

National Concrete Masonry Association
 an information series from the national authority on concrete masonry technology

SPECIFICATIONS FOR CONCRETE MASONRY UNITS

TEK 1-1A
 Codes & Specs (1995)

Keywords: absorption, area (net vs. gross), ASTM specifications, compressive strength, concrete brick, dimensions, face shell and web thickness, specifications, testing, water absorption

INTRODUCTION

The most widely used standards for specifying concrete masonry units are published by the American Society for Testing and Materials (ASTM). ASTM standards for concrete masonry units contain minimum requirements that assure properties necessary for quality performance. Requirements include conformance to specified component materials, moisture content, compressive strength, water absorption, permissible variation in dimensions, face shell and web thicknesses, and finish and appearance criteria.

Currently, six ASTM standards apply to units intended primarily for construction of concrete masonry walls, beams, columns, or specialty applications:

Type of Unit	ASTM Designation
Concrete Brick	C 55-95
Calcium Silicate Face Brick	C 73-95
Loadbearing Concrete Masonry Units	C 90-95
Nonloadbearing Concrete Masonry Units	C 129-95
Catch Basins and Manhole Units	C 139-95
Prefaced Concrete Units	C 744-95

The specifications listed above are developed under the jurisdiction of ASTM Committee C 15 on Manufactured Masonry Units and are the direct responsibility of Subcommittee C 15.03 on Concrete Masonry Units and Related Units.

The first part of an ASTM standard number is the fixed designation for that standard. For example, ASTM C 55 is the fixed designation for concrete brick. The number immediately following the fixed designation indicates the year of last revision. ASTM standards are required to be reviewed at least every 5 years. If no changes are made, the number in parenthesis after the date of last revision indicates the year of last reapproval.

LOADBEARING CONCRETE MASONRY UNITS— ASTM C 90

In 1990, the basis for compressive strength in ASTM C 90 was changed from gross area to average net area of the unit

(see Figure 1). This change was mandated by the ever-increasing use of engineered masonry design, which uses net area strength as a basis for allowable stresses. Compressive stress based on gross area of units is used with masonry designed by empirical codes, such as Chapter 9 of *Building Code Requirements for Masonry Structures* (ref. 1). Figure 1 illustrates gross area and net area for hollow concrete block.

Incorporation of net area strength permitted a change in the scope of ASTM C 90 to include both hollow and solid units and eliminated the need for a separate standard for solid units. Thus, ASTM C 145 has been discontinued.

Classification

Two types of concrete masonry units are covered by ASTM C 90: Type I, Moisture-Controlled Units, and Type II, Nonmoisture-Controlled Units.

Type I units are required to comply with the moisture content provisions listed in Table 1 at the time of delivery to the jobsite. The purpose of these requirements is to provide the specifier with a method of limiting residual drying shrinkage of units in the wall regardless of the shrinkage properties of the units (up to a maximum unit shrinkage of 0.065%).

These provisions prescribe maximum allowable moisture contents depending on: (1) shrinkage properties of the units, and (2) typical atmospheric humidity conditions at the point of use. Table 1 recognizes that the inherent linear drying shrinkage of concrete varies with materials and manufacturing

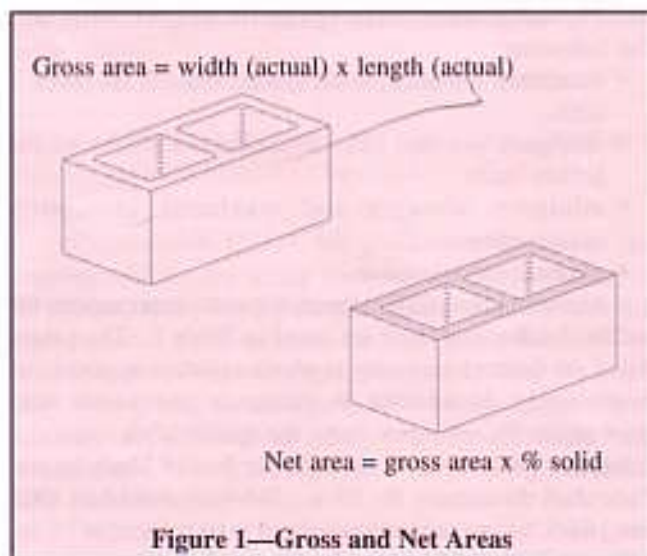


Table 1—Moisture Content Requirements for Type I Units

Linear shrinkage (%)	Maximum moisture content, % of total absorption (average of 3 units)		
	Humidity conditions at job site or point of use		
	Humid ^a	Intermediate ^b	Arid ^c
0.03 or less	45	40	35
From 0.03 to 0.045	40	35	30
0.045 to 0.065, max.	35	30	25

^aMean annual relative humidity above 75%.
^bMean annual relative humidity 50 to 75%.
^cMean annual relative humidity less than 50%.

methods used. Also, the moisture content of concrete tends to equalize with the average relative humidity. Thus, a lower moisture content is required when units are to be used in an arid environment, and a higher moisture content is permitted if units are used in a humid area. Likewise, units having lower drying shrinkage properties are permitted to have higher moisture content at time of delivery than higher shrinkage units. The appendix of ASTM C 90 includes a map of the U.S. showing mean annual relative humidity values which can be used in Table 1. Type I units should be protected from rain or other moisture at the job site before they are placed in the wall to ensure that they do not absorb additional moisture. In addition, the national *Specifications For Masonry Structures* (ref. 2) requires that the top of all unfinished masonry be covered to protect it from the weather.

Type II units, which are not required to meet a maximum moisture content, are extensively used. With exposed Type II units, closer control joint spacing or increased horizontal reinforcement may be advisable depending on the potential shrinkage properties of the units. As with Type I units, Type II units are limited to a maximum linear shrinkage of 0.065%.

Physical Requirements

Physical requirements prescribed in ASTM C 90 include the following:

- maximum moisture content requirements for Type I units,
- minimum face shell and web thickness requirements for hollow units,
- minimum strength and maximum absorption requirements,
- dimensional tolerances.

Minimum face shell and web thickness requirements for hollow loadbearing units are listed in Table 2. The values listed are deemed necessary to obtain satisfactory structural performance. In addition to minimum permissible web thicknesses for individual webs, the specification requires a minimum total thickness of webs per foot of block length. Face shell thicknesses for 10 in. (254 mm) and 12 in. (305 mm) thick hollow units are permitted to be reduced to 1 1/4 in. (32 mm) if allowable design loads are reduced in proportion

to the reduction in thickness from the basic face shell thicknesses listed.

Provisions for face shell thickness have been extended to include face shell thickness for split face units. As shown in footnote A of Table 2, a maximum of 10% of a split face shell area may be less than the minimum prescribed thickness, but not less than 3/4 in. (19 mm).

Footnote B exempts the portion of a unit to be filled with grout. This provision was included to avoid exclusion of special units, such as bond beam and open-end block, because they may not meet the web thickness requirements. Footnote C, which permits reduction in face shell thickness if the allowable design load is reduced, clarifies that such units, when fully grouted, do not require reduction in allowable load.

For solid units, the net cross-sectional area in every plane parallel to the bearing surface is 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.

In previous editions of ASTM C 90, two grades of block (N and S) were included, distinguished only by differences in compressive strength and water absorption requirements. The lower grade has been discontinued and there is now one grade, which is not given a grade classification. Compressive strength based on net cross-sectional area is required to be at least 1700 psi (11.7 MPa) for individual units and 1900 psi (13.1 MPa) for the average of three units (Table 3). Net area

Table 2—Minimum Thickness of Face Shells and Webs

Nominal width of units, in. (mm)	Face shell thickness, in. (mm)	Web thickness	
		Webs ^a , in.(mm)	Equivalent web thickness, in./linear ft ^b (mm/linear m)
3 (76) and 4 (102)	3/4 (19)	3/4 (19)	1 1/8 (136)
6 (152)	1 (25)	1 (25)	2 1/4 (188)
8 (203)	1 1/4 (32)	1 (25)	2 1/4 (188)
10 (254)	1 1/2 (35)	1 1/8 (29)	2 1/2 (209)
	1 1/4 (32) ^c		
12 (305)	1 1/2 (38)	1 1/8 (29)	2 1/2 (209)
	1 1/4 (32) ^c		

^aAverage of measurements on 3 units taken at the thinnest point when measured as described in Methods C 140. When this standard is used for split face units, a maximum of 10% of a split face shell area may have thickness less than those shown, but not less than 3/4 inch (19 mm). When the units are solid grouted, the 10% limit does not apply.

^bSum of the measured thickness of all webs in the unit divided by the length of the unit. 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.

^cThis face shell thickness is applicable where allowable design load is reduced in proportion to the reduction in thickness from basic face shell thicknesses shown, except that allowable design loads on solid grouted units shall not be reduced.

**Table 3—Strength and Absorption Requirements
for Concrete Masonry Units, ASTM C 90**

Minimum compressive strength ^a , psi (MPa) Average net area		Maximum water absorption, lb/ft ³ (kg/m ³) (average of 3 units) Weight classification — oven dry weight of concrete, lb/ft ³ (kg/m ³)		
		Average of 3 units	Individual unit	Lightweight, less than 105 (1682)
1900 (13.1)	1700 (11.7)	18 (288)	15 (240)	13 (208)

^aHigher compressive strengths may be specified where required by design. Consult with local suppliers to determine availability of units of higher compressive strength.

used for compressive strength determination is the "average" net area of the block, calculated by determining unit net volume from water displacement tests described in ASTM Test Methods C 140 (ref. 3). For cored units having tapered face shells and webs, average net area is typically the net cross-sectional area at approximately mid-height of the block.

Maximum permissible water absorption is shown in Table 3. Absorption is a measure of the total water-fillable void content of the concrete. It is determined from the weight-per-unit-volume difference between saturated and oven-dry concrete masonry units. Absorption is expressed in terms of pounds of water per cubic foot of concrete. The maximum permissible absorption ranges from 13 to 18 pcf (208 to 288 kg/m³), depending on the density of the concrete. Since absorption is a measure of the total water-fillable void content, aggregates with relatively large pores, such as some lightweight aggregate, would have a greater absorption than dense, non-porous aggregates, given the same compaction. As a result, lightweight units are permitted higher absorption values than medium or normal weight units.

Finish and Appearance

Provisions relating to finish and appearance prohibit defects that would impair the strength or permanence of the construction, but permit minor cracks incidental to the usual manufacturing methods.

For units which will be used in exposed wall construction, the presence of objectionable imperfections is based on viewing the face or faces from a distance of 20 ft (6.1 m) under diffused lighting. Similarly, the specification requires that color and texture be specified by the purchaser, and that an approved sample consisting of not less than four units, representing the range of color and texture permitted, be used to determine conformance.

CONCRETE BRICK—ASTM C 55

ASTM C 55 applies to solid brick size units, solid concrete veneer, and facing units larger than brick size.

Two grades of concrete brick are included in ASTM C 55:

- Grade N—For use as architectural veneer and facing units in exterior walls and for use where high strength and resistance to moisture penetration and severe frost action are desired.
- Grade S—For general use where moderate strength and resistance to frost action and moisture penetration are required.

Compressive strength and absorption requirements for the two grades of concrete brick are listed in Table 4. ASTM C 55 includes requirements for Type I and II units, similar to C 90. Moisture content requirements for Type I concrete brick are the same as those in ASTM C 90 (Table 1).

NONLOADBEARING CONCRETE MASONRY UNITS—ASTM C 129

ASTM C 129 covers hollow and solid non-load-bearing 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 compressive strength requirements are 500 psi (3.5 MPa) for individual units and 600 psi (4.1 MPa) for an average of three units, based on net cross-sectional area.

ASTM C 129 covers Type I and Type II units, which must meet identical moisture content and linear drying shrinkage requirements to those in ASTM C 90 (Table 1).

CALCIUM SILICATE FACE BRICK—ASTM C 73

ASTM C 73 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.
- Grade MW—Brick intended for exposure to temperatures below freezing, but unlikely to be saturated with water.

Physical requirements are listed in Table 5.

PREFACED CONCRETE AND CALCIUM SILICATE MASONRY UNITS—ASTM C 744

Specification C 744 for prefaced units establishes requirements for the facing materials applied to the surface of masonry units. For the concrete masonry units onto which the prefaced surface is molded, C 744 references the requirements contained in specifications C 55, C 90, and C 129. Facing requirements in C 744 include: resistance to crazing, surface burning characteristics, adhesion, color permanence, chemical resistance, cleansability, abrasion, and dimensional tolerances.

Table 4—Strength and Absorption Requirements for Concrete Building Brick, ASTM C 55

Minimum compressive strength, psi (MPa) (concrete brick tested flatwise) average gross area			Maximum water absorption (average of 3 bricks) with oven dry weight of concrete, lb/ft ³ (kg/m ³)		
			Weight Classification, lb/ft ³ (kg/m ³)		
Grade	Average of 3 concrete bricks	Individual concrete brick	Lightweight, less than 105 (1682)	Medium weight, less than 125 (2002) to 105 (1682)	Normal weight, 125 (2002) or greater
N-I, N-II	3500 (24.1)	3000 (20.7)	15 (240)	13 (208)	10 (160)
S-I, S-II	2500 (17.3)	2000 (13.8)	18 (288)	15 (240)	13 (208)

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

Specification C 139 covers solid precast segmental concrete masonry units intended for use in the construction of catch basins and manholes. Units are required to be at least 5 in. (127 mm) thick, with an average gross area minimum compressive strength of 2500 psi (17.3 MPa) or 2000 psi (13 MPa) for an individual unit, and a maximum water absorption of 10 pcf (16 kg/m³).

**Table 5—Physical Requirements for Calcium
Silicate Face Brick, ASTM C 73**

Designation	Minimum compressive strength average gross area (brick tested flatwise), psi (MPa)		Maximum water absorption, lb/ft ³ (kg/m ³)
	Average of 3 bricks	Individual brick	
Grade SW	4500 (31.0)	3500 (24.1)	10 (160)
Grade MW	2500 (17.3)	2000 (13.8)	13 (208)

REFERENCES

1. *Building Code Requirements for Masonry Structures*, ACI 530-92/ASCE 5-92/TMS 402-92. Reported by the Masonry Standards Joint Committee, 1992.
2. *Specifications for Masonry Structures*, ACI 530.1-92/ASCE 6-92/TMS 602-92. Reported by the Masonry Standards Joint Committee, 1992.
3. *Standard Methods of Sampling and Testing Concrete Masonry Units*, ASTM C 140-95. American Society for Testing and Materials, 1995.
4. *Standard Specification for Calcium Silicate Face Brick (Sand-Lime Brick)*, ASTM C 73-95. American Society for Testing and Materials, 1995.
5. *Standard Specification for Concrete Brick*, ASTM C 55-95. American Society for Testing and Materials, 1995.
6. *Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes*, ASTM C 139-95. American Society for Testing and Materials, 1995.
7. *Standard Specification for Loadbearing Concrete Masonry Units*, ASTM C 90-95. American Society for Testing and Materials, 1995.
8. *Standard Specification for Nonloadbearing Concrete Masonry Units*, ASTM C 129-95. American Society for Testing and Materials, 1995.
9. *Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units*, ASTM C 744-95. American Society for Testing and Materials, 1995.
10. *Standard Test Method for Drying Shrinkage of Concrete Block*, ASTM C 426-95. American Society for Testing and Materials, 1995.