
# Pipe Installation & Inspection

## Best Practices

American Concrete Pipe Association

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# Special Thanks to:



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# Shipping & Handling

## Trucking and Storage Onsite

# Installation
## Unloading

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## Unloading

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# 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

QUIZ

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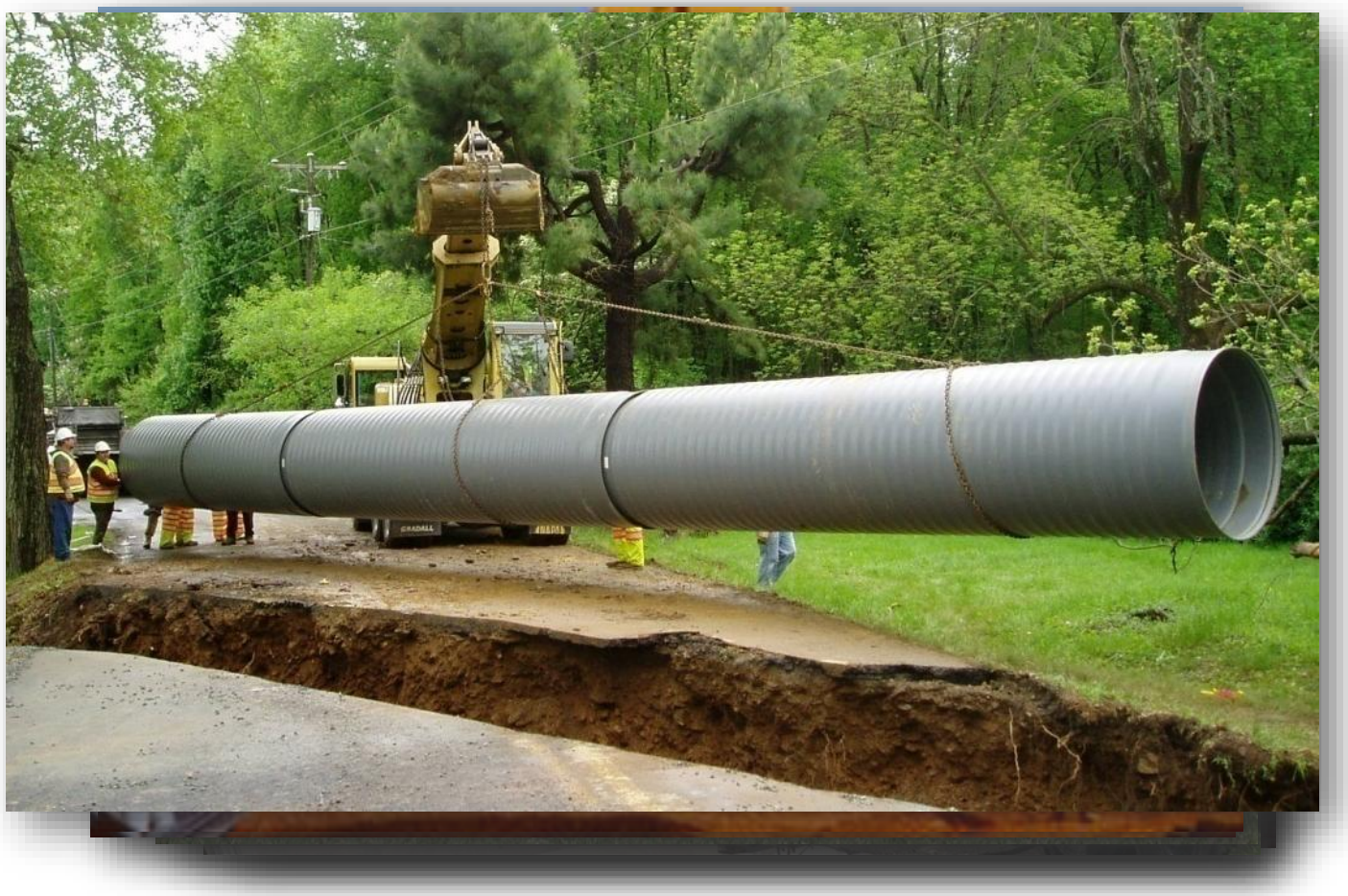
**Good**
**Practice**



**B a d**
**Practice**

# Trenches

## Introduction to Trenches

# Trench Basics
## Installation Options

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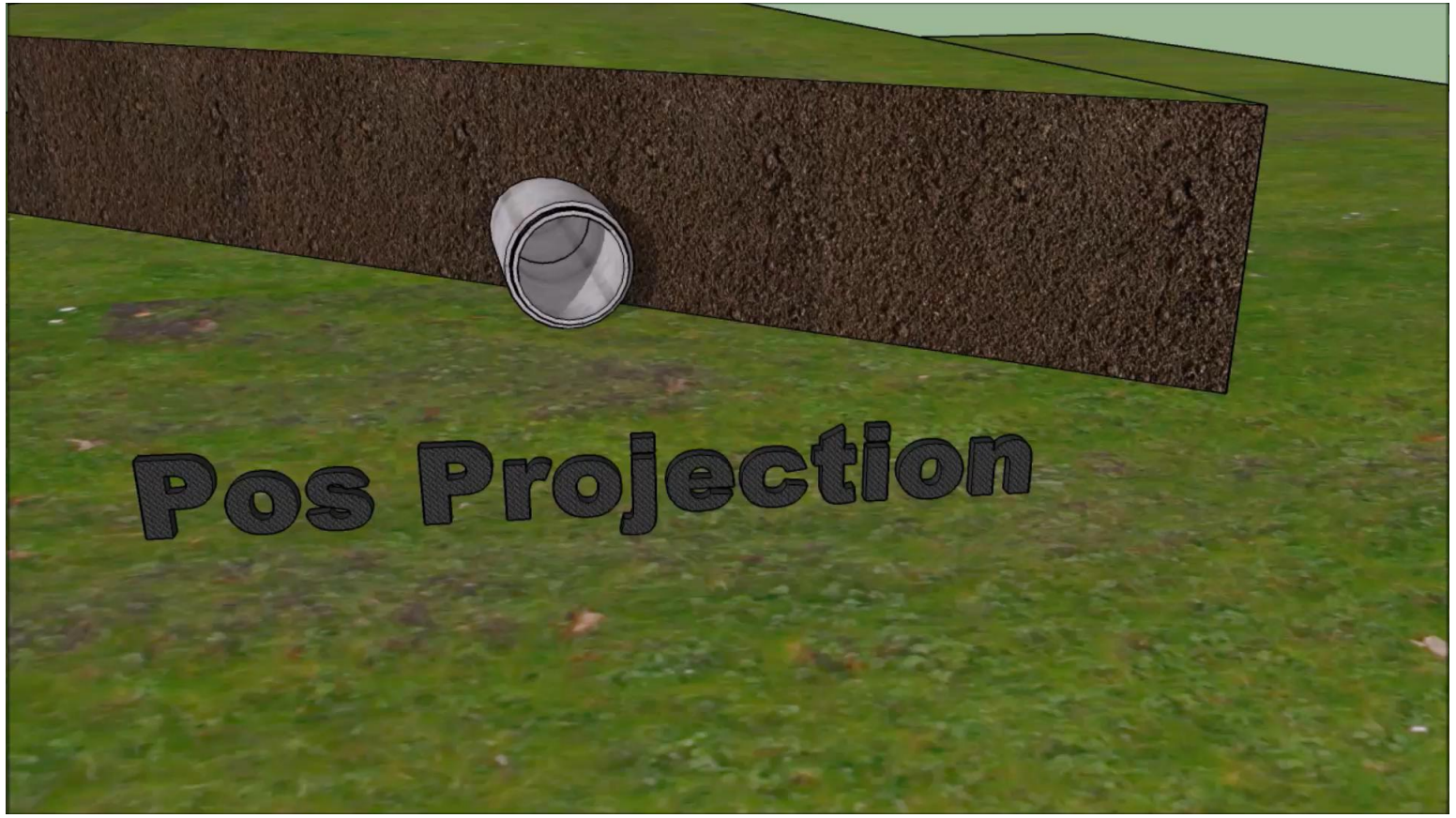
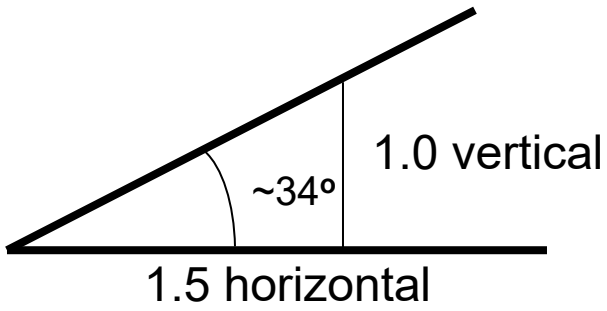
- Narrow Trench
  - Trench walls provide support to the pipe
- Negative Projection
  - Smaller trench walls provide some support
- Positive Projection
  - No in situ soils support
- Jacked/Tunneled
  - In Situ soils provide the greatest soil arch & support



