



## Standard Test Method for Breaking Strength of Ceramic Tile<sup>1</sup>

This standard is issued under the fixed designation C648; 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.

### 1. Scope

1.1 This test method covers the determination of the breaking strength of glazed ceramic wall tile, ceramic mosaic tile, quarry tile, and paver tile, having a facial area of at least 1 in.<sup>2</sup> (6.4 cm<sup>2</sup>).

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

**C242 Terminology of Ceramic Whitewares and Related Products**

**E178 Practice for Dealing With Outlying Observations**

### 3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of the types of tile listed in Section 1, refer to Terminology **C242**.

### 4. Summary of Test Method

4.1 The test method consists of supporting the tile on the ends of three cylindrical rods, or on three ball bearings for tiles having an actual facial area of 9 in.<sup>2</sup> (58 cm<sup>2</sup>) (or less), arranged in an equilateral triangle, and applying force at a definite rate to the center of the tile, which coincides with the center of the triangular support, until the specimen breaks.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee **C21** on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee **C21.06** on Ceramic Tile.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

NOTE 1—The size (facial dimensions) of otherwise equal tile affects the value of breaking strength obtained by this test method. For instance, a 6 by 6-in. (152 by 152-mm) tile equal in mature body properties and thickness to a 4¼ by 4¼-in. (108 by 108-mm) tile will have a breaking strength higher than the 4¼ by 4¼-in. tile.

### 5. Significance and Use

5.1 The test method provides means for establishing whether or not a lot of ceramic tile meets the strength requirements which may appear in tile specifications. Tile strength is the force in pounds-force (or newtons), as read from the pressure gage, necessary to cause the tile to break.

### 6. Apparatus

6.1 *Specimen-Support*, consisting of a 5½ by 5½ by 1-in. (139.7 by 139.7 by 25.4-mm) steel block. Three ¼-in. (6.4-mm) diameter and ⅜-in. (9.5-mm) deep tapped holes are arranged in an equilateral triangle having 3-in. (76.2-mm) sides and whose circumscribed circle has a radius of 1.732 in. (44.0 mm). The equilateral triangle is located on the steel block so that its center coincides with that of the steel block and one side of the triangle runs parallel to one side of the steel block. Three ⅜-in. diameter steel rods, 1⅜ in. with (34.9 mm) long, one end threaded for a distance of ⅜ in. with the same ¼-in. thread as the tapped holes, and the other end ground flat, fit into the three holes. In a similar manner, a second set of three ⅜-in. diameter steel rods, but ¾ in. (19.0 mm) long only, are threaded on one end for a distance of ⅜ in., are ground flat on the other end and fit three other ¼-in. tapped holes. The three ¼-in. holes, tapped for a distance of ⅜ in. to receive this second set of steel rods are located at the apexes of an equilateral triangle having 1½-in. (38.1-mm) long sides and whose circumscribed circle has a radius of 0.866 in. (22.0 mm). This second equilateral triangle is located within the first one in such a manner that its circumscribed circle is identical with the inscribed circle of the first triangle, and its sides are parallel to those of the larger triangle. The ball bearing support consists of three ⅛-in. (3.2-mm) ball bearings arranged in an equilateral triangle, with sides of 14 mm concentric and parallel with the other triangles. The bearings are embedded in the block to the extent of half their volume. The steel block has four more ¼-in. tapped holes to receive socket head cap screws for holding four registry stops. One of these holes is located in the center of one side, ¼ in. in from the edge. Another of these is located in the center of an adjacent side ¼ in. from the edge.

The other two are located on an adjacent side,  $\frac{1}{4}$  in. in from the edge, spaced 2 in. (50.8 mm) apart, with one located  $1\frac{3}{4}$  in. (44.4 mm) from one of the corners of the first side. The two single hole registry stops are used with the ball bearing support. The double hole registry stop and the adjacent edge single stop are to be used with the sets of rod supports. Three of the registry stops designed for use with the cylindrical rod supports consist of  $\frac{1}{8}$ -in. (3.2-mm) thick steel strips,  $\frac{3}{4}$  in. wide, 2 in. long, with a  $\frac{1}{4}$ -in. wide slot extending for the full 2-in. length of the strip. The slot is open on one end and the other end of each steel strip has a  $\frac{3}{4}$  in. wide and  $1\frac{1}{2}$  in. high projection,  $\frac{1}{8}$  in. thick, which will contact the edges of the tile when in proper position for use. The other two registry stops, designed for use with the ball bearing support, have exactly the same dimensions except for their projection height which is  $\frac{5}{8}$  in. The projection is obtained by making the steel strips actually  $3\frac{1}{2}$  in. (88.9 mm) long and bending them at right angles to obtain the  $1\frac{1}{2}$ -in. or  $\frac{5}{8}$ -in. (38.1-mm or 15.9-mm) high projection. Each of the three registry stops can be fastened

with washer and socket head cap screw through its slot in any one of numerous positions. Being adjustable, they serve as registry stops for the different sizes of tile which may be broken over these supports. For tile of dimensions  $4\frac{1}{4}$  in. (107.9 mm) or smaller, the projections will be located on that end of the strip nearest to the support block; for tile having dimensions larger than  $4\frac{1}{4}$  in., the strips are reversed so that the projections are located on the end of the steel strips away from the support block (see Fig. 1). For certain mosaic tiles with dimensions of less than 1 in. (25.4 mm) length, it is necessary to reverse the position of the registry stops so that the tile is supported with the slot ends in order to avoid interference with the force applicator.

6.2 Force Applicator— Force is applied in the exact center of the triangular support by means of a  $\frac{1}{2}$ -in. (12.7-mm) diameter stainless steel ball bearing, countersunk to a depth of  $1\frac{7}{64}$  in. (6.7 mm) into one end of a 1-in. (25.4-mm) diameter and 2-in. long steel rod. A  $\frac{3}{32}$ -in. (2.4-mm) thick retaining

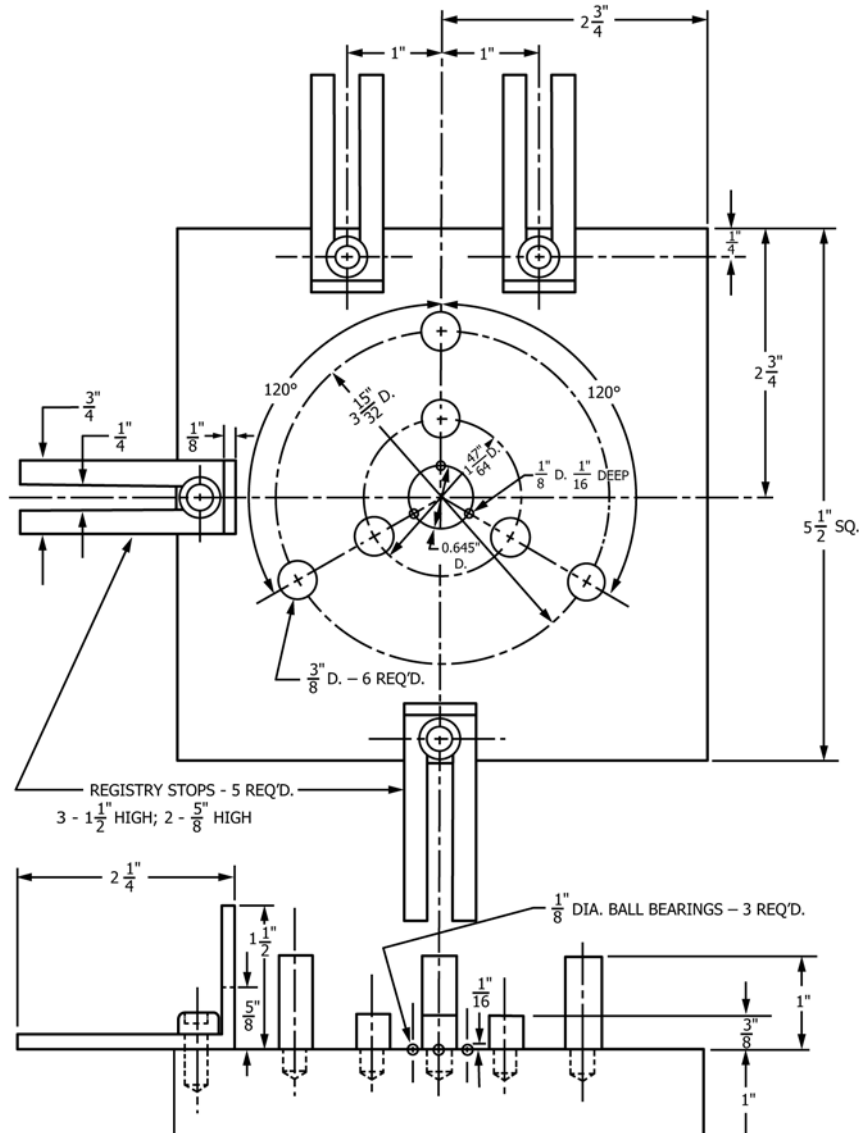


FIG. 1 Support Block Assembly (See Table 1)

**TABLE 1 Conversion of Dimensions Appearing in Figs. 1 and 2**

in.	mm	in.	mm
1/8	3.2	1 3/8	34.9
1/4	6.4	1 1/2	38.1
17/64	6.7	1 47/64	44.1
3/8	9.5	1 3/4	44.4
1/2	12.7	2	50.8
0.645	16.4	2 1/2	63.5
3/4	19.0	2 3/4	69.8
25/32	19.8	3 15/32	88.1
0.866	22.0	5 1/2	139.7
1	25.4		

collar prevents the ball from falling out of its recess and is fastened to the steel rod by four 3/32-in. 3-48 NC screws, 3/8 in. (9.5 mm) long, with countersunk heads. The opposite end of the steel rod is reduced in diameter for the proper distance and threaded to fit its female counterpart of the testing machine (see Fig. 2).

**6.3 Testing Machine**— Any apparatus, preferably motor driven, capable of maintaining a uniform load application rate of 800 to 1100 lbf (3600 to 4900 N)/min and large enough to accommodate the steel support block, shall be considered suitable testing equipment. The machine must be equipped with an interchangeable gage, which has a special peakload indicator that will remain at the highest reading reached during the test, until reset by hand to the zero point. The scale of the gage used shall have such a range that the breaking load of the

test specimens falls between 10 and 90 % of the scale capacity. The scale shall be graduated into 100 or more equal increments.

## 7. Test Specimen

**7.1 Size of Sample**—Select tile specimens at random from the lot to be tested and in the quantities designated in the specification. However, the number of tile per sample shall never be less than 10.

**7.2 Cutting of Specimens**—It may be necessary to cut tile samples down to a size that will fit the testing apparatus. A wet saw should be used for this. An equal amount may be trimmed from each edge such that the sample is the largest possible size that can be accommodated by the testing apparatus.

**7.3 Preparation of Specimens**—Remove any loosely adhering clay particles from the back of each tile with a stiff brush.

