Designation: ~~C1504 – 13~~ C1504 – 13a

Standard Specification for Manufacture of Precast Reinforced Concrete Three-Sided Structures for Culverts and Storm Drains[1]

This standard is issued under the fixed designation C1504; 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 specification covers single-cell precast conventionally reinforced concrete three-sided structures intended to be used for the construction of culverts and for the conveyance of storm water.

1.2 A complete metric companion to Specification C1504 has been developed—C1504M; therefore, no metric equivalents are presented in this specification.

NOTE 1—This specification is primarily a manufacturing and purchasing specification. The successful performance of this product depends upon the proper selection of the geometric section, bedding, backfill, and care that the installation conforms to the construction specifications. The purchaser of the precast reinforced concrete three-sided structure specified herein is cautioned that ~~he must properly correlate~~ proper correlation of the loading conditions and the field requirements with the geometric section specified and ~~provide~~provisions for inspection at the construction ~~site.~~site are required.

1.3 The values stated in ~~either SI units or~~ inch-pound units are to be regarded ~~separately as standard. 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~~ as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

~~A82/A82M~~A1064/A1064M Specification for ~~Steel Wire, Plain, for Concrete Reinforcement~~Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

~~A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete~~

~~A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement~~

~~A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete~~

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

~~A616/A616M Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement (Withdrawn 1999)[3]~~

~~A617/A617M Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement (Withdrawn 1999)[3]~~

A706/A706M Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field

C33 Specification for Concrete Aggregates

C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens

C150 Specification for Portland Cement

C260/C260M Specification for Air-Entraining Admixtures for Concrete

C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C494/C494M Specification for Chemical Admixtures for Concrete

C497 Test Methods for Concrete Pipe, Manhole Sections, or Tile

C595 Specification for Blended Hydraulic Cements

C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete

C822 Terminology Relating to Concrete Pipe and Related Products

C989 Specification for Slag Cement for Use in Concrete and Mortars

[1] This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.07 on Acceptance Specifications and Precast Concrete Box Sections.

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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.

C1116 Specification for Fiber-Reinforced Concrete and Shotcrete

2.2 *AASHTO Standard:*

~~Standard Specifications for Highway Bridges~~AASHTO LRFD Bridge Design Specification[3]

2.3 *ACI Standard:*

ACI 318 Building Code Requirements for Structural Concrete and Commentary[4]

3. Terminology

3.1 *Definitions*—For definitions of terms relating to geometric sections, see Terminology C822.

4. Types

4.1 Precast reinforced concrete three-sided structures manufactured in accordance with this specification shall be designated by span, rise, and design earth cover.

5. Basis of Acceptance

5.1 Acceptability of the three-sided sections produced in accordance with Section 7 shall be determined by the results of the concrete compressive strength tests described in Section 10, by the material requirements described in Section 6, and by inspection of the finished three-sided sections.

5.2 Three-sided sections shall be considered ready for acceptance when they conform to the requirements of this specification.

6. Materials

6.1 *Reinforced Concrete*—The reinforced concrete shall consist of cementitious materials, mineral aggregates 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 for portland cement of Specification C150 or shall be portland blast-furnace slag cement or portland-pozzolan cement conforming to the requirements of Specification C595, except that the pozzolan constituent in the Type IP portland pozzolan cement shall be fly ash.

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

6.2.3 *Ground Granulated Blast-Furnace Slag (GGBFS)*—GGBFS shall conform to the requirements of Grade 100 or 120 of Specification C989.

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

(1) Portland cement only,

(2) Portland blast-furnace slag cement only,

~~*(3)* Slag modified portland cement only,~~

(3) Portland pozzolan cement only,

(4) A combination of portland cement and fly ash,

(5) A combination of portland cement and ground granulated blast-furnace slag

(6) A combination of portland cement, ground granulated blast furnace slag, and fly ash.

(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).~~portland pozzolan cement and fly ash.

6.3 *Aggregates*—Aggregates shall conform to Specification C33, except that the requirements for gradation shall not apply.

6.4 *Admixtures and Blends*—Admixtures and blends ~~may be used with~~shall conform to Specification C494/C494M~~the approval of the purchaser.~~.

6.4.1 *Air Entraining Admixtures*—Air entraining will be required on all products produced with positive slump, wet-cast concrete and shall conform to the requirements of Specification ~~C494/C494M~~C260/C260M.

6.5 *Steel Reinforcement*—Reinforcement shall consist of welded wire reinforcement conforming to ~~Specifications~~Specification ~~A185/A185M~~A1064/A1064M ~~or~~for ~~A497/A497M or~~ steel wire and welded wire reinforcement, plain and deformed, for concrete. For circumferential reinforcement, deformed and plain steel bars for reinforced concrete are permitted conforming to Specification A706/A706M or A615/A615M, Grade 60, ~~A616/A616M, or~~and longitudinal ~~A617/A617M. Longitudinal~~ distribution reinforcement ~~may~~shall consist of welded wire reinforcement or deformed billet-steel bars conforming to Specification A706/A706M or A615/A615M, Grade 60.

NOTE 2—This specification does not address reinforcement with prestressing strand or any other form of pre-tensioning or post-tensioning.

[3] American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001.

[4] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org.

