codes & standards

Masonry Design Provisions For 2005

An Update for Structural Engineers

By Richard E. Klingner

During the 2005 cycle, the Masonry Standards Joint Committee (MSJC) updated its *Building Code Requirements for Masonry Structures*, ACI 530-05 / ASCE 5-05 / TMS 402-05 and *Specifications for Masonry Structures*, ACI 530.1-05 / ASCE 6-05 / TMS 602-05. It essentially resolved the maximum reinforcement issue for strength design; it updated empirical design as needed; it developed a new mandatory-language appendix on autoclaved aerated concrete (AAC) masonry; it made many improvements to the *Specification*; and its *Code* and *Specification* have been harmonized and cleaned up throughout.

Because the MSJC is the only source for ANSI-accredited masonry design provisions in the US, and because it has an unequalled technical understanding of masonry behavior and design, it is fundamental to the development of code provisions for masonry in the US. Because both harmonized US model building codes reference the Masonry Standards Joint Committee (MSJC) *Code and Specification* essentially verbatim, that document is the de facto basis for US building-code provisions for masonry.

The most important *Code* changes are presented in more detail.

Chapter 1 (**General Requirements**):

- Section 1.14 (Seismic Design Requirements) has been updated to clarify definitions of wall types, and to insert seismic design requirements for AAC masonry shear walls to correspond to the design provisions for AAC masonry in the new Appendix A. Although final decisions have not been made, additional requirements may be placed by model codes on the use of AAC masonry in zones of high seismic risk, until the technical background on its seismic performance can be evaluated further.
- References to ASCE 7 have been updated to ASCE 7-02 with one exception, where a reference to ASCE 7-93 has been maintained to preserve the ⅓ stress increase for allowable-stress design in a very limited number of jurisdictions.

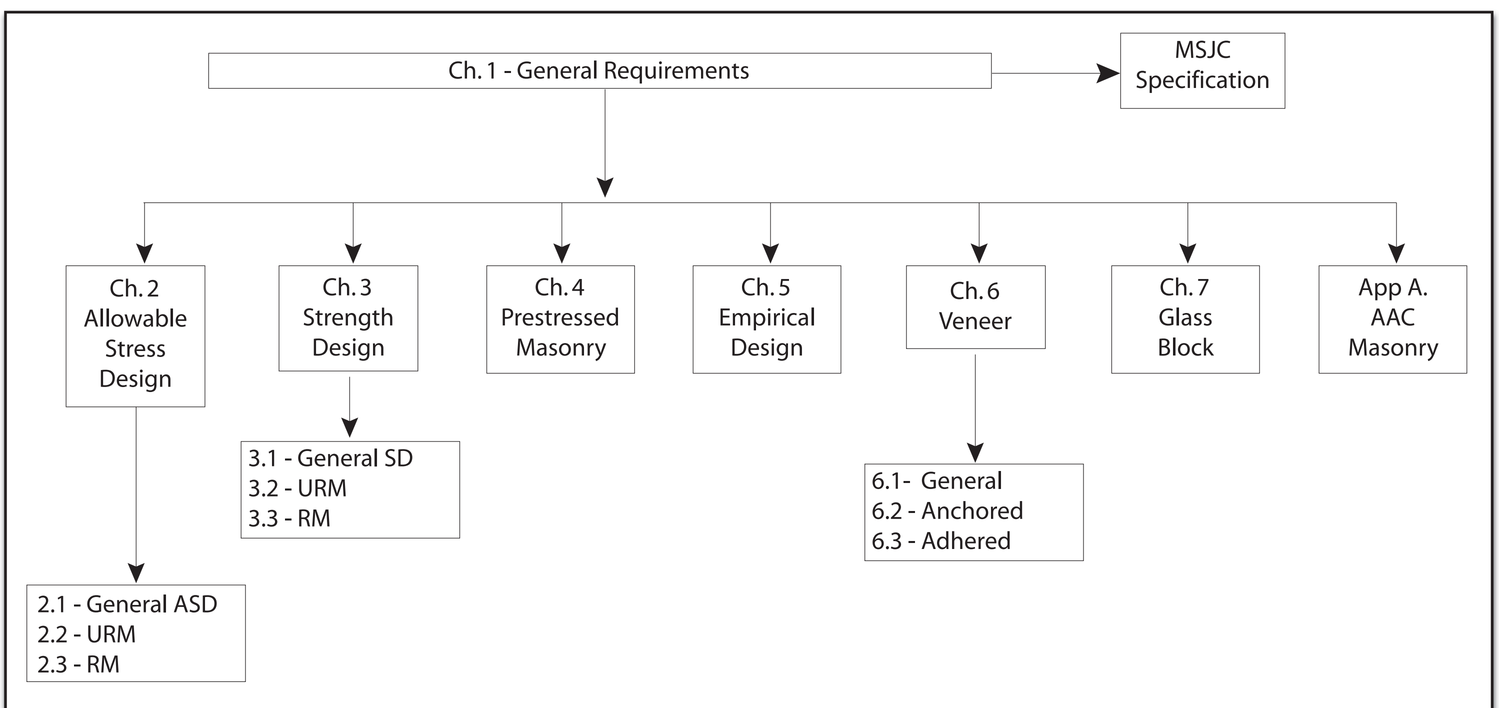
Chapter 2 (**Allowable Stress Design**):

- Allowable stresses for in-plane bending as well as out-of-plane bending are now given by Table 2.2.3.2. Although more work still needs to be done in this area, it is more reasonable to have allowable stresses for in-plane bending be given by Table 2.2.3.2, than be zero.

Chapter 3 (**Strength Design**) has been extensively updated:

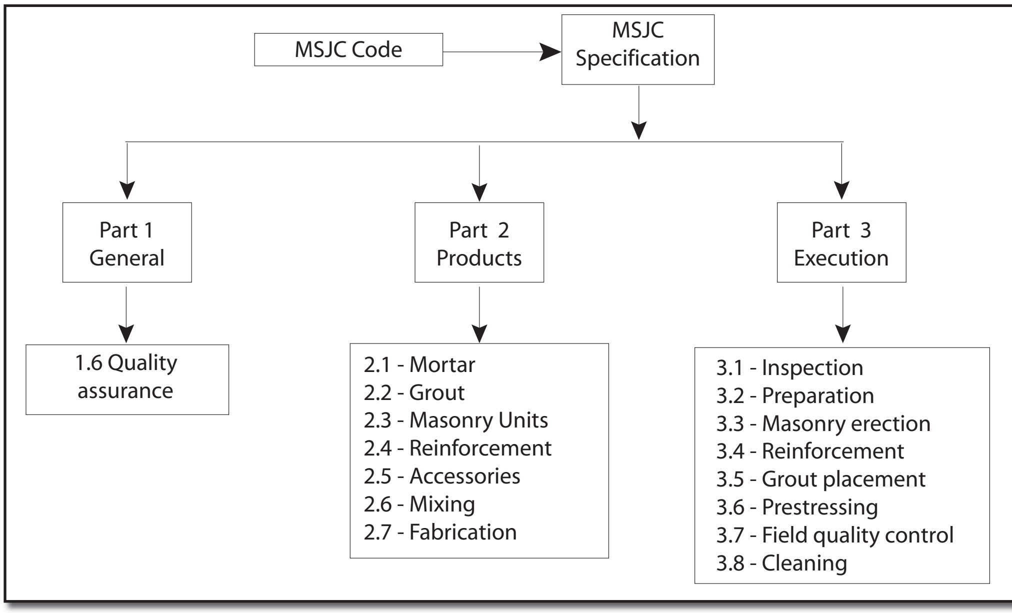
- In Section 3.3.3.5, provisions governing the maximum area of flexural tensile reinforcement have been extensively revised. The provisions of this section are still based on a critical strain gradient, similar to the approach of ACI 318-02. The maximum reinforcement provisions of the 2002 MSJC *Code* were relatively severe, and led to constructability problems in some circumstances. For the 2005 MSJC *Code*, the provisions are applied only to elements intended to be ductile. The maximum steel strain in the critical gradient has been relaxed somewhat, and is now tied directly to wall type (special, intermediate or ordinary), and hence to the expected ductility demand. Stress in tensile reinforcement need now be taken no higher than 1.0 f_y. Stress in compressive reinforcement can be included in calculating axial equilibrium even though that steel is not laterally supported by transverse reinforcement.
- The new Section 3.3.6.5 presents an alternative to the maximum flexural tensile reinforcement of Section 3.3.3.5 – the use of

Figure 1: Organization of the 2005 MSJC Code



The 2005 MSJC Specification, whose organizatyion is shown in Figure 2 is part of the MSJC Code by reference, and contains requirements intended to protect life safety

Figure 2: Organization of the 2005 MSJC Specification



confined boundary elements to increase the strain capacity of the compressive stress block. While requirements for these elements are not yet defined, procedures for defining them are laid out. The use of confined boundary elements is an option for reinforced concrete, and it should in principle be an option for reinforced masonry as well.

Chapter 4 (**Prestressed Masonry**):

- While the 2002 *Code* was based on allowable-stress design with nominal strength checks, the 2005 *Code* is based on strength design. Provisions have been harmonized with those of Chapters 1, 2, and 3.

Chapter 5 (**Empirical Design**) amended to clarify restrictions:

- In Section 5.1.2.1, gravity loads on walls and foundation piers are required to act within the kern (no net tension)
- In Section 5.1.2.3, wind speeds are given as the basic wind speed of ASCE 7-02. Also, empirical design is restricted based on combinations of geographic location and element elevation. This restriction is intended to enhance safety in the use of empirical design.

Chapter 6 (**Veneer**):

- In Section 6.2.2.11, prescriptive requirements, with appropriate modifications, have been extended to areas of high winds.

Chapter 7 (**Glass Unit Masonry**):

- In Section 7.3.2, glass unit masonry is permitted to be supported by wood, with strict limitations on weight.

