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Reorganization of ACI 318-14

- The first regulations were published in 1908 and first ACI code in 1910
- Working stress design up until 1971
- Organization unchanged
- 2008 started reorganization
- ACI 318-14 reorganized

Old and New Organization

ACI 318-11
- Mixture of member-based and behavior-based provisions
- Provisions scattered
- Does not follow the design process
- Increased potential for errors

ACI 318-14
- Primarily member-based provisions
- Supporting “toolbox” chapters
- Follows the design process
- Design roadmap for each member type

Old and New Organization

ACI 318-11
- Shear Strength, Chapter 11
- Flexural and Axial Strength, Chapter 10
- Strength Reduction Factors, Chapter 9
- Lap Splice, 12.35-12.37
- Ties in Joint, 31.10.2
- Ties, 7.305
- Stairs, 7.8.1.1
- Cover, 7.7
Old and New Organization

ACI 318-14 Organization

- General
- Analysis
- Members
- Joints/Connections/Anchors
- Seismic
- Materials and Durability
- Strength and Serviceability
- Reinforcement
- Construction
- Evaluation

General: Chapters 1 to 4
1 – General Provisions
2 – Notation and Terminology
3 – Referenced Standards
4 – Structural Systems Requirements (new)

Analysis: Chapters 5 and 6
5 – Loads
6 – Structural Analysis

Members: Chapters 7 to 14
7 – One-Way Slabs
8 – Two-Way Slabs
9 – Beams
10 – Column
11 – Walls
12 – Diaphragms (new)
13 – Foundations
14 – Plain Concrete

Joints/Connections/Anchors: Chap. 15 to 17
15 – Beam-Column and Slab-Column Joints
16 – Connections Between Members
17 – Anchoring to Concrete

Seismic: Chapter 18
18 – Earthquake Resistant Structures

Materials and Durability: Chapters 19 and 20
19 – Concrete: Design and Durability Properties
20 – Steel Reinforcement Properties, Durability and Embedments

Strength and Serviceability: Chapters 21 to 24
21 – Strength Reduction Factors
22 – Sectional Strength
23 – Strut and Tie Models
24 – Serviceability Requirements

Reinforcement: Chapter 25
25 – Reinforcement Details

Construction: Chapter 26
26 – Construction Documents and Inspection

Evaluation: Chapter 27
27 – Strength Evaluation of Existing Structures
• Changes in Seismic Provisions

- 318-11 Chapter 21 → 318-14 Chapter 18
- Seismic chapter was not reorganized
- Limited, but important, technical changes

Confinement in SMRF columns with high $P_u$

Additional cross ties are required

**ACI 318-14, 18.7.5.2(f):** Where $P_u > 0.3A_f f_y$ or $f_y > 10,000$ psi in columns with rectilinear hoops, every longitudinal bar ... around the perimeter ... shall have lateral support provided by the corner of a hoop or by a seismic hook, and the maximum value of $h_y$ shall not exceed 8 in.

Note: This same provision applies to concrete truss elements with high axial load. See 18.12.11.1

Transverse Reinforcement in SMRF Columns With High $P_u$

For high $P_u$, additional check (c) on $A_{sh}$

**Table 18.7.5.4—Transverse reinforcement for columns of special moment frames**

<table>
<thead>
<tr>
<th>Transverse reinforcement</th>
<th>Conditions</th>
<th>Applicable expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_u &lt; 0.3A_f f_y$ and $f_y &lt; 10,000$ psi</td>
<td>Greater of (a) and (b)</td>
<td>$0.25 A_s f_y$ (a)</td>
</tr>
<tr>
<td>$P_u &gt; 0.3A_f f_y$ or $f_y &gt; 10,000$ psi</td>
<td>Greatest of (a), (b), and (c)</td>
<td>$0.09 f_y^{-1}$ (b)</td>
</tr>
</tbody>
</table>

Where:
- $K_c = $ confinement effectiveness factor
- $K_n = $ confinement effectiveness factor
**Headed Bars in SMRFs at Edge Joints**

18.8.3.4: Two options for confinement of bar heads:

- Minimum Column Extension
- Add "T" Bars at Top

**Spacing of Headed Bars in Joints**

For SMRF joints, minimum 3d, clear spacing

**ACI 318-14, 18.8.5.2:** For headed deformed bars satisfying 20.2.1.6, development in tension shall be in accordance with 25.4.4, except clear spacing between bars shall be permitted to be at least 3d, or greater.

