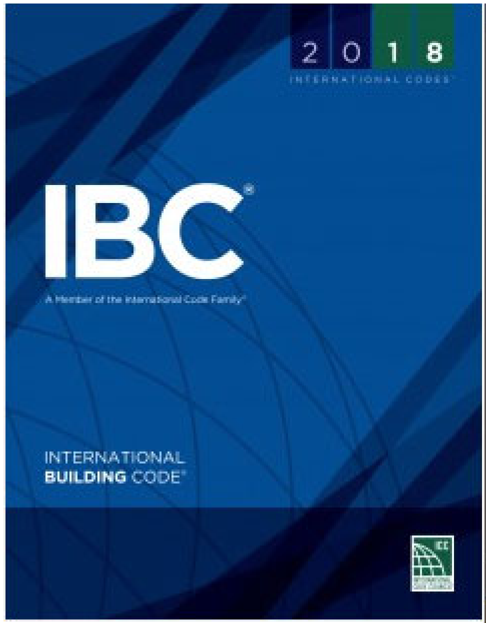

2018 IBC: Updates to Masonry Codes & Standards

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On behalf of the
New Jersey & Delaware Valley Structural Masonry Coalition

NJ Structural Masonry Coalition 2018

MASONRY CONTRACTORS OF NEW JERSEY
NEW JERSEY CHAPTER I.C.E.

New Jersey Bricklayers and Allied Craftworkers Labor Management Fund

team
UNION MASONRY CRAFTWORKERS CONTRACTORS & CONSULTANTS

International Union of Bricklayers and Allied Craftworkers

WALKOWICZ Consulting Engineers

Delaware Valley Structural Masonry Coalition 2018

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Learning Objectives

- ✓ Describe the development process of the TMS 402 Building Code Requirements & TMS 602 Specification for Masonry Structures.
- ✓ Understand the relationship between the IBC and the TMS 402/602.
- ✓ Review and understand select changes incorporated into the 2011, 2013 and 2016 TMS 402/602 and discuss the likely impact from these changes to masonry design & construction.
- ✓ Understand how to implement the new provisions for masonry design.

MSJC & TMS 402/602
DEVELOPMENT PROCESS

ICC, IBC, IRC

ICC - International Code Council (I-Codes)

- 3 year development cycle
- Multiple materials
- Structural, fire, etc.

IBC - International Building Code

- Chapter 14 Veneer
- Chapter 17 Special Inspection
- Chapter 21 Masonry

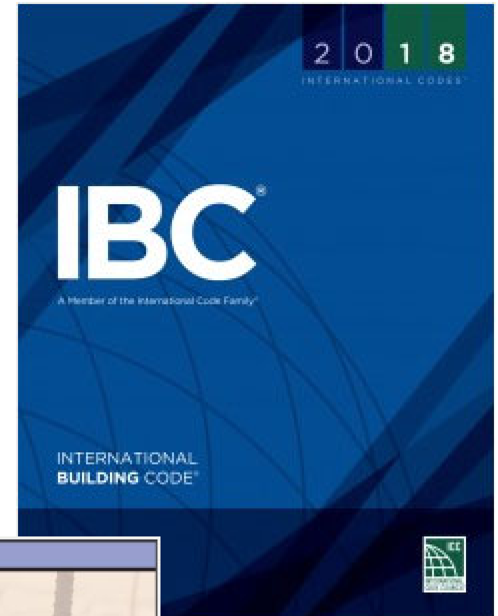
IRC – International Residential Code

- 1 and 2 family dwellings

How do they relate?

- IBC: Model code, legally adopted with or without local amendments

- MSJC & TMS 402/602: Reference documents



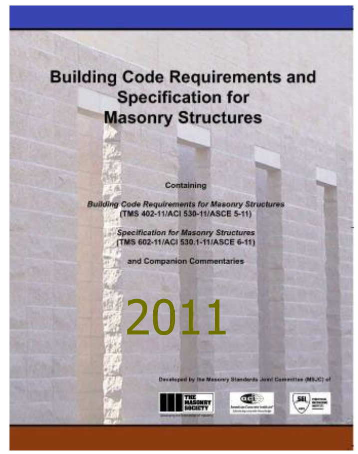
Companion Documents

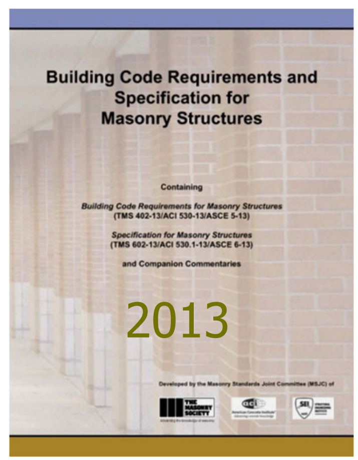
- Check the dates
- MSJC & TMS 402/602 date will be one or two years PRIOR to its companion IBC
- Also check for local amendments & adoptions

Companion Documents

- 2012 IBC references 2011 MSJC
- 2015 IBC references 2013 MSJC
- 2018 IBC references 2016 TMS 402
- **2021 IBC will reference…**

  2016 TMS 402





TMS 402/602 (MSJC) Development

- Mandatory language standards that provide minimum requirements for the design & construction of masonry
- Typically 3-year development cycle BUT currently a 6 year cycle for the TMS 402/602!
- Consensus process
  - balance, letter ballots, resolution of negatives, public comment
- Sponsoring society oversight & approval
  - ~~TMS, ACI, SEI/ASCE~~
  - TMS is sole sponsor beginning with 2016 edition! TMS 402/602
- Intended for adoption by Codes

TMS 402/602 (MSJC) Documents

Building Code Requirements for Masonry Structures

TMS 402-11 /ACI 530-11 /ASCE 5-11 (MSJC)

TMS 402-13 /ACI 530-13 /ASCE 5-13 (MSJC)

TMS 402-16 (TMS 402)

Specification for Masonry Structures

TMS 602-11 /ACI 530.1-11/ASCE 6-11 (MSJC)

TMS 602-13 /ACI 530.1-13/ASCE 6-13 (MSJC)

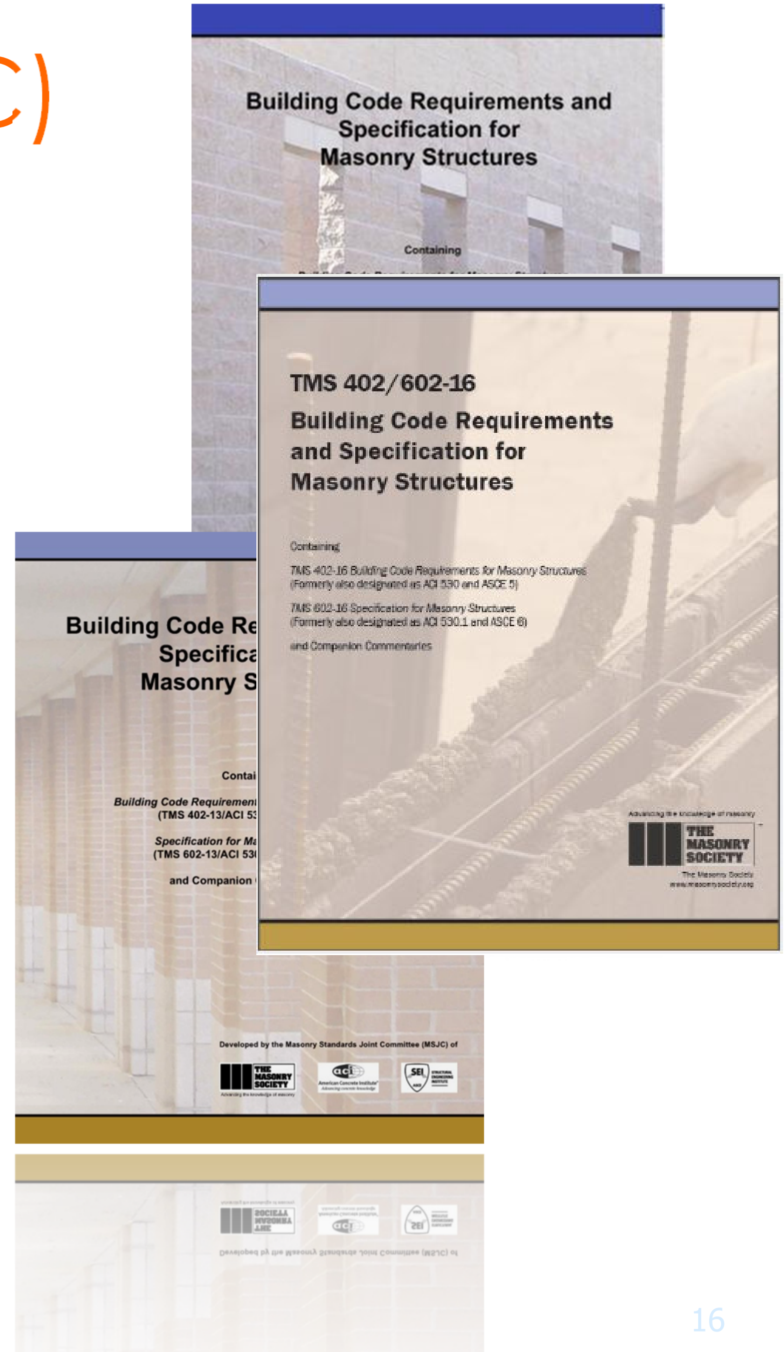
TMS 602-16 (TMS 602)

Commentary for each

Non-mandatory

TMS 402/TMS602 (MSJC)

- TMS 402 **Code** contains primarily structural design provisions but also a few Construction Requirements – Designer oriented
- Construction provisions are primarily found in the TMS 602 **Specification** – Contractor & Inspector oriented
- Companion **Commentary** to each – Non-mandatory

