Designation: C 1092 – 94

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St. Philadelphia, Pa 19103
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Standard Specification for Glass Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe[1]

This standard is issued under the fixed designation C 1092; 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.

1. Scope

1.1 This specification covers concrete pipe reinforced with substantially continuous inner and outer layers of alkali-resistant glass rovings and is designed for specific D-loads and intended to be used for conveyance of sewage, industrial wastes, and storm water and for the construction of culverts.

NOTE 1—A complete metric companion to Specification C 1092 is being developed—C 1092M; therefore, no metric equivalents are presented in this specification.

NOTE 2—Experience has shown that the successful performance of this product depends upon the proper selection of the pipe strength, the type of bedding and backfill, the care in the field construction work, and provision for adequate inspection at the construction site. This specification does not include requirements for bedding, backfill, the relationship between earth cover load and the strength designation of pipe, or durability under unusual environmental conditions. These requirements should be included in the project specification.

2. Referenced Documents

2.1 *ASTM Standards:*

C 31 Practice for Making and Curing Concrete Test Specimens in the Field[2]
C 33 Specification for Concrete Aggregates[2]
C 39 Test Method for Compressive Strength of Cylindrical Concrete Specimens[2]
C 42 Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete[2]
C 150 Specification for Portland Cement[3]
C 309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete[2]
C 497 Test Methods for Concrete Pipe, Manhole Sections, or Tile[4]
C 595 Specification for Blended Hydraulic Cements[3]
C 822 Terminology Relating to Concrete Pipe and Related Products[4]
E 105 Practice for Probability Sampling of Materials[5]

3. Terminology

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

4. Basis of Acceptance

4.1 The acceptability of the pipe design shall be determined in accordance with Section 10. After the pipe design has been accepted, or if the pipe design has been accepted previously in accordance with Section 10, the basis of acceptance shall be as described in 4.1.1.

4.1.1 Acceptance on the basis of pipe load and material tests and inspection of manufactured pipe for defects shall be determined in accordance with Sections 5, 6, 9, and 11.

NOTE 3—It is necessary that samples be selected at random. For guidance see Practice E 105.

4.2 *Age for Acceptance*—Pipe shall be considered ready for acceptance when they conform to the requirements.

5. Design and Manufacturing Data

5.1 The manufacturer shall provide the following information regarding the pipe:

5.1.1 Pipe strength, design strength, and minimum ultimate strength.

NOTE 4—The relationship of the ultimate D-load strength to the design D-load strength shall not be less than 1.5 times the design strength.

5.1.2 *Physical Characteristics*—Diameter, wall thickness, laying length, and joint details.

5.1.3 Design concrete strengths; minimum f'_c equals 5000 psi.

5.1.4 *Glass Reinforcement:*

5.1.4.1 Type of alkali-resistant glass reinforcement, and applicable specification, and

5.1.4.2 Placement, placement tolerances, spacing and cross-sectional area of glass reinforcement (strands per foot).

5.1.5 Manufacturing and curing process.

6. Materials and Manufacture

6.1 *Materials:*

6.1.1 *Cement*—Portland cement shall conform to the requirements of Specification C 150, or shall be either Portland blast-furnace slag cement or Portland-pozzolan cement conforming to the requirements of Specification C 595.

6.1.2 *Aggregates*—Aggregates shall conform to the requirements of Specification C 33, except that the requirement for gradation shall not apply.

6.1.3 *Admixtures and Blends*—Admixtures and blends shall not be used.

6.1.4 *Glass Reinforcement*—The alkali-resistant glass fibers shall contain a minimum of 7.0 % by weight of zirconium dioxide (Z_rO_2) throughout. The glass rovings should be continuous and free from oil, grease and other

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[1] This specification is under the jurisdiction of ASTM Committee C-13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.07 on Acceptance Specifications and Precast Concrete Box Sections.

Current edition approved July 15, 1994. Published September 1994. Originally published as C 1092 – 88. Last previous edition C 1092 – 88.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.01.

[4] *Annual Book of ASTM Standards*, Vol 04.05.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

TABLE 1 Limits and Frequency of Testing of Glass Rovings

Property	Limit	Minimum Frequency of Testing
Roving count	+8 % or −4 % from the nominal value stated by the glass manufacturer	1 sample per 550 lb
Loss on ignition	±20 % from nominal value stated by the glass manufacturer	1 sample per 11 000 lb

contamination. The diameter of glass fibres in the rovings shall be in the range from 8.75 to 25.0 μm. The rovings shall be sampled and tested for count and loss on ignition as described in Appendix X1 and shall comply with the appropriate limits given in Table 1.

