Engineering Notes for Design with Concrete Block Masonry

MASONRY CHRONICLES

2025

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TMS 402/602: MAJOR CHANGES TO THE 2022 EDITION

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INTRODUCTION

Major changes to the 2022 edition of TMS 402 *Building Code Requirements for Masonry Structures* and TMS 602 *Specification for Masonry Structures* are covered in this paper, with a particular emphasis on changes affecting seismic behavior and masonry design in California and Nevada. The most important non-technical change is that this was the first code produced on a six-year cycle. The six-year cycle is being retained, and the next edition of TMS 402/602 will be in 2028.

Changes will be covered Chapter by Chapter. There was a small change in chapter numbers. Appendix B on infill design was moved to Chapter 12 and subsequent chapters renumbered. Appendix A on empirical design was deleted. Appendix D on Glass Fiber Reinforced Polymer Reinforcement was added.

TMS 402 CHAPTERS 1, 2, AND 3

There were no significant changes to Chapter 1 *General Requirements*. Changes and additions to *Definitions* in Section 2.2 are covered where the term is used. Section 3.2.1 *Grouting minimum spaces* was deleted. This is a construction means and methods issue and is covered in TMS 602 Article 3.5 C and Table 7. The requirements have been in TMS 602 and there is no change to the requirements. Section 3.2.2 *Embedded Conduits, Pipes, and Sleeves* was moved to Section 4.8. There is no change to the requirements.

TMS 402 CHAPTER 4 GENERAL ANALYSIS AND DESIGN CONSIDERATIONS

Section 4.3 *Specified Compressive Strength* was added. These requirements were in Section 9.1.9.1 and were moved to Chapter 4 so they now apply to masonry designed by Allowable Stress Design as well as Strength Design. There is no change to the requirements, but the requirements are presented in tabular form for ease of use.

Section 4.4.5 *Net Shear Area* was added. There had been confusion on what the net shear area should for certain members and Table 4.4.5 *Net Shear Area for Reinforced Masonry Members* was added. In particular, the net shear area for masonry beams is defined based on d, the distance to the centroid of the tension reinforcement, and not d_v, the actual depth of the member in the direction of the shear, while for shear walls, d_v is used.

Section 4.6 *Deflection of Beams Supporting Unreinforced Mason*ry was added. The deflection limitations had been in Section 5.2.1.4.1 but were moved to Chapter 4 to make it clear that the deflection limitation applies to all beams supporting unreinforced masonry, whether it be a masonry beam, a precast concrete beam, a steel beam, or any beam.

As previously mentioned, Section 3.2.2. was moved to Section 4.8.

TMS 402 CHAPTER 5 STRUCTURAL MEMBERS

Section 5.1 *Masonry Assemblies* was reorganized and split into 5.1 *General* and 5.2 *Walls*. The purpose of Section 5.2 is to clarify the different types of wall intersections. Wall intersections may be designed and detailed as structurally independent walls, as laterally supported walls, or as fully composite walls.

The following table provides correspondence between Sections.

TMS 402-22 Section	TMS 402-16 Section
5.1.1 *Concentrated Loads*	**5.1.3**
5.1.2 *Effective Compression Width per Bar*	**5.1.2**
5.1.3 *Multiwythe Masonry*	**5.1.4**
5.2.1 *Design of Independent Walls*	**5.1.1(b)**
5.2.2 *Design of Lateral Supports for Walls, Without Composite Action at the Intersections*	**14.4.3**
5.2.3 *Design of Masonry Wall and Pilaster Intersections for Composite Action*	**5.1.1**

The only technical change was that previously running bond masonry was required for wall intersections designed for composite action. Masonry not laid in running bond is now allowed provided the wall intersection has intersecting bond beams meeting the requirements of Section 5.2.3.5 (c).

Several changes were made to Section 5.3 *Beams*.

- The minimum span length in Section 5.3.1.1 was simplified to the distance from face-to-face of supports, plus ½ of the required bearing length at each end.
- Previously, beams designed using Strength Design were required to be fully grouted, while beams designed using Allowable Stress Design were not required to be fully grouted. Section 5.3.1.2 was added which requires beams to be fully grouted if transverse reinforcement is required and the provision for full grouting in Strength Design was deleted.
- Section 8.3.5.4 which allowed the shear at $d/2$ from the face of support to be used in design if certain conditions were met was moved to Section 5.3.1.5. Since the provision was in Chapter 8 it technically only applied to Allowable Stress Design. With the provision in Chapter 5 it applies to both Allowable Stress Design and Strength Design.
- Section 5.2.1.4.1 on deflection limitations of beams supporting unreinforced masonry was moved to Section 4.6 so it was clear that it applied to beams of any type of construction.

