



Designation: **C1504M–13** **C1504M – 13a**

Standard Specification for Manufacture of Precast Reinforced Concrete Three-Sided Structures for Culverts and Storm Drains (Metric)¹

This standard is issued under the fixed designation C1504M; 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 This specification is the metric counterpart of Specification C1504; therefore, no imperial (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 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)³–13a
- ~~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
- ~~C497M~~ Test Methods for Concrete Pipe, Manhole Sections, or Tile (Metric)
- ~~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 Specifications](#)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, 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 (not to exceed 25% of the total cementitious weight), and fly ash (not to exceed 25% of the total cementitious weight).slag, and fly ash.
- (7) A combination of 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~~[MC260/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 60,420, [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 60,420.

³The last approved version of this historical standard is referenced on www.astm.org.

³ Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20004-20001, <http://www.transportation.org>.

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

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

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 47.8 of the ~~AASHTO Standard Specifications for Highway Bridges~~, 3, 5, and 12.14 of the American Association of State Highways and Transportation Officials (AASHTO) LRFD Bridge Design Specifications. The minimum concrete compressive strength shall be 35 MPa, and the minimum steel yield strength shall be ~~445~~450 MPa for welded-wire reinforcement and ~~414~~420 MPa for deformed billet-steel bars.

7.2 *Placement of Reinforcement*—The minimum cover of concrete over the circumferential ~~reinforcement~~ reinforcing diameter shall be 25 mm, ~~subject to the mm for bar reinforcement and welded wire reinforcement for all structures up to 3.6 m in span and 38 mm for longer spans subject to 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 13 mm nor more than 50 mm from the ends of each section. For three-sided sections covered by less than 0.6 m of fill, minimum cover for the reinforcement in the top of the top slab shall be 50 mm, 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 50 mm 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 50 mm but not less than 250 mm. 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 450 mm 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 (wires) reinforcement shall not be less than 50 mm nor more than 100 mm for welded wire reinforcement or less than 50 mm nor more than 200 mm for deformed billet steel bars. The spacing center to center of the longitudinal reinforcement shall not be more than 200 mm for welded wire reinforcement or more than 300 mm for deformed billet steel bars. If welds are made to Grade ~~60~~420 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 admixture, 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 280 kg/m³ 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.