Designation: C654M – 15

# Standard Specification for Porous Concrete Pipe (Metric)[1]

This standard is issued under the fixed designation C654M; 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 U.S. Department of Defense.*

## 1. Scope

1.1 This specification covers porous nonreinforced concrete pipe for use in underdrains.

1.2 This specification is the metric counterpart of Specification C654.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

C33/C33M Specification for Concrete Aggregates
C150/C150M Specification for Portland Cement
C260/C260M Specification for Air-Entraining Admixtures for Concrete
C494/C494M Specification for Chemical Admixtures for Concrete
C497M Test Methods for Concrete Pipe, Manhole Sections, or Tile (Metric)
C595/C595M 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/C989M Specification for Slag Cement for Use in Concrete and Mortars
C1017/C1017M Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C1116/C1116M Specification for Fiber-Reinforced Concrete
C1602/C1602M Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete

## 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 two classes identified as "Standard-Strength Porous Nonreinforced Concrete Pipe" and "Extra-Strength Porous Nonreinforced Concrete Pipe."

## 5. Basis of Acceptance

5.1 The acceptability of the pipe shall be determined by the results of the strength and porosity or rate of infiltration tests, and by inspection to determine whether the pipe conforms to this specification as to design and freedom from defects.

5.2 The pipe shall be acceptable under the strength tests when they have met the requirements as prescribed in Section 10.

5.3 *Acceptance as to Infiltration Properties*—Pipe shall be acceptable under the infiltration test when all test pipe conform to the test requirements as prescribed in Section 10.

## 6. Materials

6.1 *Concrete*—The concrete shall consist of cementitious materials, mineral aggregates, admixtures, if used, and water.

6.2 *Cementitious Materials:*

6.2.1 *Cement*—Cement shall conform to the requirements for portland cement of Specification C150/C150M or shall be portland blast-furnace slag cement, portland-limestone cement, or portland-pozzolan cement conforming to the requirements of Specification C595/C595M, 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 Specification C618, Class F or Class C.

6.2.3 *Slag Cement*—Slag cement shall conform to the requirements of Grade 100 or 120 of Specification C989/C989M.

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 Portland-pozzolan cement only,
6.2.4.4 Portland-limestone cement only,

[1] This specification is under the jurisdiction of ASTM Committee C13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.01 on Non-Reinforced Concrete Sewer, Drain and Irrigation 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.

6.2.4.5 A combination of portland cement or portland-limestone cement and fly ash,

6.2.4.6 A combination of portland cement or portland-limestone cement and slag cement,

6.2.4.7 A combination of portland cement or portland-limestone cement, fly ash, and slag cement, or

6.2.4.8 A combination of portland-pozzolan cement and fly ash.

6.3 *Aggregates*—Aggregates shall conform to the requirements of Specification C33/C33M, except that the requirement for gradation shall not apply.

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

6.4.1 Air-entraining admixture conforming to Specification C260/C260M;

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 *Fibers*—Synthetic fibers and nonsynthetic fibers shall be allowed to be used, at the manufacturer's option, in concrete pipe as a nonstructural manufacturing material. Synthetic fibers (Type II and Type III) and nonsynthetic fiber (Type I) designed and manufactured specifically for use in concrete and conforming to the requirements of Specification C1116/C1116M shall be accepted.

6.6 *Water*—Water used in the production of concrete shall be potable or nonpotable water that meets the requirements of Specification C1602/C1602M.

## 7. Design

7.1 *Design Tables*—Design requirements shall be in accordance with Table 1 and Table 2 and Fig. 1. Wall thickness used shall be not less than the value shown, except as affected by the tolerance herein specified.

## 8. Joints

8.1 The joints shall be of such design and the ends of the concrete pipe sections so formed that the pipe can be laid together to make a continuous line of pipe compatible with the permissible variations given in Section 7.

**TABLE 1 Physical and Dimensional Requirements of Porous Concrete Pipe**

| Internal Designated Diameter, *D* | Minimum[A] Wall Thickness, *T* | Minimum Laying Length[A] | Minimum Socket Depth, $L_s$ | Minimum Strength Three-Edge-Bearing | Minimum Infiltration |
|---|---|---|---|---|---|
| mm | mm | mm | mm | kN/m | L/s·m |
| 100 | 25 | 600 | 25 | 14.5 | 0.8 |
| 150 | 25 | 600 | 25 | 16.0 | 1.0 |
| 200 | 32 | 600 | 32 | 19.0 | 1.5 |
| 250 | 35 | 600 | 35 | 20.5 | 2.0 |
| 300 | 38 | 600 | 38 | 22.0 | 2.5 |
| 375 | 44 | 600 | 44 | 25.5 | 3.0 |
| 450 | 50 | 600 | 50 | 29.0 | 3.5 |
| 525 | 57 | 600 | 57 | 32.0 | 4.0 |
| 600 | 63 | 600 | 63 | 35.0 | 4.5 |

[A] Normally the minimum laying length is 600 mm in length, but if the owner has no objections, then 450-mm length pipe up to 300 mm in diameter shall be acceptable.

**TABLE 2 Physical and Dimensional Requirements of Extra-Strength Porous Concrete Pipe**

| Internal Designated Diameter, *D* | Minimum[A] Wall Thickness, *T* | Minimum Laying Length[A] | Minimum Socket Depth, $L_s$ | Minimum Strength Three-Edge-Bearing | Minimum Infiltration |
|---|---|---|---|---|---|
| mm | mm | mm | mm | kN/m | L/s·m |
| 150 | 32 | 600 | 32 | 32.0 | 1.0 |
| 200 | 38 | 600 | 38 | 38.0 | 1.5 |
| 250 | 41 | 600 | 41 | 41.0 | 2.0 |
| 300 | 50 | 600 | 50 | 44.0 | 2.5 |
| 375 | 57 | 600 | 57 | 46.5 | 3.0 |
| 450 | 63 | 600 | 63 | 46.5 | 3.5 |

[A] Normally the minimum laying length is 600 mm in length, but if the owner has no objections, then 450-mm length pipe up to 300 mm in diameter shall be acceptable.

**TABLE 3 Permissible Variations in Dimensions of Porous Concrete Pipe**

| | Limits of Permissible Variation | | | |
|---|---|---|---|---|
| Internal Designated Diameter, | Wall Thickness,[A] | Length, Two Opposite Sides | Length, | Depth of Socket,[A] |
| mm | mm | mm | mm/m | mm |
| 100 | –2 | 6 | –20 | –3 |
| 150 | –2 | 6 | –20 | –3 |
| 200 | –2 | 8 | –20 | –6 |
| 250 | –2 | 10 | –20 | –6 |
| 300 | –2 | 10 | –20 | –6 |
| 375 | –2 | 11 | –20 | –6 |
| 450 | –2 | 13 | –20 | –6 |
| 525 | –3 | 14 | –20 | –6 |
| 600 | –3 | 14 | –31 | –6 |

[A] The minus sign (–) indicates that the plus variation is not limited.

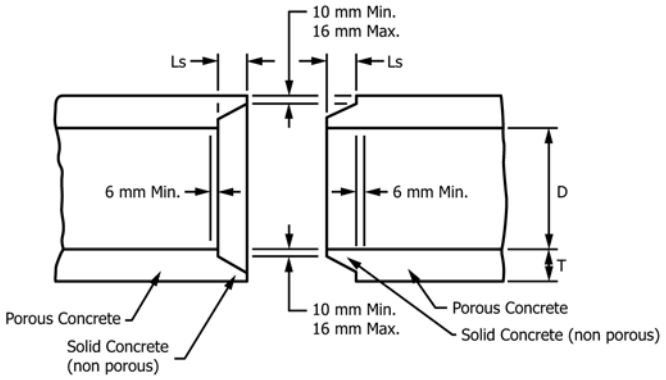
## 9. Manufacture

9.1 *Mixture*—The aggregates shall be sized, graded, proportioned, and mixed with such proportions of cementitious materials and water as will produce a homogeneous concrete mixture of such quality that the pipe will conform to the test and design requirements of this specification.

9.2 *Curing*—Pipe shall be subjected to any one of the methods of curing described in 9.2.1 through 9.2.3, or to any other method or combination of methods approved by the owner that will give satisfactory results. The pipe shall be cured for a sufficient length of time so that the concrete will develop the specified strength requirement at 28 days or less.

9.2.1 *Steam Curing*—Pipe shall be placed in a curing chamber, free from outside drafts, and cured in a moist atmosphere maintained by the injection of steam for such time and at such temperature as needed to enable the pipe to meet the strength requirements. The curing chamber shall be constructed as to allow full circulation of steam around the entire pipe.

9.2.2 *Water Curing*—Concrete pipe shall be water-cured by covering with water-saturated material or by a system of perforated pipes, mechanical sprinklers, porous hose, or by any




**NOTE—See Tables 1 and 2 for values of *D*, *T*, and $L_S$.**

**FIG. 1 Joint Dimensions**

other approved method that will keep the pipe moist during the specified curing period.

9.2.3 The manufacturer has the option to combine the methods described in 9.2.1 and 9.2.2 provided the specified strength is attained.

9.3 *Specials:*

9.3.1 *General Requirements*—Special shapes or fittings such as wyes, tees, bends, and adapters for use with concrete pipe conforming to this specification shall be made of porous or nonporous concrete in such manner as will provide strength at least equal to the class of the adjacent pipe to which they are joined; and shall conform to all other requirements specified for pipe of corresponding class and internal diameter, except minimum infiltration. Joints shall be the same type as used in the adjoining pipe.

9.3.2 *Wyes and Tees*—Fabricated branches for wyes and tees shall be securely attached to the wall of the pipe and shall be flush with the inside surface of the pipe.

## 10. Physical Requirements

10.1 *Test Specimen*—The specified number of pipe required for the tests shall be furnished by the manufacturer and shall be selected at random by the owner, and shall be pipe that would not otherwise be rejected under this specification. The selection shall be made at the point or points designated by the owner when placing the order. The test pipe shall first be freed from all visible moisture. When dry, each pipe shall be measured and inspected. The results of these observations shall be recorded.

