



**Designation: C 412 – 99**

## **Standard Specification for Concrete Drain Tile<sup>1</sup>**

This standard is issued under the fixed designation C 412; 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 ( $\epsilon$ ) 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 concrete drain tile with internal diameters from 4 to 36 in. that are intended to be used for surface and subsurface drainage.

1.2 A complete metric companion to Specification C 412 has been developed—C 412M; 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 drain tile. However, experience has shown that the successful performance of the product depends upon the proper selection of the class of drain tile, type of bedding and backfill, and care that the installation conforms to the construction specifications. The owner is cautioned that he must correlate the field requirements with the class of drain tile specified and provide for or require inspection at the construction site.

### **2. Referenced Documents**

#### 2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates<sup>2</sup>

C 150 Specification for Portland Cement<sup>3</sup>

C 497 Test Methods for Testing Concrete Pipe, Manhole Sections, or Tile<sup>4</sup>

C 595 Specification for Blended Hydraulic Cements<sup>3</sup>

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete<sup>2</sup>

C 822 Terminology Relating to Concrete Pipe and Related Products<sup>4</sup>

### **3. Terminology**

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

### **4. Classification**

4.1 Drain tile manufactured according to this specification

shall be of the following four classes:

4.1.1 *Standard-Quality Concrete Drain Tile*, intended for land drainage of ordinary soils where the tile are laid in trenches of moderate depths and widths. Standard-Quality concrete drain tile are not recommended for use where internal diameters in excess of 12 in. are required.

4.1.2 *Extra-Quality Concrete Drain Tile*, intended for land drainage of ordinary soils where the tile are laid in trenches of considerable depths or widths, or both.

4.1.3 *Heavy-Duty Extra-Quality Concrete Drain Tile*, intended for land drainage of ordinary soils where the tile are laid in trenches of large depths or widths, or both.

4.1.4 *Special-Quality Concrete Drain Tile*, intended for land drainage where special precautions are necessary for concrete tile laid in soils that are markedly acid or contain unusual quantities of sulfates (see Section 7), and where the tile are laid in trenches of considerable depths or widths, or both.

4.1.4.1 Where the calculated loads are in excess of the crushing strengths prescribed in the physical requirements for extra-quality and special-quality concrete drain tile, tile strengths must be specified in advance by the owner.

### **5. Basis of Acceptance**

5.1 The acceptability of drain tile shall be determined by (1) the results of the physical tests as specified in Section 8, and in Test Methods C 497, (2) measurements and inspection to ascertain whether the tile conform to the requirements regarding dimensions, shape, and freedom from visible defects, and (3) the manufacturer's certification in writing that the tile have been made in accordance with any special provisions, such as strength, absorption, permeability, type of cement, admixture, curing conditions, etc.

5.2 The owner shall specify in writing the class or classes of concrete tile to be supplied, whether Standard-Quality, Extra-Quality, Heavy-Duty Extra-Quality, or Special-Quality. Unless Extra-Quality, Heavy-Duty Extra-Quality, or Special-Quality concrete drain tile have been specified, Standard-Quality drain tile shall be accepted.

### **6. Materials**

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

6.2 *Cementitious Materials:*

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee C-13 on Concrete Pipe and is the direct responsibility of Subcommittee C13.01 on Reinforced Concrete Sewer, Drain, and Irrigation Pipe.

Current edition approved Aug. 10, 1999. Published September 1999. Originally published as C 412–58T. Last previous edition C 412–94.

<sup>2</sup> *Annual Book of ASTM Standards*, Vol 04.02.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 04.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 04.05.



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 requirements for gradation shall not apply.

6.4 *Admixtures and Blends*—Admixtures and blends may be used with the approval of the owner.

## 7. Chemical Requirements

### 7.1 Acid and Sulfate Resistance:

7.1.1 The owner may specify special requirements in order to increase the durability of the drain tile in cases where the soils, soil waters, or drainage waters are markedly acid or contain moderate or severe quantities of soil sulfates. Without a specific agreement in advance, no drain tile shall be rejected by reason of its composition as determined later by chemical analyses.

