CHAPTER 2—NOTATION AND TERMINOLOGY

CODE

2.1—Scope

2.1.1 This chapter defines notation and terminology used in this Code.

2.2—Notation

a = depth of equivalent rectangular stress block, in.

a_v = shear span, equal to distance from center of concentrated load to either: (a) face of support for continuous or cantilevered members, or (b) center of support for simply supported members, in.

A_1 = loaded area for consideration of bearing, strut, and node strength, in.^{2}

A_2 = area of the lower base of the largest frustum of a pyramid, cone, or tapered wedge contained wholly within the support and having its upper base equal to the loaded area. The sides of the pyramid, cone, or tapered wedge shall be sloped one vertical to two horizontal, in.^{2}

A_b = area of an individual bar or wire, in.^{2}

A_{bp} = area of the attachment base plate in contact with concrete or grout when loaded in compression, in.^{2}

A_{brg} = net bearing area of the head of stud, anchor bolt, or headed deformed bar, in.^{2}

A_c = area of concrete section resisting shear transfer, in.^{2}

$A_{c,eff}$ = concrete area containing reinforcement parallel to reinforcing bar group and enclosed within a distance $0.75h_{ef}$ from the perimeter of the reinforcing bar group, in.^{2}

A_{cf} = greater gross cross-sectional area of the two orthogonal slab-beam strips intersecting at a column of a two-way prestressed slab, in.^{2}

A_{ch} = cross-sectional area of a member measured to the outside edges of transverse reinforcement, in.^{2}

A_{cp} = area enclosed by outside perimeter of concrete cross section, in.^{2}

A_{cs} = cross-sectional area at one end of a strut in a strut-and-tie model, taken perpendicular to the axis of the strut, in.^{2}

A_{ct} = area of that part of cross section between the flexural tension face and centroid of gross section, in.^{2}

A_{cv} = gross area of concrete section bounded by web thickness and length of section in the direction of shear force considered in the case of walls, and gross area of concrete section in the case of diaphragms. Gross area is total area of the defined section minus area of any openings, in.^{2}

A_{cw} = area of concrete section of an individual pier, horizontal wall segment, or coupling beam resisting shear, in.^{2}

$A_{ef,sl}$ = effective bearing area of shear lug, in.^{2}

A_f = area of reinforcement in bracket or corbel resisting design moment, in.^{2}

A_g = gross area of concrete section, in.^{2} For a hollow section, A_g is the area of the concrete only and does not include the area of the void(s)

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A_h = total area of shear reinforcement parallel to primary tension reinforcement in a corbel or bracket, in.^{2}

A_{hs} = total cross-sectional area of hooked or headed bars being developed at a critical section, in.^{2}

A_j = effective cross-sectional area within a joint in a plane parallel to plane of beam reinforcement generating shear in the joint, in.^{2}

A_ℓ = total area of longitudinal reinforcement to resist torsion, in.^{2}

$A_{\ell,min}$ = minimum area of longitudinal reinforcement to resist torsion, in.^{2}

$A_{\ell d}$ = area of distributed reinforcement parallel to the longitudinal axis of the member within spacing $s_{\ell d}$, in.^{2}

A_n = area of reinforcement in bracket or corbel resisting factored restraint force N_{uc}, in.^{2}

A_{nz} = area of a face of a nodal zone or a section through a nodal zone, in.^{2}

A_{Na} = projected influence area of a single adhesive anchor or group of adhesive anchors, for calculation of bond strength in tension, in.^{2}

A_{Nao} = projected influence area of a single adhesive anchor, for calculation of bond strength in tension if not limited by edge distance or spacing, in.^{2}

A_{Nc} = projected concrete failure area of a single anchor or group of anchors, for calculation of strength in tension, in.^{2}

A_{Nco} = projected concrete failure area of a single anchor, for calculation of strength in tension if not limited by edge distance or spacing, in.^{2}

A_o = gross area enclosed by torsional shear flow path, in.^{2}

A_{oh} = area enclosed by centerline of the outermost closed transverse torsional reinforcement, in.^{2}

A_{pd} = total area occupied by duct, sheathing, and prestressing reinforcement, in.^{2}

A_{ps} = area of prestressed longitudinal tension reinforcement, in.^{2}

A_{pt} = total area of prestressing reinforcement, in.^{2}

A_s = area of nonprestressed longitudinal tension reinforcement, in.^{2}

A_s' = area of compression reinforcement, in.^{2}

$A_{s,min}$ = minimum area of flexural reinforcement, in.^{2}

A_{sc} = area of primary tension reinforcement in a corbel or bracket, in.^{2}

$A_{se,N}$ = effective cross-sectional area of anchor in tension, in.^{2}

$A_{se,V}$ = effective cross-sectional area of anchor in shear, in.^{2}

A_{shear} = cross-sectional area used to calculate the shear stiffness, in.^{2}

A_{sh} = total cross-sectional area of transverse reinforcement, including crossties, within spacing s and perpendicular to dimension b_c, in.^{2}

A_{si} = total area of surface reinforcement at spacing s_i in the i-th layer crossing a strut, with reinforcement at an angle α_i to the axis of the strut, in.^{2}

A_{st} = total area of nonprestressed longitudinal reinforce-

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ment including bars and excluding prestressing reinforcement, in.^{2}

A_t = area of one leg of a closed stirrup, hoop, or tie resisting torsion within spacing s, in.^{2}

A_{td} = area of distributed reinforcement transverse to the longitudinal axis of the member within spacing s_{td}, in.^{2}

A_{tp} = area of prestressing reinforcement in a tie, in.^{2}

A_{tr} = total cross-sectional area of all transverse reinforcement satisfying 25.4.2.6 within spacing s that crosses the potential plane of splitting through the reinforcement being developed, in.^{2}

A_{ts} = area of nonprestressed reinforcement in a tie, in.^{2}

A_{tt} = total cross-sectional area of parallel tie reinforcement to be considered as confining headed bars, in.^{2}

A_v = area of shear reinforcement within spacing s, in.^{2}

$A_{v,min}$ = minimum area of shear reinforcement within spacing s, in.^{2}

A_{vd} = total area of reinforcement in each group of diagonal bars in a diagonally reinforced coupling beam, in.^{2}

A_{vf} = area of shear-friction reinforcement, in.^{2}

$A_{vf,min}$ = minimum area of shear-friction reinforcement, in.^{2}

A_{vh} = area of shear reinforcement parallel to flexural tension reinforcement within spacing s_2, in.^{2}

A_{Vc} = projected concrete failure area of a single anchor or group of anchors, for calculation of strength in shear, in.^{2}

A_{Vco} = projected concrete failure area of a single anchor, for calculation of strength in shear, if not limited by corner influences, spacing, or member thickness, in.^{2}

b = width of compression face of member, in.

b_1 = dimension of the critical section b_o measured in the direction of the span for which moments are determined, in.

b_2 = dimension of the critical section b_o measured in the direction perpendicular to b_1, in.

b_c = cross-sectional dimension of member core measured to the outside edges of the transverse reinforcement composing area A_{sh}, in.

b_{cf} = effective overhanging compression flange width, in.

b_f = effective flange width, in.

b_o = perimeter of critical section for two-way shear in slabs and footings, in.

b_s = width of strut, in.

b_{sl} = width of shear lug, in.

b_{slab} = effective slab width, in.

b_t = width of that part of cross section containing the closed stirrups resisting torsion, in.

b_v = width of cross section at contact surface being investigated for horizontal shear, in.

b_w = web width or diameter of circular section, in.

