# Significant changes to ACI 318-08 relative to precast/prestressed concrete: part 1

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Significant changes have been made since American Concrete Institute (ACI) Committee 318 published the 2005 *Building Code Requirements for Structural Concrete (ACI 318-05) and Commentary (ACI 318R-05)*.[1] The changes in the new 2008 edition[2] are summarized in this paper.

The intent of this article is to provide a summary of significant changes affecting conventionally reinforced concrete, precast concrete, and prestressed concrete (including post-tensioned concrete). This information should be useful to building officials, design engineers, practitioners, and the academic community. Only changes to chapters 1 through 8 of ACI 318-08 are discussed in part 1 of this article series. Changes beyond chapter 8 will be discussed in parts 2 and 3, which will appear in subsequent issues of the *PCI Journal*.

Unlike previous releases of new ACI 318 editions, ACI's *Concrete International* did not publish a complete list of changes. Only a summary paper was published in the July 2007 issue of the magazine.[3] The changes were posted on the ACI website until August 15, 2007, when the public comment period ended. Pertinent discussion received by the August 15 deadline and the official response from ACI committee 318 will be published on ACI's website. In response to public comments, the committee has made additional changes to ACI 318-08, which has not yet been published.

ACI 318-08 will be the reference document for concrete design and construction in the 2009 edition of the *International*

## Editor's quick points

- This first of three papers describes the changes from the 2005 edition to the 2008 edition of ACI 318, *Building Code Requirements for Structural Concrete and Commentary* for chapters 1 through 8.
- ACI 318 underwent a major revision with this version.
- Parts 2 and 3 will follow in subsequent issues of the *PCI Journal*.

*Building Code* (IBC),[4] which will continue to reference ASCE 7-05.[5]

All section and chapter numbers used in this paper refer to those of ACI 318-08, unless otherwise noted.

## Chapter 1: "General Requirements"

A new section 1.1.4 permits concrete members that fall within the scope of ACI 332[6] (including cast-in-place footings; foundation walls; and slabs-on-ground for one- and two-family dwellings and multiple single-family dwellings, such as townhouses, and their accessory structures) to be designed and constructed in accordance with ACI 332, *Requirements for Residential Concrete Construction,* instead of ACI 318-08.

Section 1.1.8 clarifies that ACI 318 requirements do not apply to the composite design of structural concrete slabs constructed on stay-in-place composite steel decks. Section 1.1.8 specifically states that ACI 318 requirements do apply to portions of such slabs designed as reinforced concrete. Commentary section R1.1.8.2 explains that the design of negative moment reinforcement to make a slab continuous is an example of when a portion of the slab design should conform to ACI 318 requirements.

A new section 1.1.9 requires that the seismic design category (SDC)[4,5] of a structure be determined in accordance with the legally adopted general building code. It further requires that all structures, except those assigned to SDC A or otherwise exempted by the legally adopted general building code, must satisfy the applicable provisions of chapter 21.

The former section 1.2.3, which defined *building official*, has been deleted. A definition of this term is now found in section 2.2, where all definitions are located.

In section 1.3.2, which lists items to be included in inspection records, item (a) used to read: "Quality and proportions of concrete materials and strength of concrete."

It now reads: "Delivery, placement, and testing reports documenting the quantity, location of placement, fresh concrete tests, and other tests of all classes of concrete mixtures."

In commentary section R1.3.2, two substantive sentences have been added: "Some of the information regarding designated concrete materials on a project is often provided in a preconstruction submittal to the licensed design professional. For instance, concrete mixture ingredients and composition are often described in detail in the submittal and are subsequently identified by a mixture designation (reflected on a delivery ticket), that can also identify the placement location in the structure."

Commentary section R1.3.3 clarifies that concrete temperature, as used in section 1.3.3, may be taken as the surface temperature of the concrete. Commentary section R1.3.3 used to say: "however, during mixing and placing it is practical to measure the temperature of the mixture."

It now says: "Surface temperatures may be determined by placing temperature sensors in contact with concrete surfaces or between concrete surfaces and covers used for curing, such as insulation blankets or plastic sheeting."

Commentary section R1.1.9, "Provisions for Earthquake Resistance" (formerly section R1.1.8), has been completely rewritten with the introduction of SDC terminology into ACI 318. Table R1.1.9.1 (formerly table 1.1.8.3), which provides correspondence between the new terminology and the terminology used in legacy model codes (seismic performance categories, seismic zones) and in prior editions of ACI 318 (regions of low, moderate, and high seismic risk), has been updated.

## Chapter 2: "Notation and Definitions"

Definitions that used to be located at the beginning of chapter 21—previously "Special Provisions for Seismic Design" and now titled "Earthquake-Resistant Structures"—have been transferred to section 2.2.

The definition of *lightweight aggregate concrete* now references ASTM C330[7] and replaces "dry loose weight of 70 lb or less" with "loose bulk density of 70 lb/ft$^3$ or less, determined in accordance with ASTM C29."[8]

The definition of *building official* (previously in section 1.2.3) has been moved to section 2.2.

*All-lightweight* and *sand-lightweight* concretes are now defined separately, whereas they used to be part of the definition of *lightweight concrete*. *Normalweight concrete* is now also defined. In the definition of *lightweight concrete*, "equilibrium density not exceeding 115 lb/ft$^3$" has been replaced with "equilibrium density between 90 and 115 lb/ft$^3$."

The term *contract documents* is now defined in chapter 2.

A new definition for *specified concrete cover* has been added. The commentary to this definition points out that tolerances on specified concrete cover are provided in section 7.5.2.1.

*Design load combination* is now defined.

A *drop panel* is now defined as "a projection below the slab used to reduce the amount of negative reinforcement over a column or a minimum required slab thickness, and to increase the slab shear strength."

Important new definitions have been added for *equilibrium density*, *headed deformed bars*, and *headed shear stud reinforcement*. Commentary to the definition for *headed deformed bars* points out important differences between such bars and *headed shear stud reinforcement*.

The term *registered design professional* has been replaced with *licensed design professional*. Because *registered design professional* is the term used in the IBC, the ACI 318 definition for *licensed design professional* includes, "in other documents, also referred to as registered design professional."

The definition for *pedestal* has been modified once again for clarity.

The term *seismic design category* is defined. Also, new definitions for *shear cap*, *steel fiber-reinforced concrete*, and *work* have been added.

Finally, definitions for *special precast structural wall* and *special reinforced concrete structural wall* were added. The term *special structural wall* is now defined, and it can be made of cast-in-place or precast concrete.

## Chapter 3: "Materials"

Cementitious materials, rather than cements, are now defined in section 3.2. These include fly ash and natural pozzolans complying with ASTM C618,[9] ground-granulated blast-furnace slag complying with ASTM C989,[10] and silica fume complying with ASTM C1240,[11] in addition to portland cement complying with ASTM C150[12] and blended hydraulic cements complying with ASTM C595.[13]

Section 3.4 simply refers to ASTM C1602/C1602M[14] for water used in mixing concrete. All the text contained in prior editions of ACI 318 was deleted.

Whereas reinforcement consisting of structural steel, steel pipe, or steel tubing was previously permitted by ACI 318, reinforcement consisting of discontinuous deformed steel fibers is now additionally permitted (section 3.5.1). Deformed reinforcing bars may conform to ASTM A615,[15] ASTM A706,[16] or ASTM A996[17] type R, as before, or may now conform to ASTM A955, *Standard Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement*, section 3.5.3.1.[18] Commentary section R3.5.3.1 clarifies that stainless-steel bars are used in applications in which high corrosion resistance or controlled magnetic permeability are required. The physical and mechanical property requirements for stainless-steel bars under ASTM A955 are the same as those for carbon-steel bars under ASTM A615. Newly added section 3.5.3.3 states that deformed reinforcing bars conforming to ASTM A1035, *Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement*,[19] may now be used as transverse reinforcement as permitted by section 21.4.4 or as spiral reinforcement as permitted by section 10.9.3.

The upper limit of D-31 is placed on the size of deformed wire in section 3.5.3.5 because tests have shown that D-45 wire will achieve only about 60% of the bond strength in tension given by Eq. (12-1). Newly added section 3.5.3.10 now specifically permits the use of deformed stainless-steel wire and deformed and plain stainless-steel welded wire conforming to ASTM A1022, *Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement*,[20] as concrete reinforcement.

Headed studs and headed-stud assemblies conforming to ASTM A1044, *Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete,*[21] are now specifically recognized by the added section 3.5.5. Added section 3.5.8 requires that steel used in discontinuous fiber reinforcement must conform to ASTM A820, *Standard Specification for Steel Fibers for Fiber-Reinforced Concrete*.[22] It further requires that steel fibers be deformed to increase mechanical bond with the concrete and have a length-to-diameter ratio no less than 100.

New section 3.5.9 requires headed deformed bars to conform to ASTM A970, *Standard Specification for Headed Steel Bars for Concrete Reinforcement*.[23] It further requires that obstructions and interruptions of the bar deformations, if any, not extend more than $2d_b$ from the bearing face of the head, where $d_b$ is the diameter of the bar.

Fly ash or other pozzolans, ground-granulated blast-furnace slag, and silica fume have now been removed from section 3.6, "Admixtures," because they are included in section 3.2, "Cementitious Materials." ACI 318-05 section 3.6.2, which required that an admixture be shown capable of essentially maintaining the same composition and performance throughout the work as the product used in establishing concrete proportions in accordance with section 5.2, has been deleted. This is because it used to apply to fly ash or other pozzolans, ground-granulated blast-furnace slag, and silica fume, which are now considered cementitious materials. ACI 318-05 section 3.6.5, now section 3.6.4, has been rewritten as "Admix-

**Table 1.** ASTM reference standards added to ACI 318-08, section 3.8

| ASTM Standard | Title |
|---|---|
| A820/A820M-06 | *Standard Specification for Steel Fibers for Fiber-Reinforced Concrete* |
| A955/A955M-07A | *Standard Specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement* |
| A970/A970M-06 | *Standard Specification for Headed Steel Bars for Concrete Reinforcement* |
| A1022/A1022M-07 | *Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement* |
| A1035/A1035M-07 | *Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement* |
| A1044/A1044M-05 | *Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete* |
| C29/C29M-97 (revised 2003) | *Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate* |
| C231-04 | *Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method* |
| C1012-04 | *Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution* |
| C1116-06/C1116M-06 | *Standard Specification for Fiber-Reinforced Concrete* |
| C1602/C1602M-06 | *Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete* |
| C1609/C1609M-06 | *Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading)* |

tures for water reduction and setting time modification shall conform to ASTM C494.[24] Admixtures for use in producing flowing concrete shall conform to ASTM C1017."[25]

**Table 1** lists the ASTM reference standards added to section 3.8.

Section 3.8.9 added a reference to *Requirements for Residential Concrete Construction* (ACI 332-04)[6] and section 3.8.10 added a reference to *Acceptance Criteria for Special Unbonded Post-Tensioned Precast Structural Walls Based on Validation Testing* (ITG 5.1).[26]

## Chapter 4: "Durability Requirements"

Chapters 4 and 5 of earlier editions of ACI 318 were reformatted in 1989 to emphasize the importance of considering durability requirements before selecting $f_c'$ and the specified concrete cover over the reinforcing steel. In ACI 318-08, the format of chapter 4 is extensively revised by introducing exposure categories and classes, with applicable durability requirements given for the various classes in a unified format.

Tables in chapter 4 have been modified due to the adoption of exposure categories and classes. The coverage of durability in ACI 318 has been reorganized to make it more parallel with the approach used in the codes of some other countries. The restructuring of chapter 4 does not include any significant technical changes to the provisions included in ACI 318-05.

ACI 318 defines exposure categories and classes for concrete structures in section 4.2.1—specifically in tables 4.2.1.a through 4.2.1.d. **Tables 2** through **5** are adapted from those tables and the commentary to section 4.2.1. Associated requirements for concrete relative to the exposure classes are provided in ACI 318 section 4.3.

## Chapter 5: "Concrete Quality, Mixing, and Placing"

A new section 5.1.6 has been added, and it requires steel fiber–reinforced concrete to conform to ASTM C1116, *Standard Specification for Fiber-Reinforced Concrete*.[27] The minimum $f_c'$ for steel fiber–reinforced concrete is required to be 2500 psi (17 MPa), the same as that for conventionally reinforced concrete.

Because of the concern that material properties may change with time, a limit of 12 months has been imposed on the age of the historical data used to qualify mixture proportions under section 5.3,

**Table 2.** Exposure Category F based on freezing and thawing exposure

| Class | Description | Condition |
|---|---|---|
| F0 | Not applicable | Concrete not exposed to freezing and thawing cycles |
| F1 | Moderate | Concrete exposed to freezing and thawing cycles and that may be occasionally exposed to moisture before freezing (for example, exterior walls, beams, girders, and slabs not in direct contact with soil) |
| F2 | Severe | Concrete exposed to freezing and thawing cycles and that is in continuous contact with moisture before freezing (for example, water tanks) |
| F3 | Very severe | Concrete exposed to freezing and thawing cycles, that is in continuous contact with moisture, and where exposure to deicing chemicals is anticipated (for example, parking structures in the northern United States) |

Source: Data adapted from *Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary (ACI 318R-08)* table 4.2.1 and commentary section R4.2.1.

**Table 3.** Exposure Category S based on sulfate exposure

| Class | Description | Water-soluble sulfate in soil, % by weight | Sulfate in water, ppm | Commentary |
|---|---|---|---|---|
| S0 | Not applicable | $SO_4 < 0.10$ | $SO_4 < 150$ | Injurious sulfate attack not common |
| S1 | Moderate | $0.10 \le SO_4 < 0.20$ | $150 \le SO_4 < 1500$ sea water | More critical value of measured water-soluble sulfate concentration in soil or the concentration of dissolved sulfate in water governs |
| S2 | Severe | $0.20 \le SO_4 \le 2.00$ | $1500 \le SO_4 \le 10{,}000$ | Same as for S1 |
| S3 | Very severe | $SO_4 > 2.00$ | $SO_4 > 10{,}000$ | Same as for S1 |

Source: Data adapted from *Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary (ACI 318R-08)* table 4.2.1 and commentary section R4.2.1.
Note: ppm = parts per million.

and proportioning on the basis of field experience or trial mixtures or both is allowed.

Under section 5.3.3.2, the requirements that must be met by trial mixtures for concrete proportions established from such mixtures to be acceptable have been revised as indicated:

- Requirement (b) of section 5.3.3.2 in 318-05 used to read: "Trial mixtures having proportions and consistencies required for proposed work shall be made using at least three different water-cementitious materials ratios or cementitious materials contents that will produce a range of strengths encompassing $f'_{cr}$."

  It now reads: "Trial mixtures with a range of proportions that will produce a range of compressive strengths encompassing $f'_{cr}$ and meet the durability requirements of chapter 4."

- Requirement (c) of ACI 318-08 was: "Trial mixtures shall be designed to produce a slump within ±0.75 in. (19 mm) of maximum permitted, and for air-entrained concrete, within ±0.5% of maximum allowable air content."

  It now reads: "Trial mixtures shall have slumps within the range specified for the proposed Work; for air-entrained concrete, air content shall be within the tolerance specified for the proposed Work."

- Requirement (d) of ACI 318-05 was: "For each water-cementitious materials ratio or cementitious materials content, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C192, *Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory*.[28] Cylinders shall be tested at 28 days or at test age designated for determination of

**Table 4.** Exposure Category P based on requirements for low permeability

| Class | Description | Condition | Commentary |
|---|---|---|---|
| P0 | Not applicable | Concrete not required to have low permeability to water | — |
| P1 | Applicable | Concrete required to have low permeability to water | When the permeation of water into concrete might reduce durability or affect the intended function of the structural element |

Source: Data adapted from *Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary (ACI 318R-08)* table 4.2.1 and commentary section R4.2.1.

**Table 5.** Exposure Category C based on requirement for corrosion protection of reinforcement

| Class | Description | Condition | Commentary |
|---|---|---|---|
| C0 | Not applicable | Concrete that will be dry or protected from moisture in service | No additional protection required against the corrosion of reinforcement |
| C1 | Moderate | Concrete exposed to moisture but not to an external source of chlorides in service | — |
| C2 | High | Concrete exposed to moisture and to an external source of chlorides in service | For example, deicing chemicals, salt, brackish water, seawater, or spray from these sources |

Source: Data adapted from *Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary (ACI 318R-08)* table 4.2.1 and commentary section R4.2.1.

