




CONCRETE PIPE WEEK
United States | August 14-20, 2016



Proper Pipe Installation Practices



Understanding the installation, specification, design requirements and material differences for pipe systems



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Proper Pipe Installation Practices

Agenda

- Basic Pipe & Soil Concepts
- Trench Fundamentals
- Installation Procedure
- Backfill Testing Rates



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Expected Service Life/Benefits



- A well installed pipe should stay in service 50 to 100 years with little or no repair.
- DelDOT states 75 years for higher functional classification roads (SLI), 50 years for lower functional classification roads (SLII), 25 years for commercial/multi-family entrances (SLIII) and 15 years for residential entrances (SLIV).

PROPER INSTALLATION BENEFITS

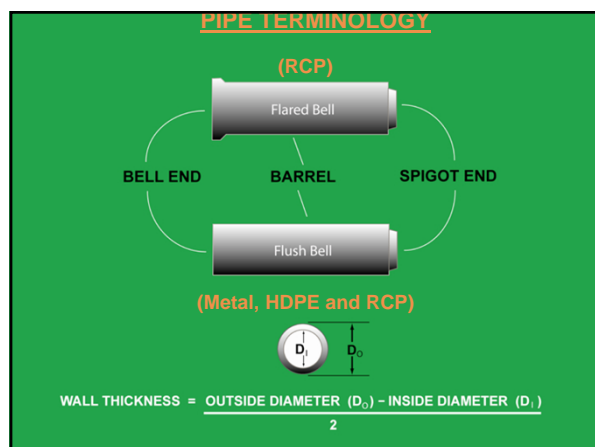
- Essential to Pavement Performance
 - Increases Bearing Capacity
 - Increases Service Life
 - Lowers Maintenance Cost

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Fundamentals and Installation of Drainage Pipe

Factors Contributing to Successful Performance

1. Hydraulic Characteristics and Capacity
2. Structural Capacity
(Cover, Loads)
3. Environment Conditions
(pH of soil and water)
(Soil Resistivity)
(Abrasion due to sand and/or gravel)
(Standing Water)



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What 2 functions **must** an underground pipe provide?

Conduit

Structure

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Reinforced Concrete Pipe

- Structural System
 - RCP Pipe Wall = Majority of Strength
 - 60% - 90% of System Strength
 - Foundation & Bedding
 - 10% - 40% of System Strength

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Rigid Pipe

Structure

56,000 lbs/ft/ft

Conduit


42" Pipe (CL IV)

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Flexible Pipe

- Structural System
 - Flexible Pipe Wall
 - 5% - 10% of System Strength
 - Foundation & Bedding Carries Majority of Load
 - 90% - 95% of System Strength





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Flexible Installation







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Construction Loading


- Culverts are generally designed for the loads they must carry after construction is completed. Construction loads often exceed design loads. These heavy loads can cause considerable damage in flexible pipes and can cause D-load cracking in rigid pipes.
- Additional temporary fill is needed to protect the pipe from construction loads.





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Verifying Pipe

- Metal Pipe**
 - Gauge: 12, 14, 16
 - Corrugation: 2 2/3" x 1/2"; 3" x 1"
- Reinforced Concrete Pipe**
 - Class III, IV, or V
- HDPE Pipe**
 - Meets AASHTO

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Pipe Storage

- Out of the way
- Stacked and chocked
- Do not stack on bells

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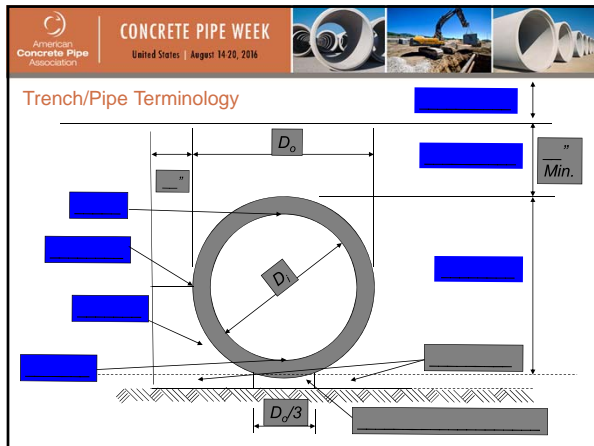
Pipe Delivery/Handling

