



Standard Specification for Circular Precast Reinforced Concrete Manhole Sections (Metric)¹

This standard is issued under the fixed designation C478M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

PART I—GENERAL

1. Scope

1.1 This specification covers the manufacture and purchase requirements of products used for the assembly and construction of circular vertical precast reinforced concrete manholes and structures used in sewer, drainage, and water works.

1.2 Part I, Sections 1 – 11, of this specification presents general requirements and requirements which are common to each precast concrete product covered by this specification.

1.3 Part II of this specification presents specific requirements for each manhole product in the following sections:

Product	Section
Grade Rings	12
Flat Slab Tops	13
Risers and Conical Tops	14
Base Sections	15
Steps and Ladders	16

NOTE 1—Future products will be included in Part II in a future revision of this specification.

1.4 This specification is the SI companion to C478.

NOTE 2—This specification is a manufacturing and purchase specification only, and does not include requirements for backfill, or the relationship between field load conditions and the strength requirements of the manhole products and appurtenances. Experience has shown, however, that the successful performance of this product depends upon the proper selection of the product strength, type of foundation and backfill, and care in the field installation of the manhole products and connecting pipes. The owner of the project for which these products are specified herein is cautioned to require inspection at the construction site.

2. Referenced Documents

2.1 ASTM Standards:²

¹ This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.06 on Manholes and Specials.

Current edition approved Jan. 1, 2015. Published January 2015. Originally approved in 1980. Last previous edition approved in 2014 as C478M – 14. DOI: 10.1520/C0478M-15.

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.

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

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

C33 Specification for Concrete Aggregates

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

C150 Specification for Portland Cement

C260 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

C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete

C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

2.2 ACI Standard:

ACI 318 Building Code, Requirements for Reinforced Concrete³

3. Terminology

3.1 *Definitions*—For definitions of terms relating to concrete pipe, see Terminology C822.

³ Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333-9094, <http://www.aci-int.org>.

4. Materials and Manufacture

4.1 General material requirements for precast reinforced concrete manhole products are presented in 4.1.1 – 4.1.9. Other materials or additional requirements for a product, if any, are covered in the Part II section for that specific product.

4.1.1 *Reinforced Concrete*—Reinforced concrete shall consist of cementitious materials, mineral aggregates, and water, in which steel reinforcement has been embedded in such a manner so that the steel reinforcement and concrete act together.

4.1.2 *Cementitious Materials:*

4.1.2.1 *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 Specification C595, except that the pozzolan constituent of the Type IP portland-pozzolan cement shall be fly ash.

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

4.1.2.3 *Slag Cement*—Slag cement shall conform to the requirements of Grade 100 or 120 of Specification C989.

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

- 4.1.3.1 Portland cement only,
- 4.1.3.2 Portland blast-furnace slag cement only,
- 4.1.3.3 Portland pozzolan cement only,
- 4.1.3.4 A combination of Portland cement and slag cement,
- 4.1.3.5 A combination of Portland cement and fly ash, or
- 4.1.3.6 A combination of Portland cement, slag cement (not to exceed 25 % of the total cementitious weight) and fly ash (not to exceed 25 % of the total cementitious weight).

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

4.1.5 *Admixtures and Blends*—The following admixtures and blends are allowable:

- 4.1.5.1 Air-entraining admixture conforming to Specification C260;
- 4.1.5.2 Chemical admixture conforming to Specification C494/C494M;
- 4.1.5.3 Chemical admixture for use in producing flowing concrete conforming to Specification C1017/C1017M;
- 4.1.5.4 Chemical admixture or blend approved by the owner.

4.1.6 *Steel Reinforcement*—Reinforcement shall consist of wire and welded wire conforming to Specification A1064/A1064M; or of bars conforming to Specification A615/A615M, Grade 280 or 420, or Specification A706/A706M, Grade 420.

4.1.7 *Water*—Water used in the production of concrete shall be potable or non-potable water that meets the requirements of Specification C1602/C1602M.

4.1.8 *Secondary Synthetic Fiber*—Collated fibrillated polypropylene virgin fibers shall not be prohibited when used in steel reinforced concrete manholes as a non-structural manufacturing enhancement. Only fibers designed and manufactured

specifically for use in concrete and so certified by the manufacturer shall be accepted.

4.1.9 *Other Materials*—Other materials required for a product and not covered in Section 4 will be covered in the Part II section for that specific product.

5. Design

5.1 Design requirements for a product are prescribed in the specific Part II section for that product.

5.1.1 The minimum compressive strength of concrete manhole products covered by this specification shall be 27.6 MPa unless specified otherwise in Part II of this specification.

5.2 *Modified or Special Design:*

5.2.1 Manufacturers are not prohibited from submitting to the owner, for approval prior to manufacture, designs other than those prescribed in the specific section for a product. If such approval is obtained, then the product shall meet all the tests and performance requirements specified by the owner in accordance with the appropriate sections on manufacture and physical requirements.

