

ASTM SPECIFICATIONS FOR CONCRETE MASONRY UNITS

TEK 1-1F
Codes & Specs (2012)

INTRODUCTION

The most widely-used standards for specifying concrete masonry units in the United States are published by ASTM International. These ASTM standards contain minimum requirements that assure properties necessary for quality performance. These requirements include items such as specified component materials, compressive strength, permissible variations in dimensions, and finish and appearance criteria. Currently, seven ASTM standards apply to units intended primarily for construction of concrete masonry walls, beams, columns or specialty applications (see Table 1).

The letter and first number of an ASTM designation is the fixed designation for that standard. For example, ASTM C55 is the fixed designation for concrete building brick. The number immediately following indicates the year of last revision (i.e., ASTM C55-11 is the version of C55 published in 2011). A date in parentheses after the last revision date is the reapproval date.

Because significant changes can be introduced into subsequent editions, the edition referenced by the building code or by a project specification can be an important consideration when determining specific requirements. Also note that it may take several years between publication of a new ASTM standard and its subsequent reference by a building code. For this reason, Table 1 includes the editions referenced in the 2006, 2009 and

2012 editions of the *International Building Code* (IBC) (ref. 1), as well as the most current ASTM edition. Code officials will commonly accept more current editions of ASTM standards than that referenced in the code, as they represent state-of-the-art requirements.

LOADBEARING CONCRETE MASONRY UNITS— ASTM C90

As the most widely-referenced ASTM standard for concrete masonry units, ASTM C90 is under continuous review and revision. The bulk of these revisions are editorial, although two recent major changes are discussed here.

In 2011, web thickness requirements were significantly revised. Prior to ASTM C90-11b (ref. 3), there were different minimum web thicknesses based on unit width. Additionally, equivalent web thickness, a measure of the width of web per foot of wall length was used to determine if sufficient web was present to transfer shear loads. In ASTM C90-11b, these requirements were replaced with a single minimum web thickness (0.75 in., 19.1 mm), regardless of unit width. The equivalent web thickness was replaced with a normalized web area, a measure of the area of web contact with the face shells per square foot of wall (see Table 2).

Table 1—ASTM Specifications for Concrete Masonry Units

Type of unit	ASTM designation	Edition referenced in:			Most current edition
		the 2006 IBC	the 2009 IBC	the 2012 IBC	
Concrete Building Brick	C55	C55-03	C55-06e ¹	C55-06e ¹	C55-11
Calcium Silicate Brick	C73	C73-99a	C73-05	C73-05	C73-10
Loadbearing Concrete Masonry Units	C90	C90-03	C90-06b	C90-08	C90-11b
Nonloadbearing Concrete Masonry Units	C129	C129-01 ^A	C129-05 ^A	C129-06 ^A	C129-11
Catch Basin and Manhole Units	C139	N/A ^B	N/A ^B	N/A ^B	C139-11
Prefaced Concrete Units	C744	C744-99	C744-05	C744-08	C744-11
Concrete Facing Brick	C1634	N/A ^B	N/A ^B	N/A ^B	C1634-11

^A Although not directly referenced in the IBC, C129 is referenced in *Specification for Masonry Structures* (ref. 2)

^B This standard is not referenced in the IBC.

Related TEK:
10-2C, 10-3, 14-22

Keywords: absorption, ASTM specifications, calcium silicate brick, compressive strength, concrete brick, dimensions, face shell and web thickness, gross area, net area, specifications, testing, water absorption

In 2000, the Type I (moisture-controlled) and Type II (non moisture-controlled) unit designations were removed from C90. The designations were withdrawn because they were difficult to effectively use and enforce, and because of newly developed concrete masonry crack control provisions. The new crack control guidelines are based on anticipated total volume changes, rather than on the specified moisture contents that formed the basis for Type I requirements. Control joint criteria can be found in References 5 and 6. For more detailed information on removal of the Type designations, see the Frequently Asked Questions section of the NCMA website (http://www.ncma.org/resources/design/Technical_FAQ).

Physical Requirements

Physical requirements prescribed by ASTM C90 include dimensional tolerances, minimum face shell and web thicknesses for hollow units, minimum strength and maximum absorption requirements, and maximum linear shrinkage.

Overall unit dimensions (width, height and length) can vary by no more than $\pm 1/8$ in. (3.2 mm) from the standard specified dimension. Exceptions are faces of split-face units and faces of slump units which are intended to provide a random surface texture. In these cases, consult local suppliers to determine achievable tolerances. Molded features such as rib and scores must be within $\pm 1/16$ in. (1.6 mm) of the specified dimension and within $\pm 1/16$ in. (1.6 mm) of the specified placement on the mold. For dry-stack masonry units, the physical tolerances are typically limited to $\pm 1/16$ in. (1.6 mm), which precludes the need for mortaring, grinding of face shell surfaces or shimming to even out courses during construction (ref. 7).

Minimum face shell and web thicknesses are those deemed necessary to obtain satisfactory structural and nonstructural performance. Note that although there are some unique face shell thickness requirements for split-faced units (see Table 2 footnote B), ground-face units (i.e., those ground after manufacture) must meet the face shell thickness requirements contained in the body

Table 2—ASTM C90-11b Minimum Face Shell & Web Requirements for Hollow Units (ref. 3) ^A

Nominal width of unit, in. (mm)	Face shell thickness, min., in. (mm) ^{B, C}	Webs	
		Web thickness ^C in. (mm)	Normalized web area, min., in. ² /ft ² (mm ² /m ²) ^D
3 (76.2) & 4 (102)	3/4 (19)	3/4 (19)	6.5 (45.14)
6 (152)	1 (25)	3/4 (19)	6.5 (45.14)
8 (203) & greater	1 1/4 (32)	3/4 (19)	6.5 (45.14)

^A Average of measurements on a minimum of 3 units when measured as described in Test Methods C140 (ref. 4).

^B For units with split surfaces, a maximum of 10% of the split surface may have thickness less than those shown, but not less than 3/4 in. (19 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 face shell.

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

^D 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.

of Table 2. In addition to minimum permissible web thicknesses for individual webs, the specification also requires a minimum total web contact area with face shells per square foot of wall area. When evaluating this normalized web area, the portion of a unit to be filled with grout is exempted. This provision avoids excluding units intentionally manufactured with reduced webs, including bond beam units and open-end block, where grout fulfills the structural role of the web.

A solid unit is one with a net cross-sectional area in every plane parallel to the bearing surface of at least 75% of the gross cross-sectional area measured in the same plane. Minimum face shell and web thicknesses are not prescribed for solid units.

The net area used to determine compressive strength is the “average” net area of the unit, calculated from the unit net volume based on tests described in ASTM C140 (ref. 4). Gross and net areas are shown in Figure 1.

Net area compressive strength is used for engineered masonry design, taking into account the mortar bedded and grouted areas. Gross area compressive strength is still used for empirically designed masonry (IBC Section 2109).

Maximum permissible water absorption is shown in Table 3. Absorption is a measure of the total water required to fill all voids within the net volume of concrete. It is determined from the weight-per-unit-volume difference between saturated and oven-dry units. Aggregates with relatively large pores, such as some lightweight aggregate, have a greater absorption than dense, nonporous aggregates, given the same compaction. As a result, lightweight units are permitted higher absorption values than medium or normal weight units.

Because concrete masonry units tend to contract as they dry, C90 limits their potential drying shrinkage to 0.065%, measured using ASTM C426 (ref. 8).

Finish and Appearance

Finish and appearance provisions prohibit defects that would impair the strength or permanence of the construction, but permit minor cracks incidental to usual manufacturing methods. For units which will be exposed, the presence of objectionable imperfections is based on viewing the unit face(s) from a distance of at least 20 ft (6.1 m) under diffused lighting. Five percent of a shipment may contain chips not larger than 1 in. (25.4 mm) in any dimension, or cracks not wider than 0.02 in. (0.5 mm) and not longer than 25% of the nominal unit height. The specification requires that color and texture be specified by the purchaser. An

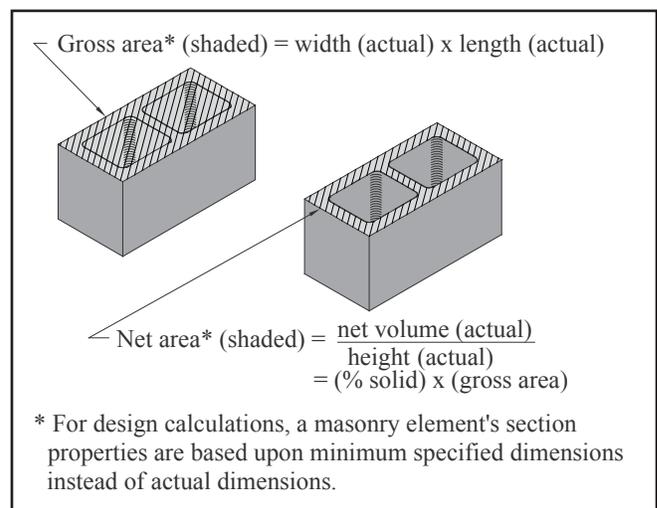


Figure 1—Gross and Net Areas

approved sample of at least four units, representing the range of color and texture permitted, is used to determine conformance.

CONCRETE BUILDING BRICK—ASTM C55

ASTM C55-03 (ref. 9a) included two grades of concrete brick: Grade N for veneer and facing applications and Grade S for general use. In 2006, the grades were removed and requirements for concrete brick used in veneer and facing applications were moved into a new standard: C1634 (see below). ASTM C55 now only applies to concrete masonry units with: a maximum width of 4 in. (102 mm); a weight that will typically permit it to be lifted and placed using one hand; and an intended use in nonfacing, utilitarian applications.