10.2 *Number and Type of Test Specimens*—The manufacturer shall furnish pipe for crushing tests, up to 0.5 % of the number of pipe of each size included in the order, except that in no case shall less than two pipes be furnished.

10.3 *External Load Crushing Requirements*—The crushing strength of porous nonreinforced concrete pipe shall conform to the requirements prescribed in Table 1 and Table 2. The individual results of the various tests for each size of pipe and for each shipment and plant shall be tabulated separately. The crushing strength shall ordinarily be applied to not less than 75 % of the pipe received for purpose of test. All tests shall be made in accordance with Test Methods C497M. Pipe shall be acceptable when all test pipe conform to the specified strength requirement. Should any of the test pipe provided in 10.2 fail to meet the strength requirement, the manufacturer will be allowed to test two pipe for each pipe that failed, and the pipe shall be acceptable only when all of these additional test pipe meet the strength requirement.

10.4 *Infiltration Requirement*—Infiltration (or porosity) shall conform to the requirements in Table 1 or Table 2.

10.4.1 The test pipe shall be placed with a spigot end down on a soft rubber nonpermeable mat, or its equivalent, and weighted or clamped down if necessary to prevent the escape of water through the spigot end of the pipe.

10.4.2 Water shall be introduced into the pipe, and the distance above the bottom of the porous section at which the water level becomes constant shall be determined. The rate of flow shall be at least equal to the required minimum infiltration for 1 m of pipe as given in Table 1 or Table 2.

10.4.3 The rate of infiltration per metre of pipe shall be determined as follows:

$$LITRES/s = L/h \quad (1)$$

where:

*LITRES/s* = infiltration rate in litres per second per metre of pipe,
*L* = litres per second of flow introduced into the test pipe, and
*h* = height in metres from the bottom of the porous section of the pipe at which the level of water becomes constant.

10.5 *Test Equipment*—The manufacturer shall furnish all equipment, facilities, and personnel necessary to perform at his plant the tests specified in Section 10. In the event that the owner elects to have tests performed at any other location, the manufacturer will not be required to furnish equipment, facilities, nor personnel.

## 11. Permissible Variations

11.1 Permissible variations from the dimensions described in Table 1 and Table 2 shall not exceed those stated in Table 3

and . This is not to be construed, however, that heavier wall thickness pipe cannot be furnished at the option of the manufacturer. Pipe intended to be straight shall not have variation in alignment of more than 10 mm/m of length.

11.2 *Internal Diameter*—See Table 4. At the manufacturer's option, the internal diameter shall be one of two alternatives, the Designated Diameter or the Converted English Diameter. Pipe sections that are intended to be jointed to each other shall be furnished with the same internal diameter alternative. The internal diameter of pipe manufactured to the Designated Diameters shall vary not more than ±3 mm from the Designated Diameter for 100 mm and 150 mm and ±6 mm for larger pipe. The internal diameter of pipe manufactured to the Converted English Diameters shall vary not more than ±3 mm from the Converted English Diameter for 102 mm and 152 mm and ±6 mm for larger pipe. For pipe manufactured to Converted English Diameters, the corresponding Designated Diameter shown in Table 4 shall apply for all other requirements of this specification.

## 12. Repairs

12.1 Pipe repaired because of imperfections in manufacture or damage during handling will be acceptable, if in the opinion of the owner, the repaired pipe conforms to the requirements of this specification.

**TABLE 4 Internal Diameters**

| Designated Diameter, mm | Eqivalent English Diameter, in. | Converted English Diameter, mm |
|---|---|---|
| 100 | 4 | 102 |
| 150 | 6 | 152 |
| 200 | 8 | 203 |
| 250 | 10 | 254 |
| 300 | 12 | 305 |
| 375 | 15 | 381 |
| 450 | 18 | 457 |
| 525 | 21 | 533 |
| 600 | 24 | 610 |

## 13. Inspection

13.1 The quality of all materials, the process of manufacture, and the finished pipe shall be subject to the inspection and approval by the owner. Such inspection shall be performed either at the point of manufacture or delivery.

## 14. Rejection

14.1 Pipe shall be subject to rejection on account of failure to conform to any of the specification requirements. It is not prohibited for individual sections of pipe to be rejected because of any of the following:

14.1.1 Fractures or cracks passing through the wall or joints, except that a single crack not exceeding 50 mm in length at either end of a pipe or a single fracture in the joints not exceeding 75 mm in width nor more than 50 mm in length shall not be considered cause for rejection unless these defects exist in more than 5 % of the entire shipment or delivery.

14.1.2 The planes of the ends of the pipe are not perpendicular to the longitudinal axis, subject to the limits of variation as shown in Table 3.

14.1.3 Defects that indicate mixing and molding not in accordance with 9.1.

14.1.4 Cracks sufficient to impair the strength, durability, or serviceability of the pipe.

## 15. Product Marking

15.1 The letters "ES" shall be legibly stamped with waterproof ink, or other permanent matter, on all extra-strength porous concrete pipe.

## 16. Keywords

16.1 concrete pipe; nonreinforced; porous; underdrains