Welcome!

Code Updates for Masonry: *What Code Officials Should Know*

Speaker: Daniel Furr, PE

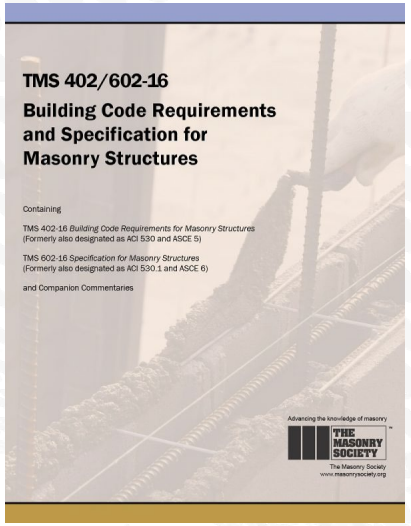
Daniel Furr

- Mt. Pleasant High School – 2013
- NC State University – 2017 (BS)
- NC State University – 2020 (MCE)
- Licensed Professional Engineer in NC & SC

- SkillsUSA National Masonry Champion – 2014
- MCAA Apprentice Champion – 2015
- WorldSkills Competitor in Sao Paulo, Brazil – 2015

The Documents

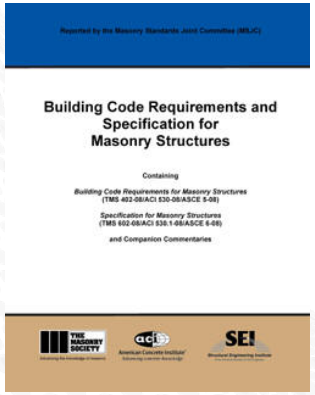
- International Codes (IBC, IECC, etc .)
- TMS 402/602
- Referenced standards (ASTM, TMS, etc.)



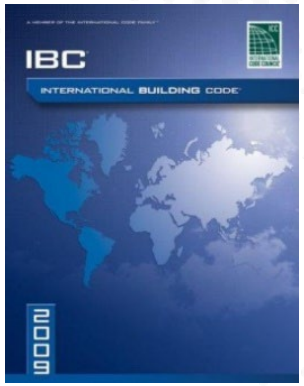
ASTM INTERNATIONAL
Standards Worldwide

Transitioning

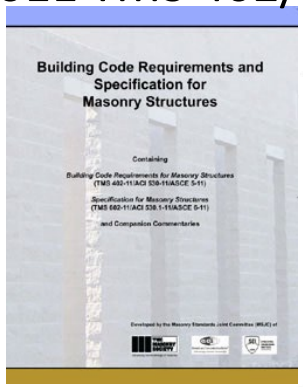
2008 TMS 402/602



2009 IBC

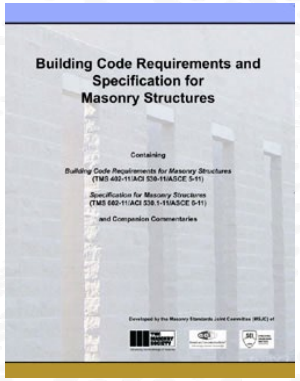


2011 TMS 402/602

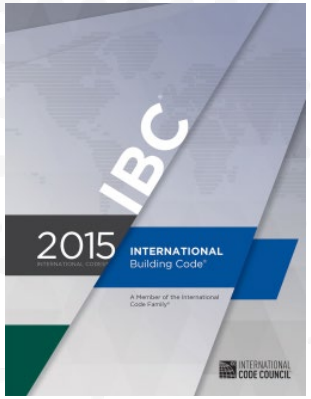


2012 IBC

2013 TMS 402/602



2015 IBC



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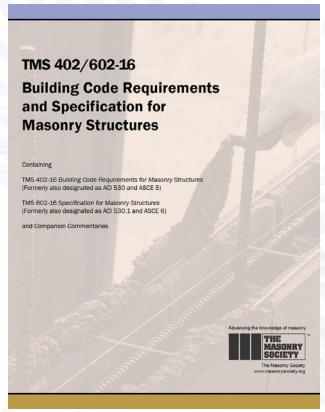
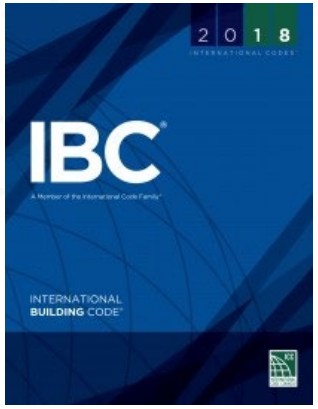
2016 TMS 402/602