5.2.2 If permitted by the owner, the manufacturer is not prohibited from requesting approval of designs of special sections, such as reducers, tees, and bases.

6. Reinforcement

6.1 This section presents requirements for reinforcement cover, continuity, laps, welds and splices. Other reinforcement requirements are presented in Section 4 and any additional requirements are given in the Part II section for a specific product.

6.2 *Cover*—The exposure of the ends of reinforcement, stirrups or spacers used to position the reinforcement during placement of the concrete shall not be cause for rejection.

6.3 *Continuity*—The continuity of the circumferential reinforcement shall not be destroyed during the manufacture of the product, except when lift holes or pipe openings are provided in the product.

6.4 *Welded Steel Cage Laps, Welds, and Splices:*

6.4.1 If splices are not welded, the reinforcement shall be lapped not less than 20 diameters for deformed bars, and 40 diameters for plain bars and cold-drawn wire. In addition, where lapped cages of welded wire fabric are used without welding, the lap shall contain a longitudinal wire.

6.4.2 When splices are welded and are not lapped to the minimum requirements in 6.4.1, there shall be a minimum lap of 50 mm and a weld of sufficient length such that pull tests of representative specimens shall develop at least 50 % of the minimum specified tensile strength of the steel. For butt welded splices in bars or wire, permitted only with helically wound cages, pull tests of representative specimens shall develop at least 75 % of the minimum specified tensile strength of the steel.

6.5 *Steel Hoop Splices*—When splices are welded and not lapped to the minimum requirements in 6.4.1, there shall be a minimum lap of 50 mm and a weld of sufficient length such that pull tests from representative specimens shall develop at least 50 % of the minimum specified tensile strength of the

steel. For butt welded splices, pull tests from representative specimens shall develop at least 75 % of the minimum specified tensile strength of the steel.

7. Precast Concrete Manufacture

7.1 Mixture—The aggregates shall be sized, graded, proportioned, and mixed with such proportions of cementitious materials and water as will produce a thoroughly-mixed concrete of such quality that the products will conform to the test and design requirements of this specification. All concrete shall have a water-cementitious ratio not exceeding 0.53 by mass. Cementitious materials shall be as specified in **4.1.2** 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 product meet the requirements of this specification.

7.2 Curing—Concrete products shall be subjected to any one of the methods of curing prescribed in **7.2.1 – 7.2.4** or to any other method or combination of methods approved by the owner that will give satisfactory results.

7.2.1 Steam Curing—Concrete products are placed in a curing chamber, free of outside drafts, and cured in a moist atmosphere maintained by the injection of steam for such time and such temperatures as may be needed to enable the products to meet the strength requirements. The curing chamber shall be so constructed as to allow full circulation of the steam around the entire product.

7.2.2 Water Curing—Concrete products are water-cured by covering with water-saturated material, or by a system of perforated pipes, mechanical sprinklers, porous hose, or by any other approved method that will keep the products moist during the curing period.

7.2.3 Sealing Membrane—A sealing membrane conforming to the requirements of Specification **C309** is applied and shall be left intact until the required concrete strength requirements are met. The concrete at the time of application of the membrane shall be within 6°C of the atmospheric temperature. All concrete surfaces shall be kept moist prior to the application of the membrane and shall be damp when the membrane is applied.

7.2.4 The manufacturer is not prohibited from combining methods prescribed in **7.2.1 – 7.2.3** provided the required concrete compressive strength is attained.

8. Acceptance

8.1 Acceptance Procedures:

8.1.1 Unless otherwise designated by the owner at the time of, or before, placing an order, acceptance procedures for precast reinforced concrete manhole products shall be as specified in the Part II section for a particular product, and shall not be prohibited from consisting of one or more of the following:

8.1.1.1 Acceptance of a product on the basis of tests of materials, including concrete compressive strength and absorption.

8.1.1.2 Acceptance of a product on the basis of inspection of the finished product, including amount and placement of

reinforcement to determine conformance with the design prescribed under this specification, and freedom from defects.

8.2 Test Methods:

8.2.1 Concrete Compressive Strength Test:

8.2.1.1 Type of Specimen—Compression tests for satisfying the minimum specified concrete strength requirement shall be made on either concrete cylinders or, at the option of the manufacturer, on cores cut from the concrete manhole product.

8.2.1.2 Compression Testing of Cylinders—Cylinders shall be made in accordance with Test Methods **C497**, and shall be tested in accordance with Test Method **C39/C39M**. For manhole products, an owner shall not be prohibited from requiring concrete compressive tests on cylinder specimens numbering in the amount of 5 % of the total order of a manhole product, but not to exceed two cylinders for each day's production. The average compressive strength of all cylinders tested shall be equal to or greater than the specified strength of the concrete. Not more than 10 % of the cylinders tested shall fall below the specified strength of the concrete. In no case shall any cylinder tested fall below 80 % of the specified strength of the concrete.

