Structural Masonry Design

A Practical Seminar for Practicing Engineers
SEAO NW Conference
Salishan Resort, Gleneden Beach, OR, August 15 - 17, 2019

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Sponsors

Northwest Concrete Masonry Association

Masonry Industry Promotion Group

Masonry Institute of Oregon

Masonry Institute of Washington

Northwest Cement Council

Structural Engineers Association of Oregon

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Seminar Credits and Objectives

- Present the majority of the changes to TMS 402-16 and the 2018 IBC
- Facilitate ease and efficiency of masonry design
- I would like to acknowledge the assistance of:
  - NWCMA and Tom Young
  - The Masonry Society, Phil Samblanet, Mark McGinely, and Dick Bennett
  - IMI and Brian Trimbel

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Current Building Codes

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TMS 402/602-16 CODE AND SPECIFICATION UPDATE

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Name Change

2013:
TMS 402/ACI 530/ASCE 5
TMS 602/ACI 530.1/ASCE 6
Developed by MSJC
(Masonry Standards Joint Committee)

2016:
TMS 402
TMS 602

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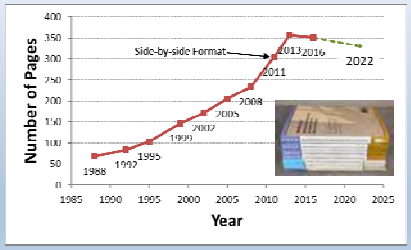
Code Facts



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Overview

- Technical Changes
  - Shear Friction
  - Anchor Bolts
  - Others
- Format/Editorial Changes
  - Reinforcement Requirements Moved to Chapter 6
  - Quality Assurance Tables
  - Others

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TMS 402/602 - relationship between Code and Specification...

- TMS 402 "Code"
  - Design provisions are given in Chapters 1 - 14 and Appendices A, B and C
  - Sections 1.2.4 and Chapter 3 require a QA program in accordance with the Specification
  - Section 1.4 invokes the Specification by reference.
- TMS 602 "Specification"
  - verify compliance with specified f'_m
  - comply with specified products and execution
  - comply with required level of quality assurance

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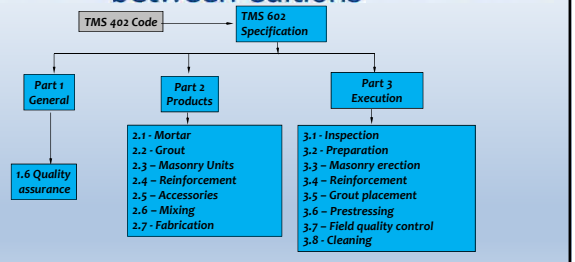
TMS 602 Specification – Format Consistent between editions



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Mandatory Specification Checklist

- List of decisions that must be made by the Engineer/Architect:
  - Specify masonry materials to be used
  - Specify compressive strength of masonry (except veneer, empirical, glass block)
  - Specify quality assurance requirements
  - Show type and location of movement joints on drawings

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Optional Specification Checklist

- List of decisions that can be made by Engineer/Architect. If not made, default values of the Specification apply .
  - Specify required submittals
  - Specify bond pattern if not running bond
  - Specify when masonry units are to be wetted prior to use
  - Specify when cross - webs are to be mortar - bedded
  - Specify masonry cleaning methods

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First, a TMS 2013 Change

- **Based on recent testing, the correlation between the compressive strength of concrete masonry units, mortar type, and resulting assembly compressive strength was substantially revised.**
- Similar format revisions were made to the unit strength table for clay masonry units, although no changes to the values in the clay masonry table were made.

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Specification & Commentary for Masonry Structures (TMS 602-11) 1.4B.2 Unit Strength Method, Table 2

For decades the unit strength table provided a quick/easy means of determining f'_m

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)	1,900 (13.10)	1,350 (9.31)
2,800 (19.31)	2,150 (14.82)	1,500 (10.34)
3,750 (25.86)	3,050 (21.03)	2,000 (13.79)
4,800 (33.10)	4,050 (27.92)	2,500 (17.24)
	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.