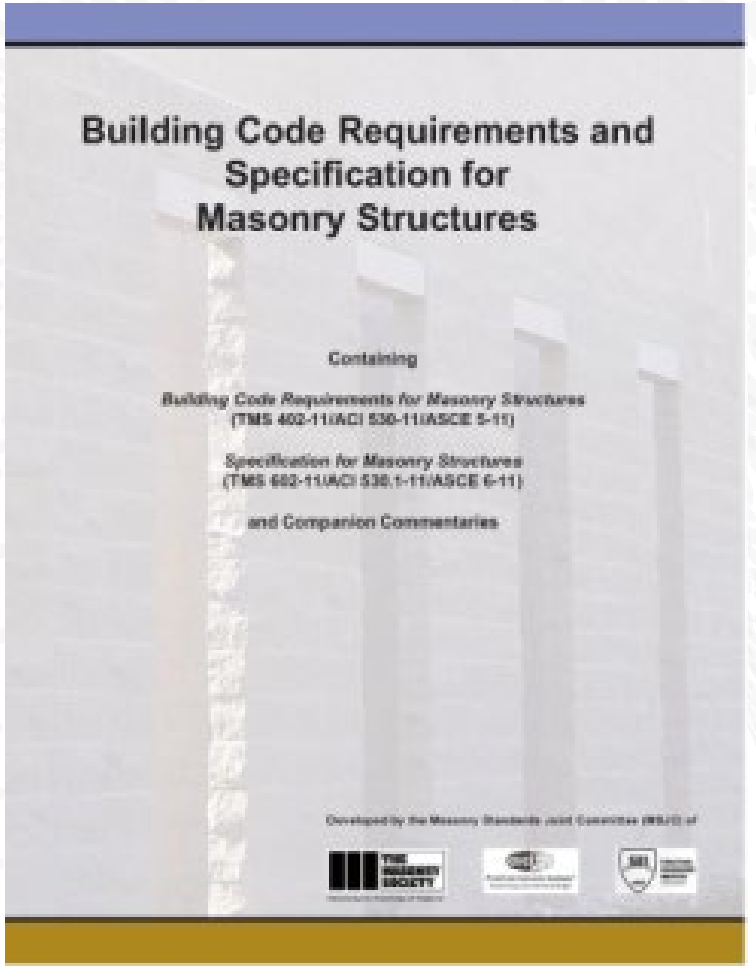


NCBIA WINTER CONFERENCE

TMS 402/602 – Before 2016

- Joint Committee with:
- The Masonry Society (TMS)
- American Concrete Institute (ACI)
- Structural Engineering Institute of the American Society of Civil Engineers (ASCE-SEI)

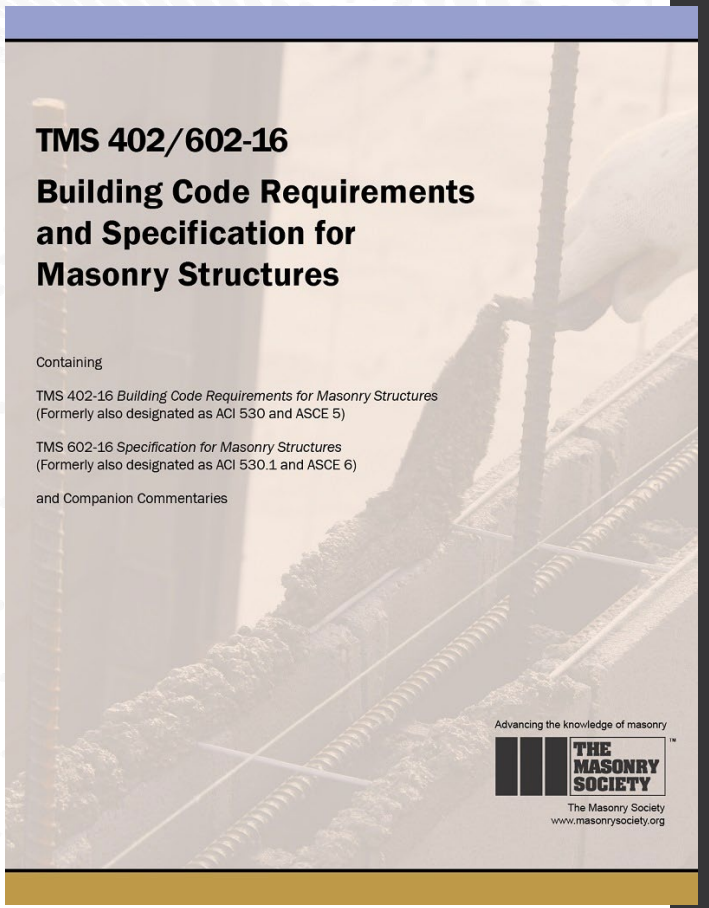
- MSJC – Masonry Standards Joint Committee