7.1.1.1 Soils or drainage waters with a pH of 6.0 or lower shall be considered to be markedly acid.

7.1.1.2 Where the sulfates are chiefly sodium or magnesium, singly or in combination, from 400 to 2000 ppm in the soil or drainage water, samples may be considered to constitute moderate sulfate quantities, while in excess of 2000 ppm shall be considered to be severe sulfate quantities.

7.1.2 Concrete drain tile that will be installed in markedly acid soils shall meet the physical requirements given in the table for Special-Quality concrete drain tile.

7.1.3 Tile that will be exposed to moderate or severe sulfate quantities (Note 2) may be specified to meet the physical requirements for Special-Quality concrete drain tile (8.3.4). Tile that will be exposed to moderate sulfate quantities (Note 2) may be specified to be made with Portland Cement (C 150) containing not more than 8 % tricalcium aluminate (C3A). Tile that will be exposed to severe sulfate quantities (Note 2) may be specified to be made with Portland Cement (C 150) containing not more than 5 % C3A. If mutually agreed upon between the manufacturer and owner, other cements, as described in Section 6, that have been proven to be adequately sulfate resistant may be used.

## 8. Physical Requirements

8.1 *Test Specimens*—The drain tile to be tested shall be selected at random by the owner at the point or points specified in the order. If agreeable to the owner, the tile may be inspected and tested in advance of shipment. Any additional expense for making tests and inspection in advance of shipment shall be paid by the manufacturer.

8.2 *Standard Sample*—Each standard physical test shall be made on five individual tile of each size ranging from 4-in. through 12-in. diameters; two individual tiles of each size ranging from 14-in. through 24-in. diameters; or on one tile of each size exceeding 24 in. in diameter. The manufacturer shall furnish tile without separate charge up to 0.5 % of each size of the order. The owner shall pay for all the tile in excess of 0.5 % of each size of the order at the same price as paid for other tile of the same size and quality.

### 8.3 External Load Crushing Strength Test Requirements:

8.3.1 For Standard-Quality concrete drain tile, the three-edge-bearing crushing strength shall meet the requirements given in Table 1, Column A, where no absorption test is required, or the three-edge-bearing crushing strength shall meet the requirements given in Table 1, Column B, where an absorption test is required of the limits noted in Table 1.

8.3.2 For Extra-Quality concrete drain tile, the three-edge-bearing crushing strength shall meet the requirements given in Table 2, Column A, where no absorption test is required, or the

**TABLE 1 Physical Test Requirements for Standard-Quality Concrete Drain Tile**

Internal Designated Diameter, in.	Maximum Wall Thickness for Indicated Strength, <sup>A</sup> in.	Standard-Quality Concrete Drain Tile					
		Three-Edge Bearing Crushing Strength <sup>B</sup>			Method A Absorption		
		Minimum Average, lbf/linear ft	Minimum Average, lbf/linear ft	Minimum for Individual Tile, lbf/linear ft	Maximum Average, %	Maximum for Individual Tile, %	
		A	B				
4	...	...	800	700	10	11	
5	9/16	900	800	700	10	11	
5	5/8	1000	800	700	10	11	
6	5/8	900	800	700	10	11	
6	3/4	1000	800	700	10	11	
8	3/4	900	800	700	10	11	
8	7/8	1000	800	700	10	11	
10	7/8	900	800	700	10	11	
10	1	1000	800	700	10	11	
12	1	900	800	700	10	11	
12 <sup>C</sup>	1 1/8	1000	800	700	10	11	

<sup>A</sup> Maximum wall thickness for the indicated minimum average crushing strength, Column A, when no absorption test is required.

<sup>B</sup> Drain tile meeting the above strength requirements are not necessarily safe against cracking in deep and wide trenches.

<sup>C</sup> Tile with diameters greater than 12 in., shall meet the requirements specified in Table 2 for Extra-Quality, Table 3 for Heavy-Duty Extra-Quality, or Table 4 for Special-Quality concrete drain tile.



