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A PREVIEW OF EXPECTED CHANGES TO TMS 402/602, WITH A LOOK AT THE 6-YEAR REVISIONS CYCLE

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ABSTRACT
Currently, revisions to the 2016 edition of Building Code Requirements and Specification for Masonry Structures (identified as TMS 402 and TMS 602 respectfully) [1] are being considered for the planned 2022 edition. This paper reviews the major expected revisions to these Standards which will include a complete revision to the veneer provisions, the addition of tension-controlled and compression-controlled sections for strength design, the likely elimination of the empirical design method, the movement of the infill provisions from an appendix to a Chapter and more. Reasons for these and other changes are given, as well as possible needs for future enhancements of the provisions.

In addition, for this Code revision cycle, a 6-year period was intentionally, and perhaps singularly, used over a more typical 3-year revision cycle. Reasons for this longer period are reviewed, but more importantly the authors' and committee's observations on the longer revision period are given related to effectiveness. Recommendations for future revision cycles with advantages and disadvantages are then provided so that future leaders can consider the benefits and drawbacks of longer revision cycles.

KEYWORDS: *code, standard, specification, structures, veneer, design*

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INTRODUCTION

The Masonry Society's (TMS) Committee TMS 402/602 is currently working to revise and update its Standards TMS 402 *Building Code Requirements for Masonry Structures* and TMS 602 *Specification for Masonry Structures* and companion commentaries, which were last published in 2016 [1] (Figure 1). While the revised Standards will not be completed, approved, and published until late 2022, much is known about changes that can be expected and why such changes were made. This paper reviews those expected changes, although the reader should be cautioned that additional changes may be made.

This paper also reflects on the effectiveness of the 6-year revision cycle for these Standards as compared to the more typical 3-year revision cycle. Recommendations for future revision cycles are presented.

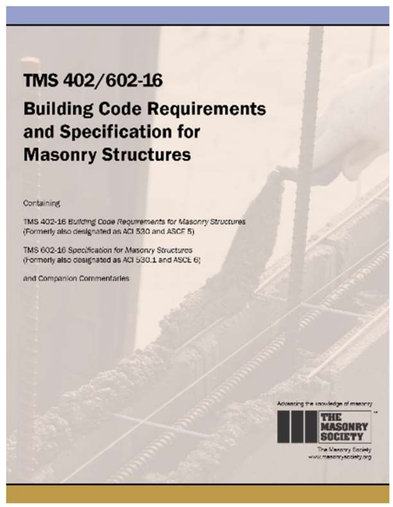

Figure 1: The Cover of the 2016 Edition of TMS 402/602 and their Commentaries

Disclaimer and Cautions with Possible Incompleteness of this Paper

This paper was requested and is offered to help users of TMS 402/602 prepare for changes expected with the 2022 editions of the Standards in keeping with similar papers presented in the past [2]. However, the reader is cautioned that the Standards are not complete at the time of the writing of this paper, nor will it be complete when presented. Major changes were approved in July 2020, and this paper reflects those changes. Based on TMS rules, the Committee approved changes were reviewed by TMS's Technical Activities Committee (TAC) who provided comments back to the Committee for consideration. The Committee is considering those comments at the time of the writing of this paper, and additional changes are being made as a result of those comments.

Additionally, in accordance with TMS and ANSI rules, the public can review the changes and offer comments. That will be done during the summer of 2021 and again, revisions could be made as a result of Public Comments.

As such, the reader should keep in mind that this paper reflects the changes known at the time of the writing, and does not reflect all changes to the Standards. Once the standard is complete, TMS will develop a more comprehensive listing of changes for the user.

Reflections on the effectiveness of the 6-year revision cycle and the financial impact to TMS are based on the status at the time the paper was written, and obviously cannot reflect possible changes in the future, which could impact long term sales of the 2016 TMS 402/602. More accurate reflections should be expected, perhaps in 2023 for the North American Masonry Conference.

Finally, primary units used in this paper are inch-pound consistent with the standard. SI equivalents or conversions are shown for information.

