CHAPTER 21—STRENGTH REDUCTION FACTORS

CODE

21.1—Scope

21.1.1 This chapter shall apply to the selection of strength reduction factors used in design, except as permitted by Chapter 27.

21.2—Strength reduction factors for structural concrete members and connections

21.2.1 Strength reduction factors ϕ shall be in accordance with Table 21.2.1, except as modified by 21.2.2, 21.2.3, and 21.2.4.

Table 21.2.1—Strength reduction factors ϕ

Action or structural element		ϕ	Exceptions
(a)	Moment, axial force, or combined moment and axial force	0.65 to 0.90 in accordance with 21.2.2	Near ends of pretensioned members where strands are not fully developed, ϕ shall be in accordance with 21.2.3.
(b)	Shear	0.75	Additional requirements are given in 21.2.4 for structures designed to resist earthquake effects.
(c)	Torsion	0.75	—
(d)	Bearing	0.65	—
(e)	Post-tensioned anchorage zones	0.85	—
(f)	Brackets and corbels	0.75	—
(g)	Struts, ties, nodal zones, and bearing areas designed in accordance with strut-and-tie method in Chapter 23	0.75	—
(h)	Components of connections of precast members controlled by yielding of steel elements in tension	0.90	—
(i)	Plain concrete elements	0.60	—
(j)	Anchors in concrete elements	0.45 to 0.75 in accordance with Chapter 17	—

21.2.2 Strength reduction factor for moment, axial force, or combined moment and axial force shall be in accordance with Table 21.2.2.

COMMENTARY

R21.1—Scope

R21.1.1 The purposes of strength reduction factors ϕ are: (1) to account for the probability of under-strength members due to variations in material strengths and dimensions; (2) to account for inaccuracies in the design equations; (3) to reflect the available ductility and required reliability of the member under the load effects being considered; and (4) to reflect the importance of the member in the structure (MacGregor 1976; Winter 1979).

R21.2—Strength reduction factors for structural concrete members and connections

R21.2.1 The strength reduction factors in this Code are compatible with the ASCE/SEI 7 load combinations, which are the basis for the required factored load combinations in Chapter 5:

(e) Laboratory tests of post-tensioned anchorage zones (Breen et al. 1994) indicate a wide range of scatter in the results. This observation is addressed with a ϕ-factor of 0.85 and by limiting the nominal compressive strength of unconfined concrete in the general zone to $\mathbf{0.7\lambda}f_{ci}'$ in 25.9.4.5.2, where λ is defined in 19.2.4. Thus, the effective design strength of unconfined concrete is $\mathbf{0.85 \times 0.7\lambda}f_{ci}' = \mathbf{0.6\lambda}f_{ci}'$ in the general zone.

(f) Bracket and corbel behavior is predominantly controlled by shear; therefore, a single value of $\phi = \mathbf{0.75}$ is used for all potential modes of failure.

(i) The strength reduction factor ϕ for plain concrete members is the same for all potential modes of failure. Because both the flexural tension strength and shear strength for plain concrete depend on the tensile strength of the concrete, without the reserve strength or ductility that might otherwise be provided by reinforcement, equal strength reduction factors for moment and shear are considered to be appropriate.

R21.2.2 The nominal strength of a member that is subjected to moment or combined moment and axial force is determined for the condition where the strain in the extreme compression fiber is equal to the assumed strain limit of 0.003. The net tensile strain ε_t is the tensile strain calculated in the extreme tension reinforcement at nominal strength,