8.2.1.3 Compression Testing of Cores—Cores shall be cut from the concrete manhole product and tested in accordance with Test Methods **C497**, except that the requirements for moisture conditioning shall not apply. One core shall be taken from a manhole product selected at random from each day's production run of a single concrete strength. When the concrete compressive strength of the core is equal to or greater than 80 % of the specified strength of the concrete, the concrete strength of the production run is acceptable. If the core does not meet the preceding concrete strength requirement, another core from the same manhole product may be taken and tested.

8.2.1.4 If the concrete compressive strength of the recore is equal to or greater than 80 % of the specified strength of the concrete, the concrete strength of the production run is acceptable. If the recore does not meet the preceding concrete strength requirement, that manhole product shall be rejected. Two manhole products from the remainder of the day's production run shall be selected at random and one core taken from each manhole product and tested. When the average concrete strength of the two cores is equal to or greater than 80 % of the specified strength of the concrete with no core below 75 % of the specified strength of the concrete, the concrete strength of the day's production run shall be acceptable.

8.2.1.5 If the concrete strength of the two cores does not meet the preceding concrete strength requirement, then the remainder of the day's production run shall be either rejected, or, at the option of the manufacturer, each manhole product of the remainder of the day's production run is not prohibited from being cored and accepted individually.

8.2.1.6 Plugging Core Holes—Core holes on accepted manhole sections shall be plugged and sealed by the manufacturer in a manner such that the manhole products will meet all of the requirements of this specification. Manhole sections so sealed shall be considered as satisfactory for use.

8.2.2 Absorption Test:

8.2.2.1 The absorption of a specimen from a concrete product, as determined in Test Methods **C497**, shall not exceed

9 % of the dry mass for Test Method A procedure or 8.5 % for Test Method B procedure. All specimens shall be free of visible cracks and shall represent the full thickness of the product.

8.2.2.2 Specimens for Test Method B shall meet the requirements of Test Methods **C497**.

8.2.2.3 Each specimen tested by Test Method A shall have a minimum mass of 1.0 kg.

8.2.2.4 When the initial absorption specimen from a concrete product fails to conform to this specification, the absorption test shall be made on another specimen from the same product and the results of the retest shall be substituted for the original test results.

8.2.3 *Retests*—When not more than 20 % of the concrete test specimens tested under either **8.2.2.1** or **8.2.2.2** fail to pass the requirements of this specification, the manufacturer is not prohibited from culling his stock and eliminating whatever quantity of product he desires and shall so mark the culled product that they will not be shipped for the order. The required tests shall be made on the balance of the order and the products shall be accepted if in conformance with the requirements of this specification.

8.3 *Test Equipment*—Every manufacturer furnishing manhole products under this specification shall furnish all facilities and personnel necessary to carry out the tests required for acceptance.

9. Repairs

9.1 Repair of manhole products shall not be prohibited, if necessary, because of imperfections in manufacture or damage during handling, and will be acceptable if, in the opinion of the owner, the repaired products conform to the requirements of this specification.

10. Inspection

10.1 The quality of materials, the process of manufacture, and the finished manhole products shall be subject to inspection and approval by the owner.

11. Product Marking

11.1 The following information shall be legibly marked on each precast concrete product:

11.1.1 Specification and product designation: MH for manhole base, riser, conical tops, and grade rings,

11.1.2 Date of manufacture, and

11.1.3 Name or trademark of the manufacturer.

11.2 Marking shall be indented into the concrete or shall be painted thereon with waterproof paint.

PART II—PRODUCTS

12. Grade Rings

12.1 *Scope*—This section covers precast reinforced concrete grade rings used for final adjustment of manholes to grade.

12.2 *Acceptance*—Acceptability of grade rings covered by this specification shall be determined by the results of such tests of materials as are required by Section **4**; by compressive strength tests on concrete cores or concrete cylinders required

by Section **8**; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by **12.4**, **12.5** and **12.6**, to determine its conformance with the design prescribed under this specification and its freedom from defects.

12.3 *Design*—The minimum wall thickness shall be one twelfth of the internal diameter of the grade ring or 100 mm, whichever is greater.

12.3.1 *Joints*—Grade rings are not required to have the joint formed with male and female ends.

12.4 Circumferential Reinforcement:

12.4.1 The circumferential reinforcement shall have an equivalent area of not less than 150 mm²/vertical m, but not less than 15 mm² in any one grade ring.

12.4.2 The circumferential reinforcement shall be one line in the center third of the wall of the grade ring.

12.5 Permissible Variations:

12.5.1 *Internal Diameter*—The internal diameter of grade rings shall not vary more than ± 1 %.

12.5.2 *Wall Thickness*—The wall thickness of grade rings shall be not less than that prescribed in the design by more than 5 % or ± 5 mm, whichever is greater. A wall thickness greater than that prescribed in the design shall not be cause for rejection.

12.5.3 *Height of Two Opposite Sides*—Variations in laying heights of two opposite sides of grade rings shall be not more than 6 mm.

12.5.4 *Height of Grade Ring*—The underrun in height of a grade ring shall be not more than 20 mm/m of height.

12.5.5 *Position of Reinforcement*—For grade rings with a 100-mm wall thickness, the maximum variation in the design position of circumferential reinforcement from that described in **12.4.1** shall be ± 10 % of the wall thickness or ± 6 mm, whichever is greater. For grade rings with a wall thickness greater than 100-mm, the maximum variation from the design position of reinforcement shall be ± 10 % of the wall thickness or ± 16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm. The preceding minimum cover limitation does not apply to the mating surfaces of the joint.

12.5.6 *Area of Reinforcement*—Steel reinforcement areas that are 10 mm²/linear m less than called for by design shall be considered as meeting the required steel reinforcement area.

12.6 Rejection

12.6.1 Grade rings shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual grade ring shall be subject to rejection because of any of the following:

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

12.6.1.2 Defects that indicate mixing and molding not in compliance with **7.1** or surface defects indicating honeycombed or open texture that would adversely affect the function of the grade ring.

12.6.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the grade ring, within the limits of permissible variations prescribed in 12.5.

12.6.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

12.6.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the wall.

13. Flat Slab Tops

13.1 *Scope*—This section covers precast reinforced concrete flat slab tops used in the construction of manholes for use in sewer, drainage, and water works.

13.2 *Acceptance:*

13.2.1 Acceptability of flat slab tops shall be determined by the results of such tests of materials as are required by Section 4; by compressive strength tests on concrete cores or concrete cylinders required by Section 8; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by 13.4 and 13.6, to determine its conformance with the design prescribed under this specification and its freedom from defects.

13.2.2 Unless otherwise designated by the owner at the time of, or before, placing an order, two separate and alternative methods of acceptance are permitted for flat slab top manufacturer designs, in addition to tests of materials and inspection required in 13.2.1.

13.2.2.1 *Acceptance on the Basis of Proof-of-Design Test*—Acceptance of flat slab tops on the basis of the results of a proof-of-design test performed in accordance with 13.5 in lieu of submission of design calculations and detailed drawings.

13.2.2.2 *Acceptance on the Basis of Rational Design*—Acceptance of flat slab tops on the basis of design calculations by a rational method and detailed drawings.

13.3 *Design:*

13.3.1 The basis of flat slab top designs shall be the appropriate sections of the latest edition of ACI 318.

13.3.2 Flat slab tops shall have a minimum thickness of 150 mm for risers up to and including 1200 mm in diameter and 200 mm for larger diameters.

13.3.3 The flat slab top access opening shall be a minimum of 600 mm in diameter.

13.3.4 *Joint*—The reinforced concrete flat slab top shall be formed with or without a male or female end so that when the manhole base, riser and top section are assembled, they will make a continuous and uniform manhole compatible with the tolerances given in Section 13.6.

13.3.4.1 Joints are designed to perform in axial compression; therefore, shear or load testing of the joint is not required.

13.4 *Reinforcement:*

13.4.1 Flat slab tops manufactured with a joint or with other indication of the top or bottom of the slab shall be manufactured with one layer of reinforcement placed near the bottom surface so that the protective cover over the reinforcement shall be 25 mm.

13.4.2 Flat slab tops manufactured without a joint or without other indication of the top or bottom of the slab shall be

manufactured with two layers of steel reinforcement, one located near the bottom surface and one near the top surface so that the protective cover over each layer is 25 mm.

13.4.3 A layer of reinforcement shall have a minimum area of 250 mm²/linear m in both directions.

13.4.4 Openings in flat slab tops shall be additionally reinforced with a minimum of the equivalent of 130 mm² of steel at 90°. Straight rods used to reinforce openings shall have a minimum length equal to the diameter of the opening plus 50 mm.

13.5 *Physical Requirements*—Physical requirements for tests shall conform to the requirements of Section 8.

13.5.1 *Proof-of-Design Test:*

13.5.1.1 If 13.2.2.2 has been designated as the basis of acceptance, one flat slab top for each design shall be tested unless the owner has indicated otherwise.

13.5.1.2 The flat slab top proof-of-design test procedures shall be in accordance with Test Methods C497.

13.5.1.3 The ultimate test load shall be the sum of at least 130 % of the dead load on the slab plus at least 217 % of the live-plus impact load on the slab. Dead load is the mass of the column of earth over the slab plus the mass of the riser supported by the slab. Live load is the maximum anticipated wheel load that may be transmitted through the riser to the slab.