# 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.

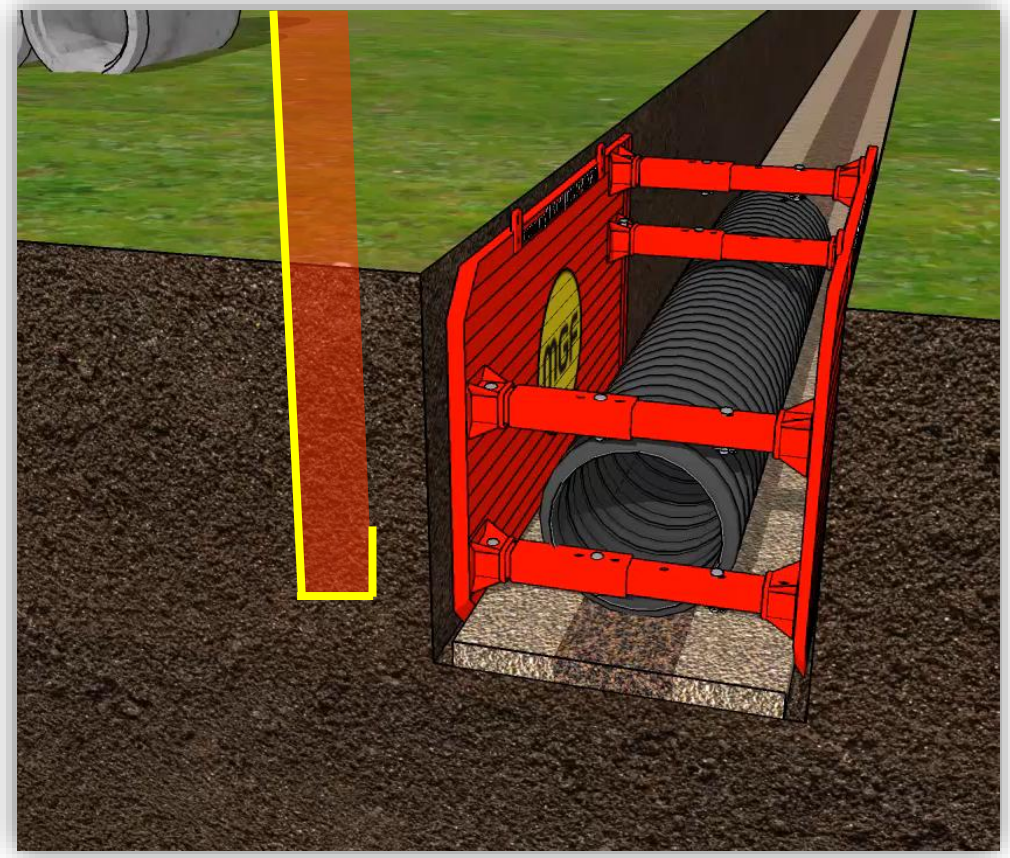



  - Use a protective system:
    - **Trench box, shoring, shields (Designed by Engineer >20')**

# 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

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# Trench Safety

## Construction Concerns

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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

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# Excavation

## Preparing the Trench

# Excavation
## Best Practices

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

# Excavation
## Dewatering

American Concrete Pipe Association

# Excavation
## Dewatering

American Concrete Pipe Association

**Buoyancy:**

Relative Densities

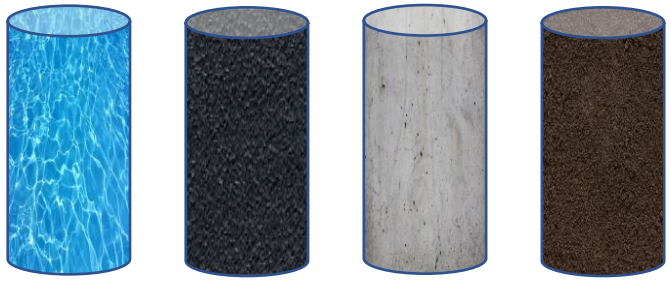
$\gamma_{HDPE}$ = 60 pcf

$\gamma_{H_20}$ = 62.4 pcf

$\gamma_{SOIL}$ = 120 pcf

$\gamma_{RCP}$ = 150 pcf

Flotation Force ≤ Soil Resistance + Pipe Weight



# Soil Basics

## Gradation & Compaction

# Soils Basics
## Gradation

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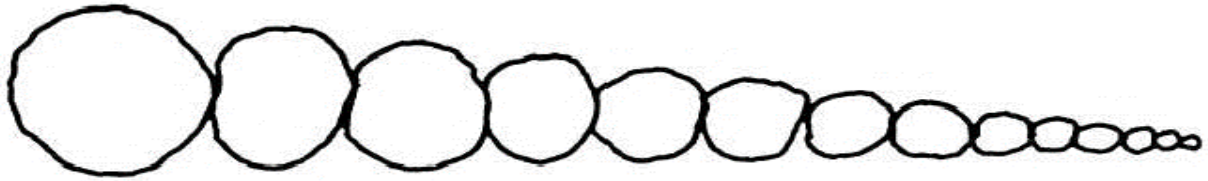
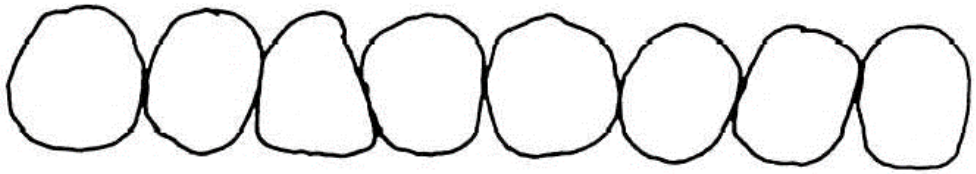
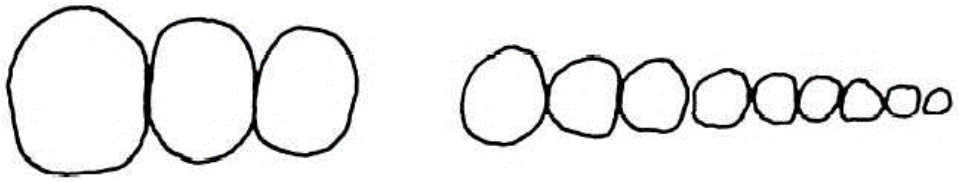
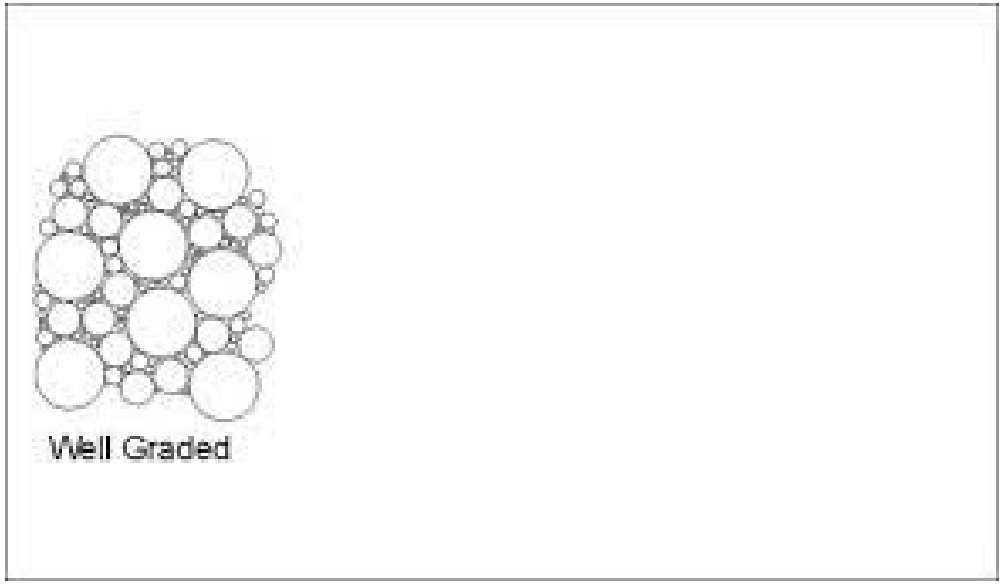
**Well-graded** soil has all sizes of material present from the No. 4 sieve to the No. 200 sieve.