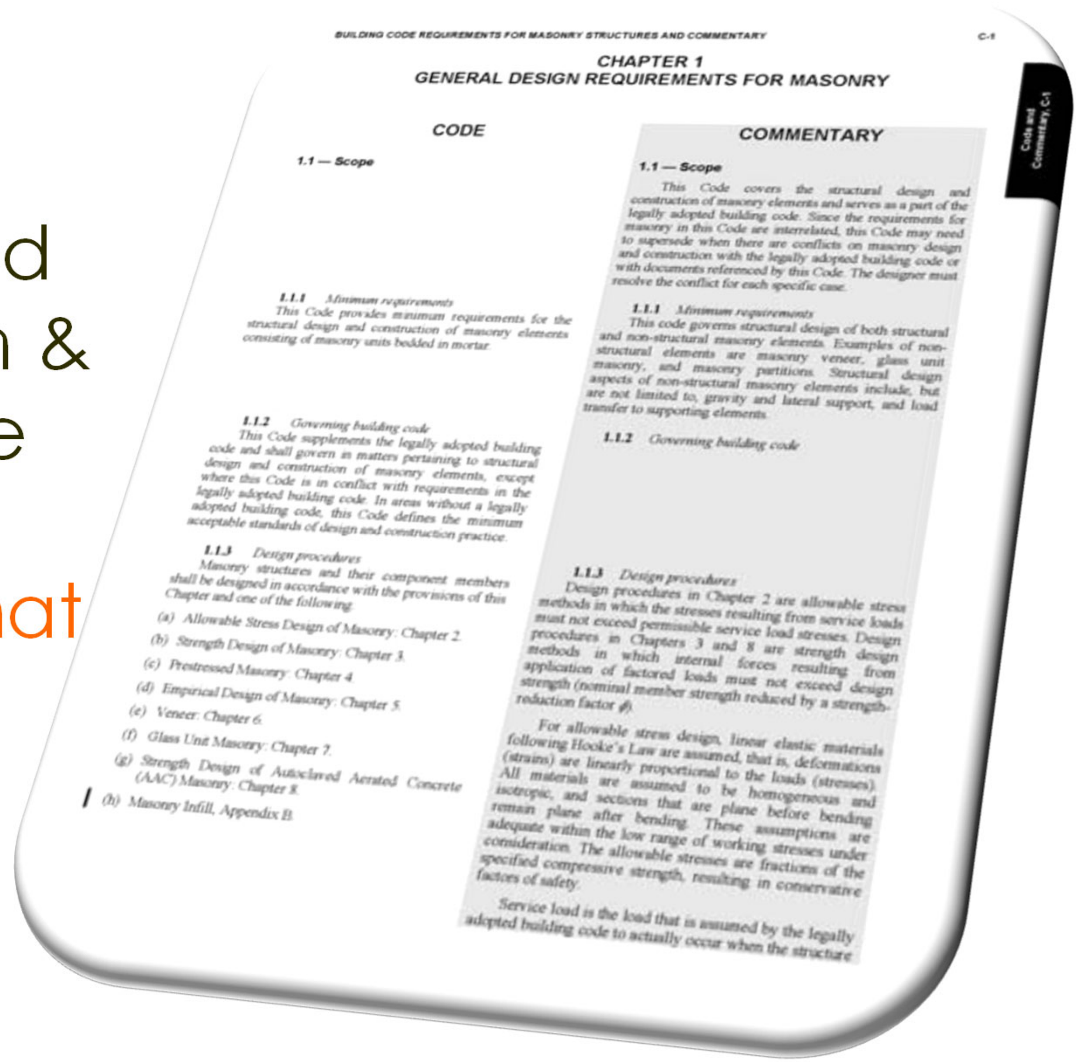


QUICK REVIEW
SELECT CHANGES – 2011 MSJC

(and some related provisions in the IBC)

2011 MSJC – Select Changes

- The Code & Commentary and the Specification & Commentary are now shown in a side by side format for easier use by users



BUILDING CODE REQUIREMENTS FOR MASONRY STRUCTURES AND COMMENTARY C-1

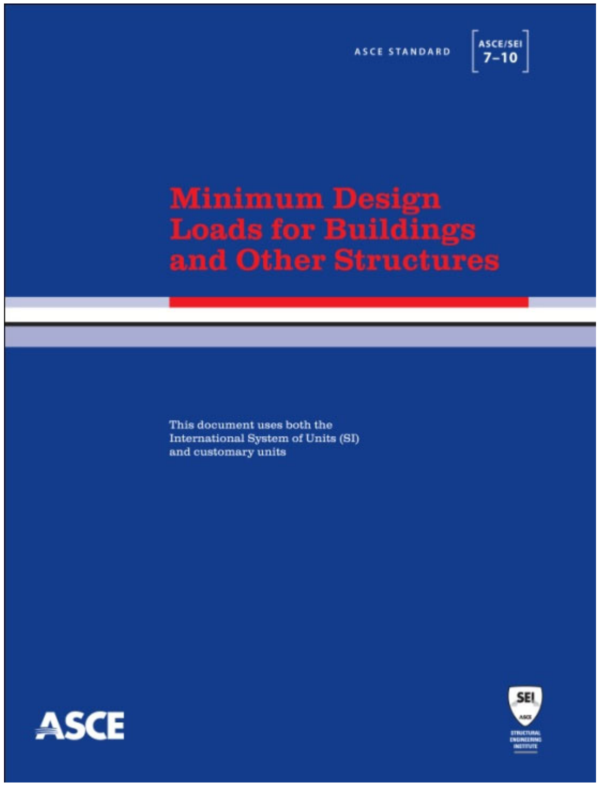
CHAPTER 1
GENERAL DESIGN REQUIREMENTS FOR MASONRY

Code and Commentary, C-1

CODE	COMMENTARY
1.1 — Scope	**1.1 — Scope** This Code covers the structural design and construction of masonry elements and serves as a part of the legally adopted building code. Since the requirements for masonry in this Code are interrelated, this Code may need to supersede when there are conflicts on masonry design and construction with the legally adopted building code or with documents referenced by this Code. The designer must resolve the conflict for each specific case.
1.1.1 *Minimum requirements* This Code provides minimum requirements for the structural design and construction of masonry elements consisting of masonry units bedded in mortar.	**1.1.1** *Minimum requirements* This code governs structural design of both structural and non-structural masonry elements. Examples of non-structural elements are masonry veneer, glass unit masonry, and masonry partitions. Structural design aspects of non-structural masonry elements include, but are not limited to, gravity and lateral support, and load transfer to supporting elements.
1.1.2 *Governing building code* This Code supplements the legally adopted building code and shall govern in matters pertaining to structural design and construction of masonry elements, except where this Code is in conflict with requirements in the legally adopted building code. In areas without a legally adopted building code, this Code defines the minimum acceptable standards of design and construction practice.	**1.1.2** *Governing building code*
1.1.3 *Design procedures* Masonry structures and their component members shall be designed in accordance with the provisions of this Chapter and one of the following: (a) Allowable Stress Design of Masonry: Chapter 2. (b) Strength Design of Masonry: Chapter 3. (c) Prestressed Masonry: Chapter 4. (d) Empirical Design of Masonry: Chapter 5. (e) Veneer: Chapter 6. (f) Glass Unit Masonry: Chapter 7. (g) Strength Design of Autoclaved Aerated Concrete (AAC) Masonry: Chapter 8. (h) Masonry Infill, Appendix B.	**1.1.3** *Design procedures* Design procedures in Chapter 2 are allowable stress methods in which the stresses resulting from service loads must not exceed permissible service load stresses. Design procedures in Chapters 3 and 8 are strength design methods in which internal forces resulting from application of factored loads must not exceed design strength (nominal member strength reduced by a strength-reduction factor ϕ). For allowable stress design, linear elastic materials following Hooke's Law are assumed, that is, deformations (strains) are linearly proportional to the loads (stresses). All materials are assumed to be homogeneous and isotropic, and sections that are plane before bending remain plane after bending. These assumptions are adequate within the low range of working stresses under consideration. The allowable stresses are fractions of the specified compressive strength, resulting in conservative factors of safety. Service load is the load that is assumed by the legally adopted building code to actually occur when the structure

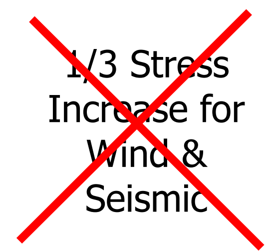
2011 MSJC – Select Changes

- Updated to ASCE 7-10
  - Required major recalibration as a result of the change by ASCE 7 to base wind loads on a "strength" level versus a service level. As a result, wind "triggers" changed for:
    - Empirical Design
    - Veneer
    - Glass Unit Masonry



2011 MSJC – Select Changes

- Recalibration of stresses
  - Removal of 1/3 stress increase option that was formerly permitted for Allowable Stress Design (ASD) when considering wind or seismic loads
  - Harmonization of ASD and SD shear provisions
  - Some Allowable Stresses increased. Reduces impact of removal of 1/3 stress increase options
  - Conflict between the MSJC ASD loading provisions permitting the 1/3 stress increase and the IBC ASCE 7 prohibition of the 1/3 stress increase has been eliminated.



Allowable Stresses - General

- Anchor Bolts: No change
  - Major Revision in 2008
  - 2008 Increased Allowables; Harmonized with Strength Design
- Bearing Stress
  - Increased from 0.25 f'_m to 0.33 f'_m
  - Nominal strength also increased from 0.60 f'_m to 0.80 f'_m
  - Changes based on comparison with other codes

Allowable Stresses – Unreinforced Masonry

- Flexural tension
  - Increased by 33% based on reliability analysis
- Unchanged
  - Axial compression
  - Combined flexural and axial compression ($0.33\ f'_m$)
  - Shear

Flexural tension usually controls with unreinforced masonry so impact of unchanged allowable stresses is minimal

Allowable Stresses – Reinforced Masonry

- Allowable stresses for axial compression not changed
- Allowable steel reinforcement stress increased to 32 ksi (Grade 60 steel)
  - Based on comparison to strength design
- Allowable masonry stress due to combined flexure and axial loads increased to $0.45f'_m$
  - Based on comparison to strength design
- Shear strength provisions now similar to strength design
  - Based on comparison to experimental data
  - Permitted to add masonry &steel shear strength

Benefits

Building perimeter: 2(350') + 2(525') = 1,750 LF of wall

2009 IBC / TMS 402: #5 Rebar at 24" o.c. =

- 875 rebar = 19,250 LF + lap splices
- 124 CY of grout

2012 IBC / TMS 402: #5 Rebar at 32" o.c. =

- 657 rebar = 14,438 LF + lap splices
  - 25% reduction / 2009 code = 33% increase!
  - 4,812 LF** less
  - 5,053 lbs.** less
- 93 CY of grout
  - 25% reduction using new codes / 33% increase if use 2009 code
  - 31 CY less = 4 to 5 trucks)

Impact of ASD Shear Design Provisions

- 2011 ASD shear provisions require approximately the same amount of reinforcement as strength design provisions
- 2011 ASD shear provisions require significantly less reinforcement than the 2008 ASD provisions for ordinary shear walls
- 2011 ASD shear provisions require approximately the same amount of reinforcement as the 2008 ASD provisions for special shear walls

2011 MSJC – Select Changes

2 Updates - Lap Splices & Development Length

$$l_d = \frac{0.13 d_b{}^2 f_y \gamma}{K\sqrt{f'_m}}$$

- The beneficial effect of larger cover for computation of development length has been changed from $5d_b$ to $9d_b$
- Option: Lap splices are permitted to be reduced where transverse reinforcement is placed within 8" of the end of the splice if it is fully developed in grouted masonry.