13.5.1.4 The flat slab top shall be acceptable if it supports the required ultimate test load without failure. Ultimate strength failure is defined as the inability of the slab to resist an increase in the applied load.

13.5.1.5 When agreed upon by the owner and manufacturer, the flat slab top shall be acceptable based on certified copies of the results of tests performed on identical flat slab tops instead of requiring new proof-of-design acceptance tests.

13.6 *Permissible Variations:*

13.6.1 *Internal Diameter*—The internal diameter of the flat slab tops entrance hole shall not vary more than ± 1 %.

13.6.2 *Thickness*—The thickness of flat slab tops shall be not less than that prescribed in the design by more than 5 % or ± 5 mm, whichever is greater. A thickness greater than that prescribed in the design shall not be cause for rejection.

13.6.3 *Length of Two Opposite Sides*—Variations in lengths of two opposite sides of flat slab tops shall be not more than 6 mm.

13.6.4 *Length*—The underrun in length of a flat slab top shall be not more than 20 mm/m of length.

13.6.5 *Position of Reinforcement*—For flat slab tops with less than a 150-mm thickness, the maximum variation in the position of reinforcement from that prescribed in 13.5 shall be ± 10 % of the thickness or ± 6 mm, whichever is greater. For flat slab tops with a thickness greater than 150-mm, the maximum variation shall be ± 10 % of the thickness or ± 16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm.

13.6.6 *Area of Reinforcement*—Steel reinforcement areas that are 10 mm²/linear m less than called for by design shall be considered as meeting the required steel reinforcement area.

13.7 *Rejection:*

13.7.1 Flat slab tops shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual flat slab top shall be subject to rejection because of any of the following:

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

13.7.1.2 Defects that indicate mixing and molding not in compliance with 7.1 or surface defects indicating honey-combed or open texture that would adversely affect the function of the flat slab top.

13.7.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the flat slab top, within the limits of permissible variations prescribed in 13.6.

13.7.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

13.7.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the slab.

14. Risers and Conical Tops

14.1 *Scope*—This section covers precast reinforced concrete risers and conical tops used in construction of manholes for use in sewer, drainage, and water works.

14.2 *Acceptance*—Acceptability of risers and conical tops covered by this specification shall be determined by the results of such tests of materials as are required by Section 4; by compressive strength tests on concrete cores or concrete cylinders required by Section 8; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by either 14.4 or 14.5 and meeting permissible variations as prescribed by 14.7, to determine its conformance with the design prescribed under this specification and its freedom from defects.

14.3 *Design*—The minimum wall thickness shall be one twelfth of the largest internal diameter of the riser or conical top.

14.4 *Welded Steel Cage Reinforcement:*

14.4.1 *Circumferential Reinforcement for Risers and Conical Tops:*

14.4.1.1 Circumferential reinforcement may consist of either one or two lines of steel. The total area of reinforcement per vertical metre shall be not less than 0.21 times the internal diameter in millimetres.

14.4.1.2 A line of circumferential reinforcement for any given total area may be composed of two layers if the layers are not separated by more than the thickness of one cross member plus 6 mm. The two layers shall be tied together to form a single cage. All other specification requirements such as laps, welds, and tolerances of placement in the wall of the riser or conical top shall apply to this method of fabricating a line of reinforcement.

14.4.1.3 Where one line of circumferential reinforcement is used, it shall be placed in the center third of the wall. The protective cover over the circumferential reinforcement in the wall shall be no less than 19 mm in accordance with 14.7.

14.4.1.4 Where two lines of circumferential reinforcement are used, each line shall be so placed that the protective covering over the circumferential reinforcement in the wall shall be 25 mm.

14.4.1.5 The location of the reinforcement shall be subject to the permissible variations in dimensions prescribed in 14.7.

14.4.1.6 The spacing center to center of circumferential reinforcement in a cage shall not exceed 150 mm.

14.4.2 *Longitudinal Members*—Each line of circumferential reinforcement shall be assembled into a cage that shall contain sufficient longitudinal bars or members to maintain the reinforcement in shape and position within the form to comply with permissible variations in 14.7.

14.4.3 *Joint Reinforcement*—The tongue or groove of the joint is not required to contain circumferential reinforcement.

14.5 *Steel Hoop Reinforcement:*

14.5.1 *Continuous Steel Hoop Reinforcement for Risers and Conical Tops up to and Including 1200 mm Diameter:*

NOTE 3—Care shall be taken to ensure that none of the steel hoop reinforcement is cut prior to installation of the riser or conical top.

14.5.1.1 Circumferential reinforcement for manhole risers and conical tops up to and including 600 mm in height shall consist of no less than two hoops of steel wire or reinforcing bars. The steel hoop shall have a minimum cross-sectional diameter of 6 mm and shall be located in each end quarter of the riser or conical top, with a minimum distance of 25 mm from the shoulder of the riser or conical top.

14.5.1.2 Circumferential reinforcement for manhole risers and conical tops greater in height than 600 mm and up to and including 1200 mm in height shall consist of no less than three hoops of steel wire or reinforcing bars. The steel hoops shall have a minimum cross-sectional diameter of 6 mm, and shall have a hoop located in each end quarter of the riser or conical top with a minimum distance of 25 mm from the shoulder of the riser or conical top. The third, or middle, hoop shall be located from the shoulder of the riser or conical top a distance equal to one-half the section height ± 150 mm.

14.5.1.3 Circumferential reinforcement for manhole risers and conical tops greater in height than 1200 mm, and up to and including 1800 mm in height shall consist of no less than four hoops of steel wire or reinforcing bars spaced equally ± 75 mm, throughout the height of the riser or conical top. The steel hoops shall have a minimum cross-sectional diameter of 6 mm and shall have a hoop located in each end quarter of the riser or conical top with a minimum distance of 25 mm from the shoulder of the riser or conical top.

14.5.1.4 The hoop reinforcement shall be placed in the center third of the riser wall or conical top. The concrete cover over the hoop reinforcement in the wall of the section shall be no less than 19 mm in accordance with 14.7.

14.5.1.5 For riser sections with openings, this section 14.5 is not permitted.

14.5.2 *Joint Reinforcement*—The tongue or groove of the joint need not contain circumferential reinforcement.

14.6 *Joints*—Precast reinforced concrete risers and conical tops shall be designed and manufactured with male and female ends, so that the assembled manhole base, riser and conical top

shall make a continuous and uniform manhole, compatible with the tolerances given in 14.7.

14.6.1 Joints are designed to perform in axial compression; therefore, shear or load testing of the joint is not required.

14.7 Permissible Variations:

14.7.1 *Internal Diameter*—The internal diameter of risers and conical tops shall not vary more than 1 %.

14.7.2 *Wall Thickness*—The wall thickness of risers and conical tops shall be not less than that prescribed in the design by more than 5 % or ± 5 mm, whichever is greater. A wall thickness greater than that prescribed in the design shall not be cause for rejection.

14.7.3 *Height of Two Opposite Sides*—Variations in laying heights of two opposite sides of risers or conical tops shall be not more than 16 mm.

14.7.4 *Height of Section*—The underrun in height of a riser or conical top shall be not more than 20 mm/m of height with a maximum of 13 mm in any one section.

14.7.5 *Position of Reinforcement*—For risers or conical tops with a 100-mm wall thickness or less, the maximum variation in the position of reinforcement from that prescribed in 14.5 and 14.6 shall be ± 10 % of the wall thickness or ± 6 mm, whichever is greater. For sections with a wall thickness greater than 100 mm, the maximum variation in shall be ± 10 % of the wall thickness or ± 16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm. The preceding minimum cover limitation does not apply to the mating surfaces of the joint.

14.7.6 *Area of Reinforcement*—Steel reinforcement areas that are $0.1 \text{ mm}^2/\text{linear m}$ less than called for by design shall be considered as meeting the required steel reinforcement area.

14.8 Rejection:

14.8.1 Risers and conical tops shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual riser or conical top shall be subject to rejection because of any of the following:

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

14.8.1.2 Defects that indicate mixing and molding not in compliance with 7.1 or surface defects indicating honey-combed or open texture that would adversely affect the function of the riser or conical top.

14.8.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the riser or conical top, within the limits of permissible variations prescribed in 14.7.

14.8.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

14.8.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the wall.

15. Base Sections

15.1 *Scope*—This section covers three types of precast concrete base sections manufactured for use in the construction of manholes used in sewer, drainage, and water works. The three types of base sections are (1) a base with riser wall and base slab cast monolithically as a single unit with or without

benching, (2) a base consisting of a riser section with a secondary poured integral base slab, with or without benching, and (3) a two-piece base consisting of a separate precast base slab and a riser section with a sealed joint between the two. The riser portions of the base section shall meet all the requirements of Section 14.

15.2 Acceptance:

15.2.1 Acceptability of base sections covered by this specification shall be determined by the results of such tests of materials as are required by Section 4; by compressive strength tests on concrete cores or concrete cylinders required by Section 8; and by inspection of the finished product, including amount and placement of reinforcement as prescribed by 15.4 and 15.7, to determine conformance with the design prescribed under this specification and its freedom from defects.

15.2.2 Unless otherwise designated by the owner at the time of, or before, placing an order, two separate and alternate methods of acceptance are permitted for the three types of base sections manufacturer designs prescribed in 15.1, in addition to test of materials and inspection required in 15.2.1.

15.2.2.1 *Acceptance on the Basis of Proof-of-Design Test*—Acceptance of base section or base slab prescribed in 15.1 on the basis of the results of a proof-of-design test performed in accordance with 15.5.1 in place of submission of design calculations and detail drawings.

15.2.2.2 *Acceptance on the Basis of Rational Design*—Acceptance of base sections prescribed in 15.1 on the basis of design calculations by rational method and detail drawings.

15.3 Design:

15.3.1 When acceptance is in accordance with 15.2.2.2, the basis of the rational design shall be the appropriate sections of the latest edition of ACI 318.

15.3.2 Base slabs or integral floors shall have a minimum thickness of 150 mm for risers up to and including 1200 mm in diameter and 200 mm for larger diameters.

15.3.2.1 When a base section is precast monolithically with a benched invert, the minimum concrete thickness from the invert to the bottom of the integral base section shall be 100 mm.

15.3.3 Benched inverts cast either monolithically with the base section or as a secondary casting in a cured base section shall have the following minimum dimensions:

15.3.3.1 Minimum slope of 40 mm/m from the channel to the inside diameter (ID) of manhole wall for the benching.

15.3.3.2 Minimum channel invert depth of one-half the pipe ID.

15.3.3.3 When a channel is cast in a cured base section, the minimum concrete thickness under the invert shall be 50 mm.

15.3.3.4 Width of channel at top of benching shall be a minimum of the pipe ID.

15.3.3.5 Invert shall provide a positive flow between inlet to outlet pipes.

15.3.3.6 The minimum channel centerline radius shall be the pipe ID.

15.4 Reinforcement:

15.4.1 Base Section Circumferential Reinforcement—Circumferential reinforcement shall meet all the requirements of Section 14, except that Paragraph 14.5 is not permitted.

15.4.2 Base Slab Reinforcement:

15.4.2.1 A layer of reinforcement shall be placed above the midpoint, and shall have a minimum area of 250 mm²/linear m in both directions.

15.4.2.2 The minimum protective cover over the reinforcement shall be 25 mm.

15.4.3 Longitudinal Members—Longitudinal bars or members used to maintain a cage of circumferential reinforcement in shape and position within the form shall meet all the requirements of Section 14.

15.4.4 Joint Reinforcement—The mating surface of the base section joint is not required to contain circumferential reinforcement.

NOTE 4—(Advisory) Base sections with multiple openings, large openings, or both may require special consideration of their handling reinforcement.

15.5 Physical Requirements—Physical requirements for test shall conform to the requirements of Section 8.

15.5.1 Proof-of-Design Test:

15.5.1.1 If 15.2.2.1 has been designated as the basis of acceptance, one base section or base slab for each design shall be tested unless the owner has indicated otherwise.

15.5.1.2 The base section or base slab proof-of-design test procedures shall be in accordance with Test Methods C497.

15.5.1.3 The ultimate test load shall be the sum of at least 130 % of the dead load on the base section or base slab plus at least 217 % of the live load on the slab. Dead load is the weight of the column of earth cover plus the weight of the riser section(s) plus surcharge transmitted through the riser section(s) to the base section or base slab. Live load is the maximum anticipated wheel load that may be transmitted through the riser to the base section or base slab. The ultimate test load shall be applied to the base section or base slab as a uniformly distributed load.

15.5.1.4 The base section or base slab shall be acceptable if it supports the required ultimate test load without failure. Ultimate strength failure is defined as the inability of the slab to resist an increase in the applied load.

15.5.1.5 When agreed upon by the owner and manufacturer, the base section or base slab shall be acceptable based on certified copies of the results of tests performed on identical base sections or base slabs instead of requiring new proof-of-design acceptance test.

15.6 Joints—Precast reinforced base sections shall be designed and manufactured with a male or female ends, so that the assembled manhole base, riser and top will make a continuous and uniform manhole, compatible with the tolerances given in 15.7.

15.6.1 Joints are designed to perform in axial compression; therefore, shear or load testing of the joint is not required.

15.7 Permissible Variations:

15.7.1 Internal Diameter—The internal diameter of base sections shall not vary more than 1 %.

15.7.2 Thickness—The thickness of a base slabs with or without benching shall be not less than that prescribed in the design by more than 5 %. A thickness greater than that prescribed in the design shall not be cause for rejection.

15.7.3 Height of Two Opposite Sides—Variations in laying heights of two opposite sides of base sections shall be not more than 16 mm.

15.7.4 Height of Sections—The underrun in height of a base section shall be not more than 20 mm/m of height with a maximum of 13 mm in any one base section.

15.7.5 Position of Reinforcement—For base slabs with monolithic benched inverts with a 100 mm thickness, the maximum variation in the position of reinforcement from that prescribed in 15.4 shall be ± 10 % of the thickness or ± 6 mm, whichever is greater. For base slabs with a thickness greater than 100-mm, the maximum variation shall be ± 10 % of the thickness or ± 16 mm, whichever is the lesser. In no case, however, shall the cover over the reinforcement be less than 19 mm. The preceding minimum cover limitation does not apply to the mating surfaces of base section joints.

15.7.6 Area of Reinforcement—Steel reinforcement areas that are 10 mm²/linear m less than called for by design shall be considered as meeting the required steel reinforcement area.

15.8 Rejection:

15.8.1 Base sections shall be subject to rejection for failure to conform to any of the specification requirements. In addition, an individual base section shall be subject to rejection because of any of the following:

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

15.8.1.2 Defects that indicate mixing and molding not in compliance with 7.1 or surface defects indicating honeycombed or open texture that would adversely affect the function of the base section.

15.8.1.3 The planes of the ends are not perpendicular to the longitudinal axis of the base section, within the limits of permissible variations prescribed in 15.7.

15.8.1.4 Damaged or cracked ends, where such damage would prevent making a satisfactory joint.

15.8.1.5 Any continuous crack having a surface width of 0.3 mm, or more and extending for a length of 300 mm or more, regardless of position in the base section.

16. Steps and Ladders

16.1 Scope:

16.1.1 This section covers manhole steps and ladders used for providing access through manholes for use in sewer and water works.

16.1.2 The user of this specification is advised that access through manholes may be by steps that are cast, mortared, or attached by mechanical means into the walls of base, riser, or conical top sections or by ladder.

16.2 Acceptance—Unless otherwise designated by the owner at the time of, or before, placing an order, acceptance of steps and ladders installed in manholes will be on the basis of tests and inspection of the completed product.

16.3 *Materials:*

16.3.1 Except as required by Section 16, manhole steps and ladders shall conform to the requirements of the Occupational Safety and Health Standards, U.S. Department of Labor.

16.3.2 Manhole steps that are cast, mortared, or attached by mechanical means into the walls of base, riser or conical top sections shall meet the requirements of 16.4 and 16.5 in addition to the following:

16.3.2.1 When dissimilar types of materials are used in the steps, appurtenances and fastenings, the materials shall be treated to prevent deleterious effects.

16.3.2.2 That portion of the step projecting into the base section, riser or conical top opening shall be free of splinters, sharp edges, burrs, or projections which may be a hazard.

16.4 *Design:*

16.4.1 Steps in base section, riser and conical top sections shall be aligned in each section so as to form a continuous ladder with rungs equally spaced vertically in the assembled manhole at a maximum design distance of 400 mm apart.

16.4.2 Steps shall be embedded in the base section, riser or conical top section wall a minimum distance of 75 mm.

16.5 *Dimensions:*

16.5.1 Ferrous metal steps not painted or treated to resist corrosion shall have a minimum cross sectional dimension of 25 mm.

16.5.2 The minimum width of rungs or cleats shall be 250 mm.

16.5.3 The rung or cleat shall project a uniform clear distance of 100 mm (minimum) to 150 mm (maximum) $\pm$ 6 mm from the wall of the base, riser, or conical top section measured from the point of embedment to the embedment side of the rung.

NOTE 5—Embedment point is considered the junction of the centerline of the step leg and the wall of the base, riser or conical top section.

16.5.4 The minimum clear distance between the rung or cleat and the opposite wall of the base, riser, or conical top shall be 450 mm measured at the center face of the rung or cleat.

16.5.5 The vertical spacing and vertical alignment between adjacent manhole steps and horizontal distance from the inside wall to the centerline of a manhole step may vary 25 mm from the design dimension.

16.6 *Physical Requirements:*

16.6.1 *Testing:*

16.6.1.1 The manufacturer furnishing manhole sections with steps under this specification shall furnish all facilities and personnel necessary to carry out the tests required in the Manhole Step Test section of Test Methods C497.

16.6.1.2 One installed manhole step of the type to be used on a project shall be tested unless certified test results are available.

16.6.1.3 Vertical and horizontal load test procedures for manhole steps shall be in accordance with Test Methods C497.

16.6.1.4 The horizontal pull out load shall be 1800 N.

16.6.1.5 The vertical load shall be 3600 N.

16.6.2 *Acceptance*—The step shall be acceptable if the following requirements are met:

16.6.2.1 The step remains solidly embedded after application of the horizontal load test.

16.6.2.2 The step sustains a permanent set of 13 mm or less after application of the vertical load test.

16.6.2.3 No cracking or fracture of the step nor spalling of the concrete is evident.

16.6.2.4 If certified test results are not available and the step selected fails to conform to the test requirements, the manufacturer may select two other steps for retests. If either of these steps fail the retest, the steps shall be rejected.

17. **Keywords**

17.1 absorption; acceptance criteria; base sections; compressive strength; concrete; cone tops; design; flat slab tops; grade rings; ladders; manhole; manufacture; reinforced; riser sections; sewer; steps; tests; water

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