**TABLE 2 Physical Test Requirements for Extra-Quality Concrete Drain Tile**

Internal Designated Diameter, in.	Extra-Quality Concrete Drain Tile						
	Wall Thickness, in.	Maximum Wall Thickness for Indicated Strength, <sup>A</sup> in.	Three-Edge-Bearing Crushing Strength <sup>B</sup>			Method A Absorption	
			Minimum Average, lbf/linear ft	Minimum Average, lbf/linear ft	Minimum for Individual Tile, lbf/linear ft	Maximum Average, %	Maximum for Individual Tile, %
			A	B			
4	1/2	...	...	1100	990	9	10
5	9/16	9/16	1200	1100	990	9	10
5	9/16	5/8	1300	1100	990	9	10
6	5/8	5/8	1200	1100	990	9	10
6	5/8	3/4	1300	1100	990	9	10
8	3/4	3/4	1200	1100	990	9	10
8	3/4	7/8	1300	1100	990	9	10
10	7/8	...	...	1100	990	9	10
12	1	...	...	1100	990	9	10
14	1 1/8	...	...	1100	990	9	10
15	1 1/4	...	...	1100	990	9	10
16	1 3/8	...	...	1100	990	9	10
18	1 1/2	...	...	1200	1080	9	10
20	1 5/8	...	...	1330	1200	9	10
22	1 3/4	...	...	1460	1320	9	10
24	2	...	...	1600	1440	9	10
26	2 1/8	...	...	1730	1560	9	10
28	2 3/8	...	...	1870	1680	9	10
30	2 1/2	...	...	2000	1800	9	10
32	2 5/8	...	...	2130	1920	9	10
34	2 7/8	...	...	2270	2040	9	10
36	3	...	...	2400	2160	9	10

<sup>A</sup> Maximum wall thickness for the indicated minimum average crushing strength, Column A, when no absorption test is required.

<sup>B</sup> For crushing strengths greater than or equal to those shown in the above table, tile may be supplied using designs with increased wall thickness, higher strength concrete, or reinforcing.

three-edge-bearing crushing strength shall meet the requirements given in Table 2, Column B, where an absorption test is required of the limits noted in Table 2.

8.3.3 For Heavy-Duty Extra-Quality concrete drain tile, the three-edge-bearing crushing strength shall meet the requirements given in Table 3.

8.3.4 For Special-Quality concrete drain tile, the three-edge-bearing crushing strength shall meet the requirements given in

Table 4, or the higher specified load.

NOTE 2—To meet the crushing strength requirements shown in the tables, the tile may be supplied using designs with increased wall thickness, high-strength concrete, or reinforcing, or a combination.

**8.4 Absorption Tests:**

NOTE 3—Method A absorption test is recommended for drain tile having diameters of 12 in. or less. When Method B absorption test is used,

**TABLE 3 Physical Test Requirements for Heavy-Duty Extra-Quality Concrete Drain Tile**

Internal Designated Diameter, in.	Heavy-Duty Extra-Quality Concrete Drain Tile				
	Wall Thickness, in.	Three-Edge-Bearing Crushing Strength <sup>A</sup>		Method A Absorption	
		Minimum Average, <sup>B</sup> lbf/linear ft	Minimum for Individual Tile, lbf/linear ft	Maximum Average, %	Maximum for Individual Tile, %
4	1/2	1300	1170	9	10
5	9/16	1300	1170	9	10
6	5/8	1300	1170	9	10
8	3/4	1300	1170	9	10
10	7/8	1400	1260	9	10
12	1	1500	1350	9	10
14	1 1/8	1750	1580	9	10
15	1 1/4	1870	1690	9	10
16	1 3/8	2000	1800	9	10
18	1 1/2	2250	2030	9	10
20	1 5/8	2500	2250	9	10
22	1 3/4	2750	2470	9	10
24	2	3000	2700	9	10
26	2 1/8	3250	2930	9	10
28	2 3/8	3500	3150	9	10
30	2 1/2	3750	3380	9	10
32	2 5/8	4000	3600	9	10
34	2 7/8	4250	3820	9	10
36	3	4500	4050	9	10

<sup>A</sup> For crushing strengths greater than or equal to those shown in the above table, tile may be supplied using designs with increased wall thickness, higher strength concrete, or reinforcing.

<sup>B</sup> Calculated average crushing strengths, for tile sizes above 10-in. diameter, are based on a minimum ultimate three-edge-bearing load of 1500 *D*, where *D* is the internal diameter of the tile in feet.



