A Guide to 23 CFR 625 Requirements for Culverts & Pipe

AASHTO LRFD Section 12 Standards

American Concrete Pipe Association

A User's Guide:

You Should Know

A Message from the American Concrete Pipe Association

American Concrete Pipe Association

Bulletin No 144

A User's Guide:

Adhering to Federal Regulation 23CFR625 in the Design of Buried Culverts

Background: In 2013, following the passage of MAP-21 which contained language granting the states autonomy on the selection of culvert pipe material type, the FHWA issued language addressing the culvert design issue in their Final Rule which was published in the Federal Register on January 28, 2013. In that rule they wrote: ***"Although section 1525 gives the States the autonomy to determine culvert and storm sewer material types, section 1525 does not relieve the States of compliance with other applicable Federal requirements, such as Buy America, culvert design standards in 23 CFR part 625…"***

FHWA July 2016 Email: On July 20, 2016, the FHWA sent an email to all of their district offices reiterating the design requirement noting the following: ***"While these requirements are routinely and rigorously applied to bridges and bridge-sized culverts, I wanted to remind you that they also extend to other applications such as smaller culverts, structural supports for signs, luminaires, traffic signals and buried pipes."***

23CFR625: Currently, section 23CFR625 of the Federal Regulations refers to: "AASHTO LRFD Bridge Design Specifications, 7th Edition, AASHTO, 2014, with 2015 Interim Revisions" for use in designing buried structures, including culverts.

AASHTO LRFD Bridge Design Specifications: Section 12 of these specifications covers the designs of concrete pipe, metal pipe and plastic pipe.

Concrete Pipe Designs in Section 12 can be performed using either Indirect or Direct design. Indirect designs for the pipe can be found in the latest edition of ASTM Specification C-76 "Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe" and can be used in conjunction with ASTM Specification C-1479 "Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations".

Plastic and Metal Pipe designs, because they are highly dependent on the soil/pipe envelope for structural strength and support, must be direct designs as soil types and properties are different at virtually all installation locations. Additionally, plastic pipe designs rely heavily on the pipe wall profile which is different for every pipe manufacturer. **Consequently, the use of typical fill height tables as a substitute for pipe/soil structural design is not valid.**

ePipe Design Notes: A series of ePipe Design notes have been developed to assist the engineer in some inconclusive areas of the plastic pipe design standard. The standard is silent on the use of trench boxes for construction. As such, without proper research into trench design arching factors, a question arises as to the accuracy of designs using trenches. Additionally, the use of sand backfills and water table levels, and resulting hydrostatic forces on plastic pipe need to be addressed by the designer beyond the guidelines in the specification.

ePipe Design Notes:

Flexible and Rigid Pipe Installation Review and Discussion	Resource # e-022
Trust, but Verify	Resource # e-023
The Importance of the Gradation of Sands With Respect to Structural Backfill Support for Plastic Pipe	Resource # e-024
Water Table Concerns for Storm Drain and Culverts	Resource # e-025
Plastic Fill Height Table Pitfalls	Resource # e-027

YSK-144 (8/16)

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A User’s Guide

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FHWA Email – July 20, 2016

From: Seabron, Sonquela (FHWA) **On Behalf Of** FHWA, Infrastructure (FHWA)
Sent: Wednesday, July 20, 2016 4:54 PM
To: FHWA-#ALLDA-OfficialMailbox
Cc: FHWA-#ALLDFS-OfficialMailbox; Collins, Bernetta (FHWA)
Subject: INFORMATION: Reminder of 23 CFR 625 Design Standards

Good Afternoon,

I wanted to call your attention to the revisions to 23 CFR 625 "Design Standards for Highways" (23 CFR 625) that became effective on November 12, 2015 (*published in the Federal Register on October 13, 2015 [Docket No. FHWA-2015-0003 or https://federalregister.gov/a/2015-25931]).* Overall, this regulation designates acceptable standards, policies, and standard specifications for application in the geometric design, the structural design and construction of highway infrastructure. While these requirements are routinely and rigorously applied to bridges and bridge-sized culverts, I wanted to remind you that they also extend to other applications such as smaller culverts, structural supports for signs, luminaires, traffic signals and buried pipes.