TMS 402 CHAPTER 6 REINFORCEMENT, METAL ACCESSORIES, AND ANCHOR BOLTS

There were numerous changes in Section 6.1 *Reinforcement*, both in organization and in the provisions. Each subsection of 6.1 is covered in the following. There was no change to Section 6.2 *Metal Accessories*. The only change to Section 6.3 *Anchor Bolts* was the addition of Section 6.8 *Effective Cross-Sectional Area of Threaded Anchor Bolts*. This section was added because of changes to how the axial and shear strength of the anchor bolt steel is calculated, which is covered in Chapter 8.

<u>6.1.1 *Scope*:</u> A scope section was added and all the subsequent sections renumbered. The scope section lists the four types of reinforcement that are covered.

- Deformed reinforcing bars
- Joint reinforcement
- Deformed reinforcing wire
- Welded deformed wire reinforcement

Although deformed wire has always been a part of TMS 402, there were minimal requirements. There was a major effort to examine all sections and modify as needed for deformed wire. Although not used a lot, deformed wire can provide an effective solution is some cases, particularly when a smaller size is useful to facilitate construction and grouting.

<u>*Section 6.1.2 Embedment:*</u> There was a small change to the requirement, adding an exception to reinforcement embedded in grout for column ties.

<u>Section 6.1.3 *Size of Reinforcement:*</u> This section was completely rewritten. Some of the previous requirements were in conflict with requirements in Section 9.3.3.1(a). The requirements were harmonized and Section 9.3.3.1(a) was deleted.

<u>Section 6.1.3.1 *Size of Reinforcement in Mortar*:</u> This includes 402-16 Section 6.1.2.3 on joint reinforcement wire size and adds in requirements for deformed wire in mortar.

<u>Section 6.1.3.2 *Size of Reinforcement in Grout*:</u> The requirements for the size of reinforcement in grout were harmonized into four requirements.

- The maximum bar size is No. 11 and the maximum deformed wire size is D31. The No. 11 had been the maximum size in Chapter 6. The maximum bar size of No. 9 in Section 9.3.3.1(a) was deleted.

- The nominal bar or wire size is one-eighth the least nominal dimension. This had been in Section 6.1.2.5.

- The diameter of the reinforcement is limited to one-third the least dimension of the gross grout space. This replaced requirements in Chapter 6 and 9 for reinforcement diameter. For standard units this requirement rarely controls.

- The area of horizontal and vertical reinforcement in clay and concrete masonry cannot exceed 4% of the gross grout space except it can be 8% at laps. This replaced requirements in Chapter 6 and 9 and also clarified that the basic limit of 4% can be doubled at lap splices.

The gross grout space is defined as: area within the continuous grouted cell, core, bond beam course, or collar joint, considering the effect of unit offset in adjacent courses but neglecting possible mortar protrusions and the presence of perpendicular reinforcement, if any. Examples of gross grout space are given in TMS 402 Figure CC-6.1-1. Sections 6.1.3.2.5.1 and 6.1.3.2.5.2 provide alternate provisions. However, the easiest method of satisfying the requirements is Commentary Tables CC-6.1.3.2.5.2.1, CC-6.1.3.2.5.2.2, and CC-6.1.3.2.5.2.3 which give maximum vertical reinforcement for most common conditions. For example, for 8 inch CMU laid in running bond and flanged units, the maximum reinforcement per cell is one #7 or two #5 bars. Larger amounts of reinforcement could be used if jamb units or open-end units are specified.

Section 6.1.4 *Placement of Bar and Deformed Wire Reinforcement*: There were no changes to the requirements.

Section 6.1.5 *Protection of Reinforcement*: There were no changes to the requirements.

Section 6.1.6 *Development*: Most of the requirements did not change. Provisions were added for deformed wire reinforcement embedded in mortar (6.1.6.2.1) and joint reinforcement (6.1.6.2.2). Section 6.1.6.3.3 *Standard Hooks* was modified. The development length with a standard hook did not change but the equation was modified as there was the possibility of misinterpretation with the previous provision.