**TABLE 4 Physical Test Requirements for Special-Quality Concrete Drain Tile**

Special-Quality Concrete Drain Tile (for tile exposed to corrosive waters)

Internal Designated Diameter, in.	Minimum Wall Thickness, in.	Minimum Individual Three-Edge-Bearing Crushing Strength, <sup>A</sup> lb/linear ft	Method A Absorption		Sulfate Exposures
			Maximum Average, %	Maximum for Individual Tile, %	
4	1/2	1100	8	9	For sulfate exposures, sulfate-resistant cement should be specified (see Section 7).
5	9/16	1100	8	9	
6	5/8	1100	8	9	
8	3/4	1100	8	9	
10	7/8	1100	8	9	
12	1	1100	8	9	
14	1 1/8	1100	8	9	
15	1 1/4	1100	8	9	
16	1 3/8	1100	8	9	
18	1 1/2	1200	8	9	
20	1 5/8	1330	8	9	
22	1 3/4	1460	8	9	
24	2	1600	8	9	
26	2 1/8	1730	8	9	
28	2 3/8	1870	8	9	
30	2 1/2	2000	8	9	
32	2 5/8	2130	8	9	
34	2 7/8	2270	8	9	
36	3	2400	8	9	

<sup>A</sup> For crushing strengths greater than or equal to those shown in the above table, tile may be supplied using designs with increased wall thickness, higher strength concrete, or reinforcing.

the absorption requirements shall be 0.5 % less than the Method A absorption requirements, as shown in Table 1, Table 2, Table 3, or Table 4. Method B absorption procedure is described in Test Methods C 497.

8.4.1 For Standard-Quality concrete drain tile, the Method A absorption test shall meet the requirements given in Table 1. No absorption tests are required if the strength requirements of Table 1, Column A, are met.

8.4.2 For Extra-Quality concrete drain tile, the Method A absorption test shall meet the requirements given in Table 2. No absorption tests are required if the strength requirements of Table 2, Column A, are met.

8.4.3 For Heavy-Duty Extra-Quality concrete drain tile, the Method A absorption test shall meet the requirements given in Table 3.

8.4.4 For Special-Quality concrete drain tile the Method A absorption test shall meet the requirements given in Table 4.

8.4.5 Specimens for the Method A absorption tests shall be selected in accordance with the following provisions:

8.4.5.1 For the tile with inside diameters of 12 in. or less, and lengths of 12 in., the absorption test shall be made on one full-length quarter segment taken from each of the five tile broken in the strength test, constituting a standard sample as defined in 8.2. By quarter segment is meant one of the four pieces into which a tile usually breaks in the strength test. If a tile breaks in such a manner that a satisfactory quarter segment cannot be obtained, then the absorption test shall be made of two or more pieces that approximate the area of a quarter tile of that size selected so that both ends and the center portion of the tile are represented. The average absorption of the pieces so selected shall be considered the absorption for that tile.

8.4.5.2 For nonreinforced tile with inside diameters or lengths in excess of 12 in., the absorption test shall be made on three specimens: one of the specimens shall be taken from one end of the tile, another specimen from the opposite end, and the third specimen from near the center. The average absorption of

the three specimens shall be considered the absorption for that tile.

8.4.5.3 For reinforced tile, the absorption test shall be made on one specimen taken from each test tile.

8.4.5.4 The specimens shall be the full thickness of the tile, as broken or cut from segments that result from the strength test. Each specimen shall have a minimum area of not less than 25 in.<sup>2</sup> as measured on one wall surface.

8.4.5.5 The average absorption for Standard-Quality, Extra-Quality, and Heavy-Duty Extra-Quality tile shall be the average of the absorption tests for the standard sample as defined in 8.2 or the average of the absorption tests for the strongest and the weakest tile as measured by the crushing strength of the standard sample. When drain tile fail to meet the absorption test requirement as computed by averaging the absorptions from the weakest and the strongest tile of a standard sample, then the average absorption test shall be computed by averaging the absorption tests from all the tile from the standard sample. The average absorption for the Special-Quality tile shall be the average of the absorption tests for the tile constituting the standard sample.