$f_c'$."

It now reads: "For each trial mixture, at least two 6 in. × 12 in. (150 mm × 300 mm) or three 4 in. × 8 in. (100 mm × 200 mm) cylinders shall be made and cured in accordance with ASTM C192. Cylinders shall be tested at 28 days or at test age designated for $f_c'$."

- Requirements (e) and (f) of ACI 318-05 read: "From results of cylinder tests a curve shall be plotted showing the relationship between water-cementitious materials ratio or cementitious materials content and compressive strength at designated test age. Maximum water-cementitious materials ratio or minimum cementitious materials content for concrete to be used in proposed Work shall be that shown by the curve to produce $f_c'$ required by 5.3.2, unless a lower water-cementitious materials ratio or higher strength is required by chapter 4."

  All of this has been replaced by a new item (e), which reads: "The compressive strength results, at designated test age, from the trial mixtures shall be used to establish the composition of the concrete mixture proposed for the Work. The proposed concrete shall achieve an average compressive strength as required in 5.3.2 and satisfy the applicable durability criteria of chapter 4."

It should be noted that ACI 318 has now recognized the use of three 4 in. × 8 in. (100 mm × 200 mm) cylinders as equivalent to the use of two 6 in. × 12 in. (150 mm × 300 mm) cylinders. This change is also reflected in section 5.6.2.4. The commentary clarifies that the confidence level of the average strength is preserved this way because 4 in. × 8 in. cylinders tend to have about 20% higher within-test variability than 6 in. × 12 in. cylinders. The commentary also points out that more than the minimum number of specimens may be desirable to allow for discarding an outlying individual cylinder strength in accordance with ACI 214R.[29]

Commentary section R5.3.3.2 provides new commentary on items (b), (d), and (e) under section 5.3.3.2.

ACI 318-05 section 5.6.5.3 reads: "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."

The section now reads: "Cores shall be obtained, moisture conditioned by storage in watertight bags or containers, transferred to the laboratory, and tested in accordance with ASTM C42." A newly added sentence requires that the specifier of tests referenced in ASTM C42[31] be a licensed design professional.

Commentary section R5.6.5 previously explained that the restriction on the commencement of core testing provides a minimum time for the moisture gradient to dissipate. It now further explains that the maximum time between coring and testing is intended to ensure timely testing of cores when strength of concrete is in question. Newly added commentary further explains that to provide reproducible moisture conditions that are representative of in-place conditions, a common moisture conditioning procedure that permits dissipation of moisture gradients is now prescribed for cores. ASTM C42 permits the specifier of tests to modify the default duration of moisture conditioning before testing.

New section 5.6.6.1 requires that steel fiber–reinforced concrete beams be tested in accordance with ASTM C1609, *Standard Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading)*.[30]

New section 5.6.6.2 states that steel fiber–reinforced concrete is to be considered acceptable for shear resistance if three given conditions are satisfied. The commentary points out that these performance criteria are based on results from flexural tests conducted on steel fiber–reinforced concrete beams with fiber types and contents similar to those used in the tests of beams that served as the basis for newly added section 11.4.6.1(f).

## Chapter 6: "Formwork, Embedments, and Construction Joints"

"Embedments" has replaced "Embedded Pipes" in the title of the chapter. Throughout the chapter, "conduits and pipes embedded in concrete" or "conduits, pipes, and sleeves embedded in concrete" have been changed to "embedments in concrete."

In section 6.4.7, shear caps, as defined in section 2.2, have been added to the list of items (beams, girders, haunches, drop panels, and capitals) that must be placed monolithically as part of a slab system.

Commentary section R6.3.2 now points out that section 6.3.2 prohibits calcium chloride or any admixture containing chloride from being used in concrete with aluminum embedments.

## Chapter 7: "Details of Reinforcement"

To permit a more consistent application of tolerances in ACI 318 and other ACI documents, *specified cover* has replaced *minimum cover* throughout chapter 7. This change affects sections 7.7.1, 7.7.2, 7.7.3, 7.7.4, 7.7.5, and 7.7.6.

Newly added section 7.7.5 requires that for headed shear-stud reinforcement, specified concrete cover for the heads or base rails shall not be less than that required for the reinforcement in the type of member in which the headed shear–stud reinforcement is placed.

