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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 C 140; 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.

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 C 90, C 129)
~~Annex A2—Concrete brick (Specifications C 55, C 73, C 1634)~~
Annex A2—Concrete and calcium silicate brick (Specifications C 55, C 73, C 1634)
Annex A3—Segmental retaining wall units (Specification C 1372)
Annex A4—Concrete interlocking paving units (Specification C 936)
Annex A5—Concrete grid paving units (Specification C 1319)
Annex A6—Concrete roof pavers (Specification C 1491)

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:

[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.**

	Section
Annexes—Test Procedures	
Concrete Masonry Units	Annex A1
~~Concrete Brick~~	~~Annex A2~~
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
Determining Plate Thickness Requirements for Compression Testing	Annex A7
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 C 1093.

1.5 The values stated in inch-pound units are to be regarded as the standard, except in Annex A4, where SI units are to be regarded as standard. The values given in parentheses throughout are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *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:*[2]

C 55 Specification for Concrete Building Brick
C 73 Specification for Calcium Silicate Brick (Sand-Lime Brick)
C 90 Specification for Loadbearing Concrete Masonry Units
C 129 Specification for Nonloadbearing Concrete Masonry Units
C 143/C 143M Test Method for Slump of Hydraulic-Cement Concrete
C 936 Specification for Solid Concrete Interlocking Paving Units
C 1093 Practice for Accreditation of Testing Agencies for Masonry
C 1209 Terminology of Concrete Masonry Units and Related Units
C 1232 Terminology of Masonry
C 1319 Specification for Concrete Grid Paving Units
C 1372 Specification for Dry-Cast Segmental Retaining Wall Units
C 1491 Specification for Concrete Roof Pavers
C 1552 Practice for Capping Concrete Masonry Units, Related Units and Masonry Prisms for Compression Testing
C 1634 Specification for Concrete Facing Brick
E 4 Practices for Force Verification of Testing Machines
E 6 Terminology Relating to Methods of Mechanical Testing

3. Terminology

3.1 Terminology defined in Terminologies C 1209, C 1232, and E 6 shall apply for these test methods.

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.

[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.

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.

5.1.2 The term "lot" refers to any number of concrete masonry units of any configuration or dimension manufactured by the producer using the same materials, concrete mix design, manufacturing process, and curing method.

5.2 *Number of Specimens*—Unless specified otherwise in the applicable annex, for the compressive strength, absorption, unit weight (density), and moisture content determinations, six units shall be selected from each lot of 10 000 units or fraction thereof and 12 units from each lot of more than 10 000 and less than 100 000 units. For lots of more than 100 000 units, six units shall be selected from each 50 000 units or fraction thereof contained in the lot. Additional specimens shall be taken if directed by the purchaser.

~~5.3~~

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.

~~5.4~~

5.5 *Received Weight*— Weigh each specimen immediately after sampling and marking, and record as W_r (received weight). Record time and place W_r was measured.

NOTE ~~3~~4—Received weights often have direct relationships with other unit properties and are therefore a useful method of evaluating results or for sorting purposes. 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.

6. Measurement of Dimensions

6.1 *Apparatus*—Unless otherwise specified in the applicable annex, use the following equipment for measurement of dimensions:

6.1.1 *Steel Scale*— shall have divisions not greater than 1/10 in. (2.5 mm).

6.1.2 *Calipers*—shall have divisions not greater than 1/100 in. (0.25 mm).

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. Document location of each measurement on a sketch or photograph of the specimen.

NOTE ~~4~~5—Specimens used for measurement of dimensions may be used in other tests.

7. Compressive Strength

7.1 *Test Apparatus*:

7.1.1 The testing machine shall have an accuracy of ±1.0 % over the anticipated load range. The upper platen 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 held in its spherical seat but shall be free to turn in any direction, and its perimeter shall have at least ¼ in. (6.3 mm) clearance from the head to accommodate specimens whose bearing surfaces are not parallel. The diameter of the upper platen (determined in accordance with Annex A7) shall be at least 6 in. (150 mm). A hardened metal bearing plate may be used beneath the specimen to minimize wear of the lower platen of the machine.

7.1.2 When the bearing area of the upper platen or lower platen is not sufficient to cover the area of the specimen, a single steel plate with a thickness equal to at least the distance from the edge of the platen to the most distant corner of the specimen shall be placed between the platen and the capped specimen. The length and width of the steel plate shall be at least ¼ in. (6 mm) greater than the length and width of the units.

7.1.3 The surfaces of the platen or plate intended for contact with the specimen shall have a hardness not less than HRC 60 (BHN 620). The surfaces of the platen and plate shall not depart from plane surfaces by more than 0.001 in. (0.03 mm) in any 6 in. (150 mm) dimension.

NOTE ~~5~~6—Research has shown that thickness of bearing plates has a significant effect on the tested compressive strength of masonry units when the bearing area of the platen is not sufficient to cover the area of the specimen. Plate bending results in nonuniform stress distributions that can influence the failure mechanisms of the tested specimens. The magnitude of this effect is controlled by the stiffness of the plate, the size of the specimen tested, and the strength of the specimen. Tested compressive strengths will typically increase with increased plate thickness and with reduced distance to the furthest corner of the specimen. Some testing laboratories have limitations that limit the practicality of eliminating plate bending entirely. Therefore the

plate thickness requirements in 7.1 are intended to provide an adequate level of accuracy in the compression test results so as to conform to the limits of practicality of the testing laboratory.

NOTE ~~6—~~ 7—Annex A7 includes guidance on determining the required plate thickness based on the configuration of the test specimen and the test machine.

