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

This standard is issued under the fixed designation C76; 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 concrete pipe intended to be used for the conveyance of sewage, industrial wastes, and storm water, and for the construction of culverts.

1.2 This specification is the inch-pound companion to Specification C76M; therefore, no SI equivalents are presented in this specification. Reinforced concrete pipe that conform to the requirements of C76M, are acceptable under this Specification C76 unless prohibited by the Owner.

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 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.

NOTE 2—Attention is called to the specification for reinforced concrete D-load culvert, storm drain, and sewer pipe (Specification C655).

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A36/A36M Specification for Carbon Structural Steel
A82/A82M Specification for Steel Wire, Plain, for Concrete Reinforcement
A185/A185M Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
A496/A496M Specification for Steel Wire, Deformed, for Concrete Reinforcement
A497/A497M Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
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
C33 Specification for Concrete Aggregates
C76M Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
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
C655 Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
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.

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[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] 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.

4. Classification

4.1 Pipe manufactured in accordance with this specification shall be of five classes identified as Class I, Class II, Class III, Class IV, and Class V. The corresponding strength requirements are prescribed in Tables 1-5.

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 specified in Tables 1-5.

5.1.1 *Acceptance on the 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 and its freedom from defects.

5.1.2 *Acceptance on the 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

TABLE 1 Design Requirements for Class I Reinforced Concrete Pipe[A]

Note 1—See Section 5 for basis of acceptance specified by the owner.

The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack			800			
D-load to produce the ultimate load			1200			

Reinforcement, in.²/linear ft of pipe wall

Internal Designated Diameter, in.	Wall A — Concrete Strength, 4000 psi				Wall B — Concrete Strength, 4000 psi			
	Wall Thickness, in.	Circular Reinforcement[B] Inner Cage	Circular Reinforcement[B] Outer Cage	Elliptical Reinforcement[C]	Wall Thickness, in.	Circular Reinforcement[B] Inner Cage	Circular Reinforcement[B] Outer Cage	Elliptical Reinforcement[C]
~~60~~	~~5~~	~~0.25~~	~~0.15~~	~~0.28~~	~~6~~	~~0.21~~	~~0.13~~	~~0.23~~
60	5	0.24	0.15	0.27	6	0.21	0.12	0.23
~~66~~	~~5½~~	~~0.30~~	~~0.18~~	~~0.33~~	~~6½~~	~~0.25~~	~~0.15~~	~~0.28~~
66	5½	0.30	0.18	0.33	6½	0.24	0.15	0.27
72	6	0.35	0.21	0.39	7	0.29	0.17	0.32
78	6½	0.40	0.24	0.44	7½	0.32	0.19	0.36
~~84~~	~~7~~	~~0.45~~	~~0.27~~	~~0.50~~	~~8~~	~~0.37~~	~~0.22~~	~~0.41~~
84	7	0.45	0.27	0.50	8	0.36	0.21	0.41
~~90~~	~~7½~~	~~0.49~~	~~0.29~~	~~0.54~~	~~8½~~	~~0.41~~	~~0.25~~	~~0.46~~
90	7½	0.49	0.29	0.54	8½	0.41	0.24	0.45
~~96~~	~~8~~	~~0.54~~	~~0.32~~	~~0.60~~	~~9~~	~~0.46~~	~~0.28~~	~~0.51~~
96	8	0.54	0.32	0.60	9	0.45	0.27	0.51
Concrete Strength, 5000 psi								
~~102~~	~~8½~~	~~0.63~~	~~0.38~~	~~Inner Circular 0.25 / Plus Elliptical 0.38~~	~~9½~~	~~0.54~~	~~0.32~~	~~Inner Circular 0.22 / Plus Elliptical 0.32~~
102	8½	0.63	0.38	Inner Circular 0.24 / Plus Elliptical 0.38	9½	0.54	0.32	Inner Circular 0.21 / Plus Elliptical 0.32
~~108~~	~~9~~	~~0.68~~	~~0.41~~	~~Inner Circular 0.27 / Plus Elliptical 0.41~~	~~10~~	~~0.61~~	~~0.37~~	~~Inner Circular 0.24 / Plus Elliptical 0.37~~
108	9	0.68	0.41	Inner Circular 0.27 / Plus Elliptical 0.41	10	0.60	0.36	Inner Circular 0.24 / Plus Elliptical 0.36
114	A	. . .	. . .	. . .	A	. . .	. . .	. . .
120	A	. . .	. . .	. . .	A	. . .	. . .	. . .
126	A	. . .	. . .	. . .	A	. . .	. . .	. . .
132	A	. . .	. . .	. . .	A	. . .	. . .	. . .
138	A	. . .	. . .	. . .	A	. . .	. . .	. . .
144	A	. . .	. . .	. . .	A	. . .	. . .	. . .

[A] For modified or special designs see 7.2 or with the permission of the owner utilize the provisions of Specification C655. Steel areas may be interpolated between those shown for variations in diameter, loading, or wall thickness. Pipe over 96 in. in diameter shall have two circular cages or an inner circular plus one elliptical cage.

[B] As an alternative to designs requiring both inner and outer circular cages the reinforcement may be positioned and proportioned in either of the following manners:
An inner circular cage plus an elliptical cage such that the area of the elliptical cage shall not be less than that specified for the outer cage in the table and the total area of the inner circular cage plus the elliptical cage shall not be less than that specified for the inner cage in the table,
An inner and outer cage plus quadrant mats in accordance with Fig. 1, or
An inner and outer cage plus an elliptical cage in accordance with Fig. 2.

[C] Elliptical and quadrant steel must be held in place by means of holding rods, chairs, or other positive means throughout the entire casting operation.

TABLE 2 Design Requirements for Class II Reinforced Concrete Pipe[A]

Note 1—See Section 5 for basis of acceptance specified by the owner.

The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack	1000
D-load to produce the ultimate load	1500

Reinforcement, in.²/linear ft of pipe wall

Internal Designated Diameter, in.	Wall A				Wall B				Wall C			
	Concrete Strength, 4000 psi				Concrete Strength, 4000 psi				Concrete Strength, 4000 psi			
	Wall Thickness, in.	Circular Reinforcement[B] Inner Cage	Outer Cage	Elliptical Reinforcement[C]	Wall Thickness, in.	Circular Reinforcement[B] Inner Cage	Outer Cage	Elliptical Reinforcement[C]	Wall Thickness, in.	Circular Reinforcement[C] Inner Cage	Outer Cage	Elliptical Reinforcement[D]
12	1¾	0.07[B]	...	...	2	0.07[B]	...	...	2¾	0.07[B]	...	...
15	1⅞	0.07[B]	...	...	2¼	0.07[B]	...	...	3	0.07[B]	...	...
18	2	0.07[B]	...	0.07[B]	2½	0.07[B]	...	0.07[B]	3¼	0.07[B]	...	0.07[B]
21	2¼	0.12	...	0.10	2¾	0.07[B]	...	0.07[B]	3½	0.07[B]	...	0.07[B]
~~24~~	~~2½~~	~~0.13~~	~~...~~	~~0.11~~	~~3~~	~~0.07[B]~~	~~...~~	~~0.07[B]~~	~~3¾~~	~~0.07[B]~~	~~...~~	~~0.07[B]~~
24	2½	0.12	...	0.11	3	0.07[B]	...	0.07[B]	3¾	0.07[B]	...	0.07[B]
~~27~~	~~2⅝~~	~~0.15~~	~~...~~	~~0.13~~	~~3¼~~	~~0.13~~	~~...~~	~~0.11~~	~~4~~	~~0.07[B]~~	~~...~~	~~0.07[B]~~
27	2⅝	0.15	...	0.12	3¼	0.12	...	0.11	4	0.07[B]	...	0.07[B]
30	2¾	0.15	...	0.14	3½	0.14	...	0.12	4¼	0.07[B]	...	0.07[B]
~~33~~	~~2⅞~~	~~0.16~~	~~...~~	~~0.15~~	~~3¾~~	~~0.15~~	~~...~~	~~0.13~~	~~4½~~	~~0.07[B]~~	~~...~~	~~0.07[B]~~
33	2⅞	0.16	...	0.15	3¾	0.15	...	0.12	4½	0.07[B]	...	0.07[B]
~~36~~	~~3~~	~~0.14~~	~~0.08~~	~~0.15~~	~~4[E]~~	~~0.12~~	~~0.07~~	~~0.13~~	~~4¾[E]~~	~~0.07~~	~~0.07~~	~~0.08~~
36	3	0.14	0.08	0.15	4[E]	0.12	0.07	0.12	4¾[E]	0.07	0.07	0.08
42	3½	0.16	0.10	0.18	4½	0.15	0.09	0.17	5¼	0.10	0.07	0.11
~~48~~	~~4~~	~~0.21~~	~~0.13~~	~~0.23~~	~~5~~	~~0.18~~	~~0.11~~	~~0.20~~	~~5¾~~	~~0.14~~	~~0.08~~	~~0.15~~
48	4	0.21	0.12	0.23	5	0.18	0.11	0.20	5¾	0.14	0.08	0.15
~~54~~	~~4½~~	~~0.25~~	~~0.15~~	~~0.28~~	~~5½~~	~~0.22~~	~~0.13~~	~~0.24~~	~~6¼~~	~~0.17~~	~~0.10~~	~~0.19~~
54	4½	0.24	0.15	0.27	5½	0.21	0.12	0.24	6¼	0.17	0.10	0.19
~~60~~	~~5~~	~~0.30~~	~~0.18~~	~~0.33~~	~~6~~	~~0.25~~	~~0.15~~	~~0.28~~	~~6¾~~	~~0.22~~	~~0.13~~	~~0.24~~
60	5	0.30	0.18	0.33	6	0.24	0.15	0.27	6¾	0.21	0.12	0.24
~~66~~	~~5½~~	~~0.35~~	~~0.21~~	~~0.39~~	~~6½~~	~~0.31~~	~~0.19~~	~~0.34~~	~~7¼~~	~~0.25~~	~~0.15~~	~~0.28~~
66	5½	0.35	0.21	0.39	6½	0.31	0.19	0.34	7¼	0.24	0.15	0.27
~~72~~	~~6~~	~~0.41~~	~~0.25~~	~~0.45~~	~~7~~	~~0.35~~	~~0.21~~	~~0.39~~	~~7¾~~	~~0.30~~	~~0.18~~	~~0.33~~
72	6	0.41	0.24	0.45	7	0.35	0.21	0.39	7¾	0.30	0.18	0.33
~~78~~	~~6½~~	~~0.46~~	~~0.28~~	~~0.51~~	~~7½~~	~~0.40~~	~~0.24~~	~~0.44~~	~~8¼~~	~~0.35~~	~~0.21~~	~~0.39~~
78	6½	0.45	0.27	0.51	7½	0.40	0.24	0.44	8¼	0.35	0.21	0.39
~~84~~	~~7~~	~~0.51~~	~~0.31~~	~~0.57~~	~~8~~	~~0.46~~	~~0.28~~	~~0.51~~	~~8¾~~	~~0.41~~	~~0.25~~	~~0.46~~
84	7	0.51	0.31	0.57	8	0.45	0.27	0.51	8¾	0.41	0.24	0.45
90	7½	0.57	0.34	0.63	8½	0.51	0.31	0.57	9¼	0.48	0.29	0.53
~~96~~	~~8~~	~~0.62~~	~~0.37~~	~~0.69~~	~~9~~	~~0.57~~	~~0.34~~	~~0.63~~	~~9¾~~	~~0.55~~	~~0.33~~	~~0.61~~
96	8	0.62	0.36	0.69	9	0.57	0.34	0.63	9¾	0.55	0.33	0.60
	Concrete Strength, 5000 psi											
~~102~~	~~8½~~	~~0.76~~	~~0.46~~	~~Inner Circular 0.30 / Plus Elliptical 0.46~~	~~9½~~	~~0.68~~	~~0.41~~	~~Inner Circular 0.27 / Plus Elliptical 0.41~~	~~10¼~~	~~0.62~~	~~0.37~~	~~Inner Circular 0.25 / Plus Elliptical 0.37~~
102	8½	0.76	0.45	Inner Circular 0.30 / Plus Elliptical 0.45	9½	0.68	0.41	Inner Circular 0.27 / Plus Elliptical 0.41	10¼	0.62	0.36	Inner Circular 0.24 / Plus Elliptical 0.36
~~108~~	~~9~~	~~0.85~~	~~0.51~~	~~Inner Circular 0.34 / Plus Elliptical 0.51~~	~~10~~	~~0.76~~	~~0.46~~	~~Inner Circular 0.30 / Plus Elliptical 0.46~~	~~10¾~~	~~0.70~~	~~0.42~~	~~Inner Circular 0.28 / Plus Elliptical 0.42~~
108	9	0.85	0.51	Inner Circular 0.34 / Plus Elliptical 0.51	10	0.76	0.45	Inner Circular 0.30 / Plus Elliptical 0.45	10¾	0.70	0.42	Inner Circular 0.27 / Plus Elliptical 0.42
114	A	...	...	...	A	...	...	...	A	...	...	...
120	A	...	...	...	A	...	...	...	A	...	...	...
126	A	...	...	...	A	...	...	...	A	...	...	...
132	A	...	...	...	A	...	...	...	A	...	...	...
138	A	...	...	...	A	...	...	...	A	...	...	...
144	A	...	...	...	A	...	...	...	A	...	...	...

[A] For modified or special designs see 7.2 or with the permission of the owner utilize the provisions of Specification C655. Steel areas may be interpolated between those shown for variations in diameter, loading, or wall thickness. Pipe over 96 in. in diameter shall have two circular cages or an inner circular plus one elliptical cage.

[B] For these classes and sizes, the minimum practical steel reinforcement is specified. The specified ultimate strength of non-reinforced pipe is greater than the minimum specified strength for the equivalent diameters.

[C] As an alternative to designs requiring both inner and outer circular cages the reinforcement may be positioned and proportioned in either of the following manners:
An inner circular cage plus an elliptical cage such that the area of the elliptical cage shall not be less than that specified for the outer cage in the table and the total area of the inner circular cage plus the elliptical cage shall not be less than that specified for the inner cage in the table,
An inner and outer cage plus quadrant mats in accordance with Fig. 1 , or
An inner and outer cage plus an elliptical cage in accordance with Fig. 2.

TABLE 3 Design Requirements for Class III Reinforced Concrete Pipe[A]

NOTE 1—See Section 5 for basis of acceptance specified by the owner.

The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack	1350
D-load to produce the ultimate load	2000

Reinforcement, in.²/linear ft of pipe wall

Internal Designated Diameter, in.	Wall A Wall Thicknesses, in.	Wall A Circular Reinforcement[B] Inner Cage	Wall A Circular Reinforcement[B] Outer Cage	Wall A Elliptical Reinforcement[C]	Wall B Wall Thicknesses, in.	Wall B Circular Reinforcement[B] Inner Cage	Wall B Circular Reinforcement[B] Outer Cage	Wall B Elliptical Reinforcement[C]	Wall C Wall Thicknesses, in.	Wall C Circular Reinforcement[B] Inner Cage	Wall C Circular Reinforcement[B] Outer Cage	Wall C Elliptical Reinforcement[C]
	Concrete Strength, 4000 psi				*Concrete Strength, 4000 psi*				*Concrete Strength, 4000 psi*			
12	1¾	0.07[D]	...	...	2	0.07[D]	...	...	2¾	0.07[D]	...	...
15	1⅞	0.07[D]	...	...	2¼	0.07[D]	...	...	3	0.07[D]	...	...
18	2	0.07[D]	...	0.07[D]	2½	0.07[D]	...	0.07[D]	3¼	0.07[D]	...	0.07[D]
21	2¼	0.14	...	0.11	2¾	0.07[D]	...	0.07[D]	3½	0.07[D]	...	0.07[D]
24	2½	0.17	...	0.14	3	0.07[D]	...	0.07[D]	3¾	0.07	...	0.07[D]
27	2⅝	0.18	...	0.16	3¼	0.16	...	0.14	4	0.08	...	0.07[D]
30	2¾	0.19	...	0.18	3½	0.18	...	0.15	4¼	0.10	...	0.08
33	2⅞	0.21	...	0.20	3¾	0.20	...	0.17	4½	0.12	...	0.10
~~36~~	~~3~~	~~0.21~~	~~0.13~~	~~0.23~~	~~4~~ [E]	~~0.17~~	~~0.10~~	~~0.19~~	~~4¾~~[E]	~~0.08~~	~~0.07~~	~~0.09~~
36	3	0.21	0.12	0.23	4 [E]	0.17	0.10	0.19	4¾[E]	0.08	0.07	0.09
~~42~~	~~3½~~	~~0.25~~	~~0.15~~	~~0.28~~	~~4½~~	~~0.21~~	~~0.13~~	~~0.23~~	~~5¼~~	~~0.12~~	~~0.07~~	~~0.13~~
42	3½	0.24	0.15	0.27	4½	0.21	0.12	0.23	5¼	0.12	0.07	0.12
48	4	0.32	0.19	0.35	5	0.24	0.14	0.27	5¾	0.16	0.10	0.18
~~54~~	~~4½~~	~~0.38~~	~~0.23~~	~~0.42~~	~~5½~~	~~0.29~~	~~0.17~~	~~0.32~~	~~6¼~~	~~0.21~~	~~0.13~~	~~0.23~~
54	4½	0.38	0.23	0.42	5½	0.29	0.17	0.32	6¼	0.21	0.12	0.23
~~60~~	~~5~~	~~0.44~~	~~0.26~~	~~0.49~~	~~6~~	~~0.34~~	~~0.20~~	~~0.38~~	~~6¾~~	~~0.25~~	~~0.15~~	~~0.28~~
60	5	0.44	0.26	0.49	6	0.34	0.20	0.38	6¾	0.24	0.15	0.27
~~66~~	~~5½~~	~~0.50~~	~~0.30~~	~~0.55~~	~~6½~~	~~0.41~~	~~0.25~~	~~0.46~~	~~7¼~~	~~0.31~~	~~0.19~~	~~0.34~~
66	5½	0.50	0.30	0.55	6½	0.41	0.24	0.45	7¼	0.31	0.19	0.34
~~72~~	~~6~~	~~0.57~~	~~0.34~~	~~0.63~~	~~7~~	~~0.49~~	~~0.29~~	~~0.54~~	~~7¾~~	~~0.36~~	~~0.22~~	~~0.40~~
72	6	0.57	0.34	0.63	7	0.49	0.29	0.54	7¾	0.36	0.21	0.40
	Concrete Strength, 5000 psi											
~~78~~	~~6½~~	~~0.64~~	~~0.38~~	~~0.71~~	~~7½~~	~~0.57~~	~~0.34~~	~~0.63~~	~~8¼~~	~~0.42~~	~~0.25~~	~~0.47~~
78	6½	0.64	0.38	0.71	7½	0.57	0.34	0.63	8¼	0.42	0.24	0.47
84	7	0.72	0.43	0.80	8	0.64	0.38	0.71	8¾	0.50	0.30	0.56
					Concrete Strength, 5000 psi				*Concrete Strength, 5000 psi*			
90	7½	0.81	0.49	0.90	8½	0.69	0.41	0.77	9¼	0.59	0.35	0.66
~~96~~	~~8~~	~~0.93~~	~~0.56~~	~~1.03~~	~~9~~	~~0.76~~	~~0.46~~	~~0.84~~	~~9¾~~	~~0.70~~	~~0.42~~	~~Inner Circular — / Plus Elliptical 0.28 / 0.42~~
96	8	0.93	0.56	1.03	9	0.76	0.45	0.84	9¾	0.70	0.42	Inner Circular 0.27 / Plus Elliptical 0.42
102	8½	1.03	0.62	Inner Circular 0.41 / Plus Elliptical 0.62	9½	0.90	0.54	Inner Circular 0.36 / Plus Elliptical 0.54	10¼	0.83	0.50	Inner Circular 0.33 / Plus Elliptical 0.50
108	9	1.22	0.73	Inner Circular 0.49 / Plus Elliptical 0.73	10	1.08	0.65	Inner Circular 0.43 / Plus Elliptical 0.65	10¾	0.99	0.59	Inner Circular 0.40 / Plus Elliptical 0.59
114	A	...	...	...	A	...	...	...	A	...	...	...
120	A	...	...	...	A	...	...	...	A	...	...	...
126	A	...	...	...	A	...	...	...	A	...	...	...
132	A	...	...	...	A	...	...	...	A	...	...	...
138	A	...	...	...	A	...	...	...	A	...	...	...
144	A	... ...	...	...	A	...	...	... ...	A	...	...	...

[A] For modified or special designs see 7.2 or with the permission of the owner utilize the provisions of Specification C655. Steel areas may be interpolated between those shown for variations in diameter, loading, or wall thickness. Pipe over 96 in. in diameter shall have two circular cages or an inner circular plus one elliptical cage.

[B] As an alternative to designs requiring both inner and outer circular cages the reinforcement may be positioned and proportioned in either of the following manners:

An inner circular cage plus an elliptical cage such that the area of the elliptical cage shall not be less than that specified for the outer cage in the table and the total area of the inner circular cage plus the elliptical cage shall not be less than that specified for the inner cage in the table,

An inner and outer cage plus quadrant mats in accordance with Fig. 1, or

An inner and outer cage plus an elliptical cage in accordance with Fig. 2.

[C] Elliptical and quadrant steel must be held in place by means of holding rods, chairs, or other positive means throughout the entire casting operation.

[D] For these classes and sizes, the minimum practical steel reinforcement is specified. The specified ultimate strength of non-reinforced pipe is greater than the minimum specified strength for the equivalent diameters.

[E] As an alternative, the reinforcement for ...

TABLE 4 Design Requirements for Class IV Reinforced Concrete Pipe[A]

Note 1—See Section 5 for basis of acceptance specified by the owner.

The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack	2000
D-load to produce the ultimate load	3000

Reinforcement, in.²/linear ft of pipe wall

Internal Designated Diameter, in.	Wall A — 5000 psi, Wall Thickness, in.	Circular Inner Cage[B]	Circular Outer Cage[B]	Elliptical Reinforcement[C]	Wall B — 4000 psi, Wall Thickness, in.	Circular Inner Cage[B]	Circular Outer Cage[B]	Elliptical Reinforcement[C]	Wall C — 4000 psi, Wall Thickness, in.	Circular Inner Cage[B]	Circular Outer Cage[B]	Elliptical Reinforcement[C]
12	1¾	0.15	...	...	2	0.07	...	...	2¾	0.07[D]	...	...
15	1⅞	0.16	...	...	2¼	0.10	...	...	3	0.07[D]	...	...
18	2	0.17	...	0.15	2½	0.14	...	0.11	3¼	0.07[D]	...	0.07[D]
21	2¼	0.23	...	0.21	2¾	0.20	...	0.17	3½	0.07[D]	...	0.07[D]
24	2½	0.29	...	0.27	3	0.27	...	0.23	3¾	0.07	0.07	0.08
~~27~~	~~2⅝~~	~~0.33~~	~~...~~	~~0.31~~	~~3¼~~	~~0.31~~	~~...~~	~~0.25~~	~~4~~	~~0.08~~	~~0.07~~	~~0.09~~
27	2⅝	0.33	...	0.31	3¼	0.31	...	0.24	4	0.08	0.07	0.09
~~30~~	~~2¾~~	~~0.38~~	~~...~~	~~0.35~~	~~3½~~	~~0.35~~	~~...~~	~~0.28~~	~~4¼~~	~~0.09~~	~~0.07~~	~~0.10~~
30	2¾	0.38	...	0.35	3½	0.35	...	0.27	4¼	0.09	0.07	0.10
33	[A]	...	...	...	3¾	0.27	0.16	0.30	4½	0.11	0.07	0.12
36	[A]	...	...	...	4	0.30	0.18	0.33	4¾	0.14	0.08	0.15
~~42~~	[A]	~~...~~	~~...~~	~~...~~	~~4½~~	~~0.35~~	~~0.21~~	~~0.39~~	~~5¼~~	~~0.20~~	~~0.12~~	~~0.22~~
42	[A]	...	...	...	4½	0.35	0.21	0.39	5¼	0.20	0.12	0.21
~~48~~	[A]	~~...~~	~~...~~	~~...~~	~~5~~	~~0.42~~	~~0.25~~	~~0.47~~	~~5¾~~	~~0.26~~	~~0.16~~	~~0.29~~
48	[A]	...	...	...	5	0.42	0.24	0.47	5¾	0.26	0.16	0.29
54	[A]	...	...	...	5½	0.50	0.30	0.55	6¼	0.34	0.20	0.38
					Concrete Strength, 5000 psi							
~~60~~	[A]	~~...~~	~~...~~	~~...~~	~~6~~	~~0.59~~	~~0.35~~	~~0.66~~	~~6¾~~	~~0.41~~	~~0.25~~	~~0.46~~
60	[A]	...	...	...	6	0.59	0.35	0.66	6¾	0.41	0.24	0.45
66	[A]	...	...	...	6½	0.69	0.41	0.77	7¼	0.51	0.31	0.57
									Concrete Strength, 5000 psi			
~~72~~	[A]	~~...~~	~~...~~	~~...~~	~~7~~	~~0.79~~	~~0.47~~	~~0.88~~	~~7¾~~	~~0.61~~	~~0.37~~	~~0.68~~
72	[A]	...	...	...	7	0.79	0.47	0.88	7¾	0.60	0.36	0.68
78	[A]	...	...	...	[A]	...	...	...	8¼	0.71	0.43	0.79
84	[A]	...	...	...	[A]	...	...	...	8¾	0.85	0.51	0.94
90	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
96	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
102	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
108	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
114	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
120	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
126	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
132	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
138	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...
144	[A]	...	...	...	[A]	...	...	...	[A]	...	...	...

