



Designation: ~~C1417-04~~ Designation: C 1417 - 08

Standard Specification for Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design¹

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1. Scope

1.1 This specification covers the manufacture and acceptance of precast concrete pipe designed to conform to the owner's design requirements and to ASCE ~~15-93~~¹⁵ or an equivalent design specification.

1.2 This specification is the companion to SI Specification C 1417M; therefore, no SI equivalents are presented in this specification.

2. Referenced Documents

2.1 *ASTM Standards:*²

A82 82/A 82M Specification for Steel Wire, Plain, for Concrete Reinforcement

A185 185/A 185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete

A496 496/A 496M Specification for Steel Wire, Deformed, for Concrete Reinforcement

A497 497/A 497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete

~~A 615/A 615M Specification for Deformed and Plain Billet Steel Bars for Concrete Reinforcement~~ Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A 706/A 706M Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

C 33 Specification for Concrete Aggregates

C 76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

C 150 Specification for Portland Cement

C 260 Specification for Air-Entraining Admixtures for Concrete

C 494/C 494M Specification for Chemical Admixtures for Concrete

C 497 Test Methods for Concrete Pipe, Manhole Sections, or Tile

C 595 Specification for Blended Hydraulic Cements (~~Metric~~)

~~C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete~~

C 655 Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe

~~C 822 Terminology Relating to Concrete Pipe and Related Products~~ Terminology Relating to Concrete Pipe and Related Products

C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars

C 1017/C 1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete

2.2 *Other Standards:*

~~ASCE 15-93~~ ASCE 15 Standard Practice for the Direct Design of Buried Precast Reinforced Concrete Pipe Using Standard Installations (SIDD)³

ACI 318 Building Code Requirements for Reinforced Concrete⁴

¹ This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.05 on ~~Least-Cost Analysis: Special Projects.~~

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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.

³ Available from American Society of Civil Engineers, 345 E. 45th Street, New York, NY 10017-2398.

³ Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, <http://www.asce.org>.

⁴ Available from American Concrete Institute, P.O. Box 19150, Detroit, MI 48219.

⁴ Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.aci-int.org>.

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms relating to concrete pipe, see Terminology C 822.

3.1.2 *group of pipe sections, n*—each day's production run of pipe sections of a single concrete strength for a specific project.

3.1.3 *lot of pipe sections, n*—total of the number of groups of pipe sections of a single concrete strength produced for a specific project.

3.1.4 *running average, n*—average concrete compressive strength of all groups of pipe sections of a single concrete strength produced for a specific project, generally determined as each group is tested.

4. Basis of Acceptance of Design

4.1 *Manufacturing Design Data*—The manufacturer shall submit the following manufacturing design data for the concrete pipe to the owner for approval.

4.1.1 Pipe wall thickness.

4.1.2 Concrete strength.

4.1.3 *Reinforcement*:

4.1.3.1 Specification,

4.1.3.2 Reinforcement Type 1, 2, or 3, where:

Type 1:	Smooth wire or plain bars
Type 2:	Welded smooth wire fabric, 8 in. maximum spacing of longitudinals
Type 2:	Welded smooth wire reinforcement, 8 in. maximum spacing of longitudinals
Type 3:	Welded deformed wire fabric, deformed wire, deformed bars, or any reinforcement with stirrups, anchored thereto
Type 3:	Welded deformed wire reinforcement, deformed wire, deformed bars, or any reinforcement with stirrups, anchored thereto

4.1.3.3 Design yield strength,

4.1.3.4 Placement and design concrete cover,

4.1.3.5 Cross-sectional diameters,

4.1.3.6 Spacing,

4.1.3.7 Cross-sectional area,

4.1.3.8 Description of longitudinal members, and

4.1.3.9 If stirrups are used, developable stirrup design stress, stirrup shape, placement, and anchorage details.

4.1.4 Design factors and the assumed orientation angle.

4.1.5 Pipe laying length and joint information.

4.2 Approval of the manufacturing design data shall be based on its conformance to the owner's design requirements and to ASCE 15-93¹⁵ or to an equivalent design specification.

5. Basis of Acceptance of Concrete Pipe

5.1 Acceptance of pipe shall be on the basis of concrete compression tests, materials tests, conformance to the manufacturing design data, conformance to this specification, and inspection of manufactured pipe for defects.

5.2 When mutually agreed in writing by the owner and the manufacturer, a certification may be made the basis of acceptance of the concrete pipe. This certification shall consist of a statement by the manufacturer that the concrete pipe conforms to the manufacturing design data and to this specification, and that the concrete and materials have been sampled and tested and conform to this specification.

5.3 *Age for Acceptance*—Pipe shall be considered ready for acceptance when they conform to the requirements of this specification.

6. Material

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 Material*:

6.2.1 *Cement*—Cement shall conform to the requirements for portland cement of Specification C 150 or shall be portland blast-furnace slag cement or slag modified portland cement or portland-pozzolan cement conforming to the requirements of Specification C 595, except that the pozzolan constituent in the Type IP portland-pozzolan cement shall be fly ash and shall not exceed 25% by weight. ash.

6.2.2 *Fly Ash or Pozzolan*—Fly ash or pozzolan shall conform to the requirements of Specification C 618, Class F or Class C. Ground Graduated Blast-Furnace Slag (GGBFS)—GGBFS shall conform to the requirements of Grade 100 or 120 of Specification C 989.

6.2.3 *Fly Ash*—Fly ash shall conform to the requirements of Specification C 618, Class F or Class C.

6.2.4 *Allowable Combinations of Cementitious Materials*—The combination of cementitious materials used in the concrete shall be one of the following:

~~6.2.3.1 Portland cement only.~~

~~6.2.3.2 Portland blast furnace slag cement only.~~

~~6.2.3.3 Portland pozzolan cement only.~~

~~6.2.3.4 A combination of portland cement and fly ash or pozzolan, wherein the proportion of fly ash is between 5 and 25% by weight (mass) of total cementitious material (portland cement plus fly ash).~~

~~6.2.4.1 Portland cement only.~~

~~6.2.4.2 Portland blast-furnace slag cement only.~~

~~6.2.4.3 Slag modified portland cement only.~~

~~6.2.4.4 Portland-pozzolan cement only.~~

~~6.2.4.5 A combination of portland cement and ground granulated blast-furnace slag.~~

~~6.2.4.6 A combination of portland cement and fly ash, or~~

~~6.2.4.7 A combination of portland cement, ground granulated blast-furnace slag (not to exceed 25 % of the total cementitious weight), and fly ash (not to exceed 25 % of the total cementitious weight).~~

6.3 *Aggregates*—Aggregates shall conform to the requirements of Specification C 33, except that the requirement for gradation shall not apply.

6.4 *Admixtures*—~~Admixtures and blends may be used with the approval of the owner.~~—The following admixtures and blends are allowable:

6.4.1 Air-entraining admixture conforming to Specification C 260;

6.4.2 Chemical admixture conforming to Specification C 494/C 494M;

6.4.3 Chemical admixture for use in producing flowing concrete conforming to Specification C 1017/C 1017M; and

6.4.4 Chemical admixture or blend approved by the owner.

6.5 *Steel Reinforcement*—Reinforcement shall consist of wire conforming to Specifications A 82 or A 496, of wire fabric conforming to Specifications A 185 or A 497, or of bars conforming to Specification A 615/A 615M. —Reinforcement shall consist of wire conforming to Specifications A 82/A 82M or A 496/A 496M; or of wire reinforcement conforming to Specifications A 185/A 185M or A 497/A 497M; or of bars conforming to Specifications A 615/A 615M, Grade 40 or 60, or A 706/A 706M, Grade 60.

7. Joints

7.1 The joints shall be designed and the ends of the concrete pipe sections shall be formed so that the sections can be laid together to make a continuous line of pipe, compatible with the permissible variations given in Section 15.

8. Manufacture

8.1 *Concrete*—The aggregates shall be sized, graded, proportioned, and mixed with cementitious material and water and admixtures, if any, to produce a homogeneous concrete mixture of such quality that the pipe will conform to the design requirements of this specification. The water-cementitious material ratio of all concrete shall be 0.53, or less, by weight. Minimum concrete strength shall be 4000 psi.

8.2 *Finish*—Pipe shall be substantially free of fractures, large or deep cracks, and surface roughness. The ends of the pipe shall be normal to walls and center line of the pipe, within the limits of variations given in Section 15.

9. Circumferential Reinforcement

9.1 A line of circumferential reinforcement for any given total area may be composed of up to two layers for pipe with wall thicknesses of less than 7 in. or three layers for pipe with wall thickness of 7 in. or greater. The layers shall not be separated by more than the thickness of one longitudinal plus ¼ in. The multiple layers shall be fastened together to form a single cage. If the multiple layers of a cage contain circumferential splices, the individual layers shall be rotated so that the splices are staggered. All other specification requirements, such as laps, welds, tolerances of placement in the wall of the pipe, and so forth, shall apply to this method of fabricating a line of reinforcement. The design shall be based on the centroid of the layers.

9.2 Reinforcement placement and concrete cover shall conform to the approved manufacturing data. The nominal concrete cover over the circumferential reinforcement shall not be less than 1 in. in pipe having a wall thickness of 2½ in. or greater, and shall not be less than ¾ in. in pipe having a wall thickness of less than 2½ in. The location of the reinforcement shall be subject to the permissible variations in dimensions given in Section 15. Requirements for placement and protective covering of the concrete from the inner or outer surface of the pipe do not apply to that portion of a cage that is flared so as to extend into the bell or reduced in diameter so as to extend into the spigot.

9.3 Where the wall reinforcement does not extend into the joint area, the maximum longitudinal distance to the last circumferential from the inside shoulder of the bell or the shoulder of the spigot shall be 3 in., except that if this distance exceeds one half of the wall thickness, the pipe wall shall contain at least a total reinforcement area of the minimum specified area per linear foot times the laying length of the pipe section. The minimum cover on the last circumferential near the spigot shoulder shall be ½ in.

9.4 Where reinforcement is in the bell or spigot, the minimum end-cover on the last circumferential shall be ½ in. in the bell or ¼ in. in the spigot.

9.5 The continuity of the circumferential reinforcing steel shall be maintained during the manufacture of the pipe, except when, as agreed upon by the owner, lift eyes or holes are provided in each pipe or the pipe is converted into a manhole tee.

10. Welds, Splices, and Development of Circumferential Reinforcement

10.1 General:

10.1.1 When pipe are not marked to show a specific orientation in the ground, any weld to, or splice of, a circumferential shall be considered to be at the point of the maximum flexural stress.

10.1.2 When pipe are marked to show a specific orientation in the ground, any weld to, or splice of, a circumferential shall be considered to be at a distance determined by the orientation angle closer to the point of maximum flexural stress than the marking indicates.

10.1.3 Splices of smooth and deformed wire shall be welded and shall meet the requirements of 10.3 and 10.4.

10.2 Notation:

- A_{wa} = actual steel area of the individual circumferential wire, in.²
 A_{wr} = steel area required for the individual circumferential wire for flexure, in.², either at the splice, for splices, or at the point of maximum moment, for quadrant mat reinforcement.
 d_b = diameter of reinforcing wire or bar, in.
 f'_c = design compressive strength of concrete, lb/in.².
 f_y = design yield strength of reinforcement, lb/in.².
 F_w = embedded weld factor (see 10.4.3).
 L_d = development length of reinforcing wire or bar, in.
 P_t = pull test strength of wire or bar at break, lbf.
 s = spacing of wire to be developed or spliced, in.

10.3 Welds:

10.3.1 For butt splices of circumferentials or where welds are made to circumferentials, pull tests of representative specimens of the circumferential across the finished weld shall demonstrate a strength of no less than 1.1 times the design yield strength of the circumferential except as provided in 10.4.

10.3.2 At the option of the manufacturer, a more detailed analysis may be made and the requirements of this section used instead of 10.3.1. For butt splices of circumferentials or where welds are made to circumferentials, pull tests, P_t , of representative specimens of the circumferential across the finished weld shall demonstrate a strength of no less than:

$$P_t = 1.1 A_{wr} f_y \quad (1)$$

or no less than:

$$P_t = 0.5 A_{wa} f_y \quad (2)$$

whichever is greater.

10.4 Lapped Splices of Circumferential Reinforcement:

10.4.1 Where lapped circumferentials are spliced by welding, they shall be lapped no less than 2 in. Pull tests of representative specimens shall develop no less than 0.9 times design yield strength of the circumferential.

10.4.2 At the option of the manufacturer, a more detailed analysis may be made and the requirements of 10.4.2 and 10.4.3 used instead of 10.4.1. Where lapped circumferentials are spliced by welding, they shall be lapped no less than 2 in. Pull tests, P_t , of representative specimens shall develop no less than:

$$P_t = F_w A_{wr} f_y \quad (3)$$

or not less than the strength required by Eq 2, whichever is the greater.

10.4.3 The embedded weld factor, F_w , relates the pull test strength of the non-embedded splice specimens to the strength of the splice embedded in the concrete of the pipe wall.

10.4.3.1 If the pull test break is in the wire, F_w shall be taken as 0.90.

10.4.3.2 If the pull test break is in the weld, F_w shall be taken as 0.70.

10.4.4 If lapped splices of circumferentials consisting of deformed bars #6 or less are not welded, they shall be lapped not less than L_d , where:

$$L_d = \frac{d_b f_y A_{wr}}{33 \sqrt{f'_c} A_{wa}} \quad (4)$$

or not less than:

$$\frac{d_b f_y}{66 \sqrt{f'_c}} \quad (5)$$

whichever is greater. Splices of larger than #6 bars shall meet the requirements of ACI 318-95318.