6.2 *Manufacture:*

6.2.1 *Concrete*—The aggregates shall be sized, graded, proportioned, and mixed with cement 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. Maximum aggregate size in the concrete covering the inner glass layer shall not exceed 75 % of the cover thickness. All concrete and slurry shall have a water-cement ratio not exceeding 0.47 by weight. All pipe manufactured under the provisions of this specification shall contain a minimum of 470 lb of cement per yd^3 of concrete unless mix designs with a lower cement content demonstrate that the quality and performance of the pipe meets the requirements of this specification.

NOTE 5—The successful field performance and durability assessment of glass reinforced concrete pipe using alkali-resistant glass rovings are based on pipe manufactured by the centrifugal spinning process.

6.2.2 *Glass Reinforcement:*

6.2.2.1 *Placement*—Glass reinforcement shall be placed, with a cement rich slurry and located, as indicated in 5.1.4.2, subject to the tolerances given in 5.1.4.2 and 8.2.2. Minimum cover of concrete over the inner circumferential glass reinforcement in the barrel of the pipe shall be 1/8 in.

6.2.3 *Joints*—The joints shall be of such design and the ends of the concrete pipe sections so formed that when the sections are laid together they will make a continuous line of pipe with a smooth interior free from appreciable irregularities in the flow line, all compatible with the permissible variations given in Section 8.

6.2.4 *Lift Holes*—If approved by the owner, lift eyes or holes may be provided in each pipe for the purpose of handling.

7. Physical Requirements

7.1 *Strength*—The design strength of the pipe shall be 66.7 % of the specified minimum ultimate D-load strength when tested in accordance with Test Methods C 497. When a load of 80 % of the minimum ultimate D-load strength is applied the pipe shall not show visible load cracks.

NOTE 6—The first visible crack as used in this specification is that observed without the aid of magnifying devices. Such a crack is defined as having a width of 0.002 in.

7.2 *Test Equipment and Facilities*—The manufacturer shall furnish, without charge, all samples, facilities, and personnel necessary to carry out the tests required by this specification.

7.3 *Pipe Load Tests*—The tests for load bearing strength, as required, shall be made in accordance with Test Methods C 497. When alternative methods of load testing are specified, tests shall be made in accordance with the alternative requirements.

8. Dimensions and Permissible Variations

8.1 *Standard Diameters*—Pipe shall be manufactured in the standard inside diameters listed in Table 2.

8.2 *Design Tolerances*—Except as specified in this section, all permissible design tolerances shall be as given in Section 5.

8.2.1 *Diameter Tolerances*—The internal diameter of 12 to 24-in. pipe shall vary not more than ±1.5 % from the designated diameter. The internal diameter of 27 to 96-in. pipe shall vary not more than ±1 % or 3/8 in., whichever is greater, from the designated diameter.

8.2.2 *Glass Reinforcement Placement Tolerance*—The variation in the position of the glass reinforcement shall be such that the maximum concrete cover over the glass does not exceed 1/4 in. for the outer layer and 3/8 in. for the inner layer. Pipe having variations in the position of the glass reinforcement exceeding those specified above shall be accepted if the three-edge bearing strength requirements obtained on a representative sample are met. In no case, however, shall the cover over the inner circumferential glass reinforcement be less than 1/8 in.

8.2.3 *Length of Two Opposite Sides*—Variations in laying length of two opposite sides of pipe shall not be more than 1/4 in. for all sizes through 24-in. internal diameter, and not more than 1/8 in./ft of internal diameter for all larger sizes, with a maximum of 5/8 in. in any pipe through 84-in. internal diameter, and a maximum of 3/4 in. for 90-in. internal diameter or larger, except where beveled-end pipe for laying on curves is specified by the purchaser.

8.2.4 *Length of Pipe*—The underrun in length of a section of pipe shall not be more the 1/8 in./ft with a maximum of 1/2 in. in any length of pipe.

8.2.5 *Wall Thickness Tolerances*—The wall thickness shall not be less than the nominal specified in the design given in 5.1.2.1 by more than 5 % or 3/16 in., whichever is greater. A wall thickness more than that required in the design is not a cause for rejection, except that such pipe may not be used for the test required in 7.3.

9. Workmanship, Finish, and Appearance

9.1 Pipe shall be substantially free of fractures, large or deep cracks, and surface roughness. The ends of the pipe shall be normal to the walls and center line of the pipe, within the limits of variations given in 8.2.3.

10. Acceptance of Design

10.1 *Acceptance by Tests of Specimens*—Three to five representative specimens, or special test pipe that are shorter than standard production pipe, as agreed upon by the owner and manufacturer, shall be tested to the first visible crack

TABLE 2 Standard Designated Inside Diameters, in.

12	24	36	60	84
15	27	42	66	90
18	30	48	72	96
21	33	54	78	...

and to ultimate strength and the results recorded. Compute the values in 10.2.1 for both the first visible crack and the ultimate strength.

10.2 In addition to the requirements of 10.1, three to five representative specimens or special test pipe, shall be assessed for durability in accordance with the requirements of 12.2 and 12.3.