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

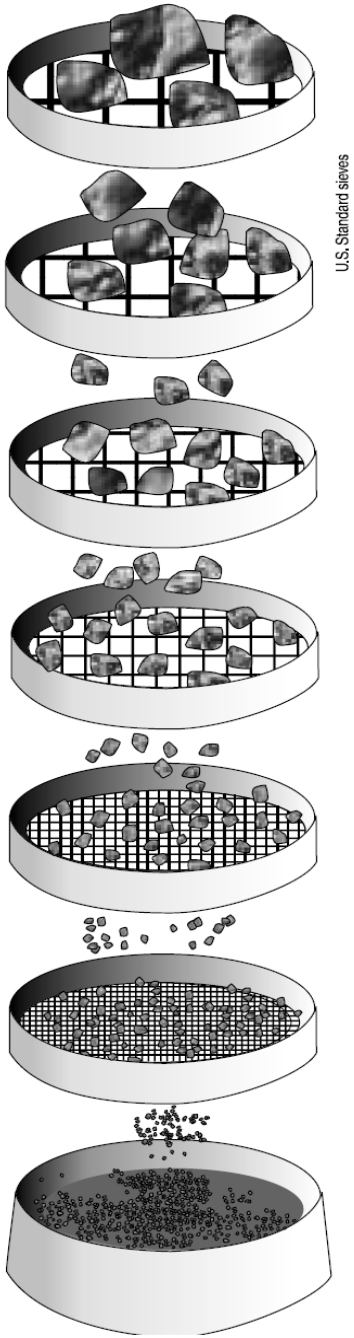






# Soils Basics

## Gradation




## USCS System

Boulders – 12”+

Cobbles – 3” to 12”

Gravel

Fine Gravel - peas to marbles

Course Gravel - grapes to tennis balls

Sand

Fine Sand - table salt

Medium Sand - Virginia Beach

Course Sand - ice cream salt

Fines

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

American Concrete Pipe Association

***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

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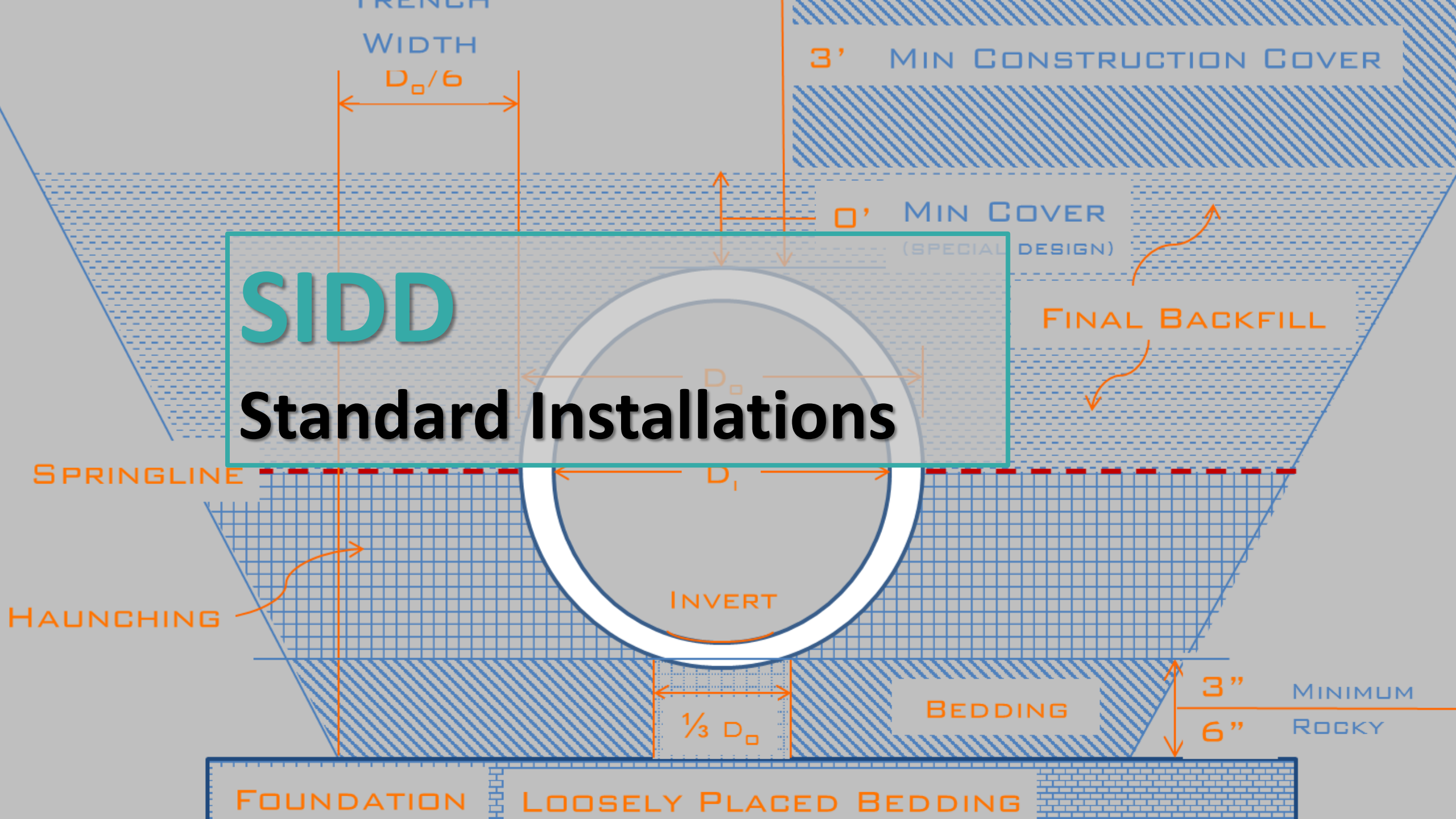
- Densification of soil by reduction of air in voids
- More difficult for water to migrate
- Reduce subsequent settling under loading
- Measured in dry unit weight (dry density)
- Increases shear strength of soil