Notable aspects of 23 CFR 625 include: (a) the descriptions and applicability of design standards for the National Highway System (NHS); (b) the applicability of design standards for federal aid projects not on the NHS (i.e., State laws, regulations, directives and standards apply); (c) the applicability of specific design standards including other FHWA regulations and design standards developed by AASHTO and others; (d) the establishment of standards regardless of funding source; (e) a description of the role of the DA; and (f) the process for exceptions. While the 23 CFR 625 revisions primarily reflected updates to AASHTO documents, we encourage Division Offices to take the opportunity to review the entire regulation to assist stewardship and oversight responsibilities. You can find the regulation and other information at:

http://www.fhwa.dot.gov/programadmin/standards.cfm
http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title23/23cfr625_main_02.tpl

Thomas D. Everett
Associate Administrator
FHWA Office of Infrastructure
Office: 202-366-0370

A User's Guide: AASHTO LRFD Bridge Design Specifications

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- Concrete Pipe Designs in Section 12 can be performed using either Indirect or Direct design.
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A User's Guide: AASHTO LRFD Bridge Design Specifications

- Plastic and Metal Pipe designs, because they are highly dependent on the soil/pipe envelope for structural strength and support, must be direct designs as soil types and properties are different at virtually all installation locations.
- Additionally, plastic pipe designs rely heavily on the pipe wall profile which is different for every pipe manufacturer.
- Trench Boxes and Water Table levels are other contributing factors which must be considered.
- Consequently, the use of typical fill height tables as a substitute for pipe/soil structural design is not valid.

A User’s Guide: Design Notes

ePipe Design Notes: A series of ePipe Design notes have been developed to assist the engineer in some inconclusive areas of the plastic pipe design standard. The standard is silent on the use of trench boxes for construction. As such, without proper research into trench design arching factors, a question arises as to the accuracy of designs using trenches. Additionally, the use of sand backfills, and water table levels and resulting hydrostatic forces on plastic pipe need to be addressed by the designer beyond the guidelines in the specification.

ePipe Design Notes:

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- Trust, but Verify — Resource # e-023
- The Importance of the Gradation of Sands With Respect to Structural Backfill Support for Plastic Pipe — Resource # e-024
- Water Table Concerns for Storm Drain and Culverts — Resource # e-025
- Plastic Fill Height Table Pitfalls — Resource # e-027
- Plastic Pipe Profile Predicament — Resource # e-028

The Importance of the Gradation of Sands With Respect to Structural Backfill Support for Plastic Pipe

American Concrete Pipe Association
www.concrete-pipe.org

An educational document from the American Concrete Pipe Association for users and specifiers

Storm drain and culvert pipe installations can be sensitive to the presence of moisture in the bedding, backfill and surrounding soil. Soils placed and compacted in the pipe envelope need to be stable in the presence of water.

The Concerns and Precautions:

According to the AASHTO LRFD code Table 12.12.3.5-2, materials that contain certain amounts of sand are not to be used as backfill for flexible pipe unless specific measures are included in the contract documents to account for proper control of moisture content and to monitor compaction of these materials during the installation process. (see note 2 below).

