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Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units[1]

This standard is issued under the fixed designation C140/C140M; 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 These test methods provide various testing procedures commonly used for evaluating characteristics of concrete masonry units and related concrete units. Methods are provided for sampling, measurement of dimensions, compressive strength, absorption, unit weight (density), moisture content, flexural load, and ballast weight. Not all methods are applicable to all unit types, however.

1.2 Specific testing and reporting procedures are included in annexes to these test methods for the following specific unit types:

Annex A1—Concrete masonry units (Specifications C90, C129)
Annex A2—Concrete and calcium silicate brick (Specifications C55, C73, C1634)
Annex A3—Segmental retaining wall units (Specification C1372)
Annex A4—Concrete interlocking paving units (Specification C936/C936M)
Annex A5—Concrete grid paving units (Specification C1319)
Annex A6—Concrete roof pavers (Specification C1491)
Annex A7—Dry-cast articulating concrete block (Specification D6684)
Annex A8—Segmental Concrete Paving Slabs (Specification C1782/C1782M)

1.3 The test procedures included in these test methods are also applicable to other types of units not referenced in these test methods, but specific testing and reporting requirements for those units are not included.

1.4 These test methods include the following sections:

	Section
Scope	1
Referenced Documents	2
Terminology	3
Significance and Use	4
Sampling	5
Measurement of Dimensions	6
Compressive Strength	7
Absorption	8
Calculations	9
Report	10
Keywords	11
Annexes—Test Procedures	
Concrete Masonry Units	Annex A1
Concrete and Calcium Silicate Brick	Annex A2
Segmental Retaining Wall Units	Annex A3
Concrete Interlocking Paving Units	Annex A4
Concrete Grid Paving Units	Annex A5
Concrete Roof Pavers	Annex A6
Dry-Cast Articulating Concrete Block	Annex A7
Segmental Concrete Paving Slabs	Annex A8
Worksheet and Test Report for Concrete Masonry Units	Appendix X1

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

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

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.7 *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.*

1.8 *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.*

[1] These test methods are under the jurisdiction of ASTM Committee C15 on Manufactured Masonry Units and are the direct responsibility of Subcommittee C15.03 on Concrete Masonry Units and Related Units.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C55 Specification for Concrete Building Brick
C73 Specification for Calcium Silicate Brick (Sand-Lime Brick)
C90 Specification for Loadbearing Concrete Masonry Units
C129 Specification for Nonloadbearing Concrete Masonry Units
C143/C143M Test Method for Slump of Hydraulic-Cement Concrete
C936/C936M Specification for Solid Concrete Interlocking Paving Units
C1093 Practice for Accreditation of Testing Agencies for Masonry
C1232 Terminology for Masonry
C1319 Specification for Concrete Grid Paving Units
C1372 Specification for Dry-Cast Segmental Retaining Wall Units
C1491 Specification for Concrete Roof Pavers
C1552 Practice for Capping Concrete Masonry Units, Related Units and Masonry Prisms for Compression Testing
C1634 Specification for Concrete Facing Brick and Other Concrete Masonry Facing Units
C1716/C1716M Specification for Compression Testing Machine Requirements for Concrete Masonry Units, Related Units, and Prisms
C1782/C1782M Specification for Segmental Concrete Paving Slabs
D1056 Specification for Flexible Cellular Materials—Sponge or Expanded Rubber
D6684 Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Systems
E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing

2.2 *Other Documents:*

SP 960-12 NIST Recommended Practice Guide – Stopwatch and Timer Calibration[3]

3. Terminology

3.1 Terminology defined in Terminologies C1232 and E6 shall apply for these test methods.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lot, n*—any number of concrete masonry units or related units, designated by the producer, of any configuration or dimension manufactured by the producer using the same materials, concrete mix design, manufacturing process, and curing method.

3.2.2 *web, n*—any portion of a hollow concrete masonry unit connecting the face shells.

3.2.2.1 *Discussion*—A web can be either an end web or interior web connecting face shells. All portions of a unit connecting face shells are considered webs.

[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.

[3] Available at http://tf.nist.gov/general/pdf/2281.pdf

4. Significance and Use

4.1 These test methods provide general testing requirements for application to a broad range of concrete products. Those general testing requirements are included in the body of this standard.

NOTE 2—Consult manufacturer, supplier, product specifications, or other resources for more specific measurement or testing guidelines for those products not addressed with the annex of this standard.

