TMS RESPONDS

Answers to questions regarding masonry design, construction, evaluation and repair
A publication of The Masonry Society to advance the knowledge of masonry

The Masonry Society **Volume 13 No. 1** **November 2015**

2015 IBC and Referenced Standards

13.1-1 In the past TMS published a list of major changes in the IBC related to masonry design and construction provisions. Do you have something for the 2015 IBC?

Response by Phillip J. Samblanet, TMS Executive Director

As with previous versions of the International Building Code (IBC), the 2015 IBC makes extensive reference to numerous standards for design and construction, while maintaining provisions not addressed by consensus standards. Relatively few changes impacting masonry design and construction were made directly to the 2015 IBC. Rather, the majority of changes result from revisions to standards referenced by the IBC. Thompson and Samblanet (2015) provide an overview of the major changes to the International Code Council's Codes and to aide users, we've reprinted with permission portions of that paper below by topic area. Additional information was also included where appropriate. Also, Chapter 17 of the Masonry Designers Guide 2013 (MDG 2013) provides a more detailed review of changes to the IBC.

Structural Masonry Design and Construction Provisions
The IBC continues to rely on *Building Code Requirements and Specification for Masonry Structures* (TMS 402/ACI 530/ASCE 5 and TMS 602/ACI 530.1/ASCE 6 which is shortened hereafter to TMS 402/602) as the primary reference for structural masonry design and construction provisions. For the 2015 IBC, the references have been updated to the 2013 edition of TMS 402/602 (Figure 1).

Chapter 21 of the 2015 IBC addresses masonry-specific design and construction requirements. As with previous editions, it uses the TMS 402/602 as the basis and no new stipulations or requirements were added directly to this chapter. As before, Section 2101 identifies permissible design methods and techniques. However, the Chapter was streamlined to remove requirements transcribed from TMS 402/602 to alleviate potential issues with transcription errors, while making differences between the IBC and TMS 402/602 easier to identify. Requirements covering tile, dry stack masonry, adobe masonry and masonry fireplaces are maintained in IBC Chapter 21 as these are not addressed in TMS 402/602. In addition, a few modifications to the Allowable Stress Design and Strength Design procedures are maintained in IBC Sections 2107 and 2108 respectively. Otherwise, masonry design and construction provisions are to follow TMS 402/602-13.

Major changes to the 2013 edition of TMS 402/602 are summarized by Throop et al. [Throop 2014]. Those related to structural design are highlighted below.

- The contents of TMS 402 were reorganized in response to requests from users and to provide a more coherent framework for the continued evolution of the standard. In short, Chapter 1 of the former 2011 TMS 402 was divided into 7 Chapters for more logical flow. As such, the Chapters that follow, were renumbered by "6" so that former Chapter 2 (Allowable Stress Design) is now Chapter 8, former Chapter 3 (Strength Design) is now Chapter 9 and so on. More significant changes to the location of some provisions also occurred to consolidate and to more properly locate the provisions. TMS has developed an informal cross reference list which can be accessed at the link below to aide users in locating provisions.

  http://www.masonrysociety.org/html/resources/MSJC_2011-2013_Cross_Reference_List_2015-11-17_Revision.pdf

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- Inclusion of a partially grouted shear strength reduction factor as previous provisions can sometimes over-predict the shear capacity of some configurations of partially grouted shear walls [Minaie 2010].
- Inclusion of a moment magnifier method for designing reinforced masonry walls subjected to out-of-plane loads.
- Addition of a new Chapter 14 on partition wall design that includes prescriptive requirements that, while rationally based, are easy to use.
- Movement of empirical requirements into an appendix due to its limited applicability.
- Addition of a new Appendix C limit design method for special reinforced masonry shear walls offering a more efficient design of highly perforated or irregularly configured shear walls in high seismic risk areas.
- Mechanical splices in flexural reinforcement in plastic hinge zones are now required to develop the specified tensile strength of the spliced bar, rather than $1.25f_y$.
- If welded splices are used, the reinforcement is now required to either conform to ASTM A706, or a chemical analysis and carbon equivalent of the reinforcement steel will need to be determined.
- Masonry cement mortar is now permitted for fully grouted participating elements in Seismic Design Category D and higher.
- Provisions have been added permitting joint reinforcement to be considered as primary reinforcement for resisting in-plane and out-of-plane loads when using the Strength Design method.
- Modulus of rupture values have been increased by approximately 33% to match the increase in allowable flexural tension stresses made in the 2011 TMS 402.

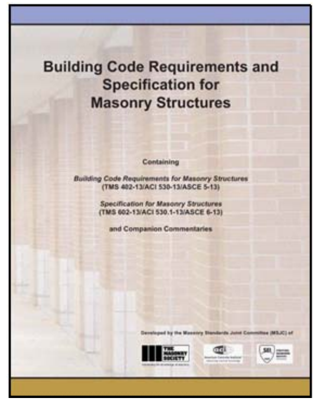

Figure 1 - The International Building Code makes extensive use of reference standards including the TMS 402 and TMS 602, shown here.

- Clarification on how and when to apply the deep beam provisions has been added.
- Provisions were included for AAC as an infill material in Appendix B – Design of Masonry Infill.
- Previous requirements for joint reinforcement and seismic clips for anchored veneer in Seismic Design Categories E and F have been eliminated based on shaking-table research [Klingner 2010].
- Based on changes to ASTM C90-11b, which replaced previous equivalent web thickness requirements for concrete masonry units with a minimum web area, a new requirement was added to the 2013 TMS 402 that requires the designer to check the shear stress within unreinforced/ungrouted concrete masonry assemblies if the minimum normalized web area is less than 27 in.^{2}/ft^2 (187,500 mm^2/m^2).
- The SI conversion equations were reviewed extensively and guidance on conversion factors are now provided in that section.

Significant revisions incorporated into the 2013 edition of TMS 602 related to design and construction of structural masonry include [Throop 2014]:

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Table 1 - TMS 602 Table 1 showing 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.

- Based on recent testing [NCMA 2012], the correlation between the compressive strength of concrete masonry units, mortar type, and resulting assembly compressive strength was substantially revised. Of particular note is that for 2000 psi (13.79 MPa) concrete masonry units laid in Type S mortar the specified prism compressive strength is now 2000 psi (13.79 MPa). Table 1 shows the new specified prism compressive strengths for concrete masonry. Similar format revisions were made to the unit strength table for clay masonry units, although no changes to the values in the clay masonry table were made.
- Tolerances for reinforcement bar placement are given in terms of *d*, where *d* is the distance from the extreme compression fiber to the centroid of the reinforcement. Figures to help illustrate *d* have been added to TMS 602 to help contractors and inspectors confirm that reinforcement is located acceptably within tolerance as illustrated in Figure 3. Figures were also added to TMS 602 for columns and beams.
- Figures illustrating joint reinforcement lap embedment have been added to the Specification.
- The allowable tolerances for the initial bed joint at a foundation or other support were increased to be compatible with concrete foundation tolerances (which are specified in documents other than the TMS 602). Bed joints are now permitted to be:
    - ¾ in. (19.1 mm) maximum when the masonry is ungrouted or partially grouted.
    - 1¼ in. (31.8 mm) maximum when the first course of masonry is solid grouted and supported by a concrete foundation.

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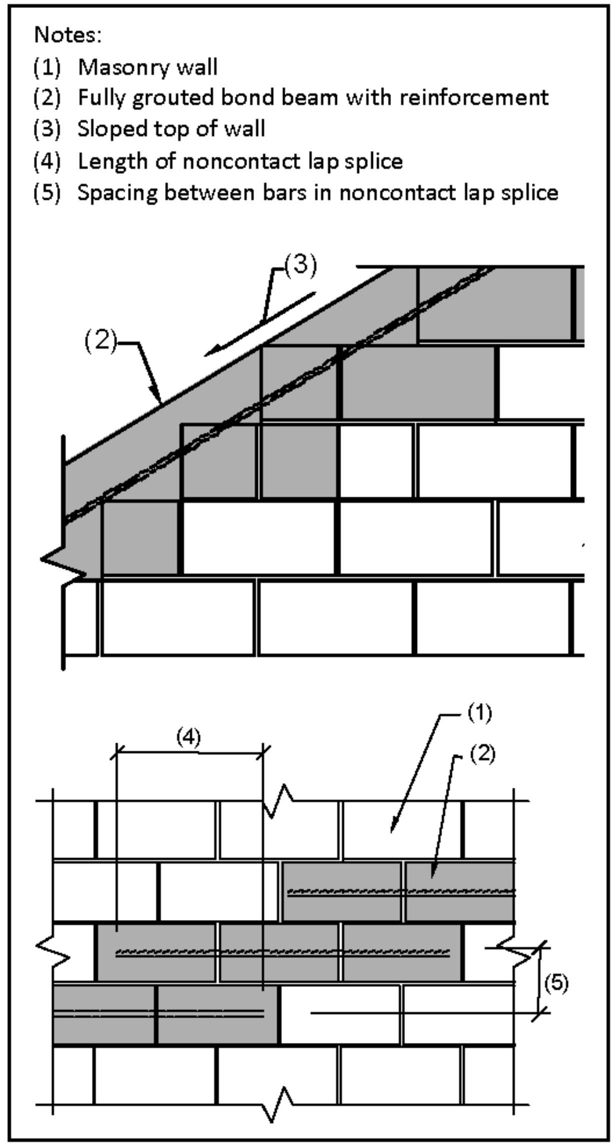

Figure 3 - Examples of a sloped bond beam and a stepped bond beam within a masonry assembly.

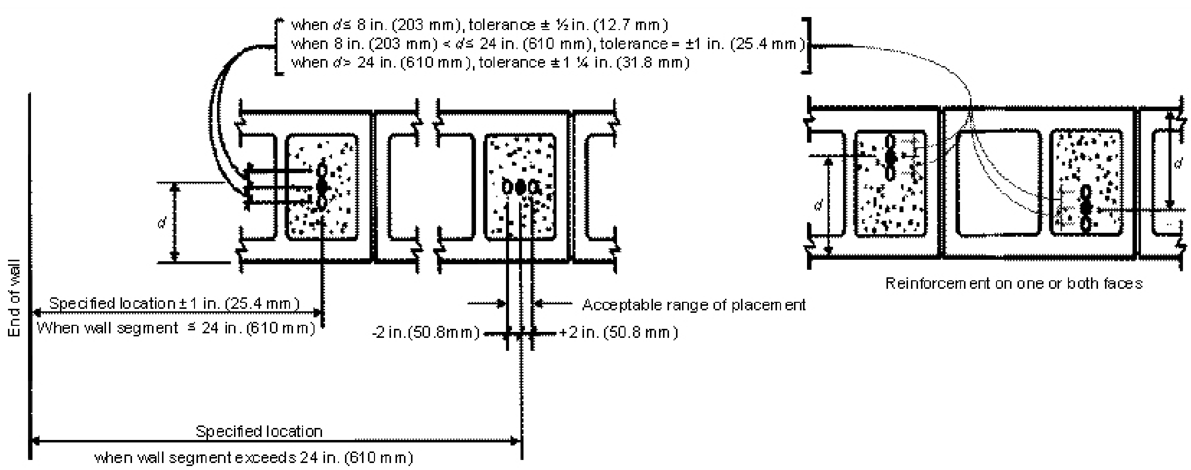

Figure 2 - Placement tolerances for reinforcement embedded in masonry construction based on the effective depth, d.

- Clarification and expansion of the tolerances for mortar joint thickness between masonry units and also between masonry unit and flashing was made.
- Figures were added to clarify that although bond beams are usually horizontal, they may be sloped or stepped, for example to match an adjacent roof as illustrated in Figure 4.
- Clarification was made that in areas where dry weather is expected, covering walls to protect against moisture intrusion during the normal progress of construction may not be required.
- Updated requirements for AAC Masonry consistent with ASTM C1691 and C1693 have been added.

In addition to changes as a result of updates to TMS 402/602, the 2015 IBC also permit the use of a newly updated *Direct Design Handbook for Masonry Structures* [TMS 403 2013], which provides a simplified design approach for common, single-story concrete masonry buildings (Figure 4).

While not a masonry-specific change, a substantive new requirement added to the 2015 IBC mandates that certain emergency and educational facilities have storm shelters. Storm shelters complying with ICC 500, *Standard for the Design and Construction of Storm Shelters* [ICC 500 2008] are required when a school's occupant load is 50 or more and when the design wind speed for tornadoes is 250 mph (402 kph) or more (which includes the majority of the mid-western U.S.). Emergency facilities such as 911 call centers and more also fall under this provision. Given the extreme nature of tornados and the resulting design loads they generate, the majority of the new schools constructed throughout the midwest incorporating masonry as part of the structural system will need to account for these critical events.

Sound Transmission

Section 1207 of the IBC provides requirements to reduce the sound transmission between adjacent dwelling units. By reference to TMS 302, *Standard Method for Determining the Sound Transmission Class Rating for Masonry Walls* [TMS 302 2013] the sound abatement properties of masonry assemblies can be easily calculated. TMS 302 (Figure 6) includes procedures for the determination of both the sound transmission classification and the outside-inside transmission class.

Fire Resistance

Fire resistance requirements of building components continue to be maintained in Chapter 7 of the 2015 IBC. As in the past, the specific requirements for fire resistance for masonry assemblies in the 2015 IBC will be based primarily on ACI 216.1/TMS 216, *Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies* (Figure 7). The 2015 IBC has updated

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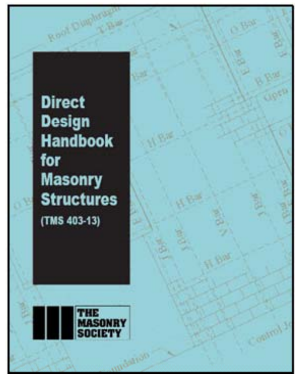

Figure 4 - The latest edition of Direct Design Handbook for Masonry Structures (TMS 403-13) is referenced by the 2015 IBC to provide a simplified, yet rationale, procedure to design single story

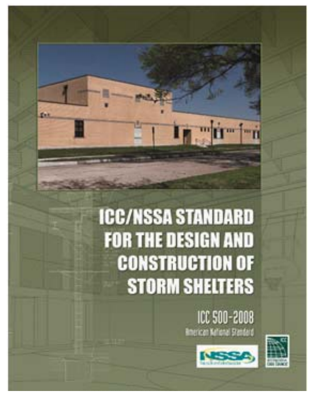

Figure 5 - The ICC 500 Standard for the Design of Strom Shelters is now required for many buildings by IBC Section 423..

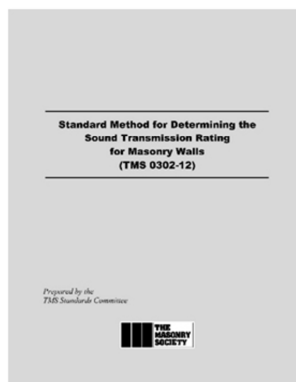

Figure 6 - TMS 302 covers methods for the calculation of the sound transmission classification (STC) and outside-inside transmission class (OITC).

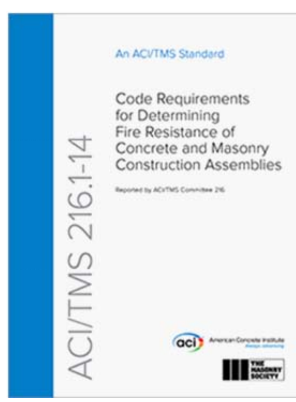

Figure 7 - ACI/TMS 216.1 covers methods for the calculation of the fire resistance properties of concrete and masonry systems.

the reference to the 2014 edition of ACI/TMS 216.1 [ACI 216.1 2014]. While few, the significant revisions incorporated into the 2014 edition of ACI/TMS 216.1 include:

- A new chapter has been introduced that covers the notations and definitions of terms used within the standard.
- The concrete masonry provisions have been consolidated into Chapter 5.
- Appendices covering the protection of steel columns by masonry assemblies have been moved from the appendix into the body of the standard.
- Detailing for the protection of control joints in concrete masonry construction have been added and clarified.

Concluding Remarks

Users of the previous editions of the IBC will find much familiar with the 2015 edition. Few direct changes were made to the 2015 IBC that affect masonry design and construction. Where changes were made to the IBC, provisions were deleted to remove redundant provisions that transcribed provisions from consensus standards. Updates to standards referenced by the IBC enhance masonry design and construction provisions, offer new design procedures, and clarify requirements so that masonry design is simpler, construction more straightforward, and the resulting construction consistent with the design intent to provide safe, reliable, and resilient masonry buildings.

13.1-2 Are there many revisions to masonry provisions in the 2015 IRC?