The TMS 402/602 Committee

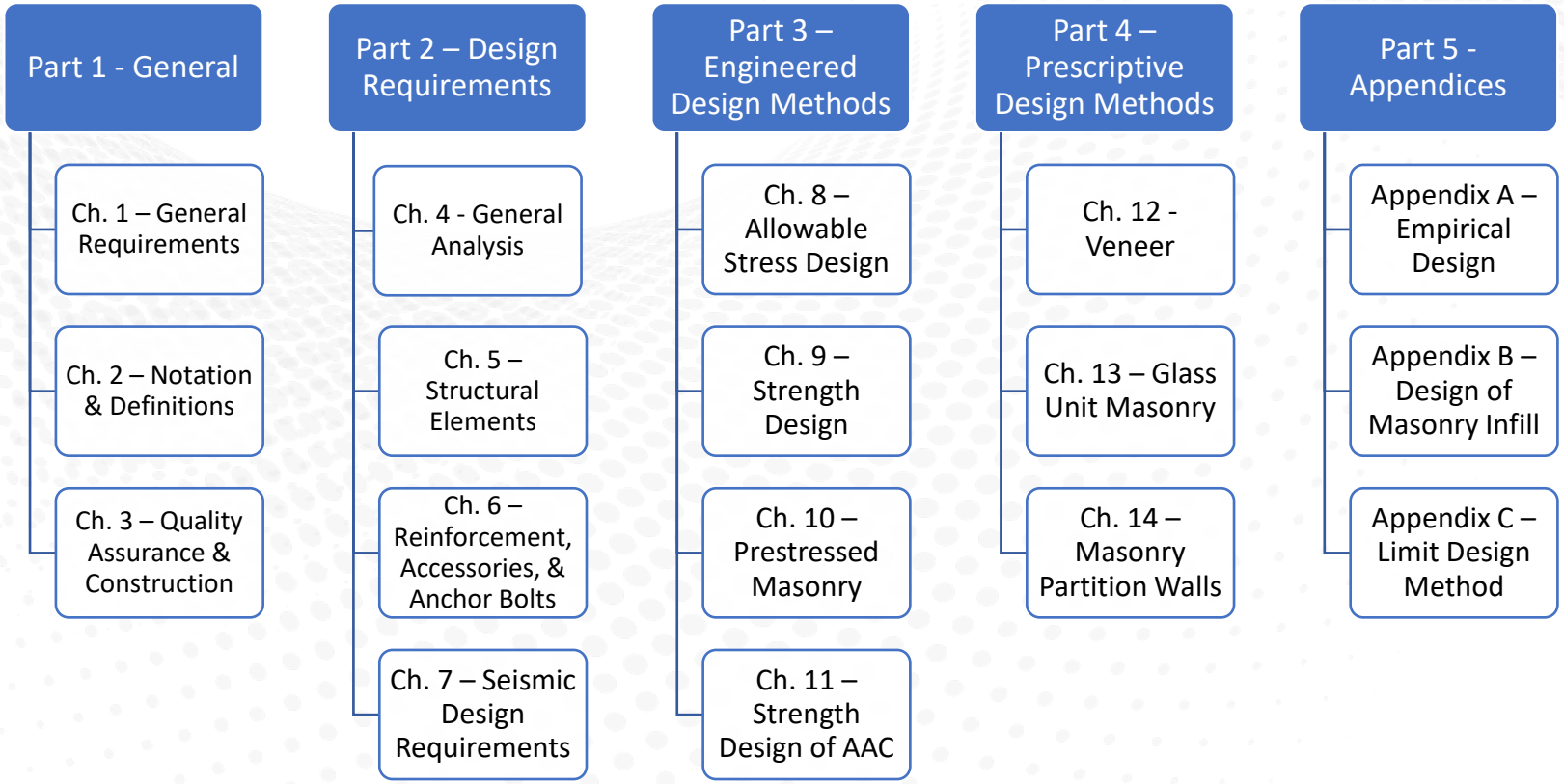
- **Beginning with the 2016 edition, TMS is the sole sponsor:**
- TMS 402/~~ACI 530/ASCE 5~~
  - Building Code Requirements for Masonry Structures
- TMS 602/~~ACI 530.1/ASCE 6~~
  - Specification for Masonry Structures
- Commentary for each
  - Non-mandatory

Make sure your SPECS are up to date!