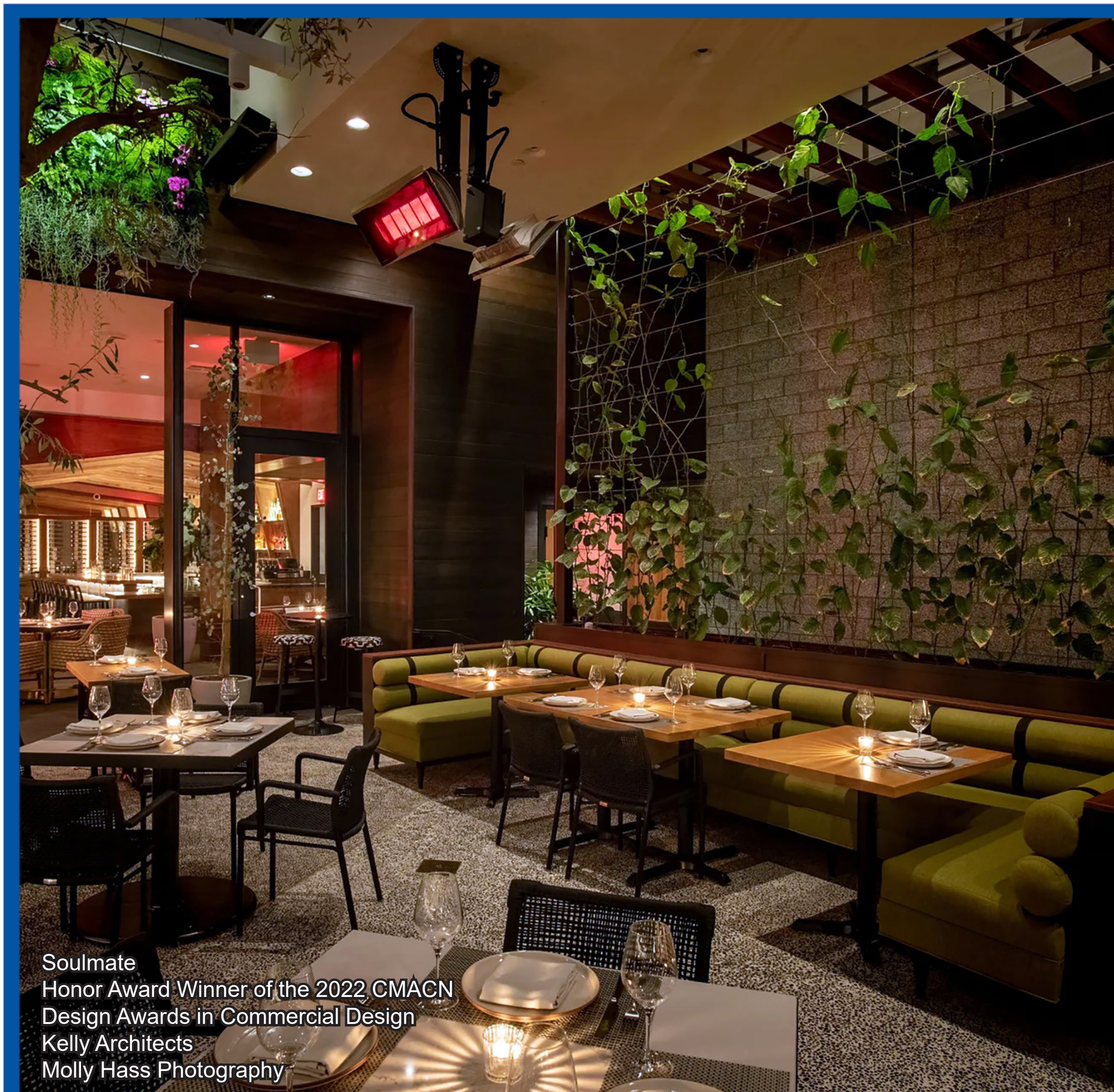
Section 6.1.7 *Splices*: Most of the requirements did not change. Provisions were added for deformed wire reinforcement embedded in mortar (6.1.7.1.1.1) and joint reinforcement (6.1.7.1.1.1.2). Section 6.1.7.2 *Mechanical Splices* was expanded to include requirements on size and placement.

Section 6.1.8 *Shear Reinforcement*: Two subsection were deleted and two subsections were added as described below.

- 402-16 Sections 6.1.7.1 and 6.1.7.2 were deleted. These were provisions for horizontal shear reinforcement and required 180° hooks around the edge vertical reinforcement or 90° hooks for intersecting walls. The requirements only applied to masonry designed by Strength Design and did not apply to masonry designed by Allowable Stress Design. The deletion was based on several research projects which showed no significant difference in strength due to changes in the bond beam reinforcement anchorage type from straight to 180° hooks. Hooks will be required in some cases in special reinforced shear walls. This will be covered in Chapter 7.
- Section 6.1.8.1 was added and provides anchorage requirements for deformed wire embedded in mortar and used as shear reinforcement.
- Section 6.1.8.2 was added and is an expansion of 6.1.7.1.3 providing anchorage requirements for joint reinforcement used as shear reinforcement.

Section 6.1.9 *Standard Hooks and Bends for Reinforcing Bars and Deformed Wire*: The requirements did not change but deformed wire provisions were added. 402-16 Table 6.1.8 was moved to TMS 602 Table 6 *Standard Hooks Geometry and Minimum Inside Bend Diameters for Steel Reinforcing Bars and Deformed Wire.*

Section 6.1.10 *Embedment of Flexural Reinforcement*: None of the requirements changed but Figure CC-6.1-8 and CC-6.1.9 were updated to provide additional clarity.



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TMS 402 CHAPTER 7 SEISMIC DESIGN REQUIREMENTS

An exception was added in Section 7.3.1 *Nonparticipating Elements* that a nonparticipating element does not need to be isolated if a deformation compatibility analysis is performed.

Empirically designed shear walls were deleted. This caused a renumbering of every subsection in Section 7.3.2 *Participating Elements*. For example, 402-16 Section 7.3.2.2 *Ordinary Plain Masonry Shear Walls* is now Section 7.3.2.1.

Several changes were made to Section 7.3.2.5 *Special Reinforced Shear Walls*, which are covered below.

- Part (a) was added which requires in-plane flexural reinforcement to be deformed reinforcing bars. Other reinforcing products, such as deformed wire, are cold worked and lack the required ductility.

- 402-16 (b) was split into parts (c) and (d). The requirements did not change but it was clarified that the 48 inch maximum spacing of horizontal reinforcement within masonry laid in running bond applies to all horizontal reinforcement (prescriptive and required for shear), while the one-third height and one-third length only applies to required shear reinforcement.

- Section (e) was added which requires joint reinforcement and deformed wire placed in mortar used as shear reinforcement to be a single piece without splices for the length of the wall. This is due to lack of research on lap spliced reinforcement in mortar under cyclic loads.

- Section (i), which determines when and what type of hooks are required for horizontal reinforcement, was completely rewritten. As covered in Chapter 6, the hook requirements for horizontal shear reinforcement were deleted based on the bar termination not affecting the strength. However, the research was not as clear as to the impact of hooks on ductility. The 402-16 Chapter 6 hook requirements of 180° hooks around the edge vertical reinforcement or 90° hooks for intersecting walls were moved here and hooks are required when $V/F_{vm}A_{nv}$ (Allowable Stress Design) or $V_u/\phi V_{nm}$ (Strength Design) > 0.40. Shear capacity design, which is covered later, requires the shear force to be doubled. Thus, at a shear ratio of 0.5, shear reinforcement would be required, and the committee felt that hooks would be important. The 0.5 was lowered to 0.4 to require hooks in prescriptive horizontal reinforcement when the shear load was 80% or greater of the masonry shear strength.
  The 2028 Code Committee realized that the grouted shear wall factor, γ_g, should have been included in the denominator, or the equations should be $V/(F_{vm}A_{nv}\,\gamma_g)$ and $V_u/(\phi V_{nm}\,\gamma_g)$. This only impacts partially grouted shear walls, as $\gamma_g = 1.0$ for fully grouted shear walls. For partially grouted shear walls, it is recommended that γ_g be included in the denominator when checking the shear demand ratio.

- Section (k) was added which prohibits welded splices in reinforcement in plastic hinge zones.

There were three changes to Section 7.3.2.5.1 *Shear Capacity Design*, with two changes being primarily editorial and one change of substance with Allowable Stress Design.

- The two subsections of 7.3.2.5.1 were switched so that Allowable Stress Design provisions were listed first, consistent with the rest of the code.

- In Strength Design, the shear capacity design provisions required the design shear strength, ϕV_n, to exceed the shear corresponding to the development of 1.25 times the nominal flexural strength, M_n , except that the nominal shear strength, V_n , need not exceed 2.5 times required shear strength, V_u. It was confusing to use ϕV_n in the first part and V_n in the second part. Thus, the second part was changed to ϕV_n need not exceed $2.0V_u$. The requirement has not changed since $\phi(2.5)=0.8(2.5)=2.0$, but the design strength ϕV_n is now used for both requirements.

- In Allowable Stress Design the seismic forces now has to be increased by a factor of 2.0 instead of 1.5. Along with this change the allowable masonry shear was approximately doubled. Instead of a factor of ¼ in F_{vm}, the factor was changed to ½ (see Chapter 8 for additional information). This provides more consistency with Strength Design.

Section 7.4.3.1 *Design of Nonparticipating Elements (SDC C)* was modified. An option was added to use deformed wire. In previous editions the prescriptive reinforcement could be in either the horizontal OR vertical direction. This was changed to requiring the reinforcement to be in the direction of the span. The 2028 committee realized that the same change should have been made in Section 7.4.4.1 *Design on Nonparticipating Elements (SDC D)*. However, this was missed and the requirement for prescriptive reinforcement is still listed as in either the horizontal OR vertical direction. Designers are encouraged to place the reinforcement in the direction of the span.

Section 4.3.2.4 *Lateral Stiffness* was modified. Although the intent is still the same, the provision was rewritten in terms of maximum stiffness provided by columns, which is 20%, with an exception if the system is designed to be essentially elastic (R=1.5). The commentary was expanded providing additional useful information to the designer.

Section 7.4.4.1.1 *Minimum Reinforcement for Masonry Columns (SDC D)* was added. Lateral ties are required for a length equal to twice the larger column plan dimension from the top and bottom of the column at each floor, even if the column is nonparticipating. Providing a level of confinement consistent with that required for participating columns is intended to maintain column integrity. There is an exception if the column is isolated or a deformation compatibility analysis is performed.

TMS 402 CHAPTER 8 ALLOWABLE STRESS DESIGN OF MASONRY

Anchor bolt steel tensile and shear strength was based on the yield strength of the anchor bolt, f_y. The yield strength is not well defined for anchor bolt steels, which is why other material codes base the anchor bolt steel strength on the ultimate tensile strength, f_u. In addition, there were inconsistencies in the commentary for 402-16 Section 9.1.3.6 and 9.1.3.6.1.1. Because of this the anchor bolt steel strength has been changed to be based on f_u. A summary of the new anchor bolt steel strengths is given in the following table. The definition A_b was clarified to be the effective area of the anchor bolt including the effect of threads, with the effective area given in a new Section 6.8. This change results in the steel anchor strength matching that of AISC and ACI.

Anchor Bolt Steel Strength	Allowable Stress Design	Strength Design
Tensile Strength	$B_{as} = 0.5A_b f_u$ Equation 8-2	$B_{ans} = A_b f_u \quad \phi = 0.75$ Equation 9-2
Shear Strength	$B_{vs} = 0.25A_b f_u$ Equation 8-7	$B_{vns} = 0.6A_b f_u \quad \phi = 0.65$ Equation 9-7

The axial load factor on the masonry strength contribution to the allowable axial load was increased from 0.25 to 0.30 in Equations 8-16 and 8-17. The equations are now:

$$P_a = \left(0.30 f'_m A_n + 0.65 A_{sf} F_s\right)[\text{Slenderness Factor}]$$

The value of the partially grouted shear wall factor, γ_g, was reduced from 0.75 to 0.70 for in-plane loading of partially grouted shear walls based on a thorough statistical analysis of test data.

Two changes were made to the allowable shear stress resisted by masonry, F_{vm}. The first change was discussed in Chapter 7; Equation 8-25 for special reinforced shear walls was deleted due to a change in the shear capacity design provisions. The second change was the factor on P/A_n was decreased from 0.25 to 0.20, which is based on ASD load combinations.

As discussed in Chapter 5, Section 8.3.5.4 that allows the shear at $d/2$ in beams to be used if certain conditions are met was moved to Chapter 5 so that it applies to both Allowable Stress Design and Strength Design.

Based on a reanalysis of the data, the allowable shear friction strength for $M/(Vd_v) \geq 1$ was changed by increasing the factor on $A_{sp}F_s$ from 0.6 to 0.75.

$$F_f = \frac{0.65(0.75 A_{sp} F_s + P)}{A_{nv}}$$

TMS 402 CHAPTER 9 STRENGTH DESIGN OF MASONRY

<u>Tension and Compression-Controlled Sections</u>

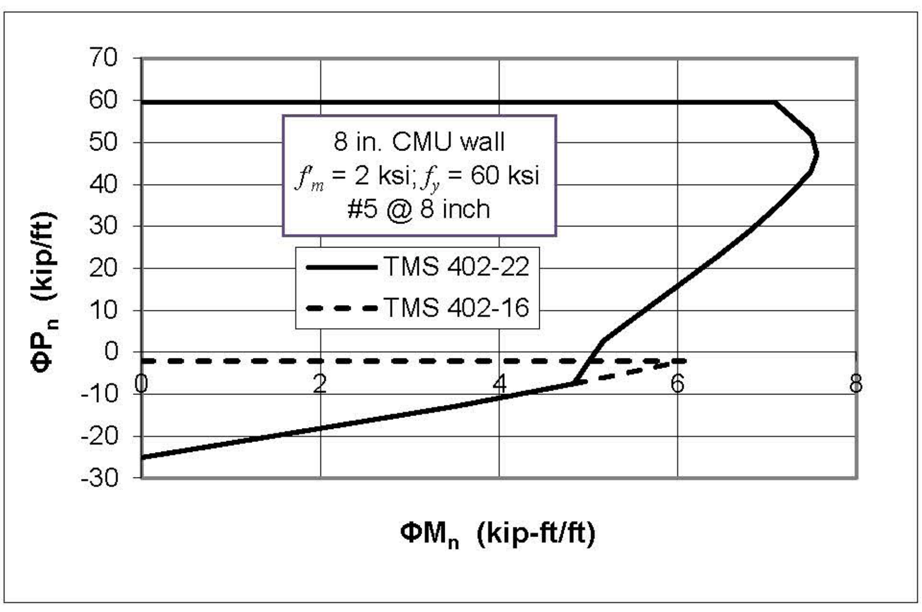
9.1.4.4 *Combinations of flexure and axial load in reinforced masonry.*

