PROPOSAL 4-4 (2009)

SCOPE: Sec. C14.2 Concrete

PROPOSAL FOR CHANGE:

Delete existing Draft Commentary for Part 2, Sec. C14.2 of Part 2 of the 2009 *Provisions* and Replace with following Commentary:

C14.2 CONCRETE:

The section adopts by reference ACI 318-08 for structural concrete design and construction. In addition, modifications to ACI 318-08 are made that are needed to coordinate the provisions of that material design standard with the provisions of ASCE/SEI 7. Work is on-going to better coordinate the provisions of the two documents (ACI 318 and ASCE 7) such that the provisions in Section 14.2 will be significantly reduced in future editions of ASCE/SEI 7.

C14.2.1 Reference Documents

C14.2.2 Modifications to ACI 318-08

C14.2.2.1 ACI 318 Section 7.10

Section 7.10.5.6 of ACI 318 prescribes reinforcement details for ties in compression members. Those details are appropriate for SDC A and B structures. This modification prescribes additional details for ties around anchor bolts in structures assigned to~~located in~~ SDC C through F.

C14.2.2.2 ACI 318 Section 2.2

The first two definitions describe wall types for which definitions currently do not exist in ACI 318. These definitions are essential to the proper interpretation of the R and C_d factors for each wall type specified in Table 12.2-1 of ASCE 7-05.

A wall pier is recognized as a separate category of structural element in this document but not ACI 318.

C14.2.2.3 Scope

This provision describes how the ACI 318 provisions should be interpreted for consistency with the ASCE/SEI 7 provisions.

C14.2.2.4 Wall Piers and Wall Segments

Wall piers are typically segments between openings in walls that are thin in the direction normal to the horizontal length of the wall. In current practice these elements are often not regarded as columns or as part of the structural walls. If not properly reinforced these elements are vulnerable to shear failure and that failure prevents the wall from developing the assumed flexural hinging. Section 21.9.10 is written to reduce the likelihood of a shear failure. Wall

segments with a horizontal length-to-thickness ratio less than 2.5 ~~and a clear height-to-length ratio of at least 2~~ are required to be designed as columns in compliance with Section 21.9 if they are utilized as part of the lateral-force-resisting system, even though the shortest cross-sectional dimension may be less than 12 in. in violation of Section 21.6.1.1. Such wall segments may be designed to comply with Section 21.13 if they are not utilized as part of the lateral-force-resisting system. Wall segments with a horizontal length-to-thickness ratio larger than or equal to 2.5, which do not meet the definition of wall piers (Section 14.2.2.2), must be designed as special structural walls or as portions of special structural walls in full compliance with Section 21.9 or 21.10.

C14.2.2.6 Foundations

The intention is that there should be no ~~re are no intended~~ conflicts between the provisions of Section 21.12 of ACI 318 and Sections 12.1.5, 12.13 or 14.2 of ASCE 7-05. However, the additional detailing requirements for concrete piles of Section 14.2.3 can result in conflicts with ACI 318 provisions if the pile in not fully embedded in the soil.

~~**C14.2.2.6 Members Not Designated as Part of the Lateral-Force-Resisting System**~~

~~Section 21.6.3.2 .. etc.~~

C14.2.2.7 Intermediate Precast Structural Walls

Section 21.4 of ACI 318 imposes requirements on precast walls for moderate seismic risk applications. Ductile behavior is~~was~~ to be ensured by yielding of the steel elements or reinforcement between panels or between panels and foundations. The 2006 Edition of the IBC restricts yielding to steel reinforcement only because of concern that steel elements in the body of a connection could fracture due to inelastic strain demands.

Several steel element connections have been tested under simulated seismic loading and the adequacy of their load-deformation characteristics and strain capacity have been demonstrated (Schultz and Magana). One such connection was used in the five-story building test that was part of the PRESSS Phase 3 research. The connection was used to provide damping and energy dissipation, and demonstrated a very large strain capacity (Nakaki, Stanton and Sritharan). Since then, several other steel element connections have been developed that can achieve similar results (Banks and Stanton), (Nakaki et al.). In view of these results, it is appropriate to allow yielding in steel elements that have been shown experimentally to have adequate strain capacity to maintain at least 80% of their yield force through the full design displacement of the structure. This provision requires the designer to determine the deformation in the connection corresponding to the earthquake design displacement, and then to check from experimental data that the connection type used can accommodate that deformation without significant strength degradation.

