

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

SAMPLING AND TESTING CONCRETE MASONRY UNITS

TEK 18-2A

Quality Assurance & Testing (2004)

Keywords: absorption, ASTM specifications, compressive strength, coupon, dimensions, sampling, shrinkage, testing

INTRODUCTION

Standards for sampling and testing concrete masonry units are developed by the technical committees of ASTM International in accordance with consensus procedures. These standards reflect the expert opinion of researchers, concrete masonry manufacturers, designers, contractors and others with an interest in quality standards for concrete masonry.

The most commonly used ASTM standards for concrete masonry unit testing include: *Standard Methods for Sampling and Testing Concrete Masonry Units and Related Units*, ASTM C 140 (ref. 1), and *Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units*, ASTM C 426 (ref. 2). In addition, *Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units*, ASTM C 744 (ref. 3), references testing methods for prefaced units.

SAMPLING & TESTING CONCRETE MASONRY UNITS, ASTM C 140

Unit Sampling

The purpose of selecting multiple samples for unit testing is to ensure that the range of results is representative of the entire lot of units from which the specimens were taken. Similarly, concrete masonry units chosen for testing should be randomly sampled. Choosing units from one portion of a pallet, or choosing the most desirable or least desirable units may misrepresent the properties of the lot.

Although a shipment may consist of several different unit configurations, samples for testing should all have the same configuration and dimensions. In some cases, such as shrinkage results under ASTM C 426-99, *Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units* (ref. 2), it is generally acceptable to consider the test results of one unit configuration to be representative of units with different configurations provided they were made using the same mix design, manufacturing and curing procedures.

Units that are representative of the entire lot of units are sampled from the job site or may be sampled from the manu-

facturer's storage inventory. Sampled units are marked with a unique identification and weighed.

Measurement of Dimensions

Unit dimensions are used: to verify that the overall length, width and height are within allowable tolerances; to calculate equivalent web thickness and equivalent thickness; and to verify that face shell and cross web thicknesses meet the requirements of the appropriate unit specification. Minimum face shell thickness is prescribed to address concerns such as ease of mortar placement, sufficient mortar coverage over joint reinforcement and resistance to lateral pressure from grouting. Minimum web thickness considerations include transfer of shear, flexural strength in the horizontal span, and resistance

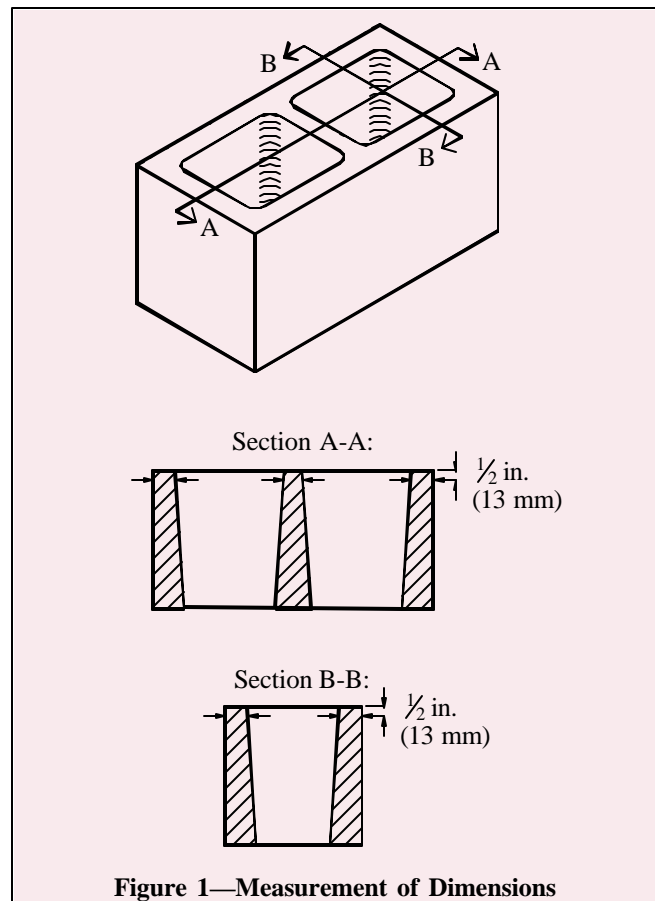


Figure 1—Measurement of Dimensions

to tensile splitting of walls under compression. Figure 1 illustrates how these measurements are taken.

Although not specified in ASTM C 140 (ref. 1), the units set aside for absorption testing are typically used for measurement of unit dimensions, before the units are immersed in water. This way, the gross volume (determined from overall unit dimensions) and the net volume (determined from water displacement) for the units are both determined from the same set of test specimens.

Absorption

Absorption describes the amount of water a unit can hold when saturated. Absorption can be an indicator of the level of compaction of the concrete mix or of the volume of voids within a block. For a given mix design and manufacturing and curing process, variations in absorption can be an indication of variations in the compaction of the concrete mix, which also can indicate variations in compressive strength, tensile strength and durability. Data collected during absorption testing is used to calculate absorption, density, net area, net volume and equivalent thickness.

During absorption testing, each unit is weighed a minimum of five times in this order: received weight; immersed weight; saturated surface dry weight; and oven-dry weight (at least twice). The saturated and immersed weights should always be determined following 24 hours of immersion and prior to oven drying the units.

Because the units are immersed in water during absorption testing, the units used for this determination should not be used for compression testing, the results of which are influenced by unit moisture content. Six units of identical size and configuration are therefore required for ASTM C 140 testing—three for compression testing and three for absorption.

Compressive Strength

Compressive strength tests are used to ensure that concrete masonry units meet the minimum strength requirements of the applicable unit specification (see refs. 10, 11). The unit compressive strength results may also be used to verify compliance with the specified compressive strength of masonry,

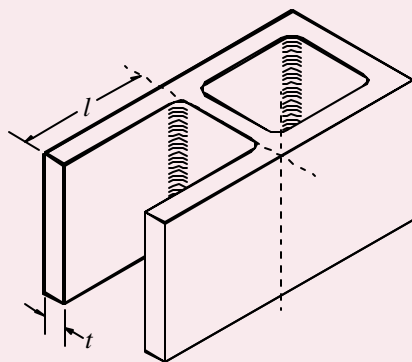
f'_m , when using the unit strength method (ref. 4, Article 1.4 B.2.b). Unit compression tests are easier and less expensive to perform than similar tests on masonry prisms, making the unit strength method the more popular.

Some of the critical areas of compression testing that are necessary to insure accurate testing include:

- Appropriate capping stations with stiff, planar plates with smooth surfaces.
- Compression machines with spherically seated heads and bearing plates of adequate planeness and thickness. For example, TEK 18-1A (ref. 8) includes an example using a compression machine with an 8-in. (203-mm) spherically seated head, where the minimum bearing plate thickness is 4.7 in. (119 mm) when testing a full-sized unit, but could be reduced to 1.41 in. (36 mm) by testing a reduced size unit.
- Proper specimen alignment within the testing machine (center of mass aligned with center of thrust).

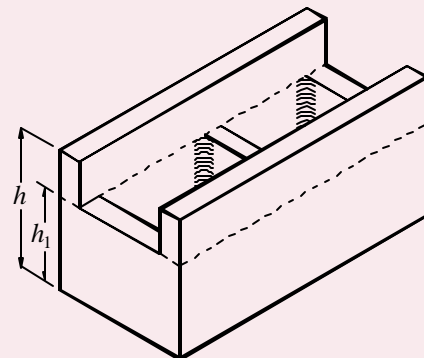
For compressive strength determination, three specimens are tested within 72 hours after delivery to the laboratory. Wherever possible, full-sized units are used. However, certain modifications are permitted or required as follows:

- Unsupported projections must be removed by saw-cutting when the length exceeds the thickness of the projection, as illustrated in Figure 2. For units with recessed webs, the face shell projecting above the web shall be removed by saw-cutting to provide a full bearing surface over the net cross section of the unit, as shown in Figure 3. The height of the saw-cut specimen should be at least $\frac{2}{3}$ of the unit's original height. If this cannot be achieved, the unit should be coupon tested.
- When the size and/or strength of the unit exceeds the testing machine capacity, a specimen may be cut to conform to the testing machine capabilities. The resulting specimen, however, must contain an enclosed four-sided cell or cells without irregular face shells or webs. See TEK 18-1A (ref. 8) for more information.
- If saw-cutting does not produce a test specimen complying with the above provisions, coupons may be saw-cut from



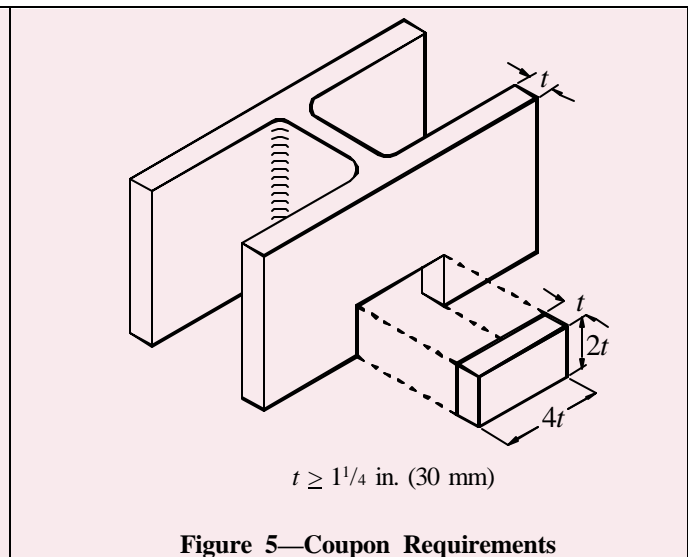
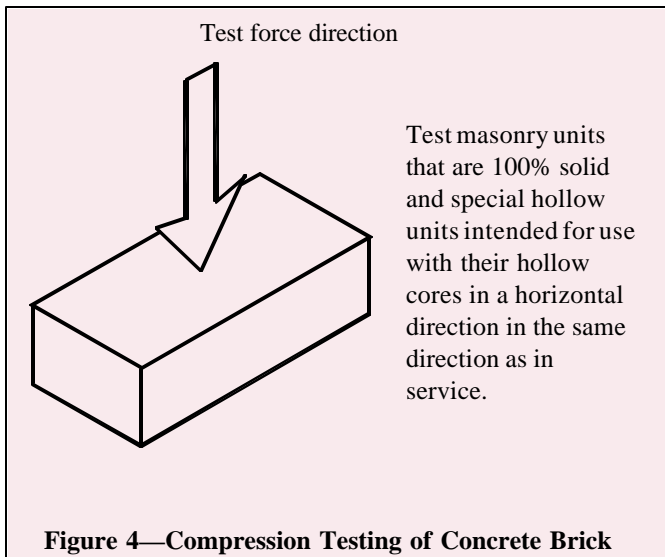
If $l > t$, remove projecting faceshells by saw-cutting.

Figure 2—Units With Unsupported Projections



Saw cut projecting faceshells to provide full bearing surface if $h_1 \geq \frac{2}{3} h$; if $h_1 < \frac{2}{3} h$, use coupon testing procedure.

Figure 3—Units With Reduced Webs



the face shells of each test specimen. Coupon requirements are shown in Figure 5.

- For concrete roof paver units, cut three test specimens from three whole paver units to produce a strip of paver with the specimen height equal to its width. Where the paver has supporting ribs, cut the coupon perpendicular to the direction of the ribs, such that any bevelled or recessed surfaces are not included in the top or bottom edges of the specimen.

The prepared specimens are then capped to provide a uniform and level bearing surface. After the specimen center of mass is located, the specimen is positioned in the testing machine such that the specimen's center of mass is aligned with the machine's center of thrust. The load is applied at a prescribed rate, and the specimen is tested to failure.

Further information on compressive strength testing is available in references 8 and 12.

Calculations

Using the data gathered in the preceding test methods, the following characteristics are determined: absorption, density, average net area, gross area, net and gross area compressive strengths, equivalent web thickness and equivalent thickness.

Density, or unit weight, of concrete block is described in terms of dry weight per cubic foot. It is determined from the three weights described previously: saturated weight, immersed weight and oven-dry weight. Using these weights the volume of concrete in a unit is readily determined and its density is the oven-dry weight divided by its net volume. Among the properties affected by density of concrete in a block are wall weight, building weight, thermal conductivity, heat capacity and acoustical properties.

Cross-sectional area is the basis for expressing compressive strength of concrete masonry units. Unit specifications require that block comply with a minimum net area compressive strength rather than gross area strength. The exception to this is units complying with ASTM C 55, *Standard Specification for Concrete Brick* (ref. 9) (see Figure 4). Net area is described in terms of the percentage of solid material in the cross section, and is measured by the ratio of net volume of the unit to gross volume of the unit. Because water displacement

is used to determine net volume, the net cross-sectional area represents the average net area of the unit rather than the minimum or maximum.

Equivalent solid thickness is used for classifying the fire resistance rating of hollow concrete masonry. It represents the average thickness of a hollow unit if the volume is configured into a solid unit of the same face dimension. It is determined by dividing the net unit volume by the unit's face area.

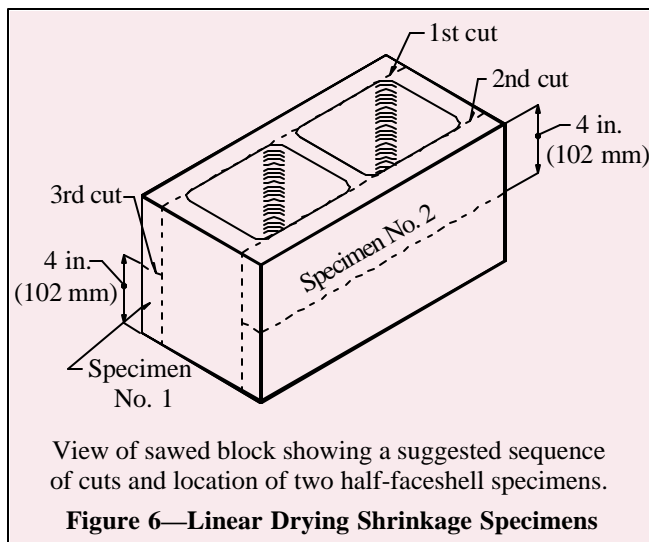
DRYING SHRINKAGE, ASTM C 426

ASTM C 426, *Standard Test Method for Drying Shrinkage of Concrete Masonry Units* (ref. 2) is intended to evaluate the potential shrinkage characteristics of concrete masonry units due to moisture loss only. Note that concrete masonry may also shrink due to factors such as carbonation and temperature changes, which are not addressed by this test method, although temperature is standardized and corrected so as not to influence the results. This test measures unit length change from a totally saturated condition to an "equilibrium" condition at 17% relative humidity. This reported value represents the potential shrinkage because the masonry is unlikely to encounter these extreme conditions under normal circumstances. The test results are used to determine concrete masonry crack control provisions.

Typically, it is not necessary to run shrinkage tests on units made with the same mix design but having different unit configurations. As long as there are no changes in materials, mix design, production methods or curing, ASTM C 426 tests are required to be performed only once every two years.

Test specimens are usually whole units with measurements taken on both faces. Alternatively, coupons may be cut from face shells, as illustrated in Figure 6. Gage plugs are mounted on the test specimens to facilitate length measurements.

This method requires the test specimens to be saturated for 48 hours, at which time the length is precisely measured and recorded. Specimens are then dried in an oven for 5 days. After drying, specimens are cooled and measured. Test specimens are then returned to the drying oven for periods of 48 hours until the length change is negligible as defined in the test method.



PREFACED UNITS

For concrete masonry units with a smooth, resinous tile-like facing adhered to the unit, *Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units*, ASTM C 744 (ref. 3) includes specification requirements and applicable test methods for the facings. The concrete masonry units to which the facing is applied must comply with the applicable unit specification. Facing requirements include:

Resistance to crazing—Prefaced units are subjected to wetting and drying to demonstrate that the facing does not craze, crack or spall.

Resistance to chemicals—The facing must remain unchanged when subjected to the specified list of chemicals for the corresponding exposure durations.

Adhesion—The facing must remain adhered to the unit when the unit is loaded to failure by an applied compression load.

Abrasion—The wear index of the facing must exceed 130 when the facing is subjected to a standard abrasion test (ASTM C 501, ref. 5).

Surface burning—The flame spread and smoke density rating of the facing must not exceed 25 and 50, respectively, when tested in accordance with ASTM E 84 (ref. 6).

Color tint & texture—The facing texture must remain unchanged and facing color difference must not exceed 5 Delta units (ref. 7) when subjected to an accelerated weathering test.

Soiling and cleansability—No more than a trace of stain may remain on the facing when subjected to a specified list of marking substances and subsequently cleaned.

REFERENCES

1. *Standard Methods for Sampling and Testing Concrete Masonry Units and Related Units*, ASTM C 140-03. ASTM International, 2003.
2. *Standard Test Method for Linear Drying Shrinkage of Concrete Masonry Units*, ASTM C 426-99. ASTM International, 1999.
3. *Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units*, ASTM C 744-99. ASTM International, 1999.
4. *Specification for Masonry Structures*, ACI 530.1-05/ASCE 6-05/TMS 602-05. Reported by the Masonry Standards Joint Committee, 2005.
5. *Standard Test Method for Relative Resistance to Wear of Unglazed Ceramic Tile by the Taber Abraser*, ASTM C 501-84 (2002). ASTM International, 2002.
6. *Standard Test Method for Surface Burning Characteristics of Building Materials*, ASTM E 84-04. ASTM International, 2004.
7. *Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates*, ASTM D 2244-02^{e1}. ASTM International, 2002.
8. *Compressive Strength Evaluation of Concrete Masonry*, TEK 18-1A. National Concrete Masonry Association, 2004.
9. *Standard Specification for Concrete Brick*, ASTM C 55-03. ASTM International, 2003.
10. *ASTM Specifications for Concrete Masonry Units*, TEK 1-1C. National Concrete Masonry Association, 2002.
11. *Specifications for Concrete Masonry Roof Pavers*, TEK 2-5A. National Concrete Masonry Association, 1999.
12. *Compressive Strength testing Variables for Concrete Masonry Units*, TEK 18-7. National Concrete Masonry Association, 2004.

Disclaimer: Although care has been taken to ensure the enclosed information is as accurate and complete as possible, NCMA does not assume responsibility for errors or omissions resulting from the use of this TEK.