A major change was made in strength design provisions, with the introduction of compression-controlled sections. In TMS 402-16, there were only tension-controlled sections (ϕ=0.9 for all combinations of moment and axial load), and rather stringent limits on the maximum reinforcement. The maximum reinforcement provisions could be quite restrictive, with No. 5 at 8 inch in an 8-inch concrete masonry wall exceeding the maximum reinforcement limits under out-of-plane load, even with no axial load. The strength-reduction factor in the 2022 Code is determined from Table 9.1.4.

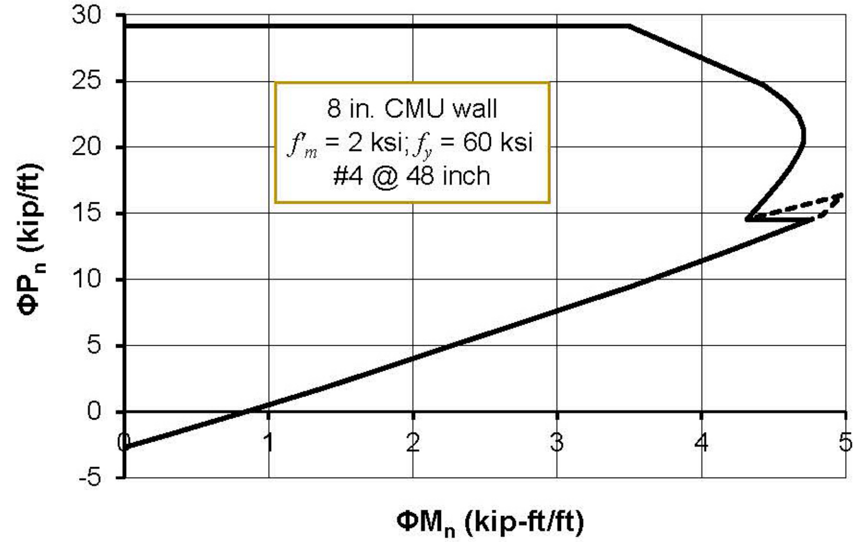
Table 9.1.4. Strength Reduction Factor ϕ for Moment, Axial load, or Combined Moment and Axial Load

Net tensile strain, ε_t	Classification	ϕ
$\varepsilon_t \le \varepsilon_{ty}$	Compression-controlled	0.65
$\varepsilon_{ty} < \varepsilon_t < 0.003 + \varepsilon_{ty}$	Transition	$0.65 + 0.25\frac{\varepsilon_t - \varepsilon_{ty}}{0.003}$
$\varepsilon_t \ge 0.003 + \varepsilon_{ty}$	Tension-controlled	0.90

The figure below compares the interaction diagram for a 12 ft high 8-inch concrete masonry wall with Grade 60 No. 5 @ 8 inch under out-of-plane loads. Although there is a small region of combinations of flexure and axial load that were allowed with TMS 402-16 that are not allowed with TMS 402-22, the compression-controlled provision in TMS 402-22 allows significantly higher axial loads.



Section 9.1.4.4.2 can be confusing on first reading. For partially grouted walls under out-of-plane loading there can be strange behavior in the transition region, as shown below by the dashed line. The nominal capacity is increasing at a slower rate than the decrease in the strength-reduction factor. Section 9.1.4.4.2 is saying the solid line needs to be used for the interaction diagram and not the dashed line.



With the adoption of compression-controlled sections, the maximum reinforcement restrictions were removed except for intermediate and special reinforced masonry shear walls under in-plane loads, and for beams. These changes are covered below under the appropriate section.

Other Changes to Chapter 9

The anchor bolt steel axial and shear strength in Section 9.1.6.3 were changed to be based on f_u instead of f_y. See Chapter 8 for further details.