B = bias factor to adjust nominal strength to seismic target reliabilities (Appendix A)

B_n = nominal bearing strength, lb

B_u = factored bearing load, lb

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c = distance from extreme compression fiber to neutal axis, in.

c_1 = dimension of rectangular or equivalent rectangular column, capital, or bracket measured in the direction of the span for which moments or joint shear forces are being determined, in.

c_2 = dimension of rectangular or equivalent rectangular column, capital, or bracket measured in the direction perpendicular to c_1, in.

$c_{a,max}$ = maximum distance from center of an anchor shaft to the edge of concrete, in.

$c_{a,min}$ = minimum distance from center of an anchor shaft to the edge of concrete, in.

c_{a1} = distance from the center of an anchor shaft to the edge of concrete in one direction, in. If shear is applied to anchor, c_{a1} is taken in the direction of the applied shear. If tension is applied to the anchor, c_{a1} is the minimum edge distance. Where anchors subject to shear are located in narrow sections of limited thickness, see 17.7.2.1.2

c_{a2} = distance from center of an anchor shaft to the edge of concrete in the direction perpendicular to c_{a1}, in.

c_{ac} = critical edge distance required to develop the basic strength as controlled by concrete breakout or bond of a post-installed anchor in tension in uncracked concrete without supplementary reinforcement to control splitting, in.

c_b = lesser of: (a) the distance from center of a bar or wire to nearest concrete surface, and (b) one-half the center-to-center spacing of bars or wires being developed, in.

c_c = clear cover of reinforcement, in.

c_{Na} = projected distance from center of an anchor shaft on one side of the anchor required to develop the full bond strength of a single adhesive anchor, in.

c_{sl} = distance from the centerline of the row of anchors in tension nearest the shear lug to the centerline of the shear lug measured in the direction of shear, in.

c_t = distance from the interior face of the column to the slab edge measured parallel to c_1, but not exceeding c_1, in.

C_m = factor relating actual moment diagram to an equivalent uniform moment diagram

d' = distance from extreme compression fiber to centroid of longitudinal compression reinforcement, in.

d = distance from extreme compression fiber to centroid of longitudinal tension reinforcement, in.

d_a' = value substituted for d_a if an oversized anchor is used, in.

d_a = outside diameter of anchor or shaft diameter of headed stud, headed bolt, or hooked bolt, in.

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c'_{a1} = limiting value of c_{a1} where anchors are located less than $1.5c_{a1}$ from three or more edges, in.; see Fig R17.7.2.1.2

C = compressive force acting on a nodal zone, lb

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d_{agg} = nominal maximum size of coarse aggregate, in.

d_b = nominal diameter of bar, wire, or prestressing strand, in.

d_p = distance from extreme compression fiber to centroid of prestressed reinforcement, in.

d_{pile} = diameter of pile at footing base, in.

D = effect of service dead load

D_s = effect of superimposed dead load

D_u = ultimate deformation capacity; the largest deformation at which the hysteresis model is deemed valid given available laboratory data or other substantiating evidence (Appendix A)

D_w = effect of self-weight dead load of the concrete structural system

e_h = distance from the inner surface of the shaft of a J- or L-bolt to the outer tip of the J- or L-bolt, in.

e_N' = distance between resultant tension load on a group of anchors loaded in tension and the centroid of the group of anchors loaded in tension, in.; e'_N is always positive

e_V' = distance between resultant shear load on a group of anchors loaded in shear in the same direction, and the centroid of the group of anchors loaded in shear in the same direction, in.; e'_V is always positive

E = effect of horizontal and vertical earthquake-induced forces

E_c = modulus of elasticity of concrete, psi

E_{cb} = modulus of elasticity of beam concrete, psi

E_{ce} = expected modulus of elasticity of concrete, psi (Appendix B)

E_{cs} = modulus of elasticity of slab concrete, psi

E_h = effect of horizontal earthquake-induced forces

EI = flexural stiffness of member, in.^{2}-lb

$(EI)_{eff}$ = effective flexural stiffness of member, in.^{2}-lb

E_{mh} = load effect due to the horizontal seismic force including overstrength, Ω_o, as defined in ASCE/SEI 7

E_p = modulus of elasticity of prestressing reinforcement, psi

E_s = modulus of elasticity of reinforcement and structural steel, excluding prestressing reinforcement, psi

f_c' = specified compressive strength of concrete, psi

$\sqrt{f_c'}$ = square root of specified compressive strength of concrete, psi

f_{ce} = effective compressive strength of the concrete in a strut or a nodal zone, psi

f_{ce}' = expected compressive strength of concrete, psi (Appendix A, B)

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d_{burst} = distance from the anchorage device to the centroid of the bursting force, T_{burst}, in.

D_i = diagonal compression component of shear flow resistance in concrete, lb

e_{anc} = eccentricity of the anchorage device or group of devices with respect to the centroid of the cross section, in.

E_{ce} = expected modulus of elasticity of concrete is calculated using expected compressive strength of concrete. (Appendix B)

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$\sqrt{f'_{ce}}$ = square root of expected compressive strength of concrete, psi

f'_{ci} = specified compressive strength of concrete at transfer of prestress, psi

$\sqrt{f'_{ci}}$ = square root of specified compressive strength of concrete at transfer of prestress, psi

f_{ct} = measured average splitting tensile strength of lightweightconcrete, psi

f_d = stress due to unfactored dead load, at extreme fiber of section where tensile stress is caused by externally applied loads, psi

f_{dc} = decompression stress; stress in the prestressed reinforcement if stress is zero in the concrete at the same level as the centroid of the prestressed reinforcement, psi

f_{pc} = compressive stress in concrete, after allowance for all prestress losses, at centroid of cross section resisting externally applied loads or at junction of web and flange where the centroid lies within the flange, psi. In a composite concrete member, f_{pc} is the resultant compressive stress at centroid of composite section, or at junction of web and flange where the centroid lies within the flange, due to both prestress and moments resisted by precast member acting alone

f_{pe} = compressive stress in concrete due only to effective prestress forces, after allowance for all prestress losses, at extreme fiber of section if tensile stress is caused by externally applied loads, psi

f_{ps} = stress in prestressed reinforcement at nominal flexural strength, psi

f_{pu} = specified tensile strength of prestressing reinforcement, psi

f_{py} = specified yield strength of prestressing reinforcement, psi

f_r = modulus of rupture of concrete, psi

f_s = tensile stress in reinforcement at service loads, excluding prestressed reinforcement, psi

f_s' = compressive stress in reinforcement under factored loads, excluding prestressed reinforcement, psi

f_{se} = effective stress in prestressed reinforcement, after allowance for all prestress losses, psi

f_t = extreme fiber stress in the precompressed tension zone calculated at service loads using gross section properties after allowance of all prestress losses, psi

f_u = specified tensile strength of nonprestressed reinforcement, psi

f_{ue} = expected tensile strength for nonprestressed reinforcement, psi (Appendix A, B)

f_{uta} = specified tensile strength of anchor steel, psi

f_y = specified yield strength for nonprestressed reinforcement, psi

f_{ya} = specified yield strength of anchor steel, psi

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f_{si} = stress in the i-th layer of surface reinforcement, psi

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f_{ye} = expected yield strength for nonprestressed reinforcement, psi (Appendix A, B)

f_{yt} = specified yield strength of transverse reinforcement, psi

F = effect of service load due to fluids with well-defined pressures and maximum heights

F_{nn} = nominal strength at face of a nodal zone, lb

F_{ns} = nominal strength of a strut, lb

F_{nt} = nominal strength of a tie, lb

F_{un} = factored force on the face of a node, lb

F_{us} = factored compressive force in a strut, lb

F_{ut} = factored tensile force in a tie, lb

h = overall thickness, height, or depth of member, in.

h_a = thickness of member in which an anchor is located, measured parallel to anchor axis, in.

h_{ef} = effective embedment depth of anchor or reinforcing bar, in.