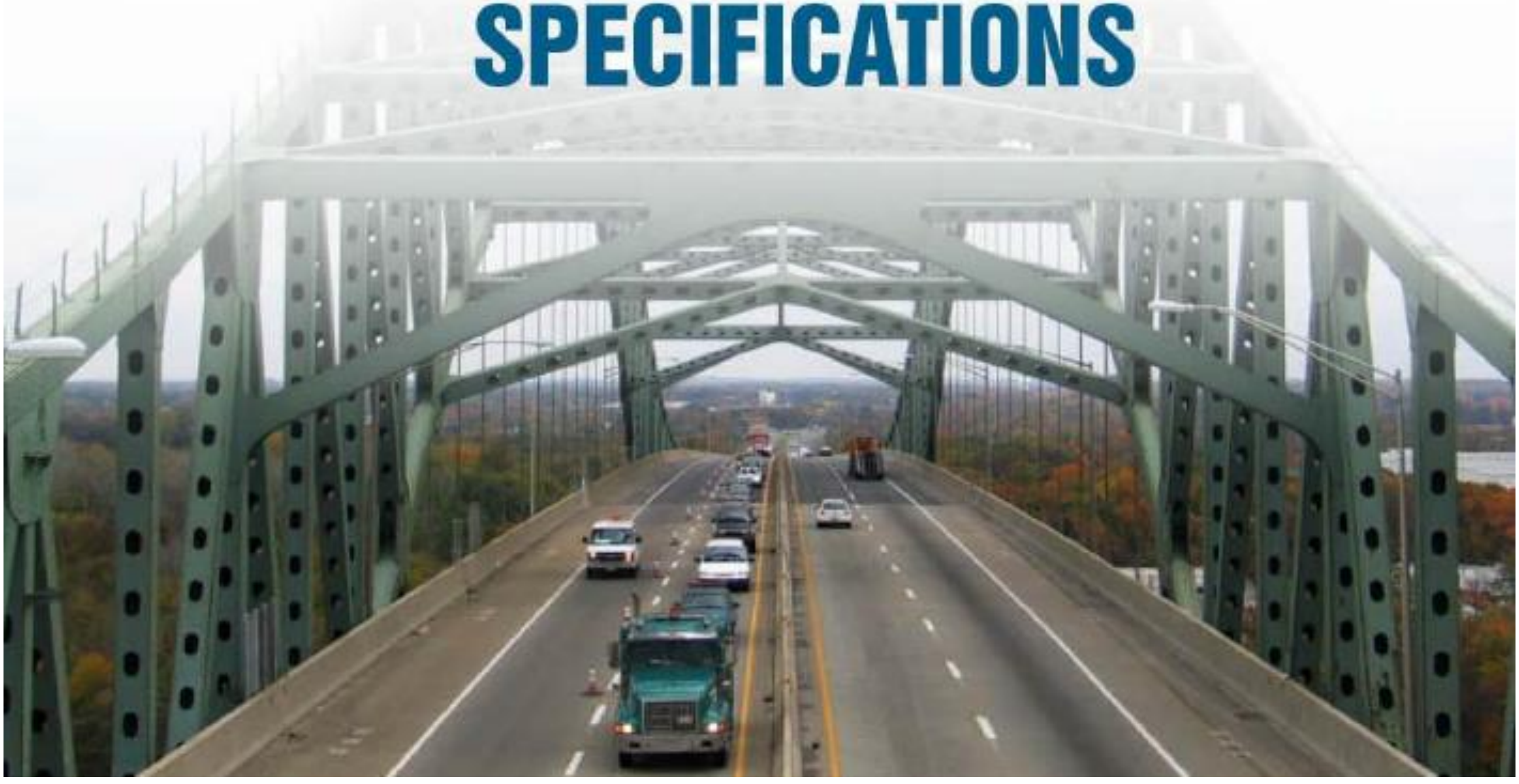
Table 12.12.3.5-2—Equivalent ASTM and AASHTO Soil Classifications

Basic Soil Type (1)	ASTM D2487	AASHTO M 145
Sn (Gravelly sand, SW)	SW, SP (2) GW, GP sands and gravels with 12% or less fines	A1, A3 (2)
Si (Sandy silt, ML)	GM, SM, ML also GC and SC with less than 20% passing a No. 200 sieve	A-2-4, A-2-5, A4

AASHTO

LRFD BRIDGE DESIGN

SPECIFICATIONS



AASHTO Section 12

SECTION 12

BURIED STRUCTURES AND TUNNEL LINERS

12.1—SCOPE

This Section provides requirements for the selection of structural properties and dimensions of buried structures, e.g., culverts, and steel plate used to support tunnel excavations in soil.

Buried structure systems considered herein are metal pipe, structural plate pipe, long-span structural plate, deep corrugated plate, structural plate box, reinforced concrete pipe, reinforced concrete cast-in-place and precast arch, box and elliptical structures, and thermoplastic pipe, and fiberglass pipe.

The type of liner plate considered is cold-formed steel panels.

AASHTO LRFD

12.10—REINFORCED CONCRETE PIPE

12.10.1—General

The provisions herein shall apply to the structural design of buried precast reinforced concrete pipes of circular, elliptical, and arch shapes.

The structural design of the types of pipes indicated above may proceed by either of two methods:

- The direct design method at the strength limit state as specified in Article 12.10.4.2, or
- The indirect design method at the service limit state as specified in Article 12.10.4.3.

12.10.2.1 Standard Installations

The contract documents shall specify that the foundation bedding and backfill comply with the provisions of Article 27.5.2 of the *AASHTO LRFD Construction Specifications.*

Minimum compaction requirements and bedding thickness for standard embankment installations and standard trench installations shall be as specified in Tables 12.10.2.1-1 and 12.10.2.1-2, respectively.

AASHTO LRFD

12.10.4.3—Indirect Design Method

C12.10.4.3.1

The indirect design method has been the most commonly utilized method of design for buried reinforced concrete pipe. It is based on observed successful past installations.

The required D-load at which the pipe develops its ultimate strength in a three-edge bearing test is the design D-load at a 0.01-in. crack multiplied by a strength factor specified in AASHTO M 170 or M 242M/M 242 (ASTM C76 or C655M and C655) for circular pipe, M 206M/M 206 (ASTM C506M and C506) for arch pipe, and M 207M/M 207 (ASTM C507M or C507) for elliptical pipe.