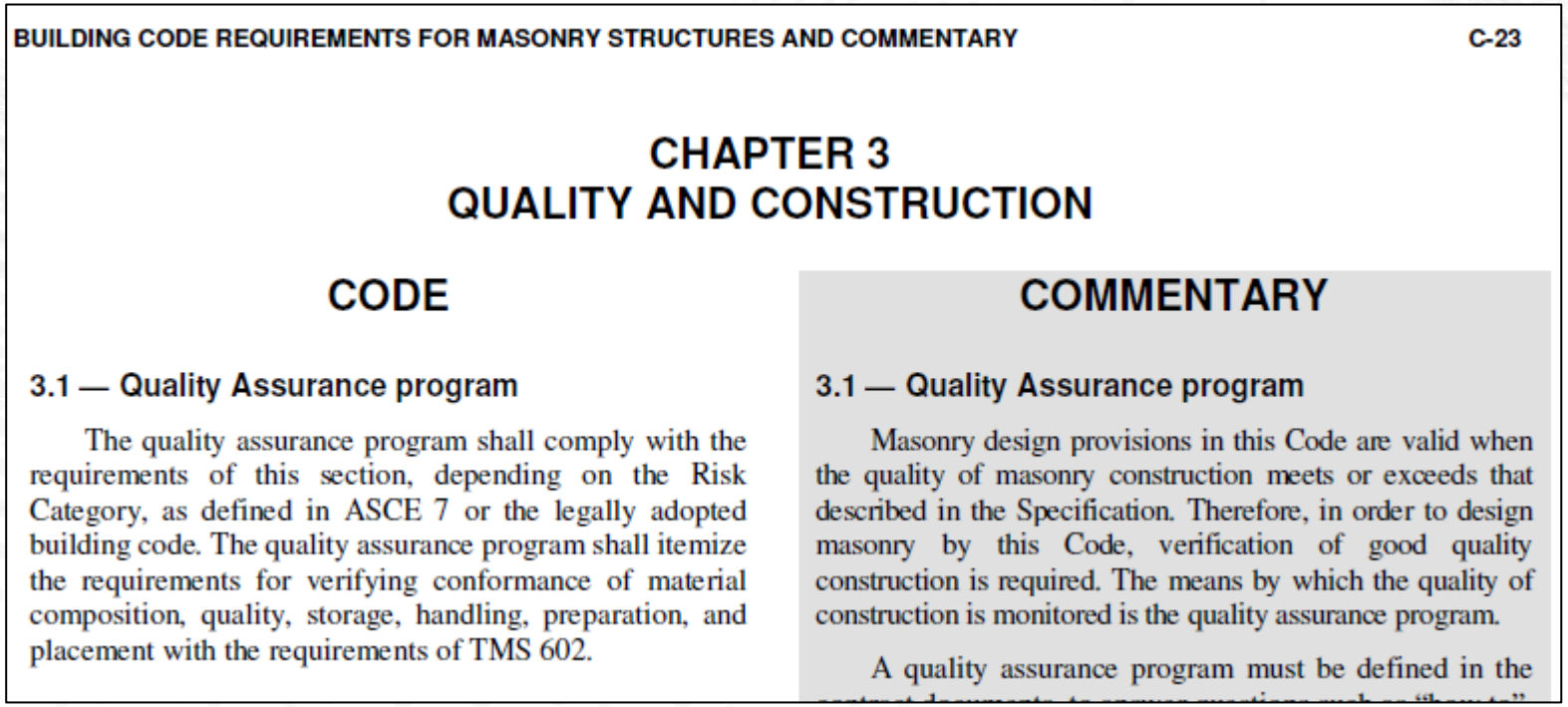
Reorganization

- The 2016 TMS 402 was completed reorganized
- Easier to find provisions



Commentary

- Commentary to code has been completely re-written to better explain provisions
  - And has been re-formatted to ‘side-by-side’ format



BUILDING CODE REQUIREMENTS FOR MASONRY STRUCTURES AND COMMENTARY C-23

CHAPTER 3
QUALITY AND CONSTRUCTION

CODE	COMMENTARY
3.1 — Quality Assurance program	**3.1 — Quality Assurance program**
The quality assurance program shall comply with the requirements of this section, depending on the Risk Category, as defined in ASCE 7 or the legally adopted building code. The quality assurance program shall itemize the requirements for verifying conformance of material composition, quality, storage, handling, preparation, and placement with the requirements of TMS 602.	Masonry design provisions in this Code are valid when the quality of masonry construction meets or exceeds that described in the Specification. Therefore, in order to design masonry by this Code, verification of good quality construction is required. The means by which the quality of construction is monitored is the quality assurance program. A quality assurance program must be defined in the

Empirical Design

- Moved to an Appendix
  - Signaling eventual removal
  - Reference TMS 402 Appendix A

Removed in **2022 version** of TMS 402/602

Table A.5.1 — Wall lateral support requirements

Construction	Maximum *l/t* or *h/t*
Load-bearing walls	
Solid units or fully grouted	20
Other than solid units or fully grouted	18
Non-load-bearing walls	
Exterior	18

In calculating the ratio for multiwythe walls, use the following thickness:

1. The nominal wall thicknesses for solid walls and for hollow walls bonded with masonry headers (Section A.7.2).
2. The sum of the nominal thicknesses of the wythes for non-composite walls connected with wall ties (Section A.7.3).

Easier Use

- Some provisions modified to place requirements within easy-to-use tables, rather than confusing text

2013 and earlier

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.

2016

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

Significant Updates

Lap Splices

- Prior to 2016 – lap splices could be very long for large bar diameters and could lead to cracking
- 2016 Provisions – added optional confinement factor

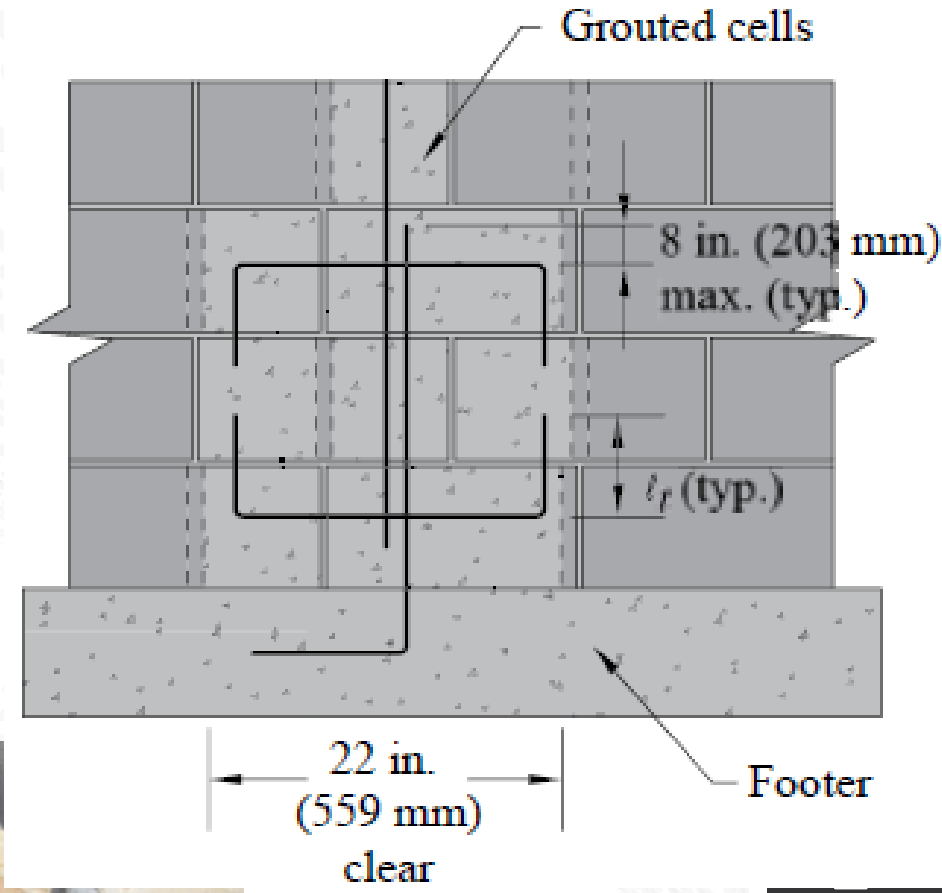
$$l_d = \left(\frac{0.13 d_b^{\,2} f_y \gamma}{K \sqrt{f'_m}} \right) \xi$$

$$\xi = 1.0 - \frac{2.3 A_{sc}}{d_b^{2.5}}$$

Lap Splice Confinement

Confinement bar limits:

