TMS 402/602-16

Changes to the Masonry Code

By Richard Bennett, Ph.D., P.E.

A new edition of *Building Code Requirements for Masonry Structures and Specification for Masonry Structures* was published in 2016 (*Figure 1*). In addition to technical updates, there were four non-technical changes. The first is that the code and specification are now solely sponsored by The Masonry Society (TMS) and are known as TMS 402 (formerly also designated as ACI 530 and ASCE 5) and TMS 602 (formerly also designated as ACI 530.1 and ASCE 6), respectively. ASCE and ACI graciously relinquished their rights to the document in recognition of the maturity of The Masonry Society. The second change is that the code has six fewer pages than the 2013 edition, being one of the few structural codes that have fewer pages than the previous edition (*Figure 2*). The third change was to incorporate user-friendly tables rather than text throughout the document. The fourth change is not a direct revision to the 2016 edition; TMS has approved a six-year code cycle, so the next TMS 402 code will be the 2022 edition.

Shear Friction Provisions

A significant technical change was the addition of shear friction provisions. Masonry shear walls that have a low axial compressive load and a low height-to-length ratio are vulnerable to shear sliding, which normally occurs at the base. Shear sliding can cause damage to the masonry due to the simultaneous actions of the shear stress, compressive stress, and dowel action. There are similar shear friction provisions for Allowable Stress Design (ASD) and Strength Design (SD). One set of equations is for low height-to-length shear walls, while the provisions for flexurally-dominated walls account for the fact that not all the reinforcement crossing the horizontal shear plane will contribute to the clamping force and provides a reduced coefficient of friction. Although shear friction will govern in a few cases, the reduction in the capacity of the wall is small, in general. Shear friction can govern with shear-dominated walls. However, these long walls (big box structures) are generally governed by architectural requirements and not structural requirements; there is usually more than sufficient structural strength. *Figure 3* provides Shear Friction Design equations.

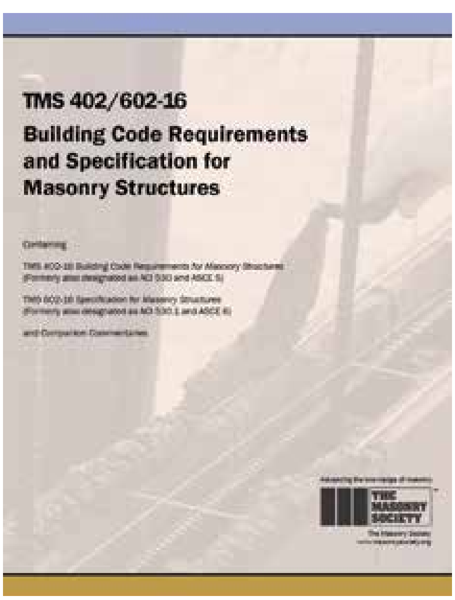

Figure 1. The 2016 TMS 402/602.

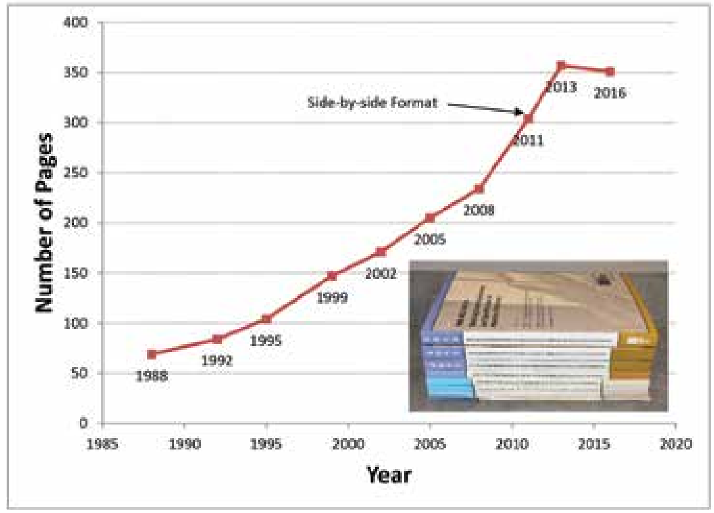

Figure 2. Code facts – historical page counts.

Anchor Bolt Provisions

There were two major changes to the anchor bolt provisions. One was to increase the nominal shear masonry crushing strength from $B_{vnc} = 1050 \sqrt[4]{f'_m A_b}$ to $B_{vnc} = 1750 \sqrt[4]{f'_m A_b}$. This increase was based on examining 345 anchor bolt tests. The average ratio of experimental strength to nominal strength was 2.33 with the previous equation. The change still results in a conservative prediction of nominal strength, with the average ratio of experimental strength to nominal strength being 1.49. A similar change was made to Allowable Stress Design. The second change was to the interaction between the tensile and shear strength of anchor bolts. Previously, there was a linear interaction diagram. This was changed to an elliptical interaction equation with an exponent of 5/3, based on testing. These two changes, coupled with a change in ASCE 7-16 that reduces the minimum design strength of anchors not governed by tensile yielding or shear yielding from 2.5 times the factored force to 2.0 times the factored force for seismic applications, will result in more efficient use of anchor bolts in masonry.

