Procedure for Earth Load Modeling:

Consult the Concrete Pipe Technology Handbook to determine the interaction of the components of soil and the load on the components. Use the earth load diagrams to determine the components of soil and the load on the components. For more detail, refer to Sheet 3 for additional instructions for usage of this standard.

Definitions:

- D1 = Inside diameter of the concrete pipe.
- A = Area of the pipe.
- h = Depth of fill.
- W = Weight of the pipe.
- Dm = Standard design factor.
- HAF = Horizontal Arching Factor.
- VAF = Vertical Arching Factor.
- f'c = Compressive strength of concrete.
- f_y = Yield strength of reinforcement.
- D = Design fill height.
- Dm = Design load.
- A1 = Design area.
- A2 = Area of reinforcement.
- V = Vertical load.
- M = Moment.
- W = Weight.
- P = Pressure.
- h1 = Height of fill.
- h2 = Height of fill.
- n1 = Number of pipes.
- n2 = Number of pipes.
- n3 = Number of pipes.
- n4 = Number of pipes.
- n5 = Number of pipes.
- A6 = Area of reinforcement.
- A7 = Area of reinforcement.
- A8 = Area of reinforcement.
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- A217 = Area of reinforcement.
- A218 = Area of reinforce...
### Table A: Design Data

<table>
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<tr>
<th>Items</th>
<th>Standard Installation</th>
<th>Trench Box/Shoring Installation</th>
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<tr>
<td><strong>Installation Type</strong></td>
<td>Type A</td>
<td>Type B</td>
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### Table B: Arching Coefficients

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<td><strong>Installation Type</strong></td>
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<td>Arching</td>
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### Table C: Factors for Trench Box or Shoring Installation

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<tr>
<th>Load Type</th>
<th>12&quot; Trench</th>
<th>18&quot; Trench</th>
<th>24&quot; Trench</th>
<th>30&quot; Trench</th>
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<tbody>
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<td><strong>Type A</strong></td>
<td>1.20</td>
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<td><strong>Type B</strong></td>
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### Table D: Factors for Trench Box or Shoring Installation for Elliptical Pipe

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<th>Load Type</th>
<th>12&quot; Trench</th>
<th>18&quot; Trench</th>
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<th>30&quot; Trench</th>
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</thead>
<tbody>
<tr>
<td><strong>Type A</strong></td>
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<td>0.30</td>
</tr>
<tr>
<td><strong>Type B</strong></td>
<td>1.20</td>
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<td>0.30</td>
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REINFORCED CONCRETE PIPE DESIGN EXAMPLES:

1. DESIGN OF A 48" DIAMETER CONCRETE PIPE UNDER 3'-0" OF FILL.

   **TYPE A (STANDARD DUTY) SOLUTION:**
   - Designer determines that a 48" diameter pipe is required and that the maximum fill height is 3'-0". The treatment and standard type of installation as per RC-30M are specified.
   - Item 4001-1001 is specified. Full range 1'-0" to 2'-0".
   - Fabricator references publication and "PAIDD Manufacturing Specifications" for a 48" diameter pipe. A standard installation pipe is selected for a 1'-0" fill height with a minimum fill height of 2'-0".

   **TYPE B (STANDARD DUTY) SOLUTION:**
   - Designer determines that a 48" diameter pipe is required and that the maximum fill height is 3'-0". The treatment and standard type B installation as per RC-30M are specified.
   - Item 4001-1001 is specified. Full range 1'-0" to 2'-0".
   - Fabricator references publication and "PAIDD Manufacturing Specifications" for a 48" diameter pipe. A standard installation pipe is selected for a 3'-0" fill height with a minimum fill height of 2'-0".

2. DESIGN OF A 36" DIAMETER CONCRETE PIPE UNDER 9'-0" OF FILL IN A TRENCH BOX INSTALLATION.

   **SOLUTION:**
   - Designer determines that a 36" diameter pipe is required and that the maximum fill height is 9'-0". The treatment and standard type installation as per RC-30M are specified.
   - Item 4001-1001 is specified. Full range 1'-0" to 7'-0".

