 850
- Bituminous Coated Corrugated Aluminum Alloy Pipe Underdrain, 850
- Bituminous Coated Corrugated Steel Pipe and Pipe Arch, 846
- Bituminous Coated Corrugated Steel Underdrain Pipe, 849
- Corrugated Aluminum Alloy Pipe and Pipe Arches, 849
- Corrugated Aluminum Alloy Pipe Underdrain, 850
- Corrugated Stainless Steel Culverts and Underdrains, 847
- End Sections for Corrugated Aluminum Alloy Pipe and Pipe Arches, 850
- End Sections for Corrugated Steel Pipe and Pipe Arches, 850
- Fiber Bonded Full Bituminous Coated Corrugated Steel Pipe and Pipe Arch, 846
- Fiber Bonded Full Bituminous Coated and Full Paved Corrugated Steel Sewer Pipe, 846
- Full Bituminous Coated Aluminum Alloy Structural Plate Pipe, Pipe Arch, and Arches, 850
- Full Bituminous Coated and Full Paved Corrugated Steel Pipe, 846
- Full Bituminous Coated Structural Plate Pipe, Pipe Arch, and Arches, 848
- Metallic Coated Corrugated Steel Pipe and Pipe Arch, 846
- Metallic Coated Corrugated Steel Underdrain Pipe, 849
- Precoated, Metallic Coated Steel Pipe and Underdrain, 851
- Stainless Steel Structural Plate Pipe, 848
- Structural Plate for Pipe, Pipe Arch, and Arches, 848

Metalizing Steel, 788

- Application of Metallic Coating, 788
- Basis of Payment, 789
- Description, 788

- Field Touch Up, 789
- Material, 788
- Method of Measurement, 789
- Minimum Requirements, 788
- Pay Items, 789
- Sealers and Top Coats, 789
- Shipping and Handling, 789

Metals, 821

- Aluminum Alloy Bolts, Nuts and Set Screws, 829
- Aluminum Alloy Drawn Tube, 829
- Aluminum Alloy Extrusions and Aluminum, 828
- Aluminum Alloy Pipes, 829
- Aluminum Alloy Rivets, 829
- Aluminum Alloy Shim Material, 829
- Aluminum Alloy Standard Structural Shapes, 829
- Aluminum Alloy Washers, 829
- Aluminum Alloys Sand Castings, 829
- Aluminum Filler Metal for Welding, 829
- Cadmium Coated Materials, 830
- Cast Iron Soil and Fittings, 828
- Coated Dowel Bars and Dowel Basket Assemblies, 823
- Copper Alloy Castings for Bearing, Expansion and Name Plates for Bridges, 823
- Expanded Metal Pavement Reinforcement, 821
- Fabricated Bar or Rod Mats for Concrete Reinforcement, 822
- Flashing for Construction and Expansion Joints, 824
- Galvanized Pipe or Tubing for Horizontal Drains, 830
- Galvanized Steel Guardrail Posts, 830
- Gray Iron, Malleable Iron and Ductile Iron Castings, 822
- High Strength Low Alloy Structural Metal, 822
- High-Strength Bolts for Structural Steel Joints Including Suitable Nuts and Hardened Washers, 824
- Hook Expansion Bolts for Fastening Wire Mesh in Shotcrete Applications, 821
- Joint Tie Bolt Assembly, 822
- Pipes for Floor Drains and Down-Spouts, 824
- Prestressing Reinforcement, 821
- Rolled Copper Alloy Bearing and Expansion Plates for Bridges, 823
- Sheet Lead, 830
- Steel Bars for Concrete Reinforcement, 821
- Steel Bolts and Nuts, 824
- Steel Castings, 823
- Steel Forgings and Steel Shafting, 823
- Steel Pile Points, 831
- Steel Posts, Post Braces and Gate Frames for Right-of-Way Fence, 830
- Steel Shells or Casings (Driven Without Mandrel) for Cast-In-Place Piles, 828
- Structural and Eyebar Steel, 822
- Welded and Seamless Steel Pipe, 823
- Welded Wire Fabric for Concrete Reinforcement, 821
- Zinc Coated Steel Sheets for use In Manufacturing Traffic Signs, 828