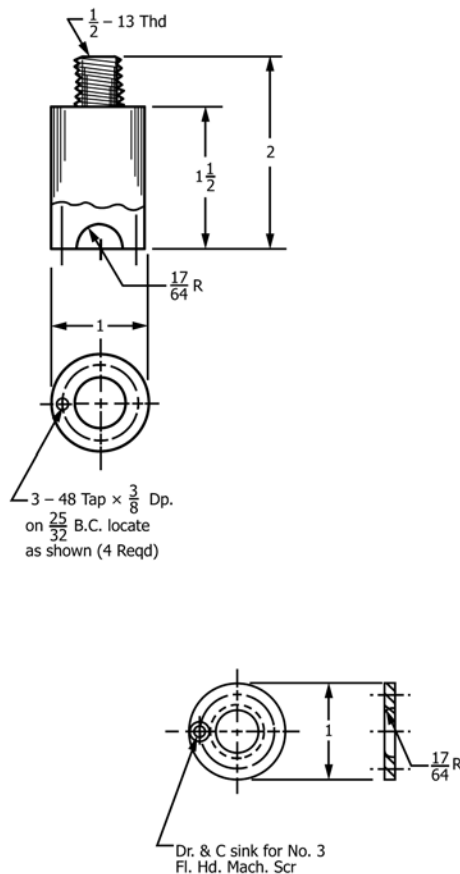
## 8. Procedure

**8.1** Place the steel support block into the testing machine so that the load applicator is directly above the center of the steel block. For tile having actual facial area greater than or equal to 62 in.<sup>2</sup> (400 cm<sup>2</sup>), use the support and rods represented by the larger triangle. For tile with actual facial areas greater than to 9 in.<sup>2</sup> and less than 62 in.<sup>2</sup> (58 cm<sup>2</sup> and 400 cm<sup>2</sup>) use the smaller triangle and rod supports. For actual facial area greater than 1 in.<sup>2</sup> and less than or equal to 9 in.<sup>2</sup> (6.4 cm<sup>2</sup> and 58 cm<sup>2</sup>) use the ball bearing support.

**8.2** Find the exact center of one tile of the sample by drawing lines across the face of the tile, connecting diagonally opposite corners, and place this tile on the proper three-point support. The face of any tile to be broken must always be in an upward position. In the case of reversible tile, such as unglazed ceramic mosaic tile, it is immaterial which side of the tile is up. Tile with directional back designs must be placed on the triangular support so that any ribs or grooves run parallel to those support rods which are arranged parallel to one side of the steel block.

**8.3** Lower the load applicator and move the tile with the diagonal lines so that its center is directly below the center of the load applicator ball. With the tile in this position, move the three adjustable registry stops so that their vertical projections are in contact with two adjacent sides of the tile and fasten them in that position. It may be necessary to remove one of the support rods, by unscrewing it from the 5 1/2 -in. (140-mm) square steel block, in order to position all the registry stops without interference. If the tile is a size such that the vertical projections on the registry stops will interfere with the force application, use the slot ends of the registry stops to fix the position of the tile. Except for minor size variations, the registry stops will now locate every tile of the sample in the relatively same spot on the support, so that force is applied in the approximate center of each tile.

**8.4** Position a safety shield around the apparatus so that no person or property will be injured from possible contact with broken tile. The use of a safety shield is mandatory in testing the breaking strength of ceramic mosaic tile, which can break into shrapnel-like fragments.

**FIG. 2 Force Applicator Details (See Table 1)**

8.5 Whenever the approximate force required to break the particular type of tile is not known, it is necessary to break several tile prior to starting the test in order to establish the range of the gage to be used. Install the proper gage and set the peak-load indicator to zero.

8.6 Apply force at the rate of 800 to 1100 lbf (3600 to 4900 N)/min until the tile actually breaks into two or more pieces. Read the force on the gage by interpolation to the nearest 1 lbf (4 N). Record this pressure and reset the gage to zero.

8.7 Remove any debris from the surface of the steel block with a brush. Place the next tile on the triangular support with two adjacent sides in contact with the registry stops and repeat the operation until all of the tile in the sample have been broken.

## 9. Calculation

9.1 Average the breaking forces for all of the tile in the sample.

9.2 If any one individual breaking force appears to deviate markedly from the others of the sample, it may be eliminated before the average is calculated only after the criteria in Practice E178 have been applied and justify elimination.

9.3 Should it become necessary to eliminate more than 20 % of the individual values in a sample in accordance with

9.2, repeat the test on sample containing twice the number of specimens in the original one. In that case, only breaking forces from the repeat test shall be used to arrive at the average strength of the sample.

## 10. Report

10.1 Report the following information:

10.1.1 Name and model number of the testing machine,

10.1.2 Range of the gage used,

10.1.3 Identification of the triangular support used in testing, by stating the length of its sides,

10.1.4 Type of tile tested, whether glazed or unglazed.

10.1.5 Number of specimens in the sample; also state whether it is a repeat test, and

10.1.6 Average strength in pounds-force (or newtons) of the sample.

## 11. Precision and Bias

11.1 The maximum difference between breaking strengths determined by laboratories testing tile from the same lots was 20 % of the lower value, and the difference was less than 5 % for 50 % of the lots tested. An overall difference of 7½ % existed between laboratories in a test series of 19 lots of wall tile.

## 12. Keywords

12.1 breaking strength; ceramic tile

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