12.6.6—Soil Envelope

12.6.6.1—Trench Installations

Revise the 1st Paragraph as follows:

The minimum trench width shall provide a 24-in. minimum side wall clearance ~~sufficient space~~ between the pipe and the trench wall to ensure sufficient working room to properly and safely place and compact backfill material.

C12.6.6.1

Revise the 1st and 2nd Paragraphs as follows:

~~As a guide, the minimum trench width should not be less than the greater of the pipe diameter plus 16.0 in.or the pipe diameter times 1.5 plus 12.0 in.~~ The use of specially designed equipment may enable satisfactory installation and embedment even in narrower trenches. If the use of such equipment provides an installation meeting the requirements of this Article, narrower trench widths may be used as approved by the Engineer.

For trenches excavated in rock or high-bearing soils, decreased trench widths may be used up to the limits required for compaction. For these conditions, the use of a flowable backfill material, as specified in Article 12.4.1.3, allows the envelope to be decreased to within 6.0 in. along each side of the pipe for pipes up to and including 42 in. in diameter or span, or 12 in. for pipes over 42 in. in diameter or span.

Revise Table C12.6.6.2-1 as follows:

Table C12.6.6.2-1—Minimum Width of Soil Envelope

Diameter, *S* (in.)	Minimum Envelope Width (ft)
<24	*S*/12
24-~~144~~-108	2.0
>~~144~~-108	5.0

Revise Table 12.6.6.3-1 as follows:

Table 12.6.6.3-1—Minimum Cover

Type	Condition	Minimum Cover*
Corrugated Metal Pipe		$S/8 \geq$ ~~12.0 in.~~ 24.0 in.
Spiral Rib Metal Pipe	Steel Conduit	$S/4 \geq$ ~~12.0 in~~. 24.0 in.
	Aluminum Conduit where $S \leq 48.0$ in.	$S/2 \geq$ ~~12.0 in.~~ 24.0 in.
	Aluminum Conduit where $S > 48.0$ in.	$S/2.75 \geq 24.0$ in.
Structural Plate Pipe Structures	—	$S/8 \geq$ ~~12.0 in.~~ 24.0 in.
Long-Span Structural Plate Pipe Structures	—	Refer to Table 12.8.3.1.1-1
Structural Plate Box Structures	—	1.4 ft. as specified in Article 12.9.1
Deep Corrugated Structure Plate Structures	—	See Article 12.8.9.4
Thermoplastic Pipe	Under unpaved areas	$ID/8 \geq$ ~~12.0 in.~~ 24.0 in.
	Under paved roads	$ID/2 \geq 24.0$ in.
* Minimum cover taken from top of rigid pavement or bottom of flexible pavement		
Type	Condition	Minimum Cover
Reinforced Concrete Pipe	Under unpaved areas or top of flexible pavement	$B_c/8$ or $B'_c/8$, whichever is greater, $\geq$ ~~12.0 in.~~ 24.0 in.
Type	Condition	Minimum Cover
Reinforced Concrete Pipe	Under bottom of rigid pavement	~~9.0 in.~~ 12.0 in.

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Revise Table 12.10.2.1-1 as follows:

Table 12.10.2.1-1—Standard Embankment Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	For soil foundation, use B_c /2 ~~ft~~ in. minimum, not less than 3.0 in. For rock foundation, use B_c ~~ft~~ in. minimum, not less than 6.0 in.	95% SW	90% SW, 95% ML, or 100% CL
Type 2—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c /2 ~~ft~~ in. minimum, not less than 3.0 in. For rock foundation, use B_c ~~ft~~ in. minimum, not less than 6.0 in.	90% SW or 95% ML	85% SW, 90% ML, or 95% CL
Type 3—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c /2 ~~ft~~ in. minimum, not less than 3.0 in. For rock foundation, use B_c ~~ft~~ in. minimum, not less than 6.0 in.	85% SW, 90% ML, or 95% CL	85% SW, 90% ML, or 95% CL
~~Type 4~~	~~For soil foundation, no bedding required. For rock foundation, use *Bc*/2 ft minimum, not less than 6.0 in.~~	~~No compaction required, except if CL, use 85% CL~~	~~No compaction required, except if CL, use 85% CL~~

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Revise Table 12.10.2.1-2 as follows:

Table 12.10.2.1-2—Standard Trench Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	For soil foundation, use B_c /2 ~~ft~~ in. minimum, not less than 3.0 in. For rock foundation, use B_c ~~ft~~ in. minimum, not less than 6.0 in.	95% SW	90% SW, 95% ML, or 100% CL, or natural soils of equal firmness
Type 2—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c /2 ~~ft~~ in. minimum, not less than 3.0 in. For rock foundation, use B_c ~~ft~~ in. minimum, not less than 6.0 in.	90% SW or 95% ML	85% SW, 90% ML, or 95% CL, or natural soils of equal firmness
Type 3—Installations are available for horizontal elliptical, vertical elliptical, and arch pipe	For soil foundation, use B_c /4 ~~ft~~ in. minimum, not less than 3.0 in. For rock foundation, use B_c ~~ft~~ in. minimum, not less than 6.0 in.	85% SW, 90% ML, or 95% CL	85% SW, 90% ML, or 95% CL, or natural soils of equal firmness
~~Type 4~~	~~For soil foundation, no bedding required. For rock foundation, use B_c /2 ft minimum, not less than 6.0 in.~~	~~No compaction required, except if CL, use 85% CL~~	~~85% SW, 90% ML, 95% CL, or natural soils of equal firmness~~

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12.10.2.1—Standard Installations

Revise Table 12.10.2.1-3 as follows:

Table 12.10.2.1-3—Coefficients for Use with Figure 12.10.2.1-1

	Installation Type			
	1	2	3	~~4~~
VAF	1.35	1.40	1.40	~~1.45~~
HAF	0.45	0.40	0.37	~~0.30~~
A1	0.62	0.85	1.05	~~1.45~~
A2	0.73	0.55	0.35	~~0.00~~
A3	1.35	1.40	1.40	~~1.45~~
A4	0.19	0.15	0.10	~~0.00~~
A5	0.08	0.08	0.10	~~0.11~~
A6	0.18	0.17	0.17	~~0.19~~
a	1.40	1.45	1.45	~~1.45~~
b	0.40	0.40	0.36	~~0.30~~
c	0.18	0.19	0.20	~~0.25~~
e	0.08	0.10	0.12	~~0.00~~
f	0.05	0.05	0.05	~~—~~
u	0.80	0.82	0.85	~~0.90~~
v	0.80	0.70	0.60	~~—~~

Add an additional paragraph and three figures after the last paragraph as follows:

When non-standard installations are used, the unfactored earth pressure on the structure shall be the prism of earth weight (prism load) above the pipe multiplied by a soil-structure interaction factor. The unit weight of soil shall not be less than 120 lbs/cu. ft. In the case that a more accurate estimate of the unit weight of soil is required, the maximum unit weight can be verified through a lab test by Geotechnical Services. Pressure distribution shall be determined by an appropriate soil-structure interaction analysis. Acceptable pressure distributions for non-standard installations are: the Olander/Modified Olander Radial Pressure Distribution - see Figure 12.10.2.1-2(a), or the Paris/Manual Uniform Pressure Distribution - see Figure 12.10.2.1-2(b). For bedding angles and lateral pressures used with the latter distributions see Figure 12.10.2.1-3 and Figure 12.10.2.1-4. Other methods for determining total load and pressure distribution may be used, if based on successful design practice or tests that reflect the appropriate design condition.

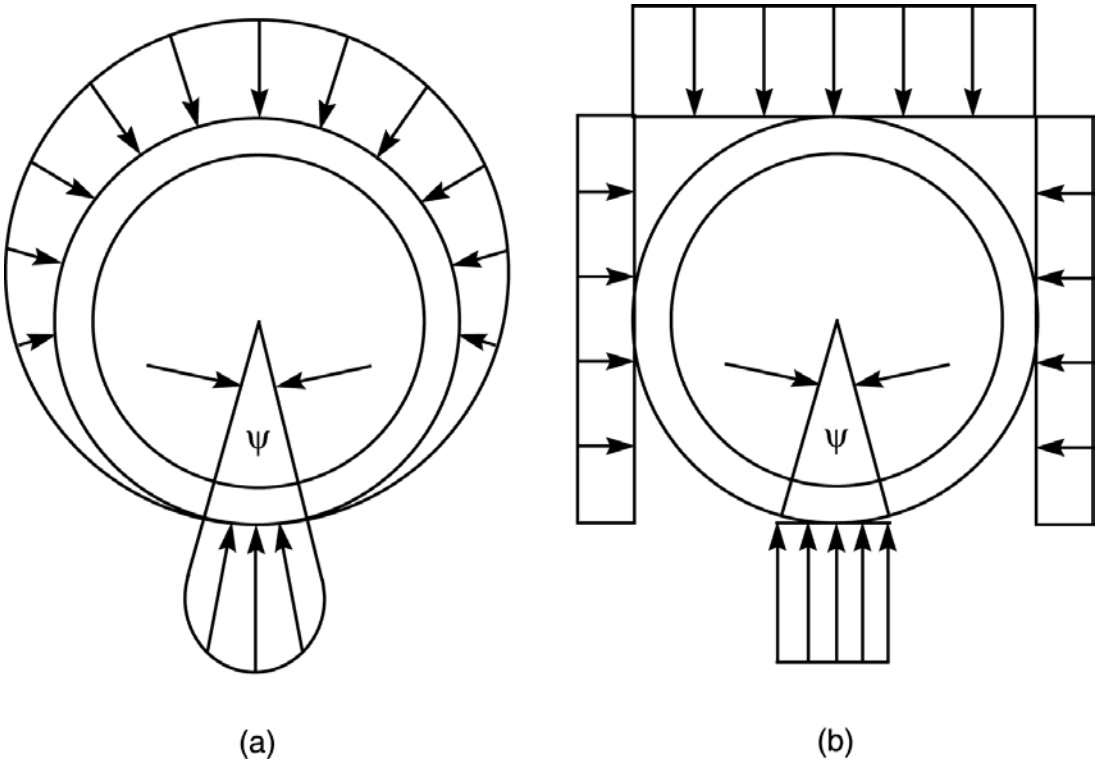


Figure 12.10.2.1-2(a)—Olander/Modified Olander Radial Pressure Distribution Diagram
Figure 12.10.2.1-2(b)—Paris/Manual Uniform Pressure Distribution Diagram

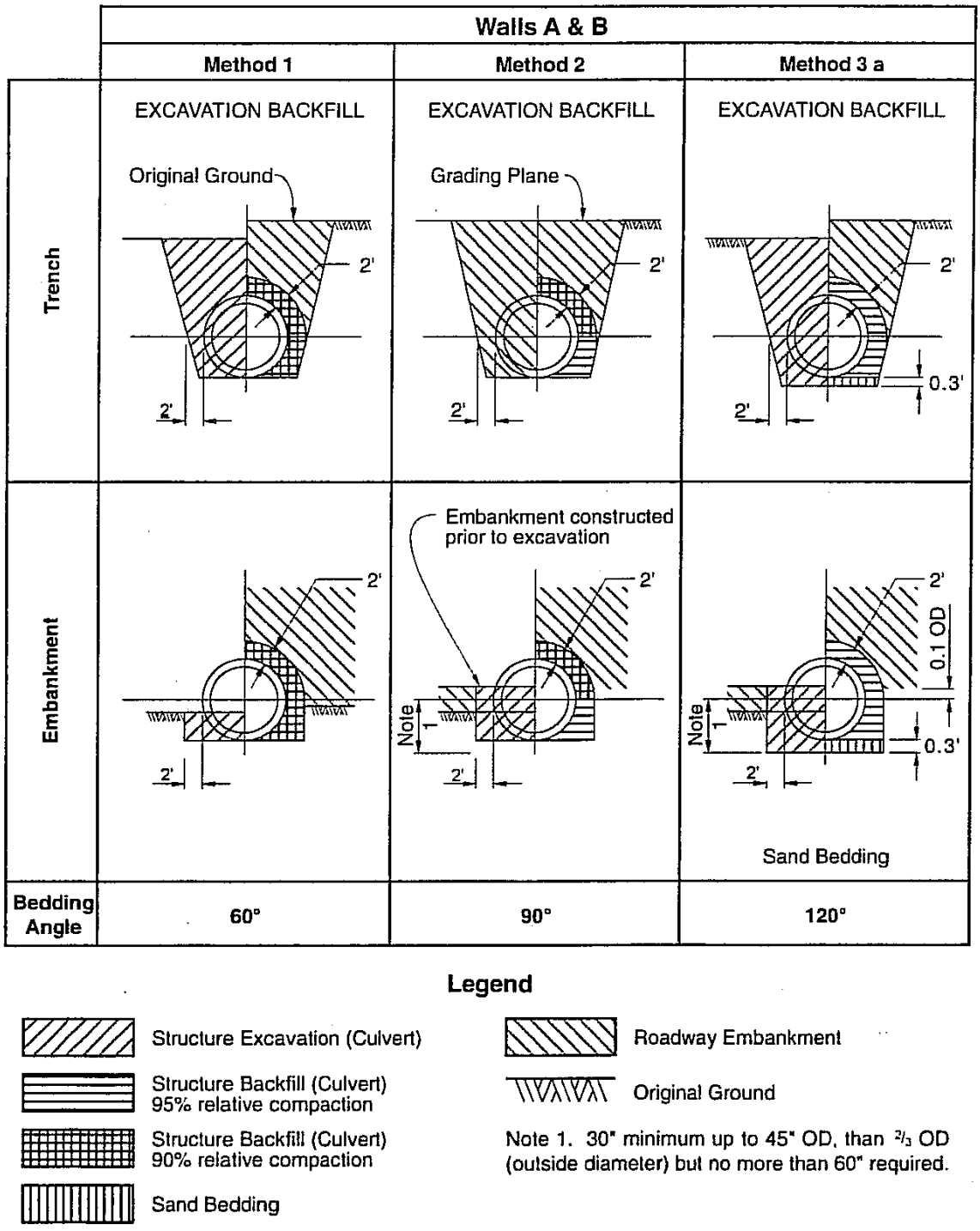
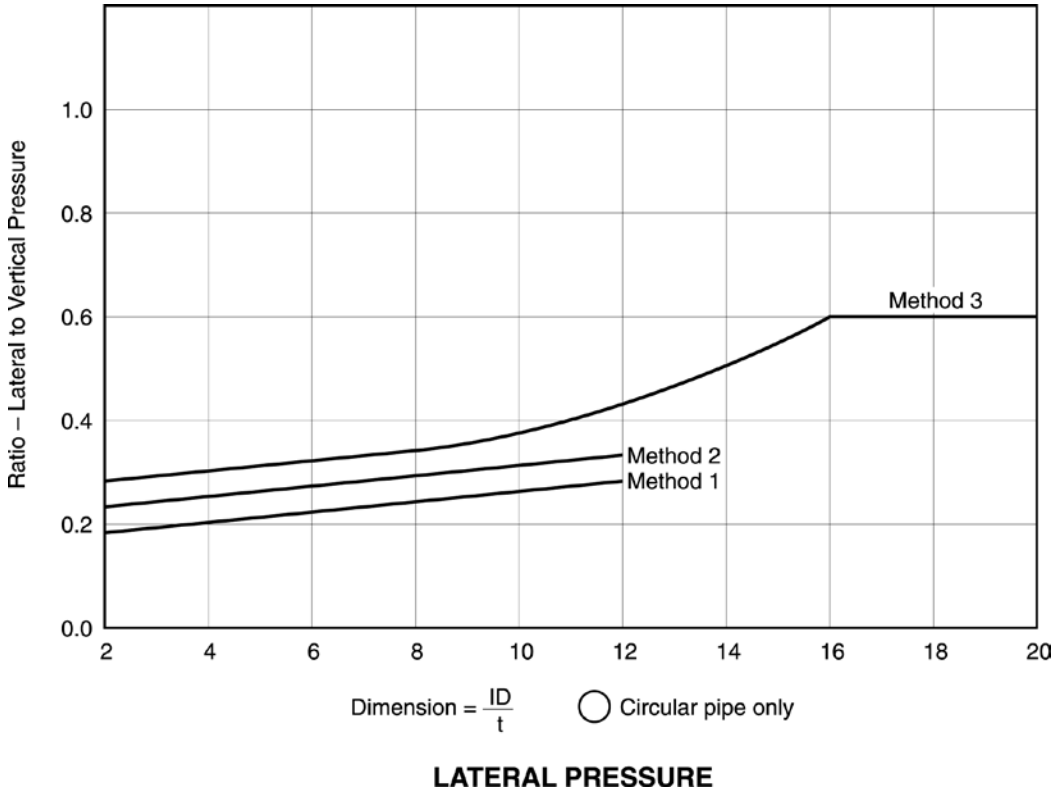


Figure 12.10.2.1-3—Trench and Embankment Backfill Bedding Angles



Legend
ID = inside diameter of pipe, t = wall thickness of pipe

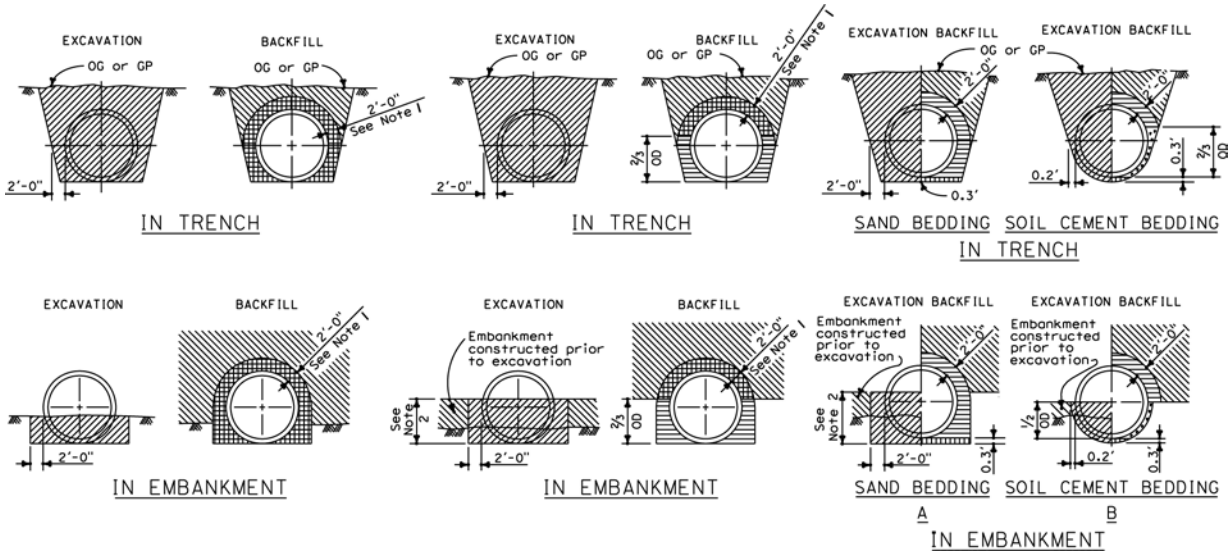
Figure 12.10.2.1-4—Non-Standard Installation Lateral Pressures Distribution

12.10.4.3—Indirect Design Method

12.10.4.3.1—Bearing Resistance

Add a new 2nd Paragraph, a figure, and a table after the 1st Paragraph as follows:

Reinforced concrete pipe culvert excavation/ backfill criteria for Caltrans non-standard installation Methods 1, 2, and 3 are summarized in Figure 12.10.4.3.1-1 below. Associated fill heights and pipe classes are indicated in the adjacent D-Load Overfill Table 12.10.4.3.1-1. Pipe backfill is to be placed over the full width of excavation except where dimensions are shown for specific backfill width or thickness. Dimensions shown are minimums. Above information is based on Caltrans research *(Transportation Record 878)*, and Caltrans *Standard Plans 2010*, A62D.