6.6 *Synthetic Fibers*—Collated fibrillated virgin polypropylene fibers may be used, at the manufacturer's option, in three-sided structures as a nonstructural manufacturing material. Only type III synthetic fibers designed and manufactured specifically for use in concrete and conforming to the requirements of Specification C1116 shall be accepted.

7. Design

7.1 *Design Criteria*—The three-sided section's dimensions and reinforcement details shall be as required by design, in accordance with Section ~~17.8 of the AASHTO Standard Specifications for Highway Bridges.~~ 3, 5 and 12.14 of the American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications. The minimum concrete compressive strength shall be 5000 psi, and the minimum steel yield strength shall be ~~65 000~~ 65 000 psi for welded-wire reinforcement and ~~60 000~~ 60 000 psi for deformed billet-steel bars.

7.2 *Placement of Reinforcement*—The minimum cover of concrete over the circumferential ~~reinforcement~~ reinforcing diameter shall be 1 ~~in.,~~ in. for bar reinforcement and welded wire reinforcement for all structures up to 12 ft in span, and 1.5 in. for longer spans subject to the provisions of Section 11. ~~for both bar reinforcement and welded wire reinforcement.~~ The clear distance of the end circumferential wires shall be not less than ½ in. nor more than 2 in. from the ends of each section. For three-sided sections covered by less than 2 ft of fill, minimum cover for the reinforcement in the top of the top slab shall be 2-in., subject to the provisions of Section 11. Reinforcement shall be assembled utilizing any combination of single or multiple layers of welded-wire reinforcement, not to exceed three layers or utilizing single or multiple layers of deformed billet steel bars, not to exceed two layers. The welded-wire reinforcement on 7.3 shall be composed of circumferential and longitudinal wires meeting the spacing requirements of 7.3 and shall contain sufficient longitudinal wires extending through the three-sided section to maintain the shape and position of reinforcement. Longitudinal distribution reinforcement may be welded-wire reinforcement or deformed billet-steel bars and shall meet the spacing requirements of 7.3. The ends of the longitudinal distribution reinforcement shall not be more than 2 in. from the ends of a three-sided section. The exposure of the ends of longitudinals, stirrups, and spacers used to position the reinforcement shall not be a cause for rejection.

7.3 *Laps, Welds, and Spacing*—Splices in the circumferential reinforcement shall be made by lapping. For welded wire reinforcement, the overlap measured between the outermost longitudinal wires of each reinforcement sheet or the outermost bars shall not be less than the spacing of the longitudinal wires plus 2 in. but not less than 10 in. For splices of deformed billet steel bars, the overlap shall meet the requirements of AASHTO. The outside circumferential reinforcement in the top slab shall be continuous with or be lapped with the outside circumferential reinforcement in the sides. If welds are made to welded wire reinforcement circumferential reinforcement, they shall be made only to selected circumferential wires that are not less than 18 in. apart along the longitudinal axis of the three-sided section. When spacers are welded to circumferential wires, they shall be welded only to these selected circumferential wires. There shall be no welding to other circumferential wires. No welds shall be made to the inside circumferential wires in the middle third of the top span. No welds shall be made to the outside circumferential wires in the top span within one fourth of the span from the corners or in any location in either leg. Welding of deformed billet steel bar circumferential reinforcement is prohibited in all cases. When distribution reinforcement is to be fastened to a cage by welding, it shall be welded only to longitudinal wires or bars and only near the ends of the three-sided section. The spacing center to center of the circumferential reinforcement shall not be less than 2 in. nor more than 4 in. for welded wire reinforcement or less than 2 in. nor more than 8 in. for deformed billet steel bars. The spacing center to center of the longitudinal reinforcement shall not be more than 8 in. for welded wire reinforcement or more than 12 in. for deformed billet steel bars. If welds are made to Grade 60 reinforcing bars, weldable bars conforming to Specification A706/A706M shall be used.

8. Joints

8.1 The precast reinforced concrete three-sided structures shall be produced with tongue and groove ends, flat butt ends or key-way ends. The ends shall be of such design and the ends of the three-sided sections so formed that each section can be laid together to make a continuous line of sections compatible with the permissible variations given in Section 11.

9. Manufacture

9.1 *Mixture*—The aggregates shall be sized, graded, proportioned, and mixed with ~~such proportions of~~ cementitious materials and water ~~as will~~ and admixtures, if any, to produce a ~~thoroughly-mixed~~ thoroughly mixed concrete of such quality that ~~each section~~the structures will conform to the ~~test and~~ design requirements of this specification. All concrete shall have a water-cementitious materials ratio not exceeding 0.53 by ~~weights.~~ weights except that for concrete exposed to cyclic freeze/thaw the water-cementitious materials ratio shall not exceed 0.45. Cementitious materials shall be as specified in 6.2 and shall be added to the mix in a proportion not less than 470 lb/yd^3 unless mix designs with a lower cementitious materials content demonstrate that the quality and performance of the three-sided sections meet the requirements of this specification. Wet cast concrete subject to freeze/thaw cycle shall be air-entrained. Air entrainment amounts shall be in accordance with ACI 318–11, Chapter 4, for the appropriate Exposure Class.

9.2 *Curing*—The three-sided sections shall be cured for a sufficient length of time so that the concrete will develop the required compressive strength by the time of delivery. Any one of the following methods of curing or combinations thereof may be used: