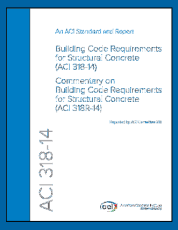
Reorganization of the ACI 318-14 Building Code and Changes in Seismic Design Provisions

The 2nd JCI & ACI Joint Seminar
July 13, 2015 Tokyo, Japan

Andrew W. Taylor, PhD, SE, FACI
KPFF Consulting Engineers, Seattle, USA

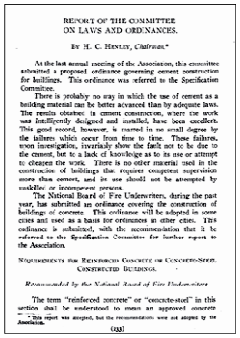
- Reorganization of ACI 318-14
- Changes in Seismic Provisions
- About ACI Technical Activities

- Reorganization of ACI 318-14



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


REPORT OF THE COMMITTEE ON LAWS AND ORDINANCES.

BY H. C. HENLEY, CHAIRMAN.*

At the last annual meeting of the Association, the committee submitted a proposed ordinance governing cement construction for buildings. This ordinance was referred to the Specification Committee.

There is probably no way in which the use of cement as a building material can be better advanced than by adequate laws. The results obtained in cement construction, where the work was intelligently designed and installed, have been excellent. This good record, however, is marred in no small degree by the failures which occur from time to time. These failures, upon investigation, invariably show the fault not to be due to the cement, but to a lack of knowledge as to its use or attempt to cheapen the work. There is no other material used in the construction of buildings that requires competent supervision more than cement, and its use should not be attempted by unskilled or incompetent persons.

The National Board of Fire Underwriters, during the past year, has submitted an ordinance covering the construction of buildings of concrete. This ordinance will be adopted in some cities and used as a basis for ordinances in other cities. This ordinance is submitted, with the recommendation that it be referred to the Specification Committee for further report to the Association.

REQUIREMENTS FOR REINFORCED CONCRETE OR CONCRETE-STEEL CONSTRUCTED BUILDINGS.

Recommended by the National Board of Fire Underwriters

The term "reinforced concrete" or "concrete-steel" in this section shall be understood to mean an approved concrete

*This report was accepted, but the recommendations were not adopted by the Association.

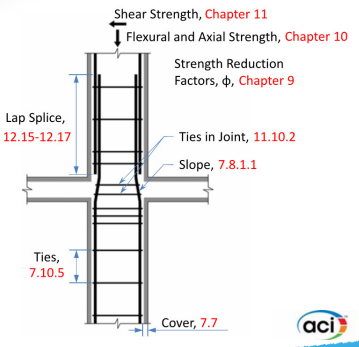
(331)

Old and New Organization

ACI 318-11	ACI 318-14
• Mixture of member-based and behavior-based provisions	• Primarily member-based provisions
• Provisions scattered	• Supporting "toolbox" chapters
• Does not follow the design process	• Follows the design process
• Increased potential for errors	• Design roadmap for each member type

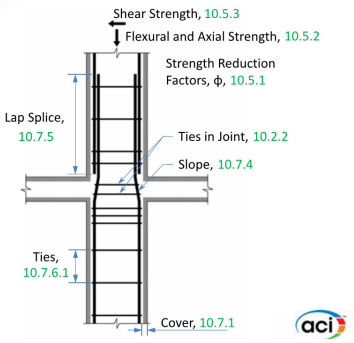
Old and New Organization

ACI 318-11 Organization



Old and New Organization

ACI 318- 14 Organization



ACI 318-14 Organization

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

ACI 318-14 Organization

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

ACI 318-14 Organization

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

ACI 318-14 Organization

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

ACI 318-14 Organization

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

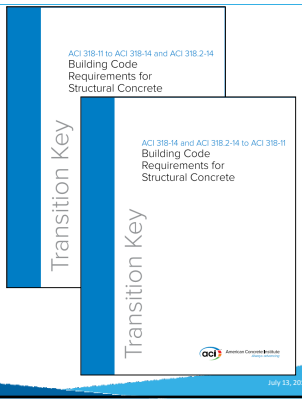
ACI 318-14 Resources

Cross Indexes:

ACI 318-11 to ACI 318-14

ACI 318-14 to ACI 318-11

Free downloads from ACI



ACI 318-14 Resources

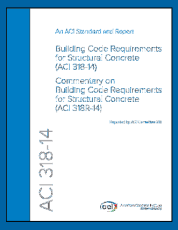
ACI 318-14 Code Update Seminars

Check ACI web site for dates and locations

Design Guide for ACI 318-14

In preparation by ACI

• Changes in Seismic Provisions



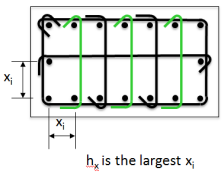
Changes in Seismic Design Provisions

- 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 $P_u > 0.3A_g f'_c$ or $f'_c > 10{,}000$ 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_x 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

Transverse reinforcement	Conditions	Applicable expressions	
	$P_u \le 0.3A_g f_c'$ and $f_c' \le 10{,}000$ psi	Greater of (a) and (b)	$0.3\left(\frac{A_g}{A_{ch}}-1\right)\frac{f_c'}{f_{yt}}$ (a)
A_{sh}/sb_c for rectilinear hoop	$P_u > 0.3A_g f_c'$ or $f_c' > 10{,}000$ psi	Greatest of (a), (b), and (c)	$0.09\frac{f_c'}{f_{yt}}$ (b)
			$0.2k_f k_n \frac{P_u}{f_{yt}A_{ch}}$ (c) New

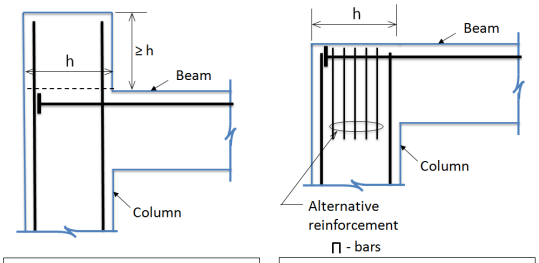
Where:

K_f = concrete strength factor ($f'c > 10{,}000$ psi)

K_n = confinement effectiveness factor

Headed Bars in SMRFs at Edge Joints

18.8.3.4: Two options for confinement of bar heads:



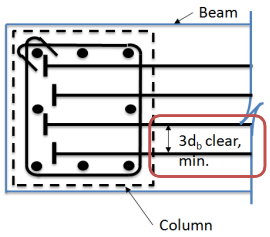
Minimum Column Extension

Add "Π" Bars at Top

Spacing of Headed Bars in Joints

For SMRF joints, minimum $3d_b$ 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 $3d_b$ or greater.

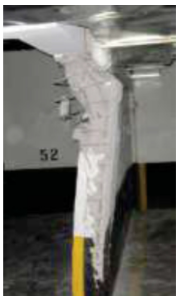


Special Structural Walls Detailing

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 $V_u > 2A_{cv}\lambda\sqrt{f'_c}$ or $h_w/\ell_w \geq 2.0$, in which h_w and ℓ_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 = 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 δ_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 $h_w/16$. ← (Unbraced Wall Height)/16

(c) For walls or wall piers with $h_w/\ell_w \geq 2.0$ 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 $c/\ell_w \geq 3/8$, 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

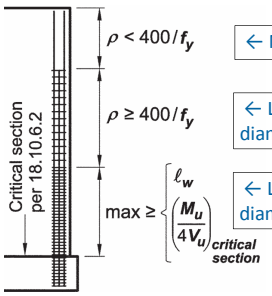
Ties in walls where special boundary elements not required:

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 $8d_b$ of the smallest vertical bars, **except** tie spacing < the lesser of 6 in. and $6d_b$ within the greater of ℓ_w and $M_u/4V_u$ 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:

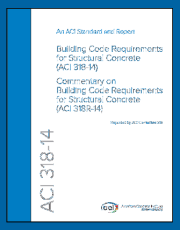


← No ties required

← Lesser of 8 inches or 8 times diameter smallest longitudinal bar

← Lesser of 6 inches or 6 times diameter smallest longitudinal bar

• About ACI Technical Activities



A Few Moments About the American Concrete Institute

Andrew W. Taylor
An ACI Ambassador

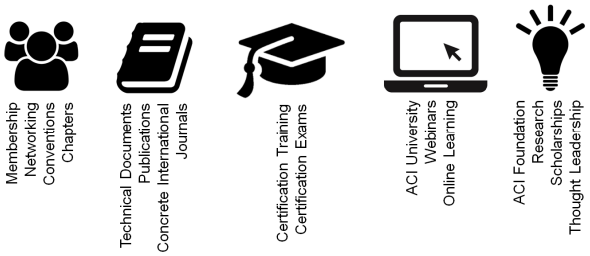
American Concrete Institute — *Always advancing*

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.

American Concrete Institute — *Always advancing*



American Concrete Institute — *Always advancing*

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, government, and more

American Concrete Institute — *Always advancing*

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

*For the most up-to-date information, please visit the American Concrete Institute at: **www.concrete.org**.*

ConcreteSmartBrief

American Concrete Institute
Always advancing