Lap Lengths in Modern Codes

Building Code Requirements for Masonry Structures – MSJC 2011 and 2013

- $ASD\ and\ SD\ Splice\ length\ = \frac{0.13 d_b{}^2 f_y \gamma}{K\sqrt{f'_m}} \geq 12"$
- K = lesser of masonry cover, splice clear spacing or **9**d_b
- γ = 1.0 for #3-#5, 1.3 for #6-#7 and 1.5 for #8-#9

International Building Code 2012 and 2015 (ASD)

- (For ASD) In lieu of/as an alternative to (MSJC equations), it shall be permitted to use:
- $Splice\ length\ = 0.002 d_b f_s \geq 40db$
- **Increase 50% where reinforcement stress > 80% of allowable!**
- **No alternate method for SD – use MSJC only….**

Lap Length Comparison – 8”

2013 MSJC (TMS 402) Lap Lengths							2015 IBC Lap Lengths		
Bar Size	Required Lap Length (in.)						Required Lap Length (in.)		
	8" CMU, Centered			8" CMU, 2.5" from face			32,000 psi	25,600 psi	24,000 psi
	2000 psi	2500 psi	3000 psi	2000 psi	2500 psi	3000 psi	64 db	51.2 db	48 db
3	12	12	12	12	12	12	36	20	18
4	13	12	12	20	18	16	48	26	24
5	20	18	16	32	28	26	60	32	30
6	38	34	31	60	54	49	72	39	36
7	52	46	42	85	76	69	84	45	42
8	79	71	65	131	117	107	96	52	48
9	102	92	84	171	153	140	108	58	54

Lap Length Comparison – 12"

2013 MSJC (TMS 402) Lap Lengths							2015 IBC Lap Lengths		
Bar Size	Required Lap Length (in.)						Required Lap Length (in.)		
	12" CMU, Centered			12" CMU, 2.5" from face			32,000 psi	25,600 psi	24,000 psi
	2000 psi	2500 psi	3000 psi	2000 psi	2500 psi	3000 psi	64 db	51.2 db	48 db
3	12	12	12	12	12	12	36	20	18
4	12	12	12	20	18	16	48	26	24
5	13	12	12	32	28	26	60	32	30
6	24	21	20	60	54	49	72	39	36
7	33	29	27	85	76	69	84	45	42
8	50	44	41	131	117	107	96	52	48
9	63	57	52	171	153	140	108	58	54

Lap Lengths in Future Codes

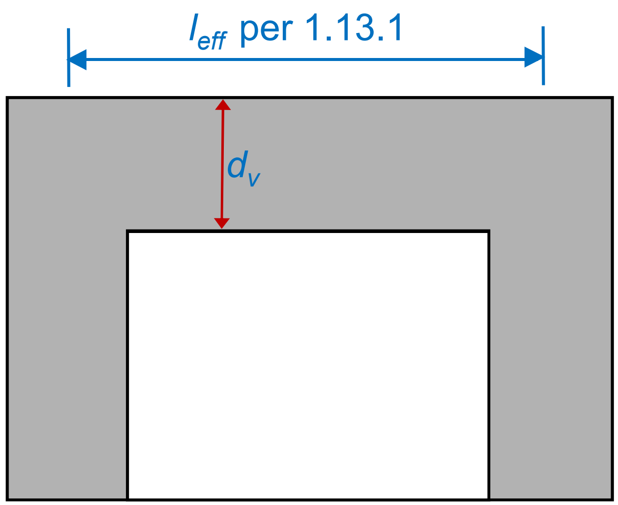
Research presented at the 12th North American Masonry Conference for flexural testing of masonry with lap lengths rather than direct pull-out as other research used.

May indicate different equations or shorter required lap lengths for some masonry application…?

Will take a while to make it to codes….

2011 MSJC – Select Changes

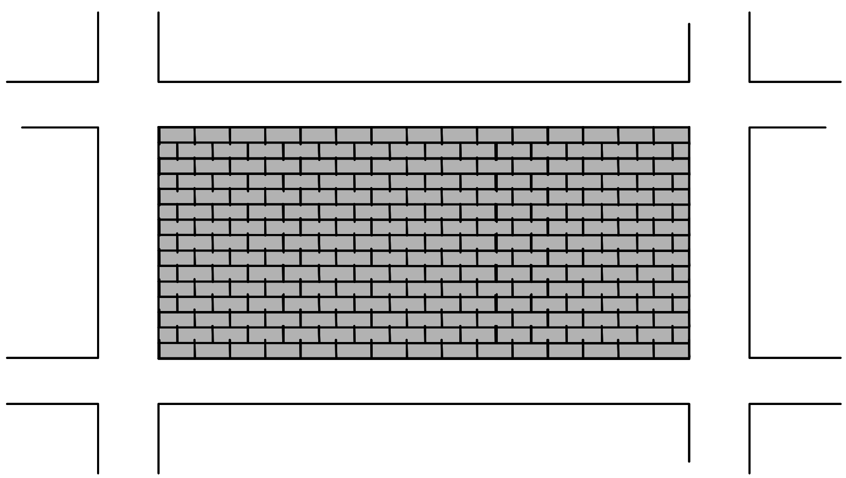
- Deep Beam Provisions added. Apply to beams where the effective span-to-depth ratio, l_{eff} / d_v is less than:
  - 3 for continuous span
  - 2 for simple span



- Requires additional analysis as well as minimum flexural and shear reinforcement (Code Section 1.13.2)

2011 MSJC – Select Changes

- New Appendix B for Masonry Infill
  - Unreinforced CMU and Clay units (AAC infill added in the 2013 MSJC)
  - Participating and non-participating infill
  - Compression strut method
  - Connectors only for out-of-plane



Masonry Infill Panels

'Semi-structural'

MUST:

- isolate from frame for gravity deflections
- Connect to the frame for out-of-plane shear

Provide proper contact to building columns

Design masonry to resist shear

Design frame for changed loads

Masonry Infill Panels

Bounding frame works with masonry panel

Steel or concrete frame

Frame movement creates diagonal corner contact and a ‘compression strut’

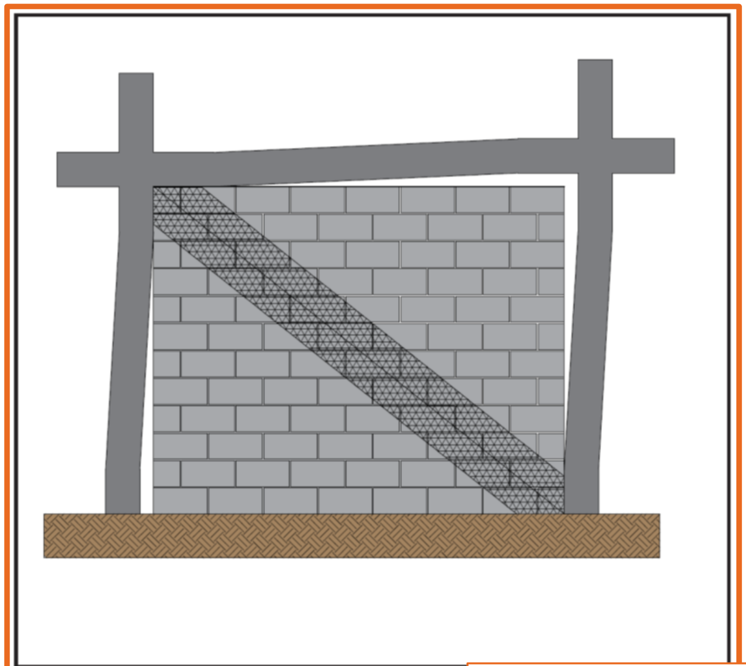


Figure 1—Concrete Maso[...] Diagonal Strut

Figure Credit: NCMA TEK 14-23r1

Masonry Infill Panels

Must connect for out of plane loads

Close contact with beam and column surfaces (flat!)

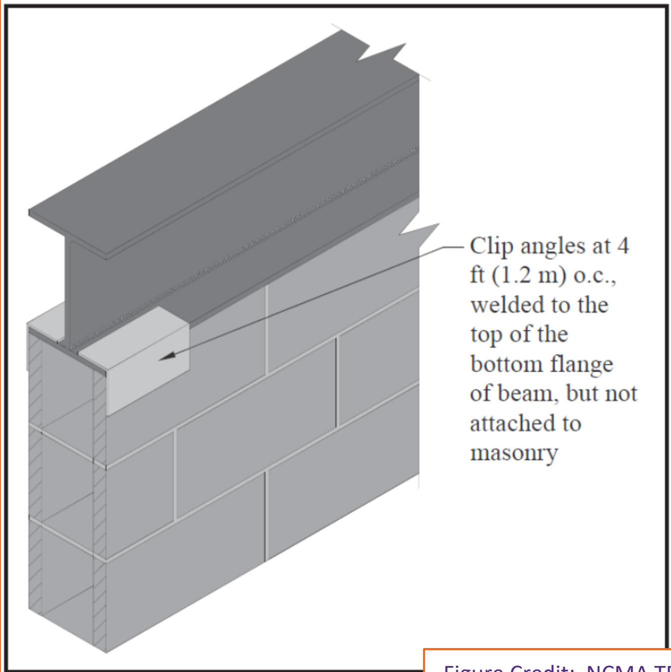
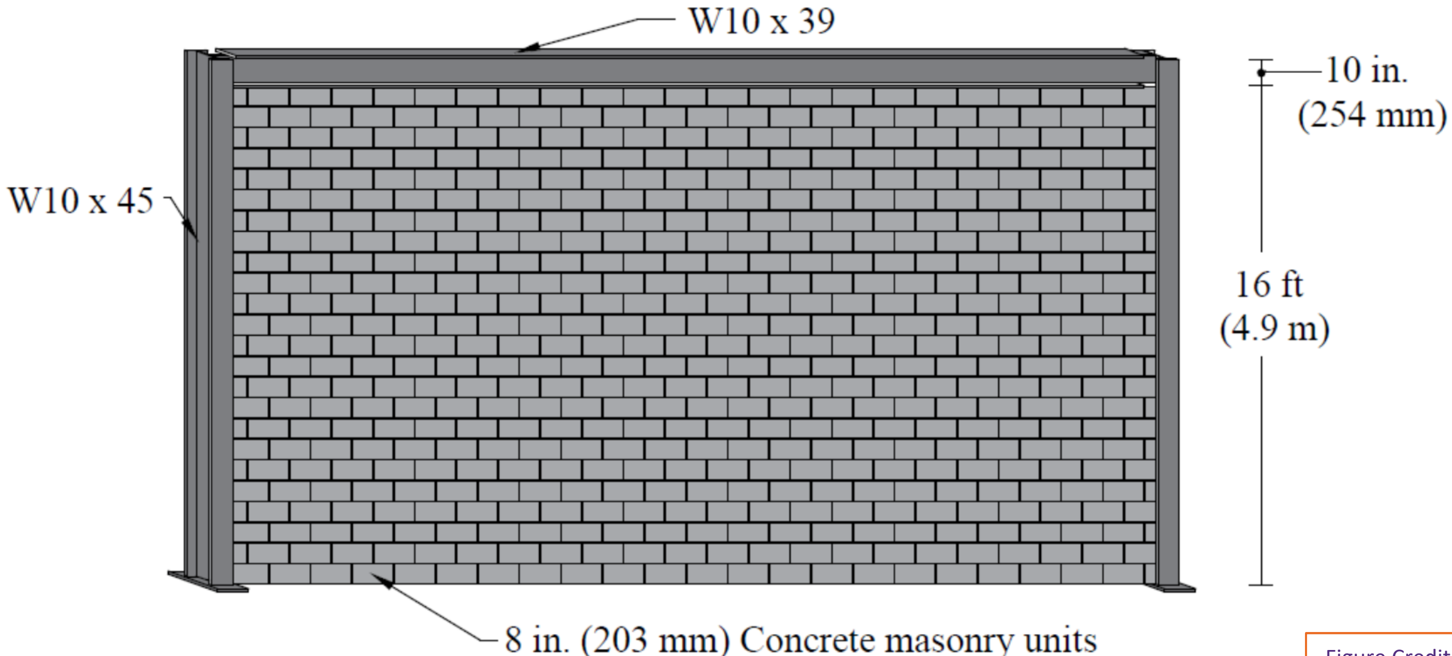


