



Designation: C67/C67M – 21

American Association State Highway and Transportation
Officials Standard
AASHTO No.: T 32-70

Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile¹

This standard is issued under the fixed designation C67/C67M; 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 reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 These test methods cover procedures for the sampling and testing of brick and structural clay tile. Although not necessarily applicable to all types of units, tests include modulus of rupture, compressive strength, absorption, saturation coefficient, effect of freezing and thawing, efflorescence, initial rate of absorption and determination of weight, size, warpage, length change, and void area. (Additional methods of test pertinent to ceramic glazes include imperviousness, chemical resistance, opacity, and resistance to crazing.

1.2 The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

NOTE 1—The testing laboratory performing this test method should be evaluated in accordance with Practice C1093.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.4 These test methods include the following sections:

Section Heading	Section
Scope	1
Referenced Documents	2
Terminology	3
Sampling	4
Specimen Preparation	5
Modulus of Rupture (Flexure Test)	6
Compressive Strength	7
Absorption	8
Freezing and Thawing	9
Initial Rate of Absorption (Suction) (Laboratory Test)	10
Efflorescence	11
Weight Per Unit Area	12

¹ These test methods are under the jurisdiction of Committee C15 on Manufactured Masonry Units and is the direct responsibility of Subcommittee C15.02 on Brick and Structural Clay Tile.

Current edition approved June 1, 2021. Published June 2021. Originally approved in 1937. Last previous edition approved in 2020 as C67/C67M – 20. DOI: 10.1520/C0067_C0067M-21.

Section Heading	Section
Measurement of Size	13
Measurement of Warpage	14
Measurement of Length Change	15
Initial Rate of Absorption (Suction) (Field Test)	16
Measurement of Void Area in Cored Units	17
Measurement of Void Area in Deep Frogged Units	18
Measurement of Out of Square	19
Measurement of Shell and Web Thickness	20
Breaking Load	21
Imperviousness Test (of Ceramic Glazes)	22
Chemical Resistance Test (of Ceramic Glazes)	23
Autoclaved Crazing Test (of Ceramic Glazes)	24
Opacity Test (of Ceramic Glazes)	25
Precision and Bias	26
Keywords	27
Safety Precautions for Autoclave Equipment and Operation	Appendix X1

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

- 2.1 *ASTM Standards:*²
- C150/C150M Specification for Portland Cement
 - C1093 Practice for Accreditation of Testing Agencies for Masonry
 - C1232 Terminology for Masonry
 - E4 Practices for Force Verification of Testing Machines
 - E6 Terminology Relating to Methods of Mechanical Testing
 - E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

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.

*A Summary of Changes section appears at the end of this standard

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—For definitions relating to sampling and testing brick, refer to Terminology E6 and Terminology C1232.

4. Sampling

4.1 *Selection and Preparation of Test Specimens*—For the purpose of these tests, full-size brick, tile, or solid masonry units shall be selected by the purchaser or by the purchaser's authorized representative. Specimens shall be representative of the lot of units from which they are selected and shall include specimens representative of the complete range of colors, textures, and sizes. Specimens shall be free of or brushed to remove dirt, mud, mortar, or other foreign materials unassociated with the manufacturing process. Brushes used to remove foreign material shall have bristles of plastic (polymer) or horsehair. Wire brushes shall not be used for preparing specimens for testing. Specimens exhibiting foreign material that is not removed by brushing shall be discarded to ensure that damaged or contaminated specimens are not tested.

4.2 Number of Specimens:

4.2.1 *Brick*—For the modulus of rupture, compressive strength, abrasion resistance, and absorption determinations, at least ten individual brick shall be selected for lots of 1 000 000 brick or fraction thereof. For larger lots, five additional specimens shall be selected from each additional 500 000 brick or fraction thereof. Additional specimens are taken at the discretion of the purchaser.

4.2.2 *Structural Clay Tile*—For the weight determination and for compressive strength and absorption tests, at least five tile shall be selected from each lot of 250 tons [250 mt] or fraction thereof. For larger lots, five additional specimens shall be tested for each 500 tons [500 mt] or fraction thereof. In no case shall less than five tile be taken. Additional specimens are taken at the discretion of the purchaser.

4.2.3 *Ceramic Glazed Units*—For imperviousness, chemical resistance, crazing, and opacity tests, select a representative of 10 units for lots of 1 000 000 units, or fraction thereof. For larger lots, select five additional specimens from each additional 500 000 units, or fraction thereof. Do not use specimens selected for 4.2.1 or 4.2.2.

4.3 *Identification*—Each specimen shall be marked so that it is identifiable at any time. Markings shall cover not more than 5 % of the superficial area of the specimen.