- Transverse Offset ≤ 1.5 in.
- Longitudinal Offset ≤ 8 in.
- Lap Splice ≥ 36d_b



Impact

Typical 8 inch Concrete Masonry Unit Lap Lengths		
Bar Size	TMS 402 Lap Length, No Confinement (in.)	TMS 402 Lap Length, With No. 5 Confinement (in.)
No. 3	12.0	13.5
No. 4	14.1	18.0
No. 5	22.5	22.5
No. 6	42.8	27.0
No. 7	59.4	31.5
No. 8	91.2	36.0
No. 9	118.3*	55.5*

Veneer Anchoring

- The maximum vertical spacing of masonry veneer ties has been increased from 18 in. to 25 in.

- The number of ties per square foot of wall is unchanged. The larger vertical spacing permits larger units to be used.

Veneer Cavity Width

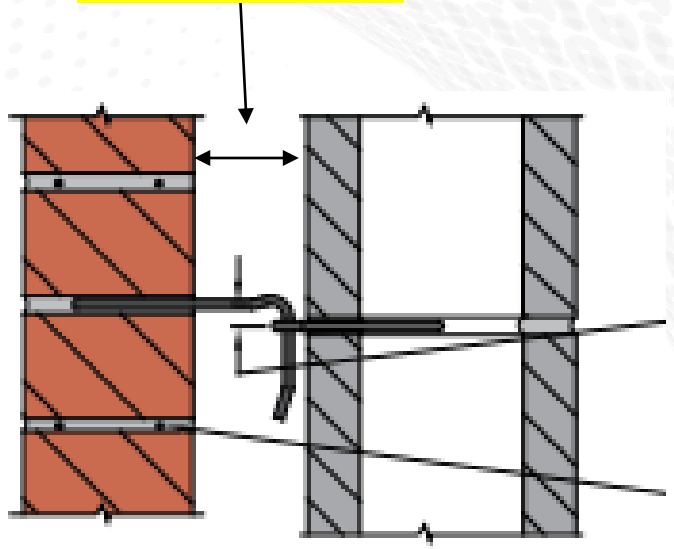
- Previous code versions had a maximum cavity width of 4.625 inches
- Some limitations on type of anchor and backing
- With 2016 TMS 402, maximum cavity width of 6.625 inches
- Must use adjustable anchors (or joint reinforcement with masonry backup to increase cavity width

2008 TMS 402

- **4.625** inches

2016 TMS 402

- **6.625** inches



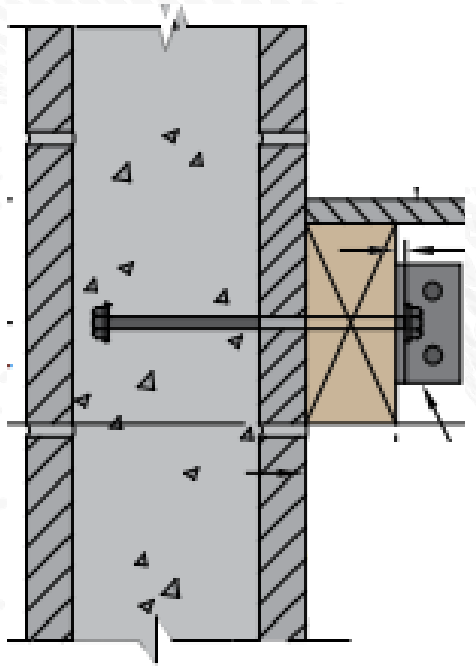
Vertical Section

Masonry Infill

- New masonry infill design provisions have been added (Appendix B)

Other TMS 402/602 Changes

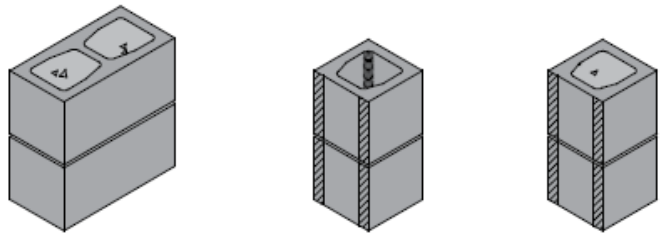
- Most deal with special cases:
  - **Anchor bolt design** – changes to increase nominal shear masonry crushing strength and interaction between tensile and shear strength.
    - Net results – much more efficient use of anchor bolts in masonry
  - **Concentrated loads** – changes to distribution of concentrated loads around openings.
    - Net result – reduce potential for un-conservative designs

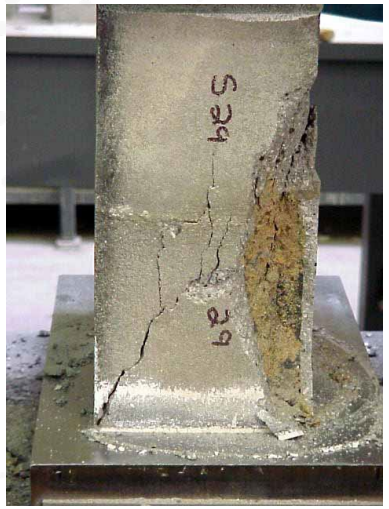


Verification of specified compressive strength of masonry, f'_m

- TMS 602 Article 1.4 defines the minimum compressive strength requirements for concrete masonry construction (f'_m). There are two ways to verify the assembly compressive strength:
- prism testing; or
- unit strength method