Figure Credit: NCMA TEK 14-23r1

Figure 2—Example of Mechanical Infill Connector

Masonry Infill Panels



Infilled Wall Elevation

Figure Credit: NCMA TEK 14-23r1

Masonry Infill Panels

Design Panel Length = 30’

Design Panel Height = 16’

Example Shear Load = 3,000#

Design Shear Capacity = 13,500#

Must design the frame for interactive loads/reactions

Data Credit: NCMA TEK 14-23r1

Masonry Infill Panels

Out of plane load resistance:

NOT by simple vertical or horizontal span!!!

Employs arching action and strength design approach based on research

Example Design Pressure: 24 psf

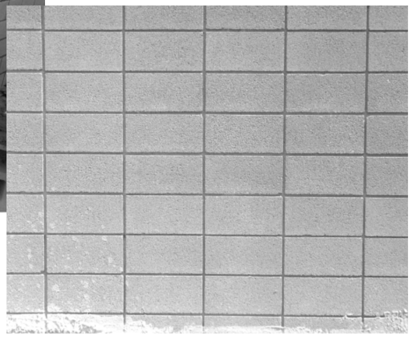
Example Design Capacity: 25 psf – OK!

Data Credit: NCMA TEK 14-23r1

New in the 2011 MSJC

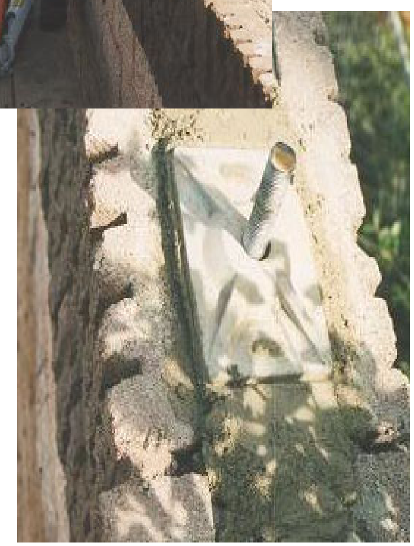
- Anchor bolt installation requirements have been revised.

- Reference only to running bond or “not in running bond” rather than reference to stack bond or other bond patterns.



New in the 2011 MSJC

- Revised equation for walls with laterally restrained or laterally unrestrained unbounded prestresssing tendons.



- Commentary guidance on seismic design coeffients for prestressed masonry shear walls. (Will be removed when included in ASCE 7)

2011 MSJC – Select Changes

- Empirical design restricted from use in structures located in Risk Category IV. (Essential Structures)
- Adhered dimension stone provisions are included.
- Single pintle ties are permitted for anchored veneer
- Clarification that drips are not permitted in wire anchors and joint reinforcement cross wires and tabs.

2011 MSJC – Select Changes

- AAC moves from an Appendix A to new Chapter 8
- Provisions for nominal sliding shear strength added at the interface of AAC and thin bed mortar.
- Quality assurance requirements for AAC masonry were expanded and clarified.

2011 MSJC – Select Changes

- MSJC QA tables
  - Direct reference in the IBC 2012
  - New column in the Tables includes reference to specific code/spec provisions

Inspection Task	Frequency [a]		Reference for Criteria	
	Continuous	Periodic	TMS 402/ ACI 530/ ASCE 5	TMS 602/ ACI 530.1/ ASCE 6
4. Verify during construction:				
a. Size and location of structural elements		X		Art. 3.3 F
b. Type, size, and location of anchors, including other details of anchorage of masonry to structural members, frames, or other construction		X	Sec. 1.16.4.3, 1.17.1	

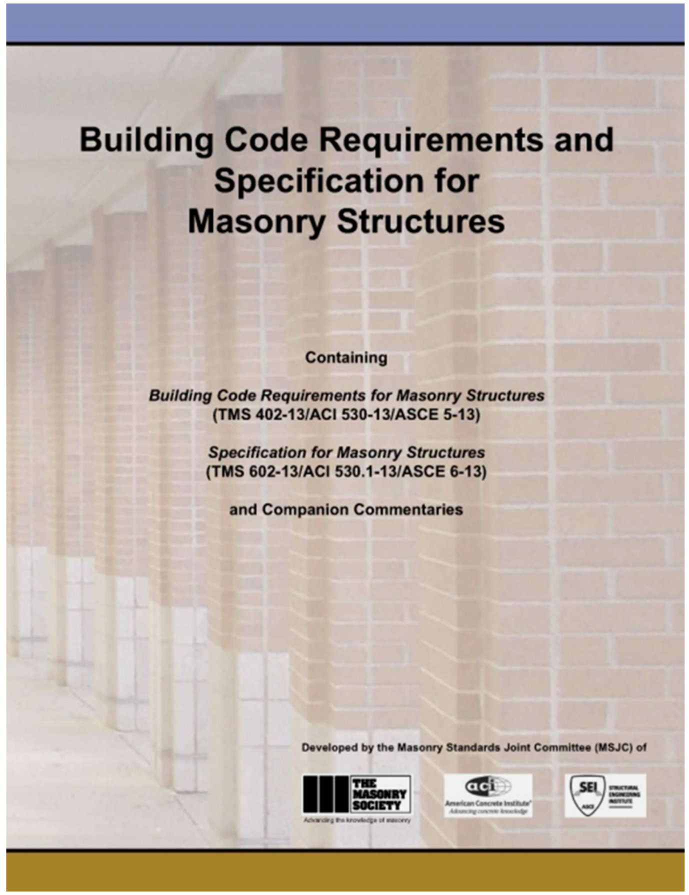
2011 MSJC – Select Changes

- Grout lift height changed to 5'-4" to accommodate modular construction.
- Prism testing provisions for specimens cut from construction were included.



2011 MSJC Select Changes

and many more…



SELECT CHANGES – 2013 MSJC

2013 MSJC - Reorganization

Part 1: General

- Chapter 1 – General Requirements
- Chapter 2 – Notations & Definitions
- Chapter 3 – Quality & Construction

Part 2: Design Requirements

- Chapter 4: General Analysis & Design Considerations
- Chapter 5: Structural Elements
- Chapter 6: Reinforcement, Metal Accessories & Anchor Bolts
- Chapter 7: Seismic Design Requirements

User Friendly/Designer Input
5 Parts with smaller focused chapters
3 Appendices

Part 3: Engineered Design Methods

- Chapter 8: ASD
- Chapter 9: SD
- Chapter 10: Prestressed
- Chapter 11: AAC

Part 4: Prescriptive Design Methods

- Chapter 12: Veneer
- Chapter 13: Glass Unit Masonry
- Chapter 14: Masonry Partition Walls

Part 5: Appendices & References

- Appendix A – Empirical Design of Masonry
- Appendix B: Design of Masonry infill
- Appendix C: Limit Design of Masonry
- References

Specification

2013 MSJC Code Reorganized

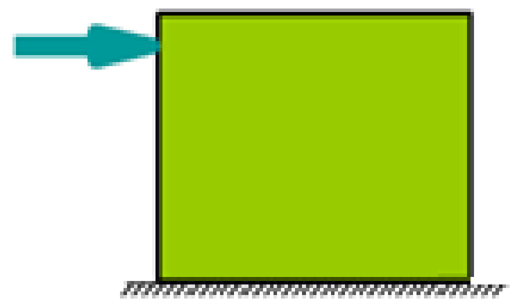
- **Part 1: General**
  - Chapter 1 – General Requirements
  - Chapter 2 – Notations & Definitions
  - Chapter 3 – Quality & Construction
- **Part 2: Design Requirements**
  - Chapter 4: General Analysis & Design Considerations
  - Chapter 5: Structural Elements
  - Chapter 6: Reinforcement, Metal Accessories & Anchor Bolts
  - Chapter 7: Seismic Design Requirements
- **Part 3: Engineered Design Methods**
  - Chapter 8: ASD
  - Chapter 9: SD
  - Chapter 10: Prestressed
  - Chapter 11: AAC
- **Part 4: Prescriptive Design Methods**
  - Chapter 12: Veneer
  - Chapter 13: Glass Unit Masonry
  - Chapter 14: Masonry Partition Walls
- **Part 5: Appendices & References**
  - Appendix A – Empirical Design of Masonry
  - Appendix B: Design of Masonry infill
  - Appendix C: Limit Design of Masonry
  - References

2013 MSJC - Limit Design

- Appendix C in 2013 MSJC
- Seismic design – Optional
- Sophisticated Analysis Method
- Perforated Walls
- *"This was a bold move for masonry and marks it as an even more serious structural material."*

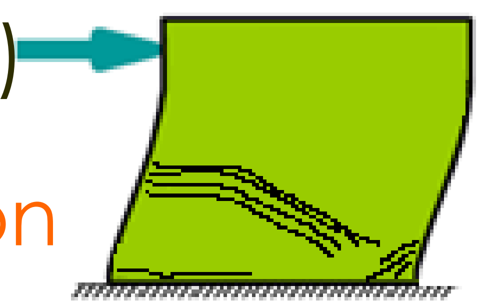
Limit Design: Seismic Design of Reinforced Masonry Structures

- force - based design
- (ASCE 7 - 10)



emphasizes strength

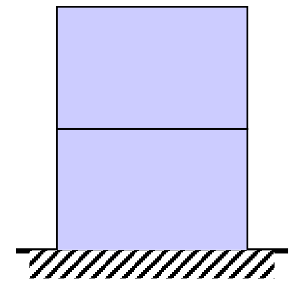
- displacement - based design
- (no code provisions yet)



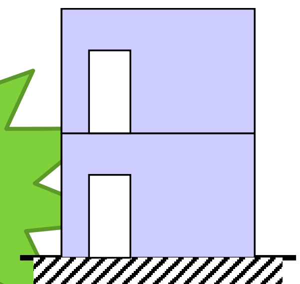
emphasizes deformation

Force-based Seismic Design Limitations

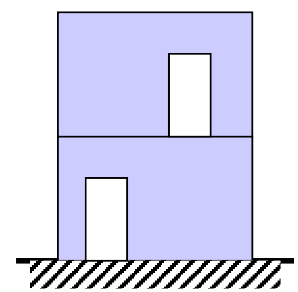
- uncoupled cantilever walls are easy to design



- coupled cantilever walls are more difficult to design



- walls with arbitrary openings may be impossible to design rationally



2013 MSJC - Empirical design

Past MSJC Codes

- Chapter 5: Empirical Design of Masonry

2013 MSJC Code

- Appendix A: Empirical Design of Masonry
  - Relocated from previous Code Chapter 5
  - Mandatory appendix
  - Checklist to make sure provisions are used correctly and appropriately.