   **SIDE SLOPE CONDITION**
   - ENSURES THAT THE SIDE SLOPE IS STABLE AND ARE SPECIFIED.
   - DESIGNER DETERMINES THAT A 48" DIAMETER CONCRETE PIPE IS REQUIRED AND THAT THE MAXIMUM FILL HEIGHT IS 9'-0". THE TREATMENT AND STANDARD TYPE B INSTALLATION AS PER RC-30M ARE SPECIFIED.
   - ITEM #0601-7537 IS SPECIFIED. FILL RANGE 10'-0" TO 3'-0".
   - DESIGNER DETERMINES THAT A 48" DIAMETER CONCRETE PIPE IS REQUIRED AND THAT THE MAXIMUM FILL HEIGHT IS 9'-0". THE TREATMENT AND STANDARD TYPE B INSTALLATION AS PER RC-30M ARE SPECIFIED.
   - ITEM #0601-7370 IS SPECIFIED. FILL RANGE 10'-0" TO 3'-0".
   - DESIGNER DETERMINES THAT A 48" DIAMETER CONCRETE PIPE IS REQUIRED AND THAT THE MAXIMUM FILL HEIGHT IS 9'-0". THE TREATMENT AND STANDARD TYPE B INSTALLATION AS PER RC-30M ARE SPECIFIED.
   - ITEM #0601-7072 IS SPECIFIED. FILL RANGE 10'-0" TO 2'-0".

   **CONCRETE PIPE LOADING CURVE**
   - DESIGN OF A 36" DIAMETER CONCRETE PIPE UNDER 9'-0" OF FILL IN A TRENCH BOX INSTALLATION.
   - DESIGNER DETERMINES THAT A 48" DIAMETER PIPE IS REQUIRED AND THAT THE MAXIMUM FILL HEIGHT IS 9'-0". THE TREATMENT AND STANDARD TYPE B INSTALLATION AS PER RC-30M ARE SPECIFIED.

   **DESIGNER:**
   - 1. DETERMINES DIAMETER OF PIPE REQUIRED BY HYDRAULICS.
   - 2. DETERMINES MAXIMUM HEIGHT OF FILL.
   - 3. ENSURES THAT THE SIDE SLOPE IS STABLE AND THAT THE PIPE IS NOT EXPECTED TO PROVIDE SLOPE STABILITY.
   - 4. SPECIFY CONCRETE PIPES AS INDICATED IN PUB. 280, SECTION 17.1.2. FOR PIPES WITH SHEATH REINFORCEMENT.
   - 5. APPROVES SHOP DETAILS, ETC.
   - 6. SPECIFIES INCREASED WALL THICKNESS, 3" REQUIRED FOR ACIDIC OR ABRASIVE CONDITIONS.

   **FABRICATOR:**
   - 1. USES PRE-APPROVED DESIGNS PREPARED BY PENNDOT.
   - 2. DETERMINES MAXIMUM HEIGHT OF FILL.
   - 3. DETERMINE SIDE SLOPE IS STABLE AND THAT THE PIPE IS NOT EXPECTED TO PROVIDE SLOPE STABILITY.
   - 4. SPECIFY CONCRETE PIPES AS INDICATED IN PUB. 280, SECTION 17.1.2. FOR PIPES WITH SHEATH REINFORCEMENT.
   - 5. APPROVES SHOP DETAILS, ETC.

   **CONTRACTOR:**
   - 1. SELECTS THE TYPE OF PIPE INSTALLATION, I.E., EMBANKMENT OR TRENCH BOXING.
   - 2. DETERMINES MAXIMUM HEIGHT OF FILL.
   - 3. ENSURES THAT THE SIDE SLOPE IS STABLE AND THAT THE PIPE IS NOT EXPECTED TO PROVIDE SLOPE STABILITY.