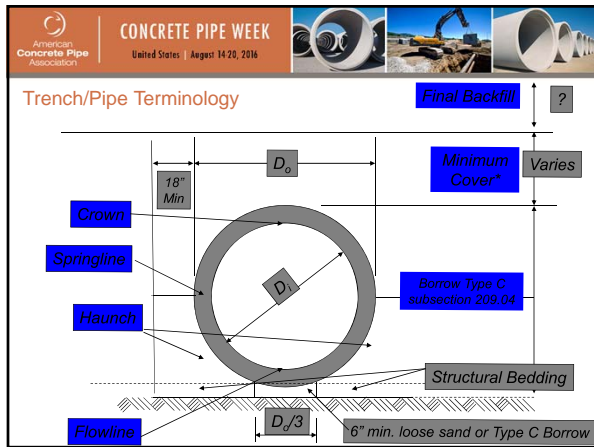
Pipe Delivery

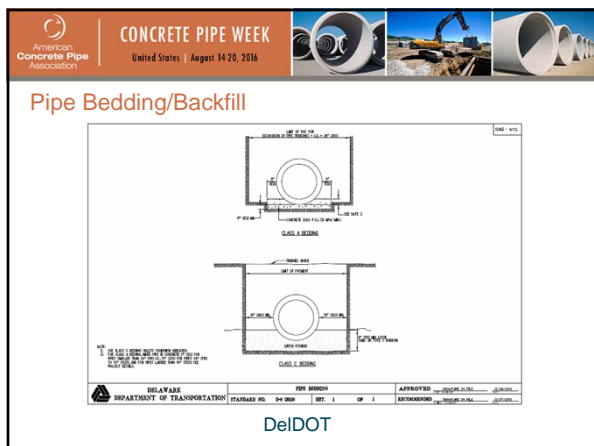
Communicate with Dispatcher


Proper Placement at Site

Protect People/Pipe (Safety)










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Soil Properties

What three major soil properties come into play when installing a pipeline?


1. Composition
2. Gradation
3. Compaction






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Composition


- *Soil* is an aggregate of loose mineral and organic particles.
- *Rock* exhibits strong and permanent cohesive forces between mineral particles.
- *Soil's* primary components are:
 - *Gravel*
 - *Sand*
 - *Silt*
 - *Clay*






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Gradation

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




Well graded

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



Uniformly graded



Gap graded



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Compaction

- Compaction is the densification of soil by the reduction of air in the soil voids.
- More difficult for water to migrate
- Reduce subsequent settling under loading
- The degree of compaction is measured in dry unit weight (dry density).
- Increase shear strength of soil






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Compaction

- Factors That Affect Compaction:
 - Water content of the soil
 - Type of Soil
 - Compactive effort
 - lift thickness, number of roller passes, weight of the roller
 - The type of compaction equipment
 - smooth drum, sheepfoot, pneumatic tire, vibrating plate, vibratory or static, etc
 - The speed of application
 - Compactive energy



WATER CONTENT



SOIL TYPE




COMPACTION EFFORT




LAYER THICKNESS





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Fundamentals and Installation of Drainage Pipe

Installation Procedures

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Installation Methods - Embankment/Trench/Jacking

Trench

Tunnel

Embankment

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There is NO Perfect Pipe

- ❑ All pipes bring certain strengths and weaknesses.
- ❑ Good designers/installers must accommodate for strengths that best benefit the project, while making sure the weaknesses don't jump up and bite you.

Installation is Key

- ❑ Careful attention to construction details such as pipe bedding, backfill material, compaction and trench width are vital.
- ❑ Poor compaction or poor quality backfill around culverts will result in uneven settlement and structural distress of the culvert which directly effects the long term performance of the pipe system.

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FLEXIBLE PIPE INSTALLATION

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RCP INSTALLATION

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INSTALLATION

- Safety
- Pipe Delivery/Handling
- Surveying
- Drainage
- Proper Eqpt./Material
- Leadership

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Pipe Installation Procedures

1. Locate Utilities
2. Excavate trench.
3. Explore Foundation
4. Place structural bedding material to grade. Do not compact.
5. Install pipe to grade.
6. Compact structural bedding outside the middle third of the pipe.
7. Place structural bedding in lifts.
8. Complete structural backfill operation by working from side to side of the pipe.



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Utilities



- Determine Location
- Locate Utilities
- Begin excavation
- Physically Locate Utilities
- Excavate trench with safety in mind
 - Sloped sides
 - Trench box



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Excavate Trench






Best Practices

Safety
Consider Bedding Thickness
Don't over/under excavate
Proper width of trench



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Excavate Trench





Best Practices

Safety
Consider Bedding Thickness
Don't over/under excavate
Proper width of Trench

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Pipe Foundation

- Explore Foundation to determine the type and condition of the foundation
- Explore to a depth equal to $\frac{1}{2}$ " per foot of fill height or 8" (whichever is greater)
- Entrance Pipes of 12" to 30" diameter under 15' of fill or less – no exploration is needed
- **Stable Foundation must be provided to ensure proper line and grade is maintained**

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Pipe Foundation

Pipes and box culverts

Foundation

Crusher run aggregate size No. 25 or 26

When standing water is in pipe foundation area, No. 57 stone can be used as a backfill in the sub-foundation:

No. 57 stone **MUST** be capped with a minimum of 4" crusher run prior to placement of pipe or box culvert

Compaction testing on No. 57 stone is not required; seat stone in trench

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Bedding

6" loosely placed
Shaped 10% of outside ϕ
Graded to distribute load
Check Grade

Standard Installation

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Bedding

- Standard Drawing D-8
- Bedding:
 - Class C Bedding
 - 6" Min. Loose Sand or Type C Borrow
 - Class A Bedding
 - 6" minimum plus Imbed pipe in concrete 6" for pipes smaller than 24"; 10" for pipes 24" to 60"; and for pipes larger than 60" see project details

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Bedding

- Ensure bedding follows grade level for bottom of pipe to ensure continuous support along barrel of pipe
- Uneven bedding creates uneven pipe invert and induces longitudinal stresses in pipe.

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Place Structural Bedding to Grade

Best Practices
Loosely Placed
Rocky Foundation Requires More
Take Your Time - Importation Step

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Place Structural Bedding to Grade

Best Practices
Loosely Placed
Rocky Foundation Requires More
Take Your Time - Importation Step

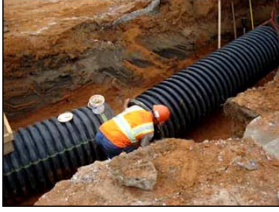


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Install Pipe to Grade






Best Practices

Use Proper Equipment
 Check Bedding Elevation/Grade
 Downstream to upstream (bell up)






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Install Pipe to Grade


Best Practices

Keep Pipe off Bedding
 Protect Joint from Damage
 Avoid Pushing Down to get Grade






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Lift Hole and Plug in Concrete Pipe





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Joints

(Joining Pipe Sections)





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What Function Do Pipe Joints Perform?

1. Provide flexibility and resiliency for movement.
2. Provide for expansion and contraction.
3. Guard against leakage.
4. Connect like materials.
5. Transition between unlike materials.
6. Transmit or transfer load.
7. Reduce stress on the material or structural member.
8. Other???




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What Function Do Pipe Joints Perform?







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Joint Assembly

- Joining Pipe:
- Begin at the downstream end (Bell faces upstream)
- Ensure spigot and bell are clean and free of debris.
- Liberally Lubricate spigot and bell with pipe lubricant.
- Is Contractor aware of the maximum insertion angle?
- Fully insert pipe. (Make a Mark on Outside of Pipe)
- Moving pipe around after joining may cause pipe joint to work apart.

•Rigid pipe - properly fitted, sealed with rubber, preformed plastic, mastic gaskets

•Flexible Pipe - properly aligned and joined with approved coupling bands



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CMP Joint Bands




Dimple

Giles

Annular







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Joint Options for HDPE

- Gasketed Spigot & Bell Joint (ST or WT)
- Split Band Coupler is used for plain end pipe or joining pipes that have been field cut.



Standard Gasketed Joint



Split Band Coupler



Plain End Pipe

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Joint Sealing Options for RCP

Butyl Mastic & Profile Rubber Gaskets

COMPOUND

SINGLE OFFSET

TONGUE AND GROOVE

Rubber O-Ring

Profile Rubber Gaskets

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Compact Structural Bedding

(Outside Middle 1/3 of Pipe)

Best Practices

- Prevent Pipe from Shifting
- Compact in Lifts (6" to 4")
- Use Proper Compaction Eqpt

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UNDISTURBED EARTH

GROUND SURFACE


HAUNCHING, TO PIPE SPRINGLINE

BEDDING MATERIAL

FOUNDATION


MIN. TRENCH WIDTH

Standard Installation




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Backfill Material

- Pipe
 - Borrow Type C for pipe trenches below the roadway or shoulders, 95% or more of maximum density
 - Borrow Type C for pipe trenches other than below roadway or shoulders, to a height 12" above top of pipe and remainder to depth shall be backfilled with existing material. 90% or more of the maximum density
 - Place an initial backfill lift that does not exceed 12" of loose material or no higher than springline. Slice backfill into the haunches. Place lifts no greater than 8" loose material.




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Pipe & Box Culvert Backfill


- Excavation must be wide enough to accommodate compaction equipment
- Simultaneously backfill on both sides
- Static roll until fill is 4 feet above top of pipe or box
- Rocks > 2" must be moved away from structures a minimum of 12"

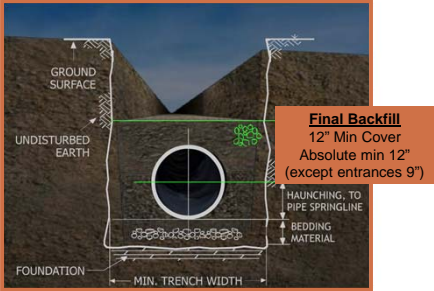




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Final Backfill
12" Min Cover
Absolute min 12"
(except entrances 9")

Standard Installation




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Connections to Structures

Pipe openings in precast drainage units shall not exceed the outside cross sectional dimensions of the pipes by more than a total of **8 inches** regardless of the placement of the pipe, their angles of intersection, or shapes of the pipes.






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Pipe – Structure Connections

Pipe Connections

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





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Pipe – Structure Connections





Pipe Connections

Rigid to Rigid
Flexible Connections w/Flexible Pipe
8 inch (Maximum) Gap
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Pipe – Structure Connections





Proper Connection Material
Rigid to Rigid
Flexible to Flexible
Don't Take Short-cuts



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Pipe – Structure Connections





Best Practices
Manhole Adapters:
A-Lok, Z-Lok, Kor-N-Seal



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Pipe – Structure Connections





Proper Connection Material
Rigid to Rigid
Flexible to Flexible
Don't Take Short-cuts




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Post Installation Inspection

Post Installation Inspection per DelDOT's Storm Sewer CCTV Manual for Storm Sewer Assessment and Acceptance and specifications



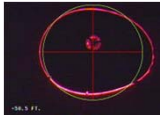
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Post Installation Inspection

- Visual/ Video/Mandrel Inspection required on:
 - All Storm Sewer Pipes (100%)
 - Selected Number of Pipe Culverts (>10%)
- Must be done with DelDOT Rep Present
- Conducted no sooner than 30 days after completion of Installation and placement of final cover (except pavement)










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Effects of Poor Installation

- All pipes
 - Open and offset joints
- Rigid pipes
 - Cracks
 - Lift holes not plugged
- Flexible pipes
 - Deflection
 - Cracks/Dents




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Effects of Poor Installation

- Poor Quality Joints
- Migration of fines
- Sinkholes
- Loss of pipe foundation
- Eventual pipe failure








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Defects Reinforced Concrete Pipe

1. Illegal brand
2. Misalignment (vertical and horizontal)
3. Spalls
4. Slabbing
5. Cracks greater than 0.1" in width
6. Cracks greater than 0.01" in width and showing efflorescence or differential settlement
7. Differential joint movement
8. Improper gasket placement
9. Joint leakage
10. Settlement
11. Joint separations exceeding manufacturer's recomm.


a. 12-36"	0.75"
b. 42" and larger	1.25"
c. All Elliptical	1.5"





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Defects Metal Culverts

1. Illegal brand
2. Uneven laps
3. Deflection greater than 7.5%
4. Elliptical shaping (circular pipe only)
5. Misalignment (vertical and horizontal)
6. Ragged or diagonal sheared edges
7. Loose, unevenly lined or spaced rivets
8. Imperfectly formed rivet heads
9. Unfinished ends
10. Lack of rigidity
11. Bruised, scaled or broken protective coating
12. Dents or bends in the metal
13. Improperly seated bells/spigots
14. Bulging or hanging gaskets
15. Joint separations exceeding manufacturer's recommendation or as follows:

a. 12-36"	0.75"
b. 42" and larger	1.25"
c. All Elliptical	1.5"