$h_{ef,sl}$ = effective embedment depth of shear lug, in.

h_n = structural height from the base to the highest level of the seismic-force-resisting system of the structure, ft, where the base is the level at which the horizontal earthquake ground motions are considered to be imparted to the structure

h_{sl} = embedment depth of shear lug, in.

h_{sx} = story height for story x, in. (Appendix A, B)

h_u = laterally unsupported height at extreme compression fiber of wall or wall pier, in., equivalent to ℓ_u for compression members

h_w = height of entire wall from base to top, or clear height of wall segment or wall pier considered, in.

h_{wcs} = height of entire structural wall above the critical section for flexural and axial loads, in.

h_x = maximum center-to-center spacing of longitudinal bars laterally supported by corners of crossties or hoop legs around the perimeter of a column or wall boundary element, in.

H = effect of service load due to lateral earth pressure, ground water pressure, or pressure of bulk materials, lb

I = moment of inertia of section about centroidal axis, in.^{4}

I_b = moment of inertia of gross section of beam about centroidal axis, in.^{4}

I_{cr} = moment of inertia of cracked section transformed to concrete, in.^{4}

I_e = effective moment of inertia for calculation of deflection, in.^{4}

I_g = moment of inertia of gross concrete section about centroidal axis, neglecting reinforcement, in.^{4}

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h_{anc} = dimension of anchorage device or single group of closely spaced devices in the direction of bursting being considered, in.

h'_{ef} = limiting value of h_{ef} where anchors are located less than $1.5h_{ef}$ from three or more edges, in.; refer to Fig. R17.6.2.1.2.

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I_s = moment of inertia of gross section of slab about centroidal axis, in.^{4}

I_{se} = moment of inertia of reinforcement about centroidal axis of member cross section, in.^{4}

k = effective length factor for compression members

k_c = coefficient for basic concrete breakout strength in tension

k_{cp} = coefficient for pryout strength

k_f = concrete strength factor

k_n = confinement effectiveness factor

K_{tr} = transverse reinforcement index, in.

L = effect of service live load

L_r = effect of service roof live load

ℓ = span length of beam or one-way slab; clear projection of cantilever, in.

ℓ_1 = length of span in direction that moments are being determined, measured center-to-center of supports, in.

ℓ_2 = length of span in direction perpendicular to ℓ_1, measured center-to-center of supports, in.

ℓ_a = additional embedment length beyond centerline of support or point of inflection, in.

ℓ_{be} = length of boundary element from compression face of member, in.

ℓ_c = length of compression member, measured center-to-center of the joints, in.

ℓ_d = development length in tension of deformed bar, deformed wire, plain and deformed welded wire reinforcement, or pretensioned strand, in.

ℓ_{db} = debonded length of prestressed reinforcement at end of member, in.

ℓ_{dc} = development length in compression of deformed bars and deformed wire, in.

ℓ_{dh} = development length in tension of deformed bar or deformed wire with a standard hook, measured from outside end of hook, point of tangency, toward critical section, in.

ℓ_{dt} = development length in tension of headed deformed bar, measured from the bearing face of the head toward the critical section, in.

ℓ_e = load bearing length of anchor for shear, in.

ℓ_{ext} = straight extension at the end of a standard hook, in.

ℓ_n = length of clear span measured face-to-face of supports, in.

ℓ_o = length, measured from joint face along axis of member, over which special transverse reinforcement must be provided, in.

ℓ_p = plastic-hinge length for analysis purposes, in. (Appendix A)

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K_{05} = coefficient associated with the 5 percent fractile

K_t = torsional stiffness of member; moment per unit rotation

ℓ_{anc} = length along which anchorage of a tie must occur, in.

ℓ_b = width of bearing, in.

ℓ_{dm} = required development length if bar is not entirely embedded in confined concrete, in.

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ℓ_{sc} = compression lap splice length, in.

ℓ_{st} = tension lap splice length, in.

ℓ_t = span of member under load test, taken as the shorter span for two-way slab systems, in. Span is the lesser of: (a) distance between centers of supports, and (b) clear distance between supports plus thickness h of member. Span for a cantilever shall be taken as twice the distance from face of support to cantilever end

ℓ_{tr} = transfer length of prestressed reinforcement, in.

ℓ_u = unsupported length of column or wall, in.

ℓ_{vh} = distance between points of zero and maximum moment along which horizontal shear is transferred across the interface, in.

ℓ_w = length of entire wall, or length of wall segment or wall pier considered in direction of shear force, in.

M_1 = lesser factored end moment on a compression member, in.-lb

M_{1ns} = factored end moment on a compression member at the end at which M_1 acts, due to loads that cause no appreciable sidesway, calculated using a first-order elastic frame analysis, in.-lb

M_{1s} = factored end moment on compression member at the end at which M_1 acts, due to loads that cause appreciable sidesway, calculated using a first-order elastic frame analysis, in.-lb

M_2 = greater factored end moment on a compression member. If transverse loading occurs between supports, M_2 is taken as the largest moment occurring in member. Value of M_2 is always positive, in.-lb

$M_{2,min}$ = minimum value of M_2, in.-lb

M_{2ns} = factored end moment on compression member at the end at which M_2 acts, due to loads that cause no appreciable sidesway, calculated using a first-order elastic frame analysis, in.-lb

M_{2s} = factored end moment on compression member at the end at which M_2 acts, due to loads that cause appreciable sidesway, calculated using a first-order elastic frame analysis, in.-lb

M_a = maximum moment in member due to service loads at stage deflection is calculated, in.-lb

M_c = factored moment amplified for the effects of member curvature used for design of compression member, in.-lb

M_{cr} = cracking moment, in.-lb

M_{cre} = moment causing flexural cracking at section due to externally applied loads, in.-lb

M_{max} = maximum factored moment at section due to externally applied loads, in.-lb

M_n = nominal flexural strength at section, in.-lb

M_{nb} = nominal flexural strength of beam including slab where in tension, framing into joint, in.-lb

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M = moment acting on anchor or anchor group, in.-lb

M_d = moment due to unfactored dead load, in.-lb

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M_{nc} = nominal flexural strength of column framing into joint, calculated for factored axial force, consistent with the direction of lateral forces considered, resulting in lowest flexural strength, in.-lb

M_{ne} = flexural strength at section, determined using expected material strengths, in.-lb (Appendix B)

M_{pr} = probable flexural strength of members, with or without axial load, determined using the properties of the member at joint faces assuming a tensile stress in the longitudinal bars of at least $1.25f_y$ and a strength reduction factor ϕ of 1.0, in.-lb

M_{sa} = maximum moment in wall due to service loads, excluding $P\Delta$ effects, in.-lb

M_{sc} = factored slab moment that is resisted by the column at a joint, in.-lb

M_u = factored moment at section, in.-lb

M_{ua} = moment at midheight of wall due to factored lateral and eccentric vertical loads, not including $P\Delta$ effects, in.-lb

n = number of items, such as, bars, wires, monostrand anchorage devices, or anchors

n_ℓ = number of longitudinal bars around the perimeter of a column core with rectilinear hoops that are laterally supported by the corner of hoops or by seismic hooks. A bundle of bars is counted as a single bar

n_s = number of stories above the critical section

N_a = nominal bond strength in tension of a single adhesive anchor, lb

N_{ag} = nominal bond strength in tension of a group of adhesive anchors, lb

N_b = basic concrete breakout strength in tension of a single anchor in cracked concrete, lb