**Special Structural Walls Detailing**

Certain special walls require two curtains of reinforcement:

**ACI 318-14, 18.10.2.2:** At least two curtains of reinforcement shall be used in a wall if $V_u > 2A_v \cdot \lambda \frac{f'}{f}$, or $h_w/e_w \geq 2.0$, in which $h_w$ and $e_w$ refer to height and length of entire wall.

Based on observations from Chile and N.Z. Earthquakes

**Special Structural Walls Detailing**

Requirement for special boundary elements modified:

- **ACI 318-14, 18.10.6.2**
- $c = \text{depth of wall neutral axis to extreme compressive fiber}$
- Need boundary element if

$$c \geq \frac{\ell_w}{600(1.5)(\delta_u/h_w)}$$

- Ratio $\delta_u/h_w$ shall not be taken less than 0.005.

**Special Structural Walls Detailing**

Minimum width (thickness) of walls in compression zone:

- **Width of wall compression zones (ACI 318-14, 18.10.6.4)**
  (b) Width of the flexural compression zone, $b$, over the horizontal distance calculated by $18.10.6.4(a)$, including flange if present, shall be at least $b = (\text{b (unbraced Wall Height)}/16$
  (c) For walls or wall piers with $h_w/e_w \geq 2.0$ that are effectively continuous from the base of structure to top of wall, designed to have a single critical section for flexure and axial loads, and with $e/w \geq 3/8$, width of the flexural compression zone $b$ over the length calculated in 18.10.6.4(a) shall be greater than or equal to 12 in.

**Special Structural Walls Detailing**

Ties in walls where special boundary elements not required:

**ACI 318-14, 18.10.6.5 (a):** If the boundary reinforcement ratio exceeds $400/f_y$, ...tie spacing < the lesser of 8 in. and $8d_y$ of the smallest vertical bar, except tie spacing < the lesser of 6 in. and $6d_y$ within the greater of $\ell_y$ and $M_y/4V_y$ above and below critical sections where yielding of longitudinal reinforcement is likely to occur as a result of inelastic lateral displacements.

See illustration in next slide →
Special Structural Walls Detailing

Ties spacing where special boundary elements not required:

\[ \rho < \frac{400}{f_p} \]

\[ \rho \geq \frac{400}{f_p} \]

\[ \text{max} \left\{ \frac{M_d}{V_d \text{critical section}} \right\} \]

- No ties required
- Lesser of 8 inches or 8 times diameter smallest longitudinal bar
- Lesser of 6 inches or 6 times diameter smallest longitudinal bar

ACI envisions a future where everyone has the knowledge needed to use concrete effectively to meet the demands of a changing world.

ACI develops and disseminates consensus-based knowledge on concrete and its uses.

A Few Moments About the American Concrete Institute

Andrew W. Taylor
An ACI Ambassador

An Institute of Members & Chapters

- Over 18,000 institute members from 120 countries
- Plus about 20,000 members from ACI’s 165+ Chapters and Student Chapters
- Engineers, researchers, students, contractors, architects, educators, manufacturers, producers, governments, and more
My Involvement with ACI

- Began in 1990 when I became a researcher at the National Institute of Standards and Technology. I have been active with ACI technical committees ever since.

Andrew W. Taylor
ACI Fellow
ACI 318 Building Code
ACI 318-H (Chair) Seismic Provisions
ACI 374 Performance-Based Design
ACI Technical Activities Committee

Thank you

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