Requirements for C55-11 (ref. 9b) units include:

- 2,500 psi (17.2 MPa) minimum compressive strength (average of three units),
- 0.065% maximum linear drying shrinkage,
- 75% minimum percent solid, and
- maximum average absorption requirements of 13 pcf for normal weight brick, 15 pcf for medium weight brick and 18 pcf for lightweight brick (208, 240 and 288 kg/m³).

Finish and appearance criteria only address defects which might affect placement or permanence of the resulting construction.

CONCRETE FACING BRICK—ASTM C1634

A facing brick (C1634) is distinguished from a building brick (C55) primarily by its intended use: a facing brick is for uses where one or more unit faces will be exposed.

Compression and absorption requirements are listed in Table 4. Linear drying shrinkage, dimensional tolerances and finish and appearance requirements are similar to those in C90, with the exception that chip size is limited to $\pm 1/2$ in. (13 mm). Both C1634 and C55 refer to C140 (ref. 4) for compression testing, which requires compression test specimens to have a height that is $60\% \pm 10\%$ of its least lateral dimension, to minimize the potential impact of specimen aspect ratio on tested compressive strengths.

NONLOADBEARING CONCRETE MASONRY UNITS—ASTM C129

ASTM C129 (ref. 11) covers hollow and solid nonloadbearing units, intended for use in nonloadbearing partitions. These units are not suitable for exterior walls subjected to freezing cycles unless effectively protected from the weather. These units must be clearly marked to preclude their use as loadbearing units. Minimum net area compressive strength requirements are 500 psi (3.45 MPa) for an individual unit and 600 psi (4.14 MPa) average for three units.

CALCIUM SILICATE FACE BRICK—ASTM C73

ASTM C73 (ref. 12) covers brick made from sand and lime. Two grades are included:

- Grade SW—Brick intended for exposures below freezing in the presence of moisture. Minimum compressive strength requirements are 4,500 psi (31 MPa) for an individual unit and 5,500 psi (37.9 MPa) for an average of three units, based on average gross area. The maximum water absorption is 15 lb/ft³ (240 kg/m³).
- Grade MW—Brick intended for exposure to temperatures below freezing, but unlikely to be saturated with water. Minimum compressive strength requirements are 3,000 psi (20.7 MPa) for an individual unit and 3,500 psi (24.1 MPa) for an average of three units, based on average gross area. The maximum water absorption is 18 lb/ft³ (288 kg/m³).

PREFACED CONCRETE AND CALCIUM SILICATE MASONRY UNITS—ASTM C744

ASTM C744 (ref. 13) establishes requirements for the facing materials applied to masonry unit surfaces. For the units onto which the surface is molded, C744 requires compliance with the requirements contained in ASTM C55, C90 or C129, as appropriate. Facing requirements in C744 include: resistance to crazing, surface burning characteristics, adhesion, color permanence, chemical resistance, cleansability, abrasion, and dimensional tolerances.

Table 3—Strength and Absorption Requirements for Concrete Masonry Units, ASTM C90 (ref. 3)

Weight classification	Oven-dry density of concrete, lb/ft ³ (kg/m ³) Average of 3 units	Maximum water absorption, lb/ft ³ (kg/m ³)		Minimum net area compressive strength, psi (MPa)	
		Average of 3 units	Individual units	Average of 3 units	Individual units
Lightweight	Less than 105 (1,680)	18 (288)	20 (320)	1,900 (13.1)	1,700 (11.7)
Medium weight	105 to less than 125 (1,680 - 2,000)	15 (240)	17 (272)	1,900 (13.1)	1,700 (11.7)
Normal weight	125 (2,000) or more	13 (208)	15 (240)	1,900 (13.1)	1,700 (11.7)

Table 4—Strength and Absorption Requirements for Concrete Facing brick, ASTM C1634 (ref. 10)

Density classification	Oven-dry density of concrete, lb/ft ³ (kg/m ³) Average of 3 units	Maximum water absorption, lb/ft ³ (kg/m ³)		Minimum net area compressive strength, psi (MPa)	
		Average of 3 units	Individual units	Average of 3 units	Individual units
Lightweight	Less than 105 (1,680)	15 (240)	17 (272)	3,500 (24.1)	3,000 (20.7)
Medium weight	105 to less than 125 (1,680 - 2,000)	13 (208)	15 (240)	3,500 (24.1)	3,000 (20.7)
Normal weight	125 (2,000) or more	10 (160)	12 (192)	3,500 (24.1)	3,000 (20.7)

CONCRETE MASONRY UNITS FOR CATCH BASINS AND MANHOLES—ASTM C139

ASTM C139 (ref. 14) covers solid precast segmental units intended for use in catch basins and manholes. Units are required to be at least 5 in. (127 mm) thick, with a minimum gross area compressive strength of 2,500 psi (17 MPa) (average of 3 units) or 2,000 psi (13 MPa) for an individual unit, and a maximum water absorption of 10 pcf (16 kg/m³) (average of 3 units). The overall unit dimensions must be within $\pm 3\%$ of the specified dimensions.

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