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Assembly Compressive Strength (f'_m)

Yet, this option has been very conservative to use due to:

- Data drawn from prism testing completed 30-60 years ago.
- Non-standardized and varying testing procedures.
- Correction factors needed to account for:
  - Gross vs. net area compressive strength
  - Face shell vs. full mortar bedding

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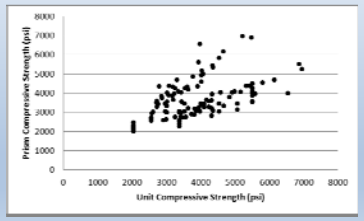
Assembly Compressive Strength (f'_m)

In 2010, a new research project was initiated to recalibrate the unit strength method.



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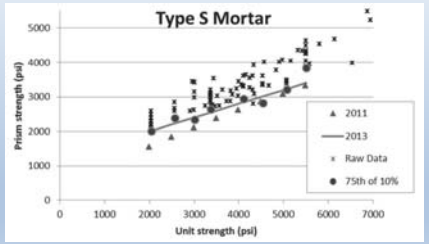
Assembly Compressive Strength (f'_m)



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Specification & Commentary for Masonry Structures (TMS 602) 1.4B.2 Unit Strength Method, Table 2

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 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)	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)	—

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

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Assembly Compressive Strength (f'_m)

At lower unit compressive strength values, Type M or S mortars produce an assembly compressive strength equal to the unit compressive strength.

1,900 psi unit → 1,900 psi f'_m

2,000 psi unit → 2,000 psi f'_m

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Assembly Compressive Strength (f'_m)

Historically f'_m= 1,500 psi has been the default baseline for the specified compressive strength of concrete masonry.

The recalibrated table doesn't even go as low as f'_m= 1,500 psi; instead starting at 1,900 psi for Type S mortar.

But f'_m= 1,900 psi feels 'irregular'...

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Assembly Compressive Strength (f'_m)

f'_m= 2,000 psi feels 'right'.

However, ASTM C90 required a minimum unit compressive strength of 1,900 psi.

The solution...change ASTM C90. Hence, in 2014 ASTM C90 was changed to have a minimum compressive strength of 2,000 psi. This is now the minimum in TMS 402-16

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Assembly Compressive Strength (f'_m)

TMS 402-16

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 concrete masonry units, psi (MPa)	
	Type M or S mortar	Type N mortar
[illegible] (12.07)		2,000 (13.79)
2,000 (13.79)	2,000 (13.79)	2,650 (18.27)
2,250 (15.51)	[illegible] (17.93)	3,400 (23.44)
2,500 (17.24)	[illegible] (22.41)	4,350 (28.96)
2,750 (18.96)	[illegible] (26.89)	----
3,000 (20.69)	[illegible] (31.03)	----

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

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Effect of f'_m = 2000 psi vs. f'_m = 1500 psi

- Allowable Stress Design
  - Small effect when allowable tension stress controls
  - Significant effect when allowable masonry stress controls
- Strength Design
  - Small effect on flexural strength
  - Significant effect on axial strength
  - Significant effect on maximum reinforcement requirements
- Both ASD and SD
  - 13% decrease in development and splice length
  - 15% increase in masonry shear strength
    - Effectively changes γ_g to 0.87 for masonry shear strength

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Overview

- Technical Changes
  - **Shear Friction**
  - Anchor Bolts
  - Others
- Format/Editorial Changes
  - Reinforcement Requirements Moved to Chapter 6
  - Quality Assurance Tables
  - Others

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Shear Friction Provisions

Allowable Stress Design	Strength Design
Where $M/(Vd_v) \le 0.5$ $F_f = \frac{\mu(A_{sp}F_s + P)}{A_{nv}}$	Where $M_u/(V_u d_v) \le 0.5$ $V_{nf} = \mu(A_{sp}f_y + P_u)$
Linear interpolation for intermediate values	
Where $M/(Vd_v) \ge 1.0$ $F_f = \frac{0.65(0.6A_{sp}F_s + P)}{A_{nv}}$	Where $M_u/(V_u d_v) \ge 1.0$ $V_{nf} = 0.42f'_m A_{nc}$ A_{nc} = area of masonry in compression at nominal moment capacity

- μ = 1.0 for masonry on concrete with unfinished surface, or concrete with a surface that has been intentionally roughened
- μ = 0.70 for all other conditions
- UBC (1997) required concrete abutting structural masonry to be roughened to a full amplitude of 1/16 inch.

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Shear Friction: Special Reinforced Shear Walls

Shear Capacity Design: (7.3.2.6.1)

- Strength Design
  - ϕV_n > shear corresponding to the development of $1.25M_n$
  - V_n need not exceed $2.5V_u$
- Allowable Stress Design
  - Calculated shear stress increased by 1.5

Per commentary, shear capacity provisions do not apply to shear friction

- Strength Design
  - The provisions of this Section only apply to the nominal shear strength, V_n, and do not apply to the nominal shear friction strength, V_{nf}.
- Allowable Stress Design
  - The 1.5 multiplier should not be applied to V when calculating the M/Vd_v ratio, or for shear friction design.

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Anchor Bolts: Two Major Changes

	Allowable Stress Design	Strength Design
Masonry Crushing	~~$B_{vc} = 350\sqrt[4]{f'_m A_b}$~~ $B_{vc} = 580\sqrt[4]{f'_m A_b}$	~~$B_{vnc} = 1050\sqrt[4]{f'_m A_b}$~~ $B_{vnc} = 1750\sqrt[4]{f'_m A_b}$
Interaction	~~$\frac{b_a}{B_a} + \frac{b_v}{B_v} \le 1$~~ $\left(\frac{b_a}{B_a}\right)^{\frac{5}{3}} + \left(\frac{b_v}{B_v}\right)^{\frac{5}{3}} \le 1$	~~$\frac{b_{au}}{\phi B_{an}} + \frac{b_{vu}}{\phi B_{vn}} \le 1$~~ $\left(\frac{b_{au}}{\phi B_{an}}\right)^{\frac{5}{3}} + \left(\frac{b_{vu}}{\phi B_{vn}}\right)^{\frac{5}{3}} \le 1$

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Anchor Bolts: Masonry Crushing

	TMS 402-13 Governing Equation		
	Breakout	Crushing	Yielding
Design Strength	$4A_{pv}\sqrt{f'_m}$	$1050\sqrt[4]{f'_m A_b}$	$0.6A_b f_y$
Number of Tests	95	188	62
Average of Test/Calculated	1.23	2.33	1.45
Standard Deviation of Ratio	0.14	0.73	0.20
Coefficient of Variation	0.11	0.31	0.14

- Several alternate equations for shear crushing were examined
- FEMA 369 equation chosen: $1750\sqrt[4]{f'_m A_b}$.

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Anchor Bolts: Masonry Crushing

	TMS 402-16 Governing Equation		
	Breakout	Crushing	Yielding
Design Strength	$4A_{pv}\sqrt{f'_m}$	$1750\sqrt[4]{f'_m A_b}$	$0.6A_b f_y$
Number of Tests	95	131	119
Average of Test/Calculated	1.23	1.49	1.44
Standard Deviation of Ratio	0.14	0.44	0.35
Coefficient of Variation	0.11	0.29	0.24

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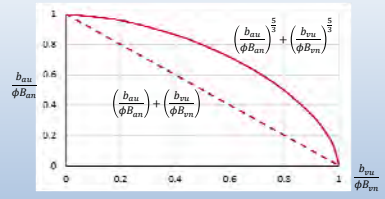
Anchor Bolts: Interaction



$\frac{b_{au}}{\phi B_{an}}$	$b_{vu}/\phi B_{vn}$	
	n = 1 (linear)	n = 5/3
0.25	0.75	0.94
0.5	0.50	0.80
0.75	0.25	0.56

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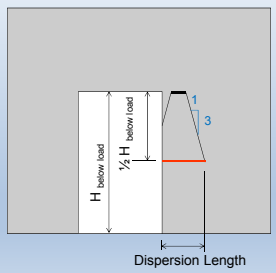
Dispersion of Load Adjacent to Opening



