



Designation: C1846/C1846M – 19

Standard Specification for Performance Based Manufacture of Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe¹

This standard is issued under the fixed designation C1846/C1846M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This performance based specification covers reinforced concrete pipe intended to be used for the conveyance of sewage, industrial wastes, and storm water, and for the construction of culverts.

1.2 It is not the intention of this standard to dictate the material quantities and properties required for a pipe to conform to this standard except those in Section 6. Specific product formulations shall be considered proprietary and allowed to remain confidential to the manufacturer.

NOTE 1—This specification is a manufacturing and purchase specification only, and does not include requirements for bedding, backfill, or the relationship between field load condition and the strength classification of pipe. However, experience has shown that the successful performance of this product depends upon the proper selection of the class of pipe, type of bedding and backfill, and care that installation conforms to the construction specifications. The owner of the reinforced concrete pipe specified herein is cautioned that he must correlate the field requirements with the class of pipe specified and provide inspection at the construction site.

NOTE 2—Attention is called to the specification for Reinforced Concrete D-load Culvert, Storm Drain, and Sewer Pipe (Specification C655). The distinction between this specification and C655 is in the D-Load specified and the practice for sampling pipe for conformance to the specification. This specification relies on standard classes of pipe (Class I-V), and sampling in accordance with Section 11.

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

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 Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:

- A36/A36M Specification for Carbon Structural Steel
- A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
- A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
- A1064/A1064M Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
- C33/C33M Specification for Concrete Aggregates
- C76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
- C76M Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
- C150/C150M Specification for Portland Cement
- C260/C260M Specification for Air-Entraining Admixtures for Concrete
- C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- C443 Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
- C494/C494M Specification for Chemical Admixtures for Concrete
- C497 Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile
- C595/C595M Specification for Blended Hydraulic Cements
- C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- C655 Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
- C822 Terminology Relating to Concrete Pipe and Related Products
- C989/C989M Specification for Slag Cement for Use in Concrete and Mortars
- C990 Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants

¹ This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.02 on Reinforced Sewer and Culvert Pipe.

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*A Summary of Changes section appears at the end of this standard

C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete

C1116/C1116M Specification for Fiber-Reinforced Concrete

C1157/C1157M Performance Specification for Hydraulic Cement

C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

C1628 Specification for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets

2.2 *AASHTO Standards:*

R073 Standard Practice for Evaluation of Precast Concrete Drainage Products

3. Terminology

3.1 *Definitions*—For definitions of terms relating to concrete pipe, see Terminology **C822**.

3.2 *Definitions:*

3.2.1 D_{design} —the D-load test criteria required to reach the design strength as defined in Test Methods **C497**.

4. Classification

4.1 Pipe furnished under this specification shall be designated as Class I, II, III, IV, or V. The corresponding strength requirements are prescribed in **Table 1**. Special designs for pipe strengths not designated in **Table 1** are permitted provided all other requirements of this specification are met. For Pipe Classes of IV or less, the minimum ratio of the D_{Ult} to D_{design} in the three-edge-bearing test shall be 1.5 rounded to the nearest 50 lb/ft² [5 N/m²]. For Class V pipe, or higher, the minimum ratio of D_{Ult} to D_{design} in the three-edge-bearing test shall be 1.25. A linear interpolation may be performed to establish the D_{Ult} to D_{design} ratio for Pipe Classes between Class IV and V.

5. Basis of Acceptance

5.1 *Acceptance on the Basis of Proof of Design Tests, Plant Load-Bearing Tests, Material Tests, and Inspection of Manufactured Pipe for Visual Defects and Imperfections*—Acceptability of the pipe in all diameters and classes shall be determined by the results of the three-edge-bearing tests as defined in Section 11 and 12.3.1; by such material tests as are required in 6.2, 6.3, 6.5, 6.6, and 6.7; by an absorption test of the concrete from the wall of the pipe as required in 12.4; and by visual inspection of the finished pipe to determine its conformance with the accepted design and its freedom from defects in accordance with Section 15.

