



Designation: B789/B789M – 16 (Reapproved 2021)

Standard Practice for Installing Corrugated Aluminum Structural Plate Pipe for Culverts and Sewers¹

This standard is issued under the fixed designation B789/B789M; 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 (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers procedures, soils, and soil placement for the proper installation of corrugated aluminum structural plate culverts and sewers in either trench or embankment installations. A typical trench installation is shown in Fig. 1, and a typical embankment (projection) installation is shown in Fig. 2. Structural plate structures as described herein are those structures factory fabricated in plate form and bolted together on site to provide the required shape, size, and length of structure. This practice applies to structures designed in accordance with Practice B790/B790M.

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

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

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

B746/B746M Specification for Corrugated Aluminum Alloy

¹ This practice is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.08 on Corrugated Aluminum Pipe and Corrugated Aluminum Structural Plate.

Current edition approved May 1, 2021. Published June 2021. Originally approved in 1988. Last previous edition approved in 2016 as B789/B789M – 16. DOI: 10.1520/B0789_B0789M-16R21.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches

B790/B790M Practice for Structural Design of Corrugated Aluminum Pipe, Pipe-Arches, and Arches for Culverts, Storm Sewers, and Other Buried Conduits

D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))

D1556/D1556M Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

D1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³))

D2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method

D6938 Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *arch*, *n*—segment of a circular shape spanning an open invert between the footings on which it rests.

3.1.2 *bedding*, *n*—earth or other material on which a pipe is supported.

3.1.3 *haunch*, *n*—portion of the pipe cross section between the maximum horizontal dimension and the top of the bedding.

3.1.4 *invert*, *n*—lowest point on the pipe cross section; also, the bottom portion of a pipe.

3.1.5 *pipe*, *n*—conduit having a full circular shape; also, in a general context, all structure shapes covered by this specification.

3.1.6 *pipe-arch*, *n*—pipe with an approximate semicircular crown, small-radius corners, and large-radius invert.

3.1.7 *underpass*, *n*—pipe with an approximate semicircular crown, large-radius sides, small-radius corners between sides and invert, and large-radius invert.

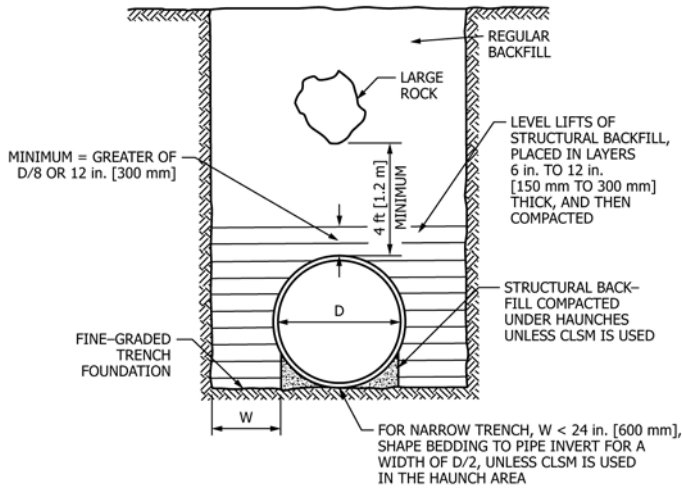


FIG. 1 Typical Trench Installation

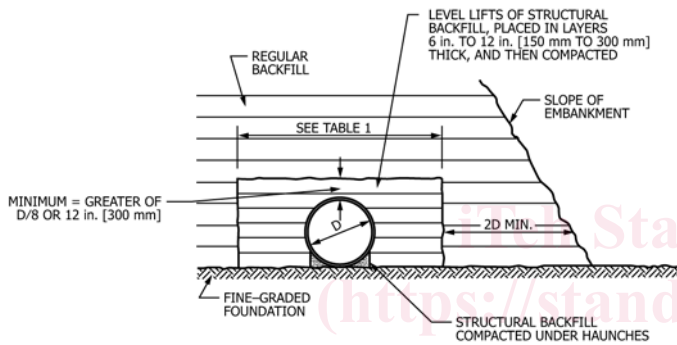


FIG. 2 Typical Embankment (Projection) Installation

4. Significance and Use

4.1 Corrugated aluminum structural plate pipe functions structurally as a flexible ring that is supported by and interacts with the compacted surrounding soil. The soil placed around the structure is thus an integral part of the structural system. It is therefore important to ensure that the soil structure is made up of the acceptable material and well-constructed. Field verification of soil structure acceptability using Test Methods D1556/D1556M, D2167, D6938, or D2937, as applicable, and comparing the results with Test Methods D698 or D1557, in accordance with the specifications for each project, is the most reliable basis for installation of an acceptable structure. The required density and method of measurement are not specified by this practice but must be established in the specifications for each project.

5. Trench Excavation

5.1 To obtain the anticipated structural performance of structural plate structures, it is not necessary to control trench width beyond the minimum necessary for proper assembly of the structure and placement of the structural backfill. However, the soil on each side beyond the excavated trench must be able to support anticipated loads. When a construction situation calls for a relatively wide trench, it may be made as wide as required for its full depth, if so desired. However, trench

excavation must be in compliance with any local, state, and federal codes and safety regulations.

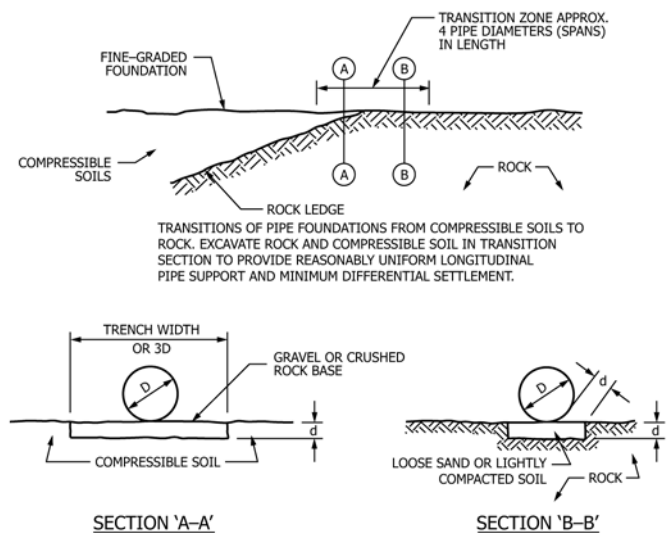
6. Foundation

6.1 The supporting soil beneath the structure must provide a reasonably uniform resistance to the imposed load, both longitudinally and laterally. Sharp variations in the foundation must be avoided. When rock is encountered, it must be excavated and replaced with soil. If the structure is to be placed on a continuous rock foundation, it will be necessary to provide a bedding of soil between the rock and the structure. See Fig. 3.

6.2 Lateral changes in foundation should never be such that the structure is firmly supported while the backfill on either side is not. When soft material is encountered in the foundation and must be removed to maintain the grade on the structure, then it must be removed, usually for a minimum of three structure widths. See Fig. 4. A smaller width of removal can sometimes be used if established by the engineer.

6.3 Performance of buried structures is enhanced by allowing the structure to settle slightly relative to the columns of earth alongside. Therefore, when significant settlement of the overall foundation is expected, it is beneficial to provide a yielding foundation under structural plate structures. A yielding foundation is one that allows the structure to settle vertically by a greater amount than the vertical settlement of the columns of earth alongside. It can usually be obtained by placing beneath the structure a layer of suitable thickness of compressible soil, less densely compacted than the soil alongside. This is particularly important on structures with relatively large-radius invert plates.

6.4 For all structures with relatively small-radius corner plates adjacent to large-radius invert plates (such as pipe-arches or underpass structures), excellent soil support must be



$d = 1/2$ in./ft [40 mm/m] of fill over pipe, with a 24-in. [600 mm] maximum
NOTE : Section B-B is applicable to all continuous rock foundations
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FIG. 3 Foundation Transition Zones and Rock Foundations

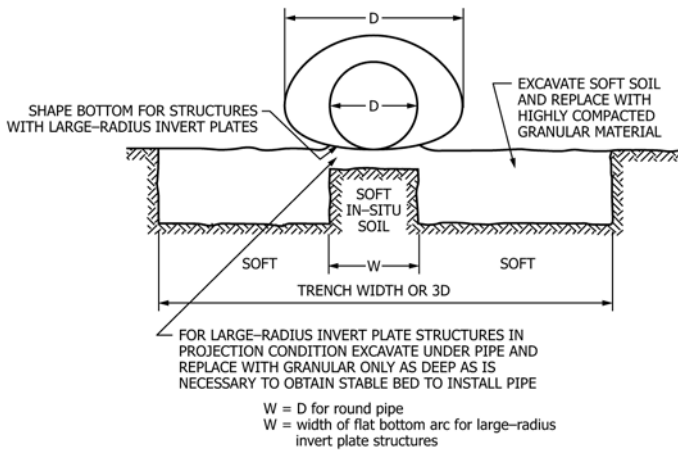


FIG. 4 Soft Foundation Treatment

provided adjacent to the small-radius corner plates by both the in-situ foundation and the structural backfill. See Fig. 4 and Fig. 5. A yielding foundation must be provided beneath the invert plates for such structures when soft foundation conditions are encountered.

7. Bedding

7.1 In most cases, structural plate structures may be assembled directly on in-situ material fine-graded to proper alignment and grade. Take care to compact the material beneath the haunches prior to placing structural backfill. For structures with relatively small-radius corner plates adjacent to large-radius invert plates, it is recommended to either shape the bedding to the invert plate radius or fine-grade the foundation to a slight v-shape. The soil adjacent to the corners must be of

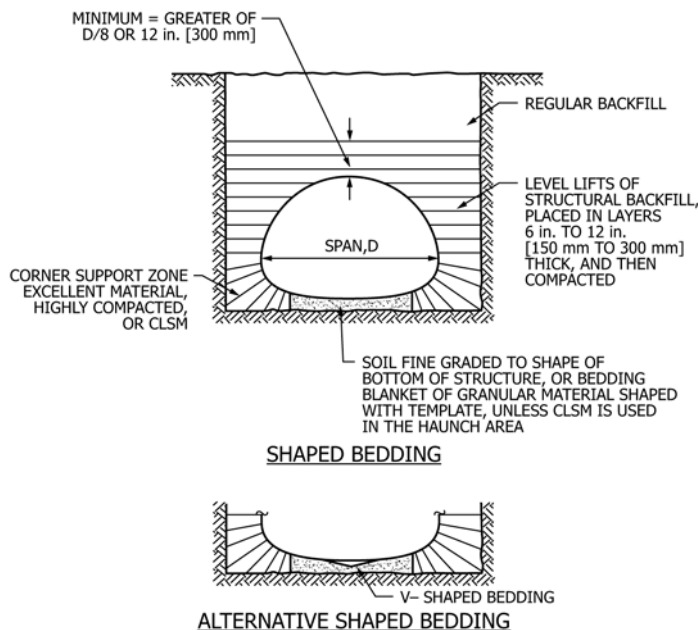


FIG. 5 Bedding and Corner Zone Treatment for Large-Radius Invert Plate Structures

an excellent quality and highly compacted to accommodate the high reaction pressures that can develop at that location. See Fig. 5.

7.2 Structures having a span greater than 15 ft [4.5 m] or a depth of cover greater than 20 ft [6 m] should be provided with a shaped bedding on a yielding foundation. The bedding should be shaped to facilitate the required compaction of the structural backfill under the haunches. A shaped bedding on a yielding foundation is always required under structures with small-radius corner plates adjacent to large-radius invert plates.

7.3 Material in contact with the pipe must not contain rock retained on a 3-in. [75 mm] diameter ring, frozen lumps, chunks of highly plastic clay, organic matter, corrosive material, or other deleterious material.

8. Assembly

8.1 Structural plate structures are furnished in components of plates and fasteners for field assembly. These components are furnished in accordance with Specification B746/B746M. Plates are furnished in a 4 ft, 6 in. [1372 mm] width and multiple lengths, preformed and punched for assembling into the required structure shape, size, and length. The plate lengths form the periphery of the structure. Arrange the single width and the multiple lengths to allow for staggered, transverse seams to avoid four-plate laps. The fabricator of the structural plate shall furnish an assembly drawing showing the location of each plate by width, length, thickness, and curvature. The plates must be assembled in accordance with the fabricator's drawing.

8.2 For structures with inverts, assembly shall begin with the invert plates at the downstream end. As the assembly proceeds upstream, plates that fall fully or partly below the maximum width of the structure are lapped over the preceding plates to construct the transverse seams.

8.3 Arches on Footings:

8.3.1 *Footings*—Arches have no integral invert and usually rest in key ways cast into footings. Key ways must be accurately set to span, line, and grade, as shown in the plans and specifications. When the arch is not a half circle, the key way must be angled (rotated) or sized to allow proper entrance of the plate. All pertinent dimensions must be shown on the drawings.

8.3.2 *Assembly*—For arch structures, assembly typically begins at the upstream end and proceeds downstream, with each succeeding plate lapping on the outside of the previous plate. There may be cases where it is more advantageous to start assembly at some other point along the length of the structure, such as is in the case where an elbow is involved. During the erection of the ring, plates are not self-supporting and must be temporarily supported. If the size of the key ways is such that the plates may move during backfilling, the plates must be temporarily blocked in the key ways to maintain span. Assemble as few plates as practical. Start with a row of several plates along both of the footings. Before finishing the bottom row of plates, start at the end of the structure with the next row of plates. Before reaching the end of the first row of plates, start again at the end of the structure with the next row of plates.

Continue this process until the first ring is closed at its top, and then continue assembling all rows in this same manner. The structure will have a “stair step” appearance as a result of this procedure. This practice helps to hold the structure’s shape.

8.4 Generally, structural plate should be assembled with as few bolts as practical. These bolts should be placed loose and remain loose until the periphery has been completed for several plate lengths. However, on large structures, it is practical to align bolt holes during assembly and tighten the bolts to maintain structure shape. After the periphery of the structure is completed for several plate lengths, all bolts may be placed and tightened. Correct any significant deviation in the structure shape before tightening bolts (see Section 10). It is advisable not to tighten bolts on the loosely assembled structure within a distance of 30 ft [9 m] of where plate assembly is ongoing. All bolts shall be tightened using an applied torque of between 100 and 150 ft-lbf [135 and 205 N·m]. It is important not to over-torque the bolts.

8.5 Standard structural plate structures, because of the bolted construction, are not intended to be watertight. On occasions where a degree of watertightness is required, it is practical to introduce a seam sealant tape within the bolted seams. The tape shall be wide enough to effectively cover all rows of holes in plate laps, and of the proper thickness and consistency to effectively fill all voids in plate laps. General procedures for installing sealant tape are as follows: On longitudinal seams, prior to placing the lapping plate, roll the tape over the seam and work into the corrugations. Do not stretch the tape. Remove any paper backing prior to making up the joint. Seal transverse seams in a like manner with tape. At all points where three plates intersect, place an additional thickness of tape for a short distance to fill the void caused by the transverse seam overlap. It is most practical to punch the tape for bolts with a hot spud wrench or sharp tool. At least two tightenings of the bolts will usually be necessary to accomplish the required torque.

9. Structural Backfill Material

9.1 Structural backfill is that material that surrounds the pipe, extending laterally to the walls of the trench or to the fill material for embankment construction, and extending vertically from the invert to an elevation of 1 ft [300 mm] or 1/8 the span, whichever is greater, over the pipe. The necessary width of structural backfill depends on the quality of the trench wall or embankment material, the type of material and compaction equipment used for the structural backfill, and in embankment construction, the type of construction equipment used to compact the embankment fill. The width of structural backfill shall meet the requirements given in Table 1.

9.2 Structural backfill material shall be readily compacted soil or granular fill material. Structural backfill may be excavated native material, when suitable, or select material. Select material such as bank-run gravel, or other processed granular materials (not retained on a 3-in. [75 mm] diameter ring) with excellent structural characteristics, is preferred. Desired end results can be obtained with such material with a minimum of compactive effort over a wide range of moisture content, lift

TABLE 1 Structural Backfill Width Requirements^{A,B}

Adjacent Material	Required Structural Backfill Width
Normal highway embankment compacted to minimum of 90 % Test Methods D698 density, or equivalent trench wall.	As needed to establish pipe bedding and to place and compact the backfill in the haunch area and beside the pipe. Where backfill materials that do not require compaction are used, such as cement slurry or controlled low strength material (CLSM), a minimum of 3 in. [75 mm] on each side of the pipe is required.
Embankment or trench wall of lesser quality.	Increase backfill width as necessary to reduce horizontal pressure from pipe to a level compatible with bearing capacity of adjacent materials.

^A For pipe arches and other multiple radius structures, as well as for all structures carrying off-road construction equipment, the structural backfill width, including any necessary foundation improvement materials, must be sufficient to reduce the horizontal pressure from the structure so that it does not exceed the bearing capacity of the adjacent material.

^B In embankment construction, the structural backfill width must be adequate to resist forces caused by the embankment construction equipment. Generally, the width on each side of the pipe should be no less than 2 ft [600 mm] for spans that do not exceed 12 ft [3.6 m], or 3 ft [900 mm] for greater spans.

depths, and compaction equipment. Soil used as structural backfill must not contain rock retained on a 3-in. [75 mm] diameter ring, frozen lumps, highly plastic clays, organic matter, corrosive material, or other deleterious foreign matter. Soil classifications are defined in Classification D2487. Acceptable soils include Groups GW, GP, GM, GC, SW, and SP, when compacted to the specified percent of maximum density, as determined by Test Methods D698 or D1557, using Test Methods D1556/D1556M, D2167, D6938, or D2937. Soil types SM and SC are acceptable but may require closer control to obtain the specified density. Soil groups ML and CL are not preferred materials, while soil groups OL, MH, CH, OH, and PT are not acceptable.

10. Shape Control

10.1 Excessive compaction, unbalanced loadings, loads from construction equipment, as well as inadequate compaction or poor structural backfill materials, can cause excessive pipe distortion. For larger pipe, the construction contractor may set up a shape monitoring system, prior to placement of structural backfill, to aid in establishing and maintaining proper installation procedures. Such a system is particularly desirable for structures having a span greater than 20 ft [6 m]. Direct measurement of span and rise, offset measurements from plumb bobs hanging over reference points, and use of surveying instruments are effective means for monitoring shape change during structural backfill placement and compaction. The final installed shape must be within the design criteria, exhibit smooth uniform radii, and provide acceptable clearances for its intended use. In general, it is desirable for the crown of the pipe to rise slightly, in a balanced concentric manner, during placement and compaction of structural backfill beside the pipe. Under the load of the completed fill and the service load, vertical deflections will be a small percentage of the pipe rise dimension if structural backfill compaction is adequate. Structures having a span greater than 20 ft [6 m]