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ASTM SPECIFICATIONS FOR CONCRETE MASONRY UNITS

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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 conformance to 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 C 55 is the fixed designation for concrete building brick. The number immediately following indicates the year of last revision (i.e., ASTM C 55-06 is the version of C 55 published in 2006). ASTM standards are required to be updated or reapproved at least every five years. If the standard is reapproved, the reapproval date is placed in parentheses after the last revision 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

2003 and 2006 editions of the *International Building Code* (IBC) (refs. 1, 2), 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 more state-of-the-art requirements for a specific material or system.

LOADBEARING CONCRETE MASONRY UNITS— ASTM C 90

As the most widely-referenced of the ASTM standards for concrete masonry units, ASTM C 90 is under continuous review and revision. The bulk of these revisions are essentially editorial, although two recent major changes are discussed here. In 2006, the minimum face shell thickness requirements were modified for units 10-in. (254-mm) and wider. Prior to ASTM C 90-06 (ref. 2), two minimum face shell thicknesses for these units were listed:

- a standard thickness, $1\frac{3}{8}$ in. for 10-in. units, $1\frac{1}{2}$ in. for 12-in. and greater (35 mm for 254-mm units and 38 mm for 305-mm and greater), and
- a reduced thickness that can be used when the allowable loads in empirical design are correspondingly reduced. Similarly, in the engineered design methods (allowable stress design and strength design), capacity is automatically reduced as the section properties are reduced.

With the introduction of ASTM C 90-06, the two sets of face shell thicknesses were replaced with one minimum thickness requirement (see Table 2).

In 2000, a prior change was made to ASTM C 90, removing the Type I (moisture-controlled) and Type II (non moisture-controlled) unit designations which is reflected in the ASTM C 90 editions adopted by the 2003 and 2006 editions of the

Table 1—ASTM Specifications for Concrete Masonry Units

Type of unit:	ASTM Designation:	Edition referenced in		
		the 2003 IBC:	the 2006 IBC:	Most current edition:
Concrete Building Brick	C 55	C 55-01a	C 55-03	C 55-06
Calcium Silicate Brick	C 73	C 73-99a	C 73-99a	C 73-05
Loadbearing Concrete Masonry Units	C 90	C 90-01a	C 90-03	C 90-06b
Nonloadbearing Concrete Masonry Units	C 129	C 129-99a ^A	C 129-01 ^A	C 129-06
Catch Basin and Manhole Units	C 139	N/A ^B	N/A ^B	C 139-05
Prefaced Concrete Units	C 744	C 744-99	C 744-99	C 744-05
Concrete Facing Brick	C 1634	N/A ^B	N/A ^B	C 1634-06

^A Although not directly referenced in the IBC, C 129 is referenced in *Specification for Masonry Structures* (refs. 17, 18)
^B This standard is not referenced in the IBC.

IBC. 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. Because the Type designations no longer influenced recommended control joint spacing or other crack control strategies, Type designations were removed. Control joint criteria can be found in References 5 and 6.

Physical Requirements

Physical requirements prescribed by ASTM C 90 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 ribs, scores, hex-shapes and patterns must be within $\pm 1/16$ in. (1.6 mm) of the specified standard 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 of Table 2. In addition to minimum permissible web thicknesses for individual webs, the specification also requires a minimum total thickness of webs per foot of block length. When evaluating this equivalent web thickness, the portion of a unit to be filled with grout is exempted from the minimum requirement. 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.

For a unit to be considered a solid unit, the net cross-sectional area in every plane parallel to the bearing surface must be 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 block, calculated from the unit net volume based on water displacement tests described in ASTM C 140 (ref. 8). For cored units having straight-tapered face shells and webs, average net area approximately equals the net cross-sectional area at the block mid-height. Gross and net areas of a concrete masonry unit are shown in Figure 1.

Net area compressive strength is used for engineered masonry design, taking into account the mortar bedded and grouted areas. Compressive strength based on gross area is still used for masonry designed by the empirical provisions of 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 concrete masonry units. Because absorption measures the water required to fill voids, aggregates with relatively large pores, such as some lightweight aggregate, would 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, ASTM C 90 limits their potential drying shrinkage to 0.065%, measured using ASTM C 426, *Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units* (ref. 9).

Finish and Appearance

Finish and appearance provisions prohibit defects that would impair the strength or permanence of the construction,

Table 2—ASTM C 90 Minimum Thickness of Face Shells and Webs for Hollow Units (ref. 3)

Nominal width of units, in. (mm)	Face shell thickness ^{B, C} , minimum, in. (mm)	Web thickness	
		Webs ^{B, C, D} in. (mm)	Equivalent web thickness, in./linear ft ^E (mm/linear m)
3 (76.2) & 4 (102)	$3/4$ (19)	$3/4$ (19)	$1\frac{5}{8}$ (136)
6 (152)	1 (25) ^D	1 (25)	$2\frac{1}{4}$ (188)
8 (203)	$1\frac{1}{4}$ (32) ^D	1 (25)	$2\frac{1}{4}$ (188)
10 (254) and greater	$1\frac{1}{4}$ (32)	$1\frac{1}{8}$ (29)	$2\frac{1}{2}$ (209)

^A Average of measurements on a minimum of 3 units when measured as described in Test Methods C 140.

^B 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 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 The minimum web thickness for units with webs closer than 1 in. (25.4 mm) apart shall be $3/4$ in. (19.1 mm).

^E Equivalent web thickness 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 equivalent web thickness.

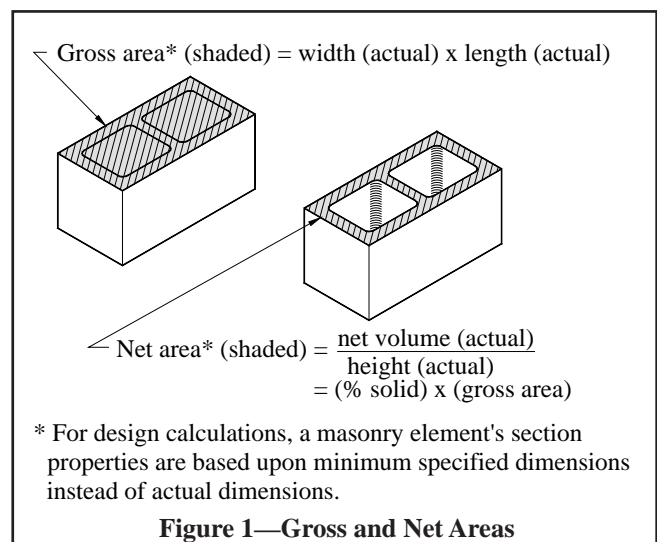


Figure 1—Gross and Net Areas

but permit minor cracks incidental to usual manufacturing methods. For units to be used in exposed walls, the presence of objectionable imperfections is based on viewing the unit face or faces 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. Similarly, the specification requires that color and texture be specified by the purchaser. An approved sample of at least four units, representing the range of color and texture permitted, is used to determine conformance.

CONCRETE BUILDING BRICK—ASTM C 55

ASTM C 55-03 (ref. 10) included two grades of concrete brick: Grade N for veneer and facing applications and Grade S for general use. In 2006, however, the grades were removed from C 55 and requirements for concrete brick used in veneer and facing applications were moved into a new standard: C 1634 (see below). ASTM C 55-06 (ref. 11) now applies to concrete building brick only, defined as 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 C 55-06 building brick 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).

The finish and appearance section of C 55-06 only addresses defects which might affect placement or permanence of the resulting construction.

CONCRETE FACING BRICK—ASTM C 1634

The introduction of this new standard in 2006 reflects the rise in popularity of concrete brick used in architectural facing applications. A facing brick (C 1634) is distinguished

from a building brick (C 55) primarily by its intended use. ASTM C 1634 (ref. 12) defines a concrete facing brick as a concrete masonry unit 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 application where one or more faces of the unit 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 C 90, with the exception that chip size is limited to $\pm 1/2$ in. (13 mm). The minimum permissible distance between any core holes in the brick and the edge of the brick is $3/4$ in. (19 mm), as it is in C 55. Both C 1634 and C 55 refer to C 140 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 C 129

ASTM C 129 (ref. 13) 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. ASTM C 129 requires that these units 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 C 73

ASTM C 73 (ref. 14) covers brick made from sand and lime. Two grades are included:

- Grade SW—Brick intended for use where exposed to temperatures 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

Table 3—Strength and Absorption Requirements for Concrete Masonry Units, ASTM C 90 (ref. 3)^A

Weight classification	Oven-dry density of concrete, lb/ft ³ (kg/m ³)	Maximum water absorption, lb/ft ³ (kg/m ³)		Minimum net area compressive strength, psi (MPa)	
	Average of 3 units	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)

^A Note that ASTM C 90-01a does not include requirements for maximum water absorption of individual units. Otherwise, the requirements are identical between C 90-03 and C 90-06b.

Table 4—Strength and Absorption Requirements for Concrete Facing Brick, ASTM C 1634 (ref. 12)

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

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 C 744

ASTM C 744 (ref. 15) for prefaced units establishes requirements for the facing materials applied to masonry unit surfaces. For the concrete masonry units onto which the surface is molded, C 744 requires compliance with the requirements contained in ASTM C 55, C 90 or C 129, as appropriate. Facing requirements in C 744 include: resistance to crazing,

surface burning characteristics, adhesion, color permanence, chemical resistance, cleansability, abrasion, and dimensional tolerances.

CONCRETE MASONRY UNITS FOR CATCH BASINS AND MANHOLES—ASTM C 139

ASTM C 139 (ref. 16) covers solid precast segmental concrete masonry 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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