Veneer Cavity Width

Increased energy requirements for building envelopes has resulted in wider cavities in brick veneer walls to accommodate increased insulation thicknesses. The code was changed to allow an increased cavity width from 4½ inches to 6⅝ inches for the prescriptive design of veneer anchors under certain conditions. The increase was primarily to allow for increased thicknesses of insulation and secondarily to recognize that ⅝-inch sheathing is typically used instead of ½-inch sheathing. The requirements for anchors are adjustable anchors with two pintles, a maximum span of the adjustable portion of 2 inches, and either ¼-inch barrel anchor, a plate or prong anchor at least 0.074-inch-thick and 1¼ inches wide, or a tab or two eyes formed of minimum size W2.8 wire welded to joint reinforcement. Joint reinforcement with cross and longitudinal wires of size W2.8 are also permitted. Anchor capacities of adjustable anchors are primarily controlled by bending of the pintles at a maximum allowed offset of 1.25 inches. This capacity is independent of cavity width and is not affected by the code change. The requirements for anchors for increased cavity widths have compression capacity that equals or exceeds current requirements.

Concentrated Loads

TMS 402 has provisions for distributing concentrated loads in walls based on a 2 vertical to 1 horizontal dispersion terminating at half the wall height, or the edge or opening of a wall. This resulted in very small distribution lengths for concentrated loads near the edge of a wall and no dispersion for loads at the edge of a wall or an opening. This could result in unconservative designs as the axial load generally increases the moment capacity. A provision was added that a concentrated load could be distributed at 3 vertical to 1 horizontal on one side of an opening. This steeper dispersion will continue away from the opening up to one-half the height of the masonry below the load so that the dispersions can be truncated independently on each side of the bearing (*Figure 4*).

Additional Changes

Other technical changes include deleting the prescriptive requirements for masonry piers in strength design, as most of the requirements were redundant with the current prescriptive seismic design. The requirement that the nominal bar diameter does not exceed one-eighth of the least nominal member dimension that

Design Method	$M/(Vd_v) \le 0.5$ or $M_u/(V_u d_v) \le 0.5$	$M/(Vd_v) \ge 1.0$ or $M_u/(V_u d_v) \ge 1.0$
ASD	$F_f = \dfrac{\mu(A_{sp}F_s + P)}{A_{nv}}$	$F_f = \dfrac{0.65(0.6A_{sp}F_s + P)}{A_{nv}}$
SD	$V_{nf} = \mu(A_{sp}f_y + P_u)$	$V_{nf} = 0.42 f'_m A_{nc}$

Use linear interpolation for $0.5 < M/(Vd_v) < 1.0$ or $0.5 < M_u/(V_u d_v) < 1.0$

A_{nc} = net cross-sectional area between the neutral axis and the compressive face
A_{nv} = net shear area
A_{sp} = cross-sectional area of reinforcement within the net shear area
d_v = depth of member in direction of shear
F_f = allowable shear friction stress
F_s = allowable tensile stress in reinforcement
f'_m = specified compressive strength of masonry
f_y = yield strength of reinforcement
M = moment
M_u = factored moment
P = axial load
P_u = factored axial load
V = shear
V_u = factored shear
V_{nf} = nominal shear friction strength
μ = coefficient of friction; 1.0 for masonry on concrete with an unfinished surface, or masonry on concrete with a finished surface that has been intentionally roughened; 0.70 for all other conditions.

Figure 3. Shear friction design equations.

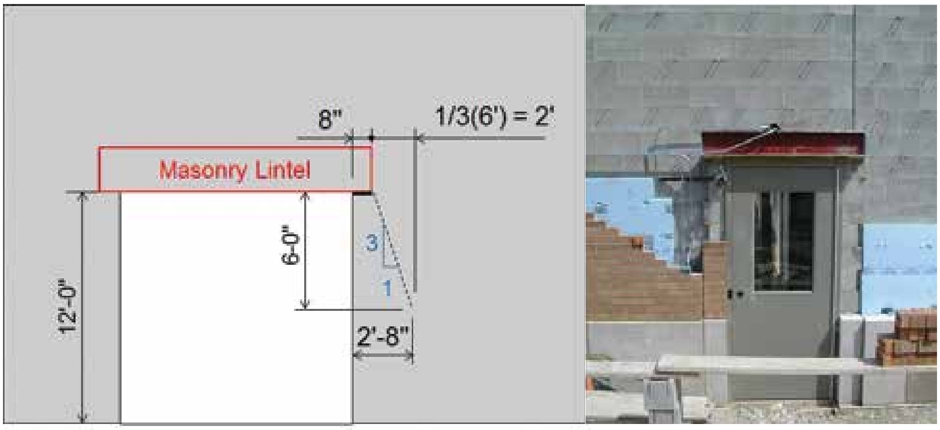

Figure 4. Load distribution at openings.

was in strength design was also added to allowable stress design. This provision minimizes the chances of splitting of the masonry. The tables for the prescriptive design of partitions in Chapter 14 were expanded to include out-of-plane loadings from 5 psf to 50 psf. Cast stone (ASTM C1364-16 Standard Specification for Architectural Cast Stone) and manufactured stone (ASTM C1670-15 Standard Specification for Adhered Manufactured Stone Masonry Veneer Units) were added as approved materials in TMS 602.

