



Designation: **C1504 – 19** **C1504 – 20**

## Standard Specification for Manufacture of Precast Reinforced Concrete Three-Sided Structures for Culverts and Storm Drains<sup>1</sup>

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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

### 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 proper correlation of the loading conditions and the field requirements with the geometric section specified and provisions for inspection at the construction site are required.

1.3 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this 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 Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

- [A1064/A1064M Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete](#)
- [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](#)
- [C31/C31M Practice for Making and Curing Concrete Test Specimens in the Field](#)
- [C33/C33M Specification for Concrete Aggregates](#)
- [C39/C39M Test Method for Compressive Strength of Cylindrical Concrete Specimens](#)
- [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](#)
- [C494/C494M Specification for Chemical Admixtures for Concrete](#)

<sup>1</sup> 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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<sup>2</sup> 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.

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

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  
C822 Terminology Relating to Concrete Pipe and Related Products  
C989/C989M Specification for Slag Cement for Use in Concrete and Mortars  
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete  
C1116/C1116M Specification for Fiber-Reinforced Concrete  
C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

2.2 *AASHTO Standard:*

AASHTO LRFD Bridge Design Specification<sup>3</sup>

2.3 *ACI Standard:*

ACI 318 Building Code Requirements for Structural Concrete and Commentary<sup>4</sup>

### 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, admixture, 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 for portland cement of Specification C150/C150M or shall be portland blast-furnace slag cement, portland-limestone cement, or portland-pozzolan cement conforming to the requirements of Specification C595/C595M, 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 *Slag Cement*—Slag cement shall conform to the requirements of Grade 100 or 120 of Specification C989/C989M.

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

6.2.4.1 Portland cement only,

6.2.4.2 Portland blast-furnace slag cement only,

6.2.4.3 Portland-pozzolan cement only,

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

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

6.2.4.4 Portland-limestone cement only,

6.2.4.5 A combination of portland cement or portland-limestone cement and fly ash,

6.2.4.6 A combination of portland cement or portland-limestone cement and slag cement,

6.2.4.7 A combination of portland cement or portland-limestone cement, slag cement, and fly ash.

6.2.4.8 A combination of portland-pozzolan cement and fly ash.

6.3 *Aggregates*—Aggregates shall conform to Specification **C33/C33M**, except that the requirements 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.

6.4.5 *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 **C260/C260M**.

6.5 *Steel Reinforcement*—Reinforcement shall consist of welded wire reinforcement conforming to Specification **A1064/A1064M** for 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, and longitudinal distribution reinforcement 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.

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 non-potable water that meets the requirements of Specification **C1602/C1602M**.

## 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 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 psi for welded-wire reinforcement and 60 000 psi for deformed billet-steel bars.

7.2 *Placement of Reinforcement*—The minimum cover of concrete over the circumferential reinforcing diameter shall be 1 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 cementitious materials and water and admixtures, if any, to produce a thoroughly mixed concrete of such quality that the structures will conform to the design requirements of this specification. All concrete shall have a water-cementitious materials ratio not exceeding 0.53 by 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<sup>3</sup> 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:

9.2.1 *Steam Curing*—The three-sided section may be low pressure, steam-cured by a system that will maintain a moist atmosphere.

9.2.2 *Water Curing*—The three-sided section may be water-cured by any method that will keep the sections moist.

9.2.3 *Membrane Curing*—A sealing membrane conforming to the requirements of Specification C309 may be applied and shall be left intact until the required concrete compressive strength is attained. The concrete temperature at the time of application shall be within 10°F 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.

9.3 *Forms*—The forms used in manufacture shall be sufficiently rigid and accurate to maintain the three-sided section dimensions within the permissible variations given in Section 11. All casting surfaces shall be smooth nonporous material.

9.4 *Handling*—Handling devices or holes shall be permitted in each three-sided section for the purpose of handling and laying.