



Pipe Installation & Inspection

Best Practices



DONALD E. MCNUTT, PE
PRESIDENT
TORRIDON GROUP LLC
DEMCNUTT@OUTLOOK.COM
803-317-3329

Special Thanks to:

PERMATILE

CONCRETE PRODUCTS COMPANY

Demand the best, Demand Permatile

800-662-5332 | permatile.com

Rinker

MATERIALS®

A QUIKRETE® COMPANY



DONALD E. McNUTT, PE
PRESIDENT
TORRIDON GROUP LLC
DEMCNUTT@OUTLOOK.COM
803-317-3329



Shipping & Handling

Trucking and Storage Onsite

Installation

Unloading



Installation

Unloading



Installation

Unloading



Installation

Unloading



Installation

Handling

- Use lifting devices.
- Use of construction equipment should be monitored closely.
- Protect pipe when using self-unloaders.
- Stockpile pipe on site in accordance to manufacturers recommendations.
- Minimize pipe movements on site.
- Store along trench whenever possible

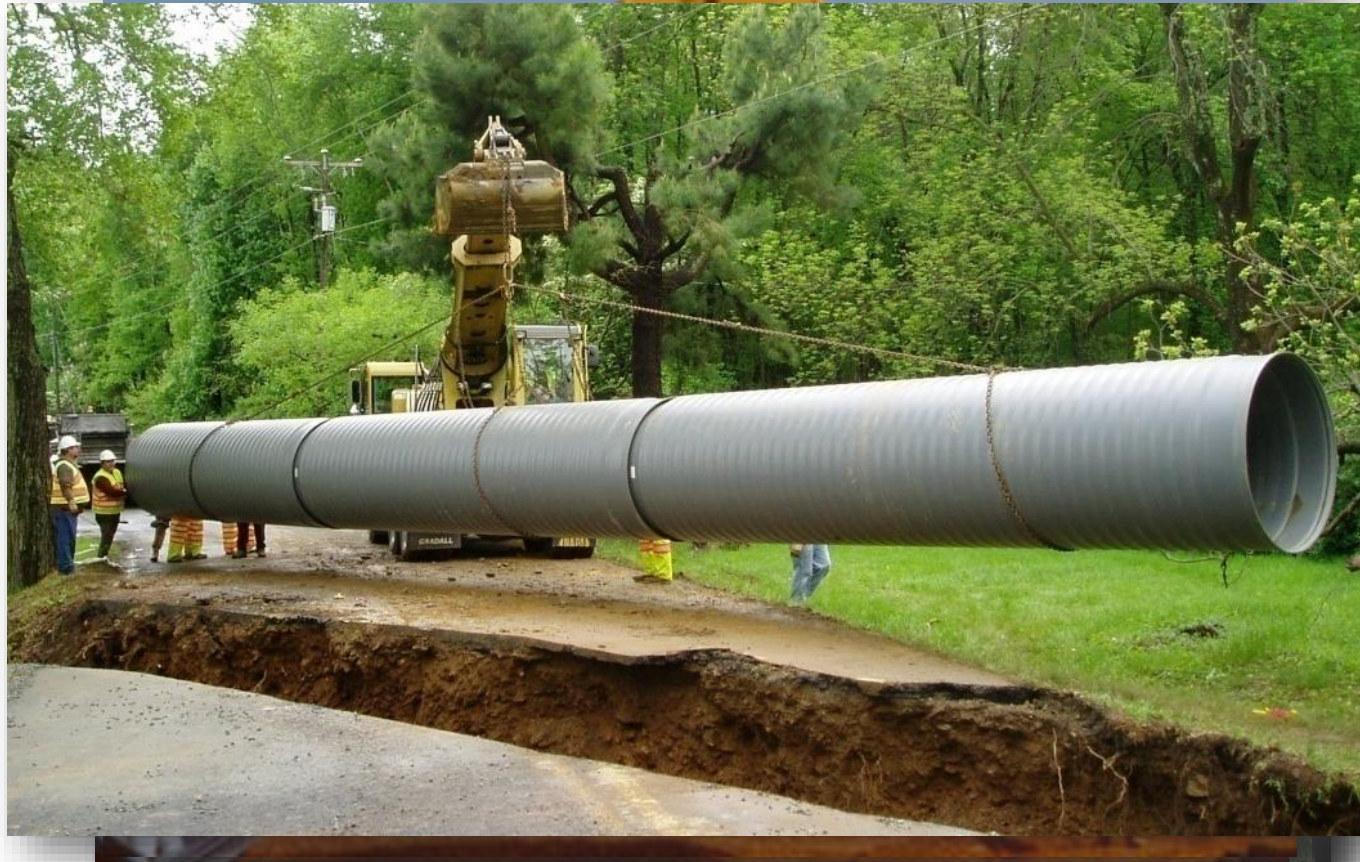


Installation

Handling



**Good
Practice**



**B a d
Practice**

Trenches

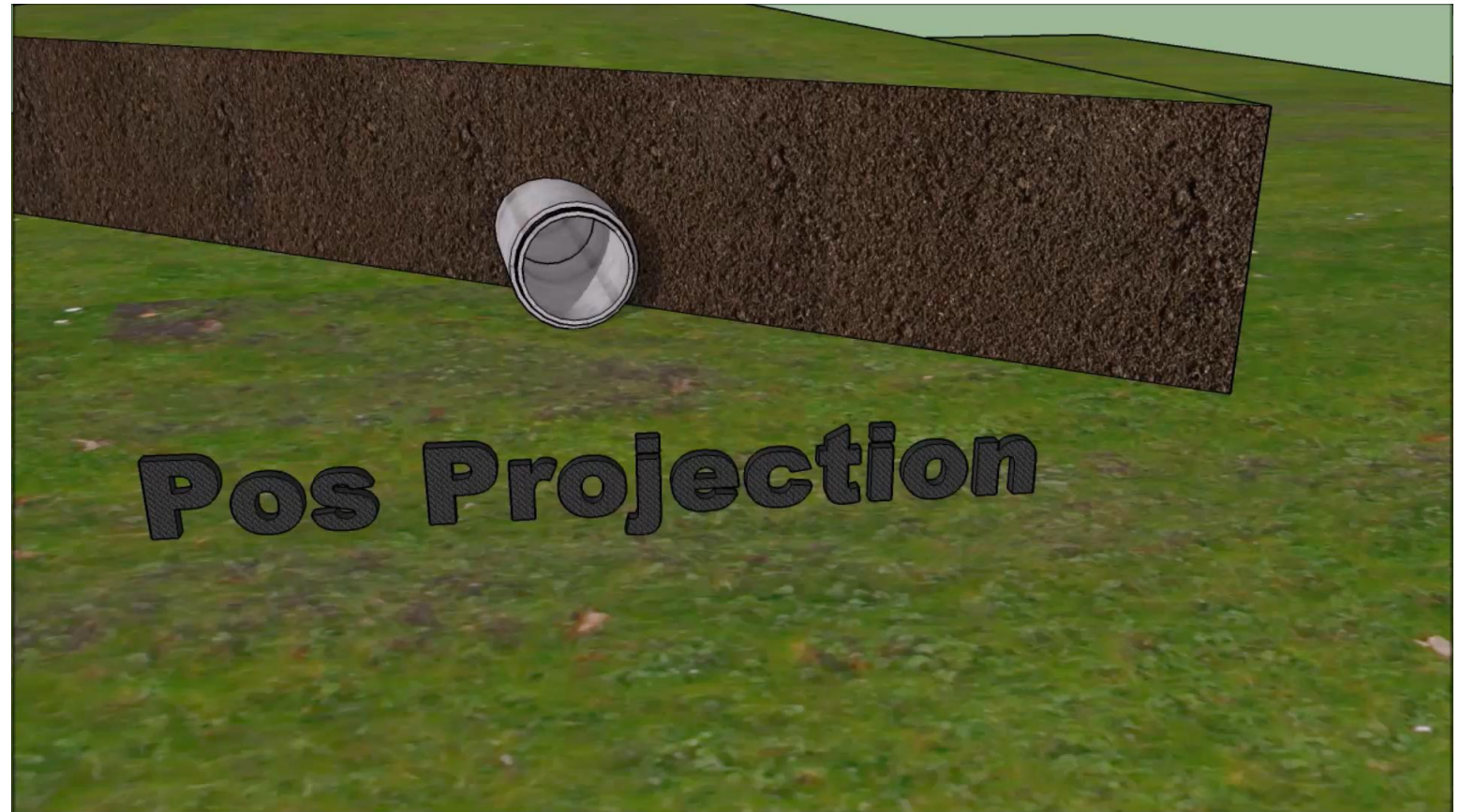
Introduction to Trenches



Trench Basics

Installation Options

- **Narrow Trench**
 - Trench walls provide support to the pipe
- **Negative Projection**
 - Smaller trench walls provide some support
- **Positive Projection**
 - No in situ soils support
- **Jacked/Tunneled**
 - In Situ soils provide the greatest soil arch & support

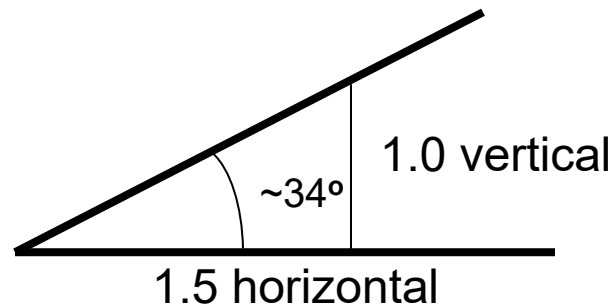


Trench Safety

Construction Concerns

OSHA 29 CFR 1926 Subpart P:

- If the trench is in **stable rock** or **less than 5 feet deep** no protective system is required
- If it is otherwise:
 - Flatten the side slopes to a 1.5 horizontal to 1 vertical or about 34 degrees.

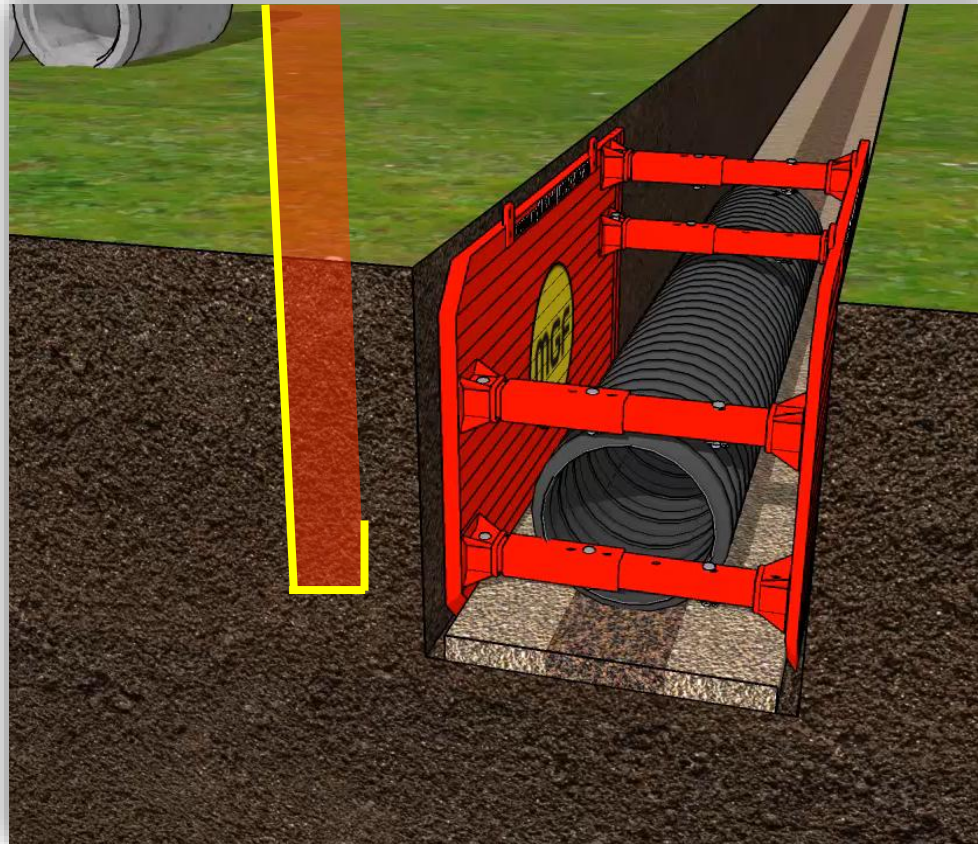


- Use a protective system:
 - **Trench box, shoring, shields (Designed by Engineer >20')**

Trench Basics

Trench Boxes

- Box length
- Will the box be lifted & placed, or pulled?



Typical Pipe Lengths

RCP – 8'

HDPE – 20' or 13'

PP – 20' or 13'

CMP – 20'

Trench Basics

Trench Widths



Trench Safety

Construction Concerns

If spoil piles are placed too close to the trench, the weight of the soil can cause collapse of the trench wall. Spoils piles should be placed more than 2' from the edge of the trench.



Trench Safety

Construction Concerns



A yellow excavator is shown in a construction site, with its bucket lowered into a deep trench. An operator wearing a white hard hat and a high-visibility vest is visible in the cab. In the foreground, another worker wearing a green hard hat with the word 'PIPE' on it and a high-visibility vest is looking up at the excavator's bucket. The background shows a wooded hillside with bare trees.

Excavation

Preparing the Trench

Excavation

Best Practices



- Safety – Safety - Safety
- Consider bedding thickness
- Don't over/under excavate
- Designed trench width



Excavation

Dewatering



Excavation

Dewatering

Buoyancy:

Relative Densities

$$\gamma_{\text{HDPE}} = 60 \text{ pcf}$$

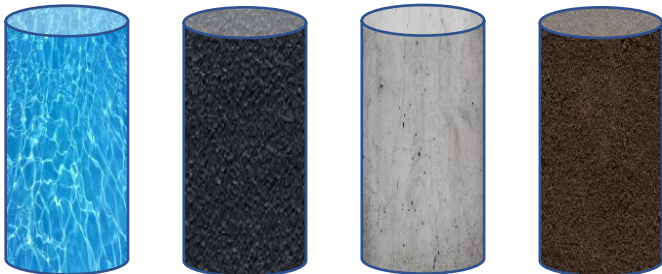
$$\gamma_{\text{H}_2\text{O}} = 62.4 \text{ pcf}$$

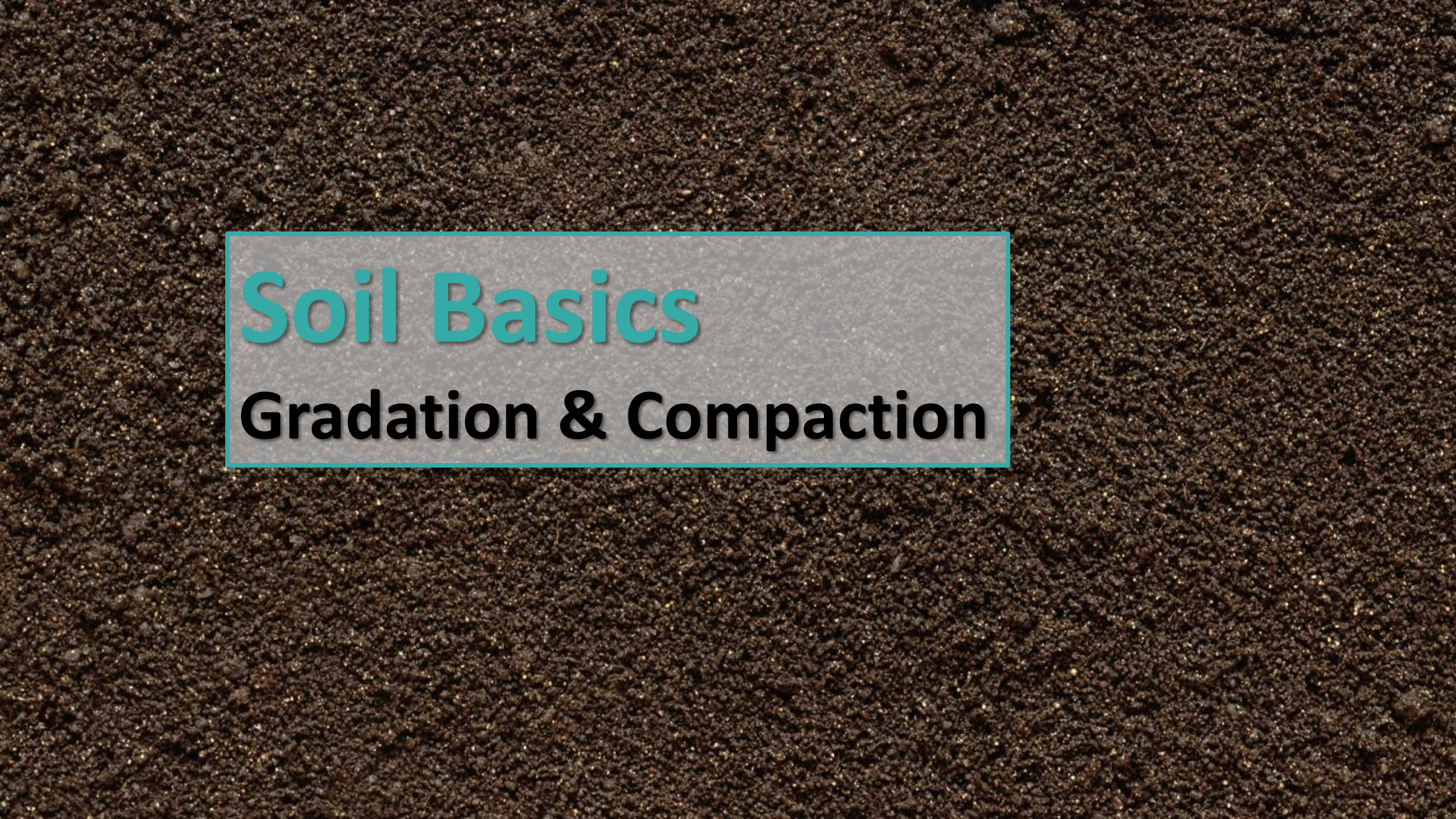
$$\gamma_{\text{SOIL}} = 120 \text{ pcf}$$

$$\gamma_{\text{RCP}} = 150 \text{ pcf}$$



$$\text{Flotation Force} \leq \text{Soil Resistance} + \text{Pipe Weight}$$



The background of the entire image is a close-up, high-resolution photograph of dark brown soil. The soil has a granular texture with many small, light-colored particles (possibly sand or organic matter) visible against the darker background. The lighting is even, highlighting the texture of the soil.

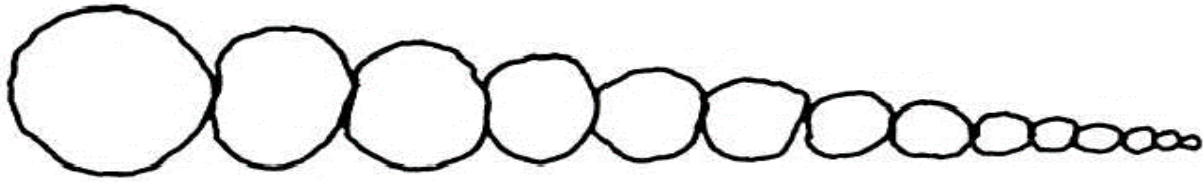
Soil Basics

Gradation & Compaction

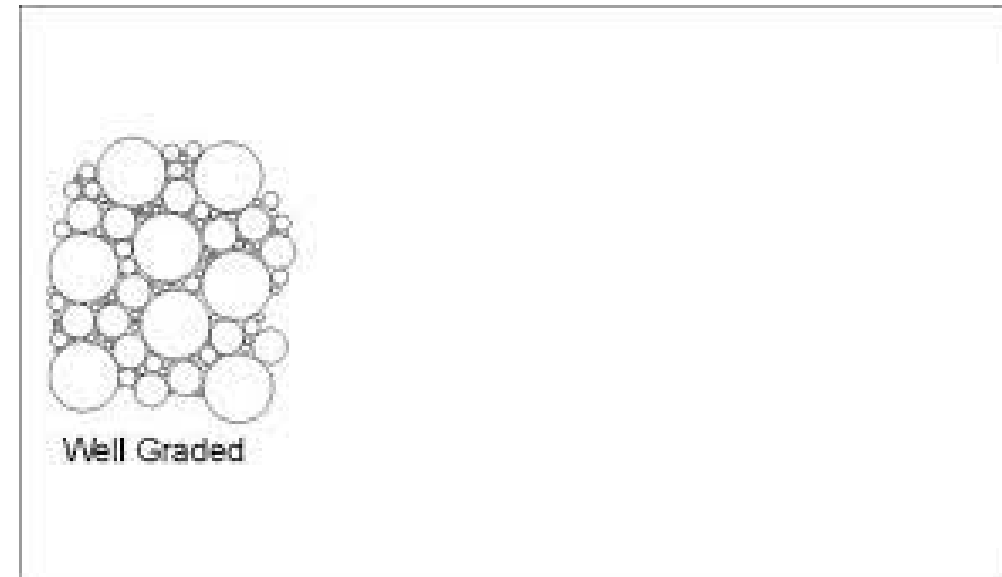
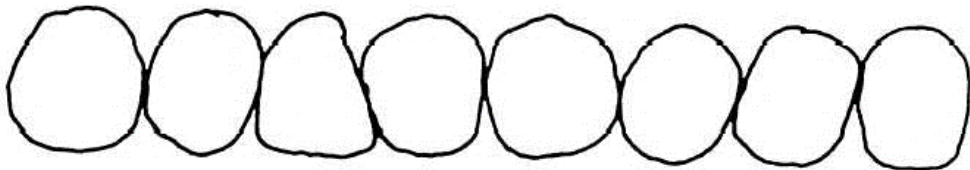
Soils Basics

Gradation

Well-graded soil has all sizes of material present from the No. 4 sieve to the No. 200 sieve.

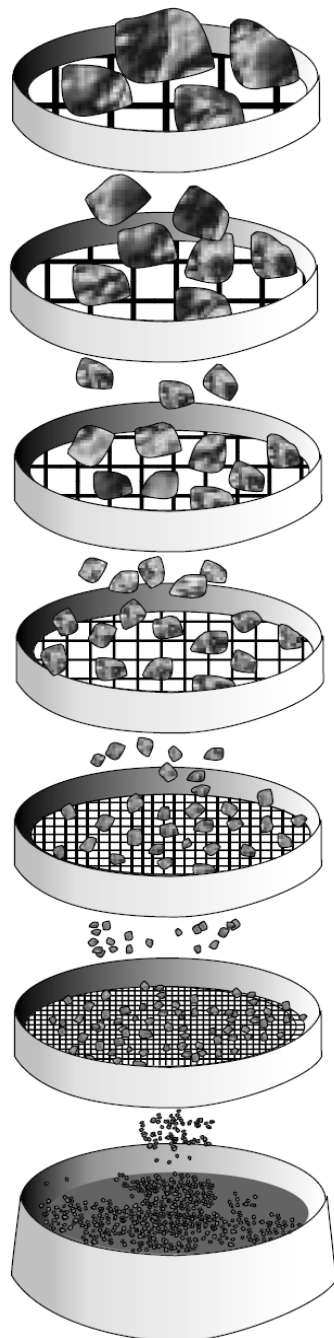


Poorly-graded soil may be **uniformed-graded** or **gap-graded**.



Soils Basics

Gradation



USCS System	
Boulders	Boulders – 12"+
Cobbles	Cobbles – 3" to 12"
Gravel	<u>Gravel</u>
	Fine Gravel - peas to marbles
	Course Gravel - grapes to tennis balls
Sand	<u>Sand</u>
	Fine Sand - table salt
	Medium Sand - Virginia Beach
	Course Sand - ice cream salt
Clay and silt	<u>Fines</u>
	Clay - talcum powder (plasticity over a range of moisture contents) (resistance to crushing when air dry)
	Silt - talcum powder (very little plasticity when moist) (little resistance to crushing when air is dry)

Soils Basics

Gradation

- Best** ➤ Crushed rock with 100% passing 3 in sieve, less than 25% passing 3/8 in sieve, and less than 12% passing the No. 200 sieve
- Well graded gravel, poorly graded gravel, well graded sand, poorly graded sand
- Silty gravel, clayey gravel, clayey sand, silty sand
- Sandy lean clay, sandy silt, sandy silty clay with 30% or more sand and/or gravel
- Lean clay, silt, silty clay containing less than 30 sand/gravel
- Worst** ➤ Organic silt, organic clay, peat, fat clay, elastic silt

assumes no cobbles or boulders, optimum moisture and in-place density of 95% Proctor

Soils Basics

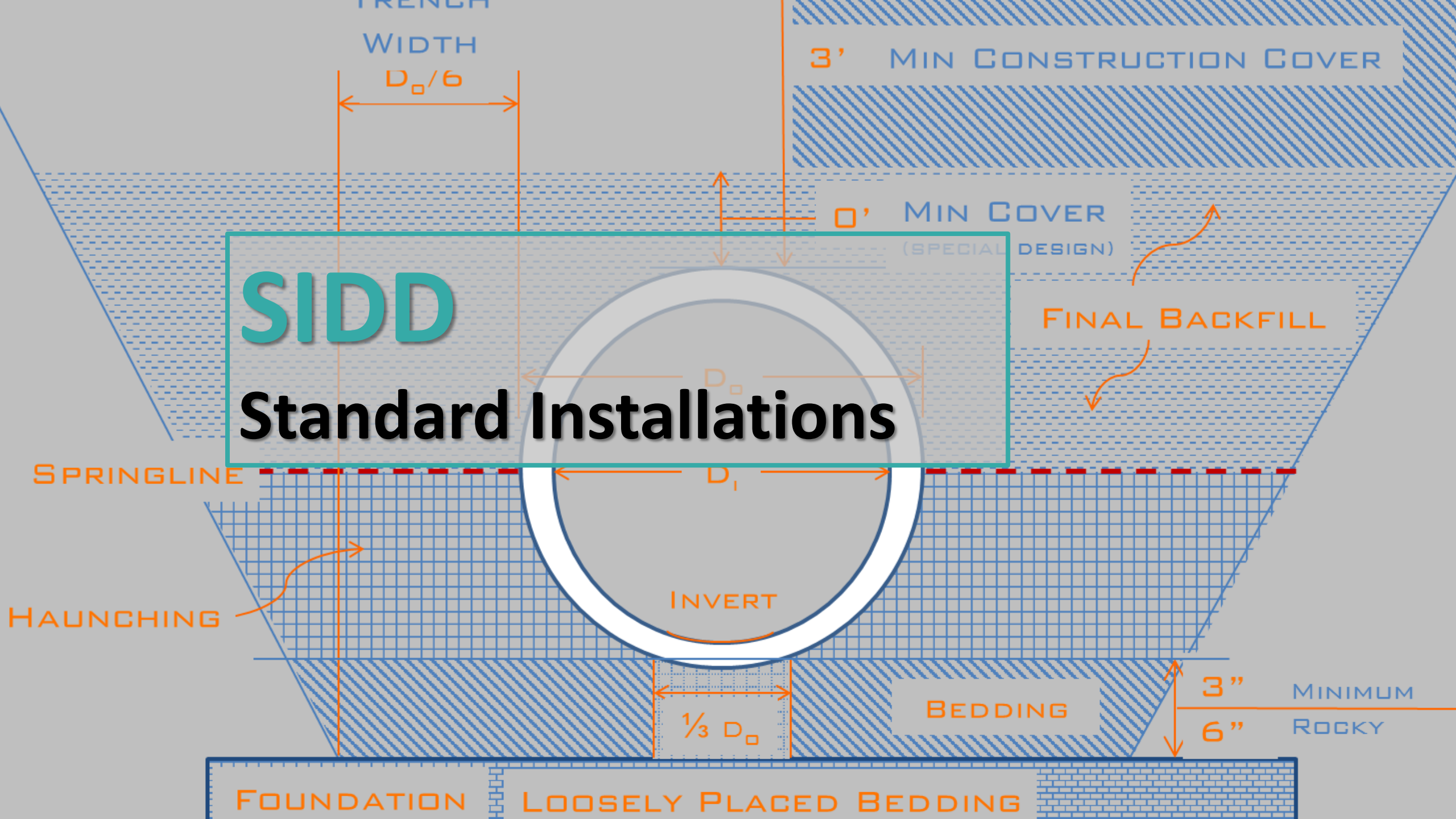
Compaction

- Densification of soil by reduction of air in voids
- More difficult for water to migrate
- Reduce subsequent settling under loading
- Measured in dry unit weight (dry density)
- Increases shear strength of soil



SIDD

Standard Installations



RCP Standard Installations Types 1 - 4:

SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	D ₀ /24 minimum; not less than 3 in. If rock foundation, use D ₀ /12 minimum; not less than 6 in.	95% Category I	Undisturbed natural soil with firmness equivalent to the following placed soils: 90% Category I, 95% Category II, or 100% Category III, or embankment to the same requirements
Type 2	D ₀ /24 minimum; not less than 3 in. If rock foundation, use D ₀ /12 minimum; not less than 6 in.	90% Category I or 95% Category II	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 3	D ₀ /24 minimum; not less than 3 in. If rock foundation, use D ₀ /12 minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 4	No bedding required, except if rock foundation, use D ₀ /12 minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

RCP Standard Installations Types 1 - 4:

SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
CLSM	D ₀ /24 minimum; not less than 3 in. If rock foundation, use D ₀ /12 minimum; not less than 6 in.	Controlled Low Strength Material	Undisturbed natural soil with firmness equivalent to the following placed soils: 90% Category I, 95% Category II, or 100% Category III, or embankment to the same requirements
Crushed Aggregate	D ₀ /24 minimum; not less than 3 in. If rock foundation, use D ₀ /12 minimum; not less than 6 in.	95% Standard Proctor	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Granular Material	D ₀ /24 minimum; not less than 3 in. If rock foundation, use D ₀ /12 minimum; not less than 6 in.	95% Standard Proctor	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements

Trench Requirements

WVDOH – 604 & DD-502 – Rigid Pipe



MINIMUM TRENCH WIDTH

DIAMETER 18" TO = 36"

DIAMETER >36" TO 96"

CLSM

18"

24"

6"

4' MIN CONSTRUCTION COVER

1' MIN COVER
(SEE DD-502)

FINAL BACKFILL ZONE
RANDOM MATERIAL $\leq 3"$ WITH
MAX 20% RETAINED ON 1-1/2"
CRUSHED AGGREGATE
CLSM

SPRINGLINE

INITIAL BACKFILL ZONE
CLSM

CRUSHED AGGREGATE

GRANULAR MATERIAL $\leq 1-1/2"$

MAXIMUM 4" LAYERS

SECTION 604.4

INVERT

$\frac{1}{3} D_o$

BEDDING

3" MINIMUM
6" ROCKY OR UNYIELDING

FOUNDATION

LOOSELY PLACED BEDDING (GRANULAR OR CRUSHED)

Fill Height Tables

WVDOH – 604 & DD-502 – Concrete Pipe



REINFORCED CONCRETE PIPES

Maximum and minimum cover heights are listed for Class III through Class V concrete pipe for backfilling with CLSM, crushed aggregate, and granular material, as listed in the WVDOH Specifications. Each of the three tables are titled by the backfill material and the corresponding backfill designation Type (1, 2, or 3) in accordance with the American Concrete Pipe Association. For fill heights that exceed those given for Class V pipe, contact a supplier for a special design. Values listed are from *American Concrete Pipe Association Fill Height Tables*, which are based on Section 12.10.4.3 of the *AASHTO LRFD Bridge Design Specifications, 8th Edition, 2017*. See WVDOH Specifications and Standard Details for further information on installation.

For Railroad installation, hydraulic and structural requirements for culverts are governed by the "Public Projects Manual" for each railroad, which can be found online.

MAXIMUM FILL HEIGHT

TYPE 1 – CLSM INSTALLATION

CIRCULAR RCP				
	Diameter (Inches)	Maximum Fill Heights (Feet)		
		Class III	Class IV	Class V
Circular pipes are also available in diameters of 21, 27, 30, 33, 42, 54, 66, 78, 90 and 102.	18	23	35	52
	24	23	35	53
	36	23	34	52
	48	23	34	52
	60	22	34	51
	72	22	33	51
	84	21	33	50
	96	21	32	50
	108	21	32	49
	120	20	31	49
	132	20	31	48
	144	19	30	47

Example: 48" Diameter RCP Under 15' of Fill

TYPE 2 – CRUSHED AGGREGATE INSTALLATION

MAXIMUM COVER FOR EMBANKMENT OR TRENCH INSTALLATION:

CIRCULAR RCP				
	Diameter (Inches)	Maximum Fill Heights (Feet)		
		Class III	Class IV	Class V
Circular pipes are also available in diameters of 21, 27, 30, 33, 42, 54, 66, 78, 90 and 102.	18	17	26	40
	24	17	26	40
	36	17	26	40
	48	17	26	40
	60	17	26	40
	72	17	25	39
	84	16	25	39
	96	16	25	39
	108	16	25	39
	120	16	25	39
	132	16	25	39
	144	15	25	39

TYPE 3 – GRANULAR MATERIAL

MAXIMUM COVER FOR EMBANKMENT OR TRENCH INSTALLATION:

CIRCULAR RCP				
	Diameter (Inches)	Maximum Fill Heights (Feet)		
		Class III	Class IV	Class V
Circular pipes are also available in diameters of 21, 27, 30, 33, 42, 54, 66, 78, 90 and 102.	18	14	21	31
	24	14	21	32
	36	13	20	31
	48	13	20	31
	60	13	20	31
	72	13	20	30
	84	12	19	30
	96	12	19	30
	108	12	19	30
	120	12	19	30
	132	11	19	30
	144	11	19	30

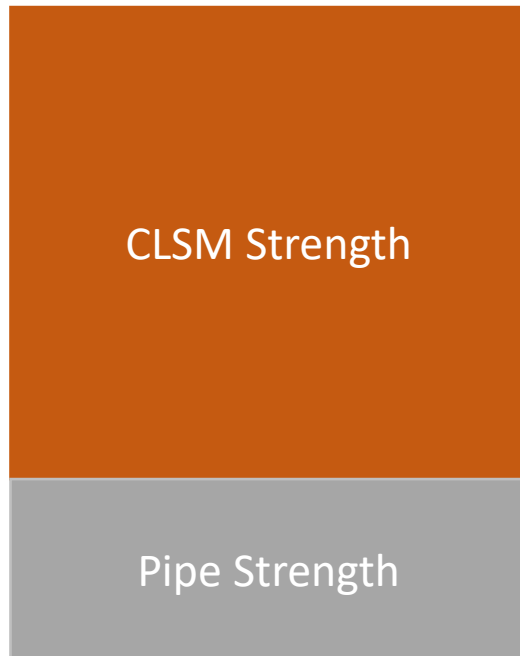
Standard Installations

Soil Strength – Pipe Strength – Rigid Pipe



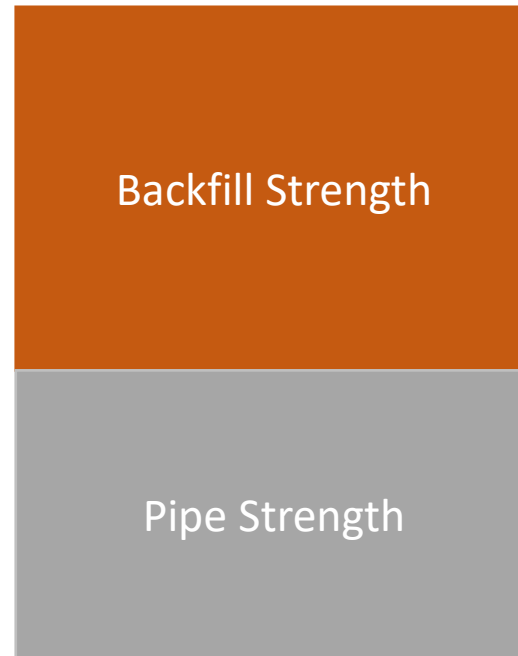
Example – 48" Diameter RCP under 15' of Fill

CLSM



Class III

Crushed Aggregate



Class III

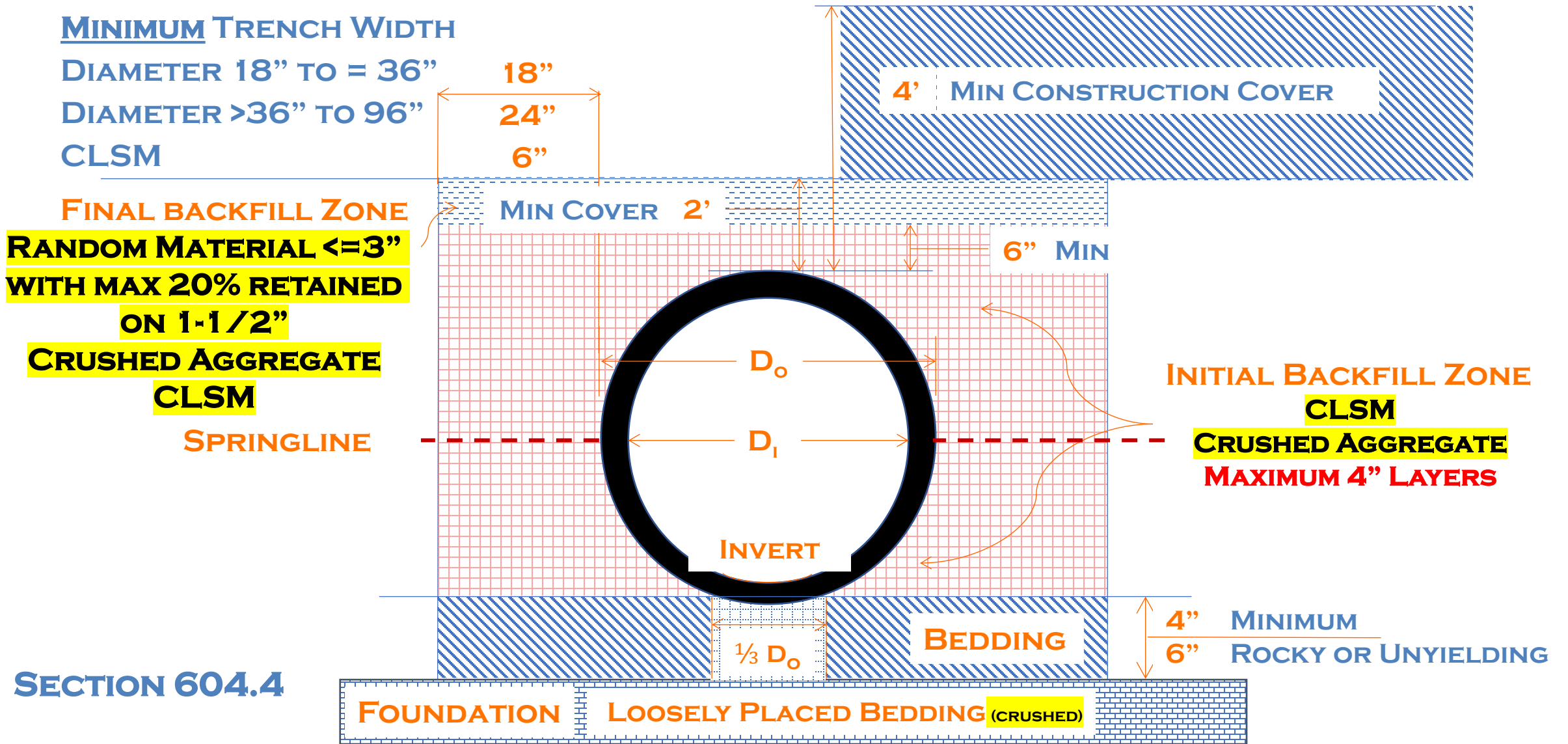
Granular Material



Class IV

Trench Requirements

WVDOH – 604 & DD-502 – Flexible Pipe



Standard Installations

WVDOH – 604 Backfilling Basics



- Backfilling with a bulldozer is **EXPRESSLY FORBIDDEN**
- Compact material in the haunches
- Place backfill material in 4" lifts
- Backfill and compact both sides simultaneously



Foundation

Supporting the Structure

Foundation

Support the Structure – *Box Springs*

- Existing (in situ) material at bottom of trench unless remediation is required
- Firm Foundation needed during installation
- Foundation should provide uniform support throughout project to minimize differential settlement
- Unsuitable foundations require remediation
- Cradles formed in foundation shouldn't be used

– *Pipeline Installation 2.0*, Amster Howard



Foundation

Support the Structure – *Box Springs*

- The foundation must support the bedding, pipe, embedment, and backfill.
- The foundation is either suitable or unsuitable for pipe installation.



Rule of Thumb:

- If a person can walk on the foundation without sinking into the soil, it is acceptable
- If person sinks, or feels the soil quiver underfoot, then it is too soft, and it is unacceptable



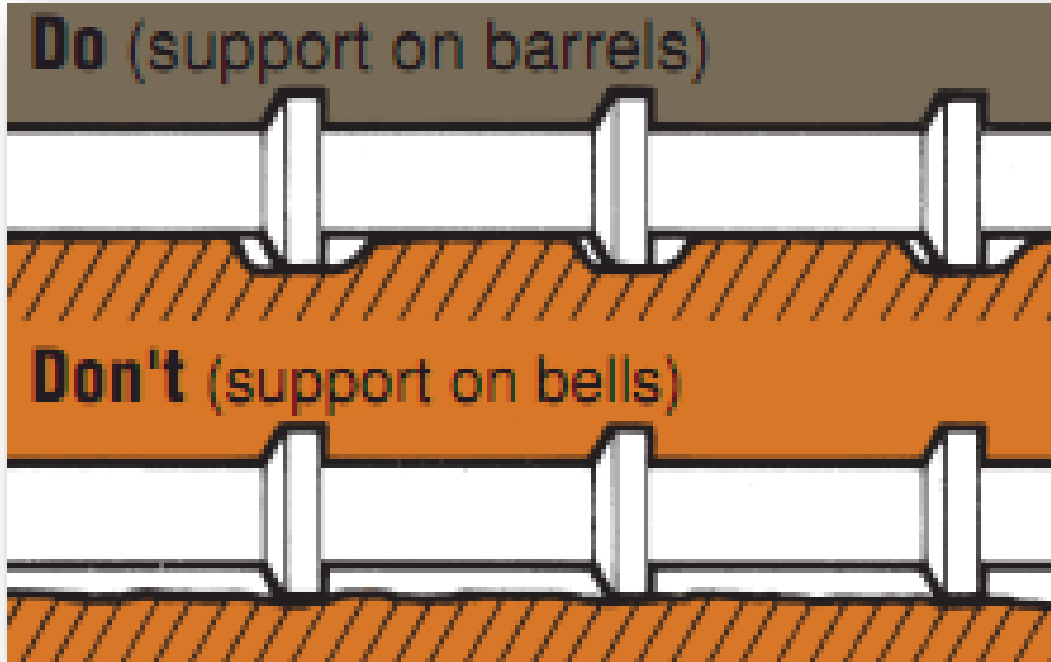
Bedding

Cushion/Load Distribution

Bedding

Cushion/Load Distribution - *Mattress*

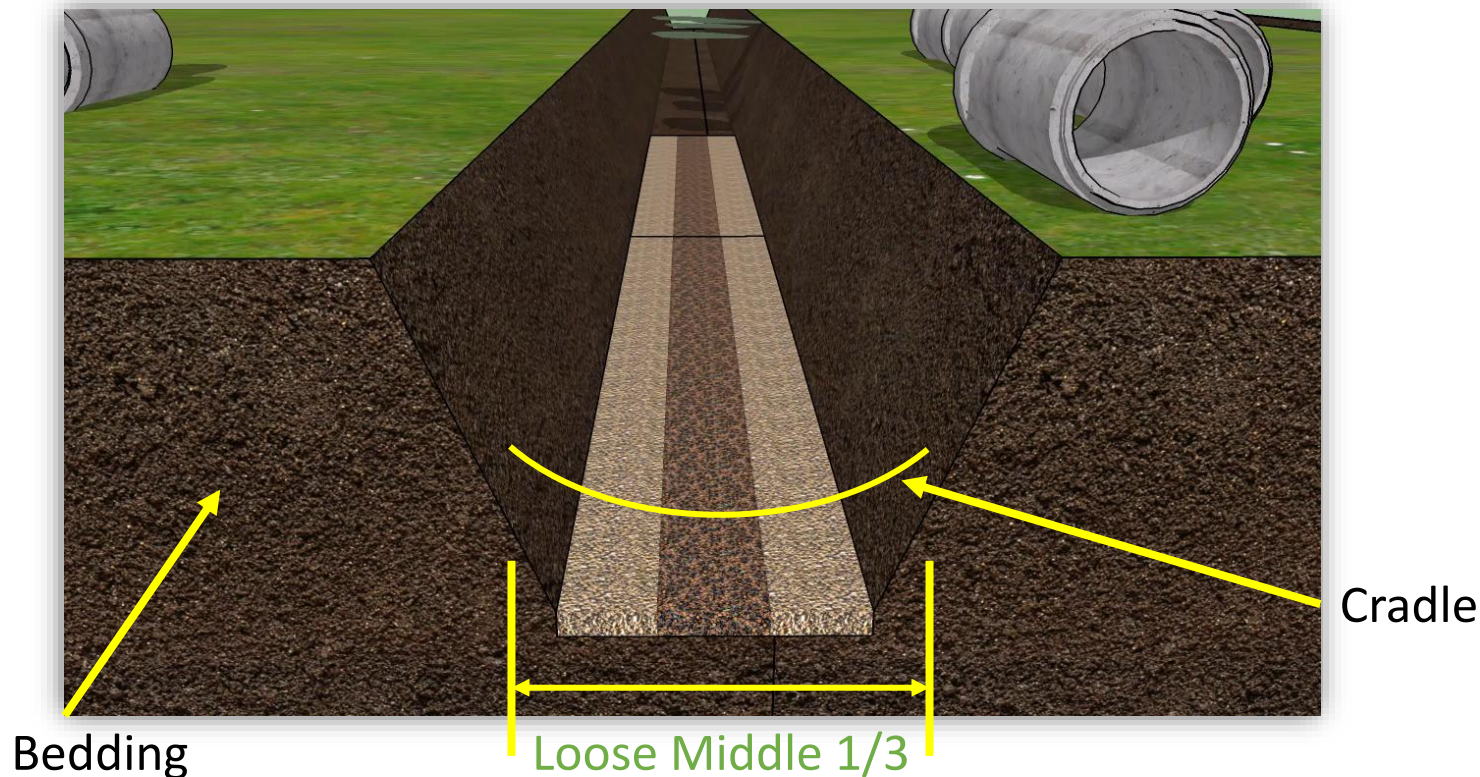
Set bedding to grade, and provide bell holes in bedding for flared bell pipe to keep bearing on pipe barrel



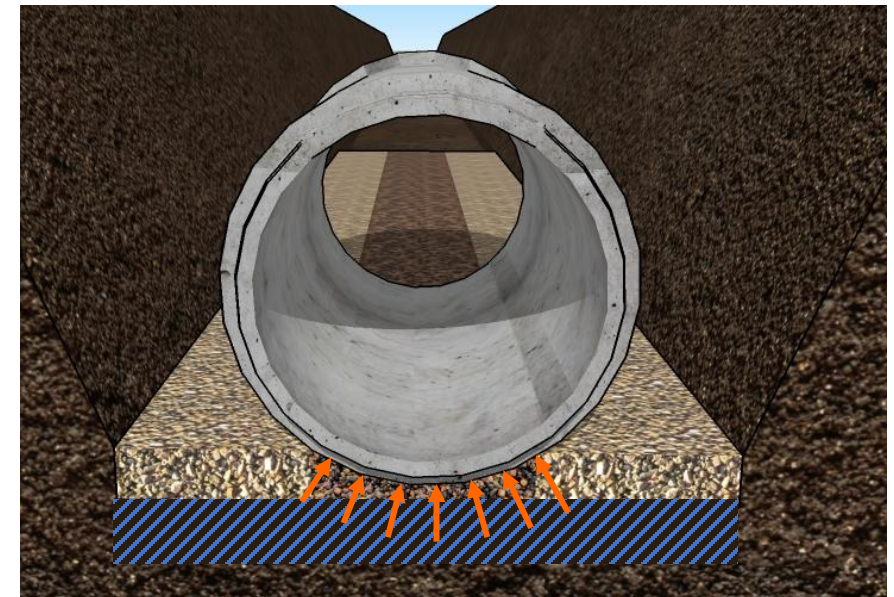
Bedding

Cushion/Load Distribution

ASTM: 3"-4"-6" thick – middle 1/3 should be loosely placed to cradle pipe invert.



The bedding acts as a cushion/cradle for the bottom of the pipe as it works to distribute the load to the foundation.





Joining

Joints & Connections

Joining

Understanding Connections

- Provide flexibility and resiliency for movement.
- Guard against leakage.
- Connect like materials.
- Transition between unlike materials.
- Transmit or transfer load.
- Reduce stress on the material or structural member.
- Provide for expansion and contraction.



Joints

Provide for Expansion and Contraction

HDPE



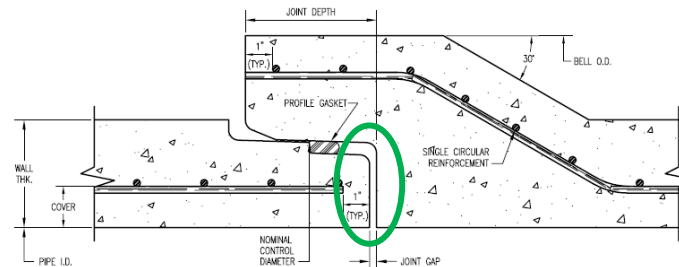
Flared bell and tapered spigot help make installation easy.

Rubber gasket meets ASTM F477.



Extra tight fit for a maximum hydraulic performance.

CONCRETE



Joining

Understanding Connections

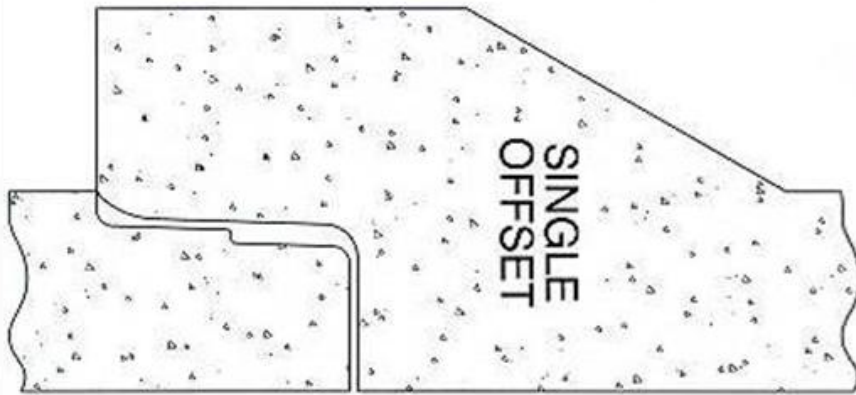
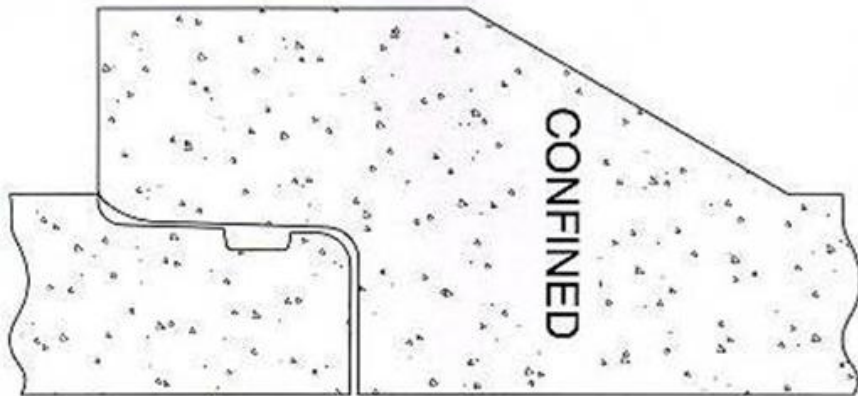
Examples of Bad Joints:



Joining

WVDOH – 604.6 Joining - Rigid

Profile Gasket (Single Offset), Confined O-Ring



Joining

WVDOH – 604.6 Joining - Rigid

Tongue & Groove



**Bitumen Sealant
ASTM C877 Type III**



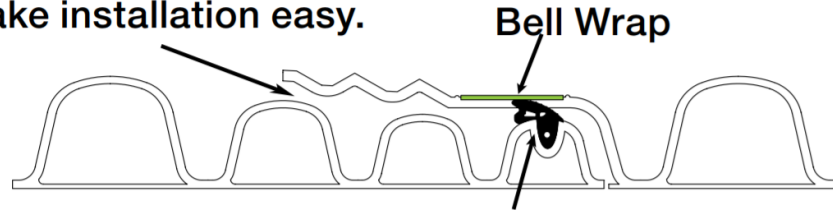
**Exterior Sealing Wrap
ASTM C877 Type III**



Joining

WVDOH – 604.6 Joining - Flexible

Flared bell and tapered spigot help make installation easy.



Omni-directional gasket increases sealing force.

ASTM D3212

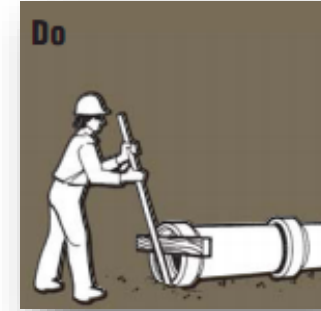
N-12 WT IB



Joining

Understanding Connections

- Begin at downstream end – Bells upstream
- Align spigot
- Keep weight off bedding
- Push home manually if possible



Joining

Understanding Connections



Joining

Understanding Connections



Joining

Understanding Connections



Joining

Understanding Connections



Connections

Understanding Connections

- Rigid to Rigid
- Flexible Connections w/Flexible Pipe
- 8 inch (Maximum) Gap
- Grouting/Booting



Connections

Understanding Connections

- Thermal Expansion Consideration
 - Length
 - Diameter



Connections

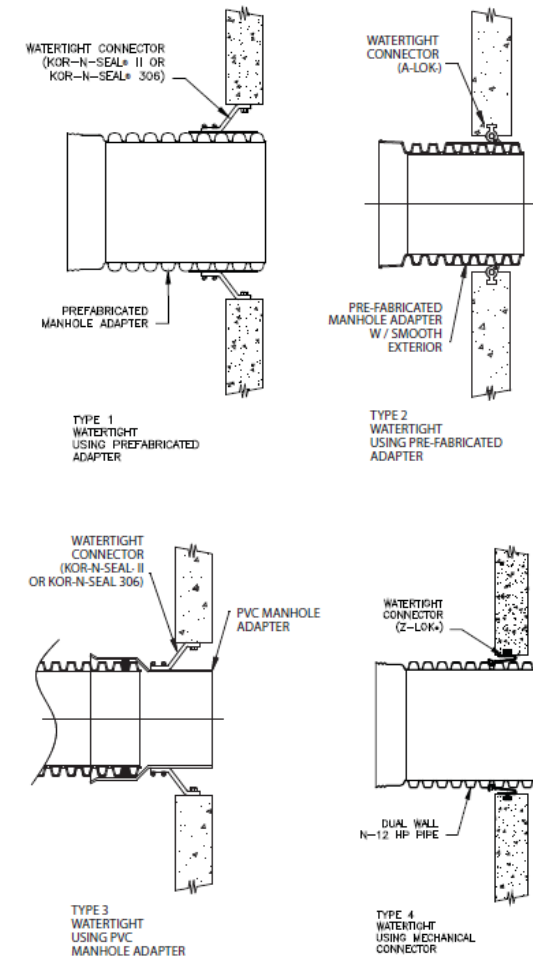
Understanding Connections

- Thermal Expansion Consideration
 - Length
 - Diameter



Figure 4:

Product Detail for Manhole Connections





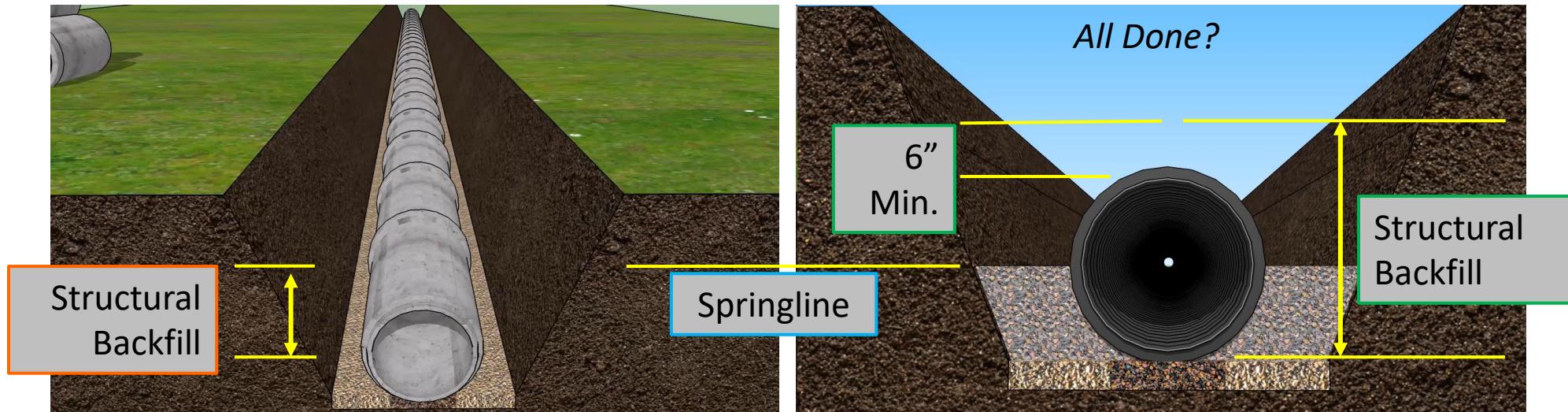
Initial Backfill

Structural Embedment

Embedment

Initial Backfill

- Provides structural support for flexible & rigid products.
- Compaction under haunches is important for rigid products & critical for flexible products.
- For flexible pipe this zone builds the soil arch – protecting the pipe from distortions due to loading



Embedment

Placing Backfill Materials



Compaction of Backfill:

Backfill materials and compaction effort can affect the strength of a soil-pipe system. Proper compaction involves placing backfill materials under haunches of all pipe types.

Embedment

WVDOH – 604.8.1 - Initial Backfill Zone



Good embedment material:

- Suitable Granular Material $\leq 1\text{-}1/2''$ – 95% Standard Proctor (Rigid Pipe Only)
- Crushed Aggregate – 95% Standard Proctor (All Pipe Materials)
- CLSM – Controlled Low Strength Material (All Pipe Materials)

Embedment

WVDOH – 604.8.1 - Initial Backfill Zone



Care shall be taken to compact the material under the haunches of the pipe...

...The backfill and compaction efforts shall be advanced simultaneously on both sides of the pipe.



Embedment

Initial Backfill



Manual compactors allow contractor to get up close to the pipe without damaging it.



Hoepacks, and other large compaction equipment can do damage to a pipe if there is not enough soil cushion over or around the pipe.



Final Backfill

a.k.a Overfill, Cover, Height

Final Backfill

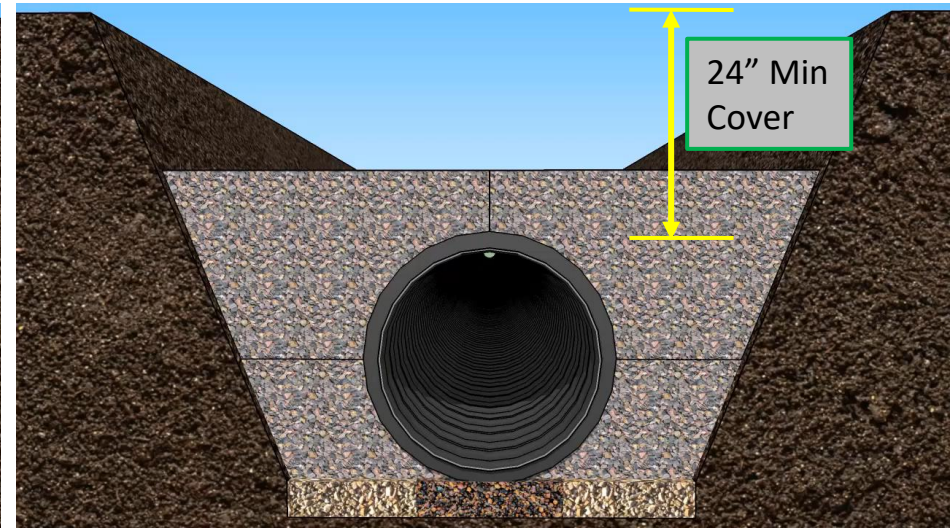
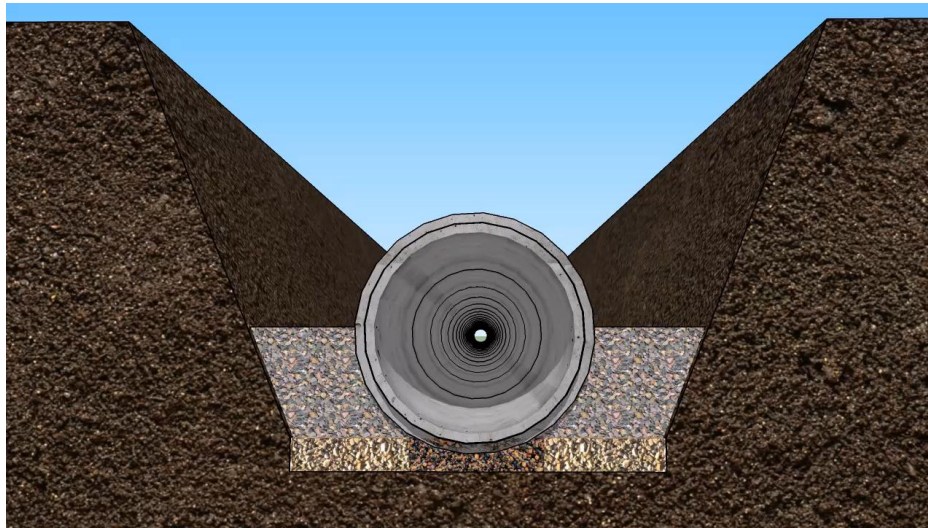
Height of Cover



Final Backfill

Height of Cover

- Does not add to strength of **rigid system** – compact as needed for improvements above.
- **AASHTO**: 2' minimum fill height for thermoplastic pipe.

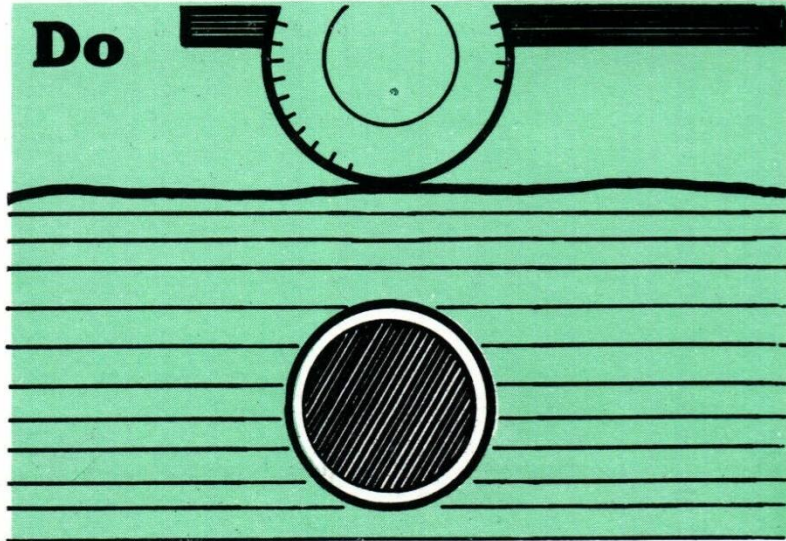


Final Backfill

WVDOH – 604.8 – Heavy Equipment

WARNING

Do



Don't

operate heavy construction equipment over the pipe until adequate backfill is in place.



**Minimum 4' Cover
Before Running Heavy Equipment**

Post Installation

WVDOH – 604.12 Inspection & Acceptance



...A post installation inspection will be conducted before final acceptance.

No sooner than 30 days following installation, the Engineer will visually inspect all culverts.

Pipes larger than 42" diameter will be manually inspected for excessive deflection of flexible pipe and excessive cracking in rigid pipe, and joint issues for all pipes.



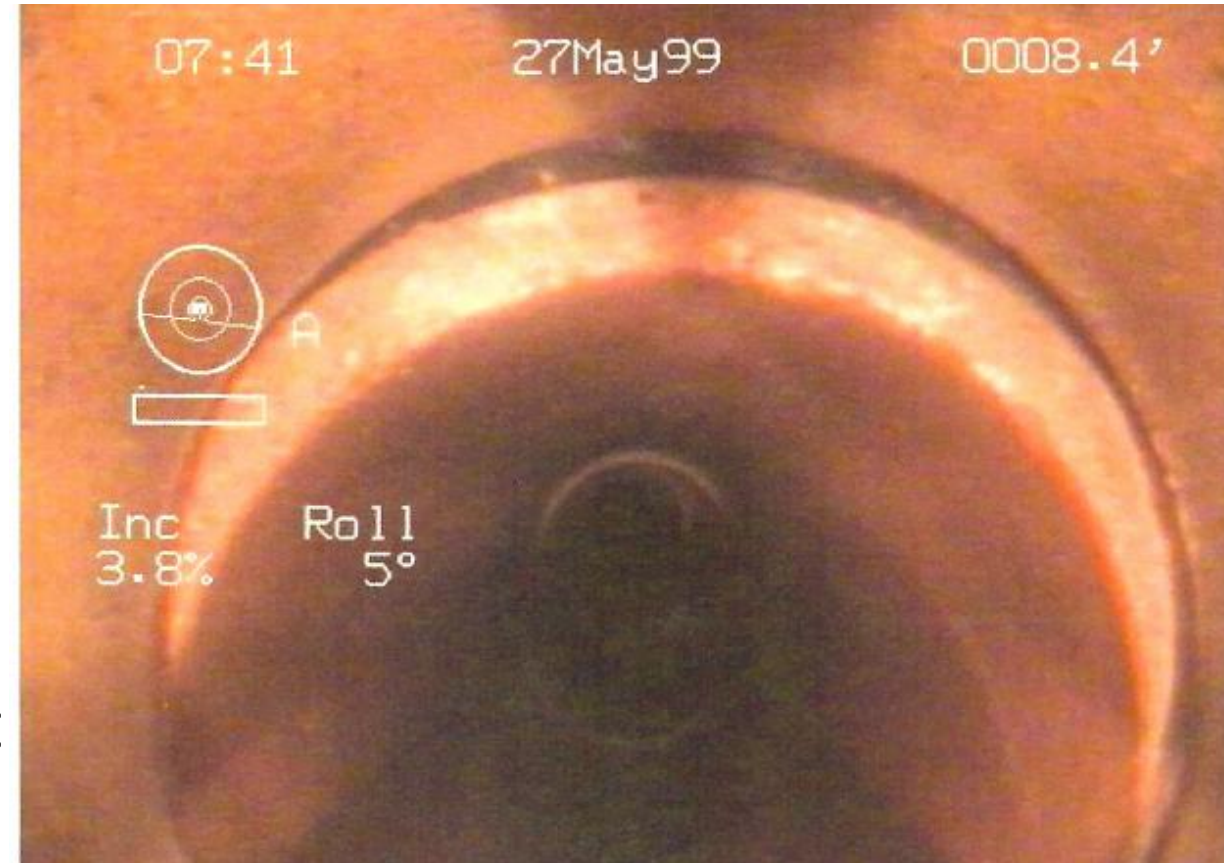
Post Installation

WVDOH – 604.12 Inspection & Acceptance



The following will be cause for repair or replacement at no cost to the division

Excessive Cracks, Differential Movement
Spalls, Exposed Reinforcement, Slabbing
Dents, Buckling, Holes, Damaged Coating
Obstructions, Improperly Engaged Joints
Improper Gasket Placement
Excessive Joint Gaps, Misaligned Joints
Excessive Deflection
Undue Horizontal or Vertical Misalignment



604.12.1 Rigid Pipe Criteria - Concrete Pipe Crack Widths...

Less than or equal to 0.01" – Considered hairline and minor

Greater than 0.01" but less than **0.05"** – Sealed by method proposed by the manufacturer and approved by the Engineer

Greater than 0.05" and less than **0.10"** – Shall be evaluated by the Engineer for repair or replacement

Greater than 0.10" – Shall be replaced by the contractor to the satisfaction of the Engineer

604.12.2 Flexible Pipe Criteria

Flexible Pipe Deflection compared to the original diameter...

Less than or equal to 5% - will not require remediation

Greater 5% up to 7.4% – evaluated by the Engineer for repair or replacement

7.5% or more – shall be replaced by the contractor

Repaired or replaced pipe must have final deflection equal to less than 5%

Flexible Pipe with any crack (interior or exterior) shall be replaced.

Pipe Installation & Inspection

Best Practices

Did You Find Value In This Information?

How Will You Use This in Your Job?



DONALD E. MCNUTT, PE
PRESIDENT
TORRIDON GROUP LLC
DEMCNUTT@OUTLOOK.COM
803-317-3329

Pipe Installation & Inspection

Thank You!

The logo for Permatile Concrete Products Company. It features the word "PERMATILE" in a bold, red, 3D block font. The letters are arranged in a way that they appear to be stacked or have depth. The background of the logo is white, and the text is set against a backdrop of a construction site with a yellow excavator and a large concrete pipe.

CONCRETE PRODUCTS COMPANY

Demand the best, Demand Permatile

800-662-5332 | permatile.com

The logo for Rinker Materials. It features the word "Rinker" in a large, bold, black serif font. A red curved line arches over the word. The background of the logo is white, and the text is set against a backdrop of a construction site with a yellow excavator and a large concrete pipe.

MATERIALS®

A QUIKRETE® COMPANY



DONALD E. MCNUTT, PE
PRESIDENT
TORRIDON GROUP LLC
DEMCNUTT@OUTLOOK.COM
803-317-3329