In section 7.7.6 on corrosive environments, "denseness and nonporosity of protecting concrete shall be considered" has been replaced by "the pertinent requirements for concrete based on applicable exposure categories in chapter 4 shall be met."

In section 7.13, "Requirements for Structural Integrity," changes have been made to the anchorage and splice requirements for structural integrity reinforcement. Continuous top and bottom structural reinforcement is now required to pass through the column core. Also, the types of transverse reinforcement used to enclose structural integrity reinforcement in perimeter beams are more clearly specified.

Section 7.13.2.1 of ACI 318-05 required that, in joist construction, at least one bottom bar be continuous or spliced with a Class A tension splice or a mechanical or welded splice. A Class B tension splice is now required. Whereas ACI 318-05 required that this bar be terminated at noncontinuous supports with a standard hook, it is now required that the bar be anchored to develop $f_y$ at the face of the support using a standard hook satisfying section 12.5 or a headed deformed bar satisfying section 12.6 at noncontinuous supports.

Section 7.13.2.2 now requires beams along the perimeter of the structure to have continuous reinforcement passing through the region bound by the longitudinal reinforcement of the column. At noncontinuous ends, this reinforcement is required to be anchored to develop $f_y$ at the face of the support using standard hooks satisfying section 12.5 or headed, deformed bars satisfying section 12.6.

Section 7.13.2.3 now requires that all continuous reinforcement required by section 7.13.2.2 for perimeter beams be enclosed by transverse reinforcement of the type specified in section 11.5.4.1 for torsion. The transverse reinforcement is required to be anchored as specified in section 11.5.4.2. It is spelled out that the transverse reinforcement need not be extended through the column.

Where splices are required to satisfy section 7.13.2.2, the top reinforcement is required to be spliced at or near midspan and the bottom reinforcement at or near the support. Splices are required to be Class B tension splices or mechanical or welded splices satisfying section 12.14.3, which was section 7.13.2.4 in ACI 318-05.

Any continuous positive-moment reinforcement (other than that in perimeter beams) provided in compliance with the requirements of section 7.13.2.5 is required to pass through the region bound by the longitudinal reinforcement of the column. Where such reinforcement is spliced, the splices are required to be Class B tension splices or mechanical or welded splices. At noncontinuous supports, such reinforcement is required to be anchored to develop $f_y$ at the face of the support using standard hooks satisfying section 12.5 or headed, deformed bars satisfying section 12.6.

A new section 7.13.2.7 refers the ACI 318 user to sections 18.12.6 and 18.12.7 for newly added structural integrity requirements for prestressed, two-way slabs.

Terms such as *structural engineer*, *registered engineer*, *registered architect*, *registered design professional*, *engineer*, *designer*, *engineer*, and *architect* have all been either replaced with *licensed design professional* or eliminated. The corresponding term in the IBC[4] is *registered design professional*.

Design requirements for earthquake-resistant structures have been rewritten in terms of SDC. The prior terminology of regions of low, moderate, and high seismic risk is gone. This change makes ACI 318 terminology the same as that used in the IBC and the ASCE 7 *Standard Minimum Design Loads for Buildings and Other Structures*[5] (since its 1998 edition). Because the IBC has emerged as the one model building code for the entire country on which the legal codes by most legal jurisdictions (such as cities, counties, and states) are based, this is a sensible and timely change. The IBC will no longer have to provide an interface between its own terminology and that of ACI 318, as it has in the past.

## Chapter 8: "Analysis and Design—General Considerations"

A new commentary section R8.2.4 has been added. It explains that the restraint of shrinkage and temperature effects can cause significant internal forces and displacements. In cases of restraint, shrinkage and temperature reinforcement requirements may exceed flexural reinforcement requirements.

In the title of section 8.4, "Redistribution of Negative Moments in Continuous Flexural Members," the word *negative* has been dropped. The section has been modified to permit moments to be redistributed away from positive-moment sections as well as negative-moment sections.

Before its 2008 edition, ACI 318 addressed moment redistribution by permitting an increase or decrease of factored negative moments above or below elastically calculated values, within a 20% limit. A decrease in the negative moment strength to 20% below the factored negative moment at the support might result in a change in the bending moment at the section of maximum positive bending moment by much more than 20%, with significant inelastic behavior probably accompanying this increase. ACI 318-08 places the same 20% limitation on changes in both positive and negative bending moments.

A new section 8.6, "Lightweight Concrete," was added to bring about consistent treatment of lightweight concrete throughout ACI 318. The factor $\lambda$ reflects the lower tensile strength of lightweight concrete, which may result in lower shear strength, frictional resistance, splitting resistance, bond between concrete and reinforcement, and increased development length, compared with the corresponding properties of normalweight concrete of the same compressive strength.

In the first of two approaches to determine $\lambda$, the tensile strength of lightweight concrete is assumed to be a fixed fraction of the tensile strength of normalweight concrete. The multipliers are based on tests of many types of structural lightweight aggregate. The second approach is based on laboratory tests to determine the splitting tensile strength $f_{ct}$ of lightweight concrete. That of normalweight concrete is assumed to be $6.7\sqrt{f_c'}$. $\lambda$ is then equal to $f_{ct}/6.7\sqrt{f_c'} \geq 1$.

A new section 8.8, "Effective Stiffness to Determine Lateral Deflections," was added. Section 8.8.2 requires that the lateral deflections of reinforced-concrete building systems resulting from factored lateral forces be determined by either:

- a detailed analysis considering the reduced stiffness of all members under the loading conditions;
- a linear analysis using (a) section properties defined in section 10.10.4(a) through (c) (section 10.10 deals with slenderness effects in compression members) or (b) 50% of stiffness values based on gross section properties.

Where two-way slabs without beams form part of the lateral-force-resisting system, section 8.8.3 permits lateral deflections resulting from factored lateral forces to be computed using linear analysis. The stiffness of slab members must be defined by a model in substantial agreement with the results of comprehensive tests and analysis, and the stiffness of other members must be as defined in section 8.8.2. In other words, no empirical stiffness assumptions are given for the slab members themselves.

According to section 8.8.1, linear analysis with member stiffness determined using 1.4 times the flexural stiffness defined in sections 8.8.2 and 8.8.3 may be used to determine lateral deflections of reinforced-concrete building systems under service-level lateral forces, or more detailed analyses must be carried out. Member properties greater than gross section properties must not be used in determining lateral deflections under service-level lateral forces.

## References


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3. Wight, J. K. 2007. Changes to Expect in the 2008 Edition of the ACI Building Code (ACI 318-08). *Concrete International*, V. 29, No. 7 (July): pp. 49–53.

4. International Code Council. 2006. *International Building Code.* Washington, DC: International Code Council.

5. Structural Engineering Institute. 2005. *Minimum Design Loads for Buildings and Other Structures*. Reston, VA: American Society of Civil Engineers (ASCE).

6. ACI Committee 332. 2004. *Requirements for Residential Concrete Construction (ACI 332-04) and Commentary (ACI 332R-04).* Farmington Hills, MI: ACI.

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## Notation

$d_b$ = nominal diameter of bar, wire, or prestressing strand

$f_c'$ = specified compressive strength of concrete

$f_{cr}'$ = required average compressive strength of concrete

$f_{ct}$ = average splitting tensile strength of lightweight concrete

$f_y$ = specified yield strength of reinforcement

$\lambda$ = modification factor reflecting the reduced mechanical properties of lightweight concrete, all relative to normalweight concrete of the same compressive strength

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## Synopsis

Significant changes have been made since American Concrete Institute (ACI) Committee 318 published the 2005 *Building Code Requirements for Structural Concrete (ACI 318-05) and Commentary (ACI 318R-05)*. The changes in the upcoming 2008 edition are summarized in this paper. In addition to changes affecting conventionally reinforced concrete, provisions affecting precast/prestressed concrete, including post-tensioned concrete, are enumerated. Only changes to chapters 1 through 8 of ACI 318-08 are discussed in this article.

## Keywords

ACI 318, codes, structural concrete.

## Reader comments

Please address any reader comments to *PCI Journal* editor-in-chief Emily Lorenz at elorenz@pci.org or Precast/Prestressed Concrete Institute, c/o *PCI Journal*, 209 W. Jackson Blvd., Suite 500, Chicago, IL 60606.