TECHNICAL CHANGES

During the 2022 cycle, the Committee began work with 36 carry-over TAC and 42 carry-over Public Comments requiring consideration and response. Many of these comments, as well suggestions from both Committee Members and Non-members were carefully vetted by the Committee and/or its Subcommittees. As a result, numerous technical, editorial, and formatting changes were made to the Standards. Some of the most significant are discussed below.

Revision of the veneer provisions

During the 2016 revision cycle, the Committee approved changes to increase the cavity width for prescriptively designed anchored veneer [2]. This change was appealed as the standard was being finalized, but the appeal was not supported. The committee determined that there was no reduction in safety based on the wider cavity width, primarily due to increased connector requirements. However, the Technical Activities Committee of TMS did charge the 2022 committee with conducting a comprehensive review of the prescriptive veneer requirements to ensure the provisions are rational and reasonable based on increasing loading requirements in codes and standards.

During the 2022 cycle, the Committee considered and balloted numerous changes to the Veneer Chapter, and ultimately revised the entire chapter to be more rational and understandable. This includes:

- 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.

Additional information on the changes is in Bennett et al (2019) [3] for anchored veneer and Thompson et al (2019) [4] for adhered veneer.

Addition of tension-controlled and compression-controlled sections for strength design

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 cases of moment and axial load), and rather stringent limits on the maximum reinforcement. There were several issues with this approach, including that it was possible to have values on the interaction diagram above the balance point, even with the maximum reinforcement provisions. On the other hand, the maximum reinforcement provisions could be quite stringent in other cases, with No. 5 (M #16) at 8 in. (203 mm) in an 8 in. (203 mm) 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 will be determined from Table 1. The value of ε_{ty} is determined as f_y/E_s, with f_y being the yield strength of the reinforcement and E_s being the modulus of elasticity of steel. An average value of the maximum useable compressive strain of concrete masonry (0.0025) and clay masonry (0.0035) of 0.003 is used. This approach is similar to that used in ACI 318.

Table 1: Strength reduction factor ϕ for moment, axial load, or combined moment and axial load

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

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. No change was made in the maximum reinforcement requirements for intermediate and special reinforced shear walls, as the maximum reinforcement provisions are needed to ensure there is adequate ductility in the walls. Maximum reinforcement provisions were kept for beams to insure a ductile failure mode.

Figure 2 shows the interaction diagram for a 12 ft high (3.66 m) 8 in. (203 mm) concrete masonry wall with Grade 60 No. 5 (M #16) @ 8 in. (203 mm) under out-of-plane loads. As mentioned previously, with TMS 402-16, the maximum reinforcement requirements can only be met if there is tension in the wall. Although there is a small region of combinations of flexure and axial load that were allowed with TMS 402-16 that will not be allowed with TMS 402-22, the compression-controlled provision in TMS 402-22 allow significantly higher axial loads.