Response by Jason J. Thompson, National Concrete Masonry Assoication, Masonry Alliance for Codes and Standards Chair

Similar to the IBC updates, revisions were incorporated into the 2015 IRC for residential construction. Unlike the IBC, however, the IRC attempts to maintain a comprehensive set of design and construction provisions within the body of the document. Prior to these changes being incorporated into the IRC, the masonry provisions evolved over time into somewhat autonomous, separate sections. As a result, unintended conflicts and disconnects manifested within the IRC requirements that resulted in confusion when applied. While the revisions were largely focused on cleaning up and consolidating the masonry provisions, there are some more technically substantive changes incorporated as well. These include:|

- Prior to the 2015 edition, the IRC did not specifically define minimum material requirements for masonry units. Provisions have been added referencing the appropriate ASTM standards covering the minimum physical properties for concrete and clay masonry products. These newly introduced requirements mirror those in the IBC and TMS 402/602.
- Several conflicts in the grouting requirements have been reconciled. For example, grout pour heights triggering cleanouts varied depending upon whether the masonry construction is multi-wythe, single wythe, or reinforced. For consistency with the IBC and TMS 402/602 requirements the grout pour heights requiring cleanouts was changed to 64 inches (1.62 m). Similarly, grout lift height requirements triggering special inspection have been increased from 60 inches (1.52 m) to 64 inches (1.62 m) for consistency.
- Several redundant provisions were removed. For example, minimum horizontal reinforcement requirements for masonry laid in stack bond were addressed in multiple places, and are now covered only once.
- The IBC prohibits the use of AAC masonry in seismic design categories D and higher. This limit was incorporated into the IRC as well.

13.1-3 Section 9.3.3.5 Maximum area of flexural tensile reinforcement in the 2013 TMS 402/ACI 530/ASCE 5. It appears to only apply to seismic regions. Is the intent of this provision to only limit area of steel provided in flexural members under seismic loading to ensure ductility? More specifically, if I do not have seismic design requirements, do I need to limit my area of steel for bearing walls with flexure, lintels and the like?

Response by Daniel P. Abrams, University of Illinois, Chair of the Seismic Subcommittee of TMS 402.

You are correct in saying that the amount of longitudinal reinforcement is limited to ensure adequate ductility. Section 9.3.3.5.1 is intended for all flexural members including beams, and ordinary reinforced masonry shear walls (additional requirements are included in Sections 9.3.3.5.2 and 9.3.3.5.4 for intermediate and special reinforced masonry shear walls). Ordinary reinforced walls are permitted in Seismic Design Categories A, B and C as noted in Section 7.3 and Commentary Table CC-7.3.2-1. They must also comply with ASCE 7 criteria, and with this section, and thus, these limits on maximum reinforcement are necessary. For such walls, the multiplier on reinforcement yield strains is small at 1.5, reflecting the rather small R factor (R=2.0) for this type of wall. Having said this, Section 9.3.3.5.4 relaxes the maximum area of flexural reinforcement in many shear walls, beams and lintels if you use an R of only 1.5 in your design. In this case, there is no upper limit on the maximum area of reinforcement for members

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where M_u/V_ud_v is less than or equal to 1 (most beams and squat walls). Furthermore, maximum reinforcement requirements for shear walls may be waived if boundary elements are used per Section 9.3.6.5.

Seismic design requirements are mandatory for all parts of the United States per ASCE 7 and the International Building Code. In areas of low seismicity, they usually do not control over wind loadings. However, the loadings and design requirements for various Seismic Design Categories need to be checked, and the detailing requirements, including the requirements of Section 9.3.3.5 must be met.

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TMS 402 2013: TMS 402-13/ACI 530-13/ASCE 5-13, Building Code Requirements for Masonry Structures, The Masonry Society, Longmont, CO, 2013.

TMS 403 2013: TMS 403-13, Direct Design Handbook for Masonry Structures, The Masonry Society, Longmont, CO, 2013.

TMS 602 2013: TMS 602-13/ACI 530.1-13/ASCE 6-13, Specification for Masonry Structures, The Masonry Society, Longmont, CO 2013.

This document is produced by:

THE MASONRY SOCIETY

The Masonry Society
105 South Sunset Street, Suite Q
Longmont, CO 80501-6172
Phone: (303) 939-9700
Fax: (303) 541-9215
Website: www.masonrysociety.org

Oversight: TMS Design Practices Committee
Reviewers for this Issue: Andrew Geister, Richard Bennett, Raymond Miller, Diane Throop, Jason Thompson.
Editor: Phillip J. Samblanet

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