Appendix A is a completely new, mandatory-language Appendix dealing with the strength design of autoclaved aerated concrete (AAC) masonry. For ease of use, formulas are expressed in a form similar to that of Chapter 3 (strength design of clay or concrete masonry). Because thin-bed AAC masonry is intended to have joints at least as strong as the AAC material itself, it requires less closely spaced reinforcement than conventional masonry, and its strength is verified using the tested or specified cube strength of the AAC material, rather than using a masonry prism.

The 2005 MSJC *Specification* has been updated editorially, and changed substantively in several respects:

- Article 1.1B clarifies the relationship between the *Code* and the *Specification*, and removes the requirement that the contractor follow the provisions of the contract documents. This requirement was legally inappropriate because the *Specification*, being referenced by the *Code*, becomes a law. It is inappropriate for a law to require somebody to follow a civil contract. The contract itself requires certain actions.
- Article 1.4B adds provisions for determination of the compressive strength of AAC masonry.
- Article 2.1C adds material construction provisions for AAC masonry.
- Article 3.3 adds masonry erection provisions for AAC masonry.
- Article 3.5D permits grout lifts of up to 12.67 ft in height, under closely controlled conditions.
- Article 3.5G adds grouting provisions for AAC masonry.

MSJC Plans For The 2008 Cycle

Easy Issues for the 2008 Cycle

1. Continue to harmonize design by strength, allowable-stress and empirical approaches,
2. Make strength design simpler (for example, by eliminating the requirement to check the moment magnifier for out-of-plane bending if walls are not very slender),
3. Clean up the logic on our prescriptive seismic requirements,
4. Continue to improve the *Specification*, and
5. Update the Commentaries

Tough Issues for the 2008 Cycle

1. Maximum reinforcement provisions. Masonry is much harder to confine than concrete; maximum reinforcement limitations must be more severe for unconfined masonry than for unconfined concrete, to avoid toe crushing. Possible solutions include more walls, increased compressive strength of masonry, practical confined boundary elements for masonry, and decreased Φ–factors rather than prohibition for compression-controlled cross-sections. In the 2008 cycle, specific provisions will be developed for confined boundary elements.
2. Prescriptive seismic requirements. How can we make prescriptive seismic reinforcement more convenient to use?
3. The ⅓ stress increase. As explained in detail in Chapter 8 of the 4th edition of *Masonry Designer's Guide*, the ⅓ stress increase is permitted by alternative allowable-stress loading combinations in some load documents, and expressly prohibited in others. It can significantly affect final designs under some conditions,

particularly unreinforced masonry in high wind areas. To the best of my knowledge, no formal test data support it and it is increasingly restricted by loading documents. The MSJC's options for addressing this issue include routinely reinforcing more masonry, or attempting to generate the data required to justify the ⅓ stress increase. To propose a global ⅓ increase in allowable stresses, without formal supporting data, would in my personal opinion be an invitation to exception by model codes. During the 2008 cycle, I hope to partially resolve this issue by increasing the allowable tensile stress for flexural reinforcement from 24 ksi to 36 ksi. That increase is in my personal opinion amply justified technically, and would also further harmonize allowable-stress design with strength design.

4. The future of empirical design. Inside and outside the masonry technical community, empirical design is distrusted by many. Inside the community, it is popular with some designers and many contractors, who believe, rightly or wrongly, that it results in more cost-effective designs and there-by protects their market share. In recent model-code hearings, the MSJC's increasingly restricted empirical design was not challenged. In my personal opinion, the MSJC should continue to defend empirical design for as long as it has potential users, while keeping it restricted and reasonably consistent with allowable stress and strength design. At the same time, the MSJC is working to develop "simplified design," a rational subset similar to the ACI/ISO simplified design publication for reinforced concrete. Ultimately, the design marketplace will decide the fate of empirical design.

How the Masonry Community Can Help the MSJC in This Effort

The masonry community, including structural engineers, can help by staying involved with the MSJC, by helping to identify areas where the MSJC Code and Specification can be improved, and by acting as a resource for the MSJC process in addressing difficult issues. Above all, interested structural engineers should work within the MSJC standards process, rather than outside of it or at the model-code level. They are encouraged to attend MSJC meetings, and give the MSJC document the benefit of their expertise.▪

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For More Information

1. MSJC Code and Specification: ACI 530-05 / ASCE 5-05 / TMS 402-05 (*Building Code Requirements for Masonry Structures*) and ACI 530.1-05 / ASCE 6-05 / TMS 602-05 (*Specifications for Masonry Structures*), American Concrete Institute, Farmington Hills, Michigan; American Society of Civil Engineers, Reston, Virginia; and The Masonry Society, Boulder, Colorado.

2. *Masonry Designers' Guide*, 4th ed., Phillip J. Samblanet, ed., The Masonry Society, Boulder, Colorado, 2003 (addresses 2002 edition of MSJC).

For additional information visit:
www.masonrystandards.org