Designation: C507M – 12

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

This standard is issued under the fixed designation C507M; 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, 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 SI companion to Specification C507.

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:*[2]

A36/A36M Specification for Carbon Structural Steel
A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
A706/A706M Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
A1064/A1064M Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
C33 Specification for Concrete Aggregates
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
C497M Test Methods for Concrete Pipe, Manhole Sections, or Tile [Metric]
C595 Specification for Blended Hydraulic Cements
C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C822 Terminology Relating to Concrete Pipe and Related Products
C989 Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1116 Specification for Fiber-Reinforced Concrete and Shotcrete

3. Terminology

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

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, there are two separate and

[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.

Current edition approved May 1, 2012. Published June 2012. Originally approved in 1980. Last previous edition approved in 2011 as C507M – 11. DOI: 10.1520/C0507M-12.

[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.

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

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, cm²/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[B], MPa			27.6		27.6		27.6		†450 to 1650 mm, 27.6 †1800 to 2100 mm, 34.5		27.6	

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

[B] 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.

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 specified in Table 1.

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 6.2, 6.3, 6.5 and 6.6; by an absorption test of the concrete from the wall of the pipe as required in 11.9; 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 the Basis of Material Test 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 6.2, 6.3, 6.5 and 6.6; 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.

TABLE 2 Design Requirements for Vertical Elliptical Pipe[A]

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^2/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[B], MPa			27.6		27.6		27.6		34.5		41.4	

[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.

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 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 of Specification C150, or shall be portland blast-furnace slag cement, or slag modified portland cement, or portland-pozzolan cement conforming to the requirements of Specification C595, except that the pozzolan constituent in the Type IP portland pozzolan cement shall be fly ash and shall not exceed 25 % by weight.

6.2.2 *Ground Granulated Blast-Furnace Slag (GGBFS)*—GGBFS shall conform to the requirements of Grade 100 or 120 of Specification C989.

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

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

6.2.4.1 Portland cement only,

6.2.4.2 Portland blast furnace slag cement only,

6.2.4.3 Slag modified portland cement only,

6.2.4.4 Portland pozzolan cement only,

6.2.4.5 A combination of portland cement and ground granulated blast-furnace slag,

6.2.4.6 A combination of portland cement and fly ash,

6.2.4.7 A combination of portland cement, ground granulated blast-furnace slag (not to exceed 25 % of the total cementitious weight) and fly ash (not to exceed 25 % of the total cementitious weight, or

6.2.4.8 A combination of portland pozzolan cement and fly ash, provided the fly ash added does not exceed 25 % by weight of the portland pozzolan cement.

6.3 *Aggregates*—Aggregates shall conform to Specification C33 except that the requirement for gradation shall not apply.

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

6.4.1 Air-entraining admixture conforming to Specification C260;

6.4.2 Chemical admixture conforming to Specification C494/C494M;

6.4.3 Chemical admixture for use in producing flowing concrete conforming to Specification C1017/C1017M; and

6.4.4 Chemical admixture or blend approved by the owner.

6.5 *Steel Reinforcement*—Reinforcement shall consist of wire conforming to Specification A1064/A1064M; or of bars conforming to Specification A36/A36M, Specification A615/A615M Grade 40 or 60, or Specification A706/A706M Grade 60.

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 C1116 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.

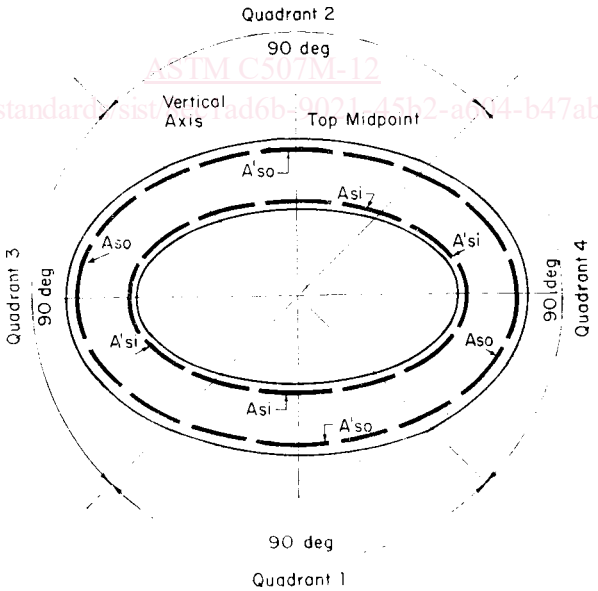
7.2.1 Footnotes to the tables herein are intended to be amplications of the tabulated requirements and are to be considered applicable and binding as if they were contained in the body of the specification.

7.3 *Modified and Special Designs:*

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.



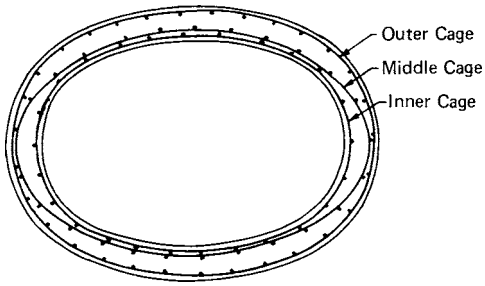
NOTE 1—The total reinforcement area (A'si) of the inner cage plus the quadrant mat in Quadrants 1 and 2 shall not be less than that specified for the inner cage in Table 1.

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

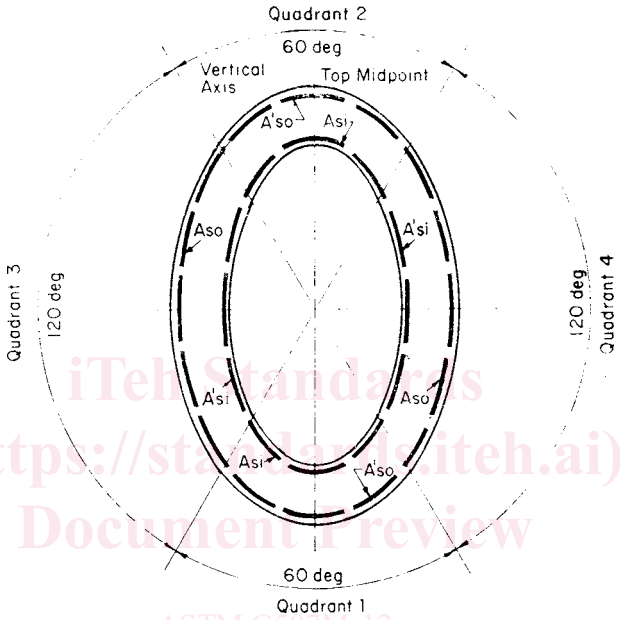
NOTE 4—The reinforcement area (A'so) of the outer cage in Quadrants 1 and 2 shall be not less than 25 % of that specified for the outer cage in Table 1.

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



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

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

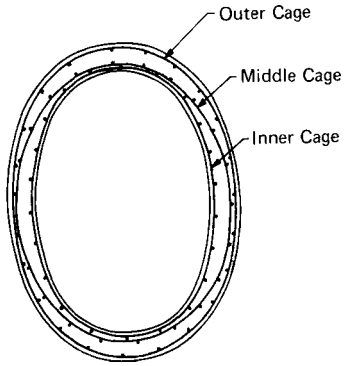
7.4 *Area*—In this specification, when the word area is not described by adjectives, such as cross-section or single wire, it shall be understood to be the cross-sectional area of reinforcement per unit lengths of pipe.

8. Reinforcement

8.1 *Circumferential Reinforcement*—A line of circumferential reinforcement for any given total area may be composed of two layers for pipe with wall thicknesses of less than 180 mm or three layers for pipe with wall thicknesses of 180 mm or greater. The layers shall not be separated by more than the thickness of one longitudinal plus 6 mm. The multiple layers shall be fastened together to form a single cage. All other specification requirements such as laps, welds, and tolerances of placement in the wall of the pipe, etc., shall apply to this method of fabricating a line of reinforcement.

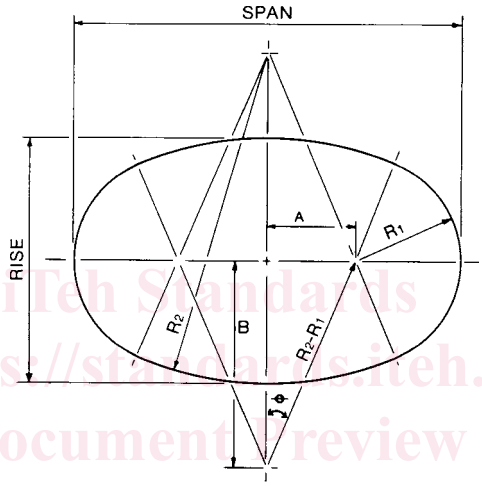
8.1.1 Where one line of reinforcement is used, it shall be placed so that the cover of the concrete over the circumferential reinforcement at the vertical and horizontal diameters of the pipe is 25 mm from the inside and outside surfaces of the pipe, except for wall thicknesses less than 62 mm, the protective cover of the concrete over the circumferential reinforcement in the wall of the pipe shall be 18 mm.

8.1.2 Where two lines of reinforcement of elliptical shape corresponding to the contour of the pipe are used, each line shall be so placed that the covering of concrete over the reinforcement is 25 mm.



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



SYMMETRICAL ABOUT AXES

Approximate Equivalent Round Size, mm	Full Flow Water Area, m^2	Rise, mm	Span, mm	*A*, mm	*B*, mm	R_1, mm	R_2, mm	θ degrees†
450	0.170	360	580	135	325	155	505	22.6
600	0.305	490	770	176	420	210	665	22.6
675	0.383	550	865	198	475	235	750	22.6
750	0.474	610	960	220	530	260	835	22.6
825	0.588	680	1065	243	580	290	920	22.6
900	0.684	730	1155	263	635	315	1000	22.6
975	0.816	800	1255	283	685	345	1085	22.6
1050	0.948	865	1355	308	733	370	1165	22.6
1200	1.20	970	1520	345	825	415	1310	22.6
1350	1.55	1105	1725	388	933	475	1485	22.6
1500	1.90	1225	1920	435	1143	525	1655	22.6
1650	2.30	1345	2110	475	1143	580	1815	22.6
1800	2.73	1470	2300	520	1245	630	1980	22.6
1950	3.21	1595	2490	560	1348	685	2145	22.6
2100	3.73	1715	2680	605	1448	735	2305	22.6
2250	4.28	1840	2870	645	1550	790	2470	22.6
2400	4.87	1960	3065	688	1655	845	2635	22.6
2550	5.49	2085	3250	730	1753	895	2795	22.6
2700	6.17	2210	3440	770	1850	950	2955	22.6
2850	6.87	2330	3635	813	1950	1005	3115	22.6
3000	7.63	2455	3825	858	2053	1055	3280	22.7
3300	9.22	2700	4205	938	2255	1165	3605	22.6
3600	11.0	2950	4590	1025	2460	1270	3935	22.6

†Editorially corrected.

NOTE 1—Rise, span, and radii are fixed; other dimensions and angles are calculated.

FIG. 5 Shape of Elliptical Pipe