Prism testing is NOT required unless specified by the designer





Verification of *f'm* (prior to 2013)

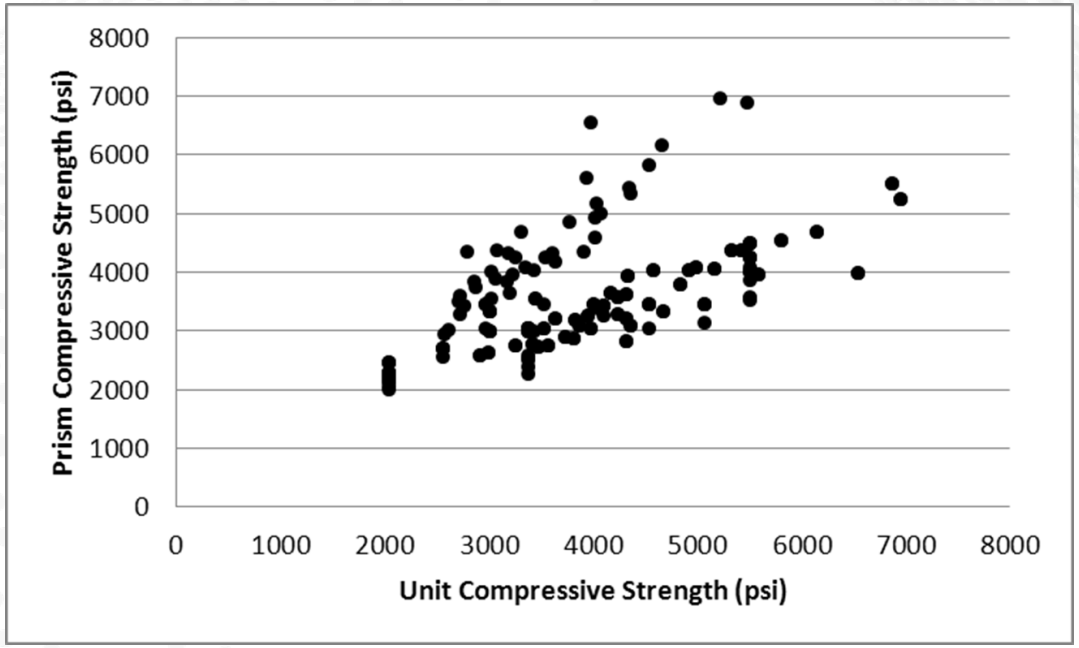
Table 2 — Compressive strength of masonry based on the compressive strength of concrete masonry units and type of mortar used in construction

Net area compressive strength of concrete masonry units, psi (MPa)		Net area compressive strength of masonry, psi[1] (MPa)
Type M or S mortar	Type N mortar	
—	1,900 (13.10)	1,350 (9.31)
1,900 (13.10)	2,150 (14.82)	1,500 (10.34)
2,800 (19.31)	3,050 (21.03)	2,000 (13.79)
3,750 (25.86)	4,050 (27.92)	2,500 (17.24)
4,800 (33.10)	5,250 (36.20)	3,000 (20.69)

[1] For units of less than 4 in. (102 mm) height, 85 percent of the values listed.

Unit Strength Method

- In 2010, a new research project was initiated to recalibrate the unit strength method.
- Tested CMU prisms – varying strengths of units, mortar, mortar composition, grouted or not



2016 - Verification of *f'm*

- ASTM C90 unit strength minimum = 2000 psi
- Results in f'_m assembly strength minimum = 2000 psi for Type S or M mortar

Net area compressive strength of concrete masonry, psi (MPa)[1]	Net area compressive strength of ASTM C90 concrete masonry units, psi (MPa)	
	Type M or S mortar	Type N mortar
1,750 (12.07)	---	2,000 (13.79)
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)	-----

Structural Impacts

- Stronger Assemblies…

18 ft wall, 8 in. CMU
40 psf wind pressure
3,000 lb/ft axial

Table 2 – Design Impact of TMS 402/602 Revisions		
Code Edition[1]	Reinforcement Size	Reinforcement Spacing
2009 IBC[2]	No. 5	40 inches
2012 IBC[2]	No. 5	48 inches
2018 IBC[3]	No. 5	96 inches[4]

[1]The 2009, 2012, and 2015 editions of the IBC adopt the 2008, 2011, and 2013 editions of TMS 402/602, respectively. 2018 and 2021 editions of the IBC adopt the 2016 TMS 402/602

[2]f'_m = 1,500 psi

[3]f'_m = 2,000 psi

[4]Incorporating 9 gage bed joint reinforcement at 16 inches.