[A] For modified or special designs see 7.2 or with the permission of the owner utilize the provisions of Specification C655. Steel areas may be interpolated between those shown for variations in diameter, loading, or wall thickness. Pipe over 96 in. in diameter shall have two circular cages or an inner circular plus one elliptical cage.

[B] As an alternative to designs requiring both inner and outer circular cages the reinforcement may be positioned and proportioned in either of the following manners:
An inner circular cage plus an elliptical cage such that the area of the elliptical cage shall be not less than that specified for the outer cage in the table and the total area of the inner circular cage plus the elliptical cage shall be not less than that specified for the inner cage in the table,
An inner and outer cage plus quadrant mats in accordance with Fig. 1, and
An inner and outer cage plus an elliptical cage in accordance with Fig. 2.
For Wall C, in sizes 24 to 33 in., a single circular cage with an area not less than the sum of the specified inner and outer circular reinforcement areas.

[C] Elliptical and quadrant steel must be held in place by means of holding rods, chairs, or other positive means throughout the entire casting operation.

[D] For these classes and sizes, the minimum practical steel reinforcement is specified.

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 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 5 Design Requirements for Class V Reinforced Concrete Pipe[A]

NOTE 1—See Section 5 for basis of acceptance specified by the owner.

The strength test requirements in pounds-force per linear foot of pipe under the three-edge-bearing method shall be either the D-load (test load expressed in pounds-force per linear foot per foot of diameter) to produce a 0.01-in. crack, or the D-loads to produce the 0.01-in. crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in feet.

D-load to produce a 0.01-in. crack	3000
D-load to produce the ultimate load	3750

Reinforcement, in.²/linear ft of pipe wall

Internal Designated Diameter, in.	Wall A (Concrete Strength, 6000 psi)				Wall B (Concrete Strength, 6000 psi)				Wall C (Concrete Strength, 6000 psi)			
	Wall Thickness, in.	Circular Reinforcement[B] Inner Cage	Circular Reinforcement[B] Outer Cage	Elliptical Reinforcement[C]	Wall Thickness, in.	Circular Reinforcement[B] Inner Cage	Circular Reinforcement[B] Outer Cage	Elliptical Reinforcement[C]	Wall Thickness, in.	Circular Reinforcement[B] Inner Cage	Circular Reinforcement[B] Outer Cage	Elliptical Reinforcement[C]
12	A	...	...	...	2	0.10	...	...	2¾	0.07[D]	...	...
15	A	...	...	...	2¼	0.14	...	...	3	0.07[D]	...	...
18	A	...	...	...	2½	0.19	...	0.16	3¼	0.10	...	...
21	A	...	...	...	2¾	0.24	...	0.21	3½	0.10	...	...
~~24~~	A	~~...~~	~~...~~	~~...~~	~~3~~	~~0.30~~	~~...~~	~~0.24~~	~~3¾~~	~~0.12~~	~~0.07~~	~~0.13~~
24	A	...	...	...	3	0.30	...	0.24	3¾	0.12	0.07	0.12
27	A	...	...	...	3¼	0.38	0.23	0.42	4	0.14	0.08	0.16
~~30~~	A	~~...~~	~~...~~	~~...~~	~~3½~~	~~0.41~~	~~0.25~~	~~0.46~~	~~4¼~~	~~0.18~~	~~0.11~~	~~0.20~~
30	A	...	...	...	3½	0.41	0.24	0.45	4¼	0.18	0.11	0.20
~~33~~	A	~~...~~	~~...~~	~~...~~	~~3¾~~	~~0.46~~	~~0.28~~	~~0.51~~	~~4½~~	~~0.23~~	~~0.14~~	~~0.25~~
33	A	...	...	...	3¾	0.45	0.27	0.51	4½	0.23	0.14	0.24
36	A	...	...	...	4	0.50	0.30	0.56	4¾	0.27	0.16	0.30
~~42~~	A	~~...~~	~~...~~	~~...~~	~~4½~~	~~0.60~~	~~0.36~~	~~0.67~~	~~5¼~~	~~0.36~~	~~0.22~~	~~0.40~~
42	A	...	...	...	4½	0.60	0.36	0.67	5¼	0.36	0.21	0.40
~~48~~	A	~~...~~	~~...~~	~~...~~	~~5~~	~~0.73~~	~~0.44~~	~~0.81~~	~~5¾~~	~~0.47~~	~~0.28~~	~~0.52~~
48	A	...	...	...	5	0.73	0.44	0.81	5¾	0.47	0.27	0.52
54	A	...	...	...	A	...	...	...	6¼	0.58	0.35	0.64
60	A	...	...	...	A	...	...	...	6¾	0.70	0.42	0.78
66	A	...	...	...	A	...	...	...	7¼	0.84	0.50	0.93
72	A	...	...	...	A	...	...	...	7¾	0.99	0.59	1.10
78	A	...	...	...	A	...	...	...	A	...	...	...
84	A	...	...	...	A	...	...	...	A	...	...	...
90	A	...	...	...	A	...	...	...	A	...	...	...
96	A	...	...	...	A	...	...	...	A	...	...	...
102	A	...	...	...	A	...	...	...	A	...	...	...
108	A	...	...	...	A	...	...	...	A	...	...	...
114	A	...	...	...	A	...	...	...	A	...	...	...
120	A	...	...	...	A	...	...	...	A	...	...	...
126	A	...	...	...	A	...	...	...	A	...	...	...
132	A	...	...	...	A	...	...	...	A	...	...	...
138	A	...	...	...	A	...	...	...	A	...	...	...
144	A	...	...	...	A	...	...	...	A	...	...	...

...

[A] For modified or special designs see 7.2 or with the permission of the owner utilize the provisions of Specification C655. Steel areas may be interpolated between those shown for variations in diameter, loading, or wall thickness. Pipe over 96 in. in diameter shall have two circular cages or an inner circular plus one elliptical cage.

[B] As an alternative to designs requiring both inner and outer circular cages the reinforcement may be positioned and proportioned in either of the following manners:

An inner circular cage plus an elliptical cage such that the area of the elliptical cage shall not be less than that specified for the outer cage in the table and the total area of the inner circular cage plus the elliptical cage shall not be less than that specified for the inner cage in the table,

An inner and outer cage plus quadrant mats in accordance with Fig. 1, or

An inner and outer cage plus an elliptical cage in accordance with Fig. 2.

[C] Elliptical and quadrant steel must be held in place by means of holding rods, chairs, or other positive means throughout the entire casting operation.

[D] For these classes and sizes, the minimum practical steel reinforcement is specified.

5.2 *Age for Acceptance*—Pipe shall be considered ready for acceptance when it conforms 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 homogenous concrete mixture of such quality that the pipe will conform to the test and design requirements of the specification. In no case, however, shall the proportion of Portland cement, blended hydraulic cement, or a combination of Portland cement and supplementary cementing materials be less than 470 lb/yd³.

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