10.2.1 Compute the estimated standard deviation, s, by Eq 1 or 2, which yield identical values:

$$s = \sqrt{[\Sigma (X_i - \bar{X})^2]/(n-1)} \quad (1)$$

$$s = \sqrt{[\Sigma X_i^2 - (\Sigma X_i)^2/n]/(n-1)} \quad (2)$$

where:

X_i = observed value of the load to produce first visible crack (and the load to develop the ultimate strength),
$\bar{X}$ = average (arithmetic mean) of the values of X_1, and
n = number of observed values.

10.2.2 Substitute into Eq 3:

$$\bar{X}_s = L + 1.07\, s \quad (3)$$

where:

$\bar{X}_s$ = computed minimum allowable arithmetic mean, and
L = specification limit (specified D-load).

In Eq 3, the value of the estimated standard deviation, s, shall be as calculated by Eq 1 or 2 or equal to 0.07 L, whichever is greater.

10.2.3 The pipe design shall be acceptable if the arithmetic mean $\bar{X}$ for the first visible crack and ultimate strength is equal to or greater than the computer values of $\bar{X}_s$, and if all the tested specimens meet or exceed the specification limit.

11. Acceptance of Pipe by Load Testing

11.1 *Lot Sampling*—For acceptance in accordance with 4.1.1, randomly select from the lot a sample size as listed in Table 3 and test each specimen to the first visible crack. When all specimen test strengths are greater than 80 % of the minimum specified ultimate D-load, the lot shall be accepted. When one or more specimen test strengths are less than 80 % of the minimum specified ultimate D-load, the values of $\bar{X}$ and s shall be computed and substituted into the applicable equation given in Table 3. When the arithmetic mean $\bar{X}$ is equal to or greater than the computed value of $\bar{X}_s$ the lot of pipe shall be acceptable. When the arithmetic mean $\bar{X}$ is less than the computed value of $\bar{X}_s$, the lot of pipe shall be rejected for that D-load strength.

11.2 *Use of Design Test Pipe*—When the pipe tested in Section 10 were selected at random from a production lot, the test data may be used in the acceptance analysis of that lot.

11.3 *Use of Pipe Tested in the First Visible Crack Load*—Pipe that have been tested without formation of the first visible crack and that meet the crack load requirements shall be acceptable for use. All pipe that test less than the minimum required crack test load shall be removed.

12. Accelerated Aging for Assessment of Durability

12.1 As verification of durability, six pipe sections (72 in. in diameter or smaller) comprising any two nominal sizes shall be randomly selected for testing. Each pipe selected shall be cut to provide three test sections having a length not less than 2 ft.

TABLE 3 Sample Size

Lot Size	Sample Size	Equation	Equation No.
0 to 300	3	$\bar{X}_s = L + 1.08\ s$	4
301 to 500	4	$\bar{X}_s = L + 1.09\ s$	5
501 to 800	5	$\bar{X}_s = L + 1.10\ s$	6
801 to 1300	7	$\bar{X}_s = L + 1.16\ s$	7

12.2 Each test section shall be immersed in potable water at 122 ± 4°F for not less than 90 days, after which it should be removed from the water and allowed to dry at ambient temperature. These test sections shall then be tested in accordance with Section 10 for compliance with the appropriate strength requirement. The test results shall then be compared with like specimens produced for acceptance of design, Section 10. The accelerated aging specimens value for $\bar{X}$ shall be equivalent in value to $\bar{X}$ for those specimens.

NOTE 7—Equivalent in value is used to acknowledge that normal sampling variations, both plus and minus, do occur in comparative testing of like specimens.

12.3 These tests shall be repeated in the event of a change in manufacturing procedures, cement or alkali-resistant glass used.

13. Inspection

13.1 The quality of materials, process of manufacture, and the finished pipe shall be subject to inspection by the owner.

14. Rejection

14.1 Pipe shall be subject to rejection for failure to conform to any of the specification requirements. Individual sections of pipe may be rejected because of any of the following:

14.1.1 Fractures or cracks passing through the wall, except for a single longitudinal end crack that does not exceed 2 in. in length.

14.1.2 Defects that indicate imperfect proportioning, mixing, and molding.

14.1.3 Damaged ends where such damage would prevent making a satisfactory joint.

15. Disposition of a Rejected Lot

15.1 A lot of pipe which fails to meet the criteria for acceptability may be utilized in accordance with a procedure mutually agreed to by the manufacturer and the owner. The procedure may demonstrate improvement in the lot, statistically calculate a reduced D-load strength for the lot, or develop an acceptable disposition. The manufacturer shall bear all expenses incurred by the procedure.

16. Repairs

16.1 Pipe may be repaired, if necessary, because of imperfections in manufacture, damage during handling, or pipe that have been cored for testing, and will be acceptable if, in the opinion of the owner, the repairs are sound and properly finished and cured and the repaired pipe conforms