TABLE 1

Pipe Class	D_{design} (lbs/linear foot/foot of diameter) [N/linear m/mm of diameter]	D_{Ult} (lbs/linear foot/foot of diameter) [N/linear m/mm of diameter]
I	800 [40.0]	1200 [60.0]
II	1000 [50.0]	1500 [75.0]
III	1350 [65.0]	2000 [100.0]
IV	2000 [100.0]	3000 [150.0]
V	3000 [140.0]	3750 [175.0]

5.2 *Age for Acceptance*—Pipe shall be considered ready for acceptance when it conforms to the requirements as indicated by the specified tests.

6. Materials

6.1 *Reinforced Concrete*—The reinforced concrete shall consist of cementitious materials; mineral aggregates; admixtures, if used; and water in which steel has been embedded in such a manner that the steel and concrete act together.

6.2 *Cementitious Materials:*

6.2.1 *Cement*—Cement shall conform to the requirements of Specification **C150/C150M** or **C1157/C1157M**, or shall be blended cement conforming to the requirements of Specification **C595/C595M**.

6.2.2 *Slag Cement*—Slag cement shall conform to the requirements of Grade 100 or 120 of Specification **C989/C989M**.

6.2.3 *Fly Ash*—Fly ash shall conform to the requirements of Class F or Class C of Specification **C618**.

6.2.4 *Allowable Combinations of Cementitious Materials*—Any combination of cementitious materials shall be acceptable for use in the concrete if the mix meets the testing requirements in this specification:

6.3 *Aggregates*—Aggregates shall conform to Specification **C33/C33M** except that the requirement for gradation shall not apply.

6.4 *Admixtures*—The following admixtures and blends are allowable:

6.4.1 Air-entraining admixture conforming to Specification **C260/C260M**;

6.4.2 Chemical admixture conforming to Specification **C494/C494M**;

6.4.3 Chemical admixture for use in producing flowing concrete conforming to Specification **C1017/C1017M**; and

6.4.4 Chemical admixture or blend approved by the owner.

6.5 *Steel Reinforcement*—Reinforcement shall consist of wire or welded wire conforming to Specification **A1064/A1064M**, or of bars conforming to Specification **A36/A36M**, Specification **A615/A615M**, Grade 40 or 60, or Specification **A706/A706M**, Grade 60. For helically wound cages only, weld shear tests are not required.

6.6 *Fibers*—Synthetic fibers and nonsynthetic fibers shall be allowed to be used, at the manufacturer's option, in concrete pipe as a nonstructural manufacturing material. Synthetic fibers (Type II and Type III) and nonsynthetic fiber (Type I) designed and manufactured specifically for use in concrete and conforming to the requirements of Specification **C1116/C1116M** shall be accepted.

6.7 *Water*—Water used in the production of concrete shall be potable or nonpotable water that meets the requirements of Specification **C1602/C1602M**.

7. Pipe Performance

7.1 The pipe shall be formulated sufficiently to pass the D_{Ult} and D_{design} requirements in **Table 1**.

7.2 *Special Classes:*

7.2.1 If permitted by the owner, the manufacturer may request approval by the owner of a special class of pipe having D_{Ult} and D_{design} values that differ from those shown in **Table 1**.

7.2.2 Such special classes of pipe shall be based on the same design/testing requirements as required for those classes found in **Table 1**.

7.3 The manufacturer shall formulate for their own production practices and records the following for each pipe product and size.

7.3.1 *Pipe Strengths*—(D_{design}) and (D_{Ult}).

7.3.2 *Material Strengths*:

(a) Minimum Compressive Strength of the Concrete - (f_c),

(b) Minimum Reinforcement Yield Strength and Ultimate Strength - (f_y) and (f_u),

(c) Minimum Elastic Modulus of Reinforcement - (E_s).

7.3.3 *Quantities of Materials*:

(a) The concrete mix design, including all materials and admixtures within the concrete matrix,

(b) Area of continuous reinforcement in units of in.²/ft [cm²/m],

(c) Volume of noncontinuous reinforcement in units of lb/yd³ [kg/m³] or percent of volume of concrete.

7.3.4 *Physical Characteristics*—Diameter, wall thickness, laying length, and joint details.