4.2 These test methods provide specific testing requirements in two distinct sections, the requirements applicable to all units covered by these test methods and those applicable to the specific unit types. The requirements applicable to all units are included in the body of these test methods and those applicable to the specific unit types are included within the annexes.

5. Sampling

5.1 *Selection of Test Specimens:*

5.1.1 For purposes of testing, full-sized units shall be selected by the purchaser or authorized representative. The selected specimens shall be of similar configuration and dimensions. Specimens shall be representative of the whole lot of units from which they are selected.

5.2 *Number of Specimens:*

5.2.1 Unless specified otherwise in the applicable annex, a set of units shall consist of six full-size units.

5.3 Remove loose material from the specimens (including the cores) prior to determining the received weight.

NOTE 3—An abrasive stone or wire brush is typically used to remove loose material.

5.4 *Identification*—Mark each specimen so that it may be identified at any time. Markings shall cover not more than 5 % of the surface area of the specimen.

5.5 *Received Weight*—Prior to performing tests, weigh each specimen after sampling and marking, and record as w_r (received weight). Record time and place w_r was measured.

NOTE 4—Received weights often have direct relationships with other unit properties and are therefore a useful method of evaluating results or for sorting purposes. It is good laboratory practice to separate sampled units for strength and absorption testing by received weight, such that the averages of the subsets of specimens are similar and representative of the sampled units. Received weight may also be useful in evaluating inconsistency in test results or unit production issues. The weight of a concrete masonry unit and related unit changes with time and exposure conditions, primarily as a result of the moisture within the unit. Therefore, to understand the context of a received weight value, it is also important to understand the point in time and the frame of reference when that weight was determined. "Time and place" should not refer to when and where the unit was sampled but when and where the received weights were determined. In addition to date and time references, it is also important to know if those weights were determined after units reached equilibrium with lab environment, or before units were shipped, or after delivery to the job site, and so forth. Moisture content is not a physical property requirement of concrete masonry units, therefore field measurement of received weight is not necessary (unless specifically specified for a particular job).

6. Measurement of Dimensions

6.1 *Apparatus:*

6.1.1 *Measurement Devices*—Devices used to measure specimen dimensions shall have divisions not greater than

0.1 in. [2.5 mm] when the dimension is to be reported to the nearest 0.1 in. [2.5 mm] and not greater than 0.01 in. [0.25 mm] when the dimension is to be reported to the nearest 0.01 in. [0.25 mm].

6.1.2 Measuring devices shall be readable and accurate to the division required to be reported. Accuracy shall be verified at least once annually. Verification record shall include date of verification, person or agency performing verification, identification of reference standard used, test points used during verification, and readings at test points.

6.2 *Specimens*—Three full-size units shall be selected for measurement of dimensions.

6.3 *Measurements*—Measure specimens in accordance with the applicable annex of this standard. For those products not covered by the annexes of this standard, measure overall dimensions (width, height, length) in at least two locations on opposite sides of the specimen to the nearest division required to be reported. Document location of each measurement on a sketch or photograph of the specimen.

NOTE 5—Specimens used for measurement of dimensions may be used in other tests.

NOTE 6—Calipers, micrometers, and steel scales and dividers of the appropriate accuracy and readability have been shown to be adequate for these measurements.

7. Compressive Strength

7.1 *Test Apparatus*—The compressive strength testing machine shall conform to Specification C1716/C1716M.

NOTE 7—Previous versions of this standard have contained specific requirements for compressive strength test machines. These requirements have been replaced with reference to Specification C1716/C1716M.

7.2 *Test Specimens:*

7.2.1 Unless specified otherwise in the applicable annex, test three specimens in compression.

7.2.2 Unless specified otherwise in the applicable annex, specimens shall be full-sized units except when the units cannot be tested full-size due to specimen configuration or testing machine requirements. In these cases, reduce the specimen size in accordance with Annex A1.

7.2.3 After delivery to the laboratory, store compression specimens (unstacked and separated by not less than 0.5 in. [13 mm] on all sides) continuously in air at a temperature of 75 ± 15°F [24 ± 8°C] and a relative humidity of less than 80 % for not less than 48 h. Alternatively, if compression results are required sooner, store units unstacked in the same environment described above with a current of air from an electric fan passing over them for a period of not less than 4 h. Continue passing air over the specimens until two successive weighings at intervals of 2 h show an increment of loss not greater than 0.2 % of the previously determined weight of the specimen and until no moisture or dampness is visible on any surface of the unit. Specimens shall not be subjected to oven-drying.