Milling of Asphalt Pavement Surfaces, 215

- Basis of Payment, 217
- Construction, 215
- Description, 215
- Method of Measurement, 217
- Pay Items, 217

Miscellaneous Materials, 855

- Asphaltum Base Paint for Tree Surgery, 891
- Bentonite, 977
- Calcium Chloride, 855
- Clay or Shale Brick, 884
- Concrete Brick, 884
- Concrete Masonry Units, 884
- Concrete Repair Materials, 855
- Elastomeric Bearing Pads, 883
- Elastomeric Bearing Pads for Bridge Railing, 884
- Elastomeric Gasket and Sealing Material, 892
- Fertilizers, 888
- Gabions, 886
- Ground Agricultural Limestone, 887
- Hydrated Lime, 855
- Inoculating Bacteria, 890
- Matting for Erosion Control, 886
- Miscellaneous Items for Landscape Plantings, 891
- Mulch Material, 888
- Packaged Dry, Hydraulic-Cement Grout (Non-Shrink), 855
- Pavement Marking Material, 893
- Precast Concrete Median Barriers (Permanent), 885
- Precast Concrete Traffic Dividers, 884
- Precast Concrete Units for Manholes and Inlets, 884
- Preformed Fabric Pads, 883
- Reinforced Plastic or Reninforced Corrosion-Resistant Rubber Manhole Steps, 892
- Seed, 889
- Seedling Plants, 890
- Sodium Chloride, 855
- Traffic Safety Devices, 906
- Traffic Signal Materials and Equipment, 911
- Trees and Shrubs, 890
- Vines and Ground Cover Plants, 890
- Warning Devices, 855
- Water for use with Hydraulic Cement, 855
- Waterproofing Fabric, 855

Miscellaneous Provisions, 93

- Common Carrier Rates, 93
- Minimum Wage Determinations, 93
- Nondiscrimination of Employees (Governor's Executive Order), 93

Mitigation Devices, 570

- Basis of Payment, 570
- General, 570
- Pay Items, 570
- Placement, 570

Mobilization, 106

- Basis of Payment, 106
- Construction Methods, 106
- Description, 106
- Materials, 106
- Method of Measurement, 106
- Pay Item, 106

Open Graded Free Draining Base Course, 159

- Basis of Payment, 161
- Composition of Optional Stabilizing Mixtures, 159
- Curing, 161
- Description, 159
- Equipment, 160
- General, 159

- Maintenance, 161
- Materials, 159
- Method of Measurement, 161
- Mixing and Transporting Requirements, 160
- Pay Item, 161
- Placing, Spreading, and/or Compacting, 160
- Preparation and Batching of Materials, 160
- Testing, 159
- Tolerance, 161
- Weather and Seasonal Limitations, 160

Overhead Sign Structures, 617

- Basis of Payment, 628
- Description, 617
- Erection, 625
- Fabrication, 619
- Materials, 617
- Method of Measurement, 628
- Pay Items, 628
- Welding of Aluminum Alloys, 620

Overlaying of Portland Cement Concrete Bridge Decks, 737

- Basis of Payment, 759
- Construction Limitations and Requirements, 754
- Construction Methods, 747
- Description, 737
- Final Bridge Deck Finish, 758
- Materials, 737
- Method of Measurement, 758
- Pay Items, 759

Paints, Coatings, Oils, and Inks, 835

- Boiled Linseed Oil, 835
- Epoxy Mastic Maintenance Coating, 836
- Inks, 838
- Inorganic Zinc Rich Primer, 839
- Mineral Spirits, 835
- Organic Primer, 835
- Overcoat Systems, 838
- Repair of Damaged Galvanized Surfaces, 839
- Temporary White or Yellow Traffic Zone Paint, 841
- White or Yellow Fast-Dry Traffic Paint (Type II), 842
- Zinc Rich Low Voc System, 839

Pavement Markings, 696

- Description, 696
- Materials, 696
- Types of Pavement Markings, 696
- Pavement Preparation-Premarking, Coding, 698
- Application, 698
- Method of Measurement, 709
- Basis of Payment, 709
- Pay Items, 710

Piling, 455

- Accuracy of Driving, 456
- Basis of Payment, 460
- Defective Piles, 457
- Description, 455
- Determination of Bearing Values, 457
- Equipment for Driving, 455
- Extensions or “Build-Ups”, 459
- Materials, 455
- Method of Driving, 456
- Method of Measurement, 459
- Pay Items, 460
- Precast Concrete Piles, 457
- Predrilled Piling, 459
- Preparation for Driving, 455
- Prestressed Concrete Piles, 458
- Steel Piling, 458

Piling Walls, 428

- Basis of Payment, 431
- Corrosion Protection, 429
- Description, 428
- Drilling, 428
- Installation of Piles, 429
- Lagging and Backfilling, 430
- Materials, 428
- Method of Measurement, 431
- Painting, 430
- Pay Items, 431

Pipe Culverts, 365

- Backfilling, 371
- Basis of Payment, 376
- Bedding, 369
- Description, 365
- Elongation, 371
- Field Paving, 372
- General, 368
- Jacking Conduit, 374
- Laying and Joining, 370
- Materials, 365
- Method of Measurement, 375
- Pay Items, 377
- Relaid Conduit, 374
- Trench Excavation, 368

Plugging Gas, Oil, and Drilled Water Wells, 714

- Basis of Payment, 715
- Description, 714
- General, 714
- Materials, 714
- Method of Measurement, 715
- Pay Items, 715
- Plugging Drilled Water Wells, 714
- Plugging Gas and Oil Wells, 714

Pneumatically Applied Mortar, 496

- Basis of Payment, 498
- Cleaning, 496
- Description, 496
- Materials, 496
- Method of Measurement, 498
- Pay Items, 498
- Placing Reinforcing Mesh, 496
- Placing Shotcrete, 497
- Proportioning and Mixing, 496

Portland Cement Concrete Pavement, 219

- Adverse Weather Condition, 246
- Basis of Payment, 248
- Curing, 241
- Description, 219
- Equipment, 225
- Final Strike-Off, Consolidation and Finishing, 238
- Handling, Measuring, and Batching Materials, 230
- Materials, 219
- Method of Measurement, 247
- Mixing Concrete, 231
- Opening Pavement To Traffic, 244
- Pavement Widening, 246
- Pay Items, 249
- Placing Concrete, 232
- Preparation of Grade, Setting Forms, and Conditioning of Subgrade, 229
- Proportioning, 220
- Protection of Pavement, 244
- Removing Forms, 243
- Sealing Joints, 243
- Strike-Off of Concrete and Placement of Reinforcement, 233
- Surface Tests, 240
- Tolerance in Pavement Thickness, 245

Precast Concrete Traffic Dividers, 424

- Basis of Payment, 424
- Construction Methods, 424
- Description, 424
- Materials, 424
- Method of Measurement, 424
- Pay Item, 424

Preformed Elastomeric Joint Sealer, 499

- Basis of Payment, 499
- Description, 499
- Installation, 499
- Materials, 499
- Method of Measurement, 499
- Pay Item, 499
- Preparation of Joint, 499

Prestressed Concrete Members, 340

- Concrete, 343
- Construction of Deck, 363
- Curing, 356
- Dimensional Tolerances, 360
- Description, 340
- Finishing, 358
- Handling, Storing, Transporting, and Erection, 362
- Materials, 340
- Measurement and Payment, 363
- Pay Items, 364
- Plant Requirements and Approval, 341
- Prestressing, 353
- Reinforcement, 343
- Working Drawings, 342
- Workmanship, 358

Procecuton and Progress, 61

- Completion Dates, 72
- Default and Termination of Contract, 73
- Determination and Extension of Contract, 68
- Field Office Overhead, 76
- Home Office Overhead, 76
- Limitation of Operations, 67
- Character of Workers, 67
- Notice to Proceed, 61
- Prosecution of the Work, 61
- Subletting of Contract, 60
- Termination of Contract for Convenience of the State, 74

Project Markers, Right-Of-Way Markers, Survey Markers, and Outlet Markers, 558

- Concrete Survey Markers, 558
- Description, 558
- Materials, 558
- Metal (Sign-Post) Project Markers, 559
- Right-Of-Way Markers, 558

Railings, 461

- Aluminum Railing, 461
- Basis of Payment, 463
- Description, 461
- Ferrous Metal Railings, 461
- Grouting of Anchor Bolts, 462
- Line and Grade, 461
- Materials, 461
- Method of Measurement, 462
- Pay Items, 463

Reinforced Soil Slopes, 581

- Acceptance, 586
- Backfill Placement, 585
- Basis of Payment, 586
- Description, 581
- Erosion Control Material Placement, 586
- Foundation Preparation, 585
- Geosynthetic Installation, 585
- Materials, 581
- Method of Measurement, 586
- Pay Item, 586

Reinforcing Steel, 336

- Bar Splices, 337
- Basis of Payment, 339
- Bending of Reinforcing Bars, 336
- Description, 336
- Fabric Reinforcement, 338
- Materials, 336
- Method of Measurement, 338
- Order Lists, 336
- Pay Items, 339
- Placing and Fastening, 337
- Protection of Materials, 336

Re-Sealing Concrete Pavement Joints, 267

- Basis of Payment, 268
- Construction Methods, 267
- Description,
- Materials, 267
- Method of Measurement, 268
- Pay Items, 268

Retaining Wall Systems, 511

- Basis of Payments, 528
- Description, 511
- Design Criteria, 511
- General, 511
- Materials, 514
- Method of Measurement, 527
- Pay Items, 528
- Submittals, 512

Right-Of-Way Fence, 405

- Basis of Payment, 412
- Clearing, Grubbing, and Trench Excavation, 406
- Concrete Footers, 406
- Description, 405
- Electrical Grounds, 411
- Erection of Fencing Materials, 409
- General, 406
- Junctions With Existing Fences, 411
- Materials, 405
- Method of Measurement, 412
- Paints and Painting, 411
- Pay Items, 412
- Spacing and Setting Posts, 407
- Temporary Fence, 411

Roadside Sign Supports, 607

- Basis of Payment, 615
- Description, 607
- Erection, 610
- Fabrication, 609
- Materials, 607
- Method of Measurement, 612
- Pay Items, 616

Roadway Lighting, 668

- Backfill, 689
- Basis of Payment, 694
- Cable-In-Duct, 690
- Cables, 689
- Concrete, 688
- Conduit, 688
- Description, 668
- Foundations, 692
- General, 688
- Grounding, 692
- Lighting Supports, 691
- Luminaires, 689
- Manholes and Junction Boxes, 689
- Materials, 668
- Method of Measurement, 694
- Pay Items, 695
- Testing, 693

Roller Compacted Concrete, 282

- Basis of Payment, 295
- Compaction, 293
- Curing, 294
- Description, 282
- Equipment and Tools, 287
- Finishing, 294
- Handling, Measuring, and Batching Materials, 290
- Joints, 293
- Maintenance, 295
- Materials, 282
- Method of Measurement, 295
- Mixing RCC, 290
- Opening to Traffic, 295
- Pay Item, 295
- Placing RCC, 291
- Preparation of Grade and Conditioning of Subgrade or Base, 290
- Proportioning, 283
- Testing, 284