The wall pier requirements of Section 21.4.5 are patterned after~~duplicate~~ the same requirements of Section 14.2.2.4 for wall piers that are part of structures in high seismic design categories~~adjoining special structural walls~~.

Schultz, A.E., and Magana, R.A., (1996) "Seismic Behavior of Connections in Precast Concrete Walls," Proceedings, Mete A. Sozen Symposium, SP-162, American Concrete Institute, Farmington Hills, MI, pp. 273-311.

Nakaki, S., Stanton, J.F., and Sritharan, S., (2001) "The PRESSS Five-Story Precast Concrete Test Building, University of California, San Diego, La Jolla, California," PCI Journal, V.46, No.5, Sept.-Oct., pp.20-26.

Banks, G., and Stanton, J., (2005) "Panel-to-Panel Connections for Hollow-Core Shear Walls Subjected to Seismic Loading", 2005 PCI Convention, Palm Springs, CA.

Bora, C., Oliva, M.G., Nakaki, S. D., and Becker, R., (2005) "Development of a Precast Concrete Shear-Wall System Requiring Special Code Acceptance", PCI Journal, V.52, No.1, Jan.-Feb., pp. 122-135.

C14.2.2.8 Detailed Plain Concrete Walls

Design requirements for plain masonry walls have existed for many years and the corresponding~~competing~~ type of concrete construction is the plain concrete wall. To allow the use of such walls as the lateral-force-resisting system in SDC A and B, this provision requires such walls to contain at least the minimal reinforcement specified in Section 22.6.7.2.

C14.2.2.9 Strength Requirements for Anchors

ACI 318-08 requires laboratory testing to establish the strength of anchor bolts greater than 2 in. in diameter or exceeding 25 in. in tensile embedment depth. This modification makes the ACI 318 equation giving the basic concrete breakout strength of a single anchor in tension in cracked concrete applicable irrespective of the anchor bolt diameter and tensile embedment depth.

Korean Power Engineering, (KPE), has made tension tests on anchors with diameters up to 4.25 in. and embedment depths up to 45 in. and found that the diameter and embedment depth limits of Section D.4.2.2 of ACI 318-08 for the design procedure for anchors in tension (Section D.5.2) can be eliminated. KPE has also made shear tests on anchors with diameters up to 3.0 in. and embedment depths as large as 30 in. and found no effect of the embedment depth on shear strength. However, the diameter tests showed that the basic shear breakout strength Eq. (D-24) needed some modification for the complete elimination of the 2in. limit to be fully appropriate. Analytical work performed at the University of Stuttgart supports the need for some modification to Eq. D-24. Changes consistent with the Korean and Stuttgart findings have already been made to the FIB Design Guide for anchors.

C14.2.3 Additional Detailing Requirements for Concrete Piles

Chapter 20 of the PCI Bridge Design Manual provides detailed information on the structural design of piles and on pile to cap connections for precast prestressed concrete piles. ACI 318 does not contain provisions governing the design and installation of portions of concrete piles, drilled piers, and caissons embedded in ground except for SDC D, E and F structures.

PCI Bridge Design Manual, 2004, "Precast Prestressed Concrete Piles", Chapter 20, PCI Publication BM-20-04, Precast/Prestressed Concrete Institute, Chicago, IL.

C14.2.3.1 Concrete Pile Requirements for Seismic Design Category C

C14.2.3.1.2 Reinforcement for Uncased Concrete Piles (SDC C):
The transverse reinforcing requirements in the potential plastic hinge zone of uncased concrete piles in Seismic Design Category C is a selective composite of two ACI 318 requirements. In the potential plastic hinge region of an intermediate moment-resisting concrete frame column, the transverse reinforcement spacing is restricted to the least of: (1) 8 times the diameter of the smallest longitudinal bar, (2) 24 times the diameter of the tie bar, (3) one-half the smallest cross-sectional dimension of the column, and (4) 12 in. Outside of the potential plastic hinge region of a special moment-resisting frame column, the transverse reinforcement spacing is restricted to the smaller of: 6 times the diameter of the longitudinal column bars and 6 in.

