Designation: C 1504 – 01

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

This standard is issued under the fixed designation C 1504; 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 and sewage.

1.2 A complete metric companion to Specification C 1504 has been developed—C 1504M; 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 the loading conditions and the field requirements with the geometric section specified and provide for inspection at the construction site.

2. Referenced Documents

2.1 *ASTM Standards:*

A 82 Specification for Steel Wire, Plain, for Concrete Reinforcement[2]

A 185 Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement[2]

A 496 Specification for Steel Wire, Deformed, for Concrete Reinforcement[2]

A 497 Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement[2]

A 615/A 615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement[2]

A 616/A 616M Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement[2]

A 617/A 617M Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement[2]

C 31/C 31M Practice for Making and Curing Concrete Test Specimens in the Field[3]

C 33 Specification for Concrete Aggregates[3]

C 39 Test Method for Comprehensive Strength of Cylindrical Concrete Specimens[3]

C 150 Specification for Portland Cement[4]

C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete[3]

C 494/C 494M Specification for Chemical Admixtures for Concrete[3]

C 497 Test Methods for Concrete Pipe, Manhole Sections, or Tile[5]

C 595 Specification for Blended Hydraulic Cements[4]

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete[3]

C 822 Terminology Relating to Concrete Pipe and Related Products[5]

2.2 *AASHTO Standard:*

Standard Specifications for Highway Bridges[6]

3. Terminology

3.1 *Definitions*—For definitions of terms relating to geometric sections, see Terminology C 822.

4. Types

4.1 Precast reinforced concrete three-sided structures shall be produced by manufacturers that meet the requirements of the purchasers, and shall designate each section 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

[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] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

[4] *Annual Book of ASTM Standards*, Vol 04.01.

[5] *Annual Book of ASTM Standards*, Vol 04.05.

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

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 C 150 or shall be portland blast-furnace slag 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.

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

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

6.2.3.1 Portland cement.

6.2.3.2 Portland blast furnace slag cement.

6.2.3.3 Portland pozzolan cement.

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

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

6.4 *Admixtures and Blends*—Admixtures and blends may be used with 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 C 494/C 494M.

6.5 *Steel Reinforcement*—Reinforcement shall consist of welded wire fabric conforming to Specifications A 185 or A 497 or deformed and plain steel bars for reinforced concrete conforming to Specification A 615/A 615M, Grade 60, A 616/A 616M, or A 617/A 617M. Longitudinal distribution reinforcement may consist of welded wire fabric or deformed billet-steel bars conforming to Specification A 615/A 615M, Grade 60.

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

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. The minimum concrete compressive strength shall be 5000 psi, and the minimum steel yield strength shall be 65 000 psi for welded-wire fabric and 60 000 psi for deformed billet-steel bars.

7.2 *Placement of Reinforcement*—The cover of concrete over the circumferential reinforcement shall be 1 in., subject to the provisions of Section 11. 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 fabric, not to exceed three layers or utilizing single or multiple layers of deformed billet steel bars, not to exceed two layers. The welded-wire fabric 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 fabric 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. The overlap measured between the outermost longitudinal wires of each fabric 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. The spacing center to center of the circumferential wires or bars shall not be less than 2 in. nor more than 4 in. The spacing center to center of the longitudinal wires or bars shall not be more than 8 in. for deformed billet steel bars; the overlap shall meet the requirements of AASHTO.

8. Joints

8.1 The precast reinforced concrete three-sided structures shall be produced with tongue and groove ends, fiat 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 produce a homogeneous concrete mixture of such quality that each section 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. 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.

9.2 *Curing*—The three-sided sections shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength in 28 days or less. 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 C 309 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.

10. Physical Requirements

10.1 *Type of Test Specimen*—Compression tests for determining concrete compressive strength may be made on either standard rodded concrete cylinders or concrete cylinders compacted and cured in like manner as the structure compacted and cured in like manner as the three-sided section, or on cores drilled from the three-sided section.

10.2 *Compression Testing of Cylinders*:

10.2.1 Cylinders shall be obtained and tested for compressive strength in accordance with the provisions of Practice C 31/C 31M and Test Method C 39, except that the cylinders may be prepared by methods comparable to those used to consolidate and cure the concrete in the actual three-sided section manufactured. Cylindrical specimens of sizes other than 6 by 12 in. may be used provided all other requirements of Practice C 31/C 31M are met. If the concrete is of a consistency too stiff for compaction by rodding or internal vibration, the alternate method described in Section II of Test Methods C 497 may be used. Cylinders shall be exposed to the same curing conditions as the manufactured three-sided sections and shall remain with the sections until tested.

10.2.2 Prepare not less than five test cylinders from each day's production of the lot of three-sided sections.

10.2.3 *Acceptability on the Basis of Cylinder Test Results*:

10.2.3.1 When the average compressive strength of all cylinders tested is equal to or greater than the design concrete strength, and not more than 10 % of the cylinders tested have a compressive strength less than the design concrete strength, and no cylinder tested has a compressive strength less than 80 % of the design concrete strength, then the lot shall be accepted.

10.2.3.2 When the compressive strength of the cylinders tested does not conform to the acceptance criteria stated in 10.2.3.1, the acceptability of the lot shall be determined in accordance with the provisions of 10.3.

10.3 *Compression Testing of Cores*:

10.3.1 Cores shall be obtained, prepared, and tested for compressive strength in accordance with the provisions of Test Methods C 497.

10.3.2 Three cores shall be taken from three sections (one core from each) selected at random from each group of 15 three-sided sections or fraction thereof of a single size from each continuous production run.

10.3.3 *Acceptability by Core Tests*:

10.3.3.1 The compressive strength of the concrete, as defined in 10.1, for each group of three-sided sections is acceptable when the test strength, defined as the average of three cores taken at random from the subject group, is equal to or greater than 85 % of the specified strength and no single core is less than 75 % of the specified strength.

10.3.3.2 If the compressive strength of the three cores does not meet the requirements of 10.3.3.1, the sections from which the cores were taken shall be rejected. Two three-sided sections from the remainder of the group shall be selected at random and one core shall be taken from each. If both cores have a strength equal to or greater than 85 % of the specified strength of the concrete, the remainder of the group is acceptable. If the compressive strength of either of the two cores tested is less than 85 % of the specified strength of the concrete, the remainder of the group of three-sided sections shall be rejected or, at the option of the manufacturer, each three-sided section of the entire group shall be cored and accepted individually, and any of these three-sided sections that have cores with less than 85 % of the specified strength of the concrete shall be rejected.

10.3.3.3 When the compressive strength of any recore is less than 80 % of the specified strength of the concrete, the three-sided section from which the core was taken shall be rejected. Two three-sided sections from the remainder of the group shall be selected at random and one core shall be taken from each. If the compressive strength of either of the two cores tested is less than 80 % of the specified strength of the concrete, the remainder of the group of three-sided sections shall be rejected or, at the option of the manufacturer, each three-sided section of the remainder of the group shall be cored and accepted individually, and any of these three-sided sections that have cores with less than 80 % of the specified strength of the concrete shall be rejected.

10.4 *Plugging Core Holes*—The core holes shall be plugged and sealed by the manufacturer in a manner such that the three-sided section will meet all of the test requirements of this specification. Three-sided sections so sealed shall be considered as satisfactory for use.

10.5 *Test Equipment*—Every manufacturer furnishing three-sided sections under this specification shall furnish all facilities and personnel necessary to carry out the tests required.

11. Permissible Variations

11.1 *Internal Dimensions*—The internal dimension shall not vary more than one percent or 2-in., whichever is less, from the design dimensions. The haunch dimensions shall not vary more than ¾-in. from the design dimensions.

11.2 *Slab and Wall Thickness*—The slab and wall thickness shall not be less than that shown in the design by more than 5 % or ½-in., whichever is greater. A thickness more than that required in the design shall not be a cause for rejection.

11.3 *Length of Opposite Surfaces*—Variations in laying lengths of two opposite surfaces of the three-sided section shall not be more than ¾-in., except where beveled ends for laying of curves are specified by the purchaser.

11.4 *Position of Reinforcement*—The maximum variation in the position of the reinforcement for 5-in. or less slab and wall thickness shall be ±⅜-in., and for greater than 5-in. slab and wall thickness shall be ±½ in. In no case, however, shall the cover over the reinforcement be less than ⅝-in., as measured to

the internal surface or the external surface except the cover over the reinforcement for the external surface of the top slab for three-sided sections with under 2 ft of cover shall not be less than 1⅝-in. The preceding minimum cover limitation does not apply at the mating surfaces of the joint.

11.5 *Area of Reinforcement*—The areas of steel reinforcement shall be the design steel areas, as required. Steel areas greater than those required shall not be cause for rejection. The permissible variation in diameter of any wire in finished fabric shall conform to the tolerances prescribed for the wire before fabrication by either Specifications A 82 or A 496 as applicable. If steel bars (Grade 60) are used in lieu of welded wire fabric, the steel areas shall be increased to account for the difference in steel yield strength, steel spacing, concrete cover, and crack control between the welded wire fabric and steel bars.

11.6 *Haunch Dimensions*—Haunch configurations shall be as required by the design.

12. Repairs

12.1 Three-sided sections may be repaired, if necessary, because of imperfections in manufacture or handling damage and will be acceptable if, in the opinion of the purchaser, the repaired three-sided section conforms to the requirements of this specification.

13. Inspection

13.1 The quality of materials, the process of manufacture, and the finished three-sided sections shall be subject to inspection by the purchaser.

14. Rejection

14.1 Three-sided structures shall be subject to rejection on account of failure to conform to any of the specification requirements. Individual three-sided structures may be rejected because of any of the following:

14.1.1 Fractures or cracks passing through the wall, except for a single end crack that does not exceed the depth of the joint,

14.1.2 Defects that indicate mixing and molding, not in compliance with 9.1, or honeycombed or open texture that would adversely affect the function of the box sections,

14.1.3 The ends of the three-sided structure are not normal to the walls and center line of the structure, within the limits of variations given in Section 11, except where beveled ends are specified, and

14.1.4 Damaged ends, where such damage would prevent making a satisfactory joint.

15. Product Marking

15.1 The following information shall be legibly marked on each three-sided structure by indentation, waterproof paint, or other approved means.

15.1.1 Three-sided structure span, rise, maximum and minimum design earth cover, and specification designation,

15.1.2 Date of manufacture, and

15.1.3 Name or trademark of the manufacturer.

16. Certification

16.1 When agreed upon in writing by the owner and manufacturer, a certification shall be made the basis of acceptance. This certification shall consist of a copy of a sealed “stamped” design by a professional engineer in accordance with the provisions of Section 7, and a copy of the manufacturers test report or a statement by the manufacturer accompanied by the test results that the structure has been sampled, tested, and inspected in accordance with the provisions of Section 4. Each certification so furnished shall be signed by an authorized agent of the manufacturer.

17. Keywords

17.1 three-sided structure