AASHTO LRFD

12.12—THERMOPLASTIC PIPES

12.12.1—General

The provisions herein shall apply to the structural design of buried thermoplastic pipe with solid, corrugated, or profile wall, manufactured of PE, PP, or PVC.

C12.12.1

These structures become part of a composite system comprised of the plastic pipe and the soil envelope.

The following specifications are applicable:

For PE:

- Solid Wall—ASTM F714,
- Corrugated—AASHTO M 294, and
- Profile—ASTM F894.

For PVC:

- Solid Wall—AASHTO M 278 and
- Profile—AASHTO M 304.

For PP:

- Corrugated—AASHTO M 330

Step 1 - Deflection

12.12.2.2—Deflection Requirement

Total deflection, Δ_t, shall be less than the allowable deflection, Δ_A, as follows:

$$\Delta_t \leq \Delta_A \qquad (12.12.2.2\text{-}1)$$

where:

Δ_t = total deflection of pipe expressed as a reduction of the vertical diameter taken as positive for reduction of the vertical diameter and expansion of horizontal diameter. (in.)

Δ_A = total allowable deflection of pipe, reduction of vertical diameter (in.)

12.12.2.2—Deflection Requirement

Total deflection, calculated using Spangler's expression for predicting flexural deflection in combination with the expression for circumferential shortening, shall be determined as:

$$\Delta_t = \frac{K_B \left(D_L P_{sp} + C_L P_L \right) D_o}{1000\left(E_p I_p / R^3 + 0.061\, M_s \right)} + \varepsilon_{sc} D \qquad (12.12.2.2\text{-}2)$$

where:

ε_{sc} = service compressive strain as specified in Article 12.12.3.10.1c

D_L = deflection lag factor , a value of 1.5 is typical

K_B = bedding coefficient , a value of 0.10 is typical

P_{sp} = soil prism pressure evaluated at pipe springline as specified in Article 12.12.3.7 (psi)

C_L = live load coefficient as specified in Article 12.12.3.5

P_L = live load pressure as specified in Article 3.6.1.2.6

D_o = outside diameter of pipe (in.) as shown in Figure C12.12.2.2-1

E_p = short- or long-term modulus of pipe material as specified in Table 12.12.3.3-1 (ksi)

I_p = moment of inertia of pipe profile per unit length of pipe (in.^{4}/in.)

R = radius from center of pipe to centroid of pipe profile (in.) as shown in Figure C12.12.2.2-1

D = diameter to centroid of pipe profile (in.) as shown in Figure C12.12.2.2-1

M_s = secant constrained soil modulus, as specified in Article 12.12.3.5 (ksi)

Plastic Pipe Wall Profiles

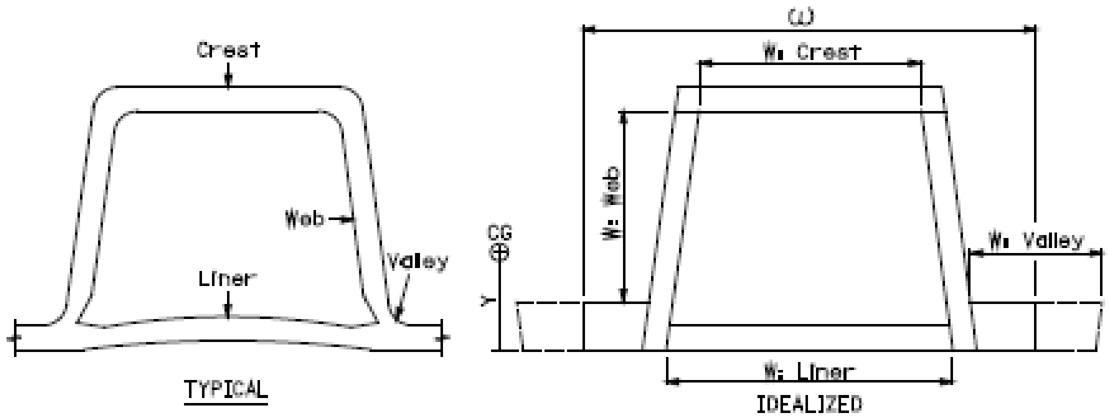


Figure 12.12.3.10.1b-1—Typical and Idealized Cross-Section of Profile Wall Pipe

$$A_{eff} = A_g - \frac{\sum (w - b_e)t}{\omega}$$

in which:

$$b_e = \rho w$$

$$\rho = \frac{\left(1 - \frac{0.22}{\lambda}\right)}{\lambda}$$

$$\lambda = \left(\frac{w}{t}\right)\sqrt{\frac{\varepsilon_{yc}}{k}} \geq 0.673$$

$$A_{eff} = \frac{P_{st} K_t}{F_u} \leq A_g$$

ePipe – The Plastic Pipe Profile Predicament

Critical Design Input:

