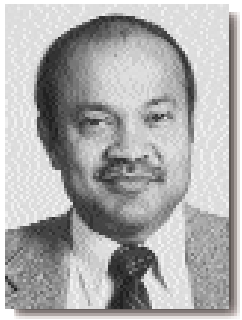
The Concrete Design and Construction Provisions of the NFPA 5000 Building Code

This article presents an overview of Chapter 40 on Concrete of the NFPA 5000 Building Code which, when published in the Fall of 2002 by the National Fire Protection Association, based in Quincy, Massachusetts, will be competing with the 2000 and 2003 editions of the International Building Code for adoption by various jurisdictions.



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While many jurisdictions (states, counties, cities) around the United States have just adopted or are considering adoption of the 2000 edition of the International Building Code, the first edition of a competing model building code, NFPA 5000, is nearing completion, with publication expected in the Fall of 2002. Anticipating that the readers of the PCI JOURNAL would have an interest in the contents of the concrete chapter of this emerging model code, an overall review of the contents is provided here.

Current Status

The latest draft of the NFPA 5000 Building Code is available for review and downloading at the NFPA website at www.NFPA.org. Public comments on this draft submitted by the designated deadline will be considered at the NFPA Annual Meeting to be held in Minneapolis during the week of May 20, 2002. Any modifications approved at this meeting will be advisory to the Standards Council of NFPA, which is scheduled to meet in Boston in mid-July. The contents of the NFPA 5000 Building Code are expected to be finalized at that meeting, with publication expected in early Fall, 2002.

Overview

Chapter 40 on Concrete of the NFPA 5000 Building Code adopts the 2002 edition of ACI 318, Building Code Requirements for Structural Concrete, by reference.

Section 37.10 of NFPA 5000 requires that earthquake resistant design of structures be in accordance with Section 9 of the 2002 edition of ASCE 7, Minimum Design Loads for Buildings and Other Structures. In some cases, ASCE 7 supplements its loading requirements with additional provisions intended to ensure satisfactory performance of structures when subjected to the design earthquake forces given in Section 9 of the standard. These supplementary provisions are to be found in Section A.9 of ASCE 7, with those specifically related to concrete being given in Section A.9.9.

In some cases, the terminology used in ASCE 7 is not consistent with that used in ACI 318, and provisions in Section A.9.9 coordinate these differences. Other provisions in Section A.9.9 deal with issues related to, or types of, seismic-force-resisting systems that are not addressed in ACI

318. In a very small number of cases, it has also been determined that certain provisions of ACI 318 need to be modified to comply with the intent of Section 9 of ASCE 7. These modifications are also to be found in Section A.9.9. Exactly two modifications to Section A.9.9 of ASCE 7-02 have been made in Chapter 40 of NFPA 5000, because the timing of the ACI 318 and ASCE 7 update processes did not permit the two documents to be completely coordinated.

NFPA 5000 makes one additional modification to the seismic detailing requirements in Chapter 21 of ACI 318-02.

Chapter 40 of NFPA 5000 has also added provisions in areas not covered, or at least not comprehensively covered, by ACI 318-02. These areas are: (1) slabs-on-ground; (2) concrete on steel form deck; (3) concrete piles, piers, and caissons; (4) shotcrete; and (5) reinforced gypsum concrete.

Section 40.1 – Scope

Conventional reinforced concrete (made using portland cement or blended cements) as well as cast-in-place reinforced gypsum concrete is included in the scope of Chapter 40.

Section 40.2 – General

The design and construction of cast-in-place or precast structural elements of plain or reinforced concrete, including prestressed concrete, are required to comply with ACI 318-02, unless modified by other provisions of Chapter 40. Two exceptions are made. The following are permitted to be designed and constructed in accordance with the provisions of PCA EB118, Prescriptive Method for Insulating Concrete Forms in Residential Construction, provided that the building meets the limitations of Table 1.1 of that document:

(1) Basement, foundation, and above-grade walls of one- and two-family dwellings using insulating concrete forms (ICF), and

(2) Basement, foundation, and above-grade walls of one- and two-family dwellings using conventional forms with flat surfaces.