8.4.6 Specimens for the Method B absorption tests shall be selected in accordance with Test Methods C 497.

**8.5 Retests:**

8.5.1 Should the tile first selected fail to conform to the test requirements, the manufacturer may, at his expense, cull the tile and have other tile selected for retest from the remaining stock. For such retests, the number of tile shall be twice the number of tile used in the previous failed test for each standard physical test. In the event of failure of the tile after retest, reject the tile without further test. The manufacturer shall pay all cost for any retest demanded and made.

8.6 *Apparatus*—All apparatus used shall be in accordance with that described in Test Methods C 497.

8.7 *Test Methods*— The test methods shall be as described



in Test Methods C 497.

## 9. Permissible Variations

9.1 *Internal Diameter*—Internal diameter shall not vary from the designated diameter by more than  $\frac{1}{4}$  in. for 4 and 5-in. tile,  $\frac{3}{8}$  in. for 6 and 8-in. tile,  $\frac{1}{2}$  in. for 10 to 14-in. tile,  $\frac{5}{8}$  in. for 15 to 18-in. tile,  $\frac{3}{4}$  in. for 20 to 24-in. tile, and 1 in. for 26 to 36-in. tile.

### 9.2 *Wall Thickness*:

9.2.1 No wall thickness is specified for Standard-Quality concrete drain tile where the crushing strength and the absorption tests are used to determine the tile quality. When only the crushing strength is used to determine Standard-Quality tile then the wall thickness for Standard-Quality tile shall be as indicated in Table 1. The wall thickness of Extra-Quality and Heavy-Duty Extra-Quality concrete drain tile at any point shall not be less than the full thickness specified in Table 2 or Table 3 by more than  $\frac{1}{16}$  in. for the tile having inside diameter of 4, 5, and 6 in.,  $\frac{3}{32}$  in. for tile having inside diameters of 8 to 10 in.,  $\frac{1}{8}$  in. for tile having inside diameters of 12 to 24 in., and  $\frac{5}{32}$  in. for tile having inside diameters of 26 to 36 in. The minimum thickness of Special-Quality drain tile walls at any point shall be not less than shown in Table 4.

9.2.2 The tile wall thickness shall be recorded as the average of 12 wall thickness measurements as made at the top, center, and bottom locations on each of the four quarter tile segments that usually result when a tile is tested for crushing strength. If a tile breaks in such a manner that a satisfactory quarter segment is not obtained, then the 12 wall thickness measurements shall be made on the broken pieces that best represent the top, center, and bottom on the four circumferential locations of the tile.

9.3 *Length of Tile*—The length of drain tile smaller than 12 in. in diameter shall be not less than 12 in. Tile of 12 to 36 in. in diameter, inclusive, shall have lengths not less than the diameters. The underrun of individual tile shall not exceed 3 % of the length.

9.4 *Shape*—All drain tile shall be circular in cross section, except when otherwise specified in advance. They shall be

approximately straight, except in the case of special connections. The ends of tile shall be so regular and smooth as to readily permit the making of satisfactory close joints and shall be so formed that when the tile are laid together the effective space at the joints will be satisfactory for good drainage.

## 10. Inspection

10.1 All drain tile shall be given a thorough inspection at the agreed delivery point by the owner, unless a satisfactory inspection has been made in advance of delivery as specified in 8.1. The purpose of the inspection shall be to determine whether the tile, independently of meeting the physical test requirements, conform to the specifications as regards shapes and sizes as prescribed in Section 9 and to eliminate defective tile as defined in Section 11. The manufacturer of the drain tile shall afford the inspector all reasonable facilities for his work, both as to the selection of tile for tests and as to inspection of the tile. Inspection shall be completed and reported promptly and full reports of all tests and inspections shall be furnished the manufacturer upon his request.

## 11. Rejection

11.1 The owner shall plainly designate all drain tile that he rejects, and such rejected tile shall be removed promptly by the manufacturer from any job to which the tile have been delivered.

11.2 Drain tile that, when placed in a vertical position, do not give a metallic ring when struck with a light metal hammer, or that are observed to have cracks that extend through the tile wall and are of a length in excess of  $\frac{1}{2}$  in., or other defects in the form or dimensions in excess of the limits permitted in this specification, shall be discarded. Outside surface irregularities that do not affect the tile strength shall not be considered reason for rejection of the tile.

## 12. Keywords

12.1 concrete drain tile; subsurface drainage; surface drainage; tile

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