- Pipe wall geometry plays an important role in the structural performance of a plastic pipeline. If the engineer allows plastic pipe in the specifications, consideration must be given to the fact that each pipe wall profile is different and requires a unique effective area (A_{eff}) for each size of pipe from each individual pipe manufacturer and manufacturing facility.
- This data is required (AASHTO LRFD code 12.12.3.10.1 *Resistance to Axial Thrust)* and must be accurate in the structural calculations – generic fill height tables will not address all available profile offerings.

Loads on Plastic Pipe

12.12.3.4—Thrust

Loads on buried thermoplastic pipe shall be based on the soil prism load, modified as necessary to consider the effects of pipe-soil interaction. Calculations shall consider the duration of a load when selecting pipe properties to be used in design. Live loads need not be considered for the long-term loading condition.

12.12.3.5—Factored and Service Loads

The factored thrust shall be taken as:

$$T_u = \left[\eta_{EV} \left(\gamma_{EV} K_{\gamma E} K_2 VAF \, P_{sp} + \gamma_{WA} P_w \right) + \eta_{LL} \gamma_{LL} P_L \, C_L F_1 F_2 \right] \frac{D_o}{2} \qquad (12.12.3.5\text{-}1)$$

The service thrust shall be taken as:

$$T_s = \left[K_2 VAF \, P_{sp} + P_L \, C_L \, F_1 F_2 + P_w \right] \frac{D_o}{2} \qquad (12.12.3.5\text{-}2)$$

Loads on Plastic pipe

in which:

$$VAF = 0.76 - 0.71 \left(\frac{S_H - 1.17}{S_H + 2.92} \right)$$

VAF = vertical arching factor

and

$$S_H = \frac{\phi_s M_s R}{E_p A_g} \qquad (12.12.3.5\text{-}4)$$

S_H = hoop stiffness factor

M_s = secant constrained soil modulus as specified in Table 12.12.3.5-1 (ksi)

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Vertical Arching Factor

C12.12.3.5

The use of the vertical arching factor is based on the behavior, demonstrated by Burns and Richard (1964), that pipe with high hoop-stiffness ratios (S_H, ratio of soil stiffness to pipe hoop stiffness) carry substantially less load than the weight of the prism of soil directly over the pipe. This behavior was demonstrated experimentally by Hashash and Selig (1990) and analytically by Moore (1995). McGrath (1999) developed the simplified form of the equation presented in this Section.

The *VAF* approach is only developed for the embankment load case. No guidance is currently available to predict the reduced loads on pipe in trench conditions. The only trench load theory proposed for flexible pipe was that by Spangler, which does not have good guidance on selection of input parameters. It is conservative to use the *VAF* approach as presented for embankments.

VAF for embankments is usually 0.4 to 0.6

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ePipe – Flexible and Rigid Pipe Installation Review and Discussion

Critical Design Input:

- Depending on the backfill materials used in a trench installation, as well as the width of the trench, lateral support for the pipe, and the relative column strength of the side-fill, soils may not develop to the same extent as assumed when a flexible pipe is installed in an embankment. The vertical load on the side-fill soils is reduced, which then reduces the stiffness of the soil columns as well as the lateral resistance that can be developed in the side-fill soils.
- In this condition, the Vertical Arching Factor (VAF) may likely be higher than assumed by equation 12.12.3.5-3 to the point that it may be more than 1.0. this means that the flexible pipe may actually see an increase to the soil prism load directly above the pipe compared to the assumed embankment condition, which is not accounted for in current designs.
- The specification is silent on the use and effect of trench boxes.

ePipe – Flexible and Rigid Pipe Installation Review and Discussion

- Until appropriate research is completed to verify the use of embankment VAF as the conservative assumption for all Flexible pipe installations, **it is recommended that trench installations not be allowed or at a minimum not receive the benefit from a VAF less than 1.0 in LRFD calculations. Minimum trench widths should be established to ensure that the installed pipe system meets the assumptions of an embankment.**

ADS Technical Note – Trench Boxes

TECHNICAL NOTE

Recommended Use for Trench Boxes

TN 5.01
March 2009

Regular Trench Installations

In installations not involving a subtrench situation, dragging a trench box should only be done if it does not damage the pipe or disrupt the backfill; otherwise, the box should be lifted vertically into its new position. If it is necessary for a trench box to be dragged through a trench, do not raise the box more than 24” above the work surface.

