CHAPTER 4
INSTALLATION OF PIPE AND TESTING OF PIPE BACKFILL

Why talk about pipe in a Soils and Aggregate School?

- Pipe-soil interaction is critical to successful performance of system
- Treatment of soils adjacent to pipes is different than normal placement of embankment
- Pipes must be adequately protected by soils, prior to allowing construction traffic

PIPE CONSTRUCTION CHECKLIST

1. Verify Pipe
2. Pipe Storage
3. Excavation
4. Foundation
5. Elevation
6. Backfill
VERIFYING PIPE

Verify that the correct pipe has been delivered for the applications on your project.

1. Metal pipe gauge
   - Examples – 12, 14, 16
2. Metal pipe corrugation dimensions
   - Examples – 2 2/3” x ½”; 3” x 1”
3. Concrete pipe strength
   - Examples – Class 3, 4, or 5
4. Maximum height of cover
   - Maximum height for each type of pipe must be given
   - Compare information from drainage summary with maximum cover chart for pipe to be used
   - Check standards for minimum height of cover

Measuring Corrugation Dimensions

2 2/3” x ½”
## Insertable Sheet A166-1

### Table: Maximum Height of Cover in Feet

<table>
<thead>
<tr>
<th>Diameter (Inches)</th>
<th>Area (SQ. FT.)</th>
<th>Maximum Height of Cover in Feet</th>
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</thead>
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<tr>
<td></td>
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<td>None/Reinforced Concrete (Strength)</td>
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<tr>
<td>12</td>
<td>0.8</td>
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<td>15</td>
<td>1.2</td>
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<td>27</td>
<td>4.0</td>
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<tr>
<td>30</td>
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<td>36</td>
<td>7.1</td>
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<td>42</td>
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<tr>
<td>72</td>
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<td>14</td>
</tr>
<tr>
<td>108</td>
<td>63.6</td>
<td>14</td>
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</tbody>
</table>

### Notes:

1. Cover heights indicated in tables are for finished construction.
2. To facilitate pipe during construction, minimum heights of cover prior to backfilling shall be 12 inches for all diameters. Minimum cover due to小学, installation shall be not less than 6 inches for all diameters. Cover due to hale shall extend the full length of the pipe, the approach fill ramp is to extend a minimum of 6 feet beyond the side of the pipe or to the intersection with a curb.
3. Standard minimum finished height of cover for all pipes except those under entrances, shall be 12 inches for all diameters, whether or not greater in cases in which these cover heights cannot be achieved, an absolute minimum finished cover height shall be 2 feet above the surface of the road. Holes shall be cut to ensure the standard minimum finished height of cover for pipes under entrances.
4. Crushing strength (pounds per linear foot) ultimate strength.
5. For height of cover greater that shown for Class V, a special design concrete pipe is required.
6. Reinforced pipe to be used only under entrances and cover tables shall be classified as EC 100B (see Sheet 1, Item 1B).
7. See standard pipeline pipe bedding and backfill requirements.
8. Pipe with less than the standard minimum cover shall be minimum Class III reinforced.
### Corrugated Steel Pipe

<table>
<thead>
<tr>
<th>PIPE DIAMETER</th>
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<tbody>
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<td>INCHES</td>
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<td>72</td>
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<td>78</td>
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<td>84</td>
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</tbody>
</table>

### Notes:
1. Cover heights indicated in tables are for finished construction.
2. To protect pipe during construction, minimum height of cover to be in accordance with tables prior to allowing construction traffic to cross installation. The cover shall extend the full length of the pipe. The approach fill ramp is to extend a minimum of 15 diameters on each side of the pipe or the intersection with a cut.
3. Standard minimum finished cover for all pipes, except under entrances, shall be 2.0' or 1/2 diameter, whichever is greater. In cases A, which these cover heights cannot be achieved, an absolute minimum finished cover height of 2.0' or 1/2 diameter, whichever is greater, will be allowed only if all possible means to obtain the standard value have been exhausted. The minimum finished height of cover for pipes under entrances is 9' for pipe diameters less than or equal to 24", and 12' for 24" diameter, whichever is greater, for pipe diameters greater than 24", where a polymer coated pipe will be placed up to a minimum of 6' above the top of the pipe.
4. 6 gauge pipe limited to those locations where pipe diameter plus cover is less than 20'.
5. The maximum height of cover shown in the cover tables is based on a soil modulus of 700 psi. All other design criteria are in accordance with the AASHTO specifications and AASHTO modifications for soil-corrugated metal structure interaction systems.
6. See Standard PB-1 for pipe bedding and backfill requirements.

### Table A

<table>
<thead>
<tr>
<th>PIPE DIAMETER</th>
<th>MINIMUM COVER HEIGHT DURING CONSTRUCTION (SEE NOTE 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12&quot; TO 30&quot;</td>
<td>18&quot;</td>
</tr>
<tr>
<td>36&quot; AND ABOVE</td>
<td>1/2 DIAMETER</td>
</tr>
</tbody>
</table>

### Concrete, Lined Corrugated Steel Pipe

Maximum height of cover to be in accordance with the tables but shall not exceed 30'.
Make sure there is adequate cover material over the pipe before construction traffic is allowed on it – minimum 3 feet

**PIPE STORAGE**

- Out of the way
- Stacked and chocked
- Store asphalt coated pipe with flowline DOWN
- Asphalt coated pipe may be protected with lime, flyash, or paper

**Moving Pipe**

- Do not pick up pipe by one end
- Use leather or nylon slings
- Use pipe fork for concrete Pipe
- Box culverts may have lift holes
- Pipe > 36” have lift holes
- Pipe ≤ 36” shall not have lift holes
The following copied notes were included in projects beginning with the September, 1997 advertisement.

**SECTION 232.02 (a) 1. CONCRETE PIPE FOR CULVERTS AND SEWERS** of the Specifications is amended to replace the first paragraph with the following:

1. **Concrete pipe for culverts and sewers** shall be circular or elliptical in cross section, either plain concrete or reinforced concrete, and of the modified tongue-and-groove design in sizes up to and including 18 inches (450 millimeters) in internal diameter and either standard or modified reinforced tongue-and-groove in sizes above 18 inches (450 millimeters) in internal diameter. Pipe shall conform to the specified AASHTO requirements, except that pipe having an internal diameter of 36 inches (900 millimeters) or less shall be manufactured without lift holes. Pipe larger than 36 inches (900 millimeters) in internal diameter may be manufactured with lift holes provided the holes are created by molding, forming, coring or other methods to be cylindrical or conical in shape and are sufficiently smooth to permit plugging with an elastomeric or other approved plug type. 4-11-97

**SECTION 302.03 PROCEDURES** of the Specifications is amended to include the following:

When lift holes are provided in concrete pipe or precast box culverts, the Contractor shall install a lift hole plug furnished by the manufacturer in accordance with the requirements of Section 232.02(a)1. of the Specifications. After pipe installation and prior to backfilling, plugs shall be installed from the exterior of the pipe or box culvert and snugly seated. 4-11-97
NO PROJECTION OF PIPE ABOVE GROUND LINE

NORMAL EARTH FOUNDATION

ROCK FOUNDATION

FOUNDATION SOFT, YIELDING, OR OTHERWISE UNSUITABLE MATERIAL

PIPE PROJECTION ABOVE GROUND LINE

NORMAL EARTH FOUNDATION

ROCK FOUNDATION

FOUNDATION SOFT, YIELDING, OR OTHERWISE UNSUITABLE MATERIAL

NOTES:

FOR PLASTIC PIPE, THE LIMITS OF THE CLASS III BACKFILL MATERIAL SHALL BE EXTENDED TO 12" ABOVE THE TOP OF THE PIPE.

FOR GENERAL NOTES ON PIPE BEDDING, SEE INSTALLATION OF PIPE CULVERTS AND STORM SEWERS GENERAL NOTES ON SHEET 107.01.

CRUSHED GLASS CONFORMING TO THE SIZE REQUIREMENTS OF CRUSHER RUN AGGREGATE SIZE 25 AND 26 MAY BE USED IN PLACE OF CLASS III BACKFILL.

INSTALLATION OF PIPE CULVERTS AND STORM SEWERS
CIRCULAR PIPE BEDDING AND BACKFILL - METHOD "A"

VIRGINIA DEPARTMENT OF TRANSPORTATION

SPECIFICATION REFERENCE
302
303

REV. B/03
107.01
NO PROJECTION OF PIPE ABOVE GROUND LINE

NORMAL EARTH FOUNDATION

ROCK FOUNDATION

FOUNDATION SOFT, YIELDING, OR OTHERWISE UNSUITABLE MATERIAL

PIPE PROJECTION ABOVE GROUND LINE

NORMAL EARTH FOUNDATION

ROCK FOUNDATION

FOUNDATION SOFT, YIELDING, OR OTHERWISE UNSUITABLE MATERIAL

NOTES:

FOR GENERAL NOTES ON PIPE BEDDING, SEE INSTALLATION OF PIPE CULVERTS AND STORM SEWERS GENERAL NOTES ON SHEET 107.00.

CRUSHED CLASS CONFORMING TO THE SIZE REQUIREMENTS FOR CRUSHER RUN AGGREGATE SIZE 25 AND 28 MAY BE USED IN PLACE OF CLASS 1 BACKFILL.

INSTALLATION OF PIPE CULVERTS AND STORM SEWERS
ELLIPITCAL PIPE BEDDING AND BACKFILL - METHOD "A"

VIRGINIA DEPARTMENT OF TRANSPORTATION

SPECIFICATION
REFERENCE
302
303
NO PROJECTION OF PIPE ARCH ABOVE GROUND LINE

NORMAL EARTH FOUNDATION

PIECE ARCH PROJECTION ABOVE GROUND LINE

NORMAL EARTH FOUNDATION

NOTE:

FOR GENERAL NOTES ON PIPE BEDDING, SEE INSTALLATION OF PIPE CULVERTS AND STORM SEWERS GENERAL NOTES ON SHEET 107.00.

CRUSHED GLASS CONFORMING TO THE SIZE REQUIREMENTS FOR CRUSHER RUN AGGREGATE SIZE 25 AND 26 MAY BE USED IN PLACE OF CLASS I BACKFILL.

INSTALLATION OF PIPE CULVERTS AND STORM SEWERS

PIPE ARCH BEDDING AND BACKFILL

VIRGINIA DEPARTMENT OF TRANSPORTATION

SPECIFICATION
REFERENCE

302
303

REV 8/07
107.03
H - HEIGHT OF COVER MEASURED FROM TOP OF CULVERT TO FINISHED GRADE.

FOR NORMAL EARTH FOUNDATION:
- FOR PRECAST AND CAST IN PLACE BOX CULVERT b = 6’

FOR ROCK FOUNDATION:
- FOR PRECAST BOX CULVERT b = 1/4’ PER 12’ OF
- H = 6’ MIN, 24’ MAX
- FOR CAST IN PLACE BOX CULVERT b=DEPTH AS SHOWN ON PLANS OR WHERE NO BEDDING IS SPECIFIED BOTTOM SLAB TO BE KEYED INTO EXISTING ROCK FOUNDATION.
- FOR SOFT, YELDING OR OTHERWISE UNSUITABLE FOUNDATION:
- FOR PRECAST AND CAST IN PLACE BOX CULVERT
  b = DEPTH AS SHOWN ON PLANS OR TO FIRM BEARING SOIL

BEDDING MATERIAL

EARTH OR ROCK

GROUND LINE

TOP OF FILL

18” MIN

18” MIN

12”
EXCAVATION

- Locate Utilities (MS Utilities)
- Determine Location (Stake Pipe)
- Begin Excavation
- PHYSICALLY Locate Utilities
- Excavate trench, keeping safety in mind
  - Sloped sides
  - Trench box

FOUNDATION

- Use PB – 1 Standard
- Minimum = 4 inch bedding under all pipe when you have normal earth foundation
- Shape foundation to minimum 1/10 diameter of pipe

Note: The foundation is to be explored below the bottom of the excavation to determine the type and condition of the foundation. The exploration should extend to a depth equal to 1/2” per foot of fill height or 8”, whichever is greater. If it is a routine entrance or crossover pipe 12” – 30” in diameter that is to be installed under fills 15 feet or less in height, no exploration is needed. The Contractor shall report findings of foundation exploration to the Engineer for approval prior to placing pipe.

Foundation Materials for Pipes and Box Culverts

- Crusher run aggregate size no. 25 and 26

- Crushed glass conforming to size requirements for crusher run aggr. size no. 25 and 26 may be used for pipe not box culverts

- When standing water is in pipe foundation area, #57 stone can be used as a backfill in the subfoundation
  - #57 stone MUST be capped with a minimum 4” crusher run prior to placement of pipe or box culvert
  - Compaction testing on #57 stone is not required; seat stone in trench
Pipe Foundation on Rock

- Explore Foundation
- Use PB-1 Standard
- Bedding $\frac{1}{2}''$ per 1 foot of cover, minimum 8” to 24”
- Shape bedding to 1/10 diameter of pipe

**ELEVATION**

- Invert/Outlet Elevation
- Proper Length
- Camber Suggested when possible

**ENSURE LEAK-RESISTANT JOINTS - JOINING PIPE**

**Rigid pipe:** The method of joining pipe sections is such that ends are fully entered and inner surfaces are reasonably flush and even.

Joints shall be sealed with any one or combination of the following to form a leak-resistant joint: rubber, preformed plastic, or mastic gaskets from the Department’s approved list; oakum and mortar; oakum and joint compound; or cold-applied pipe joint sealer.

Rubber ring gaskets shall be installed to form a flexible, leak-resistant seal. Where oakum is used, the unit shall be caulked with this material and then sealed with mortar or joint compound.

**Flexible pipe:** Flexible pipe sections shall be aligned and firmly joined by approved coupling bands to form a leak-resistant joint.

**Note:** Gaskets of pipe shall conform to the following: Rubber gaskets for ductile iron pipe and fittings shall conform to the requirements of AWWA C111; for concrete sewer pipe shall conform to the requirements of ASTM C443; and for other pipe shall conform to the requirements of AASHTO M198, Type A, and Section 237.
MINIMUM SPACING FOR PIPE JOINTS GOING INTO PRECAST UNITS

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 pipes, their angles of intersection, or the shapes of the pipes.

When filling void between pipe culverts and precast drainage structures, the contractor shall use any of the following in conjunction with mortar:

- Concrete
- Brick
- Masonry Block
- Concrete Pipe Cutoffs
- Native Stone

With exception of concrete, such materials shall be thoroughly wetted, bonded with mortar and the remaining exterior and interior voids filled with mortar to the contour of the precast structure.

When precast units are located adjacent to the subbase or base course of the pavement, precast units with chambers are to have 3-inch diameter weepholes with wire cloth to drain the subbase or base layer.
**BACKFILL MATERIAL**

- **Pipe**
  - Class I backfill – crusher run, # 25, # 26, aggregate base 21-A or 21-B, flowable fill, or crushed glass conforming to the size requirements for crusher run aggr. size no. 25 and 26 – from bedding to flow line of pipe
  - Regular excavation and borrow – from flow line of pipe to 1 foot above top of pipe.

- **Box Culvert**
  - Regular excavation or borrow from bedding to 1 foot above top of box

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**Pipe and Box Culvert Backfill**

- Excavation width must be wide enough to accommodate compaction equipment
- Simultaneously backfill on both sides
- Static roll until fill is 3 feet above top of pipe or box
- Rocks > 2" must be moved away from structure a minimum of 12"

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**Multiple Lines of Pipe**

- Bring fill up uniformly on each side of each pipe

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**Backfill Placement Requirements**

- Maximum 6" loose lifts compacted to 4"
- 95% Density
- Optimum moisture
  - ± 20% for regular excavation or borrow (flow line to 1 foot above top of pipe)
  - + 2 percentage points for Class 1 (bedding to flow line)
BACKFILL TESTING RATES

PIPES AND BOX CULVERTS

MINIMUM
ONE TEST PER LIFT ON ALTERNATING SIDES OF PIPE FOR EACH 300 FEET OF PIPE OR PORTION THEREOF. TEST PATTERN IS TO BEGIN AFTER FIRST 4” COMPACTED LAYER ABOVE THE STRUCTURES BEDDING AND CONTINUE TO 1’ ABOVE TOP OF PIPE.

![Diagram of test pattern]

DROP INLETS AND MANHOLES

MINIMUM
ONE TEST EVERY OTHER LIFT AROUND THE PERIMETER BEGINNING AFTER THE FIRST 4” COMPACTED LAYER ABOVE THE BEDDING AND CONTINUE TO TOP OF THE STRUCTURE. STAGGER TESTS TO ENSURE CONSISTENT COMPACTIVE EFFORT HAS BEEN ACHIEVED.
Stone Backfill

- Compaction Tests are REQUIRED on stone backfill (Class I backfill and bedding material)
- Consult the Materials Division for Maximum Density and Moisture Data

Other Techniques to Install Pipe

- Pipe jacking
- Boring
- Tunneling

INSTALLATION OF PIPES FOR PAVEMENT SUBSURFACE DRAINAGE

Pavement subsurface drainage is essential in obtaining a well performing pavement, whether it is flexible, rigid or composite. A drained pavement structure has a higher bearing capacity that can effectively support traffic loadings, and lead to long lasting pavement at the least maintenance cost.

A trench at the edge of the pavement provides a cavity with the least resistance for water to flow and accommodate pavement drainage. The trench’s dimensions and location are typically 1 foot wide and 2 to 4 inches below the subgrade and adjacent to the pavement edge. The specific locations are shown on the plans. There are a variety of pavement under/edge drains in the VDOT Road and Bridge Standards Volume 1 (108.01-108.09) with each addressing a specific geometric condition and groundwater condition.

The most common underdrains are known as UD-4 and UD-7. The UD-4 is used with new construction, while the UD-7 is used for retrofitting existing pavements. These underdrains are segmented systems with outlets spaced at 250 to 350 feet. The components of an underdrain system are:

1. Trench
2. Non-woven geotextile drainage fabric
3. Perforated longitudinal pipe (min. stiffness 35 psi) is the collecting conduit
4. Aggregate backfill (#8 or #57)
5. Non-perforated smooth wall outlet pipe (min. pipe stiffness 65 psi)
6. An end-wall for the protection of the outlet pipe.
The above components are designed to perform three functions to drain water from the pavement, these are:

1. Intercept
2. Collect
3. Discharge

Following is a general guide on the installation of underdrain/edge drain systems:

1. Excavate trench making sure the side walls are stable
2. Remove any sloughed materials from the trench
3. The dug out material is picked up with conveyor belt and loaded in trucks or piled on one side then picked up by a front end loader.
4. Provide a minimum 0.5 to 1% longitudinal slope to enhance positive drainage.
5. Open only as much trench as can be safely maintained by available equipment.
7. Install the longitudinal perforated pipe at the bottom of the trench without bedding material.
8. At the end of the run (250-350 feet) a 45-degree elbow is used to connect the longitudinal pipe to the non-perforated outlet pipe to force the collected water to discharge. The side is called the drainage side.
9. The outlet pipe is connected to the back of the end-wall.
10. Backfill the trench using clean #8 or #57 aggregate as soon as practical, but not later than the end of each working day.
11. Backfill depth is at least equal to the diameter of the pipe.
12. Backfill is usually placed loosely and heaped above the finished level.
13. Use vibratory plate with a welded foot to compact the aggregate backfill.
14. Fold the drainage fabric to provide 100% overlap at the top of the trench.
15. In the case of UD-4, the Open Graded Drainage Layer (OGDL) is placed on top of the completed trench.
16. In the case of UD-7, as asphalt concrete cap is used to complete the backfilling and provide the final surface that is even with the shoulder.
17. Once the system has been installed, it is critical that inspection is performed to ensure that there are no areas that are crushed, clogged or otherwise non-functioning. Inspection is performed in accordance with VTM-108.
CHAPTER 4
Study Questions

1. Asphalt coated pipe should be stored ____________________________.

2. True or False. When moving concrete pipe you should pick it up by one end.

3. The foundation for the pipe should be shaped to a minimum of ________ the diameter.

4. When backfilling around pipe test ________________________________
   ________________________________.

5. Use of a ____________________ is the best way to shape the bedding material for a pipe.

6. To be placed within 12 inches of a pipe, the maximum size a rock can be is
   ____________________________.

7. True or False. You do not have to place pipe bedding material down first when installing a UD-4.

8. Where can the typical underdrain drawings be found? ________________

9. The maximum height of cover for a 48 inch pipe diameter Class IV concrete pipe culvert is ____________________________.

10. A 36 inch diameter pipe 290 feet long is placed on a project as a drainage culvert. What is the minimum number of density tests that should be run on the backfill material?