   **COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF TRANSPORTATION BUREAU OF PROJECT DELIVERY STANDARD REINFORCED CONCRETE PIPES**

   **DESIGN EXAMPLES/ RESPONSIBILITIES**
### Design Tables for Circular Pipes - Type A Standard Installation

<table>
<thead>
<tr>
<th>Dia.</th>
<th>Fill/Cover Height</th>
<th>Steel Area - Type A (in./ft.)</th>
<th>Steel Area - Type B (in./ft.)</th>
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<tr>
<td>8&quot;</td>
<td>30&quot;</td>
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### Notes:
1. "" Indicates same steel area as shown for the lesser concrete cylinder.
2. "" Indicates special design is required. Use PADD software.
3. Elliptical reinforcing is not allowed except for quadrant reinforcement and for reinforcement of elliptical pipe.
4. For double circular steel reinforced pipe, two areas are shown. The greater area is for the inner tube steel and lesser area is for outer cage steel.
5. Combination of steel not more than 5" in less than 15" in. is permitted only with designer approval.
6. Use PADD software only for pipe design not exceeding 48" in. in any 96" in. span.
7. Steel areas specified in the fill height / steel area ratios are to be calculated using the linear of reinforcement for each layer. The layers may be calculated for the sum of the steel areas. The layers are equal to the area of steel for the entire layer. When substituting or reinforcing to the lesser area, and providing the linear of reinforcement of equivalent area is not permitted.

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**Commonwealth of Pennsylvania**

Department of Transportation

**Standard Reinforced Concrete Pipes**

**Design Tables**

Revised: Nov. 30, 2017
<table>
<thead>
<tr>
<th>DIA. (in.)</th>
<th>REQUIRED FILL/COVER HEIGHT (FT.)</th>
<th>PROOF TEST LOAD (lbs./LF/FT.OF DIAMETER)</th>
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**NOTE:** Proof loads are intended for use in standard reinforced concrete pipes. Proof loads are intended for use in standard reinforced concrete pipes. Proof loads may not be used for the maximum required fill/cover height. Use this table to determine proof load values for full height offsets greater than 10'.

**LEGEND:**
- *Type A Standard Installation*
# Design Tables and Proof Test Load Table for Circular Pipes

## Type B Standard Installation

### Required Fill/Cover Height

<table>
<thead>
<tr>
<th>Dia. (in.)</th>
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<th>60</th>
<th>72</th>
<th>90</th>
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### Proof Test Load

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<th>60</th>
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### Notes:

- Notes include a factor of safety of 1.0 for field crack control.
- Proof loads are an indication of crack control and are not necessarily strength control.
- Steel and fill thickness is based upon flexure, shearing, or welds, whichever governs.
- Substitution of pipes under fills of 3'-0" or less is permitted only with designer approval.

### Legend:

- Notes indicate the same steel area as shown for the lower concrete strength.
- E indicates a special design is required. Use FSO software.
- E indicates a special design is required. Use FSO software.
- S indicates that substitution is not allowed, except for quadrant reinforcement and for reinforcement of elliptical pipes.
- D indicates a special design is required. Use FSO software.
- P indicates a special design is required. Use FSO software.
- Q indicates a special design is required. Use FSO software.
- A indicates a special design is required. Use FSO software.
- B indicates a special design is required. Use FSO software.

### Additional Information:

- For pipes greater than 60" diameter, use Type A Standard Installation Design Tables.
- For pipes under fills of 3'-0" or less, use Type B Standard Installation Design Tables.
- For pipes under fills of 3'-0" or less, use Type B Standard Installation Design Tables.

### Additional Notes:

- For pipes greater than 60" diameter, use Type A Standard Installation Design Tables.
- For pipes under fills of 3'-0" or less, use Type B Standard Installation Design Tables.
### TYPE A SHORING/TRENCH BOX - STEEL AREAS (in./ft.)

<table>
<thead>
<tr>
<th>Dia. f'c</th>
<th>Wall Thick</th>
<th>Type B</th>
<th>Wall Thick</th>
<th>Type C</th>
<th>Wall Thick</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### DESIGN TABLES AND PROOF TEST LOAD TABLE FOR CIRCULAR PIPES

- **TYPE A SHORING/TRENCH BOX INSTALLATION**

<table>
<thead>
<tr>
<th>Dia. f'c</th>
<th>Wall Thick</th>
<th>Type B</th>
<th>Wall Thick</th>
<th>Type C</th>
<th>Wall Thick</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### TYPE B SHORING/TRENCH BOX - STEEL AREAS (in./ft.)

<table>
<thead>
<tr>
<th>Dia. f'c</th>
<th>Wall Thick</th>
<th>Type B</th>
<th>Wall Thick</th>
<th>Type C</th>
<th>Wall Thick</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### TYPE C SHORING/TRENCH BOX - STEEL AREAS (in./ft.)

