Designation: C 507 – 02

Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe[1]

This standard is issued under the fixed designation C 507; 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 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, and 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 A complete metric companion to this specification has been developed—C 507M; therefore, no metric equivalents are presented in this specification.

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 the 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:*

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

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

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

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

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

C 33 Specification for Concrete Aggregates[3]

C 150 Specification for Portland Cement[4]

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

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

C 1116 Specification for Fiber-Reinforced Concrete and Shotcrete[3]

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.

5. Basis of Acceptance

5.1 Unless otherwise designated by the owner at the time of, or before, placing an order, two separate and alternative bases of acceptance shall be permitted as follows:

[1] 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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[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.

TABLE 1 Design Requirements for Horizontal Elliptical (HE) Pipe[A]

NOTE 1—The test load in pounds per linear foot equals D-load × inside span in feet.

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, in.	Designated Rise, in. × Span, in.	Minimum Wall Thickness, in.	Reinforcement, in.²/linear ft									
			Class HE-A		Class HE-I		Class HE-II		Class HE-III		Class HE-IV	
			D-Loads									
			0.01 = 600 Ult = 900		0.01 = 800 Ult = 1200		0.01 = 1000 Ult = 1500		0.01 = 1350 Ult = 2000		0.01 = 2000 Ult = 3000	
			In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage
18	14 × 23	2¾	0.08	. . .	0.11	. . .	0.14	. . .	0.19	. . .	0.27	. . .
24	19 × 30	3¼	0.11	. . .	0.15	. . .	0.19	. . .	0.26	. . .	0.39	. . .
27	22 × 34	3½	0.14	. . .	0.18	. . .	0.23	. . .	0.31	. . .	0.46	. . .
30	24 × 38	3¾	0.10	0.10	0.13	0.13	0.17	0.17	0.23	0.23	0.34	0.34
33	27 × 42	3¾	0.12	0.12	0.17	0.17	0.21	0.21	0.28	0.28	0.41	0.41
36	29 × 45	4½	0.11	0.11	0.15	0.15	0.19	0.19	0.26	0.26	0.39	0.39
39	32 × 49	4¾	0.13	0.13	0.17	0.17	0.21	0.21	0.29	0.29	0.44	0.44
42	34 × 53	5	0.15	0.15	0.20	0.20	0.24	0.24	0.33	0.33	0.50	0.50
48	38 × 60	5½	0.17	0.17	0.23	0.23	0.28	0.28	0.39	0.39	. . .	. .
54	43 × 68	6	0.20	0.20	0.27	0.27	0.34	0.34	0.45	0.45	. . .	. . ..
60	48 × 76	6½	0.24	0.24	0.32	0.32	0.40	0.40	0.53	0.53	. . .	. . .
66	53 × 83	7	0.27	0.27	0.36	0.36	0.45	0.45	0.61	0.61	. . .	. . .
72	58 × 91	7½	0.31	0.31	0.41	0.41	0.52	0.52	0.70	0.70	. . .	. . .
78	63 × 98	8	0.34	0.34	0.45	0.45	0.56	0.56	0.78	0.78	. . .	. . .
84	68 × 106	8½	0.38	0.38	0.50	0.50	0.63	0.63	0.88	0.88	. . .	. . .
90	72 × 113	9	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
96	77 × 121	9½	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
102	82 × 128	9¾	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
108	87 × 136	10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
114	92 × 143	10½	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
120	97 × 151	11	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
132	106 × 166	12	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
144	116 × 180	13	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Concrete strength[B], psi			4000		4000		4000		18 to 66 in. 4000 72 to 84 in. 5000		4000	

[A] 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.

[B] Concrete strength for designs with reinforcement tabulated. For modified or special designs, see 7.3.

5.1.1 *Acceptance on Basis of Plant Load Bearing Tests, Material Tests, and Inspection of the Complete Product*—Acceptability of the pipe in all sizes and classes produced in accordance with 7.1 or 7.2 shall be determined by the results of the three-edge-bearing tests for either the load to produce a 0.01-in. crack or, at the option of the owner, the load to produce the 0.01-in. crack and the ultimate load; by such material tests as are required in accordance with 6.1, 6.2, and 6.4; by absorption tests on selected samples from the wall of the pipe; and by inspection of the finished pipe to determine its conformance with the design prescribed in this specification and its freedom from defects.

5.1.2 *Acceptance on Basis of Material Tests and Inspection of the Complete Product*—Acceptability of the pipe in all sizes 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 accordance with 6.1, 6.2, and 6.4 by crushing tests on concrete cores or cured concrete cylinders; by absorption tests on selected samples from the wall of the pipe; and by inspection of the finished pipe, including amount and placement of reinforcement, to determine its conformance with the design prescribed in this specification 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 The aggregate shall be so sized, graded, proportioned, and mixed with such proportions of portland cement, blended hydraulic cement, or portland cement and supplementary cementing materials, or admixtures, if used, or a combination thereof, and water to produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements of this specification. In no case, however, shall

TABLE 2 Design Requirements for Vertical Elliptical Pipe[A]

NOTE 1—Test load in pounds per linear foot equals D-load × inside span in feet.

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 springline, 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, in.	Designated Rise, in. × Span, in.	Minimum Wall Thickness, in.	Reinforcement, in.²/linear ft									
			Class VE-II		Class VE-III		Class VE-IV		Class VE-V		Class VE-VI	
			D-Loads									
			0.01 = 1000 Ult = 1500		0.01 = 1350 Ult = 2000		0.01 = 2000 Ult = 3000		0.01 = 3000 Ult = 3750		0.01 = 4000 Ult = 5000	
			In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage	In Cage	Out Cage
36	45 × 29	4½	0.08	0.05	0.11	0.07	0.16	0.10	0.23	0.14	0.31	0.19
39	49 × 32	4¾	0.09	0.05	0.12	0.07	0.18	0.11	0.26	0.16	0.35	0.21
42	53 × 34	5	0.10	0.06	0.13	0.08	0.20	0.12	0.29	0.17	0.38	0.23
48	60 × 38	5½	0.11	0.07	0.15	0.09	0.22	0.13	0.33	0.20	0.44	0.26
54	68 × 43	6	0.13	0.08	0.18	0.11	0.27	0.16	0.40	0.24	0.53	0.32
60	76 × 48	6½	0.16	0.10	0.21	0.13	0.31	0.19	0.47	0.28	. . .	. . .
66	83 × 53	7	0.18	0.11	0.25	0.15	0.36	0.22	0.55	0.33	. . .	. . .
72	91 × 58	7½	0.21	0.13	0.28	0.17	0.41	0.25	. . .	. . .	. . .	. . .
78	98 × 63	8	0.23	0.14	0.31	0.19	0.47	0.28	. . .	. . .	. . .	. . .
84	106 × 68	8½	0.26	0.16	0.35	0.21	0.53	0.32	. . .	. . .	. . .	. . .
90	113 × 72	9	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
96	121 × 77	9½	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
102	128 × 82	9¾	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
108	136 × 87	10	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
114	143 × 92	10½	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
120	151 × 97	11	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
132	166 × 106	12	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
144	180 × 116	13	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Concrete strength[B], psi			4000		4000		4000		5000		6000	

[A] 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.

[B] Concrete strength for designs with reinforcement tabulated. For modified or special designs, see 7.3.

the proportion of portland cement, blended hydraulic cement, or a combination of portland cement and supplementary cementing materials be less than 470 lb/yd^3.

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.

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, or

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 40 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.

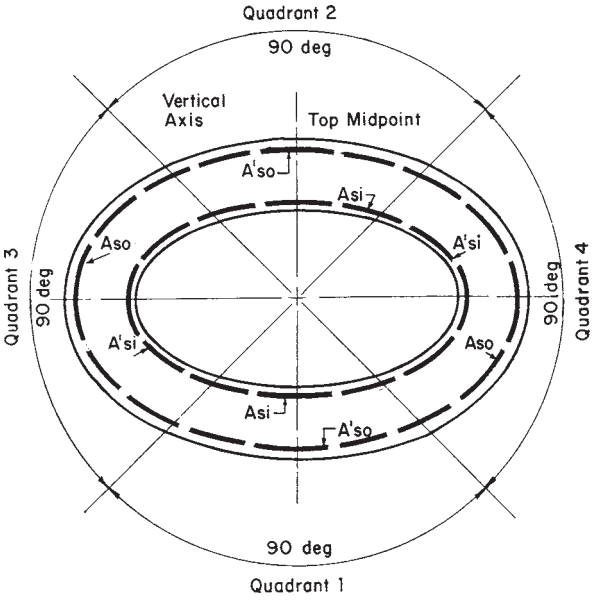
7. Design

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 the permissible variations of 12.1.

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 and Sections 11 and 12.

7.2.1 Footnotes to the tables herein are intended to be amplifications 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*:



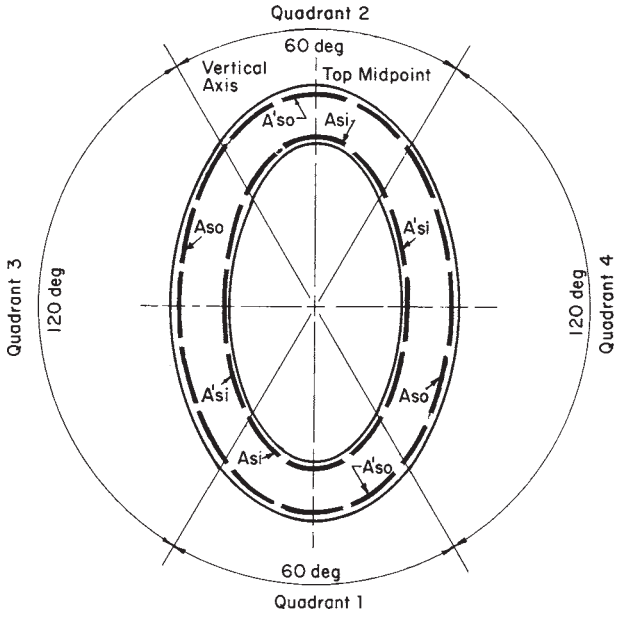
NOTE 1—The total reinforcement area (Asi) of the inner cage plus the quadrant mat in Quadrants 1 and 2 shall not be less than that specified for the inner cage in Table 1.

NOTE 2—The total reinforcement area (Aso) 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



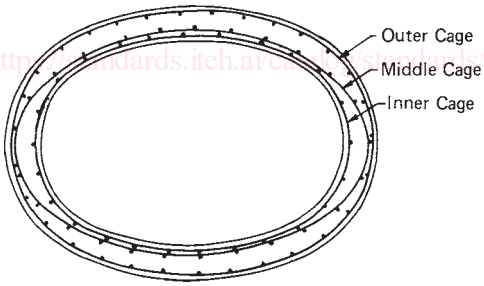
NOTE 1—The total reinforcement area (Asi) of the inner cage plus the quadrant mat in Quadrants 1 and 2 shall not be less than that specified for the inner cage in Table 2.

NOTE 2—The total reinforcement area (Aso) 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 2.

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 2.

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 2.

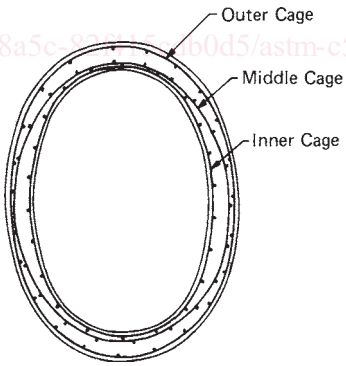
FIG. 3 Quadrant Reinforcement, Vertical Elliptical Pipe



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



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 2.

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 2.

FIG. 4 Vertical 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 7; 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