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Defects HDPE

1. Illegal brand
2. Deflection greater than 5.0%
3. Misalignment (vertical and horizontal)
4. Connections with a gap exceeding 3/16"
5. Cracking or tearing
6. Creases
7. Unpigmented or non-uniformly pigmented pipe
8. Joint separations exceeding manufacturer's recommendation



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•Deflection Limits:

- <5% - no remediation required
- 5% to 7.4% - shall be evaluated
 - if pipe has additional defects along with deflection in this range pipe shall be remediated
- >7.4% - Pipe shall be replaced


• Deflection Remediation Options:


- <5% - 100% of Unit Bid Price
- 5% to 7.4% - 75% of Unit Bid Price
- >7.4% - Pipe shall be Removed and Replaced

•Buckling, Bulging and Racking


- Flat spots or dents at the crown, sides of flow line due to racking shall be noted and evaluated

• Cracks and Coatings





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Common Types of Pavement Drains

- UD-1 (Standard Groundwater)
- UD-4 (Standard Pavement) (new construction)
- UD-7 (Standard Retrofit) (retrofitting existing)

(found in Road and Bridge Standards)

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UD-4 Standard Pavement

UD-7 Standard Retrofit

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Pavement Drains

Components

- Trench (.5 to 1% long slope)
- Non-woven geotextile drainage fabric
- Perforated long pipe (35 psi min.) collector
- Aggregate backfill (#8 or #57)
- Non-perforated smooth wall outlet pipe (35 psi)
- An end-wall for outlet pipe protection


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Pavement Drains


Pavement Drains Performance

- Intercept
- Collect
- Discharge




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General Underdrain Installation Guide

- Excavate trench making sure walls are stable.
- Remove any sloughed materials from trench
- Excavated material picked up with conveyor and/or front end loader and removed from site.
- Minimum of 0.5 to 1.0% longitudinal slope
- Open on as much trench as can be safely managed
- Line trench with non-woven drainage fabric
- Install long. perf. pipe at bottom of trench w/out bedding
- Place 45 deg. elbow at end of run, connect longit. pipe to non-perforated outlet pipe to discharge water. Drainage side
- Connect outlet pipe to back of end-wall
- Backfill trench with #8 or #57 aggregate asap nlt end of day.
- Backfill depth is at least equal to diameter of pipe.
- Backfill is usually placed loosely & heaped above finish level
- Use vibratory plate with welded foot to compact agg. Backfill
- Fold drainage fabric to provide 100% overlap at top of trench
- UD-4, Open Graded Drainage Layer placed on top of trench
- UD-7, as asphalt cap is used to complete backfilling & provide the final surface is even with shoulder.
- Inspect once complete to ensure no areas are crushed, clogged or non-functioning.
Inspect per VTM-108.




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Conclusion

- Storm Sewers and Culverts have a direct effect on Roads.
- The Inspectors level of commitment to requiring the Contractor to follow DelDOT Standards will have a direct effect on long term DelDOT Maintenance Costs and the long term Quality of Delaware Roads.




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- 1. Before starting to dig what should be located?
Utilities
- 2. True or False. When moving concrete pipe you should pick it up by one end.
 - False
- 3. What is maximum size rock to be placed no closer than 12 inches from pipe ____.
- 2"
- 4. What is the maximum backfill lift thickness?
8 inches loose (12" initial lift)
- 5. What is the maximum backfill lift thickness?
8 inches loose (12" initial lift)




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- 6. Pipe openings in precast drainage structures shall not exceed the outside cross sectional dimensions of the pipe by more than
 - 8 inches
- 7. The video inspection can be done ____ after installation is complete.
 - 30 days
- 8. The maximum allowed crack size of rigid pipe is _____.
 - 0.1 inches.
- 9. The maximum deflection allowed for flexible pipe is _____.
 - 5.0% for HDPE and 7.5% for CMP



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- 10. What end of the pipe system do you start installation?
 - downstream (bell pointed upstream)
- 11. What is the level of compaction required for pipe backfill?
 - 95% under roadways and shoulders
- 12. What is the minimum amount of cover over pipe allowed for design loads?
 - 12" minimum). 9" entrances (exception)
- 13. What is the minimum amount of cover over pipe to prevent damage from construction loads?
 - 4 feet