7.1.4 The testing machine shall be verified in accordance with Practices E 4 at a frequency defined by Practice C 1093.

7.2 *Test Specimens*:

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

7.2.2 When possible and unless specified otherwise in the applicable annex, specimens shall be full-sized units. When the units cannot be tested full-size due to specimen configuration or testing machine requirements, 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 ~~7—In~~ 8—In this test method, net area (other than certain solid units, see 9.4) 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. 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.

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 9.4.1, 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 9.4. 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 C 1552.

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 8~~Note 9). 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 ~~8—For~~ 9—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 ¼ in. (6.4 mm) and not more than ¾ in. (19.1 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. (1.3 mm). A tamping rod used for consolidation of concrete and grout for slump tests performed in accordance with Test Method C 143/C 143M 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.

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

8. Absorption

8.1 *Apparatus*—The balance used shall be sensitive to within 0.5 % of the weight of the smallest specimen tested.

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.

8.3 *Procedure*:

8.3.1 *Saturation*—Immerse the test specimens in water at a temperature of 60 to 80°F (15.6 to 26.7°C) for 24 h. Weigh the specimens while suspended by a metal wire and completely submerged in water and record W_i (immersed weight). Remove from the water and allow to drain for 1 min ± 5 s by placing them on a ⅜-in. (9.5-mm) or coarser wire mesh, removing visible surface water with a damp cloth; weigh and record as W_s (saturated weight).

8.3.2 *Drying*—Subsequent to saturation, dry all specimens in a ventilated oven at 212 to 239°F (100 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. 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 ~~9—When~~ 10—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 *Average Net Area*—Calculate average net area as follows:

$$\text{Net Volume } (V_n), \text{ ft}^3 = W_d/D = (W_s - W_i)/62.4 \quad (4)$$

$$\text{Net Volume } (V_n), \text{ mm}^3 = W_d/D = (W_s - W_i) \times 10^6$$

$$\text{Average Net Area } (A_n), \text{ in.}^2 = (V_n \times 1728)/H$$

$$\text{Average Net Area } (A_n), \text{ mm}^2 = V_n/H$$

where:

V_n = net volume of specimen, ft^3 (mm^3),
W_d = oven-dry weight of specimen, lb (kg),
D = oven-dry density of specimen, lb/ft^3 (kg/m^3),
W_s = saturated weight of specimen, lb (kg),
W_i = immersed weight of specimen, lb (kg),
A_n = average net area of specimen, in.^{2} (mm^2), and
H = average height of specimen, in. (mm).

9.4.1 Except for irregularly shaped specimens, such as those with split surfaces, calculate the net area of coupons and those specimens whose net cross-sectional area in every plane parallel to the bearing surface is the gross cross-sectional area measured in the same plane, as follows:

$$\text{Net Area } (A_n), \text{ in.}^2 \text{ (mm}^2) = L \times W \quad (5)$$

where:
A_n = net area of the coupon or specimen, in.^{2} (mm^2),
L = average length of the coupon or specimen, in. (mm), and
W = average width of the coupon or specimen, in. (mm).

9.5 *Gross Area*—Calculate gross area as follows:

$$\text{Gross Area } (A_g), \text{ in.}^2 \text{ (mm}^2) = L \times W \quad (6)$$

where:
A_g = gross area of the specimen, in.^{2} (mm^2),
L = average length of the specimen, in. (mm), and
W = average width of the specimen, in. (mm).

9.5.1 The gross cross-sectional area of a specimen is the total area of a section perpendicular to the direction of the load, including areas within cells and reentrant spaces, unless these spaces are to be occupied in the masonry by portions of adjacent masonry.

9.6 *Compressive Strength*:

9.6.1 *Net Area Compressive Strength*— Calculate the net area compressive strength of the specimen as follows:

$$\text{Net Area Compressive Strength, psi (MPa)} = P_{max}/A_n \quad (7)$$

where:
P_{max} = maximum compressive load, lb (N), and
A_n = average net area of specimen, in.^{2} (mm^2).

9.6.2 *Gross Area Compressive Strength*— Calculate the gross area compressive strength of the specimen as follows:

$$\text{Gross Area Compressive Strength, psi (MPa)} = P_{max}/A_g \quad (8)$$

where:
P_{max} = maximum compressive load, lb (N), and
A_g = gross area of specimen, in.^{2} (mm^2).

10. Report

10.1 For the purpose of reporting test results, all observed or calculated values shall be rounded using the following procedure:

10.1.1 When the digit immediately after the last place to be retained is less than 5, retain unchanged the digit in the last place retained.

10.1.2 When the digit immediately after the last place to be retained is greater than or equal to 5, increase by 1 the digit in the last place retained.

NOTE ~~10—As~~ 11—As an example, density results are required to be reported to the nearest 0.1 pcf in A1.6.3. A calculated value of 130.85 pcf should be reported as 130.9 pcf.

10.2 A complete report shall include the following general information:
10.2.1 Name and address of the testing laboratory,
10.2.2 Identification of the report and the date of issue,
10.2.3 Name and address of the client or the identification of the project,
10.2.4 Description and identification of the test sample,
10.2.5 Date of receipt of the test sample,
10.2.6 Date(s) of test performance,
10.2.7 Identification of the standard test method used and a notation of any known deviation from the test method,
10.2.8 Name of the person(s) accepting technical responsibility for the test report,
10.2.9 Age of test specimens, if known,
10.2.10 Identification of subcontractor test results, and
10.2.11 A photograph, sketch, or description of the configuration of the unit.

10.3 A complete report shall also include the results of all tests and other reporting requirements from the applicable annex.

11. Keywords

11.1 absorption; compressive strength; concrete masonry units; density; equivalent thickness; equivalent web thickness; face shell; moisture content; roof paver; webs; web thickness

ANNEXES