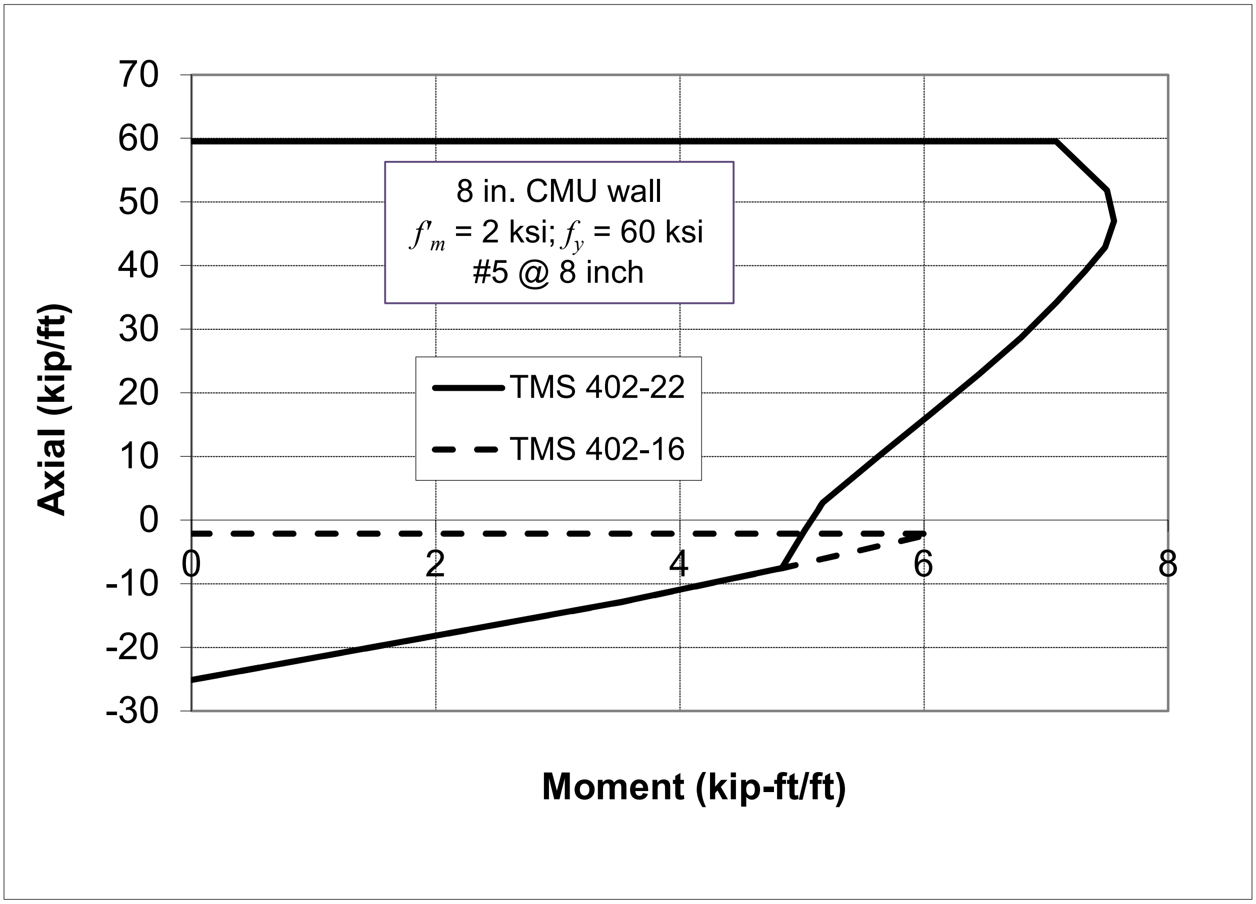

Figure 2: Comparison of TMS 402-16 and TMS 402-22 (1 kip = 4.448 kN, 1 ft = 305 mm, 1 in. =25.4 mm , 1 ksi = 0.0069 MPa)

Addition of Appendix on Glass Finer Reinforced Polymer (GFRP) Reinforced Masonry

At the request of several past comments and suggestions, a new Appendix D on Glass Fiber Reinforced Polymer (GFRP) Reinforced Masonry has been added to TMS 402. Although the use of GFRP reinforcement in masonry is not widespread at present, there is potential use in medical imaging facilities (where the nonconductivity is important) and along the ocean coast line (where the corrosion resistance is important). The appendix is limited to flexural members (non-bearing walls, lintels, and retaining walls), but it is anticipated that other members (bearing walls and shear walls) will be added with continued research. The flexural strength provisions were verified with tests [6] and [7] and tests specimens experienced significant deflections prior to ultimate failure.

Figure 3: Concrete Masonry Test Panel with 4 – No. 4 GFRP Bars [6]

Summary of other significant changes

Some of the other significant changes are listed below. This list is not comprehensive, and additional changes are expected as a result of the TAC and Public comments.

- Harmonization and simplification of reinforcement requirements, which had been different for allowable stress design and strength design. The proposed provisions are as follows.
  - Maximum bar size is #11 (M#36)
  - Nominal bar diameter cannot exceed one-eighth of least nominal dimension
  - Bar diameter cannot exceed one-third the least dimension of the gross grout space
  - Maximum reinforcement percentage is 4% of the gross grout space, with 8% allowed at laps. Tables are provided for common masonry units to show the maximum reinforcement.
- Clarification of the net shear area, A_{nv}, which is used to determine the shear strength of masonry members. This includes now allowing partial grouting for masonry beams that do not require shear reinforcement.
- Anchor bolt tension and shear strength provisions are changed to be based on the ultimate strength of the anchor, and not the yield strength. This provides consistency with anchor strength between TMS 402, ACI 318, and AISC 360.
- Provisions were added for the use of deformed wire reinforcement. The smaller size of deformed wire reinforcement can be advantageous in some situations, such as when shear reinforcement is required in masonry beams.
- Provisions were added for prestressed masonry beams. Previously, prestressed masonry provisions had been limited to just walls.
- Appendix A on empirical design was deleted.
- Appendix B on infills was moved to the main code as Chapter 12.