8. Reinforcement

8.1 Where one line of circular reinforcement is used, the protective cover of the concrete over the circumferential reinforcement in the wall of the pipe shall be 3/4 in. [19 mm].

8.2 In pipe having two lines of circular reinforcement, each line shall be so placed that the protective covering of concrete over the circumferential reinforcement in the wall of the pipe shall be 1 in. [25 mm].

8.3 In pipe having elliptical reinforcement with wall thicknesses 2 1/2 in. [63 mm] or greater, the reinforcement in the wall of the pipe shall be so placed that the protective covering of concrete over the circumferential reinforcement shall be 1 in. [25 mm] from the inner surface of the pipe at the vertical diameter and 1 in. [25 mm] from the outer surface of the pipe at the horizontal diameter. In pipe having elliptical reinforcement with wall thicknesses less than 2 1/2 in. [63 mm], the protective covering of the concrete shall be 3/4 in. [19 mm] at the vertical and horizontal diameters.

9. Joints

9.1 The joints shall be of such design and the ends of the concrete pipe sections so formed that the pipe can be laid together to make a continuous line of pipe compatible with the permissible variations given in Section 13.

9.2 Joints shall conform to the requirements of Specifications **C443**, **C990**, **C1628**, or other established joint types approved by the owner, including, but not limited to, mortar, sealant or externally-wrapped joints.

10. Manufacture

10.1 *Mixture*—The aggregates shall be sized, graded, proportioned, and mixed with such proportions of cementitious

materials, water, and admixtures, if any, to produce a thoroughly mixed concrete of such quality that the pipe will conform to the test and design requirements of this specification. Cementitious materials shall be as specified in 6.2 and shall be added to the mix in a proportion not less than 470 lb/yd³ [280kg/m³] unless mix designs with a lower cementitious materials content demonstrate that the quality and performance of the pipe meet the requirements of this specification.

10.2 *Curing*—Pipe shall be subjected to any one of the methods of curing described in 10.2.1 to 10.2.4 or to any other method or combination of methods approved by the owner, that will give satisfactory results. The pipe shall be cured for a sufficient length of time so that the specified D-load is obtained when acceptance is based on 5.1 or so that the concrete will develop the specified compressive strength at 28 days or less when acceptance is based on 5.2.

10.2.1 *Steam Curing*—Pipe shall be placed in a curing chamber, free of outside drafts, and cured in a moist atmosphere maintained by the injection of live steam for such time and such temperature as needed to enable the pipe to meet the strength requirements. At no time shall the ambient temperature exceed 160°F [71°C]. The curing chamber shall be so constructed as to allow full circulation around the inside and outside of the pipe.

10.2.2 *Water Curing*—Concrete pipe may be water-cured by covering with water saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose, or by any other approved method that will keep the pipe moist during the specified curing period.

10.2.3 A sealing membrane conforming to the requirements of Specification **C309** may be applied and should be left intact until the required strength requirements are met. The concrete at the time of application shall be within 10°F [6°C] of the atmospheric temperature. All surfaces shall be kept moist prior to the application of the compounds and shall be damp when the compound is applied.

10.2.4 The manufacturer may, at his option, combine the methods described in 10.2.1 to 10.2.3 provided the required concrete compressive strength is attained.

11. Pipe Proof of Design Testing

11.1 *Load Bearing Test*:

11.1.1 *Basis of Acceptance of Design*—Three representative specimens or special class test pipe in accordance with 7.2 shall be tested to the D_{design} load and D_{ult} strength load in accordance with the requirements of Test Methods **C497** with any laps or splices placed in the critical zone, and the results recorded and witnessed. All specimens shall meet or exceed the required limits to qualify the design of the pipe.

NOTE 3—The critical zone in 11.1.1 is at 12/6 o'clock for inner or single cages, and at 3/9 o'clock for an outer cage.

11.1.2 The pipe shall be deemed acceptable for the designated class if the D_{design} strength and ultimate strength of the tested pipe are equal to or greater than the required D_{design} and D_{Ult} for that class.

11.2 *Sample Testing of Pipe Strength*—If any part of the material or manufacture of the pipe in accordance with Section