2013 MSJC – Partition walls

Chapter ~~5~~ **14**: Masonry Partition Walls

- Partition walls are '*walls without structural function*'
- New requirements are similar to the partition wall requirements in previous empirical chapter but changes based on ASD analysis
- Tables for 5 psf and 10 psf lateral load

Example – 5 psf table shown below

Maximum *l/t*[1] and *h/t*[1] Requirements from 2013 MSJC Table 14.3.1(5) when the Lateral Load does not exceed 5 psf (0.239 kPa)

Unit and Masonry Type	**Mortar types**			
	Portland cement/lime or mortar cement		**Masonry cement or air entrained portland cement/lime**	
	M or S	**N**	**M or S**	**N**
Ungrouted and partially grouted hollow units	26	24	22	18
Solid units and fully grouted hollow units[3]	40	36	33	26

[1] *t* by definition is the nominal thickness of member

2013 MSJC - Select Changes

- Partially grouted shear walls were addressed with some refinement perhaps coming in future cycles.

- Moment magnifier provisions were added for concrete masonry, clay masonry and also for AAC masonry.

- Modulus of Rupture values were increased by approximately 33%

2013 MSJC - Select Changes

- Masonry Cement Mortar permitted for fully grouted participating elements in SDC D and higher
- AAC Infill provisions were added to Appendix B: Design of Masonry Infill

2013 MSJC – Select Changes

- Updating done for the requirements for:
  - mechanical splices in flexural reinforcement in plastic hinge zones – must develop specified tensile strength of the bar;
  - joint reinforcement and seismic clips for anchored veneer in SDC E and F no longer required.
- Joint reinforcement (with 3/16" diameter side wires) can now be used as primary reinforcement in Strength Design.

2013 MSJC – Unit Strength Table

2013 MSJC 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, psi (MPa)	Net area compressive strength of ASTM C90 concrete masonry units, psi (MPa)	
	Type M or S Mortar	Type N Mortar
1,700 (11.72)	---	1,900 (13.10)
1,900 (13.10)	1,900(13.10)	2,350 (14.82)
2,000 (13.79)	2,000 (13.79) 2800	2,650 (18.27) 3050
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) 4800	---- 5250

Select pre-2013 values

- Both unit strength tables reformatted to be more user friendly
- Values in Table 2 were recalibrated as shown above
- Generally higher masonry compressive strength tailing off at higher unit strengths
- Prism testing still an option

2013 MSJC – Unit Strength Table

Specify above the ASTM C90 minimum strength…

XXX TESTING LABORATORIES
Address
Address
Phone/fax/e-mail

Client name
Client address

Attn:

SUBJECT: Phys
PROJECT: XXX
SPECIFICATION: AST
TEST METHOD: AST
Units
DATE OF TESTS: Janu

Physical Properties
Weight Dry (lbs)
Absorption (%)
Absorption (lbs/cu.ft.)
Compressive Strength (PS
Density (lbs./cu.ft.)
Linear Shrinkage (%)

The tests show compliance v

Respectfully submitted,

XXX TESTING LABORAT

Principal

TEST RESULTS

Physical Properties	A	B	C	Average
Weight Dry (lbs)	33.60	33.55	33.60	33.58
Absorption (%)	6.99	6.86	7.14	7.00
Absorption (lbs/cu.ft.)	9.08	8.91	9.27	9.09
Compressive Strength (PSI)	3025	3101	3075	3067
Density (lbs./cu.ft.)	119.82	120.03	119.82	119.89
Linear Shrinkage (%)	0.036	0.041	0.041	0.039

The tests show compliance with ASTM C 90, “Specification for Loadbearing Concrete Masonry Units”.

2013 MSJC – ASTM C90 Changes

- Changed the web requirements:
  - C90-11a and earlier (C90-08 for 2011 MSJC):
    - Minimum thicknesses of ¾" for 3" and 4" units, 1" for 6" and 8", and 1-1/8" for 10" and greater;
    - Equivalent Web Thickness values – greater than 2 webs, less than three…
  - Starting with C90-11b (C90-12 for 2013 MSJC and C-90-15 for 2016 TMS 402):
    - Minimum thicknesses of ¾" for all units;
    - Normalized Web Area values – 6.5 sq. in./sq. ft.

2013 MSJC – ASTM C90 Changes

- Starting with C90-11b – Equivalent web area replaces equivalent web thickness.

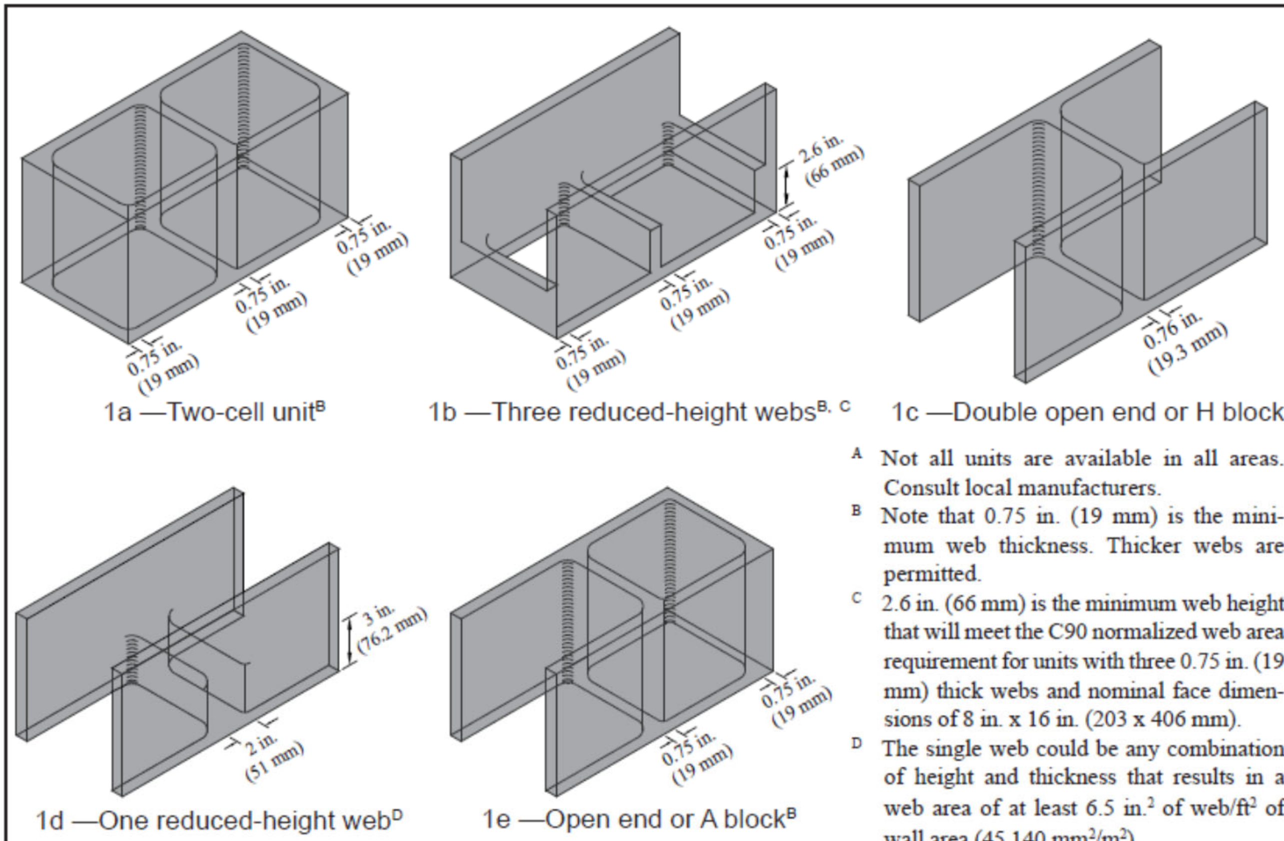
TABLE 1 Minimum ~~Thickness of~~ Face Shells and Webs Requirements[A]

Nominal Width (W) of Units, in. (mm)	Face Shell Thickness (t_{fs}), min, in. (mm)[B,C]	Webs ~~Thickness (t_w)~~	
		Web Thickness[C] (t_w), ~~Webs[B,D,C]~~ min, in. (mm)	~~Equivalent Web Thickness, min, in./linear ft[E] (mm/linear m)~~ Web Area (A_w), min, in.^{2}/ft^2 (mm^2/m^2)[D]
~~3 (76.2) and 4 (102)~~	~~¾ (19)~~	~~¾ (19)~~	~~1 5/8 (136)~~
~~6 (152)~~	~~1 (25)~~	~~1 (25)~~	~~2 ¼ (188)~~
~~8 (203)~~	~~1 ¼ (32)~~	~~1 (25)~~	~~2 ¼ (188)~~
~~10 (254) and greater~~	~~1 ¼ (32)~~	~~1 1/8 (29)~~	~~2 ½ (209)~~
3 (76.2) and 4 (102)	¾ (19)		
6 (152)	1 (25)	¾ (19)	6.5 (45,140)
8 (203) and greater	1 ¼ (32)		

Potential energy benefits, additional unit configuration options…design flexibility

2013 MSJC – ASTM C90 Changes

- Examples of unit configurations that comply with new ASTM C90 web area requirements



[A] Not all units are available in all areas. Consult local manufacturers.

[B] Note that 0.75 in. (19 mm) is the minimum web thickness. Thicker webs are permitted.

[C] 2.6 in. (66 mm) is the minimum web height that will meet the C90 normalized web area requirement for units with three 0.75 in. (19 mm) thick webs and nominal face dimensions of 8 in. x 16 in. (203 x 406 mm).

[D] The single web could be any combination of height and thickness that results in a web area of at least 6.5 in.^{2} of web/ft^2 of wall area (45,140 mm^2/m^2).