ORGANIZATION, FORMAT, AND EDITORIAL CHANGES

Due to the movement of the Infill provisions from Appendix B to Chapter 12, subsequent Chapters have been renumbered, so that veneer provisions, formerly in TMS 402-16 Chapter 12, were moved into Chapter 13, glass unit masonry provisions are now in Chapter 14, and Partition Walls are in Chapter 15. The appendices could have then been updated as a result of the deletion of the Empirical Design Provisions (formerly Appendix A) and the movement of the Infill provisions (formerly Appendix B) to Chapter 12. However, to reduce confusion that could arise by moving the Limit Design provisions from Appendix C, Appendix A and B will be left intentionally blank in TMS 402-22. As with TMS 402-16, additional provisions have been "tabulated" for clarity and ease of use by designers.

REFLECTIONS ON CODE CYCLE LENGTH

Bennett and Pierson (2019) [5] reviewed reasons why The Masonry Society's Board of Directors permitted a 6-year revision cycle between TMS 402/602-16 and the intended TMS 402/602-22 which included:

- A desire to provide a more reasonable revision period for the Committee Members
- A request to slow the revision cycle, so that the engineers and building officials would not be required to purchase and re-learn the provisions so frequently.

Implementing the 6-year revision cycle certainly provided the time necessary to accomplish the above. It has also allowed the Committee to undertake dozens of Committee and subcommittee ballots with more time to carefully consider issues, revise proposals, and reach consensus. As the "external" review period by TMS's Technical Activities Committee (TAC) and the Public takes several months, and consideration of TAC and Public Comments can take additional months, doing this only once every 6 years, versus every 3 years, provided the Committee additional time to consider substantive changes before those review periods were initiated. For example, major changes that had been considered for several cycles, such as the rewrite of the veneer chapter and the introduction of tension and compression-controlled sections, were accomplished, partly due to the longer revision cycle

Users of TMS 402/602-16 have expressed great support of the 6-year revision cycle. They note their appreciation of not having to learn a new standard as frequently. Other benefits for the users include: not having to train employees to the new standard, and reducing their cost outlay for both the standards themselves and for training on the standards.

Of most concern with a 6-year cycle was the possibility that acceptance of a new product would be delayed, due to the longer revision cycle. To date, no specific concerns in this area have been expressed. Even with the shorter 3-year code cycle, there are provisions for code-acceptance of new products between code adoption cycles. In the United States in particular, International Code Council Evaluation Service (ICC-ES) reports provide a way for products to be "allowed" for use. These are independent of the length of the TMS 402/602 code cycle length.

For TMS, there has been a concern about revenue loss after year 3 of the cycle. This could arise due to the lack of a new standard, along with other publications, educational sessions and ancillary products that are provided by TMS. To date, that has not materialized (Figure 4). However, since TMS is now the sole sponsor of the Standard, TMS is realizing more revenue per sale, which may be offsetting lower sales volume. Likewise, new delivery methods (e-versions of the Standards, bundled content with other publications, etc.) have also helped boost overall sales.

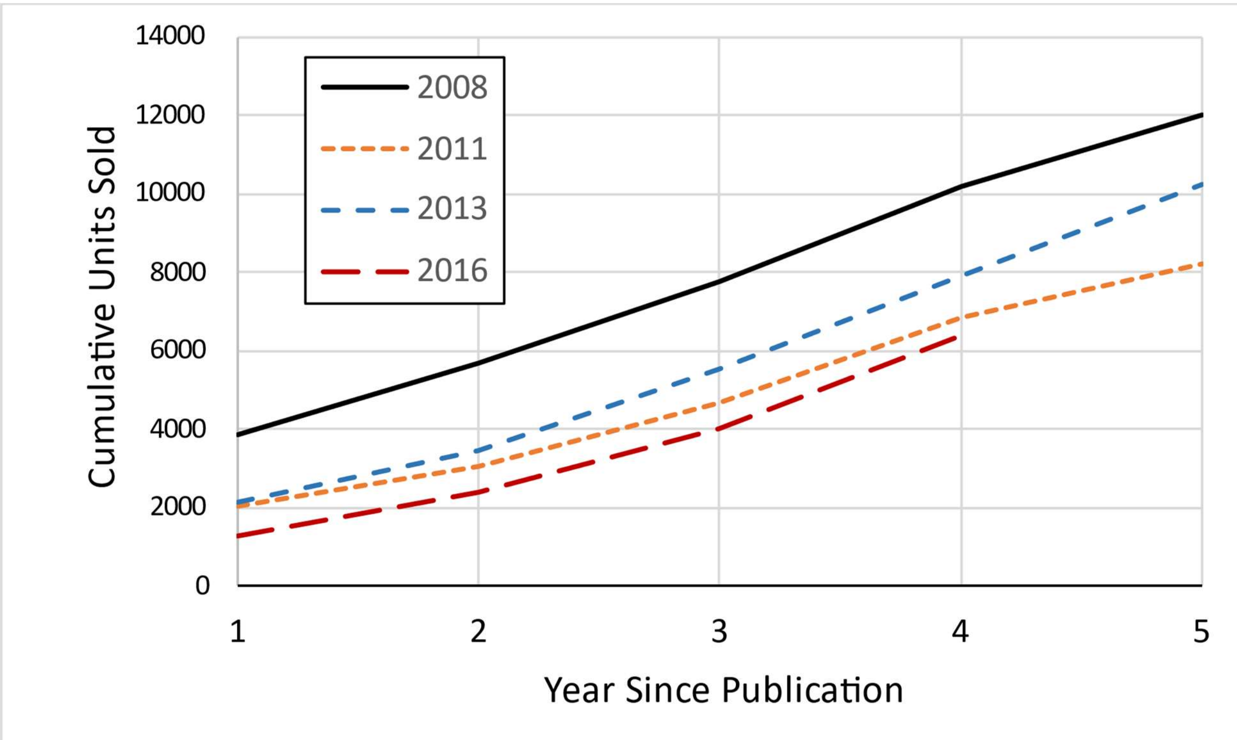

Figure 4: Cumulative Number of TMS 402/602 Units Sold for Year After Publication

The longer revision cycle also allowed TMS to redirect volunteer and staff resources to development of new products and services, which would have been difficult to do in a busier, 3-year revision cycle. These include "Assessment and Retrofit of Masonry Structures" by Hamid and Schuller, "Strength Design of Masonry" by Bennett and Hochwalt, and a number of new virtual education offerings such as Night School and several webinars.

Considering the reduction of stress on volunteers and staff, the support of users of the Standards, the lack of negative fears related to delays in new product standardizations, and the continued maintenance of income from the Standards, the longer revision cycle has been effective, at least in this case. The concerns related to delays in new product standardization and reduced income later in the revision cycle remain, and will need to be evaluated at a later date if a 6-year revision cycle is again considered after the 2022 revision cycle.

SUMMARY

Numerous technical changes and format/editorial changes are proposed for the 2022 edition of TMS 402/602 document. These changes should enhance the ease of use of the document. More importantly, when the design and construction provisions for masonry are clear and concise, masonry construction will remain competitive in the construction marketplace. As noted, additional changes could result from consideration of TAC and Public Comments.

The 6-year revision cycle provided the Committee additional needed time to carefully consider numerous carryover TAC and Public Comments as well as providing the opportunity introduce a number of new ideas and suggestions to improve the Standards. In addition, it provided TMS with time to focus on other projects and activities that it may not have been able to consider if a shorter 3-year revision cycle was used. In general, the authors believe the 6-year revision cycle was effective and should be considered for future revision cycles to provide more time to vet proposals, reduce burden on volunteers, and to allow TMS to undertake new and exciting projects.

ACKNOWLEDGEMENTS

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