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
Northwest Cement Council
Masonry Institute of Oregon
Masonry Institute of Washington
Structural Engineers Association of Oregon
Structural Engineers Association of Washington

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:
  - NWSCMA and Tom Young
  - The Masonry Society, Phil Samblanet, Mark McGinely, and Dick Bennett
  - IMI and Brian Trimbel
Current Building Codes

TMS 402/602-16 CODE AND SPECIFICATION UPDATE

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
Code Facts

Overview

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

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 $f'_{ck}$
  - comply with specified products and execution
  - comply with required level of quality assurance
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

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
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.

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

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

<table>
<thead>
<tr>
<th>Assembly Compressive Strength ($f'_m$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph of Assembly Compressive Strength ($f'_m$)" /></td>
</tr>
</tbody>
</table>

**Assembly Compressive Strength ($f'_m$)**

<table>
<thead>
<tr>
<th>Type S Mortar</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph of Type S Mortar" /></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Net area compressive strength of concrete masonry units, psi (MPa)</th>
<th>Net area compressive strength of concrete masonry units, psi (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types M, S, and N mortar</td>
<td>Types M, S, and N mortar</td>
</tr>
<tr>
<td>1,500 (11.2)</td>
<td>1,500 (11.2)</td>
</tr>
<tr>
<td>2,000 (13.9)</td>
<td>2,000 (13.9)</td>
</tr>
<tr>
<td>2,500 (17.6)</td>
<td>2,500 (17.6)</td>
</tr>
<tr>
<td>3,000 (21.3)</td>
<td>3,000 (21.3)</td>
</tr>
<tr>
<td>3,500 (25.0)</td>
<td>3,500 (25.0)</td>
</tr>
<tr>
<td>4,000 (28.8)</td>
<td>4,000 (28.8)</td>
</tr>
<tr>
<td>4,500 (32.6)</td>
<td>4,500 (32.6)</td>
</tr>
<tr>
<td>5,000 (36.3)</td>
<td>5,000 (36.3)</td>
</tr>
</tbody>
</table>

*For units of less than 4 in (102 mm) nominal length, use 85 percent of the values listed.*
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 \( f'_{m} \)
- 2,000 psi unit \( f'_{m} \)

Historically \( f'_{m} = 1,500 \text{ psi} \) has been the default baseline for the specified compressive strength of concrete masonry. The recalibrated table doesn’t even go as low as \( f'_{m} = 1,500 \text{ psi} \); instead starting at 1,900 psi for Type S mortar.

But \( f'_{m} = 1,900 \text{ psi} \) feels ‘irregular’...

\( f'_{m} = 2,000 \text{ psi} \) 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.
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

<table>
<thead>
<tr>
<th>Compressive strength of concrete masonry units (psi)</th>
<th>Type N mortar</th>
<th>Type S mortar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 (7.0)</td>
<td>2,000 (13.3)</td>
<td>2,500 (17.1)</td>
</tr>
<tr>
<td>2,500 (17.1)</td>
<td>3,000 (20.3)</td>
<td>3,500 (23.5)</td>
</tr>
<tr>
<td>5,000 (34.9)</td>
<td>4,000 (27.5)</td>
<td>4,500 (30.6)</td>
</tr>
</tbody>
</table>

For mix-strength less than 4 psi, the mortar strength, and 85% of the values listed.

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
  - 10% increase in masonry shear strength
  - Effectively changes $x_e$ to 0.07 for masonry shear strength

Overview

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

<table>
<thead>
<tr>
<th>Allowable Stress Design</th>
<th>Strength Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where ( M/(V_{n}) \leq 0.5 )</td>
<td>Where ( M/(V_{n}) \leq 0.5 )</td>
</tr>
<tr>
<td>( f_{y} = \frac{f_{d}A_{f} + f_{r}}{A_{m}} )</td>
<td>( V_{n} = f_{d}A_{f} + f_{r} )</td>
</tr>
<tr>
<td>Linear interpolation for intermediate values</td>
<td></td>
</tr>
</tbody>
</table>

Where \( M/(V_{n}) \leq 1.0 \) |
| \( f_{y} = \frac{0.4M_{d}A_{f} + f_{r}}{A_{m}} \) | \( V_{n} = 0.4M_{d}A_{f} + f_{r} \) |
| \( \mu = 1.0 \) for masonry on concrete with unfinished surface, or concrete with a surface that has been intentionally roughened |
| \( \mu = 0.70 \) for all other conditions |
| UBC (1997) required concrete abutting structural masonry to be roughened to a full amplitude of 1/16 inch. |

Shear Friction: Special Reinforced Shear Walls

Shear Capacity Design (7.1.2.6.1)
- Strength Design
  - \( \phi V_{n} \) = shear corresponding to the development of \( 1.25M_{n} \)
  - \( V'_{n} \) need not exceed \( 2.5V_{n} \)
- 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, \( V'_{n} \)
- Allowable Stress Design
  - The 1.5 multiplier should not be applied to \( V' \) when calculating the \( M/Vd \) ratio, or for shear friction design.

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**Anchor Bolts: Two Major Changes**

<table>
<thead>
<tr>
<th>Allowable Stress Design</th>
<th>Strength Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masonry Crushing</td>
<td></td>
</tr>
<tr>
<td>( f_{u_m} = \frac{500}{\sqrt{f_{c}} + 350} )</td>
<td>( f_{u} = \frac{500}{\sqrt{f_{c}}} )</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
</tr>
</tbody>
</table>
| \( \frac{f_{u_m}}{f_{c}} \cdot \frac{f_{y}}{f_{c}} \leq 1 \) | \( \frac{f_{u}}{f_{c}} \cdot \frac{f_{y}}{f_{c}} \leq 1 \)

---

**Anchor Bolts: Masonry Crushing**

<table>
<thead>
<tr>
<th>TMS 402-11 Governing Equation</th>
<th>Breakout</th>
<th>Crushing</th>
<th>Yielding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 4 \sigma_{y} \sqrt{f_{c}} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Tests</td>
<td>95</td>
<td>88</td>
<td>64</td>
</tr>
<tr>
<td>Average of Test/Calculated</td>
<td>1.23</td>
<td>1.33</td>
<td>1.45</td>
</tr>
<tr>
<td>Standard Deviation of Ratio</td>
<td>0.14</td>
<td>0.23</td>
<td>0.20</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>0.11</td>
<td>0.30</td>
<td>0.14</td>
</tr>
</tbody>
</table>

- Several alternate equations for shear crushing were examined
- FEMA 369 equation chosen: \( 1750 \sqrt{f_{c}} \)

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**Anchor Bolts: Masonry Crushing**

<table>
<thead>
<tr>
<th>TMS 402-16 Governing Equation</th>
<th>Breakout</th>
<th>Crushing</th>
<th>Yielding</th>
</tr>
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<tbody>
<tr>
<td>Design Strength</td>
<td></td>
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</tr>
<tr>
<td>( 4 \sigma_{y} \sqrt{f_{c}} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Tests</td>
<td>95</td>
<td>131</td>
<td>119</td>
</tr>
<tr>
<td>Average of Test/Calculated</td>
<td>1.23</td>
<td>1.49</td>
<td>1.44</td>
</tr>
<tr>
<td>Standard Deviation of Ratio</td>
<td>0.14</td>
<td>0.44</td>
<td>0.35</td>
</tr>
<tr>
<td>Coefficient of Variation</td>
<td>0.11</td>
<td>0.29</td>
<td>0.24</td>
</tr>
</tbody>
</table>
Anchor Bolts: Interaction

<table>
<thead>
<tr>
<th>$n_i = 1$ (linear)</th>
<th>$n_i = 5/3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>0.25</td>
<td>0.15</td>
</tr>
</tbody>
</table>

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Dispersion of Load Adjacent to Opening
Deleted Piers: Strength Design

9.3.4.3 Piers
9.3.4.3.1 The factored axial compression force on piers shall not exceed \( 0.3A_f' \).
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 \( \text{bx} \).
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.

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)
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.

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
Added to TMS 602 SPECIFICATION
2.3 Masonry unit materials
2.3F. Provide cast stone that conforms to ASTM C1364 as specified.
2.3G. 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

Qualifications of Inspectors and Testing Technicians

<table>
<thead>
<tr>
<th>J605 TMS 565 Commentary</th>
<th>J605 TMS 565 Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.6A. Testing Agency's services and duties</td>
<td>6.6A. Testing Agency's services and duties</td>
</tr>
<tr>
<td>1. Utilize qualified laboratory technicians to perform required laboratory tests.</td>
<td>1. Masonry testing laboratory personnel who are certified in accordance with ACI Masonry Laboratory Testing Technician Certification Program, or equivalent program, are qualified.</td>
</tr>
<tr>
<td>6.6B. Inspection Agency's services and duties</td>
<td>6.6B. Inspection Agency's services and duties</td>
</tr>
<tr>
<td>1. Utilize qualified field testing technicians to observe or perform the preparation and handling of test specimens, mortar specimens and/or masonry prisms.</td>
<td>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 mortar specimens.</td>
</tr>
<tr>
<td>2. Utilize qualified Special Inspectors to inspect and evaluate construction.</td>
<td>2. Special inspectors who are certified for this service by International Code Council, or other acceptable agency, are qualified.</td>
</tr>
</tbody>
</table>
### Overview

- **Technical Changes**
  - Shear Friction
  - Anchor Bolts
  - Others

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### Chapter 6: Reinforcement, Metal Accessories, And Anchor Bolts

<table>
<thead>
<tr>
<th>2005 TMS 402</th>
<th>2016 TMS 402</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Details of reinforcement and metal accessories</td>
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</tr>
<tr>
<td>6.1.1 Embedment</td>
<td>6.1.1 Embedment</td>
</tr>
<tr>
<td>6.1.2 Size of reinforcement</td>
<td>6.1.2 Size of reinforcement</td>
</tr>
<tr>
<td>6.1.3 Placement of reinforcement</td>
<td>6.1.3 Placement or reinforcement</td>
</tr>
<tr>
<td>6.1.4 Protection of reinforcement and metal accessories</td>
<td>6.1.4 Protection of reinforcement</td>
</tr>
<tr>
<td>6.1.5 Standard hooks</td>
<td>6.1.5 Development of bar reinforcement in tension or compression</td>
</tr>
<tr>
<td>6.1.6 Minimum bend diameter for reinforcing bars</td>
<td>6.1.6 Development of wire in tension</td>
</tr>
</tbody>
</table>

- **6.1.1 Embedment**
  - 6.1.1.1 Splices of bar reinforcement
    - 6.1.1.1.1 Lap splices
    - 6.1.1.1.2 Welded splices
    - 6.1.1.1.3 Mechanical splices
    - 6.1.1.1.4 End bearing splices
  - 6.1.1.2 Splices of wire in tension
    - 6.1.1.2.1 Lap splices
    - 6.1.1.2.2 Welded splices
    - 6.1.1.2.3 Mechanical splices
Chapter 6: Reinforcement, Metal Accessories, And Anchor Bolts

<table>
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<th>2016 TMS 402</th>
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<tr>
<td>6.1.1 Embedment</td>
<td>6.1.2 Shear reinforcement</td>
</tr>
<tr>
<td>6.1.2 Size of reinforcement</td>
<td>6.1.3 Horizontal shear reinforcement</td>
</tr>
<tr>
<td>6.1.3 Placement of reinforcement</td>
<td>6.1.4 Stirrups</td>
</tr>
<tr>
<td>6.1.4 Protection of reinforcement and metal accessories</td>
<td>6.1.5 Tied wire reinforcement</td>
</tr>
<tr>
<td>6.1.5 Standard hooks</td>
<td>6.1.6 Embedment of flexural reinforcement</td>
</tr>
<tr>
<td>6.1.6 Minimum bend diameter for reinforcing bars</td>
<td>6.1.7 General</td>
</tr>
<tr>
<td>6.1.7 Standard hooks</td>
<td>6.1.8 Development of positive moment reinforcement</td>
</tr>
<tr>
<td>6.1.8 Shear reinforcement</td>
<td>6.1.9 Development of negative moment reinforcement</td>
</tr>
<tr>
<td>6.1.9 Embedment of flexural reinforcement</td>
<td>6.1.9.1 General</td>
</tr>
<tr>
<td>6.1.9.2 Development of positive moment reinforcement</td>
<td>6.1.9.3 Development of negative moment reinforcement</td>
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<td>6.1.9.4 Standard hooks</td>
</tr>
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<td>6.1.9.5 Protection of metal accessories</td>
</tr>
<tr>
<td>6.1.9.5 Embedment of flexural reinforcement</td>
<td>6.2 Anchor bolts</td>
</tr>
<tr>
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<td>6.3 Anchor bolts</td>
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</tbody>
</table>

Quality Assurance Tables

<table>
<thead>
<tr>
<th>2013 TMS 402</th>
<th>2016 TMS 402</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tables were in TMS 402 Chapter 3 and TMS 602 Article 1.6.</td>
<td>Tables just in TMS 602 and referenced from TMS 402 Chapter 3.</td>
</tr>
<tr>
<td>Three tables:</td>
<td>Two tables:</td>
</tr>
<tr>
<td>• Quality Assurance Level A</td>
<td>• Minimum verification requirements</td>
</tr>
<tr>
<td>• Quality Assurance Level B</td>
<td>• Minimum special inspection requirements</td>
</tr>
<tr>
<td>• Quality Assurance Level C</td>
<td></td>
</tr>
</tbody>
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2013 Quality Assurance Tables

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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 imposed 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.

**Definition of Loads: TMS 402**

2013 TMS 402:
- Working stresses
- Nominal 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.
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 is permitted to be filled with mortar or grout.

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.
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

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)

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
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

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

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.
New to Chapter 21, Masonry, of the 2018 IBC

- Other structural changes related to masonry.
  - 72\(d_y\) 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

\[
L_p = \frac{0.13 \cdot d^2 \cdot f_y}{K \sqrt{f_m}}
\]

Lap Splice Length may be reduced to 72\(d_y\), despite what may be required by lap length equation

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)

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
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.

Structural Masonry Design

Questions?