Another alternative for when the box will be dragged is to use a well-graded granular backfill material at least two diameters on either side of the pipe and compact it to a minimum of 90% standard Proctor density before moving the box. After the trench box is moved, immediately fill the area between the pipe/backfill structure and the trench wall with a granular material.

Constrained Soil Modulus (M_s)

The constrained modulus is the slope of the secant from the origin of the curve to a point on the curve corresponding to the soil prism pressure, P_{sp}, $\boxed{\text{Figure}}$ $\boxed{\text{C12.12.3.5-1.}}$

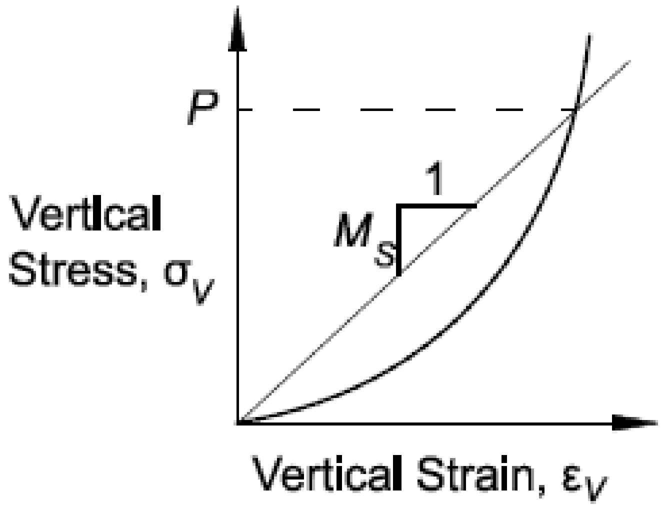


Figure C12.12.3.5-1—Schematic One-Dimensional Stress-Strain Curve of Soil Backfill

Constrained Soil Modulus (M_s)

In the absence of site-specific data, the secant constrained soil modulus, M_s, may be selected from Table 12.12.3.5-1 based on the backfill type and density and the geostatic earth pressure, P_{sp}. Linear interpolation between soil stress levels may be used for the determination of M_s.

Table 12.12.3.5-1—M_s Based on Soil Type and Compaction Condition

1. The soil types are defined by a two-letter designation that indicates general soil classification, Sn for sands and gravels, Si for silts and Cl for clays. Specific soil groups that fall into these categories, based on ASTM D2487 and AASHTO M 145, are listed in Table 12.12.3.5-2.
2. The numerical suffix to the soil type indicates the compaction level of the soil as a percentage of maximum dry density determined in accordance with AASHTO T 99.

Soil Type Table

Table 12.12.3.5-2—Equivalent ASTM and AASHTO Soil Classifications

Basic Soil Type (1)	ASTM D2487	AASHTO M 145
Sn (Gravelly sand, SW)	SW, SP (2) GW, GP sands and gravels with 12% or less fines	A1, A3 (2)
Si (Sandy silt, ML)	GM, SM, ML also GC and SC with less than 20% passing a No. 200 sieve	A-2-4, A-2-5, A4
Cl (Silty clay, CL)	CL, MH, GC, SC also GC and SC with more than 20% passing a No. 200 sieve	A-2-6, A-2-7, A5, A6

1. The soil classification listed in parentheses is the type that was tested to develop the constrained soil modulus values in Table 12.12.3.5-1. The correlations to other soil types are approximate.
2. Uniformly graded materials with an average particle size smaller than a No. 40 sieve shall not be used as backfill for thermoplastic culverts unless specifically allowed in the contract documents and special precautions are taken to control moisture content and monitor compaction levels.

ePipe – The Importance of Gradation of Sands With Respect to Structural Backfill Support for Flexible Pipe

- As the AASHTO Section 12 Plastic Pipe Design procedure warns, uniformly graded material with an average particle size smaller than a No. 40 sieve **"should not be used as backfill for thermoplastic culverts."**
- If, however, the design engineer allows the use of such material, that decision **requires extra precautions** during design and installation.
- The design engineer must take into consideration the actual moisture content and compaction levels of the chosen backfill material **and additionally monitor and measure these factors** during construction.

