



NEW CONCRETE MASONRY UNIT CONFIGURATIONS UNDER ASTM C90

TEK 2-5B Unit Properties (2012)

INTRODUCTION

The most widely-used standard for specifying concrete masonry units in the United States is ASTM C90, *Standard Specification for Loadbearing Concrete Masonry Units* (ref. 1). ASTM C90 contains minimum requirements that assure properties necessary for quality performance, including specified constituent materials, minimum face shell and web thicknesses, minimum compressive strength, permissible variations in dimensions, and finish and appearance criteria.

In 2011, C90 was modified to permit the cross webs of units to be configured in different ways to meet specific project needs and performance requirements. Under new C90 requirements, web configurations are no longer regulated by their thickness, but rather the cross-sectional area of the web connecting the face shells of a unit.

It is important to note that these web configuration changes *do not require* any change to web configurations or unit properties—most traditional two-cell concrete masonry units still comply with ASTM C90.

Allowing the option to reduce the web thickness and/or area allows for a greater array of unit configurations. This change was motivated by a desire to provide designers, contractors, and masonry producers with the flexibility to meet more demanding requirements and performance expectations by allowing concrete masonry unit configurations to be varied where needed.

Using less material in production reduces: the demand on resources; the energy necessary to manufacture products; and the fuel required to transport units to job sites—while maintaining the high durability, low impact solution inherent in concrete masonry. Units with smaller webs will also have higher R-values and allow more varied insulation options to meet demanding energy code requirements and green initiatives. Lighter units also reduce foundation loads and increase construction productivity and reduce mason fatigue, which can reduce construction costs for concrete masonry wall systems.

Not every unit configuration is available in every market.

Contact your local CMU manufacturer to explore the range of possibilities available.

ASTM C90 WEB THICKNESS REQUIREMENTS

Minimum face shell and web thicknesses in ASTM C90 are those deemed necessary to obtain satisfactory structural and nonstructural performance. Considerations for minimum web thickness and/or area include the ability to efficiently produce the unit, durability during handling and shipping, as well as the structural performance of the resulting wall.

Table 1—ASTM C90-11b Minimum Face Shell & Web Requirements for Hollow Units (ref. 1) ^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 (45,140)
6 (152)	1 (25)	³ / ₄ (19)	6.5 (45,140)
8 (203) & greater	1 ¹ / ₄ (32)	³ / ₄ (19)	6.5 (45,140)

^A Average of measurements on a minimum of 3 units when measured as described in Test Methods C140 (ref. 2).

^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.

Related TEK:
6-3, 6-11A, 6-14A,
7-1C, 13-1B, 18-2B

Keywords: ASTM standards, unit configurations, energy efficiency, fire resistance ratings, productivity, reinforced concrete masonry, sound transmission class ratings, structural design considerations, sustainability

Previous versions of ASTM C90 required units to meet an equivalent web thickness, calculated by adding all web thicknesses together and dividing by the unit length. The intent was to provide a minimum amount of concrete connecting the face shells. This approach, however, did not account for web height. Hence, units with very short webs were permitted, even though these units may have had very little concrete connecting the face shells. In addition, the numerical values of these previous requirements was somewhat arbitrary and based on empirical experience.

The revised web requirements in C90-11b were developed using a rational approach, and are intended to ensure that a unit can be produced consistently and uniformly while safeguarding the structural performance and life safety attributes of assemblies in service. The C90-11b web requirements are shown in Table 1 and summarized here:

1. The equivalent web thickness (the sum of the individual web thicknesses per foot of block length) has been removed.
2. The minimum thickness of each web is $\frac{3}{4}$ in. (19 mm). This minimum thickness ensures that web area can be adequately filled during manufacture.
3. The total cross-sectional area of the webs connecting the face shells of the unit must be at least 6.5 in.² of web/ft² of wall area (45,140 mm²/m²), which equates to at least 5.8 in.² (40,280 mm²) of web area per unit for units with 8 by 16 in. (203 by 406 mm) nominal face dimensions. This area was determined based on common design loading scenarios.

IMPACTS ON UNIT CONFIGURATION

As stated previously, the revised web requirements in C90-11b do not require any change to currently available concrete masonry units. The changes will, however, facilitate innovation in unit configurations to meet the needs of local markets. Local market conditions and preferences will continue to drive specific nuances of unit configuration. Figure 1 illustrates a few of the alternate configurations that are permitted under the revised C90 web criteria. Local manufacturers should be consulted for specific unit availability.

Although there are regional variations and countless unique, specialized, and proprietary unit configurations in use today, the current ‘standard’ unit configuration is a two-cell, three-web unit (similar to that shown in Figure 1a). For a nominal 8 x 8 x 16 in. (203 x 203 x 406 mm) unit, the three webs would each need to measure at least 1 in. (25 mm) in thickness to comply with the previous ASTM C90 minimum web requirements. In its simplest form, the C90-11b requirements permit the web configuration of this ‘standard’ unit to be reduced to one full-height web measuring 0.76 in. (19.3 mm) in thickness as shown in Figure 1c. This is not a novel unit configuration, as such H-block or double-open-ended units have been used in some markets for decades.

In markets where partially grouted construction is common, A-block (consisting of one closed cell and one open cell and shown in Figure 1e) may be preferred to confine grout to locations where it is needed.

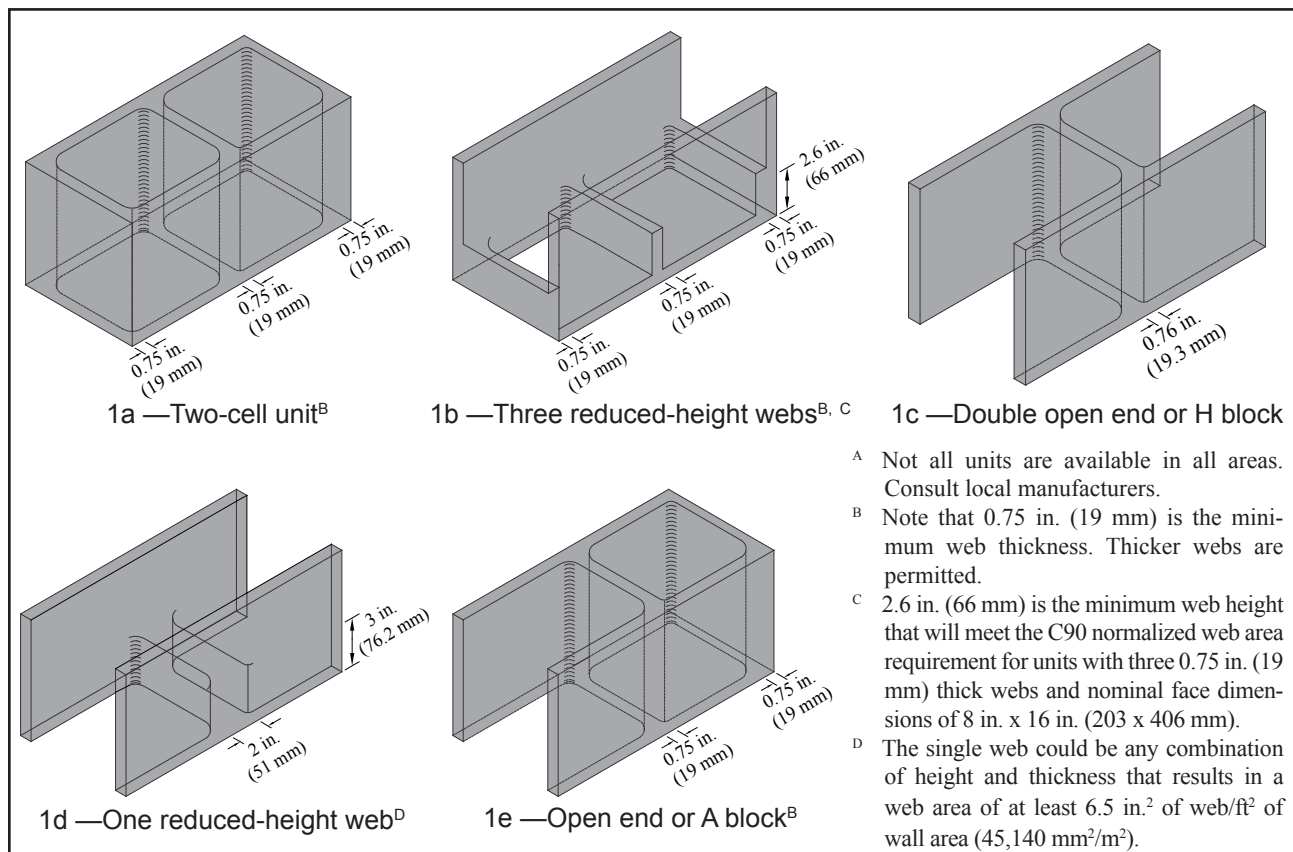


Figure 1—Examples of Web Configurations Permitted Under ASTM C90-11b^A

TEK 18-2B, *Sampling and Testing Concrete Masonry Units*, (ref. 12) discusses unit testing procedures for a variety of unit configurations.

POTENTIAL BENEFITS

The discussion below highlights some of the potential advantages of producing units with smaller webs. Reducing the size of concrete masonry webs can impact production, transportation, construction efficiency, energy performance and sustainability attributes, as discussed below. Consult local manufacturers on locally available products and their impacts on these issues.

Sustainability

Concrete masonry provides a wide range of sustainable attributes, including energy efficiency, the ability to incorporate recycled materials, the ability to be recycled at the end of a building's life, low maintenance, long life, durability, as well as being a local resource. Some masonry producers may view the new web requirements as an opportunity to further increase sustainability, by developing products that use less raw materials and less energy during production. Units with smaller webs will also weigh less, decreasing the amount of fuel required for transport.

Energy Efficiency

Concrete masonry contributes to a building's energy efficiency in a number of ways. Masonry construction goes beyond simply providing steady-state thermal resistance (i.e., R-value) by also: providing thermal storage which can reduce heating and cooling loads and allow for smaller HVAC equipment; and enhancing comfort by dampening temperature swings; and providing air-tight construction, which reduces energy loss. See references 3 through 6 for more information.

For masonry units with alternate web configurations, the most significant impact on thermal performance is on the wall's R-value. Because the webs provide a direct heat transfer path through a masonry unit, changing the size of the webs can have a significant impact on the resulting thermal properties of an unfinished single wythe assembly. Unless the resulting assembly is to be solid grouted, in which case the web configuration is irrelevant to the thermal efficiency, the effect is simple: smaller webs result in higher R-values. This effect is most prominent in cell-insulated single wythe walls. In walls with continuous insulation (such as cavity walls), web configuration has little impact on the overall assembly R-value.

As part of a building's exterior envelope, single-wythe concrete masonry construction serves the dual role of providing both enclosure and structural strength. As such, these assemblies almost always contain reinforcement and grout. While the reinforced cells of an assembly increase the strength of the system, the grout provides a larger area for heat flow, creating a larger 'thermal short' within the assembly. The net result is a decrease in the steady-state R-values. The numerical impact of grouting on R-value varies directly with the amount of grout in the wall.



Figure 2—Open-Ended Block Facilitates Placement Around Vertical Reinforcement

Construction

Smaller webs correspondingly produce lower unit weights. Lighter units, in turn, increase mason productivity and reduce mason injury and fatigue.

Smaller webs can also enhance construction of reinforced masonry. An advantage of reduced web thickness is increased unit cell sizes, which reduces cell congestion and facilitates the placement and consolidation of grout. Open-ended units (A- or H-block) also facilitate laying block around vertical reinforcement, as shown in Figure 2.

IMPACTS ON CONCRETE MASONRY DESIGN

Concrete masonry design and calculation methods generally remain the same when units with an alternate web configuration is used. In many cases, however, the end result may be different from traditional units, depending on how the webs impact the design attribute being considered. Some of these considerations are outlined below.

Structural Design

Concrete masonry unit configuration can influence the strength and stiffness of the assembly. Designers should understand the assumptions and conditions upon which the structural design method is developed and verify that the unit configuration used in actual construction is consistent with the assumptions in the design resource.

Structural design of concrete masonry assemblies is governed by the MSJC Code, *Building Code Requirements for Masonry Structures* (ref. 7). The code accounts for unit configuration by requiring that the section properties of the assembly be taken into consideration. Net section properties (A_n , I_n and S_n) are calculated based on the minimum net cross-sectional area of an assemblage, which typically precludes the web area. Hence, net section properties are not affected by differences in web configuration. Average section properties (A_{avg} , I_{avg} , S_{avg} and r_{avg}), on the other hand, correspond to an average cross-sectional area of an assemblage, so these values may change with differences in web configuration. Average

section properties are used to determine stiffness or deflection due to an applied load.

Fire and Sound Resistance

In practice, the fire resistance of concrete masonry assemblies is most commonly determined using the equivalent thickness method detailed in ACI 216.1/TMS 216, *Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies* and **TEK 7-1C** (refs. 8, 9). This method is still applicable to the new shapes, however, a reduction in web area reduces the equivalent thickness of the unit and therefore reduces the calculated fire resistance rating if the cells are left unfilled. Note that the results of concrete masonry assemblies evaluated under a listing service (such as UL or FM Global) are only applicable to the configuration of the unit tested and

cannot be extrapolated to alternative unit configurations. As with specifying any fire resistance rating for a concrete masonry assembly, these variables need to be taken into consideration during design and procurement.

TMS 302-07, *Standard Method for Determining the Sound Transmission Class Rating for Masonry Walls*, and **TEK 13-1B** (refs. 10, 11) outline procedures for determining the STC rating of concrete masonry assemblies as a function of the installed weight of the wall. For assemblies where the cells are left unfilled or partially filled with an approved material (grout, sand, etc.), the reduction in the equivalent web thickness would reduce the installed weight of the assembly. As with fire resistance ratings, this should be accounted for when sound transmission is a consideration.

REFERENCES

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