



**STANDARD INSTALLATIONS**

**STRENGTH**

**DURABILITY**

**VERSATILITY**

**HYDRAULIC EFFICIENCY**

**NON-FLAMMABLE**

**CORROSION RESISTANT**

**SELF-HEALING**

**CHOICE OF CLASSES**

**CONTRACTOR-FRIENDLY**

**ENVIRONMENTALLY SAFE**

**LOCALLY AVAILABLE**

**FULL RANGE OF SIZES**



American  
**Concrete Pipe**  
Association

## **Indirect Design**

Comparison of the structural strength of the pipe (Three-Edge-Bearing Test) to the field supporting strength of a buried pipe.

## **Direct Design**

The design of pipe in the installed condition. The magnitude and distribution of loads are determined and the physical properties necessary to support those loads are calculated. For more information regarding concrete pipe design refer to the ACPA's Concrete Pipe Design Manual.

Since the early 1920's, designers of buried pipe have specified embedment details based on Class A, B, C and D beddings developed by Marston & Spangler at Iowa State University. Many of the design practices in current use are based on this research.

By the 1970's, ACPA members realized that new analytical knowledge and field experience were available that could lead to improvements in understanding the structural behavior of buried pipe in its installed condition and thus, lead to improvements in design practice for buried concrete pipe. In view of this, ACPA instituted a long-range research program with the overall objective of evaluating the performance of concrete pipe-soil

installations and improving design practice for pipe-soil installations. The structural behavior of these installations was examined using state-of-the-art analytical tools of structural and geotechnical engineering and computer science and by comparing the results of

analytical studies with observations and measurements on prototype pipe in both three-edge bearing tests and field installations.

These research results provide the basis for a more advanced design practice for pipe-soil installations based on direct design of the pipe for its installed conditions. They also provide the basis for recommending standardized installation types that differ significantly from those originally developed by Marston and Spangler and currently used in indirect design practice.

Essentially, the same installation types are defined for both trench and embankment installations. These Standard Installations have several advantages over Class A, B, C and D beddings because of the following considerations of practical construction:

- A flat foundation and bedding simplifies construction.
- Bedding cannot be shaped within sufficient tolerance to provide uniform support to the outside of the pipe over a shaped bedding angle.
- Embedment soil cannot be compacted in the lower haunch area up to about 40 degrees from the invert.
- Standard Installations should permit the use of a range of embedment soils from the best quality granular soils that are easily compacted to various lesser quality soils that may be readily available at a site. They should also include the option to use many native soils without compaction around the pipe for bedding, embedment and backfill.
- Requirements for compaction with, or without, the use of high-quality embedment soils should be limited to those zones around the pipe where the embedment provides beneficial vertical or lateral support to the pipe.

These new Standard Installations identify four principal zones (which are critical to the pipe-soil system) surrounding the lower half of the pipe. The four zones – middle bedding, outer bedding, haunch and lower side – are shown in Figures 1 and 2 for trench and embankment installations. The type of material (based on soil characteristics) and level of compaction varies with the installation type, i.e., 1, 2, 3, or 4, and the material utilized in construction of these important zones.

**Installation – Type 4** Type 4 is intended for installations where the most cost effective design approach is to specify minimal requirements for soil type and compaction, together with a pipe having sufficient strength to safely resist the increased structural effects that result from using low quality soils. Thus, Type 4 has little or no requirement for control of compaction and type of placed soil used in the bedding and haunch areas, except if silty clay soils are used in the haunch and outer bedding zones, they must be compacted. It is desirable to scarify (loosen) hard native soils before placing pipe.

**Installation – Type 3** Type 3 permits the use of soils in the haunch and bedding zones having easily attained compaction requirements, justifying less stringent inspection requirements with granular and some native soils. Silty clays may be used in the haunch zone if adequately compacted. In addition to the foundation similar to Type 4, a bedding layer with a minimum thickness of 3 inches is required to avoid placing the pipe directly on hard or variable subgrade.

**Installation – Type 2** Type 2 is a standard installation where certain native soils are

permitted to be used with proper compaction in the haunch and bedding zones. Adequately compacted native silty granular soils or select granular soils may be used in the haunch and outer bedding zones. This is intended to allow the use of soil frequently found at a site. Any natural soil adjacent to the pipe should have a firmness equivalent to the placed soils. Foundation and bedding requirements are similar to Type 3.

**Installation – Type 1** Type 1 requires well compacted, select granular soil to be placed in the haunch and bedding zones. The structural design of the pipe section then takes advantage of the support provided by this high quality soil envelope, making this installation often the most cost effective for pipe 60 inches in diameter and larger in deep fills.



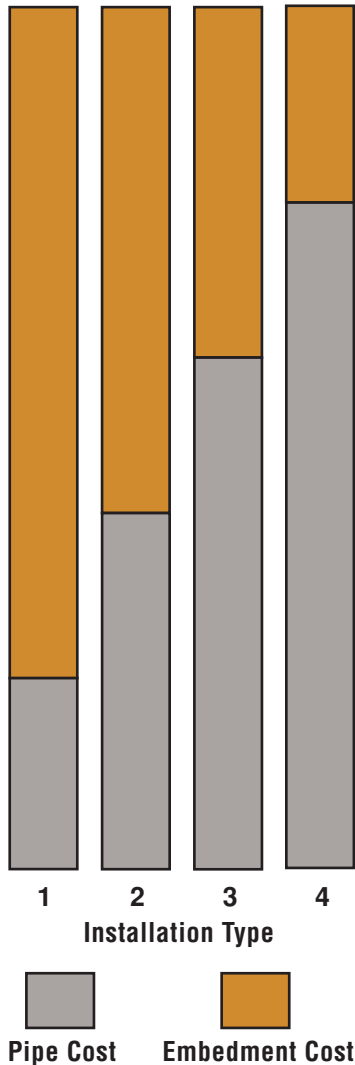
# Beneficial Characteristics

**Versatile** - One can choose between installation types and pipe strengths (classes) to suit specific site conditions and budgetary constraints. The four standard installations can be used to optimize the total installed cost by evaluation of the ratio of pipe cost to backfill material cost.

**Conservative** - Analyses are based on the worst case (embankment) loadings, voids in the haunch zone, the greatest predicted loads, and measurable requirements that more accurately assess long-term performance of the system.

**Quantifiable** - Definite and measurable levels of acceptance are prescribed, which provides better direction for the designer and the contractor.

## Relative Comparison Embedment vs Pipe Cost

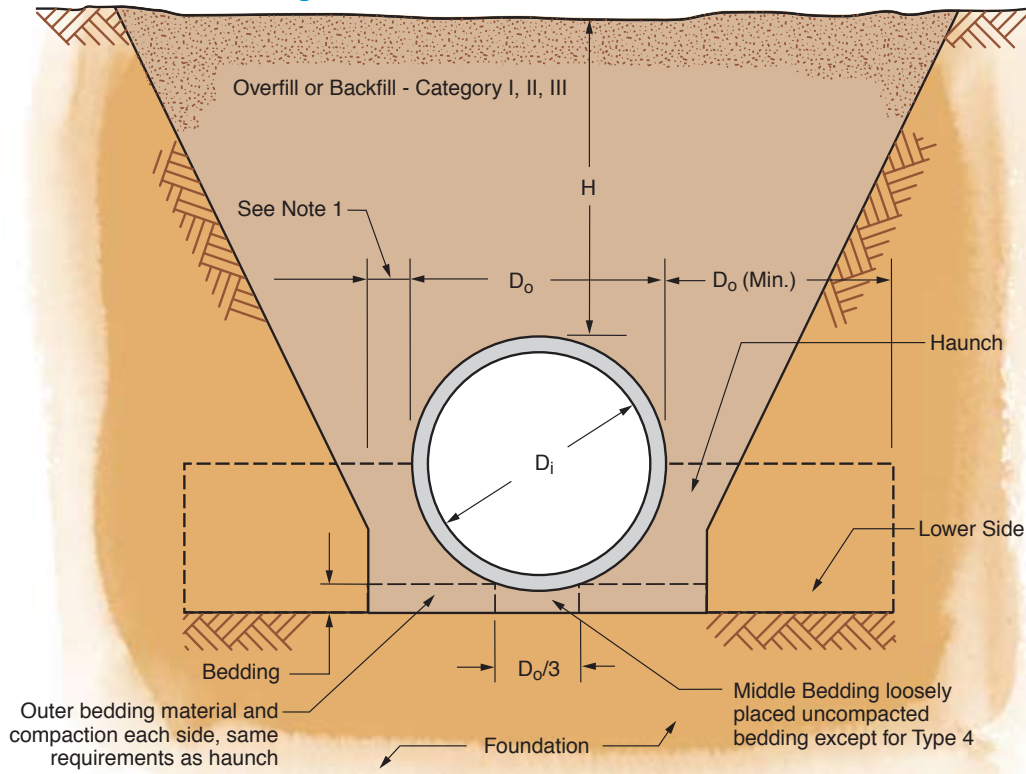


## Equivalent USCS and AASHTO Soil Classifications for Soil Designations

Soil	Representative Soil Types		Percent Compaction	
	USCS ASTM D 2487	AASHTO M 145	Standard Proctor	Modified Proctor
Category I	Clean, coarse grained soils: SW, SP, GW, GP or any soil beginning with one of those symbols with 12% or less passing a #200 sieve	A-1, A-3	100 95 90 85	95 90 85 80
Category II	Course grained soils with fines: GM, GC, SM, SC or any soil beginning with one of these symbols, containing more than 12% passing a #200 sieve; Sandy or gravelly fine-grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with 30% or more retained on a #200 sieve	A-2-4, A-2-5, A-2-6; or A-4 or A-6 soils with 30% or more retained on a #200 sieve	100 95 90 85	95 90 85 80
Category III	Fine-grained soils: CL, ML, (or CL-ML, CL/ML, ML/CL) with less than 30% retained on a #200 sieve	A-2-7; or A-4 or A-6 with less than 30% retained on a #200 sieve	100 95 90 85	90 85 80 75
Category IV but not allowed for haunch or bedding	MH, CH, OL, OH, PT	A-5, A-7	100 95 90	90 85 80

NOTE 1: Compaction Specifications:  
 Standard proctor density – AASHTO T 99, T 310, or Test Methods D 698  
 Modified proctor density – AASHTO T 180 or Test Methods D 1557

**Figure 1. Standard Trench Installation**



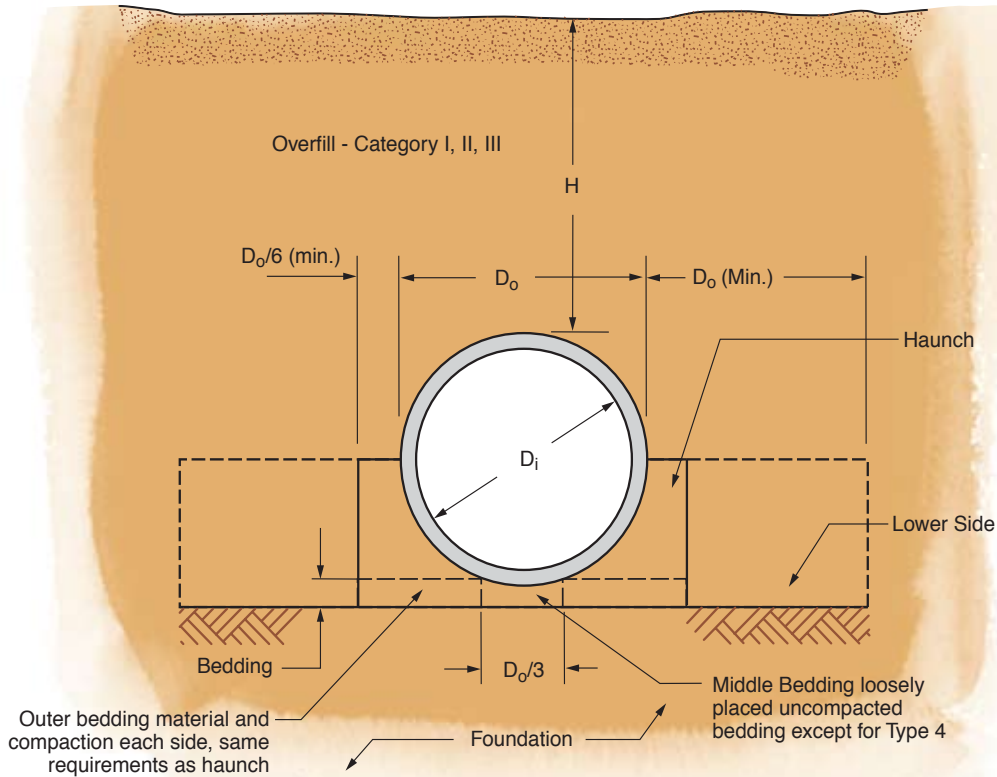
Note 1: Clearance between pipe and trench wall shall be adequate to enable specific compaction, but not less than  $D_o/6$ .

**SOIL AND MINIMUM COMPACTION REQUIREMENTS**

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	$D_o/24$ minimum; not less than 3 in. If rock foundation, use $D_o/12$ minimum; not less than 6 in.	95% Category I	Undisturbed natural soil with firmness equivalent to the following placed soils: 90% Category I, 95% Category II, or 100% Category III, or embankment to the same requirements
Type 2	$D_o/24$ minimum; not less than 3 in. If rock foundation, use $D_o/12$ minimum; not less than 6 in.	90% Category I or 95% Category II	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 3	$D_o/24$ minimum; not less than 3 in. If rock foundation, use $D_o/12$ minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	Undisturbed natural soil with firmness equivalent to the following placed soils: 85% Category I, 90% Category II, or 95% Category III, or embankment to the same requirements
Type 4	No bedding required, except if rock foundation, use $D_o/12$ minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

- Note 1. Compaction and soil symbols, i.e. 95% Category I, refer to a soil material category with a minimum standard proctor density. See Table on page 4 for equivalent modified proctor values and soil types.
- Note 2. When the trench width specified must be exceeded, the owner shall be notified.
- Note 3. The trench width shall be wider than shown if required for adequate space to attain the specified compaction in the haunch and bedding zones.
- Note 4. Embankment loading shall be used when trench walls consist of embankment unless a geotechnical analysis is made and the soil in the trench walls is compacted to a higher level than the soil in the backfill zone.
- Note 5. Required bedding thickness is the thickness of the bedding prior to placement of the pipe.
- Note 6. "Dumped" material without additional compactive effort will not provide the design haunch support required for Type 1 and 2 installations and it should be checked for Type 3 installations.

## Figure 2. Standard Embankment Installation



### SOIL AND MINIMUM COMPACTION REQUIREMENTS

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	95% Category I	90% Category I, 95% Category II, or 100% Category III
Type 2	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	90% Category I or 95% Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	$D_0/24$ minimum; not less than 3 in. If rock foundation, use $D_0/12$ minimum; not less than 6 in.	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	No bedding required, except if rock foundation, use $D_0/12$ minimum; not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

- Note 1. Compaction and soil symbols, i.e. 95% Category I, refer to a soil material category with a minimum standard proctor density. See Table on page 4 for equivalent modified proctor values and soil types.
- Note 2. Soil in the outer bedding, haunch, and lower side zones, except within  $D_0/3$  from the pipe springline, shall be compacted to at least the same compaction as the majority of soil in the overfill zone.
- Note 3. Required bedding thickness is the thickness of the bedding prior to placement of the pipe.
- Note 4. A subtrench is defined as a trench with its top below finished grade by more than  $0.1H$  or, for roadways, its top is at an elevation lower than 1 ft below the bottom of the pavement base material. The minimum width of a subtrench shall be  $1.33 D_0$  or wider, if required for adequate space to attain the specified compaction in the haunch and bedding zones. For subtrenches, except within  $D_0/3$  from the springline, any portion of the lower side zone in the subtrench wall shall be at least as firm as an equivalent soil placed to the compaction requirements specified for the lower side zone and as firm as the majority of soil in the overfill zone, or it shall be removed and replaced with soil compacted to the specified level.
- Note 5. "Dumped" material without additional compactive effort will not be provided the design haunch support required for Type 1 and 2 installations and it should be checked for Type 3 installations.

## STANDARDS:

- ASTM C 1479 Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
- AASHTO Standard Specifications for Highway Bridges
- ASCE 15 Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

## REFERENCES:

- Concrete Pipe Technology Handbook
- Concrete Pipe Design Manual
- Concrete Pipe Handbook
- Design Data 40  
(American Concrete Pipe Association Publications)



# ACPA'S WEBSITE PROVIDES WEALTH OF ON-LINE INFORMATION



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The American Concrete Pipe Association's website, [www.concrete-pipe.org](http://www.concrete-pipe.org), has become one of the most popular Internet websites for design engineers and specifiers of drainage pipe products – and for good reason! The site provides visitors with a wealth of information on precast concrete pipe products. Information available includes loads and supporting strengths, hydraulics, installation standards, fill height tables, latest design software, and installation guidelines. The popular Concrete Pipe Design Manual is on-line and available for order in both hard copy and CD format. The website also serves as a “gateway” to access member locations, related associations – even Internet addresses for state DOT websites. Visitors can also purchase additional resources through ACPA's Resource Center.

If you haven't already, you will want to add ACPA's website to your “favorite” list on your browser, so you can access complete information on precast concrete pipe products for culverts, storm drains and sanitary sewer applications.

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