SIGNIFICANT CHANGES IN THE 2002 ACI CODE – INCLUDING CHANGES AFFECTING PRECAST/PRESTRESSED CONCRETE

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The author summarizes the significant changes made since the publication of the 1999 ACI 318 Building Code that are reflected in the 2002 edition of the Code, which is expected to be released early in 2002.

The 2002 edition of the American Concrete Institute's "Building Code Requirements for Structural Concrete" (ACI 318-02) is in final stages of preparation. The significant changes from the previous edition of the ACI Code (ACI 318-99) are summarized in this article.

The changes were published in the June 2001 issue of ACI's *Concrete International*[1]. Pertinent discussion will be published in a future issue of *Concrete International*, if received by September 1, 2001. ACI Committee 318 is required to respond in writing to all the discussion that comes in. In the process of responding to public comments, the Committee may decide to make modifications to the published changes. However, major changes are not anticipated at this stage.

This summary is provided with the intent that anyone interested in finding out how code regulations are changing for conventionally reinforced as well as post-tensioned concrete, and not just for precast, prestressed concrete, will find the information useful.

ACI 318-02 will be the reference document for concrete design and construction in the 2003 edition of the *International Building Code*, the 2002 edition of the ASCE 7 Standard *Minimum Design Loads for Buildings and Other Structures*, and the first (2002) edition of the NFPA 5000 Building Code, currently under development by the National Fire Protection Association.

All section numbers refer to the 2002 Code, unless otherwise noted. In the following paragraphs, strike-out marks indicate deletion of existing (ACI 318-99) text, and underlining indicates addition of new text.

(1) Section 3.2.1, Blended Cement - Blended Hydraulic Cement complying with ASTM C1157 is added as a cement conforming to ACI 318 requirements.

(2) Sections 3.5.3.1, 3.5.4.1, 3.8.1, ASTM Specifications for Reinforcing Bars - ASTM has combined specifications A616/A616M and A617/A617M into a new specification A996/A996M. ASTM specification A706/A706M for low-alloy steel reinforcing bars was revised in 1996 to include plain bars, so that plain low-alloy steel bars could be used in spiral reinforcement. This change updates Code sections 3.5.3.1, 3.5.4.1 and 3.8.1 to reflect the current ASTM specifications for reinforcing bars.

(3) R4.3.1, Sulfate Exposures - The following correction is made: The blended cements under ASTM C 595 ~~made with Portland Cement clinker with less than 8 percent C_3A qualify for~~ with the MS designation, ~~and therefore~~, are appropriate for use in moderate sulfate exposures.

(4) Reference 4.13, Chloride Permeability - AASHTO T 277-83 is replaced with ASTM C 1202-97, "Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration," ASTM Book of Standards, Part 04.02, ASTM, Philadelphia, Pa.

(5) Section 5.1.1, Minimum Concrete Strength - New requirement has been added:
…For concrete designed and constructed in accordance with the code, f'_c shall not be less than 2500 psi.

(6) Section 5.2.3, Water-Cementitious Ratio - The current text of 5.2.3 can be misinterpreted to mean that if you satisfy 5.3, you don't need to satisfy the durability requirements of Chapter 4. This is not the intent. Thus the section has been rewritten as follows:

5.2.3 – Concrete proportions shall be established in accordance with 5.3 or, alternatively, 5.4 and shall meet applicable requirements of Chapter 4.

(7) Section 5.6.5.3, Conditioning of Cores Before Testing - Bartlett and MacGregor[2] have found that cores in an as received condition after drilling are the closest to the in-situ strength of the concrete represented by the core. This is independent of the wet or dry in-service condition of the concrete. Cores air-dried for 7 days are 5 to 9 percent stronger and cores soaked 40 hours are 14 percent lower in strength as compared to the in-service strength they represent.