NOTE 8—In this test method, net area (other than certain solid units, see 9.5) is determined from specimens other than those subjected to compression testing. The compressive strength method is based on the assumption that units used for determining net volume (absorption specimens) have the same net volume as units used for compression testing. Sampled split face units, which have irregular surfaces, should be divided at the time they are sampled from the lot, such that the absorption test specimens have a net volume that is visually representative and a weight that is representative of the compression test specimens.

7.2.4 Where saw-cutting of test specimens is allowed or required by the standard or applicable annex, sawing shall be performed in an accurate, competent manner, subjecting the specimen to as little saw vibration as possible. Use a diamond saw blade of proper hardness. Following cutting, residue from the cutting operation shall be removed prior to continuing testing (see Note 9). If the specimen is wetted during sawing, allow the specimen to dry to equilibrium with laboratory air conditions before testing, using the procedures outlined in 7.2.3.

NOTE 9—For specimens cut with a wet saw, rinsing with clean water is typically sufficient for removing cutting residue. For specimens cut with a dry saw, brushing with a soft-bristle brush is typically sufficient for removing cutting residue.

7.2.5 If compression test specimens have been saw-cut from full-sized units and the net area of the compression test specimens can not be determined by 9.5.1, saw-cut an additional three units to the dimensions and configuration of the three compression test specimens. The average net area for the saw-cut compression specimens shall be taken as the average net area of the additional three saw-cut units calculated as required in 9.5. Calculated net volumes of saw-cut specimens shall not be used in calculating equivalent thickness.

7.3 *Capping*—Cap test specimens in accordance with Practice C1552.

7.4 *Compression Testing Procedure:*

7.4.1 *Position of Specimens*—Test specimens with the centroid of their bearing surfaces aligned vertically with the center of thrust of the spherically seated steel bearing block of the testing machine (Note 10). Except for special units intended for use with their cores in a horizontal direction, test all hollow concrete masonry units with their cores in a vertical direction. Test masonry units that are 100 % solid and special hollow units intended for use with their hollow cores in a horizontal direction in the same direction as in service. Prior to testing each unit, ensure that the upper platen moves freely within its spherical seat to attain uniform seating during testing.

NOTE 10—For those masonry units that are symmetrical about an axis, the location of that axis can be determined geometrically by dividing the dimension perpendicular to that axis (but in the same plane) by two. For those masonry units that are nonsymmetrical about an axis, the location of that axis can be determined by balancing the masonry unit on a knife edge or a metal rod placed parallel to that axis. If a metal rod is used, the rod shall be straight, cylindrical (able to roll freely on a flat surface), have a diameter of not less than 0.25 in. [6 mm] and not more than 0.75 in. [19 mm], and its length shall be sufficient to extend past each end of the specimen when placed upon it. The metal rod shall be placed on a smooth, flat, level surface. Once determined, the centroidal axis shall be marked on the end of the unit using a pencil or marker having a marking width of not greater than 0.05 in. [1.5 mm]. A tamping rod used for consolidation of concrete and grout for slump tests performed in accordance with Test Method C143/C143M is often used as a balancing rod.

7.4.2 *Moisture Condition of Specimens*—At the time the specimens are tested, they shall be free of visible moisture or dampness.

7.4.3 *Speed of Testing*—Apply the load (up to one half of the expected maximum load) at any convenient rate, after which adjust the controls of the machine as required to give a uniform rate of travel of the moving head such that the remaining load is applied in not less than 1 nor more than 2 min. The results of the first specimen shall not be discarded so long as the actual loading time for the second half of the actual load is greater than 30 s.

NOTE 11—The allowance for a loading rate outside of 1 to 2 min for the first specimen acknowledges that the expected load may be different than the actual maximum load. The load rate for the remaining two specimens should be adjusted based on the first specimen results.

7.4.4 *Maximum Load*—Record the maximum compressive load in pounds [newtons] as P_{max}.

8. Absorption

8.1 *Apparatus*—Unless specified otherwise in the appropriate annex, the following equipment shall be used:

8.1.1 *Balance*—A balance readable and accurate to 0.1 % of the weight of the smallest specimen tested. Balances shall be calibrated in accordance with Practice C1093.

8.1.2 *Oven*—A ventilated oven of appropriate size capable of maintaining a uniform temperature of 230 ± 9°F [110 ± 5°C]. Ovens shall be verified in accordance with Practice C1093.