Figure 1—Examples of Web Configurations Permitted Under ASTM C90-11b[A]

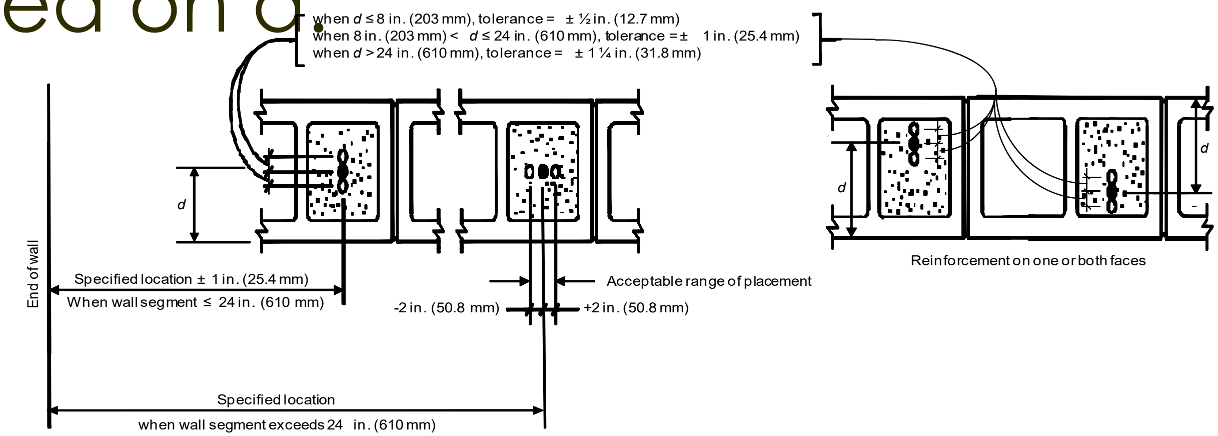
NCMA TEK 2-5B

2013 MSJC - Select Changes

- ASTM C90-12 referenced in the 2013 MSJC triggering a requirement to check normalized web area:
  - ASD and SD – Min. normalized web area of 27 in^2/ft^2 (revised to 25 in^2/ft^2 in the 2016 TMS 402) or do a calculated web shear stress check.
  - Partitions and Empirical – Min. normalized web area of 27 in^2/ft^2 (revised to 25 in^2/ft^2 in the 2016 TMS 402) required unless section is solidly grouted to use prescriptive provisions. This allows the web shear stress check to be avoided.
  - Looking at deleting or significantly dropping the limit – originally based on old web areas for 2-core block

2013 MSJC - Select Changes

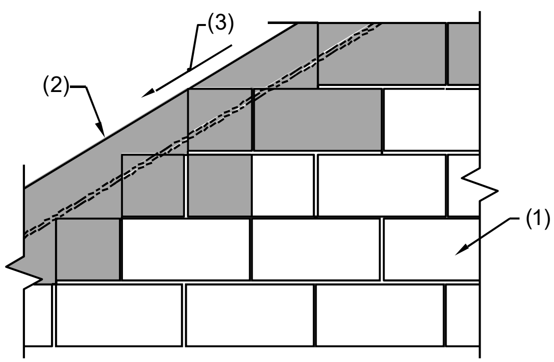
- *d* distance figures were added to the Specification to help illustrate tolerances based on d



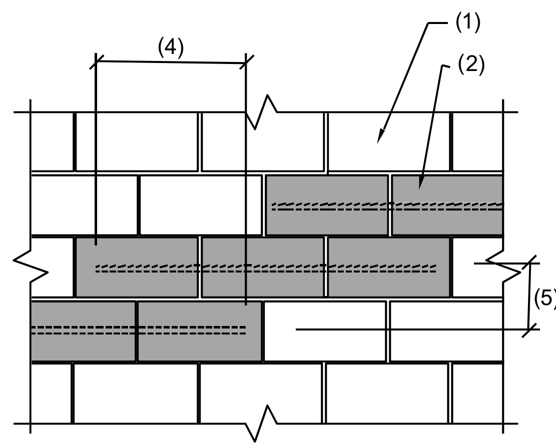
- Mortar joint tolerances at foundations and at flashings were clarified.

2013 MSJC - Select Changes

- Clarification that bond beams may be stepped or sloped.



Example of sloped bond beam

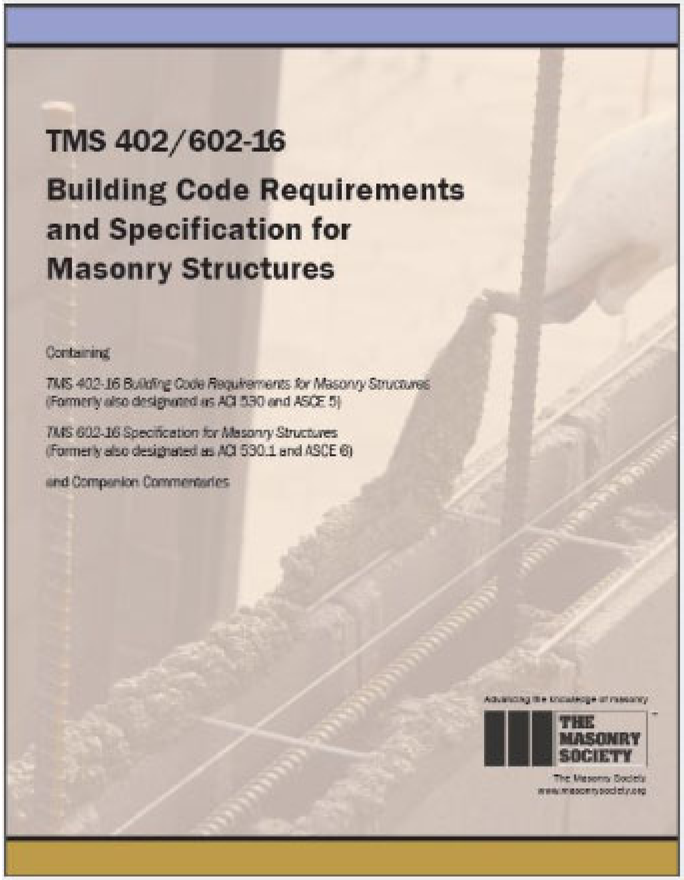


Example of stepped bond beam

Figure SC-1: Sloped and Stepped Bond Beams

2013 MSJC Select Changes

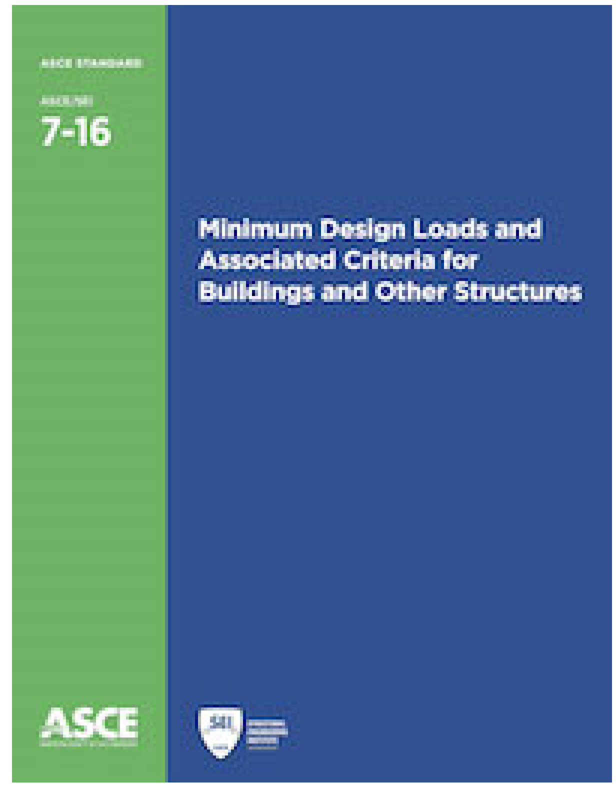
and many more…



SELECT CHANGES – 2016 TMS 402/TMS 602

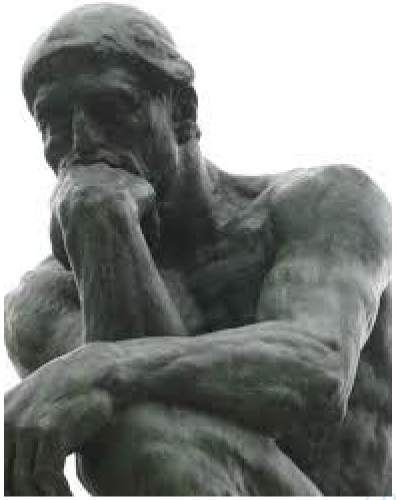
2016 MSJC – Select Changes

- Updated to ASCE 7-16
- ASCE 7-16 Features:
  - Recalibration of wind speeds in hurricane/non-hurricane zones
  - K_e Ground Elevation Factor
  - Roof Pressure Coefficients
  - Seismic
  - Online Hazard Tool
    - Seismic, Ground Snow Loads, Basic Wind Speeds, Atmospheric Icing Thickness



2018 IBC – Lap Length Equation

- ASD
  - 12" or $40d_b < l_d = 0.002d_b f_s$
  - 50% penalty if $f_s > 0.8F_s$
  - *… but need not be > 72* d_b
- *SD*
  - *Equation (6-1) TMS*
  - *…need not be > 72* d_b



Remember this slide???

Building Code Requirements for Masonry Structures – MSJC 2011 and 2013

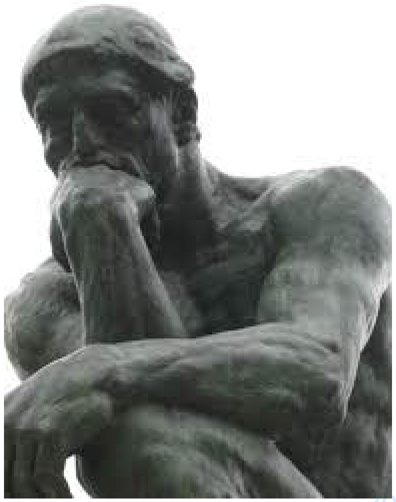
- $ASD\ and\ SD\ Splice\ length\ = \frac{0.13 d_b{}^2 f_y \gamma}{K\sqrt{f'_m}} \geq 12"$
- K = lesser of masonry cover, splice clear spacing or **9**d_b
- γ = 1.0 for #3-#5, 1.3 for #6-#7 and 1.5 for #8-#9

International Building Code 2012 and 2015 (**ASD**)

- (For ASD) In lieu of/as an alternative to (MSJC equations), it shall be permitted to use:
- $Splice\ length\ = 0.002 d_b f_s \geq 40db$
- **Increase 50% where reinforcement stress > 80% of allowable!**
- **No alternate method for SD – use MSJC only….**

2018 IBC – Lap Length Equation

- ASD – still allowed to use IBC equation as an alternate lap length design
  - 12" or $40d_b < l_d = 0.002 d_b f_s$
  - 50% penalty if $f_s > 0.8F_s$
  - ***… but need not be > 72 d_b***
- *SD – still no alternate…*
  - *Equation (6-1) TMS*
  - ***…need not be > 72 d_b per Development Length modifications***



Remember the rebar benefits?

Building perimeter: 2(350’) + 2(525’) = 1,750 LF of wall

2009 IBC / TMS 402: #5 Rebar at 24” o.c. =

- 875 rebar = 19,250 LF + lap splices
- 124 CY of grout

2012 IBC / TMS 402: #5 Rebar at 32” o.c. =

- 657 rebar = 14,438 LF + lap splices
  - 25% reduction / 2009 code = 33% increase!
  - 4,812 LF** less
  - 5,053 lbs.** less
- 93 CY of grout
  - 25% reduction using new codes / 33% increase if use 2009 code
  - 31 CY less = 4 to 5 trucks)

How about additional benefits?

Building perimeter: 1,750 LF of wall

2009 IBC / TMS 402: #5 Rebar at 24" o.c. =

- 875 rebar = 19,250 LF + lap splices
- 4'-8" low lift practical limit (5'-0" not masonry module)
- Lap splices add:
  - 16,400 LF for IBC laps
  - 13,100 LF for TMS 402 laps

2012 and later IBC / TMS 402: #5 Rebar at 32" o.c. =

- 657 rebar = 14,438 LF + lap splices
- 5'-4" low lift code/practical limit
  - 12,300 LF for IBC laps
  - 7,100 LF for TMS 402 laps

How about additional benefits?

Building perimeter: 1,750 LF of wall

Summary:

Weight of excess steel compared to 2016 TMS 402 laps?

- **2009 IBC laps: 14,800 lbs.**
- **2008 TMS 402 laps: 11,340 lbs.**
- **2018 IBC laps: 5,450 lbs.**

- **2018 TMS 402 laps: 0 lbs.!!!**
  - **Allowable stress benefits**
  - **Pour/Lift height benefits**
  - **Lap length improvements**

2016 TMS 402/TMS 602

- Shear-friction and Shear-friction Strength
- Current intention is for shear walls…
- Future applications could include addressing cold joints in walls or extending walls
- Or, even beams???

2016 TMS 402/TMS 602

- Shear-friction and Shear-friction Strength provisions were added to both ASD (Section 8.3.6) and SD (Section 9.3.6.5)
  - Shear transfer across horizontal interfaces in walls subjected to in-plane loads.
  - When subjected to in-plane lateral loads, walls that have a low axial compressive load and a low shear-span ratio are vulnerable to shear sliding, which normally occurs at the base.
  - Function of the roughness at the base.
  - Separate equations for both ASD and SD but they are coordinated.

2016 TMS 402/TMS 602

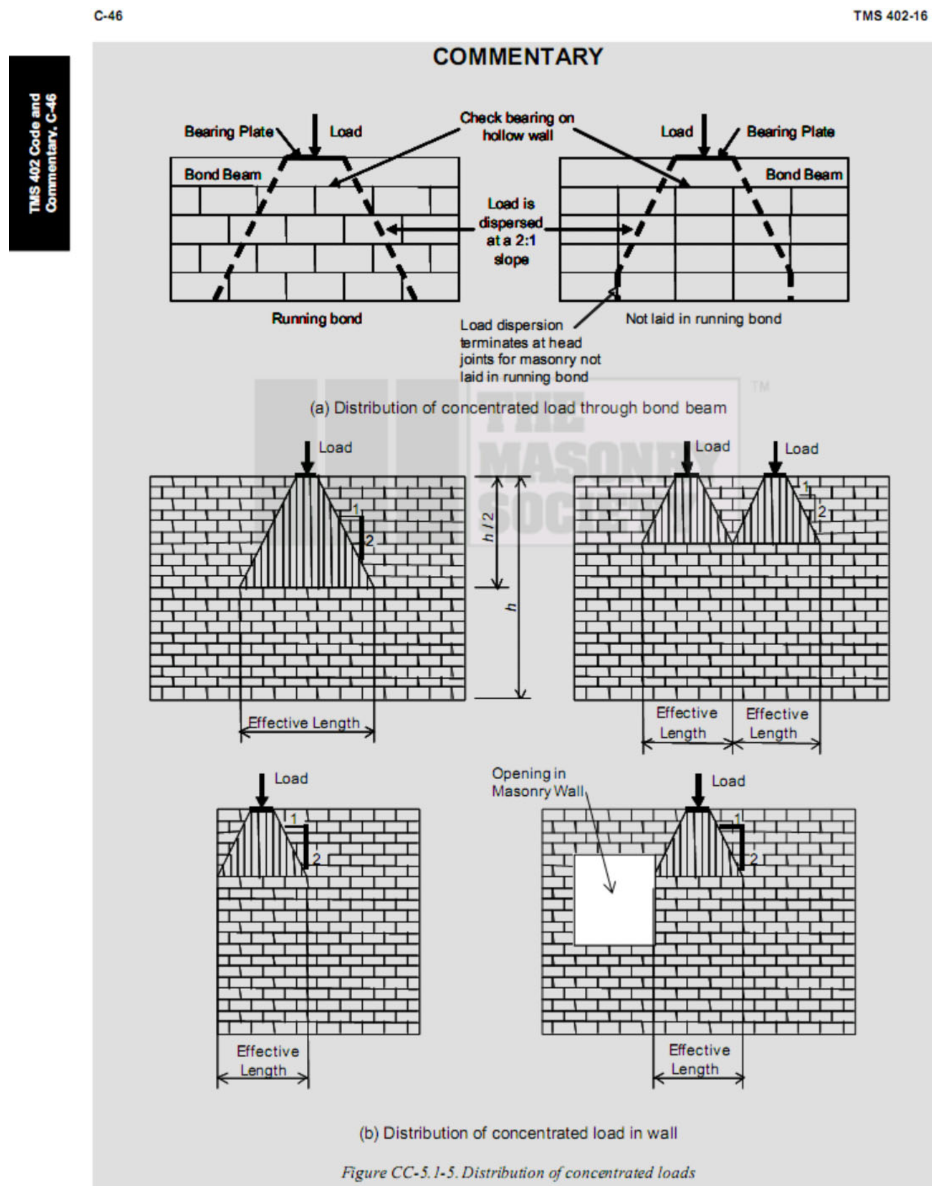
- Anchor bolts:
- Shear crushing strength
  - Raised 66% / 67% (ASD/SD) based on re-examination of research
  - Can frequently be the controlling criteria for bolts in shear
- Interaction equation changed from linear to elliptical (similar to other anchors with 5/3 factor)

2016 TMS 402/TMS 602

- Veneer Anchor/Cavity Changes
- When criteria is met, prescriptive cavity width may be as much as 6 5/8”
  - Addresses greater insulation thickness
  - And common use of 5/8” thick sheathing on framing
- Criteria:
  - (2) pintles
  - 2” maximum air-space/pintel span
  - Connecting part:
    - Adjustable Anchors: ¼” barrel; 0.074”x1.5” plate; or W2.8 (3/16”) eyelets
    - Joint reinforcement with W2.8 (3/16”) wires

2016 TMS 402/TMS 602

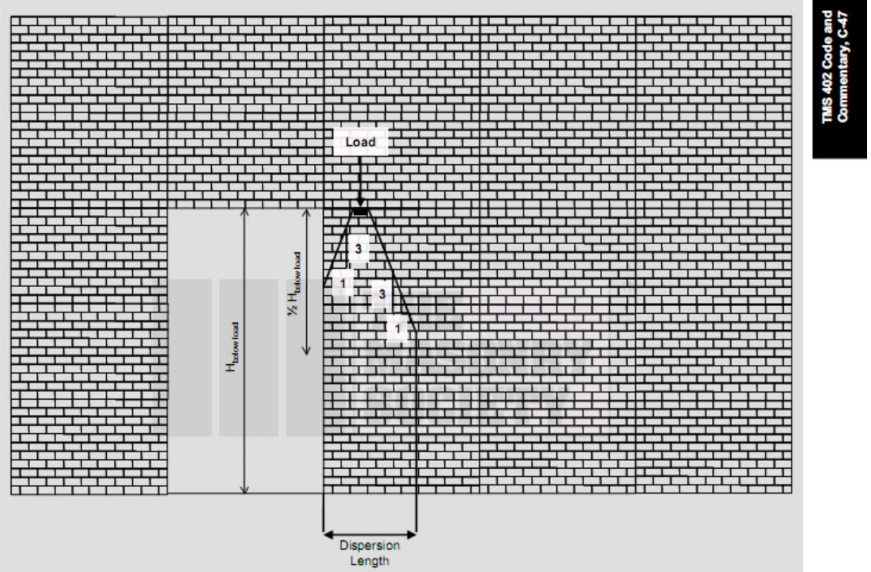
- Concentrated Load Distribution
- Formerly 2:1 Vertical : Horizontal distribution and truncated at edge of wall/opening



2016 TMS 402/TMS 602

- Concentrated Load Distribution
- Now also 3:1 Vertical : Horizontal distribution when close to or at an edge/opening

COMMENTARY



(c) Distribution of concentrated load in a wall adjacent to an opening

Figure CC-5.1-5 (Continued). Distribution of concentrated loads

2016 TMS 402/TMS 602

- Cast Stone and Manufactured Stone added as approved materials in TMS 602

2016 TMS 402/TMS 602

- Reorganization efforts continued with a primary focus on moving common provisions into Chapter 6 - Reinforcement, Metal Accessories and Anchor Bolts.
- Splice and development length requirements were consolidated into Chapter 6 and removed from the individual chapters. (No equation changes)
- Nominal bar diameter requirement (Bar diameter shall not exceed one-eighth of the nominal member thickness)which applied only to SD in previous editions was moved to Chapter 6. It now applies to ASD and SD.

2016 TMS 402/TMS 602

Chapter 14: Masonry Partition Walls

- Previously tables for 5 psf and 10 psf lateral load for unreinforced masonry walls were included.
  - Concern expressed for seismic loading
  - Limited use for designers

- New tables added for h/t and l/t lateral loadings from 5 psf to 50 psf
  - Table 14.3.1 for ungrouted or partially grouted unreinforced walls.
  - Table 14.3.2 for solidly grouted unreinforced walls.
  - Some of the restrictions on use were removed.

2016 TMS 402/TMS 602

Table 14.3.1 Partition Walls – Ungrouted or Partially Grouted

(See Table 14.3.2 for solidly grouted walls)

Table 14.3.1 – Maximum *l/t* or *h/t* for partition walls of ungrouted or partially grouted hollow units

Maximum combined allowable stress level out-of-plane load acting on simple span partition wall	Mortar type			
	Portland cement/lime or mortar cement		Masonry cement or air entrained portland cement/lime	
	M or S	N	M or S	N
5 psf (0.239 kPa)	26	24	22	18
10 psf (0.479 kPa)	18	16	14	12
15 psf (0.718 kPa)	15	13	12	9
20 psf (0.958 kPa)	13	11	10	8
30 psf (1.436 kPa)	10	9	8	6
40 psf (1.915 kPa)	9	8	7	5
50 psf (2.394 kPa)	8	7	6	5

Example:

15 psf load. Partially grouted 8″ wall. PCL mortar. Simple support.

h/t = 15 (from table) t = 8″ (nominal dimension of an 8″CMU)

Solve for h: h = (15*8″)/12 = 10′ maximum height.

2016 TMS 402/TMS 602

- Loads terminology made consistent throughout the document. *'Allowable stress level loads'* and *'Strength level loads'* now are used rather than a mix of 'nominal loads' 'service loads' and more. Both terms are also defined to help with clarity:
  - *Load, allowable stress level* – Loads resulting from allowable stress design load combinations.
  - *Load, strength level* – Loads resulting from strength design load combinations.

- Definitions were added for 'Beam', 'Lintel', 'Pilaster' and 'Cavity' as well as modification to the 'Collar Joint' and inconsistencies in the use of the terms were eliminated.

- Piers were deleted from Strength Design

2016 TMS 402/TMS 602

- Tables, instead of written provisions, were incorporated in several locations to more clearly explain the requirements.
  - Ease of use by the user
  - Similar to ACI 318-14 formatting
  - Highlighted underlying confusion in some cases which is now clarified.

2016 TMS 402/TMS 602

This:

TABLE 3.1 MINIMUM QUALITY ASSURANCE LEVEL

DESIGNED IN ACCORDANCE WITH	RISK CATEGORY I,II OR III	RISK CATEGORY IV
Part 3 or Appendix B or Appendix C	Level 2	Level 3
Part 4	Level 1	Level 2
Appendix A	Level 1	Not permitted

Not This:

~~**3.1.1** *Level 1 Quality Assurance*~~
~~The minimum quality assurance program for masonry in Risk Category I, II, or III structures and designed in accordance with Part 4 or Appendix A shall comply with the Level 1 requirements of TMS 602 Tables 3 and 4.~~

~~**3.1.2** *Level 2 Quality Assurance*~~
~~**3.1.2.1** The minimum quality assurance program for masonry in Risk Category IV structures and~~
~~designed in accordance with Chapter 12 or 13 shall comply with the Level 2 requirements of TMS 602 Tables 3 and 4.~~
~~**3.1.2.2** The minimum quality assurance program for masonry in Risk Category I, II, or III structures and designed in accordance with chapters other than those in Part 4 or Appendix A shall comply with the~~
~~Level 2 requirements of TMS 602 Tables 3 and 4.~~

~~**3.1.3** *Level 3 Quality Assurance*~~
~~The minimum quality assurance program for masonry in Risk Category IV structures and designed in accordance with chapters other than those in Part 4 or Appendix A~~
~~shall comply with the Level 3 requirements of TMS 602 Tables 3 and 4.~~

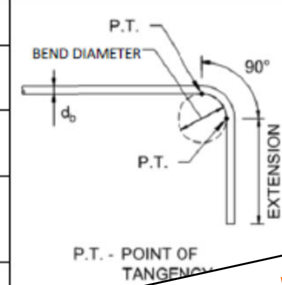
2016 TMS 402/TMS 602

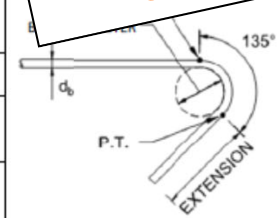
This:

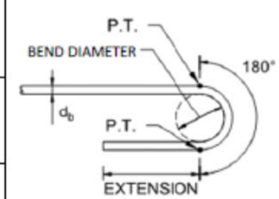
TABLE 6.1.8
STANDARD HOOKS GEOMETRY AND MINIMUM INSIDE BEND DIAMETERS FOR REINFORCING BARS, STIRRUPS & TIES

Standard Hook Type and Use	Bar Grade	Bar Size	Min. Inside Bend Diameter	Extension
90 Degree Hook – Reinforcing Bars	40 (M280)	No.3 - No. 7 (M#10 - #22)	$5d_b$	$12\ d_b$
	50 or 60 (M350 or 420)	No. 3 - No. 8 (M#10 - #25)	$6\ d_b$	$12\ d_b$
	50 or 60 (M350 or 420)	No. 9 - No. 11 (M#29 - #36)	$8\ d_b$	$12\ d_b$
90 Degree Hook – Stirrups & Ties	40, 50, 60 (M280,350 or 420)	No.3 - No.5 (M#10 - #16)	$4d_b$	$6\ d_b$ but not less than 2-1/2 in. (64 mm)
	40 (M280)	No.6 and No.7 (M#19 - #22)	$5\ d_b$	$6\ d_b$
	50 or 60 (M350 or 420)	No.6 - No.8 (M#19 - #25)	$6\ d_b$	$6\ d_b$
	50 or 60 (M350 or 420)	No.9 - No.11 (M#29 - #36)	$8\ d_b$	$6\ d_b$
135 Degree Hook – Stirrups & Ties	40, 50, 60 (M280, 350 or 420)	No.3 - No.5 (M#10 - #16)	$4\ d_b$	$6\ d_b$
	40 (M280)	No.6 and No.7 (M#19 - #22)	$5\ d_b$	$6\ d_b$
	50 or 60 (M350 or 420)	No.6 - No.8 (M#19 - #25)	$6\ d_b$	$6\ d_b$
	50 or 60 (M350 or 420)	No.9 - No.11 (M#29- #36)	$8\ d_b$	$6\ d_b$
180 Degree Hook – Reinforcing Bars	40 (M280)	No.3 - No.7 (M#10 - #22)	$5\ d_b$	$4\ d_b$ but not less than 2-1/2 in. (64 mm)
	50 or 60 (M350 or 420)	No.3 - No.8 (M#10 - #25)	$6\ d_b$	$4\ d_b$ but not less than 2-1/2 in. (64 mm)
	50 or 60 (M350 or 420)	No.9 -- No.11 (M9 -#36)	$8\ d_b$	$4\ d_b$

Standard Hook Figures







Replaces language in multiple sections of the Code and consolidates into one table

2016 TMS 402/TMS 602

- Quality Assurance Tables were rewritten and simplified.
  - Duplicate tables were deleted from the TMS 402 Code which now refers to the TMS 602 Tables.
  - Components of the change:
    - List current Inspection Requirement tasks for all levels into a single table.
    - Segregate Minimum Verification Requirements from the Minimum Special Inspection Requirements.
    - Changed QA Levels A, B, C to QA Levels 1,2,3. (Consistent with IBC)

2016 TMS 402/TMS 602

- Quality Assurance Provisions were revised.
  - Special Inspector's Qualifications required to be submitted.
    - ICC
  - Qualified Lab and Testing Technician requirements added (when used)
    - ASTM C1093
    - ACI (Accreditation and courses)
    - TMS (Courses)

2016 TMS 402/TMS 602

- Quality Assurance Tables

Table 3 — Minimum Verification Requirements

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
During construction, verification of f'_m and f'_{AAC} for every 5,000 sq. ft. (465 sq. m).	NR	NR	R	Art. 1.4 B
During construction, verification of proportions of m the project site for premixed or preblended mortar, p grout other than self-consolidating grout.				

(a) R=Required, NR=Not Required

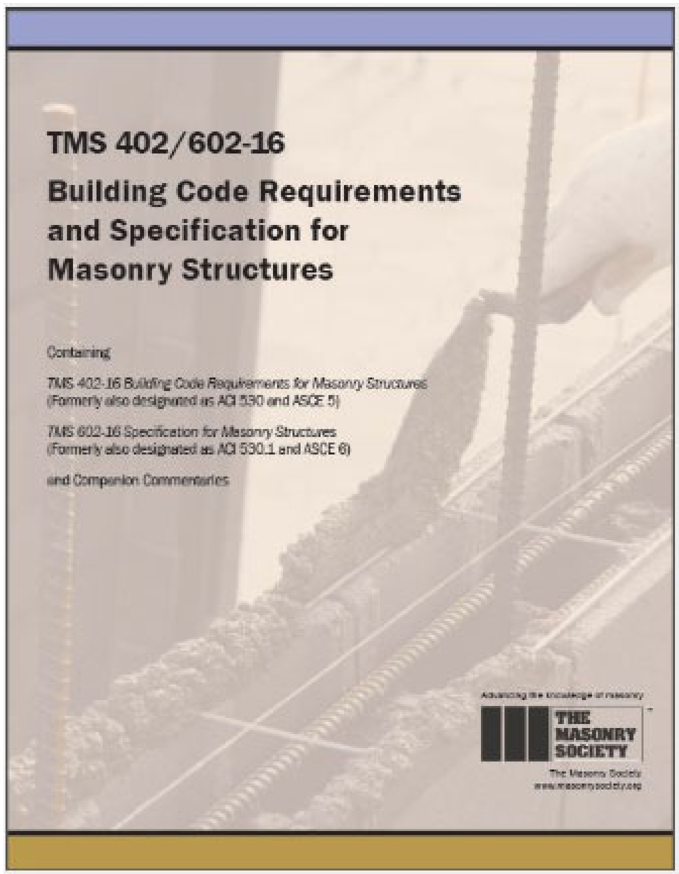
Table 4 — Minimum Special Inspection Requirements

MINIMUM SPECIAL INSPECTION					
Inspection Task	Frequency [a]			Reference for Criteria	
	Level 1	Level 2	Level 3	TMS 402	TMS 602
1. As masonry construction begins, verify that the following are in compliance:					
a. Proportions of site-prepared mortar	NR	P	P		Art. 2.1, 2.6 A, & 2.6 C
b~~e~~. Grade and size of prestressing tendons and anchorages	NR	P	P		Art. 2.4 B & 2.4 H
c. Grade, type and size of reinforcement, connectors, anchor bolts,and prestressing tendons and anchorages	NR	P	P		Art. 3.4 & 3.6 A
d. Prestressing technique	NR	P	P		Art. 3.6 B
e. Properties of thin-bed mortar for AAC masonry	NR	C[b]/P[c]	C		Art. 2.1 C.1
f. Sample panel construction	NR	P	C		Art. 1.6 D
2. Prior to grouting, verify that the following are in compliance:					
a. Grout space	NR	P	C		Art. 3.2 D & 3.2 F
b. Placement of prestressing tendons and					

Excerpt of Table 4 only

2016 TMS 402/TMS 602

and many more…



IN CONCLUSION….

Code Adoption Time Lines - 2011 & 2013 MSJC and 2016 TMS 402/602

- 2011MSJC Referenced in the 2012 IBC and IRC
- 2013 MSJC Referenced in the 2015 IBC and IRC
- 2016 TMS 402/ TMS 602 Completed Fall 2016
  Referenced in the 2018 IBC
- 2022 TMS 402/TMS 602 - **A six year cycle**!
  Work started Fall 2016 for reference in the 2024 IBC

Check for local adoption status and
potential local amendments