CONCRETE PIPE 101
Agenda

- Terminology
- Manufacturing Methods
- ASTM Specifications
- Pipe Joints
- Pipe Testing
- Fittings
- Manholes
- Sizing
- Flotation
Manufacturing Methods

- **Wet Cast**
- **Dry Cast**
Manufacturing Methods

- **Wet Cast** - Uses a concrete mix that is wet relative to the mixes used in other processes. Usually contains a slump less than 4 inches and used for production of large diameter pipe.

- **Dry Cast** - Uses a concrete mix with zero slump. The method has several variations but all use low frequency-high amplitude vibration to distribute and densely compact dry mix in the form.
Two Methods of Dry Cast Manufacturing

- Internal Hydraulic
- External Pneumatic Electric Hydraulic
Dry Cast 84”x 16’
Dry Cast Box Culvert
3 Types of ASTM Standards

- Manufacturing
- Testing
- Installation
Manufacturing Specifications

- C-14 – Non-reinforced Concrete Pipe
- C-76 – Reinforced Concrete Pipe
- C-361 – Low Pressure RCP
- C-443 – Rubber Gasket Joints for RCP
- C-478 – Manholes
- C-506 – Arch RCP
- C-507 – Elliptical RCP
- C-1433 – Precast Box Culverts

Replaced C-789 & C-850
Pipe Design Considers Installation

Note from ASTM C76: This specification is a manufacturing and purchase specification only, and does not include requirements for bedding, backfill, or the relationship between field load condition and the strength classification of pipe. However, experience has shown that the successful performance of this product depends upon the proper selection of the class of pipe, type of bedding and backfill, and care that installation conforms to the construction specifications. The owner of the reinforced concrete pipe specified herein is cautioned that he must correlate the field requirements with the class of pipe specified and provide inspection at the construction site.
Test Specifications

- C-497 – Test Methods for RCP & MH
  - 3 Edge Bearing
  - Core & Cylinder Strength
  - Hydrostatic Test
- C-924 – Low Pressure Air Testing, up to 24”
- C-969 – Infiltration/Exfiltration Test of Installed Concrete Pipe
- C-1214 – Vacuum Testing of Installed Pipe
- C-1244 – Vacuum Testing of Installed MH
Installation Specifications

- C-1479 – Installation of RCP Using Standard Installations
  - Companion Design Spec w/ ASCE 15
- Section 27 of AASHTO LRFD Bridge Construction Specifications
Joints

The links that make the system whole

Additional Info in the Concrete Design Manual - click here
Bell & Spigot or Tongue & Groove
What’s the Deal?

Female end of pipe (bell, groove) – portion of the end of the pipe, regardless of shape, which overlaps a portion of the end of the adjoining pipe

Male end of pipe (spigot, tongue) - portion of the end of the pipe, regardless of shape, which is overlapped by portion of the end of the adjoining pipe
Arch & Elliptical Shapes
Define the Service Requirements

- Soil Tight
- Silt Tight
- Watertight gravity
- Watertight pressure
Soil Tight/ Silt Tight

- Storm drains and culverts only!
- Intended to preclude soil / silt transfer through joint
- Non-precision joint
  - Mastic sealant
  - Preformed butyl sealant
  - Mortar Joint
  - Fabric
  - External Wrap

- ASTM C990
Soil Tight Joint
Soil Tight Joint with Fabric
Pushing Box Joint Home
Soil Tight/Silt Tight Joint with External Wrap

ASTM C877
Soil/ Silt Tight Joint
Soil Tight Joint
Watertight – Gravity*

- **Precision Joint**
  - O-Ring gasket
  - Profile gasket
- **ASTM C443**
- **ASTM C1628**

* Tested to zero leakage in the manufacturing plant
Watertight - Gravity Joint

Confined Gasket - O-Ring or Profile
Watertight - Gravity Joint
Watertight - Gravity Joint