5. Specimen Preparation

5.1 Drying and Cooling:

5.1.1 *Drying*—Dry the test specimens in a ventilated oven at 221 to 239°F [105 to 115°C] for not less than 24 h and until two successive weighings at intervals of 2 h show an increment of loss not greater than 0.2 % of the last previously determined weight of the specimen.

5.1.2 *Cooling*—After drying, cool the specimens in a drying room maintained at a temperature of $75 \pm 15^\circ\text{F}$ [$24 \pm 8^\circ\text{C}$], with a relative humidity between 30 and 70 %. Store the units free from drafts, unstacked, with separate placement, for a

period of at least 4 h and until the surface temperature is within 5°F [2.8°C] of the drying room temperature. Do not use specimens noticeably warm to the touch for any test requiring dry units. The specimens shall be stored in the drying room with the required temperature and humidity maintained until tested.

5.1.2.1 An alternative method of cooling the specimens to approximate room temperature is permitted as follows: Store units, unstacked, with separate placement, in a ventilated room maintained at a temperature of $75 \pm 15^\circ\text{F}$ [$24 \pm 8^\circ\text{C}$], with a relative humidity between 30 and 70 % for a period of 4 h and until the surface temperature is within 5°F [2.8°C] of the ventilated room temperature, with a current of air from an electric fan passing over them for a period of at least 2 hours. The specimens shall be stored in the ventilated room with the required temperature and humidity maintained until tested.

5.2 Weight Determination:

5.2.1 Weigh five full size specimens that have been dried and cooled (see 5.1). The scale or balance used shall have a capacity of not less than 3000 g and shall be sensitive to 0.5 g.

5.2.2 Report results separately for each specimen to the nearest 0.1 g, with the average of all specimens tested to the nearest 0.1 g.

5.3 *Removal of Silicone Coatings from Brick Units*—The silicone coatings intended to be removed by this process are any of the various polymeric organic silicone compounds used for water-resistant coatings of brick units. Heat the brick at $950 \pm 50^\circ\text{F}$ [$510 \pm 28^\circ\text{C}$] in an oxidizing atmosphere for a period of not less than 3 hours. The rate of heating and cooling shall not exceed 300°F [149°C] per hour.

NOTE 2—Additional specimen preparation requirements for specific tests are indicated in the individual test methods.

6. Modulus of Rupture (Flexure Test)

6.1 *Test Specimens*—The test specimens shall consist of whole full-size units that have been dried and cooled (see 5.1). Five such specimens shall be tested.

6.2 Procedure:

6.2.1 Support the test specimen flatwise unless specified and reported otherwise (that is, apply the load in the direction of the depth of the unit) on a span approximately 1 in. [25 mm] less than the basic unit length and loaded at midspan. Specimens having recesses (panels or depressions) shall be placed so that such recesses are on the compression side. Apply the load to the upper surface of the specimen through a steel bearing plate $\frac{1}{4}$ in. [6 mm] in thickness and $1\frac{1}{2}$ in. [38 mm] in width and of a length at least equal to the width of the specimen.

6.2.2 Make sure the supports for the test specimen are free to rotate in the longitudinal and transverse directions of the test specimen and adjust them so that they will exert no force in these directions.

6.2.3 *Speed of Testing*—The rate of loading shall not exceed 2000 lbf [9000 N]/min. This requirement is considered as being met when the speed of the moving head of the testing machine immediately prior to application of the load is not more than 0.05 in. [1.25 mm]/min.

6.3 Calculation and Report:

6.3.1 Calculate and report the modulus of rupture of each specimen to the nearest 1 psi [0.01 MPa] as follows:

$$S = 3W(l/2 - x)/bd^2 \quad (1)$$

where:

- S = modulus of rupture of the specimen at the plane of failure, lb/in.² [Pa],
- W = maximum load indicated by the testing machine, lb [N],
- l = distance between the supports, in. [mm],
- b = net width, (face to face minus voids), of the specimen at the plane of failure, in. [mm],
- d = depth, (bed surface to bed surface), of the specimen at the plane of failure, in. [mm], and
- x = average distance from the midspan of the specimen to the plane of failure measured in the direction of the span along the centerline of the bed surface subjected to tension, in. [mm].

6.3.2 Calculate and report the average of the modulus of rupture determinations to the nearest 1 psi [0.01 MPa].

7. Compressive Strength

7.1 Test Specimens:

7.1.1 *Brick*—The test specimens shall consist of half brick units that have been dried and cooled (see 5.1), the full height and width of the unit, with a length equal to one half the full length of the unit ± 1 in. [25 mm], except as described below. When the test specimen, described above, exceeds the testing machine capacity, the test specimens shall consist of dry pieces of brick, the full height and width of the unit, with a length not less than one quarter of the full length of the unit, and with a gross cross-sectional area perpendicular to bearing not less than 14 in.² [90 cm²]. Test specimens shall be obtained by any method that will produce, without shattering or cracking, a specimen with approximately plane and parallel ends. Five specimens shall be tested.

7.1.2 *Structural Clay Tile*—Test five tile specimens that have been dried and cooled (see 5.1) in a bearing bed length equal to the width ± 1 in. [25 mm]; or test full-size units.

7.2 Capping Test Specimens:

7.2.1 All specimens shall be dry and cool within the meaning of 5.1.1 and 5.1.2 before any portion of the capping procedure is carried out.

7.2.2 Fill recessed or paneled surfaces that will become bearing surfaces during the compression test with a mortar composed of 1 part by weight of quick-hardening cement conforming to the requirements for Type III cement of Specification C150/C150M, and 2 parts by weight of sand. Age the specimens at least 48 h before capping them. Where the recess exceeds 1/2 in. [12.5 mm], use a brick or tile slab section or metal plate as a core fill. Cap the test specimens using one of the two procedures described in 7.2.3 and 7.2.4.

7.2.3 *Gypsum Capping*—Coat the two opposite bearing surfaces of each specimen with shellac and allow to dry thoroughly. Bed one of the dry shellacked surfaces of the specimen in a thin coat of neat paste of calcined gypsum (plaster of paris) that has been spread on an oiled nonabsorbent plate, such as glass or machined metal. The casting surface

plate shall be plane within 0.003 in. [0.1 mm] in 16 in. [400 mm] and sufficiently rigid; and so supported that it will not be measurably deflected during the capping operation. Lightly coat it with oil or other suitable material. Repeat this procedure with the other shellacked surface. Take care that the opposite bearing surfaces so formed will be approximately parallel and perpendicular to the vertical axis of the specimen and the thickness of the caps will be approximately the same and not exceeding 1/8 in. [3 mm]. Age the caps at least 24 h before testing the specimens.

NOTE 3—A rapid-setting industrial type gypsum is frequently used for capping.

7.2.4 *Sulfur-Filler Capping*—Use a mixture containing 40 to 60 weight % sulfur, the remainder being ground fire clay or other suitable inert material passing a No. 100 [150- μ m] sieve with or without plasticizer. The casting surface plate requirements shall be as described in 7.2.3. Place four 1-in. [25-mm] square steel bars on the surface plate to form a rectangular mold approximately 1/2 in. [12.5 mm] greater in either inside dimension than the specimen. Heat the sulfur mixture in a thermostatically controlled heating pot to a temperature sufficient to maintain fluidity for a reasonable period of time after contact with the surface being capped. Take care to prevent overheating, and stir the liquid in the pot just before use. Fill the mold to a depth of 1/4 in. [6 mm] with molten sulfur material. Place the surface of the unit to be capped quickly in the liquid, and hold the specimen so that its vertical axis is at right angles to the capping surface. The thickness of the caps shall be approximately the same. Allow the unit to remain undisturbed until solidification is complete. Allow the caps to cool for a minimum of 2 h before testing the specimens.

7.3 Procedure:

7.3.1 Test brick specimens flatwise (that is, the load shall be applied perpendicular to the bed surface of the brick with the brick in the stretcher position). Test structural clay tile specimens in a position such that the load is applied in the same direction as in service. Center the specimens under the spherical upper bearing within 1/16 in. [2 mm].

7.3.2 The testing machine shall conform to the requirements of Practices E4.

7.3.3 The upper bearing shall be a spherically seated, hardened metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall lie at the center of the surface of the block in contact with the specimen. The block shall be closely held in its spherical seat, but shall be free to turn in any direction, and its perimeter shall have at least 1/4 in. [6 mm] clearance from the head to allow for specimens whose bearing surfaces are not exactly parallel. The diameter of the bearing surface shall be at least 5 in. [125 mm]. Use a hardened metal bearing block beneath the specimen to minimize wear of the lower platen of the machine. The bearing block surfaces intended for contact with the specimen shall have a hardness not less than HRC60 (HB 650). These surfaces shall not depart from plane surfaces by more than 0.001 in. [0.03 mm]. When the bearing area of the spherical bearing block is not sufficient to cover the area of the specimen, place a steel plate with surfaces machined to true planes within \pm

0.001 in. [0.03 mm], and with a thickness equal to at least one third of the distance from the edge of the spherical bearing to the most distant corner between the spherical bearing block and the capped specimen.

7.3.4 Speed of Testing—Apply the load to the specimens in accordance with 7.3.4.1 or 7.3.4.2.

7.3.4.1 Speed of Testing—Time Limit—Apply the load, up to one half of the expected maximum load, at any convenient rate, after which, adjust the controls of the machine so that the remaining load is applied at a uniform rate in not less than 1 nor more than 2 min.