8.1.3 *Timer*—A timer readable and accurate to 1 second. Timers shall be verified in accordance with Practice C1093. (See Note 12.)

NOTE 12—Recommended procedures for verifying timers can be found in NIST Special Publication 960-12 (2009): NIST Recommended Practice Guide—Stopwatch and Timer Calibrations.

8.2 *Test Specimens:*

8.2.1 Unless specified otherwise in the applicable annex, test three specimens in absorption.

8.2.2 Unless specified otherwise in the applicable annex, tests shall be performed on full-sized units or specimens saw-cut from full-sized units. Calculated values for absorption and density of reduced-size absorption specimens shall be considered as representative of the whole unit.

8.2.2.1 When test specimens are saw-cut from full-sized units, the test specimen shall have an initial weight after cutting of no less than 20 % of the initial received weight of the full-sized unit.

NOTE 13—When performing absorption tests on reduced-sized specimens, it is preferable to have a test specimen that is as large as practically possible and can be accommodated by laboratory equipment. This helps to reduce any location-specific variability from the absorption results.

8.3 *Procedure:*

8.3.1 Immerse the test specimens in water at a temperature of 60 to 80°F [15 to 27°C] for 24 to 28 h such that the top surfaces of the specimens are at least 6 in. [150 mm] below the surface of the water. Specimens shall be separated from each other and from the bottom of the immersion tank by at least 0.125 in. [3 mm], using wire mesh, grating, or other spacers. The spacer shall not cover more than 10 % of the area of the face that is in direct contact with the spacer (see Note 14).

NOTE 14—The intent of the requirement for spacer contact with the specimen surface is to limit the possibility of reduced absorption of water due to blockage by the spacer. In order to determine compliance, only the area of the surface of the specimen in contact with the spacer should be considered. For example, when a spacer is used between the bottom of the specimen and the bottom of the tank, only the area of the bottom of the unit should be used to determine the 10 % limit (not the surface area of the entire specimen).

8.3.2 Weigh the specimens while suspended by a metal wire and completely submerged in water and record w_i (immersed weight).

8.3.3 Remove the specimens from water and allow to drain by placing them on a 0.375-in. [10-mm] or coarser wire mesh. While the specimen is draining and before weighing, remove visible surface water with a damp cloth. Weigh specimens 60 ± 5 s following removal from water. Record as w_s (saturated weight).

8.3.4 Subsequent to saturation, dry all specimens in a ventilated oven at 230 ± 9°F [110 ± 5°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. Record weight of dried specimens as w_d (oven-dry weight).

9. Calculations

9.1 *Absorption*—Calculate absorption as follows:

$$\text{Absorption, lb/ft}^3 = [(w_s - w_d)/(w_s - w_i)] \times 62.4 \quad (1)$$

$$[\text{Absorption, kg/ m}^3 = [(w_s - w_d)/(w_s - w_i)] \times 1000]$$

$$\text{Absorption, \%} = [(w_s - w_d)/w_d] \times 100$$

where:

w_s = saturated weight of specimen, lb [kg],
w_i = immersed weight of specimen, lb [kg], and
w_d = oven-dry weight of specimen, lb [kg].

9.2 *Moisture Content*—Calculate the moisture content of the unit at the time it is sampled (when w_r is measured) as follows:

$$\text{Moisture Content, \% of total absorption} = [(w_r - w_d)/(w_s - w_d)] \times 100 \quad (2)$$

where:

w_r = received weight of unit, lb [kg],
w_d = oven-dry weight of unit, lb [kg], and
w_s = saturated weight of unit, lb [kg].

NOTE 15—When determining the moisture content of a unit or set of units, the value determined is a measure of the water content of a unit based upon the received weight of the unit w_r. Thus, the moisture content calculation above is only applicable to the unit moisture content at the time the received weight, w_r, is obtained.

9.3 *Density*—Calculate oven-dry density as follows:

$$\text{Density (D), lb/ft}^3 = [w_d / (w_s - w_i)] \times 62.4 \quad (3)$$

$$[\text{Density (D), kg/ m}^3 = [w_d / (w_s - w_i)] \times 1000]$$

where:

w_d = oven-dry weight of specimen, lb [kg],
w_s = saturated weight of specimen, lb [kg], and
w_i = immersed weight of specimen, lb [kg].

9.4 *Net Volume*—Calculate net volume in accordance with either 9.4.1 or 9.4.2: