Date: January 6th, 2015
To: All Interested Parties in Masonry Production, Design and Installation
From: The Masonry Association of Florida
RE: White Paper on Increased Design Strength of Masonry Provided in the *2013 Building Code Requirements and Specification for Masonry Structures* (TMS 402/602-13, ACI 530/530.1-13, ASCE 5/6-13)

The Building Code Requirements and Specification for Masonry Structures contains two standards and their commentaries: *Building Code Requirements for Masonry Structures* (TMS 402, ACI 530, ASCE 5) and *Specification for Masonry Structures* (TMS 602, ACI 530.1, ASCE 6). These standards are produced through the joint efforts of The Masonry Society (TMS), the American Concrete Institute (ACI), and the Structural Engineering Institute of the American Society of Civil Engineers (SEI/ASCE) through the Masonry Standards Joint Committee (MSJC). The mission of the MSJC is to develop and maintain design and construction standards for masonry for reference by or incorporation into model building codes regulating masonry construction.[1]

For the purposes of this paper we will refer to *The Building Code Requirements and Specification for Masonry Structures* as TMS 402 and the *Specification for Masonry Structures* as TMS 602. These are the most common designations for the code and specification. TMS 402/602 form the basis for masonry design in both the ICC and FBC and have for many years. For the purpose of this paper it is important to note that the latest edition available of TMS 402/602 is routinely adopted by the ICC and FBC. TMS 402/602 is considered as the authoritative base code for masonry design in the United States.

The 2008 edition of TMS 402/602 forms the basis of the current Chapter 21 of the 2010 FBC. The 2011 edition of TMS 402/602 forms the basis of Chapter 21 of the FBC 5th Edition. The 2011 edition of TMS 402/602 was used simply because it was the latest edition of TMS 402/602 available at the time the masonry Chapter 21 of the FBC 5th Edition was locked into Florida's code development process.

Significant changes to the allowable compressive strength of masonry were introduced in the 2013 edition of TMS 402/602. These changes were the result of extensive research conducted by NCMA (see Attachment 1). This research was not completed in time for inclusion in the 2011 edition of TMS 402/602 and thus was not able to be included in the FBC 5th Edition.

This white paper focuses on how the increased code values of masonry compressive strength can be utilized on projects immediately and how these valuable provisions of the 2013 TMS 402/602 may become more readily usable in the near future. These increases are summarized in the following Table 1 below and can be found in TMS 602-13 Section 1.4 B.2. Table 2 (see Attachment 1).

Table 1

TMS 402/602 Code	Net Area Block Strength (psi)	Design Strength f'm (psi)
2008 and 2011 Editions	1900 psi – Current Min Block Strength per C90	1500 psi – Historic f'm Design Value
2013 Edition	1900 psi – Current Min Block Strength per C90	1900 psi - New Standard Min f'm Design Value

ASTM C90 is the national standard that tells us what criteria a concrete masonry unit must meet. It requires that all concrete masonry units must have an average net area compressive strength of 1900 psi and that no individual block tested has a net area compressive strength less than 1700 psi.

The Unit Strength Method outlined in TMS 602 Section 1.4 B.2 (see Attachment 1) allows us to determine what the f'm design strength (the value used by engineers and architects in design) is based on this C90 net area strength. As shown in the table above, this f'm design value is increasing from 1500 psi to 1900 psi.

We want to stress that there is nothing different that has to happen to take advantage of this increase in design strength of approx. 27%. Modern methods in the uniform production and testing of masonry units have simply resulted in a better understanding of the allowable f'm design strength of concrete masonry materials. This is not something that is going to happen in the future – it is already part of the national code. The Masonry Society, the American Concrete Institute and the American Society of Civil Engineers have determined that the allowable compressive design strength of any standard concrete masonry unit, produced according to ASTM C90, is now 1900 psi.

However the Florida Building Code, which governs the use of concrete masonry in the State of Florida, does not acknowledge this increase because of the offset timing in the development and release of the FBC. In most cases overcoming this glitch in the Code acceptance cycle is quick and straightforward for any designer wishing to take advantage of the increased allowable strengths by using the 2013 edition of TMS 402/602.

Any architect or structural engineer wishing to design according to the criteria of the 2013 edition of TMS 402/602 would need the local building official to approve the use of said standard as an "alternate design" in accordance with Section 104.11 of the 2010 Florida Building Code. This approval would apply to a specific job and would have to be obtained for any specific job the designer was working on. However, once the Building Official approves the use of the 2013 TMS 402/602 there should be no reason to refuse approval on subsequent jobs. The use of the standard should be specified on the plans along with wind loads and other critical and required structural information. The Masonry Association of Florida is available to assist in explaining the latest 2013 TMS 402/602 standard to the local Building Official in the case that he has reservations concerning its use.

Although the increased design strength of CMU was approved by the MSJC and published in the 2013 TMS 402/602, the use of the increased design values is not related to any other provision of the 2013 Code. An example of this would be where other safety factors and design equations in the 2013 TMS 402/602 were modified to work in conjunction with the increased design strengths. **This is not the case.** The increased design values are "stand alone". They are a true increase in allowable f'm design strength and can be applied to design equation and procedures in the 2008 or 2011 TMS 402/602 as well.

For this reason, in order to take advantage of the increased values a designer may also choose to simply state the design f'm used in his project and then include a statement such as "Determined by Unit Strength Method per TMS 602-13 Section 1.4 B.2. Table 2" as the justification. This, again, would have to be approved by the local Building Official having jurisdiction over the project being designed. Obviously, this approval by the Building Official should be in advance of actually doing the design to ensure that the increased design values from Table 2 will be accepted.