402-16 Section 9.1.9.1 *Compressive Strength* was moved to Section 4.3 so that is also applicable to Allowable Stress Design.

402-16 9.3.3.1 *Reinforcement Size Limitations* was deleted. The requirements were harmonized with Allowable Stress Design and put in Chapter 6. See Chapter 6 for details.

Due to adding transition and compression-controlled regions, 402-16 Section 9.3.3.2 *Maximum Area of Flexural Reinforcement* was deleted. The maximum reinforcement requirements were retained for intermediate and special reinforced masonry shear walls and are in Section 9.3.5.6.1.

402-16 Section 9.3.3.3 *Bundling of Reinforcing Bars* was moved to Section 6.1.4.4.

402-16 Section 9.3.3.4 *Joint Reinforcement Used as Shear Reinforcement* was moved to Section 7.4.1.2.1 and 7.4.3.2.6 since the requirements were seismic related.

The value of the partially grouted shear wall factor, γ_g, was reduced from 0.75 to 0.70 for in-plane loading of partially grouted shear walls based on a thorough statistical analysis of test data.

402-16 Section 9.3.4.2.4 *Construction* which required beams to be fully grouted was deleted. See Chapter 5 for more information.

With the removal of the maximum reinforcement requirements for flexural reinforcement, Section 9.3.3.2.4 *Maximum Reinforcement (Beams)* was added which requires beams to be tension controlled.

Equation 9-28 for determining the cracked moment of inertia, I_{cr}, for calculating out-of-plane deflections was modified. There had been a $t_{sp}/2d$ factor which was an empirical modifier to account for non-centered reinforcement. The new equation is mechanics based. The new equation does reduce to the previous equation for centered reinforcement.

The shear friction equation for $M_u/(V_u d_v) \geq 1.0$ was changed to match the Allowable Stress Design format. This results in easier calculations, particularly when linear interpolation is required.

The ductility requirements for shear walls were modified for clarity. Section 9.3.5.6 *Ductility Requirements* was added to emphasize there are two methods for showing sufficient ductility of shear walls. The first method is Section 9.3.5.6.1 *Maximum Area of Flexural Reinforcement*. These requirements were moved from Section 9.3.3.1 with the only change being that they now only apply to intermediate and special reinforced shear walls under in-plane loading. The second method is Section 9.3.5.6.2 *Alternate Approaches to Wall Ductility*. These requirements were moved from Section 9.3.6.6 and sometimes were referred to as boundary element provisions. The requirements remained unchanged except for the following.

- A_g was changed to A_n in Section 9.3.5.6.2.1(1). The calculation of stresses in Section 9.3.5.6.2.4 was changed to be based on net area instead of gross area. Both changes have no effect on fully grouted shear walls, but the net area is more appropriate for partially grouted shear walls.

- The deflection used to calculate the required length of special boundary elements in Section 9.3.6.6.3 was changed to be based on the displacement associated with the Risk Targeted Maximum Considered Earthquake (MCER).

TMS 402 CHAPTERS 10, 11, 12, 14, AND 15

Requirements for the design of prestressed masonry beams were added to Chapter 10, *Prestressed Masonry*. The Masonry Designer's Guide provides an overview of the prestressed masonry beam requirements and an example. No significant changes were made to Chapter 11 *Strength Design of Autoclaved Aerated Concrete (AAC) Masonry*, Chapter 12 *Design of Masonry Infills* (formerly Appendix B), and Chapter 15 *Masonry Partition Walls*. Chapter 14 *Glass Unit Masonry* was slightly reorganized for ease of use. The panel size limitations were put in a table and the limitations on thin unit panels were added to Figure 14.2.

TMS 402 CHAPTER 13 VENEER

The Veneer Chapter was completely rewritten for the 2022 edition. Some of the major changes include:

- Simplification of prescriptive requirements for anchored veneer, particularly for high wind and high seismic exposure.
- Simple method to check the out-of-plane stability of the backing.
- An engineered method with veneer tie forces based on a factor times the tributary area, with the factor being a function of tie stiffness (stiffer veneer ties result in higher tie forces).
- "Deemed to comply" stiffness and strength values for common veneer ties, with basic requirements for a test method for other veneer ties.
- Expanded adhered veneer requirements, both prescriptive and engineered.
- Tables for fasteners for adhered veneer assemblies based on assembly weight and cavity width.

Since the requirements have completely changed there is no correspondence to previous provisions. The reader is referred to the Masonry Designers' Guide for information and examples on the new provisions.

TMS 402 APPENDIX C LIMIT DESIGN METHOD

The deformation demand on plastic hinges was based on imposing the design displacement, δ_u, at the roof level of the yield mechanism in 2016. The deflection was changed to δ_{MCE}, the displacement due to the Maximum Considered Earthquake, in the 2022. The purpose was to align the deformation capacity checks with the intent of ASCE/SEI 7 to have a low probability of collapse in the MCE_R event. This change did, however, over double the displacement and hinge rotation demand.

TMS 402 APPENDIX D GLASS FIBER REINFORCED POLYMER (GFRP) REINFORCED MASONRY

Appendix D was added on *Glass Fiber Reinforced Polymer (GFRP) Reinforced Masonry*. The scope of the Appendix is new construction and GFRP bars embedded in grout in clay and concrete masonry. The Appendix does not cover external GFRP reinforcement used in seismic retrofit. The scope of the Appendix is also limited to non-participating elements (isolated walls and lintels within those walls, and retaining walls) in Seismic Design Category C and below. The Masonry Designers Guide provides an overview of the requirements, suggested design methods, and several examples.

Due to the addition of Appendix D, TMS 602 Article 1.7 F was added on delivery, storage, and handling of GFRP bars. Article 2.4 C. was added which requires GFRP bars to be solid bars conforming to ASTM D7957/D7957M. Article 2.7 B. was added with hook requirements for GFRP reinforcement. Article 3.4 B.10 was added on field cutting of GFRP reinforcement.

TMS 602 ARTICLE 1 GENERAL

Periodic inspection requirements were added in Table 4 *Minimum Special Inspection Requirements* for both anchored and adhered veneer more than 60 ft above the grade plane for Quality Assurance Level I and II. Note that for TMS 402 Part 4 *Prescriptive Design Methods*, Quality Assurance Level III is never specified.

TMS 602 ARTICLE 2 PRODUCTS

ASTM C1714 *Standard Specification for Preblended Dry Mortar Mix for Unit Masonry* was added to Article 2.1 A. Although preblended mortar could be used prior to 2022 since ASTM C1714 requires the mortar to conform to ASTM C270, the explicit addition of ASTM C1714 removes any possible confusion.

Article 2.1 B. was added which requires adhered veneer setting bed mortar to be ANSI A118.4 or A118.15 modified mortar.

Article 2.4 C. was split into three different articles: Article 2.4 D. *Joint Reinforcement*, 2.4 F. *Deformed Reinforcing Wire*, and 2.4 G. *Welded Deformed Wire Reinforcement*.

Typical stainless steel used for joint reinforcement does not meet the yield and ultimate strength requirements of ASTM A951 *Standard Specification for Steel Wire for Masonry Joint Reinforcement*. Therefore Article 2.4 D. was modified to require stainless steel joint reinforcement to be fabricated with AISI Type 304 or Type 316 having a minimum yield strength of 45 ksi and a minimum ultimate tensile strength of 90 ksi.

A new Article 2.4 E *Veneer Wire Reinforcement* was added. TMS 402-16 required anchored veneer not laid in running bond to have "joint reinforcement of at least one wire." Joint reinforcement by definition has at least two wires. Although there did not seem to be a misunderstanding, the new term veneer wire reinforcement was created. Veneer wire reinforcement can either be a single knurled in conformance with ASTM A951, deformed wire, or joint reinforcement.

ASTM F1554 bent-bar and headed anchor bolts were added to Article 2.4 J. *Anchor Bolts*.

Several Articles were added with most related to adhered veneer: Article 2.4 H *Mechanical Splices*; 2.4.O *Lath*; 2.5 F. *Veneer Tie Fasteners*; 2.5 G. *Cementitious Backer Units*; 2.5 H. *Lath Fasteners*; 2.5 I. *Weep Screed.*

TMS 402 Table 6.1.8 was moved to TMS 602 Table 6: *Standard Hooks Geometry and Minimum Inside Bend Diameters for Steel Reinforcing Bars and Deformed Wire*. The table was expanded to include deformed wire.

TMS 602 ARTICLE 3 EXECUTION

Article 3.3 D. *Adhered Veneer* was completely rewritten to match the changes in TMS 402 Chapter 13.

Article 3.4 D. *Veneer Ties* (formerly 3.4 E. *Veneer Anchors*) was completely rewritten to match the changes in TMS 402 Chapter 13. The Article includes a placement tolerance of ±1.0 inch.

Article 3.4 F. *Adhered Veneer Fasteners* was added which specified a placement tolerance of veneer fasteners of ±0.25 inch.

Figure SC-20 *Grout Pour Height and Grout Lift Height* was added to the TMS 602 Commentary. Although none of the requirements have changed the Figure provides an excellent summary of the grout pour and lift requirements, which can be confusing.

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