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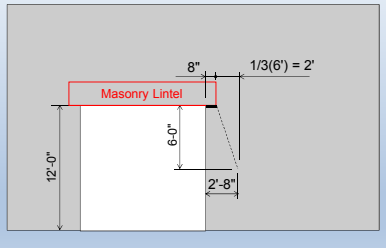
Example



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Deleted Piers: Strength Design

9.3.4.3 *Piers*

9.3.4.3.1 The factored axial compression force on piers shall not exceed $0.3A_n f'_m$.

9.3.4.3.2 *Longitudinal reinforcement* —

- symmetrically reinforced
- at least one bar in each end cell
- minimum area of longitudinal reinforcement shall be 0.0007 *bd*.

9.3.4.3.3 *Dimensional limits* —

- nominal thickness of a pier shall not exceed 16 in.
- distance between lateral supports of a pier shall not exceed 25 times the nominal thickness or design as a wall
- nominal length shall not be less than three times the nominal thickness nor greater than six multiplied by its nominal thickness. The clear height of a pier shall not exceed five multiplied by its nominal length.

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Harmonized One Reinforcement Requirement

6.1.2 *Size of reinforcement*

6.1.2.1 The maximum size of reinforcement used in masonry shall be No. 11. {No. 9 in strength design, 9.3.3.1}

6.1.2.2 The diameter of reinforcement shall not exceed one-half the least clear dimension of the cell, bond beam, or collar joint in which it is placed. {one-quarter least clear dimension in strength design, 9.3.3.1}

6.1.2.3 Longitudinal and cross wires of joint reinforcement shall have a minimum wire size of W1.1 (MW7) and a maximum wire size of one-half the joint thickness.

6.1.2.4 Area of vertical reinforcement shall not exceed 6 percent of the area of the grout space. {4 percent in strength design, 9.3.3.1}

6.1.2.5 The nominal bar diameter shall not exceed one-eighth of the least nominal member dimension. {Previously only in strength design}

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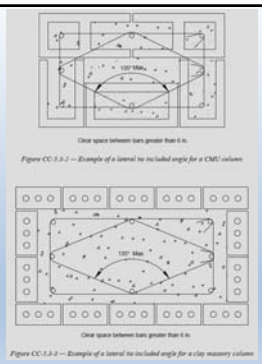
Added Figure for Tie Requirements

5.3.1.4 *Lateral ties* — Lateral ties shall conform to the following:
(c) Lateral ties shall be arranged so that every corner and alternate longitudinal bar shall have lateral support provided by the corner of a lateral tie with an included angle of not more than 135 degrees. No bar shall be farther than 6 in. (152 mm) clear on each side along the lateral tie from such a laterally supported bar.



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Veneer Anchors

Increased allowed cavity width for prescriptive design to 6-5/8 in. under certain conditions

- 4 in. to 6 in. to accommodate increased insulation thicknesses
- 1/2 in to 5/8 in. to accommodate 5/8 in. sheathing
- Required conditions
  - Adjustable anchors
    - Two pintles required
    - Maximum span of adjustable portion is 2 in.
    - Part attached to backing either 1/4 in. barrel anchor, a plate or prong anchor at least 0.074 in. thick and 1-1/4 in. wide; or a tab or two eyes formed of minimum size W2.8 wire welded to joint reinforcement.
  - Joint reinforcement
    - Cross and longitudinal wires of wire size W2.8

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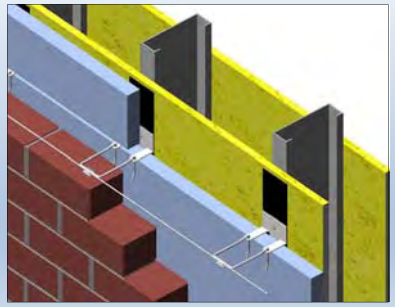
Veneer Anchors



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Expanded Tables for Partition 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

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Cast Stone and Manufactured Stone

Added to TMS 602 SPECIFICATION

2.3 — Masonry unit materials

2.3 F. Provide cast stone that conforms to ASTM C1364 as specified.

2.3 G. Provide manufactured stone that conforms to ASTM C1670 as specified.

ASTM C1364-16 Standard Specification for Architectural Cast Stone

ASTM C1670-15 Standard Specification for Adhered Manufactured Stone Masonry Veneer Units

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Qualifications of Inspectors and Testing Technicians

2016 TMS 602 Specification	2016 TMS 602 Commentary
1.6 A. *Testing Agency's services and duties* 1. Utilize qualified laboratory technicians to perform required laboratory tests.	1. Masonry testing laboratory personnel who are certified in accordance with ACI Masonry Laboratory Testing Technician Certification Program, or equivalent program, are qualified.
1.6 B. *Inspection Agency's services and duties* 1. Utilize qualified field testing technicians to observe or perform the preparation and handling of grout specimens, mortar specimens and/or masonry prisms.	1. Field technicians who are certified in accordance with the requirements of ACI Masonry Field Testing Technician Certification Program, or an equivalent program, are qualified to observe and/or prepare masonry specimens.
2. Utilize qualified Special Inspectors to inspect and evaluate construction.	2. Special inspectors who are certified for this service by International Code Council, or other acceptable agency, are qualified.

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Overview

- Technical Changes
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- Format/Editorial Changes
  - **Reinforcement Requirements Moved to Chapter 6**
  - Quality Assurance Tables
  - Others

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Chapter 6: Reinforcement, Metal Accessories, And Anchor Bolts

2013 TMS 402	2016 TMS 402
6.1 Details of reinforcement and metal accessories 6.1.1 Embedment 6.1.2 Size of reinforcement 6.1.3 Placement of reinforcement 6.1.4 Protection of reinforcement and metal accessories 6.1.5 Standard hooks 6.1.6 Minimum bend diameter for reinforcing bars	6.1 Reinforcement 6.1.1 Embedment 6.1.2 Size of reinforcement 6.1.3 Placement or reinforcement 6.1.4 Protection of reinforcement 6.1.5 Development 6.1.5.1 Development of bar reinforcement in tension or compression 6.1.5.2 Development of wires in tension 6.1.6 Splices 6.1.6.1 Splices of bar reinforcement 6.1.6.1.1 Lap splices 6.1.6.1.2 Welded splices 6.1.6.1.3 Mechanical splices 6.1.6.1.4 End-bearing splices 6.1.6.2 Splices of wires in tension 6.1.6.2.1 Lap splices 6.1.6.2.2 Welded splices 6.1.6.2.3 Mechanical splices

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Chapter 6: Reinforcement, Metal Accessories, And Anchor Bolts

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Chapter 6: Reinforcement, Metal Accessories, And Anchor Bolts

2013 TMS 402	2016 TMS 402
6.1 Details of reinforcement and metal accessories 6.1.1 Embedment 6.1.2 Size of reinforcement 6.1.3 Placement of reinforcement 6.1.4 Protection of reinforcement and metal accessories 6.1.5 Standard hooks 6.1.6 Minimum bend diameter for reinforcing bars	6.1 Reinforcement 6.1.7 Shear reinforcement 6.1.7.1 Horizontal shear reinforcement 6.1.7.2 Stirrups 6.1.7.3 Welded wire reinforcement 6.1.8 Standard hooks and bends for reinforcing bars, stirrups, and ties 6.1.9 Embedment of flexural reinforcement 6.1.9.1 General 6.1.9.2 Development of positive moment reinforcement 6.1.9.3 Development of negative moment reinforcement
	6.2 Metal accessories 6.2.1 Protection of metal accessories
6.2 Anchor bolts	6.3 Anchor bolts

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Quality Assurance Tables

2013 TMS 402	2016 TMS 402
Tables were in TMS 402 Chapter 3 and TMS 602 Article 1.6.	Tables just in TMS 602 and referenced from TMS 402 Chapter 3.
Three tables: • Quality Assurance Level A • Quality Assurance Level B • Quality Assurance Level C	Two tables: • Minimum verification requirements • Minimum special inspection requirements

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2013 Quality Assurance Tables


Table 4 — Level B Quality Assurance

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2016 Verification Requirements

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 materials as delivered to the project site for premixed or preblended mortar, prestressing grout, and grout other than self-consolidating grout.	NR	NR	R	Art. 1.4 B

(a) R=Required, NR=Not Required

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2016 Inspection Requirements

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	D		Art. 2.1, 2.6 A & 2.6 C
c. Grade and size of prestressing tendons and anchorages	NR	P	D		Art. 2.4 B & 2.4 H
e. Grade, type and size of reinforcement, connectors, anchor bolts and prestressing tendons and anchorages	NR	P	D		Art. 2.4 & 3.6 A
d. Prestressing technique	NR	P	P		Art. 1.6 B
e. Properties of dry-bed mortar for AAC masonry	NR	C(W) P(O)	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. 1.2 D & 3.2 F
b. Placement of prestressing tendons and anchorages	NR	P	P		Art. 2.4 & 3.6
c. Placement of reinforcement, connectors, and anchor bolts	NR	P	C	Sec. 6.1, 6.3.1, 6.3.6, & 6.3.7	Art. 1.2 E & 3.4
d. Proportions of site-prepared grout and prestressing grout for bonded tendons	NR	P	P		Art. 2.6 B & 2.4 G 1.b

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- Format/Editorial Changes
  - Reinforcement Requirements Moved to Chapter 6
  - Quality Assurance Tables
  - **Others**

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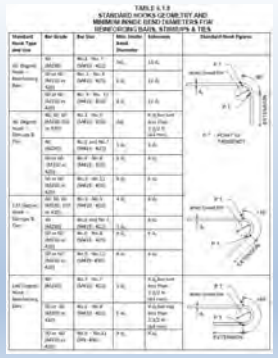
Changed Wording to Tables

- Ease of use by the user
- Similar to ACI 318-14 formatting



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Definition of Loads: ASCE 7

ALLOWABLE STRESS DESIGN: A method of proportioning structural members such that elastically computed stresses produced in the members by nominal loads do not exceed specified allowable stresses (also called "working stress design").

FACTORED LOAD: The product of the nominal load and a load factor.

NOMINAL LOADS: The magnitudes of the loads specified in this standard for dead, live, soil, wind, snow, rain, flood, and earthquake loads.

SERVICE LOADS: Loads imparted on a building or other structure because of (1) self-weight and superimposed dead load, (2) live loads assumed to be present during normal occupancy or use of the building or other structure, (3) environmental loads that are expected to occur during the defined service life of a building or other structure, and (4) self-straining forces and effects. Service live loads and environmental loads for a particular limit state are permitted to be less than the design loads specified in the standard. Service loads shall be identified for each serviceability state being investigated.

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Definition of Loads: TMS 402

2013 TMS 402:

- Working stresses
- Service loads {Load specified by the legally adopted building code.}
- Nominal loads {Chapter 8 design procedures follow allowable stress design methodology, in which the calculated stresses resulting from nominal loads must not exceed permissible masonry and steel stresses}.
- Factored loads/unfactored loads
- Design loads

2016 TMS 402

Load, allowable stress level – Loads resulting from allowable stress design load combinations.

Load, strength level – Loads resulting from strength design load combinations.

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Definitions

New definitions

Beam - A member designed primarily to resist flexure and shear induced by loads perpendicular to its longitudinal axis.

Lintel - See Beam.

Pilaster - A vertical member, built integrally with a wall, with a portion of its cross -section typically projecting from one or both faces of the wall.

New and modified definitions; eliminated inconsistencies in usage

Cavity — A continuous air space, between wythes, which may contain insulation.

Collar joint — Vertical longitudinal space between wythes of composite masonry ~~or between masonry wythe and backup construction, which~~ that is ~~permitted to be~~ filled with mortar or grout.

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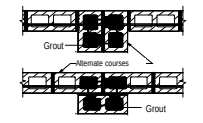
Pilasters



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Other Changes

References

Updated references to a consistent format and citation method.

Member vs. Element

- "member" and "element" used somewhat interchangeably.
- Committee and ACI 318 agreed to move toward using "member" for physical members, and "element" for a representation of the member, such as finite element.
- Some of the exceptions include:
  - boundary elements
  - collectors – elements that act in axial tension or compression
  - seismic topics, where "element" such as "lateral-force-resisting element" has a long history of use and good understanding.

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ASCE 7-16 Code Changes Affecting Masonry

Chapters 13, 14, and 15

The minimum design strength of anchors not governed by tensile yielding or shear yielding was reduced from 2.5 times the factored force to 2.0 times the factored force.

Chapter 14

- One-third stress increase restrictions removed: TMS 402-11 removed the allowable one-third stress increase
- Deep beam provisions removed: TMS 402-11 added deep beam provisions
- Lap splice provisions changed

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The I-Codes and the IBC

- I-Codes or "International" Codes
  - Model Building Code prepared for adoption (with or without amendments) by local jurisdictions
- Replaced former "legacy" codes
  - UBC, BOCA NBC, SBC
- Published on a 3 year cycle
- IBC = International Building Code (our focus for this seminar)

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Relationship between IBC & MSJC

- IBC and other I-Codes
  - reference standards (with or without modification) related to material, design & construction requirements
- IBC and IRC referenced the "MSJC" for the design & construction of structural masonry.
- Each IBC referenced the latest edition of MSJC
  - 2012 IBC references the 2011 MSJC
  - 2015 IBC references the 2013 MSJC
- **2018 IBC updated to reference TMS 402/602-16**

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2018 International Building Code (IBC)

- Chapter 14 - Masonry veneer
- Chapter 17 - Special Inspection and Testing
- Chapter 18 - Foundations
- Chapter 21 - Masonry design
- References TMS 402-16
- State amendments, if any

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Major Changes in 2018 IBC related to Masonry Quality Assurance

- None
- IBC Chapter 17 continues to refer to TMS 602 for Special Inspection and Testing
- TMS 602 did consolidate tables as noted for Quality Assurance

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New to Chapter 21 of the 2018 IBC

- Standards for Architectural Cast Stone (TMS 404-16, TMS 505-16 and TMS 604-16) referenced in the IBC for the design, fabrication, and installation of architectural cast stone.

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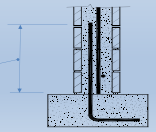
New to Chapter 21, Masonry, of the 2018 IBC

- Other structural changes related to masonry.
  - 72d_b cap on ASD lap splice lengths added consistent with SD
    - Equation requires long lap lengths at small cover depths, or with large bars. Some feel research was not consistent with how splices actually are loaded and perform

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

Lap Splice Length may be reduced to 72 d_b, despite what may be required by lap length equation



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Chapter 21, Masonry, of the 2018 IBC

- Few other major structural changes. Some other changes you may wish to know about:
  - AAC masonry unit standards updated based on changes in ASTM (from ASTM C 1386 to ASTM C1691 and ASTM C1693 for the strength class specified)
  - Adhered manufactured stone masonry veneer units conforming to ASTM C1670 added (consistent with TMS 602)

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Chapter 21, Masonry, of the 2018 IBC

- Other structural changes related to masonry.
  - ASD (Allowable Stress Design) Modification to TMS 402/602 related to "Maximum" Bar Size (2015 IBC Section 2107.4) eliminated because this is now addressed directly in TMS 402, Section 6.2.1

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Chapter 21, Masonry, of the 2018 IBC

- Other structural changes related to masonry.
  - Empirical Design requirements limited for "conventional" masonry and expanded for adobe masonry
    - TMS 402/602 almost deleted empirical design during the 2016 cycle. Problem was IBC referenced those requirements
    - IBC change to remove link. Now clay and concrete masonry must be designed by ASD or SD
    - Adobe industry not prepared for change. Slightly expanded/clarified their requirements. Will change further in future editions of IBC.

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Structural Masonry Design

Questions?

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