Offset Spigot - Profile Gasket
Watertight - Gravity Joint
Watertight - Pressure

○ **Precision Joint**
  - O-Ring gasket

○ **ASTM C361**
Steel Joint Ring Pipe
Gasket materials

- Polyisoprene - standard use
- Chloroprene - moderate hydrocarbon resistance
- Nitrile / Viton - high hydrocarbon resistance

o-ring gasket
profile gasket
Joint Testing

Ensures joint integrity after installation

ASTM C497
- **Bevels / Radius**, not always available
- **Bends**
- **Tees**

**NOTE:** Check supplier for availability

Additional Info in the Concrete Design Manual - [click here](#)
Bevels / Radius Pipe or Boxes

Curved Alignment

Additional Info. – **Click Here**
Figure 3  **Radius Pipe**

Figure 4  **Curved Alignment Using Radius Pipe**

Common method of manufacturing radius pipe.

Projection of joints do not converge at common point, but are tangents to a common circle whose diameter is equal to pipe length.
Fittings

- Bends
- Tees/Wyes
- Reducers/
  - Increasers
- Adapters
Fittings

- Bends
- Tees/Wyes
- Reducers/Increasers
- Adapters
Manholes

- Testing
- Sizing
- Flotation
- Connectors & Joint Sealants
- Depth – Round or Square

Additional Design Data – Click Here

Additional Info in the Concrete Design Manual - click here
Vacuum Testing Manholes
ASTM C-1244
Standard Test Method for
Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill

This standard is issued under the fixed designation C 1244; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ɛ) indicates an editorial change since the last revision or reapproval.

Note—Permissive language and a value in Table 1 were editorially corrected in August 2004.

1. Scope

1.1 This test method covers procedures for testing precast concrete manhole sections when using the vacuum test method to demonstrate the integrity of the installed materials and the construction procedures. This test method is used for testing concrete manhole sections utilizing mortar, mastic, or gasketed joints.

1.2 This test method is intended to be used as a preliminary test to enable the installer to demonstrate the condition of the concrete manholes prior to backfill.

1.3 This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.4 This test method is the companion to metric Test C 969 Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines

3. Terminology

3.1 For definitions of terms relating to manholes, see Terminology C 822.

4. Summary of Practice

4.1 All lift holes and any pipes entering the manhole are to be plugged. A vacuum will be drawn and the vacuum drop over a specified time period is used to determine the acceptability of the manhole.

5. Significance and Use

5.1 This is not a routine test. The values recorded are applicable only to the manhole being tested and at the time of
Design Data 41

Manhole Flotation

Introduction
The proper functioning of a sewer system is dependent to a large degree on the performance of its appurtenances, and especially its manholes. As with many buried structures, the proper design of manholes should take into account the effect of the water table and its specific effect on installation and operating conditions.

The Buoyancy Concept
From a fluid dynamics standpoint, the buoyant force acting on a submerged object is equal to the weight of fluid which that object displaces. In the case of a buried structure or manhole, this concept is applicable when a high ground water table or other subaqueous condition exists. As with the design of buried pipe, flotation should be checked when conditions such as the use of flooding to consolidate backfill, flood plains or future man-made drainage changes are anticipated.

Manhole Buoyancy Analysis
Vertical manhole structures of two types (Figure 1) are generally constructed, and each type should be considered when analyzing the flotation potential. The first case to be considered is a structure in which the base does not extend past the walls of the manhole. This structure will be called a smooth-wall manhole installation. Smooth-wall manholes utilize the weight of the structure itself and the downward frictional resistance of the soil surrounding the manhole to resist the upward buoyant force. Some manufacturers and designers use an extended base to provide additional resistance to buoyant forces. These structures are constructed with a...
Manhole Sizing

- Flexibility
- Handling
- Weight
SIZING MANHOLES
MULTIPLE HOLES AT SAME ELEVATION

<table>
<thead>
<tr>
<th>MH Dia.</th>
<th>M, in/deg</th>
</tr>
</thead>
<tbody>
<tr>
<td>48”</td>
<td>0.4189</td>
</tr>
<tr>
<td>60”</td>
<td>0.5236</td>
</tr>
<tr>
<td>72”</td>
<td>0.6283</td>
</tr>
<tr>
<td>84”</td>
<td>0.7330</td>
</tr>
<tr>
<td>96”</td>
<td>0.8378</td>
</tr>
</tbody>
</table>

M = Circumference/360°

M x Angle = Y
Y - Pipe #1 Opening/2 - Pipe #2 Opening/2 = a
A = Distance between the two openings
Minimum “a” is ≥ 6” for 48” - 72” Dia. MH and
≥ 8” for ≥ *4” Dia. MH

Example:
Pipe #1 = 36” RCP “B” Wall @ 6:00
Pipe #2 = 36” RCP “B” Wall @ 3:00
Angle = 90°
Try 72” Dia. MH
Y = 0.6283 x 90° = 56.55
A = 56.55” - 53/2 - 53/2 = 3.55” < 6”; too small
Therefore, try 84” Dia. MH:
Y = 0.7330 x 90° = 65.97”
A = 65.97” - 51/2 - 51/2 = 14.97” > 8”; OK
<table>
<thead>
<tr>
<th>Pipe Dia., in.</th>
<th>Hole chord Dim., in.</th>
<th>Hole Size (Arc) per MH Diameter, in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>48”Ø</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>20.5</td>
</tr>
<tr>
<td>15</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>18</td>
<td>27</td>
<td>29</td>
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<tr>
<td>224</td>
<td>34</td>
<td>38</td>
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<tr>
<td>30</td>
<td>41</td>
<td>45</td>
</tr>
<tr>
<td>36</td>
<td>48/50</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>55/57</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>62/64</td>
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<tr>
<td>54</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>85</td>
<td></td>
</tr>
</tbody>
</table>

Note: Where two dimensions are shown, i.e. 48/50, the first one is for “B” Wall pipe and the second one is for “C” Wall pipe. Use the Arc length for calculations.
Concrete Pipe Design Basics
Fact:
Buried Pipe Must Perform Two Critical Functions

Buried Pipe
Conduit
Structure
Loads

Supporting Strength

Rigid Pipe

Foundation

Bedding

Haunching

Initial Backfill

Final Backfill

Earth Load

Traffic Load
Unstable Foundation!
How do we define the strength of concrete pipe?
D-Load?

3-Edge Bearing

Class

Wall Thickness?
Wall Thickness & Reinforcement

- **A-Wall** – Wall thickness in inches = Diameter in feet
- **B-Wall** – Wall thickness in inches = Diameter in feet + 1”
- **C-Wall** – Wall thickness in inches = Diameter in feet + 1.75”

- 24” Pipe = 2” Wall
- 24” Pipe = 3” Wall
- 24” Pipe = 3.75” Wall
Three-Edge-Bearing

ASTM C76, C506, C507
ASTM C497
**D-Load**

Supporting strength of a pipe loaded under three-edge bearing test conditions, expressed in pounds per linear foot per foot of inside diameter or horizontal span when tested according to ASTM C497.

\[ D_{0.01} = \text{load (lbs/ft. span/ft. length) to produce 0.01” crack, 12” long} \]

\[ D_{ULT} = \text{load (lbs/ft. span/ft. length) to cause structural failure} \]
Gravity Pipe **Classes**

<table>
<thead>
<tr>
<th>Class</th>
<th>D-Load .01</th>
<th>D-Load Ult.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>800</td>
<td>1200</td>
</tr>
<tr>
<td>II</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>III</td>
<td>1350</td>
<td>2000</td>
</tr>
<tr>
<td>IV</td>
<td>2000</td>
<td>3000</td>
</tr>
<tr>
<td>V</td>
<td>3000</td>
<td>3750</td>
</tr>
</tbody>
</table>

**AASHTO M170**

**ASTM C76**
60" ASTM C-76 Class IV 8’

D_{0.01} = 2000
D_{ULT} = 3000

Total Load Required:
D_{0.01} = (60/12)(8)(2000)
= 80,000 lbs.
D_{ULT} = (60/12)(8)(3000)
= 120,000 lbs.
80,000 lbs.

60" CI IV RCP
Loads on Pipe

- Earth
- Live
- Construction
- Other

Additional Design Data – Click Here
Selection of Pipe Strength

\[
D\text{-}load.\,01 = \left( \frac{W_E}{B_{FE}} + \frac{W_L}{B_{FL}} \right) \times \frac{FS}{D}
\]

Where:

\(D\text{-}load.\,01\) = Required structural capacity, \(lb./ft.\)^2

\(W_E\) = Earth load, \(lb./ft.\)

\(W_L\) = Live load, \(lb./ft.\)

\(D\) = Pipe diameter, ft.

\(B_{FE}\) = Earth Load Bedding Factor

\(B_{FL}\) = Live Load Bedding Factor

\(FS\) = Factor of safety

Additional Info in the Concrete Design Manual - click here
## Gravity Pipe Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>D-Load .01</th>
<th>D-Load Ult.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>800</td>
<td>1200</td>
</tr>
<tr>
<td>II</td>
<td>1000</td>
<td>1500</td>
</tr>
<tr>
<td>III</td>
<td>1350</td>
<td>2000</td>
</tr>
<tr>
<td>IV</td>
<td>2000</td>
<td>3000</td>
</tr>
<tr>
<td>V</td>
<td>3000</td>
<td>3750</td>
</tr>
</tbody>
</table>

AASHTO M170
ASTM C76
### Prescriptive Specification

**“Cook Book Spec”**

**TABLE 3 Design Requirements for Class III Reinforced Concrete Pipe**

**Note:** See Section 5 for basis of acceptance specified by the order.

Strength test requirements as pressure-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (last load experienced in pseudotriangular force under the three-edge-bearing method) or the D-load to produce a 0.014-in. crush of the load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.014-in. crush

<table>
<thead>
<tr>
<th>Internal Diameter</th>
<th>Wall A</th>
<th>Wall B</th>
<th>Wall C</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>14</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>14</td>
<td>16</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>16</td>
<td>18</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>18</td>
<td>20</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>22</td>
<td>21</td>
<td>20</td>
</tr>
</tbody>
</table>

* For models or special designs see 7.2.4 with the understanding that the rules in Appendix A of Specification C 659. Stresses may be determined between those shown for variations in diameter, loading, or wall thickness. Pipes over 24 in. in diameter shall have hoop circular cages or one integral pipe. An inner circular cage plus an elliptical cage shall have a hoop circular cage on the area of the elliptical cage plus the hoop circular cage, unless otherwise specified for the outer cage of the pipe. An inner and outer cage plus an elliptical cage shall be less than that specified for the outer cage in the table and this total area. An inner and outer cage plus an elliptical cage shall be less than that specified for the outer cage in the table. An inner and outer cage plus an elliptical cage shall be less than that specified for the outer cage in the table. An inner and outer cage plus an elliptical cage shall be less than that specified for the outer cage in the table.

**Indications of the maximum permissible stresses for the maximum permissible stress in the pipe.**

- **Circular:** The maximum permissible stress in the pipe shall be less than the specified stress in the table. The maximum permissible stress in the pipe shall be less than the specified stress in the table. The maximum permissible stress in the pipe shall be less than the specified stress in the table.
- **Elliptical:** The maximum permissible stress in the pipe shall be less than the specified stress in the table. The maximum permissible stress in the pipe shall be less than the specified stress in the table. The maximum permissible stress in the pipe shall be less than the specified stress in the table.
Bedding Factor depends on type and quality of installation

Standard Installations – Click here
Who Is Responsible for Bedding Factor?

- **Engineer** via specification, inspection and testing
- **Contractor** via installation means and methods
- **Inspector** via inspection and testing

Additional Info in the Concrete Design Manual - [click here](#)
How do we design concrete pipe?
System Design

Structure

Durability

Joint
System Design

Structure
Design Basics

Installation
Methodology &
Earth Load
Determination

Additional Info in the Concrete Design Manual - click here
Pipe Installation Methods

- **Trench**
- **Positive projection embankment**
- **Negative projection embankment**
- **Jacked, bored, or tunneled**

Additional Info in the Concrete Design Manual - [click here](#)
Positive Projecting Embankment

Final Grade

Existing Grade
Negative Projecting Embankment

Final Grade

Existing Grade
Negative Projecting Embankment
Installation (embedment) Types or Classes

Additional Info in the Concrete Design Manual - click here
Standard Installations

- $D_o/6 \text{ Min.}$
- $D_o$
- $D_o \text{ Min.}$
- $H$

- Lower Side
- Haunch
- Outer Bedding
- Middle Bedding
- Foundation

$D_o/3$
# Standard Installations - ASTM & AASHTO

<table>
<thead>
<tr>
<th>Installation Type</th>
<th>Bedding Thickness</th>
<th>Haunch &amp; Outer Bedding</th>
<th>Lower Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td>$D_o/24$ minimum, not less than 3 in. (75 mm). If rock foundation, use $D_o/12$ minimum, not less than 6 in. (150 mm).</td>
<td>95% Category I</td>
<td>90% Category I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>95% Category II</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>100% Category III</td>
</tr>
<tr>
<td>Type 2</td>
<td>$D_o/24$ minimum, not less than 3 in. (75 mm). If rock foundation, use $D_o/12$ minimum, not less than 6 in. (150 mm).</td>
<td>90% Category I</td>
<td>85% Category I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>95% Category II</td>
<td>90% Category II</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>95% Category III</td>
</tr>
<tr>
<td>Type 3</td>
<td>$D_o/24$ minimum, not less than 3 in. (75 mm). If rock foundation, use $D_o/12$ minimum, not less than 6 in. (150 mm).</td>
<td>85% Category I</td>
<td>85% Category I</td>
</tr>
<tr>
<td></td>
<td></td>
<td>85% Category I</td>
<td>90% Category II</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>95% Category II</td>
</tr>
<tr>
<td>Type 4</td>
<td>No bedding required except if rock foundation, use $D_o/12$ minimum, not less than 6 in. (150 mm).</td>
<td>No compaction required, except if Category III, use 85%</td>
<td>No compaction required, except if Category III, use 85%</td>
</tr>
</tbody>
</table>
Standard Installations

<table>
<thead>
<tr>
<th>Type</th>
<th>Pipe Cost</th>
<th>Construction Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Options for Finding Required Pipe Strength

- **Plug & chug - blue book**
- **Fill height tables**
- **Computer software - PipePac 2000**
Steps for Determining the Required Pipe Strength

- 1 - Select the method of installation (trench, embankment, etc.)
- 2 - Determine the earth load (Installation Type: 1-4)
- 3 - Determine the live load
- 4 - Determine the bedding factor (installation type: 1 – 4)
- 5 - Calculate the required D-Load
- 6 - Specify the class
\[ D\text{-load}_{01} = \left( \frac{W_E}{B_{FE}} + \frac{W_L}{B_{FL}} \right) \times \frac{FS}{D} \]
Step 1

Determine the Method of Installation

Additional Info in the Concrete Design Manual - click here
Step 2

Determine Earth Load

Additional Info in the Concrete Design Manual - click here
## Ordinary Clay $K_u = 0.130$

<table>
<thead>
<tr>
<th>Trench Width at Top of Pipe</th>
<th>Transition Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>5'-0&quot;</td>
<td>5'-0&quot;</td>
</tr>
<tr>
<td>5'-6&quot;</td>
<td>5'-6&quot;</td>
</tr>
<tr>
<td>6'-0&quot;</td>
<td>6'-0&quot;</td>
</tr>
<tr>
<td>6'-6&quot;</td>
<td>6'-6&quot;</td>
</tr>
<tr>
<td>7'-0&quot;</td>
<td>7'-0&quot;</td>
</tr>
<tr>
<td>7'-6&quot;</td>
<td>7'-6&quot;</td>
</tr>
<tr>
<td>8'-0&quot;</td>
<td>8'-0&quot;</td>
</tr>
<tr>
<td>8'-6&quot;</td>
<td>8'-6&quot;</td>
</tr>
<tr>
<td>9'-0&quot;</td>
<td>9'-0&quot;</td>
</tr>
<tr>
<td>10'-0&quot;</td>
<td>10'-0&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height of Backfill $H$ Above Top of Pipe, Feet</th>
<th>Design Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Pipe</td>
<td>Design Manual</td>
</tr>
</tbody>
</table>

| Transition loads (bold type) and widths based on $K_u = 0.19$, $r_{sdp} = 0.5$ in the embankment equation. Interpolate for intermediate heights of backfill and/or trench widths. |

* For backfill weighing 110 pounds per cubic foot, increase loads 10%; for 120 pounds per cubic foot, increase loads 20%.
\( W_E = VAF \times PL \)

- **VAF – Vertical Arching Factor**
  - Type 1: \( VAF = 1.35 \)
  - Type 2: \( VAF = 1.40 \)
  - Type 3: \( VAF = 1.40 \)
  - Type 4: \( VAF = 1.45 \)

- **PL – Prism Load**, the weight of the column of earth cover over the pipe outside diameter
Step 3

Determine the Live Load

Additional Info in the Concrete Design Manual - click here
Live Load Sources

- Highway loads
- Railroad loads
- Aircraft loads
- Construction loads
- Other
### Highway Loads on Circular Pipe

**Pounds per Linear Foot**

<table>
<thead>
<tr>
<th>Bc (ft.)</th>
<th>0.5</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
<th>3.5</th>
<th>4.0</th>
<th>5.0</th>
<th>6.0</th>
<th>7.0</th>
<th>8.0</th>
<th>9.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>3780</td>
<td>2080</td>
<td>1470</td>
<td>1080</td>
<td>760</td>
<td>550</td>
<td>450</td>
<td>380</td>
<td>290</td>
<td>230</td>
<td>190</td>
<td>160</td>
<td>130</td>
</tr>
<tr>
<td>15</td>
<td>4240</td>
<td>2360</td>
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### Notes:
1. Unsurfaced roadway.
2. Loads — AASHTO HS 20, two 16,000 lb. dual-tired wheels, 4 ft. on centers with loading, four 12,000 lb. dual-tired wheels, 4 ft. on centers with alternate loading.
3. Critical loads:
   a. For H = 0.5 and 1.0 ft., a single 16,000 lb. dual-tired wheel.
   b. For H = 1.5 through 4.0 ft., two 16,000 lb. dual-tired wheels.
   c. For H > 4.0 ft., alternate loading.
4. Truck live loads for H = 10.0 ft. or more are insignificant.
Step 4

Determine the Bedding Factor

Additional Info in the Concrete Design Manual - click here
## Bedding Factors, Embankment Conditions

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**Notes:**

1. For pipe diameters other than listed in Illustration 4.21, embankment condition factors, $B_{fe}$ can be obtained by interpolation.
2. Bedding Factors are based on the soils being placed with the minimum compaction specified in Illustration 4.4 for each standard installation.
Step 5

Calculate the Required D-Load

Additional Info in the Concrete Design Manual - click here
Selection of Pipe Strength

\[ D\text{-load}_{01} = \left( \frac{W_E}{B_{FE}} + \frac{W_L}{B_{FL}} \right) \times \frac{FS}{D} \]

Where:

- \( D\text{-load}_{01} = \text{Required structural capacity, lb./ft.}^2 \)
- \( W_E = \text{Earth load, lb./ft.} \)
- \( W_L = \text{Live load, lb./ft.} \)
- \( D = \text{Pipe diameter, ft.} \)
- \( B_{FE} = \text{Earth Load Bedding Factor} \)
- \( B_{FL} = \text{Live Load Bedding Factor} \)
- \( FS = \text{Factor of safety} \)

Additional Info in the Concrete Design Manual - [click here](#)
Step 6

Select the Class
## Gravity Pipe Classes

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Fill Height Tables are based on:
1. A soil weight of 120 lb/ft²
2. AASHTO HS20 live load
3. Embankment installation

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### Fill Height Tables

Fill Height Tables are based on:
1. A soil weight of 120 lb/ft³
2. AASHTO HS20 live load
3. Embankment installation

#### Type 1 Bedding

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[Source: Canadian Pipe Association 2021]
### Fill Height Tables

Fill Height Tables are based on:
1. A soil weight of 120 lbs/ft³
2. AASHTO HS20 live load
3. Embankment installation

#### Type 1 Bedding

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Computer Program

PipePac 2000
Congratulations! You are almost finished.

Please see remaining slides for the exam questions and submittal form to receive your PDH.

PDH for this course: 2.0
Non Member Fee: $99.00
Member & Non Industry Engineer Fee: no charge
Instructions for Submitting Exam

- Print out the exam submittal form and test.
- Complete the exam by circling the answers on the form.
- Complete submittal form.
- Mail your exam, submittal form and payment (if applicable) to:
  American Concrete Pipe Association
  8445 Freeport Parkway, Suite 350
  Irving, TX 75063
  Attn: Professional Membership – Online Exam
- Your exam will be graded by the ACPA and the results provided to you within 60 days of receipt.
RCP 101 Exam Submittal Form

Required Contact Information:
Name: ________________________________ Date: ________________________________
Street Address: ________________________________________________________________
Mailing Address: ________________________________________________________________
City: __________________ State: ______ Zip Code: ________________
Telephone: ______________ Fax: ___________________________
Website: www ______________________ E-mail: ____________________________

Certification of ethical completion: I certify that I read the course presentation, understood the learning objective, and completed the exam questions to the best of my ability. Additionally, the contact information provided above is true and accurate.
Signature: __________________________ Date: ________________________________

PDH Value: Your exam answers will be graded by The American Concrete Pipe Association. If you answer at least 75 percent of the questions correctly, you will receive a certificate of completion from The American Concrete Pipe Association within 60 days and will be awarded 2.0 professional development hour (equivalent to 0.2 continuing education unit in most states). Note: It is the responsibility of the licensee to determine if this method of continuing education meets his or her board(s) of registration’s requirements.

Instructions: Select one answer for each exam question and clearly circle the appropriate letter.
1) a b c d 5) a b c d
2) a b c d 6) a b c d
3) a b c d 7) a b c d
4) a b c d 8) a b c d

Fee: $99.00

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American Concrete Pipe Association
8445 Freeport Parkway, Suite 350, Irving, TX 75063 (972) 506-7216 Fax (972) 506-7682
www.concretepipe.org
Which two methods are used to manufacture concrete pipe?
- Wet cast and wet-out
- Packerhead and Hydrostatic
- Packerhead and dry cast
- Internal and external hydraulic

Soil Tight Joints are used for what two design types?
- Culverts and Storm Drains
- Manholes and Culverts
- Storm Drains and Manholes
- Sanitary Sewer and Manholes

The supporting strength of a pipe loaded under three-edge bearing test conditions is the same as in the installed condition.
- True
- False

Which installation method results in the highest soil load on the pipe?
- Negative projecting
- Positive projecting
- Trench
- Tunnel
Name the two different types of Watertight joints.
- Soil Tight and Water Tight
- Tongue & Groove and Bell & Spigot
- O-ring and Profile
- Pressure and O-ring

What is the test used to determine D-load in a pipe?
- There is no test
- Three-Edge Bearing Test
- Joint Shear Test
- Hydrostatic Test

What two critical functions must buried concrete pipe perform?
- Barrier and Structure
- Framework and System
- Structure and Conduit
- Channel and Aqueduct

The earth load, live load and bedding factor are all considered in determining what?
- D-Load
- Hydraulic Capacity
- Diameter of Pipe
- Type of Joint
Thank you for participating in ACPA’s online training.

Please send us an email at info@concretepipe.org if you would like to suggest a training topic to be added in the future. In the subject line include “online training topic.”

www.concretepipe.org