# SIDD

## Standard Installations

# SIDD
# AASHTO Standard Installations

American Concrete Pipe Association

## 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 |

# SIDD

# WVDOH – 604 & DD-502

American Concrete Pipe Association

## 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

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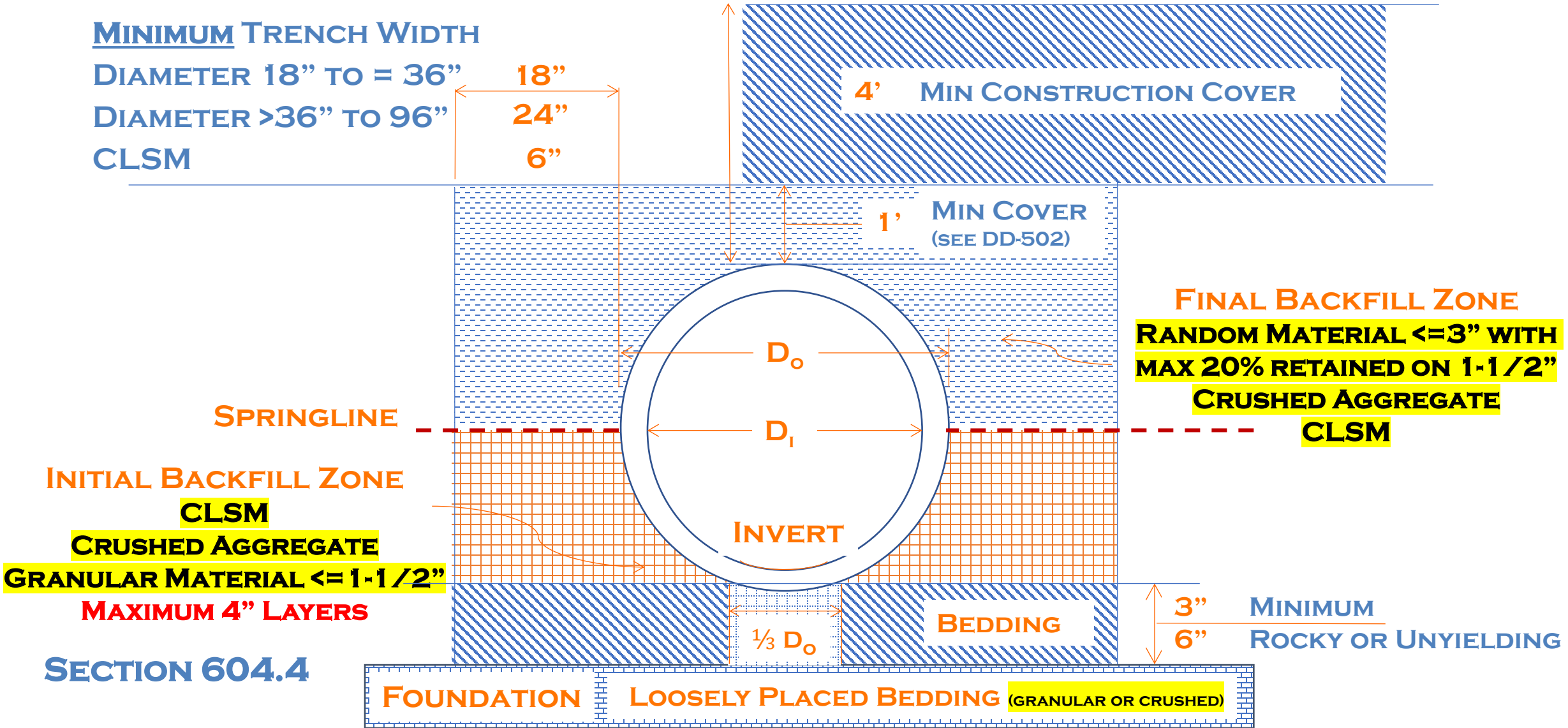


# Fill Height Tables

# WVDOH – 604 & DD-502 – Concrete Pipe

American Concrete Pipe Association

## 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.

**Example: 48" Diameter RCP Under 15' of Fill**

### 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 |

### 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

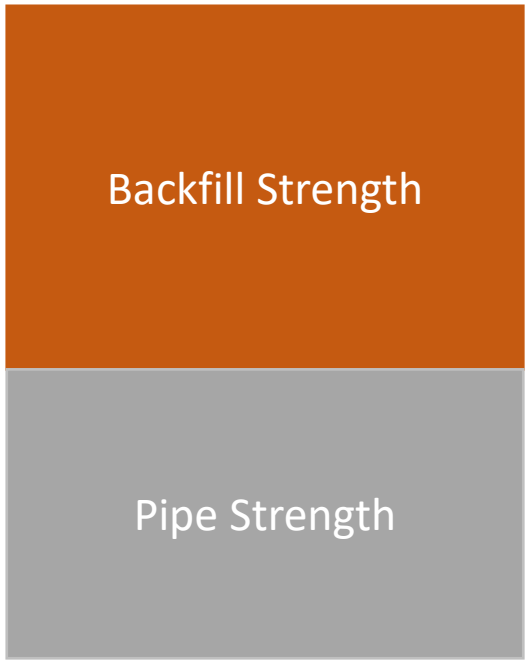
American Concrete Pipe Association

**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

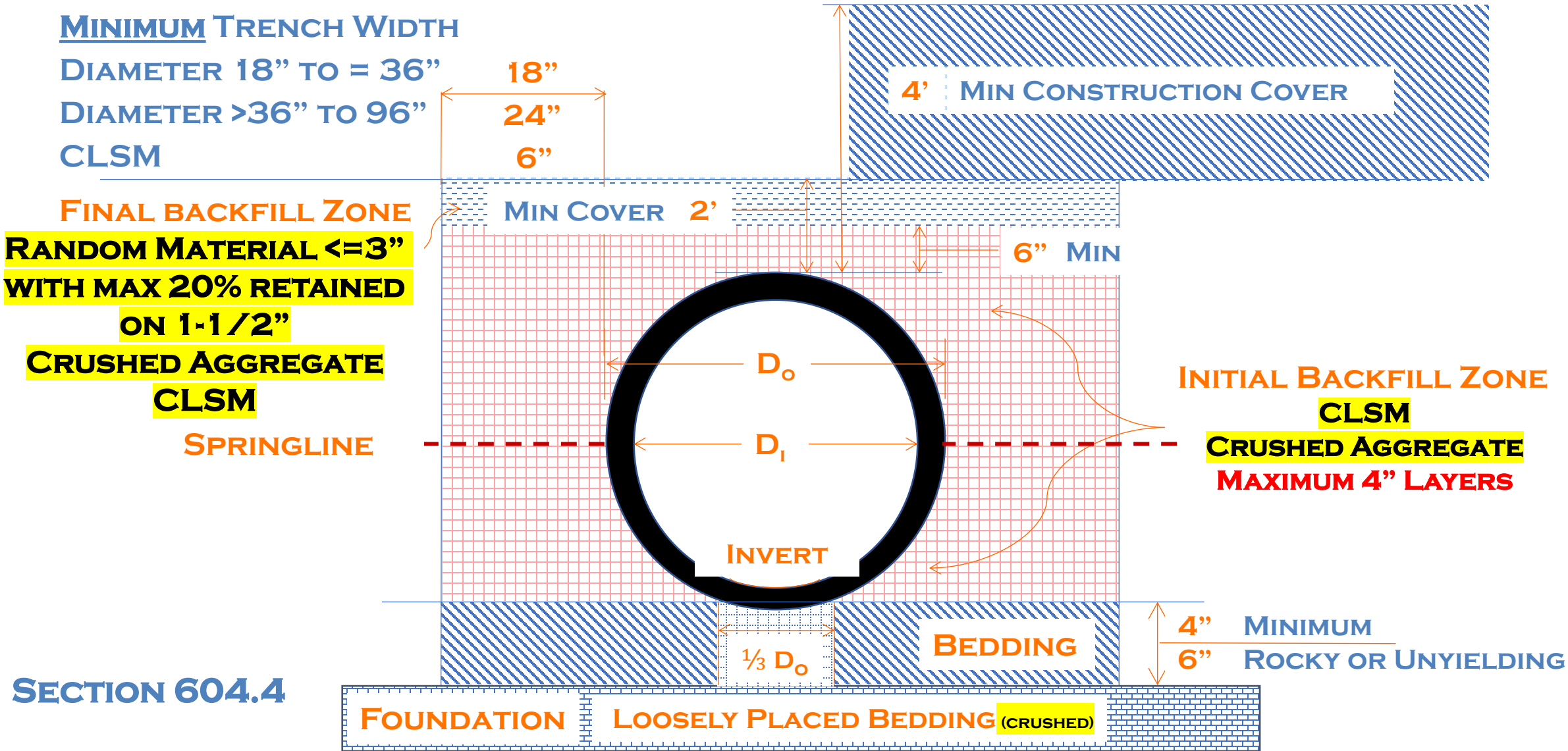
American Concrete Pipe Association

**Minimum Trench Width**

Diameter 18" to = 36" 18"

Diameter >36" to 96" 24"

CLSM 6"




Section 604.4

# Standard Installations

## WVDOH – 604 Backfilling Basics

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- 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*

American Concrete Pipe Association

- 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*

American Concrete Pipe Association

- 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

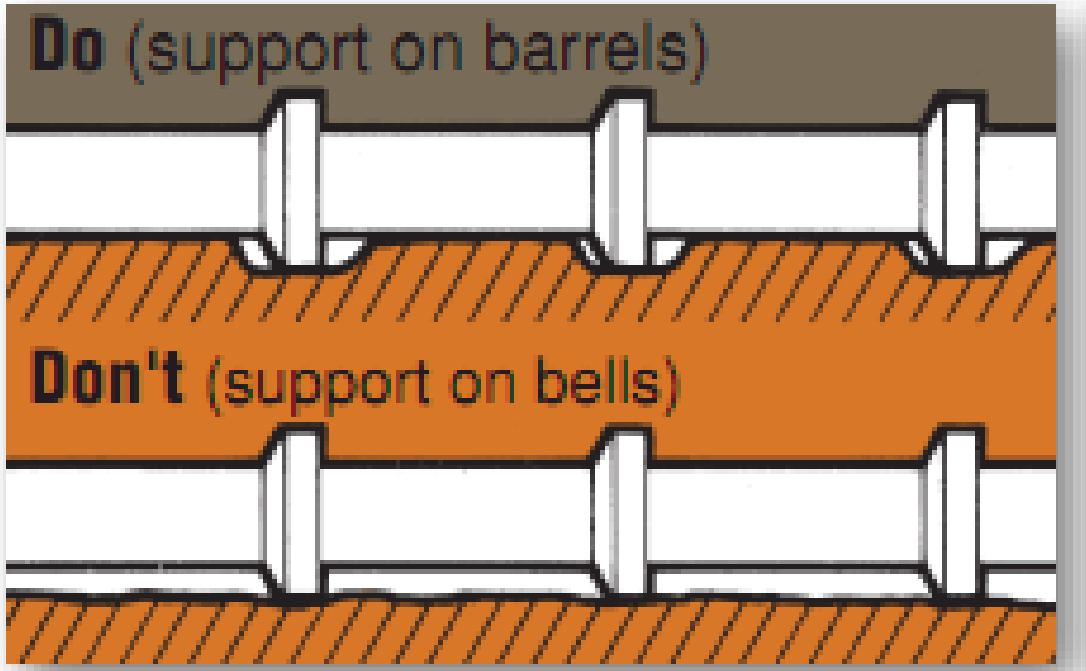
## Cushion/Load Distribution

# Bedding

## Cushion/Load Distribution - *Mattress*

American Concrete Pipe Association

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




# Bedding
## Cushion/Load Distribution

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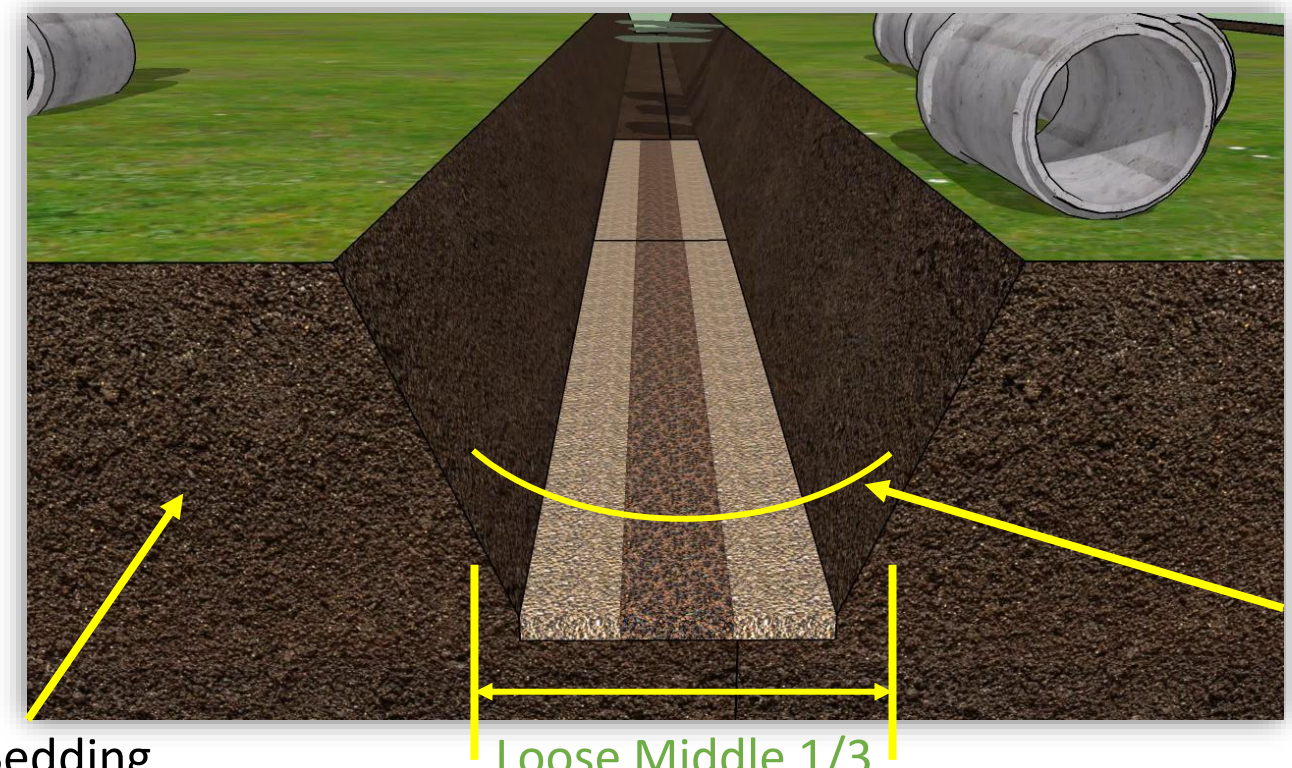
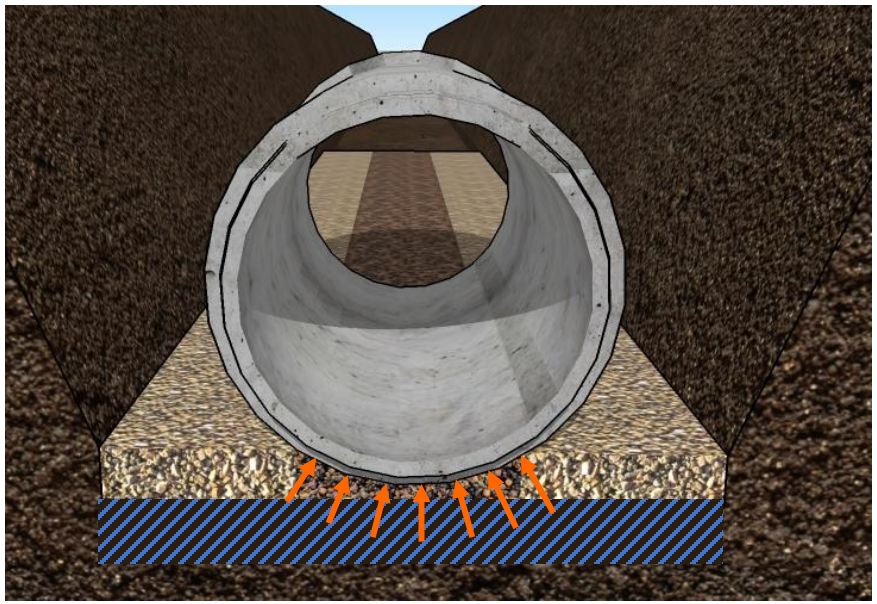
**ASTM**: 3”-4”-6” thick – middle 1/3 should be loosely placed to cradle pipe invert.




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

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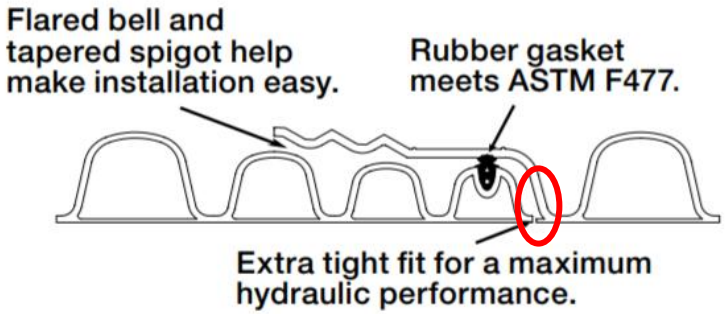
- Provide flexibility and resiliency for movement.
- Guard against leakage.
- Connect like materials.
- Transition between unlike materials.
- Transmit or transfer load.
- Reduce stress on the material or structural member.
- Provide for expansion and contraction.

