



Designation: C90 – 16a

# Standard Specification for Loadbearing Concrete Masonry Units<sup>1</sup>

This standard is issued under the fixed designation C90; 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 ( $\epsilon$ ) 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 This specification covers hollow and solid (see 5.3 and 5.4) concrete masonry units made from hydraulic cement, water, and mineral aggregates with or without the inclusion of other materials. There are three classes of concrete masonry units: Normal Weight, Medium Weight, and Lightweight. These units are suitable for both loadbearing and nonloadbearing applications.

1.2 Concrete masonry units covered by this specification are made from lightweight or normal weight aggregates, or both.

NOTE 1—The requirements of this specification have been researched, evaluated, and established for over a century, resulting in the physical properties and attributes defined here. These requirements are uniquely and solely applicable to concrete masonry units manufactured on equipment using low or zero slump concrete and the constituent materials defined herein. Many performance attributes of concrete masonry units are indirectly accounted for, or inherently reflected within, the requirements of this specification without direct measurement, assessment, or evaluation. Applying the requirements of this specification to products that may be similar in appearance, use, or nature to those covered by this specification may not address all pertinent physical properties necessary to ensure performance or serviceability of the resulting construction in real-world applications under typical exposure environments. Products manufactured using alternative materials, manufacturing methods, or curing processes not covered by this specification should not be evaluated solely using the requirements in this specification; however, developers of new products can consider the property requirements of this specification as a beginning benchmark for unit performance. It is reasonable to test new products for system performance as well as unit performance.

1.3 The text of this specification 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.

1.4 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.

NOTE 2—When particular features are desired such as surface textures

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for appearance or bond, finish, color, or particular properties such as density classification, higher compressive strength, fire resistance, thermal performance or acoustical performance, these features should be specified separately by the purchaser. Suppliers should be consulted as to the availability of units having the desired features.

## 2. Referenced Documents

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

- C33/C33M Specification for Concrete Aggregates
- C140/C140M Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
- C150/C150M Specification for Portland Cement
- C331/C331M Specification for Lightweight Aggregates for Concrete Masonry Units
- C426 Test Method for Linear Drying Shrinkage of Concrete Masonry Units
- C595/C595M Specification for Blended Hydraulic Cements
- C618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
- C979/C979M Specification for Pigments for Integrally Colored Concrete
- C989/C989M Specification for Slag Cement for Use in Concrete and Mortars
- C1157/C1157M Performance Specification for Hydraulic Cement
- C1232 Terminology of Masonry
- C1240 Specification for Silica Fume Used in Cementitious Mixtures
- C1314 Test Method for Compressive Strength of Masonry Prisms
- E519/E519M Test Method for Diagonal Tension (Shear) in Masonry Assemblages
- E72 Test Methods of Conducting Strength Tests of Panels for Building Construction

## 3. Terminology

3.1 Terminology defined in Terminology C1232 shall apply for this specification.

<sup>2</sup> 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

## 4. Materials

4.1 *Cementitious Materials*—Materials shall conform to the following applicable specifications:

4.1.1 *Portland Cement*—Specification **C150/C150M**.

4.1.2 *Modified Portland Cement*—Portland cement conforming to Specification **C150/C150M**, modified as follows:

(1) *Limestone*—If calcium carbonate is added to the cement, the CaCO<sub>3</sub> content shall not be less than 85 %.

(2) *Limitation on Insoluble Residue*—1.5 %.

(3) *Limitation on Air Content of Mortar*—Volume percent, 22 % max.

(4) *Limitation on Loss on Ignition*—7 %.

4.1.3 *Blended Hydraulic Cements*—Specification **C595/C595M**.

4.1.4 *Hydraulic Cement*—Specification **C1157/C1157M**.

4.1.5 *Pozzolans*—Specification **C618**.

4.1.6 *Blast Furnace Slag Cement*—Specification **C989/C989M**.

4.1.7 *Silica Fume*—Specification **C1240**.

4.2 *Aggregates*—Aggregates shall conform to the following specifications, except for the grading requirements:

4.2.1 *Normal Weight Aggregates*—Specification **C33/C33M**.