Quality Assurance Tables

- Appear only in TMS 602 *Specification*
- Only 2 tables:
  - Table 2: Minimum Verification Requirements
  - Table 3: Minimum Special Inspection Requirements
- Quality Assurance Levels 1, 2 and 3 (correspond to previous Levels A, B, and C)

Minimum Verification	Required for Quality Assurance[a]			Reference for Criteria
	Level 1	Level 2	Level 3	TMS 602
Prior to construction, verification of compliance of submittals.	R	R	R	Art. 1.5
Prior to construction, verification of f'_m and f'_{AAC}, except where specifically exempted by the Code.	NR	R	R	Art. 1.4 B
During construction, verification of Slump flow and Visual Stability Index (VSI) when self-consolidating grout is delivered to the project site.	NR	R	R	Art. 1.5 & 1.6.3

CMU Configuration – ASTM C90

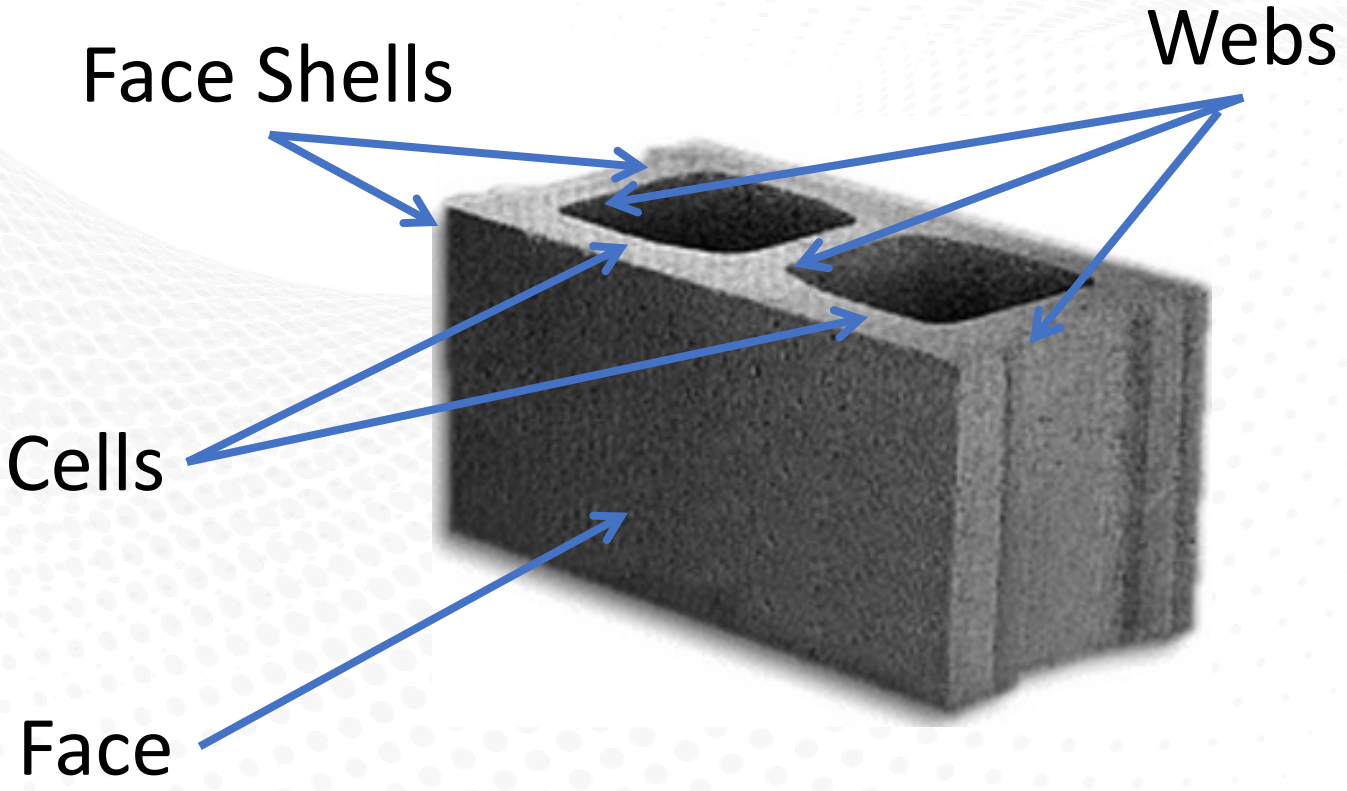
- Covers hollow and solid concrete masonry units intended for loadbearing and non-loadbearing applications
- Can be normal weight, medium weight, or lightweight

Designation: C90 – 11b

- Significant revisions (starting around 2011) that allow the webs of units to be thinner or reconfigured (within limits) to meet evolving marketplace requirements.

CMU Terminology

- Parts of a Concrete Masonry Unit

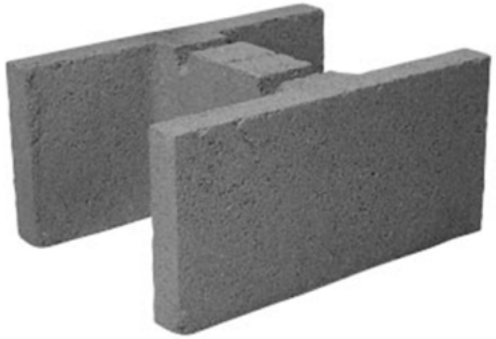


ASTM C90 Changes

- ASTM C90 now permits different unit configurations using alternative web configurations – based on web area, not only thickness.