There were several organizational, format, and editorial changes. Reinforcement requirements, particularly development and splice length requirements, had been scattered across three chapters: Chapter 8 – Allowable Stress Design, Chapter 9 – Strength Design, and Chapter 11 – AAC Masonry. These requirements were consolidated and moved to Chapter 6 – Reinforcement, Metal Accessories, and Anchor Bolts.

The 2013 TMS 402/602 had three quality assurance tables (Quality Assurance Level A, B, and C) and the tables were repeated in both the code (TMS 402) and the specification (TMS 602). The tables were removed from TMS 402; TMS 402 now references TMS 602. The tables were also modified so that there are now two tables, one table for Minimum Verification Requirements and one table for Minimum Special Inspection Requirements. This approach segregates minimum test requirements from the inspection tables.

Some formatting changes include combining requirements that were in multiple sections, and challenging to follow, into tables. This is for the ease of users (*see the sidebar for further information*). Definitions were added for beams and pilasters, and other definitions were modified and clarified. In particular, there were inconsistencies in definitions of loads. TMS 402 now just refers to either allowable stress design level loads or strength level loads.▪

Richard Bennett is a Professor of Civil and Environmental Engineering at the University of Tennessee, Knoxville. He was chair of the 2016 TMS 402/602 Committee and is currently 2nd Vice-Chair of the 2022 TMS 402/602 Committee.

User-Friendly Tables

By Charles Haynes, P.E., LEED AP

The author is a principal at one of the Southeast's largest structural engineering firms and has participated in the TMS 402/602 code development for over 10 years. During the 2013 TMS 402/602 code cycle, Charles was actively involved in efforts to simplify the organization and layout of the code to make it more designer-friendly – provisions that would be easier for the user to locate and reduce flipping back and forth between chapters during design. The result was an entirely new layout to the code based on the way a project is engineered.

Bolstered by the positive response to the designer focused efforts in the 2016 TMS402/602 code cycle, further efforts were launched to help the user by unpacking some specific sections into user-friendly tables to quickly identify needed information.

As the saying goes, a picture is worth a thousand words. That may be a stretch in this case, but a table is worth several words and, more importantly, your time and sanity. Time demands on everyone in this industry have seemed to sky-rocket, and codes have become much more complex and harder to follow.

Consider the example herein from a provision in the 2013 TMS 402 for the Effective Flange Width when designing the intersection of a wall. You might read the 2013 code language several times and then your phone rings, and you think, "What did I just read?" Now consider the same provision shown as it is presented in the 2016 TMS 402. The implementation of a table format allows users to identify necessary information quickly.

As a user, the author applauds the efforts of the committee to simplify the TMS 402/602. The new, user-friendly tables are one example of this. As the committee has now moved to a 6-year code cycle, the next release will be the 2022 TMS 402, and we can look forward to more user-friendly updates.

Charles Haynes is a Principal with Structural Design Group (SDG) in Nashville, TN. Charles is a member of the Board of Directors for The Masonry Society (TMS) and on several TMS 402 committees, including TMS 402 Main Committee, and is actively involved in developing and maintaining masonry building codes (TMS 402/602) adopted by the International Building Code.

5.1.1.2.3 The width of flange considered effective on each side of the web shall be the smaller of the actual flange on either side of the web wall or the following:

(a) 6 multiplied by the nominal flange thickness for unreinforced and reinforced masonry, when the flange is in compression

(b) 6 multiplied by the nominal flange thickness for unreinforced masonry, when the flange is in flexural tension

(c) 0.75 multiplied by the floor-to-floor wall height for reinforced masonry, when the flange is in flexural tension.

The effective flange width shall not extend past a movement joint.

Excerpt – 2013 TMS 402

5.1.1.2.3 The width of flange considered effective each side of the web shall be the smaller of the actual flange on either side of the web wall and the value shown in Table 5.1.1.2.3, based on the state of stress in the flange and whether or not the masonry is reinforced. The effective flange width shall not extend past a movement joint.

Table 5.1.1.2.3 Effective Flange Width

Stress State in Flange	Unreinforced (U) or Reinforced (R) Masonry	Effective Flange Width
Compression	U, R	6 x nominal flange thickness
Tension	U	6 x nominal flange thickness
	R	0.75 x floor-to-floor wall height

Excerpt – 2016 TMS 402