As can be seen in Table 2 on Attachment 1 the correlation between net area strength and the f'm design strength remains 1 to 1 up to 2000 psi. The option is available for the designer to specify a net area strength of 2000 psi thus attaining an f'm of 2000 psi rather than 1900 psi. Most blocks manufactured in Florida will meet the 2000 psi net area requirement with no modification to the production process. You can quickly determine if there would be any additional cost for 2000 psi block rather than 1900 psi block by making a call to any of your local block suppliers. The block supplier would provide a certificate stating the net area strength of his block at 2000 psi.

Again, the 2000 psi is being recommended because most CMU in Florida already meet 2000 psi. If not, the added cost of production to increase the strength from 1900 psi to 2000 psi should be very minimal[2]. Additionally, the 2014 edition of ASTM C90 has increased the minimum strength of concrete masonry from 1900 psi to 2000 psi (the Florida Building Code 5th Edition references ASTM C90-11b which sets the minimum strength at 1900 psi).

Net area strengths greater than 2000 psi are readily available across the State from all manufactures. Increasing the strength can be a very cost effective alternative to decreasing steel spacing, increasing wall thicknesses or including pilasters in the design. The 2013 TMS 402/602 code allows for higher values of f'm for all net area strengths. Thus, we recommend using the 2013 TMS 402/602 Unit Strength Method for the determination of your f'm for high strength masonry also.

The current 2010 FBC and the soon to be published FBC 5th Edition contain modifications to specific sections of the TMS 402/602 code. The modified sections of the TMS 402/602 code are unchanged in the 2013 Edition and are unaffected by the code allowed increase in f'm design strength. The most important of these modifications involves the gamma factor in the development length equations. These factors were modified to remove the effects of earthquakes from the Florida lap calculation as required by the Florida legislature. The lap equation, factors for calculations and use of this equation are unaltered in the 2013 TMS 402/602. We would hope that the building official would allow continued use of the Florida factors in calculating laps from the 2013 TMS 402/602.

Increasing your f'm design strength from 1500 psi to 2000 psi can have a significant impact on the cost and materials required for your masonry structure. It is the hope of the concrete masonry industry that all engineers and architects reading this paper will be encouraged to immediately begin using the best design values currently available in the 2013 TMS 402/602. Currently, all that is required to do this is the approval of the local Building Official.

The masonry industry is currently working with the Florida Building Commission to get this straightforward update to the referenced TMS 402/602 code recognized across Florida. There are several way in which this might be accomplished and we are currently exploring the best options. We fully expect that by mid 2015 TMS 402/602-13 will be recognized by the Florida Building Commission as the governing masonry design code in Florida.

[1] Wording from 2013 *Building Code Requirements and Specification for Masonry Structures* – Abstract

[2] The strength of CMU is generally governed by the rate of breakage rather than a necessity to meet the requirements of ASTM C90. CMU are cubed and transported to the block yard via forklift usually within 16 hours of manufacturing. Within this 16 hour window the block must gain enough strength to survive this process. The strength required to keep the rate of breakage to an acceptable threshold during cubing and transport is generally what governs the ultimate 28 day strength. This strength is generally above 2000 psi.

SPECIFICATION

1.4 B.2. *Unit strength method* (Continued)

b. *Concrete masonry* — Use Table 2 to determine the compressive strength of concrete masonry based on the strength of the unit and type of mortar specified. The following Articles must be met:

1) Units are sampled and tested to verify conformance with, ASTM C90.

2) Thickness of bed joints does not exceed $^5/_8$ in. (15.9 mm).

3) For grouted masonry, the grout conforms to Article 2.2.

COMMENTARY

b. *Concrete masonry* — Prior to the 2013 Specification, the standardized correlations between unit compressive strength, mortar type, and resulting assembly compressive strength of concrete masonry were established using prism test results collected from the 1950s through the 1980s. The result was a database of prism compressive strengths with statistically high variability, which when introduced into the Specification, drove the lower bound design values between unit, mortar, and prism to very conservative values. The reasons for the inherent historical conservatism in the unit strength table are twofold: 1) When originally introduced, the testing procedures and equipment used to develop the prism test data were considerably less refined than they are today. Changes introduced into ASTM C1314, particularly requirements for stiffer/thicker bearing platens on testing equipment, produce more consistent, repeatable compressive strength results. 2) Previous testing procedures either did not control the construction, curing, and testing of masonry prisms, or permitted many procedures for doing so. As a result, a single set of materials could produce prism test results that varied significantly depending upon how the prisms were constructed, cured, and tested. Often, a field-constructed and field-cured prism would test to a lower value than a laboratory-constructed and laboratory-cured prism. Consequently, the compressive-strength values for concrete masonry prisms used to develop historical versions of the unit strength tables are not directly comparable to the compressive-strength values that would be obtained today.

Table 2 — Compressive strength of masonry based on the compressive strength of concrete masonry units and type of mortar used in construction

Net area compressive strength of concrete masonry, psi (MPa)	Net area compressive strength of concrete masonry units, psi (MPa)	
	Type M or S mortar	Type N mortar
1,700 (11.72)	---	1,900 (13.10)
1,900 (13.10)	1,900 (13.10)	2,350 (14.82)
2,000 (13.79)	2,000 (13.79)	2,650 (18.27)
2,250 (15.51)	2,600 (17.93)	3,400 (23.44)
2,500 (17.24)	3,250 (22.41)	4,350 (28.96)
2,750 (18.96)	3,900 (26.89)	-----
3,000 (20.69)	4,500 (31.03)	-----

[1] For units of less than 4 in. (102 mm) nominal height, use 85 percent of the values listed.