7.3.4.2 Speed of Testing—Rate Limit—Apply the load, up to one half of the expected maximum load, at any convenient rate, after which, the remaining load is applied at a rate of 3000 ± 500 lbf/s [1360 ± 228 kg/s].

7.4 Calculation and Report:

7.4.1 Calculate and report the compressive strength of each specimen to the nearest 10 psi [70 kPa] as follows:

$$\text{Compressive strength, } C = W/A \quad (2)$$

where:

C = compressive strength of the specimen, lb/in.² [or kg/cm²] [or Pa·10⁴],

W = maximum load, lbf, [or kgf] [or N], indicated by the testing machine, and

A = average of the gross areas of the upper and lower bearing surfaces of the specimen, in.² [or cm²].

NOTE 4—When compressive strength is to be based on net area (example: clay floor tile), substitute for A in the above formula the net area, in in.² [or cm²], of the fired clay in the section of minimum area perpendicular to the direction of the load.

7.4.2 Calculate and report the average of the compressive strength determinations to the nearest 10 psi [70 kPa].

8. Absorption

8.1 Accuracy of Weighings:

8.1.1 Brick—The scale or balance used shall have a capacity of not less than 2000 g, and shall be sensitive to 0.5 g.

8.1.2 Tile—The balance used shall be sensitive to within 0.2 % of the weight of the smallest specimen tested.

8.2 Test Specimens:

8.2.1 Brick—The test specimens shall consist of half brick conforming to the requirements of 7.1.1. Five specimens shall be tested.

8.2.2 Tile—The specimens for the absorption test shall consist of five tile or three representative pieces from each of these five tile. Two of the three representative pieces shall be taken from the shells and one from an interior web, the weight of each piece being not less than 225 g. The specimens shall have had their rough edges or loose particles ground off. Pieces taken from tile that have been subjected to compressive strength tests shall be free of cracks due to failure in compression.

8.3 5-h and 24-h Submersion Tests:

8.3.1 Procedure:

8.3.1.1 Dry and cool the test specimens in accordance with 5.1 and weigh each one in accordance with 5.2.

8.3.1.2 Saturation—Submerge the dry, cooled specimen, without preliminary partial immersion, in clean water (soft, distilled or rain water) at 60 to 86°F [15.5 to 30°C] for the specified time. Remove the specimen, wipe off the surface water with a damp cloth and weigh the specimen. Complete weighing of each specimen within 5 min after removing the specimen from the bath.

8.3.2 Calculation and Report:

8.3.2.1 Calculate and report the cold water absorption of each specimen to the nearest 0.1 % as follows:

$$\text{Absorption, \%} = 100(W_s - W_d)/W_d \quad (3)$$

where:

W_d = dry weight of the specimen, and

W_s = saturated weight of the specimen after submersion in cold water.

8.3.2.2 Calculate and report the average cold water absorption of all specimens to the nearest 0.1 %.

8.4 1-h, 2-h, and 5-h Boiling Tests:

8.4.1 Test Specimens—The test specimens shall be the same five specimens used in the 5-h or 24-h cold-water submersion test where required and shall be used in the state of saturation existing at the completion of that test.

8.4.1.1 Dry and cool the test specimens in accordance with 5.1 when performing the boiling water absorption test without previously conducting the cold water absorption test.

8.4.2 Procedure:

8.4.2.1 Return the specimen that has been subjected to the cold-water submersion to the bath, and subject it to the boiling test as described in 8.4.2.2.

8.4.2.2 Submerge the specimen in clean water (soft, distilled or rain water) at 60 to 86°F [15.5 to 30°C] in such a manner that water circulates freely on all sides of the specimen. Heat the water to boiling, within 1 h, boil continuously for specified time, and then allow to cool to 60 to 86°F [15.5 to 30°C] by natural loss of heat. Remove the specimen, wipe off the surface water with a damp cloth, and weigh the specimen. Complete weighing of each specimen within 5 min after removing the specimen from the bath.

8.4.2.3 When the tank is equipped with a drain so that water at 60 to 86°F [15.5 to 30°C] passes through the tank continuously and at such a rate that a complete change of water takes place in not more than 2 min, make weighings at the end of 1 hour.

8.4.3 Calculation and Report:

8.4.3.1 Calculate and report the boiling water absorption of each specimen to the nearest 0.1 % as follows:

$$\text{Absorption, \%} = 100(W_b - W_d)/W_d \quad (4)$$

where:

W_d = dry weight of the specimen, and

W_b = saturated weight of the specimen after submersion in boiling water.

8.4.3.2 Calculate and report the average boiling water absorption of all specimens to the nearest 0.1 %.

8.5 Saturation Coefficient: