



Designation: C 507M – 05

METRIC

## Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe [Metric]<sup>1</sup>

This standard is issued under the fixed designation C 507M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

### 1. Scope

1.1 This specification covers reinforced elliptically shaped concrete pipe to be used for the conveyance of sewage, industrial wastes, storm water, and for the construction of culverts.

1.2 Pipe designed for placement with the major axis horizontal shall be designated as “Horizontal Elliptical Pipe.” Pipe designed for placement with the major axis vertical shall be designated as “Vertical Elliptical Pipe.”

1.3 This specification is the metric counterpart of Specification C 507.

NOTE 1—This specification is a manufacturing and purchase specification only, and does not include requirements for bedding, backfill, or the relationship between field load condition and the strength classification of pipe. However, experience has shown that the successful performance of this product depends upon the proper selection of the class of pipe, type of bedding and backfill, and care that the installation conforms to construction specifications. The owner of the reinforced concrete pipe specified herein is cautioned that he must correlate the field requirements with the class of pipe specified and provide inspection at the construction site.

### 2. Referenced Documents

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

- A 82 Specification for Steel Wire, Plain, for Concrete Reinforcement
- A 185 Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
- A 496 Specification for Steel Wire, Deformed, for Concrete Reinforcement

- A 497 Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
- A 615/A 615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement [Metric]
- C 33 Specification for Concrete Aggregates
- C 150 Specification for Portland Cement
- C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete
- C 497M Test Methods for Concrete Pipe, Manhole Sections, or Tile [Metric]
- C 595 Specification for Blended Hydraulic Cements
- C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- C 822 Terminology Relating to Concrete Pipe and Related Products
- C 1116 Specification for Fiber-Reinforced Concrete and Shotcrete

### 3. Terminology

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

### 4. Classification

4.1 Pipe manufactured according to this specification shall be of five classes each for horizontal elliptical and vertical elliptical pipe with identification as follows:

Horizontal Elliptical Pipe	Vertical Elliptical Pipe
Class HE-A	Class VE-II
Class HE-I	Class VE-III
Class HE-II	Class VE-IV
Class HE-III	Class VE-V
Class HE-IV	Class VE-VI

4.2 The strength requirements for horizontal elliptical pipe are prescribed in Table 1 and for vertical elliptical pipe are prescribed in Table 2.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.02 on Reinforced Sewer and Culvert Pipe.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



**TABLE 1 Design Requirements for Horizontal Elliptical (HE) Pipe<sup>A</sup>**

NOTE 1—The test load in kilonewtons per linear metre equals D-load × inside span in millimetres.

NOTE 2—Single cage reinforcement, providing tension steel at the top, bottom, and springline, shall be permitted instead of double cage reinforcement. The area of such reinforcement shall be 112 % of the tabulated inner cage area.

NOTE 3—An inner and outer cage plus quadrant mats shall be permitted instead of double cage reinforcement. The area of such reinforcement shall be in accordance with Fig. 1.

NOTE 4—An inner and outer cage plus a middle cage shall be permitted instead of double cage reinforcement. The area of such reinforcement shall be in accordance with Fig. 2.

Designated Diameter, Equivalent Round Size, mm	Designated Rise, mm × Span, mm	Minimum Wall Thickness, mm	Reinforcement, cm <sup>2</sup> /linear m									
			Class HE-A		Class HE-I		Class HE-II		Class HE-III		Class HE-IV	
			D-Loads									
			0.3 = 30 Ult = 45		0.3 = 40 Ult = 60		0.3 = 50 Ult = 75		0.3 = 65 Ult = 100		0.3 = 100 Ult = 150	
			In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage
450	365 × 575	69	1.7	...	2.3	...	3.0	...	4.0	...	5.7	...
600	490 × 770	82	2.3	...	3.2	...	4.0	...	5.5	...	8.3	...
675	550 × 865	88	3.0	...	3.8	...	4.9	...	6.6	...	9.7	...
750	610 × 960	94	2.1	2.1	2.8	2.8	3.6	3.6	4.9	4.9	7.2	7.2
825	670 × 1055	94	2.5	2.5	3.6	3.6	4.4	4.4	5.9	5.9	8.7	8.7
900	730 × 1150	113	2.3	2.3	3.2	3.2	4.0	4.0	5.5	5.5	8.3	8.3
975	795 × 1250	119	2.8	2.8	3.6	3.6	4.4	4.4	6.1	6.1	9.3	9.3
1050	855 × 1345	125	3.2	3.2	4.2	4.2	5.1	5.1	7.0	7.0	10.6	10.6
1200	975 × 1535	138	3.6	3.6	4.9	4.9	5.9	5.9	8.3	8.3	...	...
1350	1095 × 1730	150	4.2	4.2	5.7	5.7	7.2	7.2	9.5	9.5	...	...
1500	1220 × 1920	163	5.1	5.1	6.8	6.8	8.5	8.5	11.2	11.2	...	...
1650	1340 × 2110	175	5.7	5.7	7.6	7.6	9.5	9.5	12.9	12.9	...	...
1800	1465 × 2305	188	6.6	6.6	8.7	8.7	11.0	11.0	14.8	14.8	...	...
1950	1585 × 2495	200	7.2	7.2	9.5	9.5	11.9	11.9	16.5	16.5	...	...
2100	1705 × 2690	213	8.0	8.0	10.6	10.6	13.3	13.3	18.6	18.6	...	...
2250	1830 × 2880	225	...	...	...	...	...	...	...	...	...	...
2400	1950 × 3070	238	...	...	...	...	...	...	...	...	...	...
2550	2075 × 3265	244	...	...	...	...	...	...	...	...	...	...
2700	2195 × 3455	250	...	...	...	...	...	...	...	...	...	...
2850	2315 × 3648	263	...	...	...	...	...	...	...	...	...	...
3000	2440 × 3840	275	...	...	...	...	...	...	...	...	...	...
3300	2680 × 4225	300	...	...	...	...	...	...	...	...	...	...
3600	2925 × 4610	325	...	...	...	...	...	...	...	...	...	...
Concrete strength <sup>B</sup> , MPa			27.6		27.6		27.6		†450 to 1650 mm, 27.6		27.6	
									†1800 to 2100 mm, 34.5			

<sup>A</sup> Concrete strength for designs with reinforcement tabulated. For modified or special designs, see 7.3.

<sup>B</sup> For sizes and loads beyond those shown in this table, pipe designs are available that make use of one or a combination of the following: shear steel, multiple cages, or thicker walls in accordance with the provisions of 7.3.

## 5. Basis of Acceptance

5.1 Unless otherwise designated by the owner at the time of, or before, placing an order, there are two separate and alternative bases of acceptance. Independent of the method of acceptance, the pipe shall be designed to meet both the 0.01-in. crack and ultimate strength requirements.

5.1.1 *Acceptance on Basis of Plant Load-Bearing Tests, Material Tests, and Inspection of Manufactured Pipe for Visual Defects and Imperfections*—Acceptability of the pipe in all diameters and classes produced in accordance with 7.1 or 7.2 shall be determined by the results of the three-edge-bearing tests as defined in 11.3.1; by such material tests as are required in 6.1, 6.2, and 6.4; by an absorption test of the concrete from the wall of the pipe for each mix design that is used on an order; and by visual inspection of the finished pipe to determine its conformance with the accepted design prescribed and its freedom from defects.

5.1.2 *Acceptance on Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections*—

Acceptability of the pipe in all diameters and classes produced in accordance with 7.1 or 7.2 shall be determined by the results of such material tests as are required in 6.1, 6.2, and 6.4; by crushing tests on concrete cores or cured concrete cylinders; by an absorption test of the concrete from the wall of the pipe for each mix design that is used on an order; and by inspection of the finished pipe, including amount and placement of reinforcement, to determine its conformance with the accepted design and its freedom from defects.

5.1.3 When agreed upon by the owner and the manufacturer, any portion or any combination of the tests itemized in 5.1.1 or 5.1.2 may form the basis of acceptance.

5.2 *Age for Acceptance*—Pipe shall be considered ready for acceptance when they conform to the requirements as indicated by the specified tests.

## 6. Materials

6.1 *Reinforced Concrete*—The reinforced concrete shall consist of cementitious materials, mineral aggregates, and

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**TABLE 2 Design Requirements for Vertical Elliptical Pipe<sup>A</sup>**

NOTE 1—Test load in kilonewtons per linear metre equals D-load × inside span in millimetres.

NOTE 2—An inner and outer cage plus quadrant mats shall be permitted instead of double cage reinforcement. The area of such reinforcement shall be in accordance with Fig. 3.

NOTE 3—Single cage reinforcement, providing tension steel at the top, bottom, and spring line shall be permitted instead of double cage reinforcement. The area of such reinforcement shall be 112 % of the tabulated inner cage area.

NOTE 4—An inner and outer cage plus a middle cage shall be permitted instead of double cage reinforcement. The area of such reinforcement shall be in accordance with Fig. 4.

Designated Diameter, Equivalent Round Size, mm	Designated Rise, mm × Span, mm	Minimum Wall Thickness, mm	Reinforcement, cm <sup>2</sup> /linear m									
			Class VE-II		Class VE-III		Class VE-IV		Class VE-V		Class VE-VI	
			D-Loads									
			0.3 = 50 Ult = 75		0.3 = 65 Ult = 100		0.3 = 100 Ult = 150		0.3 = 140 Ult = 175		0.3 = 190 Ult = 235	
			In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage
900	1150 × 730	113	1.7	1.1	2.3	1.5	3.4	2.1	4.9	3.0	6.6	4.0
975	1250 × 795	119	1.9	1.1	2.5	1.5	3.8	2.3	5.5	3.4	7.4	4.4
1050	1345 × 855	125	2.1	1.3	2.8	1.7	4.2	2.5	6.1	3.6	8.0	4.9
1200	1535 × 975	138	2.3	1.5	3.2	1.9	4.7	2.8	7.0	4.2	9.3	5.5
1350	1730 × 1095	150	2.8	1.7	3.8	2.3	5.7	3.4	8.5	5.1	11.2	5.8
1500	1920 × 1220	163	3.4	2.1	4.4	2.8	6.6	4.0	9.9	5.9	...	...
1650	2110 × 1340	175	3.8	2.3	5.3	3.2	7.6	4.7	11.6	7.0	...	...
1800	2305 × 1465	188	4.4	2.8	5.9	3.6	8.7	5.3	...	...	...	...
1950	2495 × 1585	200	4.9	3.0	6.6	4.0	9.9	5.9	...	...	...	...
2100	2690 × 1705	213	5.5	3.4	7.4	4.4	11.2	6.8	...	...	...	...
2250	2880 × 1830	225	...	...	...	...	...	...	...	...	...	...
2400	3070 × 1950	238	...	...	...	...	...	...	...	...	...	...
2550	3265 × 2075	244	...	...	...	...	...	...	...	...	...	...
2700	3455 × 2195	250	...	...	...	...	...	...	...	...	...	...
2850	3648 × 2315	263	...	...	...	...	...	...	...	...	...	...
3000	3840 × 2440	275	...	...	...	...	...	...	...	...	...	...
3300	4225 × 2680	300	...	...	...	...	...	...	...	...	...	...
3600	4610 × 2925	325	...	...	...	...	...	...	...	...	...	...
Concrete strength <sup>B</sup> , MPa			27.6		27.6		27.6		34.5		41.4	

<sup>A</sup> For sizes and loads beyond those shown in this table, pipe designs are available which make use of one or a combination of the following: shear steel, multiple cages, or thicker walls in accordance with the provisions of 7.3.

<sup>B</sup> Concrete strength for designs with reinforcement tabulated. For modified or special designs, see 7.3.

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 Class F or Class C of Specification C 618.

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

- 6.2.3.1 Portland cement only,
- 6.2.3.2 Portland blast furnace slag cement only,
- 6.2.3.3 Portland pozzolan cement only,
- 6.2.3.4 A combination of portland cement and fly ash.

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

6.4 *Admixtures and Blends*—Admixtures and blends may be used with the approval of the owner.

6.5 *Steel Reinforcement*—Reinforcement shall consist of wire conforming to Specification A 82 or Specification A 496,

or of wire fabric conforming to Specification A 185 or Specification A 497, or of bars of Grade 300 steel conforming to Specification A 615/A 615M.

6.6 *Synthetic Fibers*—Collated fibrillated virgin polypropylene fibers may be used, at the manufacturer's option, in concrete pipe 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 C 1116 shall be accepted.

**7. Design**

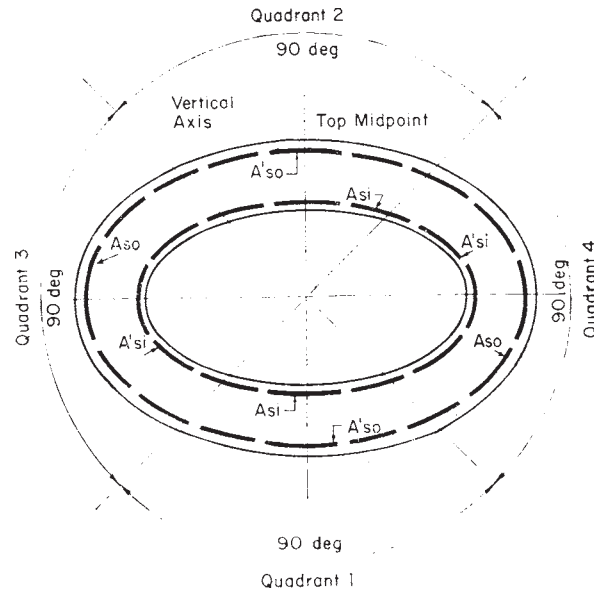
7.1 *Size and Shape*—The standard sizes of elliptical pipe shall be as listed in Table 1 and Table 2. The internal shape for each size pipe shall be defined by the internal dimensions shown in Fig. 5, subject to permissible variations.

7.2 *Design Tables*—The wall thickness, compressive strength of concrete, and the area of circumferential reinforcement shall be as prescribed in Table 1 and Table 2, subject to the provisions of 7.3, 11.4, and Section 12.

7.2.1 Footnotes to the tables herein are intended to be applications of the tabulated requirements and are to be considered applicable and binding as if they were contained in the body of the specification.

7.3 *Modified and Special Designs:*

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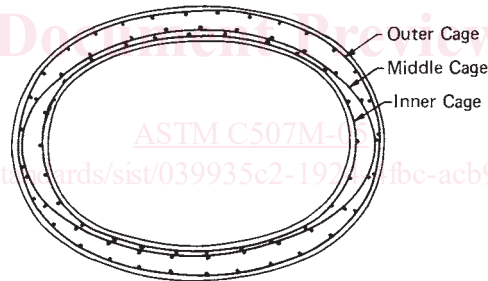
NOTE 1—The total reinforcement area ( $A'si$ ) of the inner cage plus the quadrant mat in Quadrants 1 and 2 shall not be less than that specified for the inner cage in **Table 1**.

NOTE 2—The total reinforcement area ( $A'so$ ) of the outer cage plus the quadrant mat in Quadrants 3 and 4 shall not be less than that specified for the outer cage in **Table 1**.

NOTE 3—The reinforcement area ( $A'si$ ) of the inner cage in Quadrants 3 and 4 shall be not less than 25 % of that specified for the inner cage in **Table 1**.

NOTE 4—The reinforcement area ( $A'so$ ) of the outer cage in Quadrants 1 and 2 shall be not less than 25 % of that specified for the outer cage in **Table 1**.

**FIG. 1 Quadrant Reinforcement, Horizontal Elliptical Pipe**



NOTE 1—The total reinforcement area of the inner cage plus the middle cage shall not be less than that specified for the inner cage in **Table 1**.

NOTE 2—The total reinforcement area of the outer cage plus the middle cage shall not be less than that specified for the outer cage in **Table 1**.

**FIG. 2 Horizontal Elliptical Pipe**

7.3.1 If permitted by the owner, the manufacturer may request approval by the owner of modified designs which differ from the designs in this section; or special designs for sizes and loads beyond those shown in **Table 1** and **Table 2**; or special designs for pipe sizes that do not have steel reinforcement areas shown in **Table 1** and **Table 2**.

7.3.2 Such modified and special designs shall be based on rational or empirical evaluations of the ultimate strength and cracking behavior of pipe and shall fully describe to the owner any deviations from the requirements of this section. The descriptions of modified or special designs shall include the wall thickness, the concrete strength, and the area, type, placement, number of layers, and strength of the steel reinforcement.

7.3.3 The manufacturer shall submit to the owner proof of the adequacy of the proposed modified and special design. Such proof may comprise the submission of certified three-edge-bearing tests already made, which are acceptable to the owner or, if such three-edge-bearing tests are not available or acceptable, the manufacturer may be required to perform proof tests on sizes and classes selected by the owner to demonstrate to the correctness and adequacy of the proposed design.

7.3.4 Such pipe shall meet all of the test and performance requirements specified by the owner in accordance with **Section 5**.