<table>
<thead>
<tr>
<th>Dia. f'c</th>
<th>Wall Thick</th>
<th>Type B</th>
<th>Wall Thick</th>
<th>Type C</th>
<th>Wall Thick</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:**
1. *Indicates same steel area as shown for the lesser concrete strength.
2. **Indicates a special design is required, use the data as given.
3. **Indicates elliptical reinforcing is assumed, except for quadrant reinforcing at the pipe ends.
4. For circular steel, steel reinforced areas shown are shown in Fig. 8.5. Use these areas as the inner cage steel for the circular pipe, except as noted.
5. **Indicates for pipe diameters greater than 48", use Table 8.5.25 for special design.
6. **Indicates for full strength greater than indicated, use the data as given.
7. M - Design load factor, k.
8. Substitution of steel sizes falls of 3" or less is permitted only after design approval.
9. Use data only for pipe designs not provided by SH-25.
10. Steel used shall be in the full-strength condition. Steel used shall be to the design strength specified in the contract, unless otherwise approved by the Department. The design load factor, k, is assumed to be 1.15 for steel in the full-strength condition. The design load factor, k, is assumed to be 1.0 for steel in the partial-strength condition. The design load factor, k, is assumed to be 1.0 for steel in the full-strength condition.

**DESIGN TABLES AND PROOF TEST LOAD TABLE FOR CIRCULAR PIPES**

- **TYPE B SHORING/TRENCH BOX INSTALLATION**

<table>
<thead>
<tr>
<th>Dia. f'c</th>
<th>Wall Thick</th>
<th>Type B</th>
<th>Wall Thick</th>
<th>Type C</th>
<th>Wall Thick</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### STANDARD REINFORCED CONCRETE PIPES DESIGN TABLES

**LEGEND:**

- For information only. Proof load test may be required. Proof load test shall be the same as the test of this member.

- **COMMONWEALTH OF PENNSYLVANIA DEPARTMENT OF TRANSPORTATION**

- **RECOMMENDED NOV. 1, 2017**

- **SHEET 7 OF 10**
### DESIGN TABLES FOR HORIZONTAL ELLIPTICAL PIPE - STANDARD INSTALLATION - TYPE A / TYPE B

<table>
<thead>
<tr>
<th>Table</th>
<th>Rise (in.)</th>
<th>Span (ft.)</th>
<th>f'c (psi)</th>
<th>Steel Area (in./ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>36</td>
<td>4000</td>
<td>0.56</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>36</td>
<td>4000</td>
<td>0.50</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>24</td>
<td>4000</td>
<td>0.42</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>18</td>
<td>4000</td>
<td>0.32</td>
</tr>
</tbody>
</table>

**NOTES:**
1. * Indicates same steel area as shown for the lesser concrete strength.
2. ** Indicates a special design is required. Use CAD software.
3. Elliptical reinforcing is not allowed except for quadrant reinforcement of elliptical pipe.
4. For double circular steel-reinforced pipe, two areas are shown. The smaller area is for the inner cage steel and lesser area is for outer cage steel.
5. W = Design wall weight, psi.
6. Substitution of pipes under falls of 3° or less is permitted only with designer approval.
7. For design of a Type A standard elliptical pipe follow these steps:
   1. Select the largest dimension of span or rise from elliptical pipe sizes shown in the Type A design weight tables for elliptical pipes. E.g., Rise dimension for vertical elliptical.
   2. Use the Type A standard installation table for circular pipe.
   3. Use the rise dimension for vertical elliptical designs or the span dimension for the horizontal elliptical designs as the diameter for the Type A standard installation tables for circular pipe. Use the next larger available diameter of the Type A standard installation tables for circular pipe to determine the steel area.
8. Use two layers of steel for the inner cage of the Type A standard installation tables for circular pipe. This area for each, inner and outer, cage for the elliptical pipe design.
9. Use two layers of steel for the inner cage of the Type A standard installation tables for circular pipe. This area for each, inner and outer, cage for the elliptical pipe design.
10. For the selected dimension, wall thickness, design wall weight and concrete strength, determine the area of steel required using the inner cage of the Type A standard installation tables for circular pipe. This area for each, inner and outer, cage for the elliptical pipe design.
11. To determine the equivalent area for each, inner and outer, cage for the elliptical pipe design.
### Table: Load Table for Vertical Elliptical Pipe

<table>
<thead>
<tr>
<th>Required Fill/Cover Height (ft.)</th>
<th>Proof Test Loads (lbs/LF/ft.of Diameter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2' H 1'</td>
<td>3' H 7'</td>
</tr>
<tr>
<td>1.0 ft</td>
<td>36 lbs</td>
</tr>
<tr>
<td>1.5 ft</td>
<td>45 lbs</td>
</tr>
<tr>
<td>2.0 ft</td>
<td>54 lbs</td>
</tr>
<tr>
<td>2.5 ft</td>
<td>63 lbs</td>
</tr>
<tr>
<td>3.0 ft</td>
<td>72 lbs</td>
</tr>
<tr>
<td>3.5 ft</td>
<td>81 lbs</td>
</tr>
<tr>
<td>4.0 ft</td>
<td>90 lbs</td>
</tr>
<tr>
<td>4.5 ft</td>
<td>99 lbs</td>
</tr>
<tr>
<td>5.0 ft</td>
<td>108 lbs</td>
</tr>
</tbody>
</table>

**Notes:**
- This table is for use in the design and construction of reinforced concrete pipes for vertical elliptical applications.
- See other tables for horizontal and circular designs.
- Design is required for fill and cover heights of 2'-0" or less. See fill and cover table for fill requirements.
- For design, see example on sheet 2 at circumference of 1.13 ft. See pipe design for fill and cover requirements.
- See other tables for shoring and proof load requirements.
**BE-636M**

**REINFORCED CONCRETE PIPES**

**THE AREA OF STEEL FOR THE SINGLE LAYER CAGE. WHEN SUBSTITUTING, SPACING OF**

* (b) SELECT THE LARGER DIMENSION OF SPAN OR RISE FROM ELLIPTICAL PIPE SIZES SHOWN

* (c) GO TO TYPE A STANDARD INSTALLATION TABLES FOR CIRCULAR PIPES.

* (d) FOR THE SELECTED DIAMETER, WALL THICKNESS, DESIGN FILL HEIGHT AND CONCRETE

**AVAILABLE IN THE TYPE A STANDARD INSTALLATION TABLES FOR CIRCULAR PIPE, USE**

* (a) SELECT THE LARGER DIMENSION OF SPAN OR RISE FROM ELLIPTICAL PIPE SIZES SHOWN

* (b) GO TO TYPE A STANDARD INSTALLATION TABLES FOR CIRCULAR PIPES.

* (c) GO TO TYPE A STANDARD INSTALLATION TABLES FOR CIRCULAR PIPES.

* (d) FOR THE SELECTED DIAMETER, WALL THICKNESS, DESIGN FILL HEIGHT AND CONCRETE

**RECOMMENDED TEXT AREA**

**COMMONWEALTH OF PENNSYLVANIA**

**DEPARTMENT OF TRANSPORTATION**

**BUREAU OF PRODUCTS INSPECTION**

**STANDARD**

**REINFORCED CONCRETE PIPES**

**ELLiptical PIPE DESIGN TABLES**

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**Design Tables and Proof Test Load Table for Vertical & Horizontal Elliptical Pipes**

- Type B Shoring/Trench Box Installation

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**NOTE:**

1. **Notes:**
   - **Notes:**
   - **Notes:**

2. **Notes:**
   - **Notes:**
   - **Notes:**

3. **Notes:**
   - **Notes:**
   - **Notes:**

4. **Notes:**
   - **Notes:**
   - **Notes:**

5. **Notes:**
   - **Notes:**
   - **Notes:**

6. **Notes:**
   - **Notes:**
   - **Notes:**

7. **Notes:**
   - **Notes:**
   - **Notes:**

8. **Notes:**
   - **Notes:**
   - **Notes:**

9. **Notes:**
   - **Notes:**
   - **Notes:**

10. **Notes:**
    - **Notes:**
    - **Notes:**

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**Commonwealth of Pennsylvania Department of Transportation Bureau of Products Inspection Standard Reinforced Concrete Pipes Elliptical Pipe Design Tables**

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**BD-636M**