Sanitary Sewers, 728

- Abandoning Manholes, 735
- Adjusting Manholes, 735
- Backfilling, 732
- Basis of Payment, 736
- Bedding, 731
- Capping Manholes, 735
- Casing Pipe, 732
- Description, 728
- General, 728
- Jointing, 732
- Junction Boxes, 735
- Manhole, 735
- Materials, 728
- Method of Measurement, 735
- Pay Items, 736
- Pipe Laying, 731
- Reconstructed Sanitary Sewer, 735
- Testing Installations, 732
- Thrust Blocking and Anchorage, 732
- Trench Excavation, 730

Scope of Work, 19

- Alteration of Plans or Character of Work, 19
- Bridge Plate, 21
- Differing Site Conditions, 21
- Extra Work, 19
- Final Clean Up, 21
- Funding Source Identification Signs, 26
- Intent of Contract, 19
- Maintenance of Traffic, 20
- Significant Changes in the Character of Work, 23
- Suspension of Work Ordered by the Engineer, 23
- Temporary Structures, 19

Sealing Cracks in Concrete Pavement, 252

- Description, 252
- Materials, 252
- Preparation of Material before use, 252
- Preparation of Joints for Sealing, 252
- Equipment for Applying Sealer, 253
- Placement Requirements, 253
- Method of Measurement, 253
- Basis of Payment, 253

- Pay Item, 253

Seeding and Mulching, 589

- Applying Mulch and Fertilizer, 592
- Area Preparation for Seeding and Mulching, 590
- Basis of Payment, 594
- Description, 589
- Maintenance of Seeded and Mulched Areas, 593
- Materials, 589
- Method of Measurement, 594
- Pay Items, 594
- Season of Work, 589
- Second and Third Step Seeding, Fertilizing and Mulching, 593
- Sowing Seed, 590

Seedling Planting, 605

- Basis of Payment, 606
- Care During and After Delivery, 606
- Description, 605
- Materials, 605
- Method of Measurement, 606
- Pay Item, 606
- Planting Seedling Plants, 605
- Replacement of Seedling Plants, 605

Sewer and Waterline Material, 983

- Bedding Material, 984
- Casing-Pipe (Steel), 984
- Copper Service Line, 983
- Fine Aggregate, 984
- Fire Hydrants, 984
- Gate Valves, 983
- Iron Pipe, 983
- Meters, 984
- Miscellaneous Steel (Clamps, Rods, Etc.), 984
- Plastic Pipe (Polyethylene), 983
- Plastic Pipe (PVC), 983
- Valve Boxes, 983

Shop Painting Metal Structures, 772

- Description, 772
- General, 772
- Paint Application Requirements, 773
- Submittals, 777

Shoulders and Ditches, 150

- Basis of Payment, 150
- Description, 150
- Ditches, 150
- Materials, 150
- Method of Measurement, 150
- Pay Item, 151
- Shoulders, 150

Sidewalks, 413

- Description, 413
- Dry Bed, 415
- Expanding Joints, 415
- Finishing, 416
- Forms, 415
- Materials, 413
- Mixing and Placing Concrete, 415
- Subgrade Preparation, 415

Sign Lighting, 629

- Basis of Payment, 638
- Description, 629
- General, 633
- Materials, 629
- Method of Measurement, 638
- Pay Item, 638

Slope and Foundation Protection, 141

- Basis of Payment, 145
- Description, 141
- Foundation Protection, 143
- Method of Measurement, 144
- Pay Items, 145
- Slope Protection, 141
- Sodium Chloride, 711, 837

Special Rock Fill, 140

- Basis of Payment, 140
- Construction Methods, 140
- Description, 140
- Materials, 140
- Method of Measurement, 140
- Pay Item, 140

Steel Grid Flooring, 480

- Arrangement of Sections, 480
- Basis of Payment, 482
- Concrete Filler, 481
- Connection to Supports, 481
- Description, 480
- Field Assembly, 481
- Materials, 480
- Method of Measurement, 481
- Painting, 481
- Pay Items, 482
- Provision of Camber, 480
- Welding, 481

Steel Structures, 432

- Assembly, 444
- Basis of Payment, 454
- Erection, 450
- Fabrication, 435
- General, 432
- Materials, 434
- Measurement and Payment, 452
- Pay Items, 454
- Working Drawings, 433

Stone and Crushed Aggregate, 801

- Aggregate for Base or Subbase Course, 801
- Dumped Rock Gutter, 801
- Filter Material, 804
- Shot Rock, 804
- Special Rock Fill, 801
- Stone for Gabions, 801
- Stone for Masonry, 801
- Stone for Riprap, 801

Structural Concrete, 297

- Adverse Weather Conditions, 318
- Basis of Payment, 334
- Curing and Protecting Concrete, 328
- Description, 297
- Equipment and Tools, 308
- Finishing Concrete Surfaces, 323

- Forms, 311
- Handling, Measuring, and Batching of Materials, 310
- Materials, 297
- Method of Measurement, 334
- Mixing, 310
- Pay Items, 335
- Placing Concrete, 319
- Proportioning, 299
- Protective Surface Treatment, 330
- Testing, 306

Structure Rock, and Wet Excavation, 135

- Backfilling, 136
- Basis of Payment, 138
- Cofferdams, 135
- Description, 133
- Drainage, 136
- General, 135
- Inspection, 135
- Material, 135
- Materials, 133
- Method of Measurement, 137
- Pay Items, 139
- Preparation of Foundation, 136
- Pumping, 135

Subgrade Preparation, 149

- Basis of Payment, 149
- Construction Methods, 149
- Description, 149
- Materials, 149
- Method of Measurement, 149
- Pay Item, 149

Surface Preparation and Powder Coating of New Galvanized Steel for Highway Signing and Lighting Structures, 790

- Basis of Payment, 792
- Environmental Conditions, 791
- General, 790
- Inspection, 792
- Powder Coating, 791
- Powder Coating Application, 792
- Products, 790
- Repair of Damaged Coating, 792
- Surface Preparation and Powder Coating, 791

Surface Treatments, 183

- Application of Aggregate, 186
- Application of Bituminous Material, 186
- Basis of Payment, 189
- Brooming and Rolling, 186
- Cleaning and Sweeping, 186
- Description, 183
- Equipment, 185
- Joints, 187
- Materials, 183
- Method of Measurement, 188
- Pay Items, 189
- Preparing and Repairing Existing Surface, 186
- Protection of Pavement and Traffic Control, 187
- Sequence of Operations and Quantities of Materials, 187
- Weather Restrictions, 185

Tack Coat, 190

- Application of Asphalt Material, 191
- Application of Cover Aggregate, 192
- Basis of Payment, 193
- Cleaning and Sweeping, 191
- Description, 190
- Equipment, 191
- Joints, 192
- Materials, 190
- Method of Measurement, 193
- Pay Item, 193
- Preparing and Repairing Base or Existing Surfaces, 191
- Protection of the Pavement and Traffic Control, 192
- Quantities of Materials, 192
- Weather Restriction, 190

Temporary Pollution Control, 571

- Basis of Payment, 580
- Description, 571
- General Requirements, 572
- Materials, 571
- Method of Measurement, 578
- Pay Items, 580
- Preconstruction Conference, 572
- Seeding and Mulching, 574

Three-Sided Reinforced Concrete**Bridge/Culvert, 469**

- Basis of Payment, 479
- Construction Methods, 476
- Description, 469
- Design Criteria, 469
- General, 469
- Materials, 472
- Method of Measurement, 478
- Pay Items, 479
- Submittals, 471

Timber Bridge Structures, 483

- Basis of Payment, 495
- Construction Methods, 490
- General, 483
- Materials, 483
- Method of Measurement, 494
- Pay Items, 495
- Quality Control, 489
- Shop and Erection Drawings, 490

Traffic Safety Devices, 711

- Basis of Payment, 713
- Construction Methods, 711
- Description, 711
- Method of Measurement, 713
- Pay Item, 713

Traffic Signals, 641

- Basis of Payment, 654
- Cabinets, 647
- Conduit, 648
- Description, 641
- Excavating and Backfilling, 642
- Foundations, 643
- General, 642
- Junction Boxes, 649
- Loop Traffic Detectors, 644
- Maintaining Traffic, 642

- Materials, 641
- Messenger Cable, 648
- Method of Measurement, 653
- Pay Items, 655
- Power Service, 652
- Removing and Replacing Improvements, 642
- Removing Existing Signal Equipment, 642
- Signal Heads, 645
- Support Structures, 648
- Testing, 652
- Wiring, 650

Traffic Signs and Delineators, 656

- Basis of Payment, 666
- Description, 656
- Erection, 662
- Fabrication, 659
- Materials, 656
- Method of Measurement, 665
- Pay Items, 667

Tree and Shrub Planting, 598

- Basis of Payment, 603
- Care After Delivery, 599
- Care and Replacement of Plants, 602
- Clean-Up After Planting, 601
- Description, 598
- Digging Holes for Plants, 599
- Inspection and Delivery of Plant Material, 598
- Materials, 598
- Method of Measurement, 602
- Mulching, 601
- Pay Items, 603
- Plant Backfill, 599
- Planting, 600
- Pruning, 601
- Rain Basins, 601
- Staking and Guying, 601
- Wrapping and Foliage Protection, 601

Tunnel Liner Plate Pipe, 425

- Basis of Payment, 426
- Description, 425
- Field Paving, 426
- General, 426
- Grouting, 426
- Materials, 425
- Method of Measurement, 426
- Pay Items, 427
- Tunneling and Lining, 426

Underdrains, 383

- Basis of Payment, 389
- Construction Methods, 385
- Description, 383
- Materials, 383
- Method of Measurement, 388
- Pay Items, 390

Vine and Ground Cover Planting, 595

- Basis of Payment, 597
- Care During and After Delivery, 596
- Care of Vines and Ground Cover, 596
- Description, 595
- Materials, 595
- Method of Measurement, 596
- Pay Items, 597
- Planting of Vines and Ground Cover Plants, 595
- Replacement of Vines and Ground Cover, 596

Water, 557

- Basis of Payment, 557
- Construction Methods, 557
- Description, 557
- Materials, 557
- Method of Measurement, 557
- Pay Item, 557

Waterline Installation, 716

- Basis of Payment, 726
- Casing Pipe, 725
- Description, 716
- Fire Hydrants, 725
- Gate Valves and Valve Boxes, 725
- General, 716
- House Connection, 725
- Materials, 716
- Meters, Meter Boxes, and Special Valves and Appurtenances, 725
- Method of Measurement, 726
- Pay Items, 727
- Special Structures, 725

Waterproofing, 466

- Basis of Payment, 468
- Dampproofing, 467
- Description, 466
- Details, 468
- Materials, 466
- Membrane Waterproofing, 467
- Method of Measurement, 468
- Pay Items, 468
- Preparation of Surface, 466
- Protection Course, 468

Winter Grade Asphalt Patching Mixture, 213

- Basis of Payment, 214
- Description, 213
- Materials, 213
- Method of Measurement, 214
- Mixing Proportions, 213
- Pay Item, 214
- Preparation of Mix, 213

Wood Materials, 833

- Common Lumber, 834
- Plywood, 834
- Preservative Treatment, 833
- Service and Lighting Poles, 834
- Species and Grade, 833
- Structural Materials, 833
- Wood Posts, 833