Concrete on Steel Form Deck – In many buildings with structural steel framing, concrete floor and roof slabs are cast on stay-in-place steel form deck.

Where the steel deck serves only as the form for the concrete and remains in place after the concrete hardens, it is referred to as a non-composite deck. The design and construction of concrete slabs cast on such decks are required to comply with the provisions of ACI 318.

Where the steel deck serves as the form for the concrete, remains in place after the concrete hardens, and serves as the positive moment reinforcement for the slab, it is referred to as a composite deck. The design and construction of concrete slabs cast on such decks are required to comply with the provisions of ASCE 3 Standard for the Structural Design of Composite Slabs. Concrete used in the construction of such slabs is required to comply with the applicable portions of Chapters 1 through 7 of ACI 318.

Concrete Piles, Piers and Caissons – Chapter 39 of NFPA 5000 regulates the design and construction of deep foundations, as long as the soil is capable of providing adequate lateral support to the foundation.

Portions of concrete piles, piers, and caissons in soil not capable of providing lateral support, or in air or water, must comply with the provisions of ACI 318.

The 1999 edition of ACI 318 for the first time included special seismic detailing requirements for certain foundation elements, including deep foundations. These requirements apply only to structures assigned to Seismic Design Category D, E, or F, and must be complied with if a structure is assigned to one of these seismic design categories. Section A.9.7 of ASCE 7 also has special detailing requirements for foundations of structures assigned to Seismic Design Categories C, D, E or F. In case of conflicting provisions, those of NFPA 5000 (Chapter 30) and ASCE 7 (Section A.9.7) would apply.

Section 40.3 – Construction Documents

For information that is required to be shown on construction documents, this section simply refers the user to Section 1.2.1 of ACI 318.

Section 40.4 – Quality Assurance

Sections 38.3.7 and 38.3.8 of NFPA 5000 provide requirements concerning quality assurance of concrete construction.

Section 40.5 – Seismic Requirements

This section makes two modifications to the supplementary provisions of Section A.9.9 of ASCE 7-02, to enable use, under the NFPA 5000 Building Code, of the new precast structural systems provision introduced in Chapter 21 of ACI 318-02.

The first modification classifies "special reinforced concrete structural walls" and the new "special precast structural walls" as "special reinforced concrete shear walls." Special precast structural walls can thus be designed utilizing the existing design parameters and height limitations applicable to special reinforced concrete structural walls. The only difference between a cast-in-place special reinforced concrete structural wall and the new special precast structural wall is that connections between precast wall panels and between precast wall panels and the foundation must comply with Sections 21.13.2 and 21.13.3 of ACI 318-02.

The second modification recognizes the new "intermediate structural wall" and states that, in buildings assigned to Seismic Design Category C, ordinary reinforced concrete shear walls constructed of precast concrete elements must comply with the additional requirements of Section 21.13 of ACI 318 for intermediate precast concrete structural walls. Intermediate precast structural walls may thus be designed utilizing the existing design parameters and height limitations applicable to ordinary reinforced concrete structural walls. The only difference between a cast-in-place ordinary reinforced concrete structural wall and the new intermediate precast structural wall is that connections between precast wall panels and between precast wall panels and the foundation must comply with Sections 21.13.2 and 21.13.3 of ACI 318-02.

Section 40.6 – Modifications to ACI 318

This section makes just one modification to Chapter 21 of ACI 318-02. It applies to columns of frames that are designed to be not part of the lateral-force-resisting system (so-called gravity frames) of a building assigned to Seismic Design Category D, E, or F. The modification exempts the requirement that lap splices of longitudinal reinforcement in such columns be confined to the middle half of the column height. This would permit lap splices of longitudinal column reinforcement just above the floor levels, where they are normally placed in non-seismic construction.

