

Figure 1: Preparing a Concrete
Masonry Prism

Unit Strength Method for concrete masonry is detailed in Section 2105.2.2.1.2. The compressive strength of masonry is based on the strength of the concrete masonry unit and the type of mortar specified for the project. The concrete masonry units must conform to ASTM C55 or ASTM C90, and sampled and tested in accordance with ASTM C140; the thickness of bed joints cannot exceed 5/8 of an inch; and, for grouted masonry, the grout must conform to ASTM C476 Table 1 (Table 1); or the grout must have a minimum compressive strength of at least the specified f'_m , but not less than 2,000 psi when tested in accordance with ASTM C1019. To determine the required compressive strength of the concrete masonry unit, we refer to Table 2105.2.2.1.2. (Table 2) For example; for a project requiring an f'_m of 2,000 psi, using Type S mortar, the concrete masonry unit must have a compressive strength of at least 2,800 psi.

Compliance with f'_m

Concrete Masonry Association of California and Nevada's (CMACN) recent educational efforts with owners, designers, specifiers and inspectors have been focused on optimizing the use of concrete masonry products. Green building initiatives and efforts require that we optimize the use of all construction materials used in our new buildings. One method of optimizing the use of materials in concrete masonry construction is in the selection of the method by which f'_m is determined.

The 2007 California Building Code (CBC), based on the 2006 International Building Code (IBC), provides two methods for determining the compressive strength of a masonry assemblage. Those methods are outlined in Section 2105 – Quality Assurance in both the CBC and the IBC.

Table 1

ASTM C 476, TABLE 1 GROUT PROPORTIONS BY VOLUME FOR MASONRY CONSTRUCTION				
TYPE	PARTS BY VOLUME OF PORTLAND CEMENT OR BLENDED CEMENT	PARTS BY VOLUME OF HYDRATED LIME OR LIME	AGGREGATE, MEASURED IN A DAMP, LOOSE CONDITION	
			Fine	Coarse
Fine grout	1	0-1/10	2 1/4-3 times the sum of the volumes of the cementitious materials	—
Coarse grout	1	0-1/10	2 1/4-3 times the sum of the volumes of the cementitious materials	1-2 times the sum of the volumes of the cementitious materials

Table 2

TABLE 2105.2.2.1.2 COMPRESSIVE STRENGTH OF CONCRETE MASONRY		
NET AREA COMPRESSIVE STRENGTH OF CONCRETE MASONRY UNITS (psi)		NET AREA COMPRESSIVE STRENGTH OF MASONRY (PSI) ^a
Type M or S mortar	Type N mortar	
1,250	1,300	1,000
1,900	2,150	1,500
2,800	3,050	2,000
3,750	4,050	2,500
4,800	5,250	3,000

a. For units less than 4 inches in height, 85 percent of the values listed.

Prism Test Method is outlined in Section 2105.2.2.2. The compressive strength of concrete masonry is determined by the prism test method when: The prism test method is specified in the construction documents, or where the masonry does not meet the requirements for application of the unit strength method. It should be noted that the prism test method does not require a minimum compressive strength of concrete masonry units, or grout greater than those found in the ASTM Standards; nor is the prism test method dependant on type of mortar used.

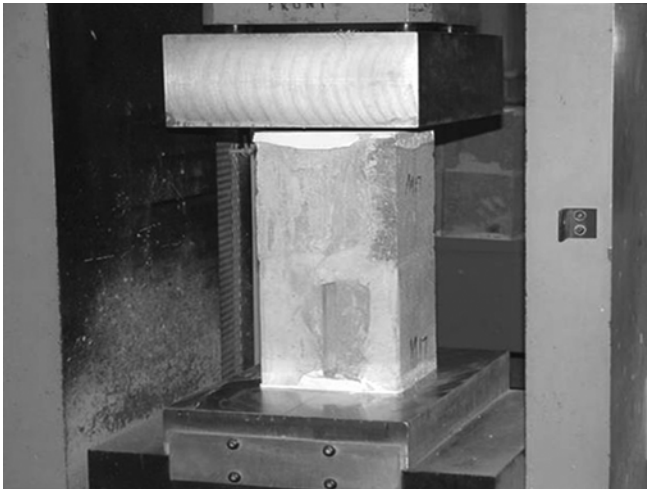


Figure 2: Compression Testing a Concrete Masonry Prism

The code requires that compliance with f'_m be determined by compressive strength. The compressive strength is determined by the unit strength method or prism test method, not both. It is common to see in project specifications both methods outlined and specified. This is not appropriate. One method should be selected for the project by the design professional.

In California and Nevada, the majority of structural concrete masonry walls are fully grouted. In an eight-inch thick wall, the CMU is approximately half of the gross area of the wall, and grout contributes the other half of the gross area. In ten, twelve, and sixteen-inch thick walls, grout contributes to well over half of the gross area of the wall. It is easy to see that in fully grouted walls, the compressive strength of the grout contributes at least half of the total compressive strength required to meet the specified f'_m . The code requires that the compressive strength of the grout equals or exceeds f'_m , but not be less than 2,000 psi. Field mixed grout generally conforms to ASTM C476 Table 1 (Table 1). Ready-mix grout constituents are often batched by weight (not by volume) and test records are maintained by the supplier offering a statistical record of the compressive strength of each mix design. The majority of all grout used in fully grouted walls is supplied by off-site ready-mix plants. Any mix design from a ready-mix supplier submitted to the design professional must equal or exceed the required f'_m . Experience has shown that grout mixes in most of California and Nevada can well exceed 3,000 psi.

Concrete masonry units that meet the requirements of ASTM C90 must have a minimum compressive strength of 1,900 psi. When a design professional uses an f'_m of 1,500 psi to design a wall, a CMU meeting the requirements of ASTM C90 used in conjunction with Type S mortar, and grout with a compressive strength of at least 2,000 psi fulfills the requirements of the unit strength method of determining f'_m . But, in an eight-inch wall, half the gross area is CMU, and half the area is grout. Using the minimum 1,900 psi CMU, and the minimum 2,000 grout, the compressive strength of the assemblage would be near 1,950 psi.



Figure 3: Concrete Masonry Prisms Capped and Ready for Testing

It is common that concrete masonry units produced in California and Nevada exceed the minimum strength required by ASTM C90, and that field and ready-mixed grout exceed the minimum requirement of 2,000 psi. A producer that commonly provides a CMU with compressive strength of 2,500 psi can only provide those CMU's to a project with f'_m of 1,500 psi when compliance with f'_m is determined by unit strength method. But if the prism method were used to determine compliance with f'_m , that same 2,500 psi CMU could be combined with a grout specified with a minimum compressive strength of 2,500 psi and meet the f'_m design requirement of 2,500 psi. In this example, a premium CMU would not be required to meet the job required f'_m 2,500 psi. For a large job, this could be a considerable cost savings to the project with a very small increase in the cost of material testing.

Occasionally, due to a variety of reasons which may include anomalies in testing procedures, improper sampling, curing or handling of CMU's, grout, or prisms, the Unit Strength Method and Prism Test Method may not accurately represent the masonry assemblage conformance with the required f'_m . Section 2105.3 of the IBC and Section 2105A.3 of the CBC outline provisions for testing prisms from constructed masonry. This is a destructive test method requiring repair of the concrete masonry. This destructive test method should be employed before rejecting a completed masonry wall, which may in fact be structurally sound.

f'_m and Essential Services Buildings

Establishing f'_m for essential services buildings (schools, hospitals, etc.) in California differs from non-essential structures.

CBC section 2105A.2.1 adds additional language to CBC section 2105.2.1. Section 2105A.2.1 states that "The specified compressive strength, f'_m assumed in design shall be 1,500 psi for all masonry construction using materials and details of construction required herein." We know that all essential services buildings are not designed with an f'_m compressive strength of 1,500 psi. How does the designer use an f'_m greater than 1,500 psi when designing an essential services building? Section 2105A.2.1 offers an exception that will allow use of concrete masonry with a designed f'_m greater than 1,500 psi. The exception states "... Higher values of f'_m may be used in the design of reinforced grouted masonry and reinforced hollow-unit masonry. The approval shall be based on prism test results submitted by the architect or engineer, which demonstrate the ability of the proposed construction to meet prescribed performance criteria for strength and stiffness...In no case shall the f'_m assumed in design exceed 2,500 psi."

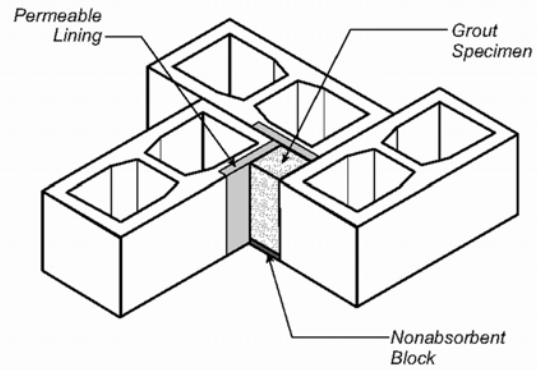


Figure 4 : Grout Mold for Testing (Note: Front Unit Not Shown to Allow View of Specimen)

When design values greater than f'_m 1,500 psi are used for an essential services building, compliance with f'_m cannot be by unit strength method. Prism method of compliance is required by the CBC for essential services buildings. Compliance with f'_m based on prism method may allow use of concrete masonry units that do not meet the higher strength requirements of the unit strength method. This may allow the use of standard strength units in essential services buildings with a design f'_m strength in excess of 1,500 psi.

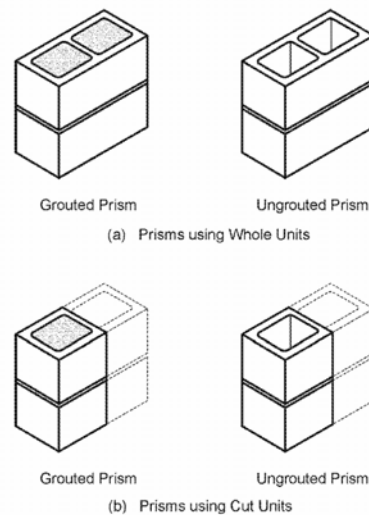
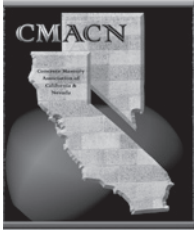


Figure 5: Prisms

CMACN is working with owners, designers, specifiers and inspectors to better optimize the use of concrete masonry products. Concrete masonry is economical, beautiful, earth quake resistant, fire resistant, and safe and sound.

This edition of *Masonry Chronicles* was written by Kurtis K. Siggard, Executive Director, Concrete Masonry Association of California and Nevada.



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