C14.2.3.1.3 Reinforcement for Metal-Cased Concrete Piles (SDC C)
C14.2.3.1.4 Reinforcement for Concrete-Filled Pipe Piles (SDC C)

C14.2.3.1.5 Reinforcement for Precast Nonprestressed Concrete Piles (SDC C)
Transverse reinforcement requirements in and outside of the plastic hinge zone of precast nonprestressed piles are clarified. The transverse reinforcement requirement in the potential plastic hinge zone is a composite of two ACI 318 requirements (see Section C14.2.3.1.2). Outside of the potential plastic hinge region the eight longitudinal-bar-diameter spacing is doubled. The maximum 8-in. tie spacing comes from current building code provisions for precast concrete piles.

C14.2.7.1.6 Reinforcement for Precast Prestressed Piles (SDC C)
The transverse and longitudinal reinforcing requirements given in ACI 318, Chapter 21, were never intended for slender precast prestressed concrete elements and will result in unbuildable piles. These requirements are based on the *Recommended Practice for Design, Manufacture and Installation of Prestressed Concrete Piling*, PCI Committee on Prestressed Concrete Piling, 1993.

Equation 14.2-1, originally from ACI 318, has always been intended to be a lower-bound spiral reinforcement ratio for larger diameter columns. It is independent of the member section properties and can therefore be applied to large or small diameter piles. For cast-in-place concrete piles and precast prestressed concrete piles, the resulting spiral reinforcing ratios from this formula are considered to be sufficient to provide moderate ductility capacities. (Fanous et al., 2007).

Full confinement per Eq. 14.2-1 is required for the upper 20 ft.of the pile length where curvatures are large. The amount is relaxed by 50 percent outside of that length in view of lower curvatures and in consideration of confinement provided by the soil.

Fanous, A., Sritharan, S., Suleiman, M., and Arulmoli, A., " Minimum Spiral Reinforcement Requirements and lateral Displacement Limits for Prestressed Concrete Piles in High Seismic Regions" ISU-ERI Ames Report, Department of Civil, Construction and Environmental Engineering, Iowa State University, September, 2007. 157p.

C14.2.3.2 Concrete Pile requirements for Seismic Design Categories D through F.
C14.2.3.2.1 Site Class E or F Soil
C14.2.3.2.2 Nonapplicable ACI 318 Sections for Grade Beams and Piles

C14.2.3.2.3 Reinforcement for Uncased Concrete Piles (SDC D through F).
The reinforcement requirements for uncased concrete piles are taken from the 2006 IBC ~~code~~ requirements, and should be adequate to provide ductility in the potential plastic hinge zones (Fanous et al., 2007).

C14.2.3.2.4 Reinforcement for Metal-Cased Concrete Piles (SDC D through F)

C14.2.3.2.5 Reinforcement for Precast Concrete Piles (SDC D through F).
The transverse reinforcement requirements for precast nonprestressed concrete piles are taken from the 2006 IBC ~~code~~ requirements and are should be adequate to provide ductility in the potential plastic hinge zones (Fanous et al., 2007).

C14.2.3.2.6 Reinforcement for Precast-Prestressed Piles (SDC D through F).
The reduced amounts of transverse reinforcement specified in this provisions compared to those required for column members in ACI 318 are justified by the results of the study by Fanous et al., 2007. The last paragraph of the provision provides minimum transverse reinforcement requirements outside of the zone of prescribed ductile detailing.

REASON FOR PROPOSAL:

To replace existing Draft Commentary with Commentary consistent with the Sec. 14.2 Provisions as amended in Proposals 4-2 and 4-3.

TS-4 VOTE: In a ballot canvassed 12/14/07 TS-4 voted as follows:
YES = 5 *Yes with Reservations = 1* *No = 3* *Not Voting = 2*
Revisions were made to the original proposal in response to the Y/R and No votes. With those revisions the No voters withdrew their No votes.