Section 40.7 – Slabs-on-Ground

Durability – Concrete used in slabs-on-ground is required to comply with the durability requirements in Chapter 4 of ACI 318-02.

Minimum Thickness – The minimum thickness of slabs-on-ground is required to be $3^1/_2$ in. (90 mm).

Vapor Retarder – A vapor retarder having a perm rating not exceeding 0.5 or a 6-mil (0.15 mm) thickness of polyethylene is required to be placed between the top of the subgrade or base material and the bottom of a slab-on-ground.

Joints in the vapor retarder are required to be lapped a minimum of 6 in. (150 mm).

A vapor retarder is not required to be provided under certain conditions that are spelled out.

Section 40.8 – Shotcrete

Shotcrete is defined as concrete or mortar thrust pneumatically at high velocity onto a surface.

Specifications for shotcrete are required to comply with the ACI 506.2, Specification for Shotcrete. Because of this requirement, if a project regulated by NFPA 5000 would involve the use of shotcrete, the project specifications must include wording such as: "Shotcrete shall conform to all the requirements of ACI 506.2, except as modified by these contract documents."

Section 40.9 – Reinforced Gypsum Concrete

Materials used in reinforced gypsum concrete are required to comply with ASTM C 317, Standard Specification for Gypsum Concrete.

Gypsum concrete is made from a dry mill-mixed product that is formulated and packaged based on the requirements of ASTM C 317. The packaged material may also contain aggregate, which may consist of natural or manufactured sand, perlite or vermiculite. Wood chips or shavings may also be added at times.

Regardless of whether aggregate is introduced at the mill or at the site, it must be of one of the types permitted by ASTM C 317. On site, the packaged material is mixed with aggregate, if not already included, and water to produce a slurry that is poured in place over reinforcing mesh and formboards supported by subpurlins or primary framing members.

The design and installation of cast-in-place reinforced gypsum concrete is required to be in accordance with ASTM C 956, Standard Specification for Installation of Cast-in-Place Reinforced Gypsum Concrete, which in turn requires that the design of reinforced gypsum concrete be performed in accordance with the principles of reinforced concrete design embodied in ACI 318. Since allowable stresses for the gypsum concrete and reinforcement are given in ASTM C 956, and since Appendix A (Alternative Design Method, similar to working stress design) of the last several editions of ACI 318 has been deleted from the 2002 edition, the design professional will need to use Appendix A of ACI 318-99 or an earlier edition of ACI 318.

Precast gypsum concrete is allowed to be used only where approved.

Limitations of Use – Cast-in-place reinforced gypsum concrete is required to be constructed with nonabsorptive formboard or surfacing where used for either of the following:

(1) For occupancies producing unusually high humidities.
(2) For ceilings of structures not completely enclosed.

Concentrated loads, such as from water tanks, fan bases, cooling towers, flagpoles, and signs, are required to be transmitted directly to the primary roof framing members, walls, or footings.

Testing – Testing of gypsum concrete is required to be in accordance with the criterion set forth in ASTM C 472, Standard Test Methods for Physical Testing of Gypsum, Gypsum Plasters and Gypsum Concrete.

One test of each day's pour of cast-in-place gypsum concrete is required to be made and the results thereof are required to be reported to the authority having jurisdiction.

Concluding Remarks

The NFPA 5000 Building Code requires the design and construction of plain, reinforced and prestressed (cast-in-place as well as precast) concrete structures to be in accordance with the provisions of ACI 318-02. Modifications to ACI 318-02 are minor and small in number.

Provisions have been added in the following areas not covered, or at least not comprehensively covered, by ACI 318: (1) slabs-on-ground; (2) concrete on steel form deck; (3) concrete piles, piers, and caissons; (4) shotcrete; and (5) reinforced gypsum concrete.

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