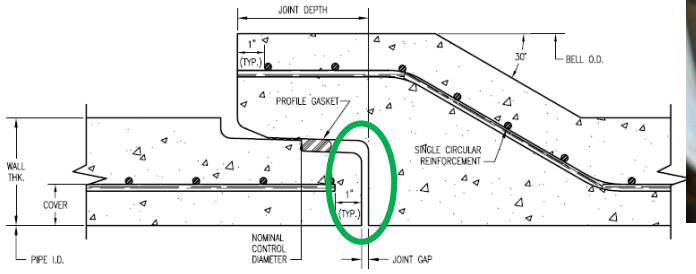
# Joints
## Provide for Expansion and Contraction

American Concrete Pipe Association

**HDPE**




**CONCRETE**


# Joining
## Understanding Connections

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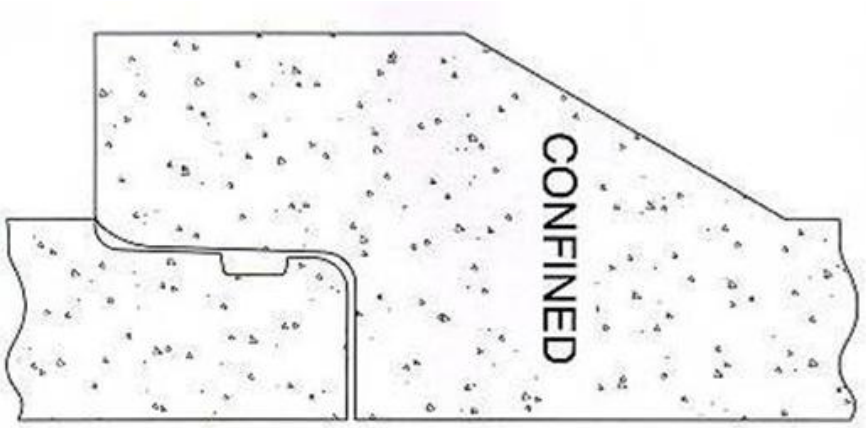
### Examples of Bad Joints:

# Joining

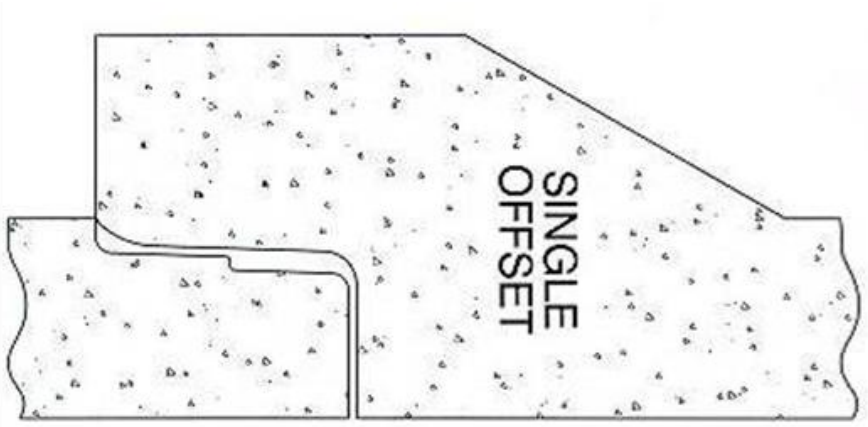
# WVDOH – 604.6 Joining - Rigid

American Concrete Pipe Association

## Profile Gasket (Single Offset), Confined O-Ring




**Rubber O-Ring**
**ASTM C443**



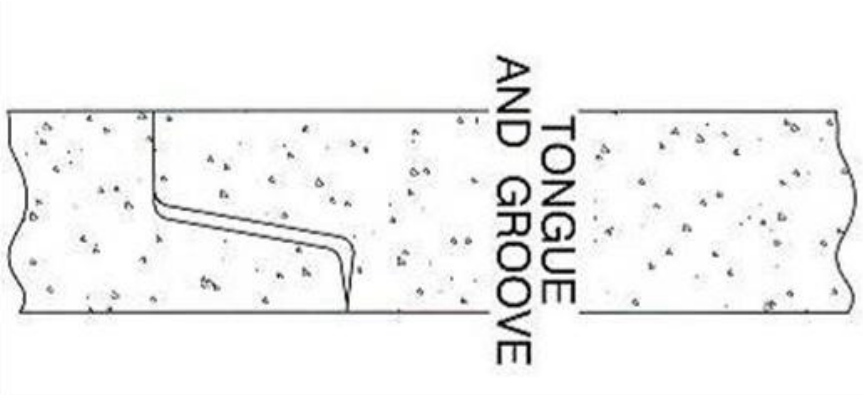

**Profile Rubber Gaskets**
**ASTM C443**

# Joining

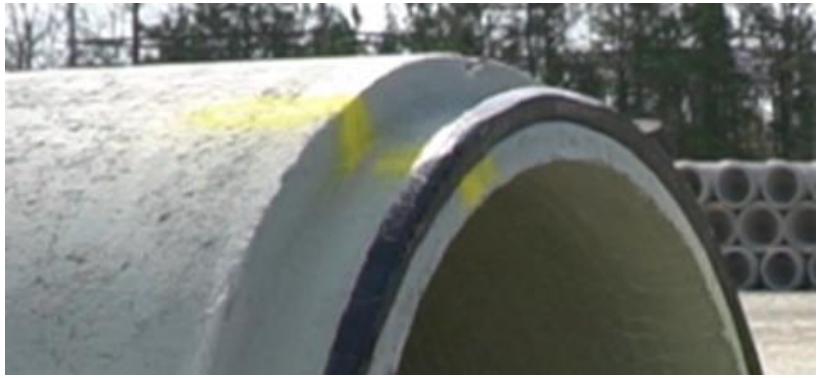
# WVDOH – 604.6 Joining - Rigid

American Concrete Pipe Association

## Tongue & Grove



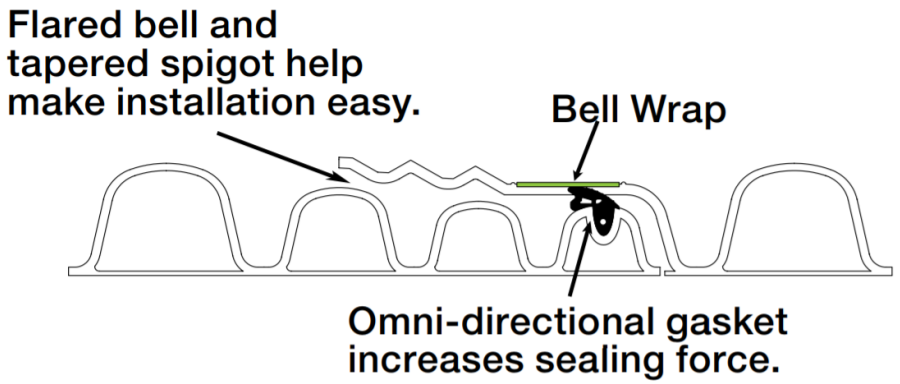

**Bitumen Sealant**
**ASTM C877 Type III**



**Exterior Sealing Wrap**
**ASTM C877 Type III**

# Joining

# WVDOH – 604.6 Joining - Flexible




**N-12 WT IB**

**ASTM D3212**

# Joining
## Understanding Connections

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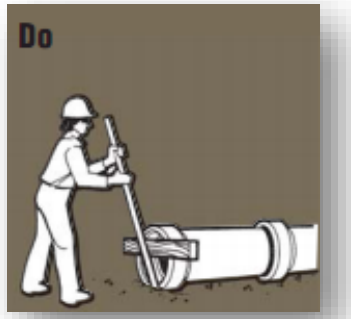
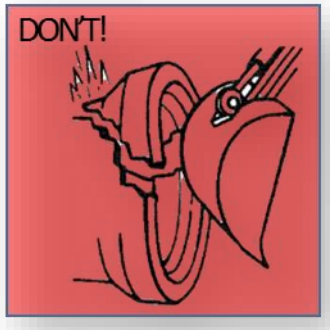
- Begin at downstream end – Bells upstream
- Align spigot
- Keep weight off bedding
- Push home manually if possible




# Joining
## Understanding Connections

American Concrete Pipe Association

# Joining
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American Concrete Pipe Association

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American Concrete Pipe Association

# Joining
## Understanding Connections

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# Connections

## Understanding Connections

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

# Connections

## Understanding Connections

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- Thermal Expansion Consideration
  - Length
  - Diameter

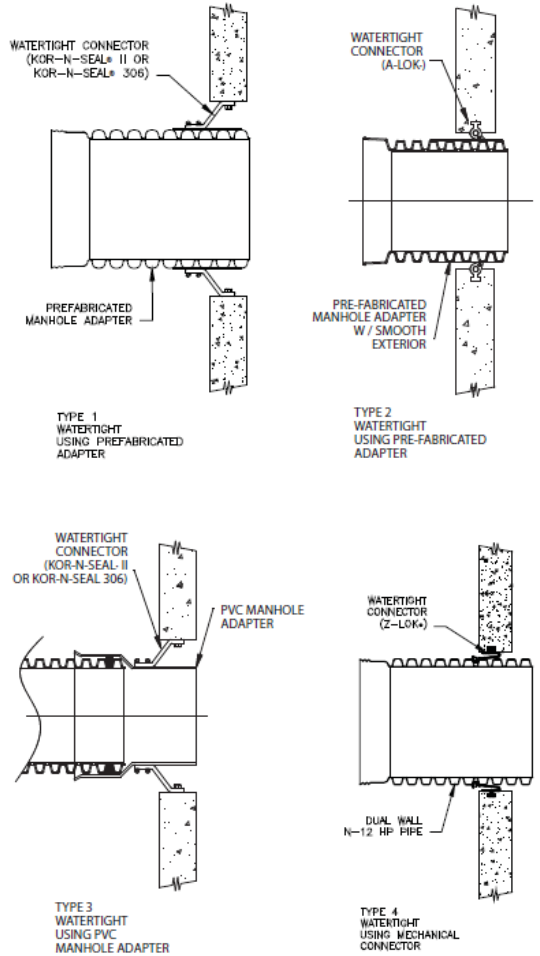
# Connections

## Understanding Connections

- Thermal Expansion Consideration
  - Length
  - Diameter

Figure 4:

**Product Detail for Manhole Connections**



# Initial Backfill

## Structural Embedment

# Embedment
## Initial Backfill

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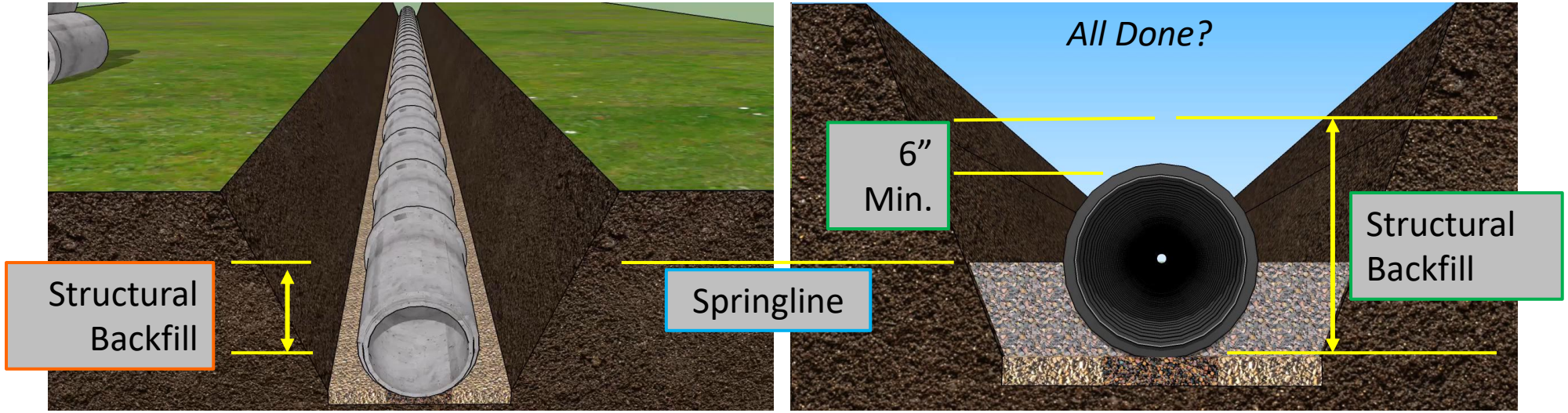
- Provides structural support for flexible & rigid products.
- Compaction under haunches is important for rigid products & critical for flexible products.
- For flexible pipe this zone builds the soil arch – protecting the pipe from distortions due to loading



# 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

American Concrete Pipe Association

Good embedment material:

- Suitable Granular Material <= 1-1/2” – 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

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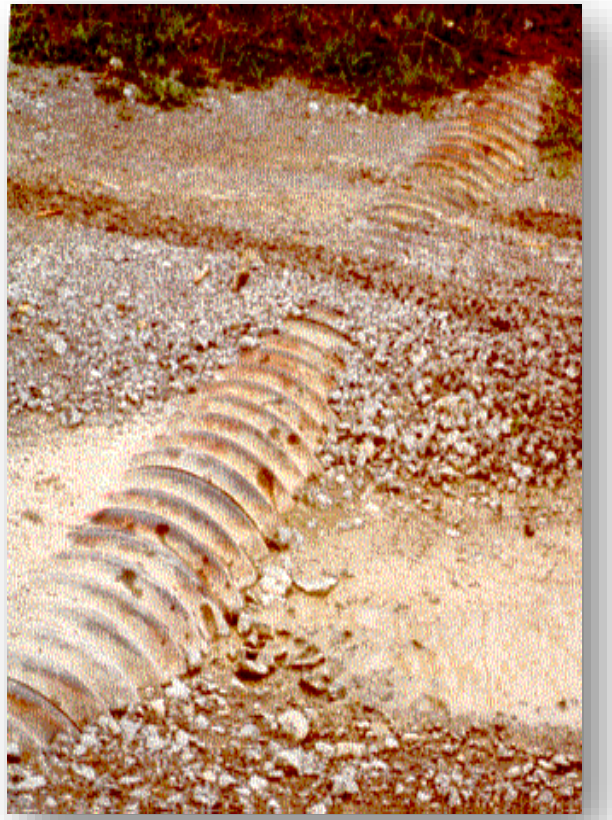
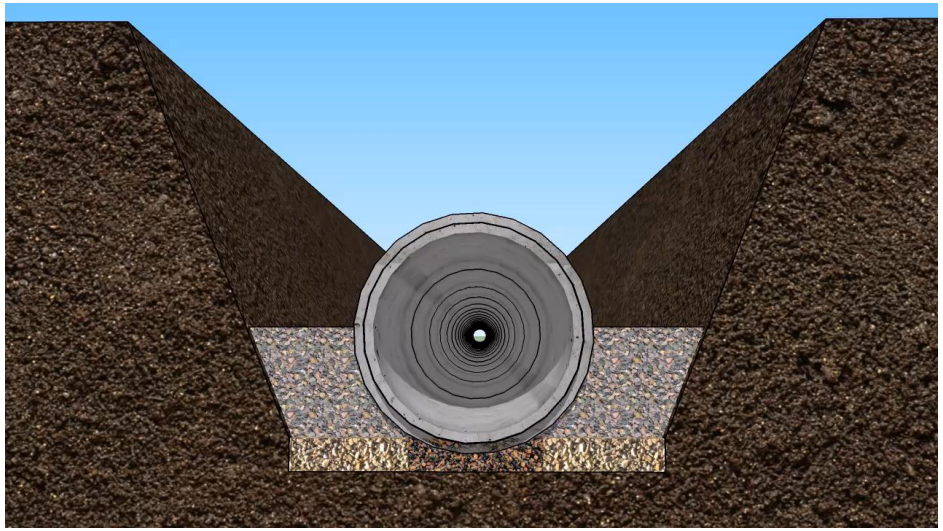
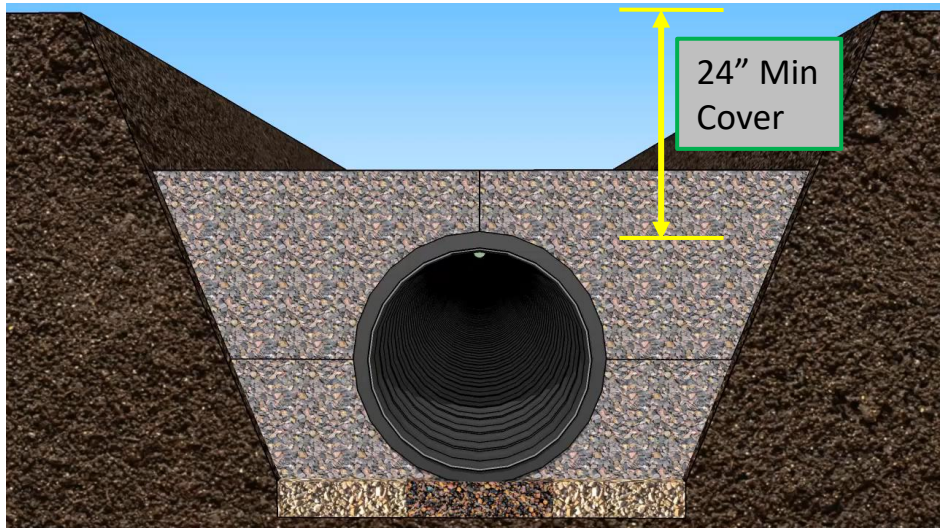