N_{ba} = basic bond strength in tension of a single adhesive anchor, lb

N_c = resultant tensile force acting on the portion of the concrete cross section that is subjected to tensile stresses due to the combined effects of service loads and effective prestress, lb

N_{cb} = nominal concrete breakout strength in tension of a single anchor, lb

N_{cbg} = nominal concrete breakout strength in tension of a group of anchors, lb

N_{cp} = basic concrete pryout strength of a single anchor, lb

N_{cpg} = basic concrete pryout strength of a group of anchors, lb

N_n = nominal strength in tension, lb

$N_{n,c}$ = nominal strength in tension of a single anchor governed by concrete breakout, pullout, or side-face blowout strength, lb

$N_{n,cg}$ = nominal strength in tension of an anchor group governed by concrete breakout, pullout, or side-face blowout strength, lb

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n_t = number of threads per inch

N = tension force acting on anchor or anchor group, lb

N_i = axial tension component of shear flow resistance in longitudinal reinforcement, lb

$N_{n,c}$ = Nominal strength in tension of a single anchor is given in Table 17.5.2

$N_{n,cg}$ = Refer to the concrete failure modes given in Table 17.5.2

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N_p = pullout strength in tension of a single anchor in cracked concrete, lb

N_{pn} = nominal pullout strength in tension of a single anchor, lb

N_{rg} = nominal concrete breakout strength of reinforcing bar group, lb

N_{sa} = nominal strength of a single anchor or individual anchor in a group of anchors in tension as governed by the steel strength, lb

N_{sb} = side-face blowout strength of a single anchor, lb

N_{sbg} = side-face blowout strength of a group of anchors, lb

N_{srg} = contribution of parallel reinforcement to the nominal breakout strength of a reinforcing bar group, lb

N_u = factored axial force normal to cross section occurring simultaneously with V_u or T_u; to be taken as positive for compression and negative for tension, lb

N_{ua} = factored tensile force applied to anchor or individual anchor in a group of anchors, lb

$N_{ua,g}$ = total factored tensile force applied to anchor group, lb

$N_{ua,i}$ = factored tensile force applied to most highly stressed anchor in a group of anchors, lb

$N_{ua,s}$ = factored sustained tension load, lb

N_{uc} = factored restraint force applied to a bearing connection acting perpendicular to and simultaneously with V_u, to be taken as positive for tension, lb

$N_{uc,max}$ = maximum restraint force that can be transmitted through the load path of a bearing connection multiplied by the load factor used for live loads in combinations with other factored load effects

p_{cp} = outside perimeter of concrete cross section, in.

p_h = perimeter of centerline of outermost closed transverse torsional reinforcement, in.

P_a = maximum allowable compressive strength of a deep foundation member, lb

P_c = critical buckling load, lb

P_n = nominal axial compressive strength of member, lb

P_{ne} = axial compressive strength of member, determined using expected material strengths, lb (Appendix B)

$P_{n,bal}$ = nominal axial strength at the balanced strain condition, lb

$P_{n,max}$ = maximum nominal axial compressive strength of a member, lb

P_{nte} = axial tensile strength of member, determined using expected material strengths, lb (Appendix B)

P_{nt} = nominal axial tensile strength of member, lb

$P_{nt,max}$ = maximum nominal axial tensile strength of member, lb

P_o = nominal axial strength at zero eccentricity, lb

P_{pu} = factored prestressing force at anchorage device, lb

P_s = unfactored axial load at the design, midheight section including effects of self-weight, lb

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p_o = perimeter of area A_o, in.

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P_u = factored axial force; to be taken as positive for compression and negative for tension, lb

$P\Delta$ = secondary moment due to lateral deflection, in.-lb

q_u = factored load per unit area, lb/ft^2

Q = stability index for a story

r = radius of gyration of cross section, in.

r_b = bend radius at the inside of a bar, in.

R = cumulative load effect of service rain load

R_n = nominal strength (Appendix B)

R_{ne} = expected yield strength (Appendix A)

$R_{ne,w}$ = expected strength of reinforced concrete member using f_{ce}' and f_{ye} (Appendix B)

s = center-to-center spacing of items, such as longitudinal reinforcement, transverse reinforcement, tendons, or anchors, in.

s_2 = center-to-center spacing of longitudinal shear or torsional reinforcement, in.

s_i = center-to-center spacing of reinforcement in the i-th direction adjacent to the surface of the member, in.

$s_{\ell d}$ = center-to-center spacing of longitudinal distributed reinforcement measured over the height of the member, in.

s_o = center-to-center spacing of transverse reinforcement within the length ℓ_o, in.

s_s = sample standard deviation, psi

s_{td} = center-to-center spacing of transverse distributed reinforcement measured in the longitudinal direction of the member, in.

s_w = clear distance between adjacent webs, in.

s_{wd} = center-to-center spacing of curtains or planes of longitudinal or transverse distributed reinforcement measured across the width or thickness of the member, in.

S = effect of service snow load

S_{DS} = 5% damped, spectral response acceleration parameter at short periods determined in accordance with the general building code

S_e = moment, shear, or axial force at connection corresponding to development of probable strength at intended yield locations, based on the governing mechanism of inelastic lateral deformation, considering both gravity and earthquake effects

S_m = elastic section modulus, in.^{3}

S_n = nominal moment, shear, axial, torsion, or bearing strength

S_y = yield strength of connection, based on f_y of the connected part, for moment, shear, torsion, or axial force, psi

t = wall thickness of hollow section, in.

t_{cf} = effective compression flange thickness, in.

t_f = thickness of flange, in.

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$P\delta$ = secondary moment due to individual member slenderness, in.-lb

q = shear flow, lb/in.

R = reaction, lb

CODE

t_{sl} = thickness of shear lug, in.

T = cumulative effects of service temperature, creep, shrinkage, differential settlement, and shrinkage compensating concrete

T_{cr} = cracking torsional moment, in.-lb

T_n = nominal torsional moment strength, in.-lb

T_t = total test load, lb

T_{th} = threshold torsional moment, in.-lb

T_u = factored torsional moment at section, in.-lb

U = strength of a member or cross section required to resist factored loads or related internal moments and forces in such combinations as stipulated in this Code

v_c = stress corresponding to nominal two-way shear strength provided by concrete, psi

v_n = equivalent concrete stress corresponding to nominal two-way shear strength of slab or footing, psi

v_s = equivalent concrete stress corresponding to nominal two-way shear strength provided by reinforcement, psi

v_u = maximum factored two-way shear stress calculated around the perimeter of a given critical section, psi

v_{ug} = factored shear stress on the slab critical section for two-way action due to gravity loads without moment transfer, psi

v_{uv} = factored shear stress on the slab critical section for two-way action, from the controlling load combination, without moment transfer, psi

V_b = basic concrete breakout strength in shear of a single anchor in cracked concrete, lb

$V_{brg,sl}$ = nominal bearing strength of a shear lug in direction of shear, lb

V_c = nominal shear strength provided by concrete, lb

V_{cb} = nominal concrete breakout strength in shear of a single anchor, lb

$V_{cb,sl}$ = nominal concrete breakout strength in shear of attachment with shear lugs, lb

V_{cbg} = nominal concrete breakout strength in shear of a group of anchors, lb

V_{ci} = nominal shear strength provided by concrete where diagonal cracking results from combined shear and moment, lb

V_{cp} = nominal concrete pryout strength of a single anchor, lb

COMMENTARY

T = tension force acting on a nodal zone in a strut-and-tie model, lb (T is also used to define the cumulative effects of service temperature, creep, shrinkage, differential settlement, and shrinkage-compensating concrete in the load combinations defined in 5.3.6)

T_{burst} = tensile force in general zone acting ahead of the anchorage device caused by spreading of the anchorage force, lb

V = shear force acting on anchor or anchor group, lb

$V_{||}$ = maximum shear force that can be applied parallel to the edge, lb

$V_{\perp}$ = maximum shear force that can be applied perpendicular to the edge, lb

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CODE

V_{cpg} = nominal concrete pryout strength of a group of anchors, lb

V_{cw} = nominal shear strength provided by concrete where diagonal cracking results from high principal tensile stress in web, lb

V_d = shear force at section due to unfactored dead load, lb

V_e = design shear force for load combinations including earthquake effects, lb

V_i = factored shear force at section due to externally applied loads occurring simultaneously with M_{max}, lb

V_n = nominal shear strength, lb

$V_{n,c}$ = nominal strength in shear of a single anchor governed by concrete breakout or pryout strength, lb

$V_{n,cg}$ = nominal strength in shear of an anchor group governed by concrete breakout or pryout strength, lb

$V_{n,x}$ = shear strength in the x-direction

$V_{n,y}$ = shear strength in the y-direction

V_{ne} = expected shear strength, lb (Appendix A)

V_{nh} = nominal horizontal shear strength, lb

V_p = vertical component of effective prestress force at section, lb

V_s = nominal shear strength provided by shear reinforcement, lb

V_{sa} = nominal shear strength of a single anchor or individual anchor in a group of anchors as governed by the steel strength, lb

V_u = factored shear force at section, lb

$V_{u,x}$ = factored shear force at section in the x-direction, lb

$V_{u,y}$ = factored shear force at section in the y-direction, lb

V_{ua} = factored shear force applied to a single anchor or group of anchors, lb

$V_{ua,g}$ = total factored shear force applied to anchor group, lb

$V_{ua,i}$ = factored shear force applied to most highly stressed anchor in a group of anchors, lb

V_{uEh} = factored shear force from load combinations including primary load E, considering only horizontal earthquake load effect E_h

V_{uh} = factored shear force along contact surface in composite concrete flexural member, lb

V_{us} = factored horizontal shear in a story, lb

w/cm = water-cementitious material ratio

w_c = density, unit weight, of normalweight concrete or equilibrium density of lightweight concrete, lb/ft^3

w_t = effective height or width of concrete concentric with a tie, used to dimension the nodal zone in a strut-and-tie model, in.

w_u = factored load per unit length of beam or one-way slab, lb/in.

W = effect of wind load

COMMENTARY

$V_{n,c}$ = Refer to the concrete failure modes given in Table 17.5.2

$V_{n,cg}$ = Refer to the concrete failure modes given in Table 17.5.2

V_{uEh} = Refer to 5.3.1(e) and (g)

w_n = length of the side of a nodal zone, in.

w_s = width of a strut perpendicular to the axis of the strut, in.

$w_{t,max}$ = maximum effective height or width of concrete concentric with a tie, in.

CODE

W_{MRI} = wind effect with specified mean recurrence interval (MRI) (Appendix B)

y_t = distance from centroidal axis of gross section, neglecting reinforcement, to tension face, in.

z = distance between the tension resultant of anchors loaded in tension and compression resultant acting on the concrete in contact with baseplate

α = angle defining the orientation of reinforcement

α_1 = minimum angle between unidirectional distributed reinforcement and a strut

α_c = coefficient defining the relative contribution of concrete strength to nominal wall shear strength

α_f = ratio of flexural stiffness of beam section to flexural stiffness of a width of slab bounded laterally by centerlines of adjacent panels, if any, on each side of the beam

α_{fm} = average value of α_f for all beams on edges of a panel

α_s = constant used to calculate V_c in slabs and footings

α_{sh} = shape factor to define the shear stress limit for walls

β = ratio of long to short dimensions: clear spans for two-way slabs, sides of column, concentrated load or reaction area; or sides of a footing

β_1 = factor relating depth of equivalent rectangular compressive stress block to depth of neutral axis

β_b = ratio of area of reinforcement cut off to total area of tension reinforcement at section

β_c = confinement modification factor for struts and nodes in a strut-and-tie model

β_{dns} = ratio used to account for reduction of stiffness of columns due to sustained axial loads

β_{ds} = the ratio of maximum factored sustained shear within a story to the maximum factored shear in that story associated with the same load combination

β_n = factor used to account for the effect of the anchorage of ties on the effective compressive strength of a nodal zone

β_s = factor used to account for the effect of cracking and confining reinforcement on the effective compressive strength of the concrete in a strut

γ_f = factor used to determine the fraction of M_{sc} transferred by slab flexure at slab-column connections

γ_p = factor used for type of prestressing reinforcement

γ_s = factor used to determine the portion of reinforcement located in center band of footing

γ_v = factor used to determine the fraction of M_{sc} transferred by eccentricity of shear at slab-column connections

δ = moment magnification factor used to reflect effects of member curvature between ends of a compression member

δ_c = wall displacement capacity at top of wall, in.

COMMENTARY

W_a = service-level wind load, lb

W_{MRI} = Wind effect with specified mean recurrence interval (MRI) depends on the risk category of the building and is provided in ASCE/SEI Prestandard for Performance-Based Wind Design. (Appendix B)

α_f = $E_{cb}I_b/E_{cs}I_s$

CODE

δ_s = moment magnification factor used for frames not braced against sidesway, to reflect lateral drift resulting from lateral and gravity loads

δ_u = design displacement, in.

$\delta_{x,w}$ = maximum story drift ratio expected in story x, according to analyses for wind demands. Drift ratio is calculated as relative difference of lateral displacement between the top and bottom of a story, divided by the story height. (Appendix B)

Δ_1 = maximum deflection, during first load test, measured 24 hours after application of the full test load, in.

Δ_2 = maximum deflection, during second load test, measured 24 hours after application of the full test load. Deflection is measured relative to the position of the structure at the beginning of the second load test, in.

Δ_{cr} = calculated out-of-plane deflection at midheight of wall corresponding to cracking moment M_{cr}, in.

Δ_L = deformation limit (strain, rotation, displacement) (Appendix B)

Δ_n = calculated out-of-plane deflection at midheight of wall corresponding to nominal flexural strength M_n, in.

Δ_o = relative lateral deflection between the top and bottom of a story due to V_{us}, in.

Δ_r = residual deflection measured 24 hours after removal of the test load. For the first load test, residual deflection is measured relative to the position of the structure at the beginning of the first load test. For the second load test, residual deflection is measured relative to the position of the structure at the beginning of the second load test, in.

Δ_s = out-of-plane deflection due to service loads, in.

Δ_u = calculated out-of-plane deflection at midheight of wall due to factored loads, in.

Δ_x = design story drift of story x, in.

Δf_p = increase in stress in prestressed reinforcement due to factored loads, psi

Δf_{ps} = stress in prestressed reinforcement at service loads less decompression stress, psi

ε_t = net tensile strain in extreme layer of longitudinal tension reinforcement at nominal strength, excluding strains due to effective prestress, creep, shrinkage, and temperature

ε_{ty} = value of net tensile strain in the extreme layer of longitudinal tension reinforcement used to define a compression-controlled section

COMMENTARY

Δf_{pt} = difference between the stress that can be developed in the prestressed reinforcement at the section under consideration and the stress required to resist factored bending moment at section, M_u/ϕ, psi

ε_{cu} = maximum usable strain at extreme concrete compression fiber

ε_s = strain in steel

CODE

ε_{ye} = expected yield strain of reinforcement (Appendix B)

θ = angle between axis of strut, compression diagonal, or compression field and the tension chord of the members

θ_y = yield rotation, radians (Appendix A)

θ_{ye} = expected yield rotation of member determined using expected material strengths, radians (Appendix B)

λ = modification factor to reflect the reduced mechanical properties of lightweight concrete relative to normalweight concrete of the same compressive strength

λ_a = modification factor to reflect the reduced mechanical properties of lightweight concrete in certain concrete anchorage applications

λ_s = factor used to modify shear strength based on the effects of member depth, commonly referred to as the size effect factor

λ_Δ = multiplier used for additional deflection due to long-term effects

μ = coefficient of friction

ξ = time-dependent factor for sustained load

ρ' = ratio of A_s' to bd

ρ = ratio of A_s to bd

ρ_ℓ = ratio of area of distributed longitudinal reinforcement to gross concrete area perpendicular to that reinforcement

ρ_p = ratio of A_{ps} to bd_p

ρ_s = ratio of volume of spiral reinforcement to total volume of core confined by the spiral, measured out-to-out of spirals

ρ_t = ratio of area of distributed transverse reinforcement to gross concrete area perpendicular to that reinforcement

ρ_v = ratio of tie reinforcement area to area of contact surface

ρ_w = ratio of A_s to $b_w d$

τ_{cr} = characteristic bond stress of adhesive anchor in cracked concrete, psi

τ_{uncr} = characteristic bond stress of adhesive anchor in uncracked concrete, psi

ϕ = strength reduction factor

ϕ_{cc} = strength reduction factor for compression-controlled sections

COMMENTARY

ε_y = yield strain of steel

λ = in most cases, the reduction in mechanical properties is caused by the reduced ratio of tensile-to-compressive strength of lightweight concrete compared to normalweight concrete. There are instances in the Code where λ is used as a modifier to reduce expected performance of lightweight concrete where the reduction is not related directly to tensile strength.

σ = wall boundary extreme fiber concrete nominal compressive stress, psi

ς = exponent symbol in tensile/shear force interaction equation

τ = shear stress, psi

ϕ_K = stiffness reduction factor

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CODE

ϕ_p = strength reduction factor for moment in pretensioned member at cross section closest to the end of the member where all strands are fully developed

ϕ_s = seismic resistance factor for force-controlled actions (Appendix A)

ψ_a = factor used to modify post-installed anchor strength based on assessment in accordance with ACI CODE-355.2 or ACI CODE-355.4

$\psi_{brg,sl}$ = shear lug bearing factor used to modify bearing strength of shear lugs based on the influence of axial load

ψ_c = factor used to modify development length based on concrete strength

ψ_{cc} = factor used to modify development length based on cover

$\psi_{c,N}$ = breakout cracking factor used to modify tensile strength of anchors based on the influence of cracks in concrete

$\psi_{c,P}$ = pullout cracking factor used to modify pullout strength of anchors based on the influence of cracks in concrete

$\psi_{c,V}$ = breakout cracking factor used to modify shear strength of anchors based on the influence of cracks in concrete and presence or absence of supplementary reinforcement

$\psi_{cm,N}$ = breakout compression field factor used to increase breakout strength for cases where a compression field inhibits concrete fracture development

$\psi_{cp,N}$ = breakout splitting factor used to modify tensile strength of post-installed anchors intended for use in uncracked concrete without supplementary reinforcement to account for the splitting tensile stresses

$\psi_{cp,Na}$ = bond splitting factor used to modify tensile strength of adhesive anchors intended for use in uncracked concrete without supplementary reinforcement to account for the splitting tensile stresses due to installation

ψ_e = factor used to modify development length based on reinforcement coating

$\psi_{ec,N}$ = breakout eccentricity factor used to modify tensile strength of anchors based on eccentricity of applied loads

$\psi_{ec,Na}$ = breakout eccentricity factor used to modify tensile strength of adhesive anchors based on eccentricity of applied loads

$\psi_{ec,V}$ = breakout eccentricity factor used to modify shear strength of anchors based on eccentricity of applied loads

$\psi_{ed,N}$ = breakout edge effect factor used to modify tensile strength of anchors based on proximity to edges of concrete member

$\psi_{ed,Na}$ = breakout edge effect factor used to modify tensile strength of adhesive anchors based on proximity to edges of concrete member

$\psi_{ed,V}$ = breakout edge effect factor used to modify shear strength of anchors based on proximity to edges of concrete member

COMMENTARY

CODE

ψ_g = factor used to modify development length based on grade of reinforcement

$\psi_{h,V}$ = breakout thickness factor used to modify shear strength of anchors located in concrete members with $h_a < 1.5c_{a1}$

ψ_o = factor used to modify development length of hooked and headed bars based on side cover and confinement

ψ_p = factor used to modify development length for headed reinforcement based on parallel tie reinforcement

ψ_r = factor used to modify development length based on confining reinforcement

ψ_s = factor used to modify development length based on reinforcement size

ψ_t = factor used to modify development length for casting location in tension

ψ_w = factor used to modify development length for welded deformed wire reinforcement in tension

ω_v = factor to account for dynamic shear amplification

Ω_o = amplification factor to account for overstrength of the seismic-force-resisting system determined in accordance with the general building code

Ω_v = overstrength factor to account for wall flexural overstrength at the wall critical section

2.3—Terminology

action, deformation-controlled—action allowed to exceed the expected yield deformation of the element being evaluated. (Appendix B)

action, force-controlled—action not allowed to exceed the design strength of the element being evaluated. (Appendix B)

adhesive—chemical components formulated from organic polymers, or a combination of organic polymers and inorganic materials that cure if blended together.

admixture—material other than water, aggregate, cementitious materials, and fiber reinforcement used as an ingredient, which is added to grout, mortar, or concrete, either before or during its mixing, to modify the freshly mixed, setting, or hardened properties of the mixture.

aggregate—granular material such as sand, gravel, crushed stone, iron blast-furnace slag, or recycled aggregates including crushed hydraulic cement concrete, used with a cementing medium to form concrete or mortar.

aggregate, lightweight—aggregate meeting the requirements of ASTM C330 and having a loose bulk density of 70 lb/ft^3 or less, determined in accordance with ASTM C29.

COMMENTARY

R2.3—Terminology

action, deformation-controlled—Deformation-controlled actions are those under which elements exhibit acceptable degree of inelastic response and are deemed to have failed upon exceedance of a predefined deformation level or number of cycles. (Appendix B)

action, force-controlled—Force-controlled actions are those under which elements exhibit limited ductility and are deemed to have failed upon exceedance of design strength. (Appendix B)

aggregate—The use of recycled aggregate is addressed in the Code in 2019. The definition of recycled materials in ASTM C33 is very broad and is likely to include materials that would not be expected to meet the intent of the provisions of the Code for use in structural concrete. Use of recycled aggregates including crushed hydraulic-cement concrete in structural concrete requires additional precautions. See 26.4.1.2.1(c).

aggregate, lightweight—In some standards, the term "lightweight aggregate" is being replaced by the term "low-density aggregate."

CODE

alternative cement—an inorganic cement that can be used as a complete replacement for portland cement or blended hydraulic cement, and that is not covered by applicable specifications for portland or blended hydraulic cements.

anchor—a steel element either cast into concrete or post-installed into a hardened concrete member and used to transmit applied loads to the concrete.

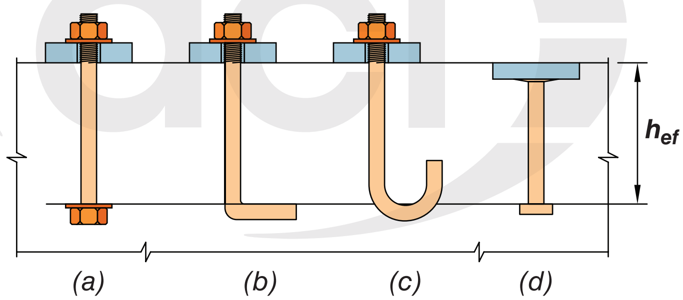
anchor, adhesive—a post-installed anchor, inserted into hardened concrete with an anchor hole diameter not greater than 1.5 times the anchor diameter, that transfers loads to the concrete by bond between the anchor and the adhesive, and bond between the adhesive and the concrete.

COMMENTARY

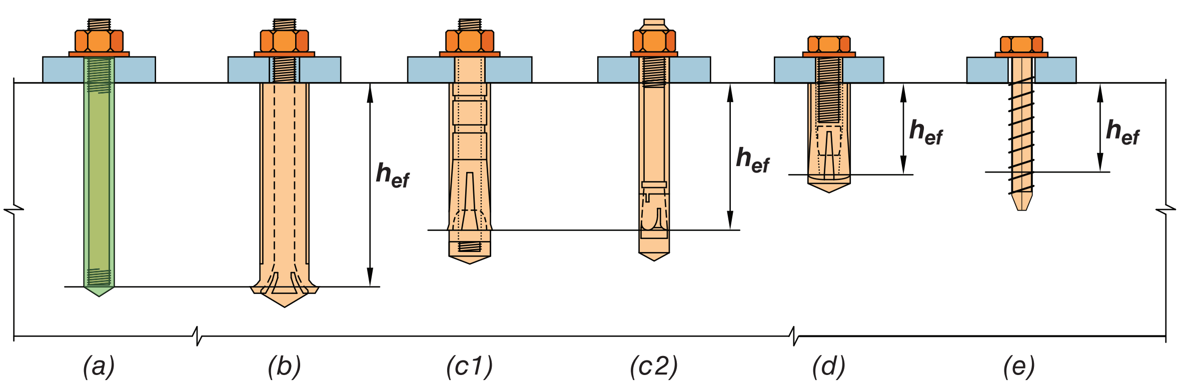
alternative cement—Alternative cements are described in the references listed in R26.4.1.1.1(b). Refer to 26.4.1.1.1(b) for precautions when using these materials in concrete covered by the Code.

anchor—Cast-in anchors include headed bolts, hooked bolts (J- or L-bolt), and headed studs. Post-installed anchors include expansion anchors, undercut anchors, and adhesive anchors; steel elements for adhesive anchors include threaded rods, deformed reinforcing bars, or internally threaded steel sleeves with external deformations. Anchor types are shown in Fig. R2.1.

anchor, adhesive—The design model included in Chapter 17 for adhesive anchors is based on the behavior of anchors with hole diameters not exceeding 1.5 times the anchor diameter. Anchors with hole diameters exceeding 1.5 times the anchor diameter behave differently and are therefore excluded from the scope of Chapter 17 and ACI CODE-355.4. To limit shrinkage and reduce displacement under load, most adhesive anchor systems require the annular gap to be as narrow as practical while still maintaining sufficient clearance for insertion of the anchor element in the adhesive filled hole and ensuring complete coverage of the bonded area over the embedded length. The annular gap for rein-



(A) Cast-in anchors: (a) hex head bolt with washer;
(b) L-bolt; (c) J-bolt; and (d) welded headed stud.



(B) Post-installed anchors: (a) adhesive anchor; (b) undercut anchor;
(c) torque-controlled expansion anchors [(c1) sleeve-type and (c2) stud-type];
(d) drop-in type displacement-controlled expansion anchor; and (e) screw anchor.

Fig. R2.1—Types of anchors.

CODE

anchor, cast-in—headed bolt, headed stud, or hooked bolt installed before placing concrete.

anchor, expansion—post-installed anchor, inserted into hardened concrete that transfers loads to or from the concrete by direct bearing or friction, or both.

anchor group—a number of similar anchors having approximately equal effective embedment depths with spacing *s* between adjacent anchors such that the projected areas overlap.

anchor, horizontal or upwardly inclined—Anchor installed in a hole drilled horizontally or in a hole drilled at any orientation above horizontal.

anchor, post-installed—anchor installed in hardened concrete; adhesive, expansion, screw, and undercut anchors are examples of post-installed anchors.

anchor pullout strength—the strength corresponding to the anchoring device or a major component of the device sliding out from the concrete without breaking out a substantial portion of the surrounding concrete.

anchor, screw—a post-installed threaded, mechanical anchor inserted into hardened concrete that transfers loads to the concrete by engagement of the hardened threads of the screw with the grooves that the threads cut into the sidewall of a predrilled hole during anchor installation.

anchor, undercut—post-installed anchor that develops its tensile strength from the mechanical interlock provided by undercutting of the concrete at the embedded end of the anchor. Undercutting is achieved with a special drill before installing the anchor or alternatively by the anchor itself during its installation.

anchorage device—in post-tensioned members, the hardware used to transfer force from prestressed reinforcement to the concrete.

COMMENTARY

forcing bars is generally greater than that for threaded rods. The required hole size is provided in the Manufacturer's Printed Installation Instructions (MPII).

anchor, expansion—Expansion anchors may be torque-controlled, where the expansion is achieved by a torque acting on the screw or bolt; or displacement controlled, where the expansion is achieved by impact forces acting on a sleeve or plug and the expansion is controlled by the length of travel of the sleeve or plug.

anchor group—For all potential failure modes (steel, concrete breakout, pullout, side-face blowout, and pryout), only those anchors susceptible to a particular failure mode should be considered when evaluating the strength associated with that failure mode.

anchor, horizontal or upwardly inclined—Figure R2.2 illustrates the potential hole orientations for horizontal or upwardly inclined anchors.

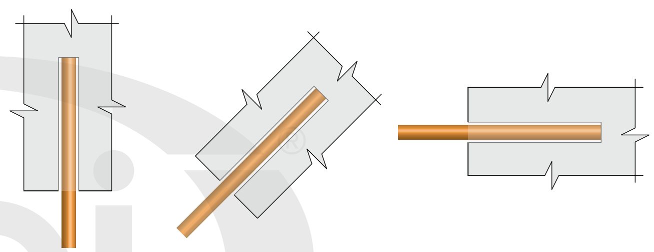


Fig. R2.2—Possible orientations of overhead, upwardly inclined, or horizontal anchors.

anchor, screw—The required predrilled hole size for a screw anchor is provided by the anchor manufacturer.

anchorage device—Most anchorage devices for post-tensioning are standard manufactured devices available from commercial sources. In some cases, non-standard details or assemblages are developed that combine various wedges and wedge plates for anchoring prestressed reinforcement. Both standard and non-standard anchorage devices may be classified as basic anchorage devices or special anchorage devices as defined in the Code and AASHTO LRFDUS.

CODE

anchorage device, basic monostrand—anchorage device used with any single strand or a single 5/8 in. or smaller diameter bar that is in accordance with 25.8.1, 25.8.2, and 25.9.3.1(a).

anchorage device, basic multistrand—anchorage device used with multiple strands, bars, or wires, or with single bars larger than 5/8 in. diameter that satisfies 25.8.1, 25.8.2 and 25.9.3.1(b).

anchorage device, special—anchorage device that satisfies tests required in 25.9.3.1(c).

anchorage zone—in post-tensioned members, portion of the member through which the concentrated prestressing force is transferred to concrete and distributed more uniformly across the section; its extent is equal to the largest dimension of the cross section; for anchorage devices located away from the end of a member, the anchorage zone includes the disturbed regions ahead of and behind the anchorage device.

attachment—structural assembly, external to the surface of the concrete, that transmits loads to or receives loads from the anchor.