Hydrostatic Pressure

12.12.3.8—Hydrostatic Pressure

The pressure due to ground water shall be calculated as:

$$P_w = \frac{\gamma_w \, K_{wa} \, H_w}{144} \qquad (12.12.3.8\text{-}1)$$

where:

P_w = hydrostatic water pressure at the springline of the pipe (psi)

γ_w = unit weight of water (lb/ft^3)

K_a = factor for uncertainty in level of groundwater table

Hydrostatic Pressure

I-75 Sarasota, FL 2016

American **Concrete Pipe** Association

Common St. - Lake Charles, LA

Manufacturer's Cautions

minimum 85% Standard Proctor density.

Backfill should begin immediately after pipes are joined to prevent unwanted displacement. The height of loose back-fill material required to prevent flotation of empty Ultra-Rib™ pipe is equal to three times the pipe diameter.

In traffic areas with dynamic loading and with burials three feet or less, special precautions may be needed to protect road surface from the effect of pipe de-flecting and rebounding under these conditions.

ADS Technical Note - Flotation

TECHNICAL NOTE

Pipe Flotation

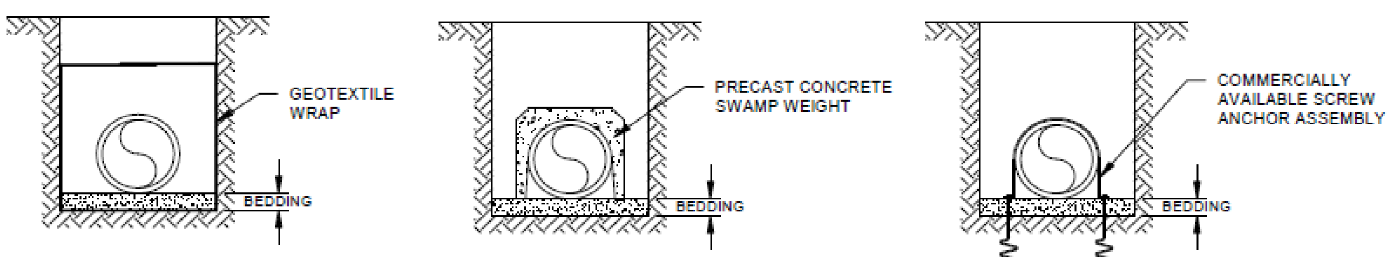
TN 5.05
March 2016

Anchoring Systems

In many instances pipe flotation may simply be addressed with adequate cover. In those situations where adequate cover cannot be achieved, there are a number of acceptable alternate methods for restraining the pipe. Several examples are shown in Figure 3.

Due to the variations in in-situ soil densities, water table heights, and the restraining force of the anchors, the Engineer should evaluate the project-specific conditions to determine the required anchor type and spacing to prevent flotation. The maximum spacing between anchor supports should not exceed 10 feet. In this manner, pipe is supported at each joint and at the midpoint of each length of pipe to ensure adequate stabilization.

Figure 3
Pipe Stabilizing Alternatives



(a) Geotextile wrap (b) Concrete collar (c) Screw anchor

ePipe – Water Table Concerns for Storm Drains and Culverts

- The soil-pipe interaction analysis needs to account for the buoyant effect on the pipe and impact on the **critical passive** soil pressure that a water table has on the soils used in the installation of plastic pipe**.**
- Fluctuations in the water table have a limited effect on rigid concrete pipe since the **active** lateral earth pressure pushing on the sides of the pipe actually increases when the internal friction in the soil is reduced, and **buoyant forces are negligible compared to concrete pipe weight**.
- Because of this, **engineers have become accustomed to using fill height tables without regard to the elevation of the water table.**

ePipe – Water Table Concerns for Storm Drains and Culverts

- The buoyant force on a flexible pipe can add between 5% and 20% to the vertical load assumed in the design, thereby increasing the Vertical Arching Factor that is calculated per the current AASHTO LRFD code.
- (Note: The loss of side soil support due to migration caused by water table fluctuations can be critical to the structural capacity of flexible pipe and must be considered by the design engineer.)
- **Designers default to using manufacturer tables without taking into consideration all of the design caveats.**

ePipe – Plastic Fill Height Table Pitfalls
Water Table Impact:

- According to AASHTO LRFD Code 12.12.3.7 – Soil Prism, there are three different equations to utilize in design based on the elevation of the top of pipe relative to the elevation of the water table.
- Not knowing this exact project variable for each section of a line, the design engineer cannot use the provided manufacturer fill height tables if water tables are present since this variable is not addressed in the tables.

Soil Prism Load

12.12.3.7—Soil Prism

The soil-prism load shall be calculated as a pressure representing the weight of soil above the pipe springline. The pressure shall be calculated for three conditions:

- If the water table is above the top of the pipe and at or above the ground surface:

$$P_{sp} = \frac{\left(H + 0.11\dfrac{D_o}{12}\right)\gamma_b}{144} \qquad (12.12.3.7\text{-}1)$$

- If the water table is above the top of the pipe and below the ground surface:

$$P_{sp} = \frac{1}{144}\left[\begin{array}{c}\left[\left(H_W - \dfrac{D_o}{24}\right) + 0.11\dfrac{D_o}{12}\right]\gamma_b + \\ \left[H - \left(H_w - \dfrac{D_o}{24}\right)\right]\gamma_s\end{array}\right] \qquad (12.12.3.7\text{-}2)$$

- If the water table is below the top of the pipe:

$$P_{sp} = \frac{\left(H + 0.11\dfrac{D_o}{12}\right)\gamma_s}{144} \qquad (12.12.3.7\text{-}3)$$

ADS Technical Note – Fill Height Tables

ADS

TECHNICAL NOTE

Minimum and Maximum Cover Heights for Corrugated HDPE Pipe (per AASHTO)

TN 2.01
September 2014

Introduction

The information in this document is designed to provide answers to general cover height questions; the data provided is not intended to be used for project design. The design procedure described in the *Structures* section (Section 2) of the Drainage Handbook provides detailed information for analyzing most common installation conditions. This procedure should be utilized for project specific designs.

The two common cover height concerns are minimum cover in areas exposed to vehicular traffic and maximum cover heights. Either may be considered "worst case" scenario from a loading perspective, depending on the project conditions.

Table 3
Maximum Cover for ADS N-12, N-12 ST, and N-12 WT Pipe (per AASHTO), ft (m)

Notes:
1. *Results based on calculations shown in the Structures section of the ADS Drainage Handbook (v20.2). Calculations assume no hydrostatic pressure and a density of 120 pcf (1926 kg/m^3) for overburden material.*
2. *Installation assumed to be in accordance with ASTM D2321 and the Installation section of the Drainage Handbook.*
3. *For installations using lower quality backfill materials or lower compaction efforts, pipe deflection may exceed the 5% design limit; however controlled deflection may not be a structurally limiting factor for the pipe. For installations where deflection is critical, pipe placement techniques or periodic deflection measurements may be required to ensure satisfactory pipe installation.*
4. *Backfill materials and compaction levels not shown in the table may also be acceptable. Contact ADS for further detail.*
5. *Material must be adequately "knifed" into haunch and in between corrugations. Compaction and backfill material is assumed uniform throughout entire backfill zone.*
6. *Compaction levels shown are for standard Proctor density.*
7. *For projects where cover exceeds the maximum values listed above, contact ADS for specific design considerations.*
8. *Calculations assume no hydrostatic pressure. Hydrostatic pressure will result in a reduction in allowable fill height. Reduction in allowable fill height must be assessed by the design engineer for the specific field conditions.*
9. *Fill height for dumped Class I material incorporate an additional degree of conservatism that is difficult to assess due to the large degree of variation in the consolidation of this material as it is dumped. There is limited analytical data on its performance. For this reason, values as shown are estimated to be conservatively equivalent to Class 2, 90% SPD.*

Florida DOT – Fill Height Tables

LRFD Assumptions

- Soil Properties
  - Density = 120 pcf
- Groundwater
  - Pipes above GWT
- Pipe Trench Excavation
  - Per FDOT Specification 125-4.4
- Pipe Trench Backfill
  - Allowable soils, bedding, & compaction per FDOT Specification 125-8
- Pipes
  - Max. deflection = 5% Per FDOT SS 430
  - Max. strains per AASHTO

Florida DOT – Fill Height Tables

ePipe – Plastic Fill Height Table Pitfalls
Trench Installations:

- A design omission within the AASHTO LRFD Section 12 code deals with a lack of trench installation investigation. The impact of this lack of investigation is compounded when a trench box is utilized for a particular installation.
- A critical component of the structural capacity of the soil-plastic pipe system is dependent on the design of the backfill envelope where the side supporting fill must be strong enough to support the horizontal deflection.
- When a trench box is utilized and placed within the pipe zone, this all important side fill is dramatically disturbed when the box is moved to the next section.
- This action creates voids in this critical haunch and side embedment zone thereby reducing any vertical arching benefit, reducing the soil column strength on each side of the pipe, and subjecting the pipe to strains beyond those allowed by design.

Owner's & Engineer's Liability

- The engineering community will help **reduce their liability** when specifying a plastic pipe system by following the **very important** steps outlined above for **each and every** project.
- The structural design for a plastic soil/pipe system simply cannot be standardized.