METHOD 1 **METHOD 2** **METHOD 3**

Note:

1. Embankment compaction requirements govern over the 90% relative compaction backfill requirement within 2′-6″ of finished grade.
2. Embankment height prior to excavation for installation of all classes of RCP under Method 2 and Method 3A shall be as follows:

   Pipe sizes 1′-0″ to 3′-6″ ID = 2′-6″
   Pipe sizes 4′-0″ to 7′-0″ ID = 2/3 OD
   Pipe sizes larger than 7′-0″ ID = 5′-0″

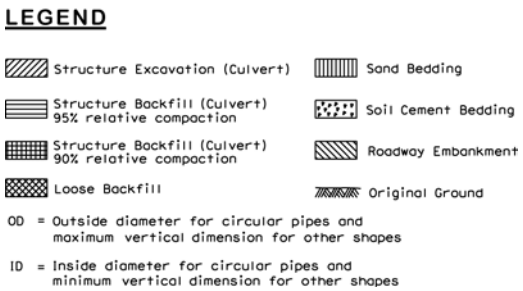


Figure 12.10.4.3.1-1—Non-Standard Installation Excavation Backfill

Table 12.10.4.3.1-1—D-Load Overfill Table

MINIMUM ALLOWABLE CLASSES OF RCP FOR METHOD 1

COVER	MINIMUM CLASS AND D-LOAD
5.9′	Class II 1000D
6.0′ - 7.9′	Class III 1350D
8.0′ - 9.9′	Class III Special 1700D
10.0′ - 11.9′	Class IV 2000D
12.0′ - 13.9′	Class IV Special 2500D
14.0′ - 16.9′	Class V 3000D
17.0′ - 20.0′	Class V Special 3600D

METHOD 1

MINIMUM ALLOWABLE CLASSES OF RCP FOR METHOD 2

COVER	MINIMUM CLASS AND D-LOAD
15.9′	Class II 1000D
16.0′ - 19.9′	Class III 1350D
20.0′ - 24.9′	Class III Special 1700D
25.0′ - 27.9′	Class IV 2000D
28.0′ - 34.9′	Class IV Special 2500D
35.0′ - 41.9′	Class V 3000D
42.0′ - 50.0′	Class V Special 3600D

METHOD 2

MINIMUM ALLOWABLE CLASSES OF RCP FOR METHOD 3

COVER	MINIMUM CLASS AND D-LOAD
25.9′	Class II 1000D
26.0′ - 31.9′	Class III 1350D
32.0′ - 37.9′	Class III Special 1700D
38.0′ - 44.9′	Class IV 2000D
45.0′ - 55.9′	Class IV Special 2500D
56.0′ - 67.9′	Class V 3000D
68.0′ - 80.0′	Class V Special 3600D

METHOD 3

REINFORCED CONCRETE PIPE

The maximum size for all classes or RCP placed under Method 1 is 78" ID.

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12.10.4.3.2a—EarthLoad Bedding Factor for Circular Pipe

Revise Table 12.10.4.3.2a-1 as follow:

Table 12.10.4.3.2a-1—Bedding Factors for Circular Pipe

Pipe Diameter, in.	Standard Installations			
	Type 1	Type 2	Type 3	~~Type 4~~
12	4.4	3.2	2.5	~~1.7~~
24	4.2	3.0	2.4	~~1.7~~
36	4.0	2.9	2.3	~~1.7~~
72	3.8	2.8	2.2	~~1.7~~
144	3.6	2.8	2.2	~~1.7~~

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12.15—REFERENCES

Add the following references:

Alfred E. Bacher, Albert N. Banke, and Daniel E. Kirkland. 1963. "Reinforced Concrete Pipe Culverts: Design Summary and Implementation." *Transportation Record 878.* Committee on Culverts and Hydraulic Structures, California Department of Transportation, Sacramento, CA.

Caltrans, *Standard Plans 2010*, California Department of Transportation, Sacramento, CA.

Caltrans, *Standard Specifications 2010*, California Department of Transportation, Sacramento, CA.

Caltrans, *Bridge Design Specifications, LFD Version*, April 2000 Section 17 – Soil Reinforced Concrete Structure Interaction Systems, California Department of Transportation, Sacramento, CA.

Caltrans, *CA Test* 216 Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates, California Department of Transportation, Sacramento, CA.

Caltrans, *CA Test* 231 Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates Using Nuclear Gage, California Department of Transportation, Sacramento, CA.

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