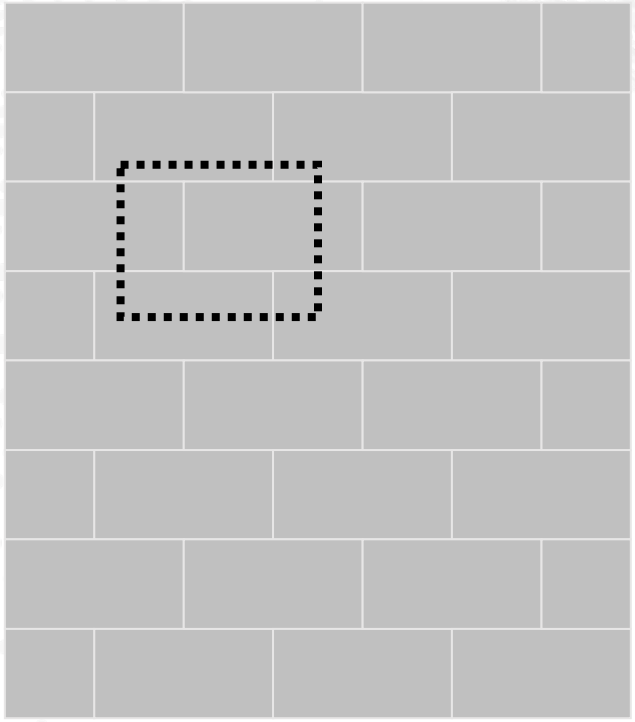
Nominal Width (W) of Units, in. (mm)	Webs	
	Web Thickness[C] (t_w), min, in. (mm)	Normalized Web Area (A_{nw}), min, $in.^2/ft^2$ (mm^2/m^2)[D]
3 (76.2) and 4 (102)	¾ (19)	6.5 (45,140)
6 (152)	¾ (19)	6.5 (45,140)
8 (203) and greater	¾ (19)	6.5 (45,140)

ASTM C90 Units – Evolved to Meet Market Demands



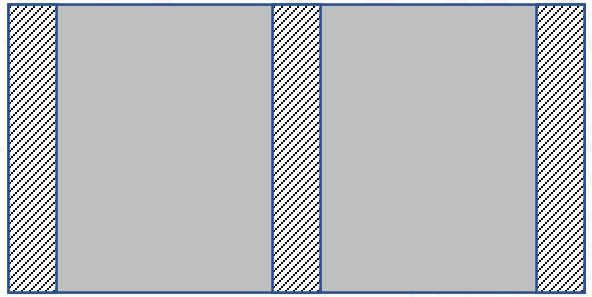
ASTM C90 Changes

- Literally, this new requirement means that for every square foot of wall surface, no less than 6.5 in.^2 of web must connect the front and back face shells, with no web measuring less than 0.75 in in thickness.



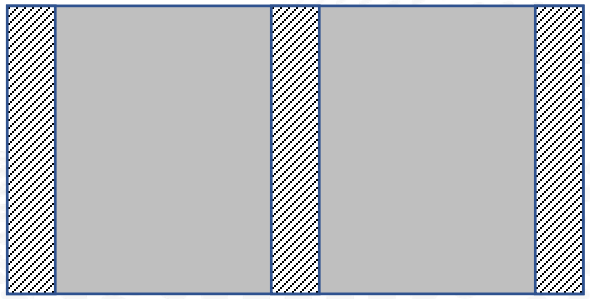
ASTM C90 Web Revisions

This unit is OK…



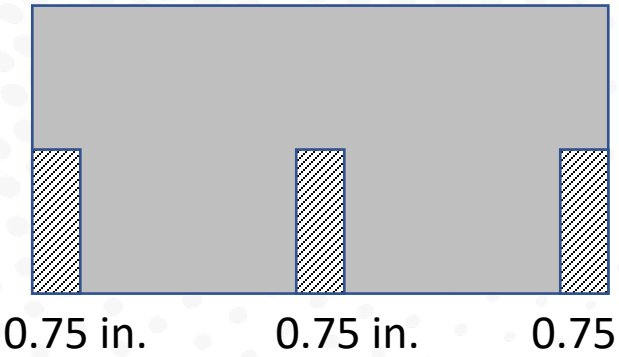
A_{nw} = 25.7 in^2/ft^2

As well as this…..



A_{nw} = 19.3 in^2/ft^2

And this…..

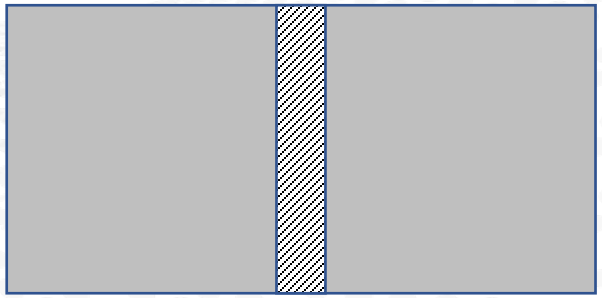


A_{nw} = 9.7 in^2/ft^2

ASTM C90 Web Revisions

- 6.5 $in.^2/ft^2$ = 5.78 $in.^2$ of web for an 8 x 16 in. unit with at least one web 0.75 in. in thickness.

And this…..



A_{nw} = 6.5 in^2/ft^2

Compliance with New Requirements

- If a unit met previous C90 requirements – it will meet the new web area requirements
- Compressive strength unaffected by web changes
- Potential for more energy efficient designs (30% improvement or more) especially with foam in place insulation

Resources

- SCMA – www.scmaonline.org
- NCMA – www.ncma.org (click on Menu, TEK Solutions Center)
- The Masonry Society – www.masonrysociety.org
- Brick Industry Association – www.gobrick.com
- International Masonry Institute – www.imiweb.org
- Mason Contractors Association of America – www.masoncontractors.org

Questions?
Thanks to
NCMCA
SCMA
Southeast Concrete Masonry Association