The following section has been deleted:
5.6.5.3 – If concrete in the structure will be dry under service conditions, cores will be air dried (temperature 60 to 80 F, relative humidity less than 60 percent) for 7 days before test and shall be tested dry. If concrete in the structure will be more than superficially wet under service conditions, cores will be immersed in water for at lest 40 hr and be tested wet.

The following section has been substituted:

5.6.5.3 – Cores shall be prepared for transport and storage by wiping drilling water from their surfaces and placing the cores in watertight bags or containers immediately after drilling. Cores shall be tested not later than 7 days after coring unless approved by the engineer.

(8) Section R5.6.4, Core Testing - Add to R5.6.4, third paragraph (R5.6.5, ACI 318-99): A core obtained through the use of a water-cooled bit results in a moisture gradient between the exterior and interior of the core being created during drilling. This adversely affects the core's compressive strength [Bartlett & MacGregor[2]]. Cores obtained by using water-cooled bits should not be tested within 24 hrs. of coring to allow time for the moisture gradient created by the wetting during drilling to dissipate.

(9) Section 7.5.2.2, Tolerance at Ends of Members - The aim is to resolve a conflict in a tolerance value between ACI 318 and ACI 117. Section 7.5.2.2 requires a ± ½ in. tolerance on ends of reinforcement at discontinuous ends of members while the tolerance standard, ACI 117[3], specifies ± 1 in. This change attempts to resolve this conflict. Portions of 7.5.2.2 have been rewritten as follows:

7.5.2.2. - … the tolerance shall be ± ½ in. at the discontinuous ends of brackets and corbels, and ± 1 in. at the discontinuous ends of other members. The tolerance for minimum cover of 7.5.2.1 shall also apply at discontinuous ends of members.

(10) Section 7.13.2, Requirements for Structural Integrity for Cast-in-Place Construction - Section 7.13.2 has been revised to: (a) permit use of mechanical and welded splices for splicing reinforcing bars; and (b) enhance the effectiveness of the reinforcement details in perimeter beams to provide catenary action in the event the support of a beam sustains damage.

(11) Section 9.2, Load Combination Update - This change updates the ASCE 7 reference to the 1998 edition; adjusts load combinations of 9.2 for new wind loads and strength-based earthquake loads of ASCE 7-98 and IBC 2000; and corrects the commentary of Appendix C to reflect the updated ASCE 7 reference.

Load Combinations:

Old (9.2) $U = 0.75\,(1.4D + 1.7L + 1.7W)$

$= 0.75(1.4D + 1.7L) + 1.275\,W$

Old (9-2), Substitute 1.1E for W:

$U = 0.75(1.4D + 1.7L) + 1.4E$

New (9.2) $U = 0.75\,(1.4D + 1.7L) + (1.6W \text{ or } 1.0E)$

(12) Sections 9.2, 9.3, Move Appendix C to chapter 9, and Move Traditional Load Combinations and Strength Reduction Factors to Appendix C Load Combinations

9.2 - $U = 1.4 (D + F)$ (9-1)
$= 1.2 (D + F + T) + 1.6 (L + H) + 0.5 (L_r \text{ or } S \text{ or } R)$ (9-2)
$= 1.2D + 1.6 (L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.8W)$ (9-3)
$= 1.2D + 1.6W + 0.5L + 0.5 (L_r \text{ or } S \text{ or } R)$ (9-4)
$= 1.2D + 1.0E + 0.5L + 0.2S$ (9-5)
$= 0.9D + 1.6W + 1.6H$ (9-6)
$= 0.9D + 1.0E + 1.6H$ (9-7)

9.2 – (a) The load factor on L in Eq. (9-3) to (9-5) shall equal 1.0 for garages, areas occupied as places of public assembly, and all areas where the live load is greater than 100 psf.
9.2 – (b) The load factor on H shall be set equal to zero in Eq. (9-6) and (9-7) if the structural action due to H counteracts that due to W or E. Where lateral earth pressure provides resistance to structural actions from other sources, it shall not be included in H but shall be included in the design resistance.