4.2.2 *Lightweight Aggregates*—Specification **C331/C331M**.

NOTE 3—The grading requirements of Specifications **C33/C33M** and **C331/C331M** may not be suitable for concrete masonry production. Because of this, producers are allowed to modify grading to meet their needs and the requirements of this specification.

4.3 *Pigments for Integrally Colored Concrete*—Specification **C979/C979M**.

4.4 *Other Constituents*—Air-entraining agents, integral water repellents, and other constituents shall be previously established as suitable for use in concrete masonry units and shall conform to applicable ASTM standards or shall be shown by test or experience not to be detrimental to the durability of the concrete masonry units or any material customarily used in masonry construction.

## 5. Physical Requirements

5.1 At the time of delivery to the purchaser, units shall conform to the physical requirements prescribed in **Table 1** and **Table 2**. All units shall be sound and free of cracks or other defects that interfere with the proper placement of the unit or significantly impair the strength or permanence of the construc-

tion. Minor cracks, incidental to the usual method of manufacture or minor chipping resulting from customary methods of handling in shipment and delivery, are not grounds for rejection.

NOTE 4—Higher compressive strengths than those listed in **Table 2** may be specified where required by design. Consult with suppliers to determine availability of units of higher compressive strength.

NOTE 5—Oven-dry densities of concrete masonry units generally fall within the range of 85 to 145 lbf/ft<sup>3</sup> (1360 to 2320 kg/m<sup>3</sup>). Because available densities will vary, suppliers should be consulted before specifying project requirements.

5.1.1 When higher compressive strengths than those listed in **Table 2** are specified, the tested average net area compressive strength of three units shall equal or exceed the specified compressive strength, and the tested individual unit net area compressive strength of all three units shall exceed 90 % of the specified compressive strength. Compressive strength shall be tested in accordance with **8.2**.

5.2 At the time of delivery to the purchaser, the average linear shrinkage of the three units tested shall not exceed 0.065 % when tested in accordance with **8.3**.

NOTE 6—The purchaser is the public body or authority, association, corporation, partnership, or individual entering into a contract or agreement to purchase or install, or both, concrete masonry units. The time of delivery to the purchaser is FOB plant when the purchaser or the purchaser's agent transports the concrete masonry units, or at the time unloaded at the worksite if the manufacturer or the manufacturer's agent transports the concrete masonry units.

### 5.3 Hollow Units:

5.3.1 Face shell thickness ( $t_{fs}$ ) and web thickness ( $t_w$ ) shall conform to the requirements prescribed in **Table 1**.

NOTE 7—Web thickness ( $t_w$ ) not conforming to the requirements prescribed in **Table 1** may be approved, provided equivalent structural capability has been established when tested in accordance with the applicable provisions of Test Methods **E72**, **C1314**, **E519/E519M**, or other applicable tests and the appropriate design criteria developed is in accordance with applicable building codes.

### 5.4 Solid Units:

5.4.1 The net cross-sectional area of solid units in every plane parallel to the bearing surface shall be not less than 75 % of the gross cross-sectional area measured in the same plane.

### 5.5 End Flanges:

5.5.1 For units having end flanges, the thickness of each flange shall not be less than the minimum face shell thickness.

NOTE 8—Flanges beveled at the ends for mortarless head joint

**TABLE 1 Minimum Face Shells and Web Requirements<sup>A</sup>**

Nominal Width (W) of Units, in. (mm)	Face Shell Thickness ( $t_{fs}$ ), min. in. (mm) <sup>B,C</sup>	Webs	
		Web Thickness <sup>C</sup> ( $t_w$ ), min. in. (mm)	Normalized Web Area ( $A_{nw}$ ), min. in. <sup>2</sup> /ft <sup>2</sup> (mm <sup>2</sup> /m <sup>2</sup> ) <sup>D</sup>
3 (76.2) and 4 (102)	3/4 (19)	3/4 (19)	6.5 (45,140)
6 (152)	1 (25)	3/4 (19)	6.5 (45,140)
8 (203) and greater	1 1/4 (32)	3/4 (19)	6.5 (45,140)

<sup>A</sup>Average of measurements on a minimum of 3 units when measured as described in Test Methods **C140/C140M**.

<sup>B</sup>When this standard is used for units having split surfaces, a maximum of 10 % of the split surface is permitted to have thickness less than those shown, but not less than 3/4 in. (19.1 mm). When the units are to be solid grouted, the 10 % limit does not apply and Footnote C establishes a thickness requirement for the entire faceshell.

<sup>C</sup>When the units are to be solid grouted, minimum face shell and web thickness shall be not less than 5/8 in. (16 mm).

<sup>D</sup>Minimum normalized web area does not apply to the portion of the unit to be filled with grout. The length of that portion shall be deducted from the overall length of the unit for the calculation of the minimum web cross-sectional area.

**TABLE 2 Strength, Absorption, and Density Classification Requirements<sup>A</sup>**

Density Classification	Oven-Dry Density	Maximum Water		Minimum Net Area	
	of Concrete, lb/ft <sup>3</sup> (kg/m <sup>3</sup> )	Absorption, lb/ft <sup>3</sup> (kg/m <sup>3</sup> )		Compressive Strength, lb/in <sup>2</sup> (MPa)	
	Average of 3 Units	Average of 3 Units	Individual Units	Average of 3 Units	Individual Units
Lightweight	Less than 105 (1680)	18 (288)	20 (320)	2000 (13.8)	1800 (12.4)
Medium Weight	105 to less than 125 (1680–2000)	15 (240)	17 (272)	2000 (13.8)	1800 (12.4)
Normal Weight	125 (2000) or more	13 (208)	15 (240)	2000 (13.8)	1800 (12.4)

<sup>A</sup>Compressive strength, absorption, and density determined in accordance with 8.2.

applications that will be filled with grout are exempt from this requirement. Flanges which are specially shaped for mortarless head joint applications which have been shown by testing or field experience to provide equivalent performance are exempt from this requirement.

## 6. Permissible Variations in Dimensions

6.1 *Standard Units*—For standard units, no overall dimension (width, height, and length) shall differ by more than  $\pm 1/8$  in. (3.2 mm) from the specified dimensions.

6.2 *Particular Feature Units*—For particular feature units, dimensions shall be in accordance with the following:

6.2.1 For molded face units, no overall dimension (width, height, and length) shall differ by more than  $\pm 1/8$  in. (3.2 mm) from the specified standard dimension. Dimensions of molded features shall be within  $\pm 1/16$  in. (1.6 mm) of the specified standard dimensions and shall be within  $\pm 1/16$  in. (1.6 mm) of the specified placement of the molded feature.

NOTE 9—Molded features include, but are not limited to: ribs, scores, hex-shapes, and patterns.

6.2.2 For split-faced units, all non-split overall dimensions shall differ by not more than  $\pm 1/8$  in. (3.2 mm) from the specified standard dimensions.

6.2.3 For slump units, no overall height dimension shall differ by more than  $\pm 1/8$  in. (3.2 mm) from the specified standard dimension.

NOTE 10—On faces that are split or slumped, overall dimensions will vary. Consult with suppliers to determine achievable dimensional tolerances for products including these features.

## 7. Finish and Appearance

7.1 No more than 5 % of the units in the shipment shall exhibit one or more of the characteristics described in 7.1.1 through 7.1.4 and 7.2.

7.1.1 Units with dimensions not meeting the requirements of 6.1.

7.1.2 Units with finished face(s) containing chips larger than 1 in. (25.4 mm) in any direction.

7.1.3 Units with finished face(s) containing cracks wider than 0.02 in. (0.5 mm) and longer than 25 % of the nominal height of the unit.

7.1.4 Units that are broken.

NOTE 11—Units specified to have particular features or finishes, such as split-face and tumbled units, should not be evaluated for conformance of such features to the requirements of 7.1.2.

7.2 Where units are to be used in exposed wall construction, the face or faces that are to be exposed shall not show chips or cracks, not otherwise permitted in 7.1.2 and 7.1.3, or other imperfections when viewed from a distance of not less than 20 ft (6.1 m) under diffused lighting.

7.3 The color and texture of units shall be specified by the purchaser. The finished surfaces that will be exposed in place shall conform to an approved sample, consisting of not less than four units, representing the range of texture and color permitted.

NOTE 12—Concrete masonry units are produced using a wide variety of natural aggregates and other materials. As such, slight variations inherent from natural materials should be expected. Since specifying units and approving samples can take place several months prior to production of actual units for a project, slight variations in appearance from the approved sample are to be expected.

## 8. Sampling and Testing

8.1 The purchaser or authorized representative shall be accorded proper facilities to inspect and sample the units at the place of manufacture from the lots ready for delivery.

8.2 Compressive strength, absorption, density, and dimensional tolerances shall be based on tests of concrete masonry units of any configuration or dimension made with the same materials, concrete mix design, manufacturing process, and curing method, conducted in accordance with Test Methods C140/C140M and not more than 12 months prior to delivery.

8.3 Total linear drying shrinkage shall be based on tests of concrete masonry units of any configuration or dimension made with the same materials, concrete mix design, manufacturing process, and curing method, conducted in accordance with Test Method C426 and not more than 24 months prior to delivery.

## 9. Compliance

9.1 If a sample fails to conform to the specified requirements, the manufacturer shall be permitted to remove units from the shipment. A new sample shall be selected by the purchaser from remaining units from the shipment with a similar configuration and dimension and tested. If the second sample meets the specified requirements, the remaining portion of the shipment represented by the sample meets the specified requirements. If the second sample fails to meet the specified requirements, the remaining portion of the shipment represented by the sample fails to meet the specified requirements.

NOTE 13—Unless otherwise specified in the purchase order, the cost of tests is typically borne as follows: (1) if the results of the tests show that the units do not conform to the requirements of this specification, the cost is typically borne by the seller; (2) if the results of the tests show that the units conform to the specification requirements, the cost is typically borne by the purchaser.

## 10. Keywords

10.1 absorption; compressive strength; concrete masonry units; equivalent web thickness; face shell; flange; lightweight; linear drying shrinkage; loadbearing; medium weight; normal weight; webs

## APPENDIXES

### (Nonmandatory Information)

#### X1. WATER PENETRATION RESISTANCE

X1.1 Exterior walls are often subjected to moisture penetration from one or more sources. For example, basement walls may be exposed to water from saturated soil. Above-grade exterior walls are usually exposed to wind-driven rain. To prevent water penetration, proper detailing, construction,

flashing, and drainage should be provided. Proper water penetration resistant treatments should be applied to the walls. While it is not within the scope of Specification C90 to include information on resistance to water penetration, such information and guidelines are available from other organizations.

#### X2. CRACK CONTROL

X2.1 Restrained or differential movement in building elements and building materials can result in cracking. Some common causes of movement are: loads created by wind, soil pressure, seismic forces, or other external sources; settlement of foundations; or volume changes in materials. For example, volume changes in concrete masonry units can be caused by moisture gain and loss, thermal expansion and contraction, and carbonation. To limit and control cracking due to these and

other causes, proper design, detailing, construction, and materials are necessary. Specification C90 provides a maximum limitation on the total linear drying shrinkage potential of the units, but it is not within the scope of this specification to address other design, detailing, construction, or material recommendations. This type of information and related guidelines for crack control are available from other organizations.

## SUMMARY OF CHANGES

Committee C15 has identified the location of selected changes to this standard since the last issue (C90 – 16) that may impact the use of this standard. (December 15, 2016)

(1) Testing frequency in Section 8 was modified to be based on time of delivery.

Committee C15 has identified the location of selected changes to this standard since the last issue (C90 – 15) that may impact the use of this standard. (July 1, 2016)

(1) Modified 5.1.1, 5.2, and Table 2 to clarify determining of compliance for physical properties.

(2) Modified 4.2 and added Note 3 to clarify requirements for aggregate gradations.

Committee C15 has identified the location of selected changes to this standard since the last issue (C90 – 14) that may impact the use of this standard. (December 15, 2015)

(1) Revised 1.1 to remove numerals preceding density classifications.

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