# Final Backfill
## Height of Cover

American Concrete Pipe Association

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

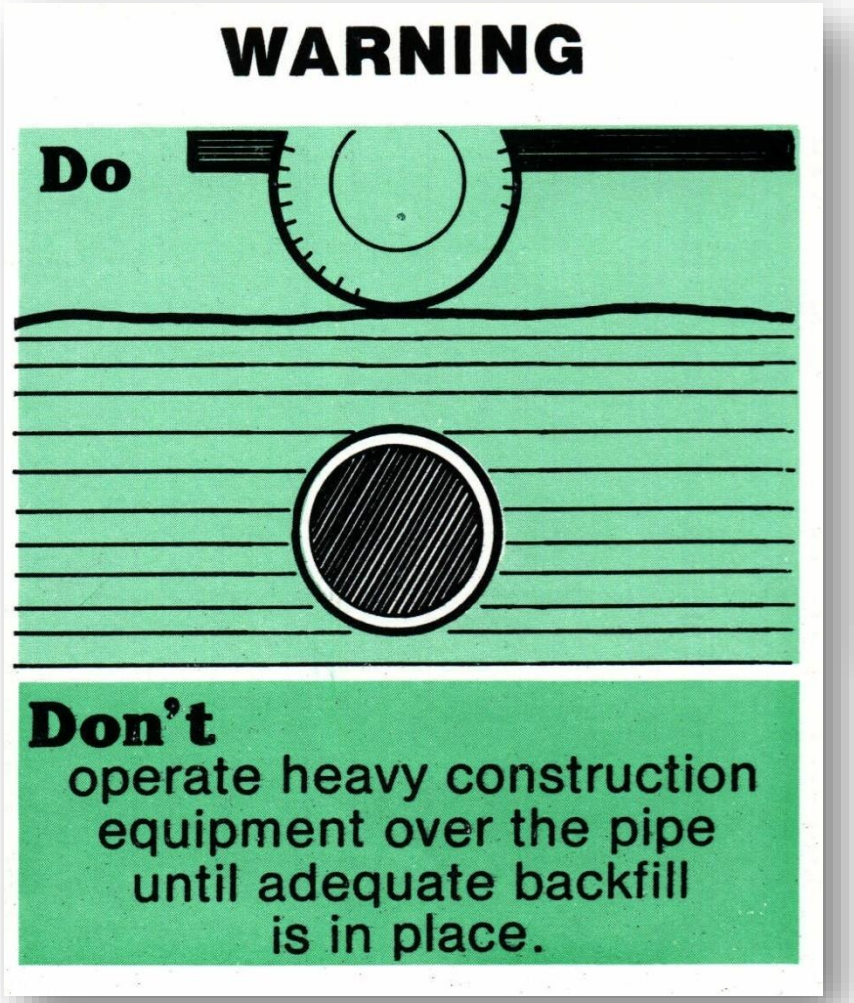




# Final Backfill

## WVDOH – 604.8 – Heavy Equipment

American Concrete Pipe Association




**Minimum 4' Cover**

**Before Running Heavy Equipment**

# Post Installation

## WVDOH – 604.12 Inspection & Acceptance

American Concrete Pipe Association

…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

American Concrete Pipe Association

**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

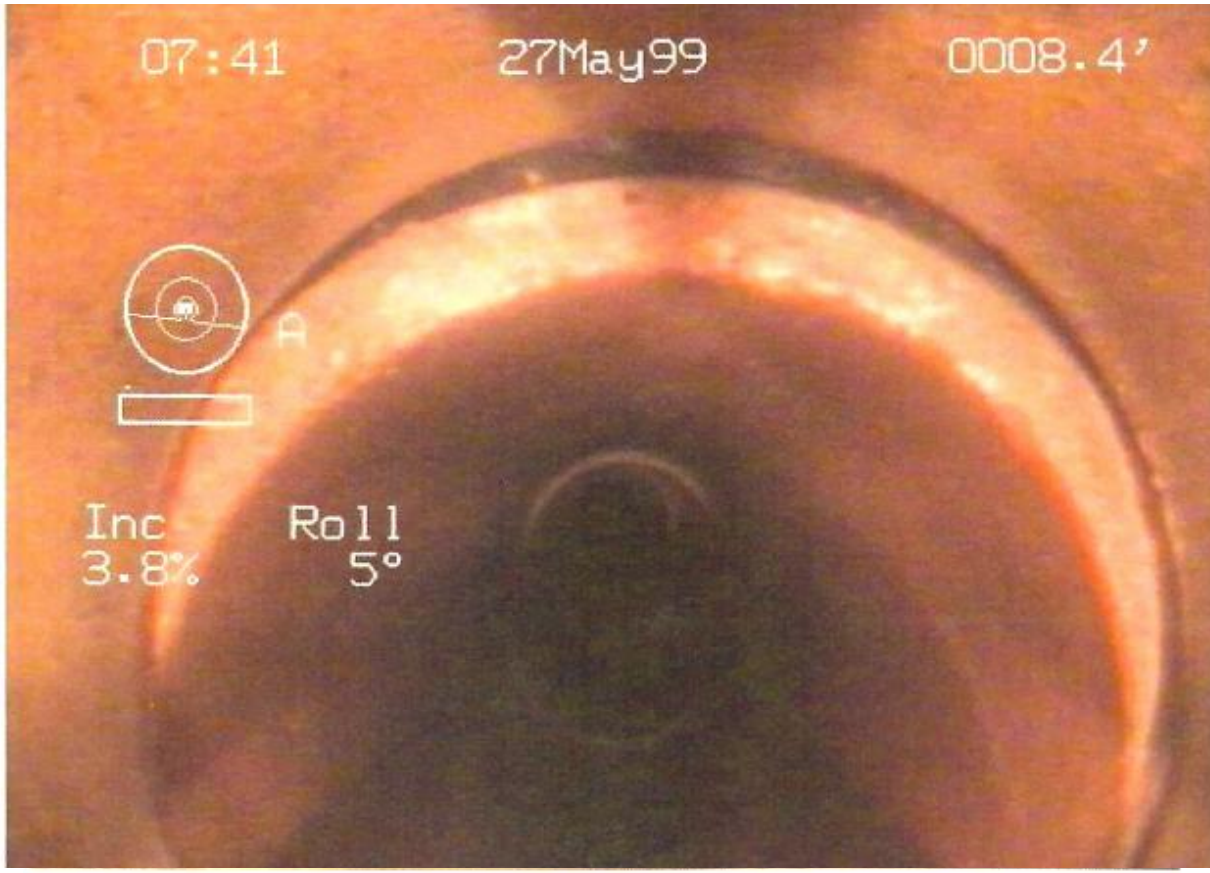
Obstructions, Improperly Engaged Joints

Improper Gasket Placement

Excessive Joint Gaps, Misaligned Joints

Excessive Deflection

Undue Horizontal or Vertical Misalignment



# Post Installation

## WVDOH – 604.12 Inspection & Acceptance

American Concrete Pipe Association

**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

# Post Installation

## WVDOH – 604.12 Inspection & Acceptance

American Concrete Pipe Association

**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?**

American Concrete Pipe Association

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# Pipe Installation & Inspection

## Thank You!



American Concrete Pipe Association

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