9.3.2 - Strength-reduction factor ϕ shall be as follows:
9.3.2.1 – Flexure, without axial load….0.90
9.3.2.2 – (a)Axial tension, and axial tension with flexure………..0.85

(13) Section 10.5.2, Minimum Reinforcement of Flexural Members - The requirements are editorially modified; required quantity remains the same.

(14) Section 10.6.7, Skin Reinforcement - A simplified version of ACI 318 Section 10.6.7 was developed by Subcommittee SC5 of ISO Technical Committee TC71. It results in the same amount of reinforcement as 10.6.7, but is easier to apply. The simplified version is adopted. This is also an editorial change.

(15) Section 10.15.3, Transmission of Column Loads through Floor System - Research [Ospina and Alexander[4]] has shown that heavily loaded slabs do not provide as much confinement as lightly loaded slabs when ratios of column concrete strength to slab concrete strength exceed about 2.5. Consequently, a limit is placed on the strength ratio.

10.15.3 – For columns laterally supported on four sides by beams of approximately equal depth or by slabs and where the specified strength of concrete in a column is not greater than 2.5 times that specified for the floor system, strength of the column shall be permitted to be based on an assumed concrete strength in the column joint equal to 75 percent of column concrete strength plus 35 percent of floor concrete strength.

(16) Sections 11.0, 11.6.1, Threshold Torsion in Hollow Sections - When the torsion provisions of the ACI Code are applied to hollow sections, the threshold torque, below which torsional effects can be ignored, is a larger fraction of the cracking torque than for solid sections. This situation is corrected.

(17) Sections 11.1.2.1, 11.5.5.3, Upper Limits on Shear Strength Contributed by Concrete - The 1989 provision, which led to a sudden increase in the minimum amount of transverse reinforcement at a compressive strength of 10,000 psi, has been replaced by a gradual increase in the minimum A_v as f'_c increases, as given by Eq. (11-13).

11.1.2.1 – Values of $\sqrt{f'_c}$ greater than 100 psi shall be permitted in computing V_c, V_{ci}, and V_{cw} for reinforced or prestressed concrete beams and concrete joist construction having minimum web reinforcement ~~equal to f'c/5000 times, but not more than three times, the amounts required by~~ in accordance with 11.5.5.3, 11.5.5.4, or 11.6.5.2.

11.5.5.3 – Where shear reinforcement is required by 11.5.5.1 or for strength and where 11.6.1 allows torsion to be neglected, the minimum area of shear reinforcement for prestressed (except as provided for in 11.5.5.4) and nonprestressed members shall be computed by:

A_V = ~~50~~0.75$\sqrt{f'_c}\,(b_w s/f_y)$ (11.13)

but no less than $(50\, b_w s/f_y)$, where b_w and s are in inches.

(18) Section 11.12.3, Shear Reinforcement in Slabs - For increased safety, the minimum slab depth in which bent bars or wire and single- or multiple-leg stirrups are used as shear reinforcement is given in terms of effective depth, d, as opposed to overall slab depth. In addition to a numeric value, the minimum effective depth is set at 16 times the bar diameter to limit the size of bars used as shear reinforcement in thinner slabs. Also, it is required that slab shear reinforcement must engage the flexural reinforcement in the direction under consideration.

(19) Section 12.0, Compression and Hooked Tension Reinforcement Development Length - This change clarifies the notation in Section 12.0 including the definitions for l_d, l_{db}, and l_{dh}. It also parallels the description of tension reinforcement with the description for compression and hooked tension reinforcement (i.e. it removes reference to "basic" development length).

Section 12.0 has been rewritten as follows:

l_d = development length of deformed bars and deformed wire in tension, in.
~~= l_{db} x applicable modification factors~~
l_{dc} = development length of deformed bars and deformed wire in compression, in.
~~l_{db} = basic development length, in.~~
l_{dh} = development length of standard hook in tension, measured from critical sections to outside end of hook (straight embedment length between critical section and start of hook [point of tangency] plus radius of bend and one bar diameter), in.
~~= l_{hb} x applicable modification factors~~

(20) Sections 12.5.3.3, 12.5.4, R12.5, Clarify the Enclosure of Hooks and Prescribe the Location of First Tie or Stirrup - The wording in 12.5.3.3 is clarified, the location of the first tie or stirrup is specified relative to the corner of the hook in 12.5.3.3, 12.5.4.

(21) Sections 12.9.1, 12.9.1.1, 12.9.2, Development of Prestressing Strand - New Eq. (12-2) was moved from the Commentary to replace the unnumbered relationship formerly shown. It is this form of the equation that is used for analysis and clarifies the design transfer length.

Sections 12.9.2 and R12.9.2 emphasize that it may be unconservative to only investigate sections required to develop full design strength.

Guidance is given for determining capacity at sections where strand may not be fully developed.

(22) Section 12.5.4, "Less than Full" Mechanical and Welded Splices - Editorial clarifications made.

(23) Section R12.2, Development of Deformed Bars and Deformed Wire in Tension - The commentary has been shortened with most of the repetitive comments eliminated. Dated comments comparing 1989 and 1995 provisions have been removed.

Commentary on the behavior of developing and spliced bars in high-strength concrete is added with encouragement for use of transverse reinforcement to promote ductile behavior[5, 6]. Subcommittee B of ACI 318 has been working with Committee 408 on code provisions. Consensus was not achieved on code language. As an interim step for the 2002 Code, Subcommittee B decided to include text in the commentary to encourage designers to provide transverse reinforcement.

(24) Section 16.6.2.3, Positive Moment Reinforcement in Precast Members - The changes in end tolerances for reinforcement in 7.5.2.2 (see above) can result in the end bearing of precast members being on plain concrete when supports satisfy the minimum dimensions of 16.6.2.2. Section 16.6.2.3 is therefore rewritten as follows:

16.6.2.3 – The requirements of 12.11.1 shall not apply to the positive bending moment reinforcement for statically determinate precast members, but at least one-third of such reinforcement shall extend, after consideration of tolerances, to the center of the bearing length.

(25) Chapters 1, 2, 3, 7, 8, 9, 11, 18, 19, 20, 21, Prestressed Concrete Terminology - The code uses terminology that is inconsistent with current practice and with respect to at least one document it references (PTI "Specification for Unbonded Single Strand Tendons"). Definitions were modified or added to clarify terminology. A word search was conducted to find all occurrences of the word "tendon." Where the word was used inappropriately, the suggested modification is given.

(26) Sections 18.3, 18.4, Serviceability Requirements for Nonprestressed and Prestressed Members -This change unifies the serviceability requirements for nonprestressed and prestressed concrete. It permits a seamless transition between serviceability requirements for nonprestressed and fully prestressed members. Performance criteria relating to cracking and deflection, consistent with the performance criteria for nonprestressed reinforced concrete, are given (Table 1).

Table 1: Serviceability Design Requirements

	Prestressed			Non-prestressed
	Class U	Class T	Class C	
Assumed behavior	Uncracked	Transition between uncracked and cracked	Cracked	Cracked
Section properties for stress calculation at service loads	Gross section 18.3.4	Gross section 18.3.4	Cracked section 18.3.4	No requirement
Allowable stress at transfer	18.4.1	18.4.1	18.4.1	No requirement
Allowable compressive stress based on uncracked section properties	18.4.2	18.4.2	No requirement	No requirement
Tensile stress at service loads 18.3.3	$\leq 7.5\sqrt{f'_c}$	$7.5\sqrt{f'_c} < f_t \leq 12\sqrt{f'_c}$	No requirement	No requirement
Deflection calculation basis	9.5.4.1 Gross section	9.5.4.2 Cracked section, bilinear	9.5.4.2 Cracked section	9.5.2, 9.5.3 Effective moment of inertia
Crack control	No requirement	No requirement	10.6.4 Modified for strand	10.6.4
Computation of Δf_{ps} or f_s for crack control			Cracked section analysis	$M / (A_s$ x lever arm) or $0.6\ f_y$
Side skin reinforcement	No requirement	No requirement	10.6.7	10.6.7

(27) R18.1.3, Design of Prestressed Concrete Slabs - Secondary moments in prestressed slabs can be induced by eccentric straight tendons, and they can be absent with concordant curved tendons. Thus R18.1.3 is rewritten as follows:

R18.1.3 – The design of prestressed concrete slabs requires recognition of secondary moments induced by ~~the undulating profile of~~ the prestressing tendons.

(28) Section 21.4.2, High-Strength Lightweight Aggregate Concrete - The upper limit on the compressive strength of lightweight aggregate concrete is increased from 4000 to 5000 psi, in view of findings from test results.

(29) Sections 21.6, 21.8, 21.11, 21.13, Precast Construction - New provisions for special moment frames and structural walls constructed of precast concrete (Sections 21.6 and 21.8, respectively) are provided. The new sections are inserted following existing related sections for special moment frames and structural walls. New provisions for intermediate structural walls constructed of precast concrete (Section 21.13), additional provisions for frame systems not proportioned to resist forces induced by earthquake motions (Section 21.11), and additional notations and definitions are also provided.

Reason: ACI 318-99 provided no guidance for the design of earthquake-resistant precast concrete systems.

(30) Section 21.11.3.3, Longitudinal Reinforcement in Gravity Columns - The following change is made:

21.11.3.3 – members with factored gravity axial forces exceeding $A_g f'_c/10$ shall satisfy 21.4.3.1, 21.4.4, 21.4.5, and 21.5.2.1. This change applies to gravity columns that are going to become inelastic under imposed design displacements, and subjects those columns to the minimum and maximum longitudinal reinforcement ratios of 1% and 6%, respectively.

(31) Sections 21.12.4.2, 21.12.5.1, Hoops in Intermediate Moment Frames - For intermediate moment frames, the likelihood of spalling and loss of shell concrete in some regions of the frame elements is high. Both observed behavior in actual earthquakes and experimental research have shown repeatedly that unless the transverse reinforcement is bent around the longitudinal reinforcement and its ends project into the core of the element, the transverse reinforcement will open at the ends and lose the ability to confine the core concrete. Transverse reinforcement of the ends of beams are required to be hoops by this code change.

(32) Section 21.12.6.2, Reinforcement Placement at Slab Edge and Corner Connections - The following addition has been made: 21.12.6.2 - …Effective slab width for exterior and corner connections shall not extend beyond the column face a distance greater than c_t measured perpendicular to the slab span. SeeFig.1.

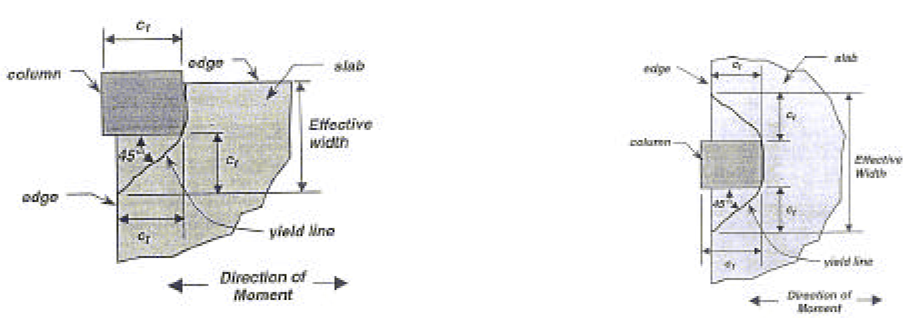

Fig. 1: Width for reinforcement placement in edge and corner connections

Reason: For edge and corner slab-column connections, flexural reinforcement perpendicular to the edge is not fully effective unless placed close to the column.

(33) Section 21.12.6.8, Shear Strength of Two-Way Slabs without Beams in Intermediate Moment Frames Slab-column frames are susceptible to punching-shear failures during earthquakes if the shear stresses due to gravity loads are high. Thus, the following requirement is added:

21.12.6.8 – At the critical sections for columns defined in 11.12.1.2, two-way shear caused by factored gravity loads shall not exceed $0.4\phi V_c$, where V_c shall be calculated as defined in 11.12.2.1 for nonprestressed slabs and 11.12.2.2 for prestressed slabs. It shall be permitted to waive this requirements if the contribution of the earthquake-induced factored two-way shear stress transferred by eccentricity of shear in accordance with 11.12.6.1 and 11.12.6.2 at the point of maximum stress does not exceed one-half of the stress ϕV_n permitted by 11.12.6.2.

(34) Section 21.7.7.4, Coupling Beams - Section 21.7.4.5 limits coupling beams to a maximum nominal shear stress of $10A_{cp}\sqrt{f'_c}$. At the same time, Section 21.7.7.4 Item (2) limits the nominal shear stress to $10\sqrt{f'_c}b_wd$. Hence, one provision uses A_{cp}, while the other specifies b_wd for the respective areas. Although this difference may be small in some instances, it impacts design by up to 15-20%. This change replaces b_wd by A_{cp}.

(35) Chapter 21, Editorial Revisions - Many editorial revisions are made to the Code and the Commentary. The following table (without the caption) is added to the Commentary to Section 1.1.8.3:

Table 2: Seismic Risk Terminology in the Model Building Codes and Other Resource Documents

Code, Standard or Resource Document and Edition	Level of Seismic Risk or Assigned Seismic Performance or Design Categories as defined in Code Section		
	Low (21.2.1.2)	Moderate / Intermediate (21.2.1.3)	High (21.2.1.4)
International Building Code 2000; NEHRP 1997	SDC A, B	SDC C	SDC D, E, F
BOCA National Building Code 1993, 1996, 1999; Standard Building Code 1994, 1997, 1999; ASCE 7-93, 7-95, 7-98; NEHRP 1991, 1994	SPC A, B	SPC C	SPC D, E
Uniform Building Code 1991, 1994, 1997	Seismic Zone 0, 1	Seismic Zone 2	Seismic Zone 3, 4

(36) Section 22.5.1, Allowable Flexural Stresses in Plain Concrete -

$\phi M_n \geq M_u$

$M_n = 5\sqrt{f'_c}S$ — <u>if tensions controls</u>, and

<u>M_n= 0.85$\sqrt{f'_c}$S</u> — <u>if compression controls</u>

Reason: To clarify that the expression for M_n in the 1999 Code applies when tension controls and to provide a corresponding expression when compression controls.

(37) Section 22.10.1, Plain Concrete - (b) For all other structures, plain concrete footings supporting <u>cast-in-place reinforced concrete or reinforced masonry</u> walls are permitted provided the footings are reinforced longitudinally with not less than two continuous reinforcing bars.

This is to further restrict the application of plain concrete in areas of significant seismicity.

(38) 1999 Appendix A, Alternate Design Method - The Strength Design Method is almost universally accepted as the preferred design method for concrete design. The Strength Design Method has been the primary design procedure of the ACI Code since the early 1960s. It has been and is being continuously updated based on concrete research and empirical data. The Alternate Design Method or Working Stress Design was relegated to an Appendix in the 1971 ACI Code. Since that time it has not been the subject of continuous review or research as has been the Strength Design Method. The Alternate Design Method thus has been removed from the 2002 edition of the ACI Code.

(39) 1999 Appendix B, Incorporate Appendix B (Unified Flexure) - 1999 Appendix B (Unified Flexure) has been placed in the main body of the Code. The idea is to simplify the design for flexure and axial load. The idea is also to make the code more obviously applicable to all cross-sectional shapes, and for both prestressed and nonprestressed reinforcement in the same member. The code and commentary material replaced by this transfer of Appendix B to the code is transferred to a new Appendix B.

(40) Appendix D, Anchoring to Concrete - The ACI Building Code has included specific provisions for anchoring to concrete for the first time. As has been done in the past with a number of new sections and chapters, the new material has been presented as an Appendix.

An appendix may be judged not to be an official part of a legal document unless specifically adopted. Therefore specific reference is made to the Appendix in the main part of the Code, to make it a legal part of the Code.

Parallel to development of the ACI 318-99 provisions for anchoring to concrete, ACI 355 developed a provisional test method to define the level of performance required for post-installed anchors. This specification, ACI 355.2, contains requirements for testing and certification of post-installed anchors for both cracked and uncracked concrete applications.

(41) Appendix A, Strut-and-Tie Models - Strut-and-tie models are added in a new Appendix A. Included are changes needed to introduce the concept of strut-and-tie models. Also included are changes needed to permit the use of Appendix A. The definitions of a deep beam in ACI Sections 10.7.1 and 11.8.1 have been changed to make them agree with each other, and to correspond to the definitions assumed in Appendix A. The equations for V_c and V_s for deep beams in 1999 Code Section 11.8 have been deleted because of the severe discontinuities that these equations give when l_n/d is varied.

CONCLUDING REMARKS

Cagley[7] has provided a differently formatted summary of the changes form ACI 318-99 to ACI 319-02, and has commented on the relative importance of the changes. His conclusions are quoted below.

> The proposed revisions to ACI 318-99, when incorporated to form 318-02, will cause some fairly major changes in the way engineers design concrete structures. We don't want designers to believe that their world has completely changed, but we also don't want to minimize the magnitude of these revisions.
>
> In my opinion, the proposed changes that will have the greatest effect on designers and the concrete industry are moving the 1999 Appendices B and C into the body of the Code, adding the new Appendix D – Anchorage to Concrete, adding seismic provisions for precast, and, to a lesser extent, adding the new Appendix A – Strut-and-tie Models. There are many more changes, but the revision to ASCE 7-98 load combinations and to the strain-based provisions of ACI 318-99 Appendix B will have a major effect on our lives, but interestingly will not necessarily have a major effects on the results.

The author agrees with all of the above. The biggest changes definitely are the new load combinations in Chapter 9 and the incorporation of unified design (previously in Appendix B) into the body of the Code. In addition, the relatively few practitioners who are still using the Alternate Design Method of Appendix A will miss the appendix. Continued use of the deleted appendix will presumably be allowed by the following sentence added to the Commentary on Section 1.1: "the Alternate Design Method of the 1999 ACI Code may be used in place of applicable sections of the 2002 ACI Code." How legal such commentary language is going to be regarded by building departments remains to be seen.

REFERENCES

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3. ACI Committee 117, "Standard Tolerances for concrete Construction and Materials (ACI 117-90)," American Concrete Institute, Farmington Hills, MI, 22 pp. Also *ACI Manual of Concrete Practice*, Parts 2 and 5.
4. Ospina C.E., and Alexander, S.D.B., "Transmission of Interior Concrete Column Loads Through Floors," *ASCE Journal of Structural Engineering*, v. 124, No. 6, June 1998.
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6. Azizinamini, A., Darwin, D., Eligehausen, R., Pavel, R., and Ghosh, S.K., "Proposed Modifications to ACI 318-95 Development and Splice Provisions for High Strength Concrete," *ACI Structural Journal*, V. 96, No. 6, November-December 1999, pp. 922-926.
7. Cagley, J.R., "Changing from ACI 318-99 to ACI 318-02 – What's New?", *Concrete International*, V. 23, no. 6, June 2001, pp. 69-72.