B-region—portion of a member in which it is reasonable to assume that strains due to flexure vary linearly through section.

balanced strain condition—strain profile in which the extreme tension reinforcement is at the yield strain and the extreme concrete compression fiber is at a strain of 0.003.

base of structure—level at which horizontal earthquake ground motions are assumed to be imparted to a building. This level does not necessarily coincide with the ground level.

basis of design—formal document prepared by the licensed design professional expressing the performance objectives, acceptance criteria, analysis methods, and design methods to be used in the overall building design. (Appendix B)

beam—member subjected primarily to flexure and shear, with or without axial force or torsion; beams in a moment frame that forms part of the lateral-force-resisting system are predominantly horizontal members; a girder is a beam.

boundary element—portion along wall and diaphragm edge, including edges of openings, strengthened by longitudinal and transverse reinforcement.

breakout strength, concrete—strength corresponding to a volume of concrete surrounding the anchor or group of anchors separating from the member.

COMMENTARY

anchorage device, basic monostrand—Devices that are so proportioned that they can be checked analytically for compliance with bearing stress and stiffness requirements without having to undergo the acceptance-testing program required of special anchorage devices.

anchorage device, basic multistrand—Devices that are s_o proportioned that they can be checked analytically for compliance with bearing stress and stiffness requirements without having to undergo the acceptance-testing program required of special anchorage devices.

anchorage device, special—Special anchorage devices are any devices (monostrand or multistrand) that do not meet the relevant PTI or AASHTO LRFDUS bearing stress and, where applicable, stiffness requirements. Most commercially marketed multi-bearing surface anchorage devices are special anchorage devices. As provided in 25.9.3, such devices can be used only if they have been shown experimentally to be in compliance with the AASHTO requirements. This demonstration of compliance will ordinarily be furnished by the device manufacturer.

anchorage zone—In post-tensioned members, the portion of the member through which the concentrated prestressing force is transferred to the concrete and distributed more uniformly across the section. Its extent is equal to the largest dimension of the cross section. For anchorage devices located away from the end of a member, the anchorage zone includes the disturbed regions ahead of and behind the anchorage devices. Refer to Fig. R25.9.1.1b.

CODE

building official—term used to identify the Authority having jurisdiction or individual charged with administration and enforcement of provisions of the building code. Such terms as building commissioner or building inspector are variations of the title, and the term "building official" as used in this Code, is intended to include those variations, as well as others that are used in the same sense.

caisson—see drilled pier.

cementitious materials—materials that have cementing value if used in grout, mortar, or concrete, including portland cement, blended hydraulic cements, expansive cement, fly ash, raw or calcined natural pozzolan, slag cement, silica fume, and ground-glass pozzolan.

class of concrete—characterization of concrete of various qualities or usages, usually by compressive strength. (Appendix C)

collector—element that acts in axial tension or compression to transmit forces between a diaphragm and a vertical element of the lateral-force-resisting system.

column—member, usually vertical or predominantly vertical, used primarily to support axial compressive load, but that can also resist moment, shear, or torsion. Columns used as part of a lateral-force-resisting system resist combined axial load, moment, and shear. See also **moment frame**.

column capital—enlargement of the top of a concrete column located directly below the slab or drop panel that is cast monolithically with the column.

compliance requirements—construction-related code requirements directed to the contractor to be incorporated into construction documents by the licensed design professional, as applicable.

composite concrete flexural members—concrete flexural members of precast or cast-in-place concrete elements, constructed in separate placements but connected so that all elements respond to loads as a unit.

compression-controlled section—cross section in which the net tensile strain in the extreme tension reinforcement at nominal strength is less than or equal to the compression controlled strain limit.

compression-controlled strain limit—net tensile strain at balanced strain conditions.

concrete—mixture of portland cement or any other cementitious material, fine aggregate, coarse aggregate, and water, with or without admixtures.

concrete, all-lightweight—lightweight concrete containing only lightweight coarse and fine aggregates that conform to ASTM C330.

concrete-filled pipe piles—steel pipe with a closed end that is driven for its full length in contact with the surrounding soil, or a steel pipe with an open end that is driven for its full length and the soil cleaned out; for both installation procedures, the pipe is subsequently filled with reinforcement and concrete.

COMMENTARY

cementitious materials—Cementitious materials permitted for use in the Code are addressed in 26.4.1.1. Fly ash, raw or calcined natural pozzolan, slag cement, silica fume, and ground-glass pozzolan are considered supplementary cementitious materials.

compliance requirements—Although primarily directed to the contractor, the compliance requirements are also commonly used by others involved with the project.

CODE

concrete, lightweight—concrete containing lightweight aggregate and having an equilibrium density, as determined by ASTM C567, between 90 and 135 lb/ft^3.

concrete, nonprestressed—reinforced concrete with at least the minimum amount of nonprestressed reinforcement and no prestressed reinforcement; or for two-way slabs, with less than the minimum amount of prestressed reinforcement.

concrete, normalweight—concrete containing only coarse and fine aggregates that conform to ASTM C33 and having a density greater than 135 lb/ft^3.

concrete, plain—structural concrete with no reinforcement or with less than the minimum amount of reinforcement specified for reinforced concrete.

concrete, precast—structural concrete element cast elsewhere than its final position in the structure.

concrete, prestressed—reinforced concrete in which internal stresses have been introduced by prestressed reinforcement to reduce potential tensile stresses in concrete resulting from loads, and for two-way slabs, with at least the minimum amount of prestressed reinforcement.

concrete, reinforced—structural concrete reinforced with at least the minimum amounts of nonprestressed reinforcement, prestressed reinforcement, or both, as specified in this Code.

concrete, sand-lightweight—lightweight concrete containing only normalweight fine aggregate that conforms to ASTM C33 and lightweight coarse aggregate that conforms to ASTM C330.

concrete, steel fiber-reinforced—concrete containing a prescribed amount of dispersed, randomly oriented, discontinuous deformed steel fibers.

concrete strength, specified compressive, (f_c')—compressive strength of concrete used in design and evaluated in accordance with provisions of this Code, psi; wherever the quantity f_c' is under a radical sign, the square root of numerical value only is intended, and the result has units of psi.

connection—region of a structure that joins two or more members; a connection also refers to a region that joins members of which one or more is precast.

connection, ductile—connection between one or more precast elements that experiences yielding as a result of the earthquake design displacements.

COMMENTARY

concrete, nonprestressed—Nonprestressed concrete usually contains no prestressed reinforcement. Prestressed two-way slabs require a minimum level of compressive stress in the concrete due to effective prestress in accordance with 8.6.2.1. Two-way slabs with less than this minimum level of precompression are required to be designed as nonprestressed concrete.

concrete, normalweight—Normalweight concrete typically has a density (unit weight) between 135 and 160 lb/ft^3, and is normally taken as 145 to 150 lb/ft^3.

concrete, plain—The presence of reinforcement, nonprestressed or prestressed, does not exclude the member from being classified as plain concrete, provided all requirements of Chapter 14 are satisfied.

concrete, prestressed—Classes of prestressed flexural members are defined in 24.5.2.1. Prestressed two-way slabs require a minimum level of compressive stress in the concrete due to effective prestress in accordance with 8.6.2.1. Although the behavior of a prestressed member with unbonded tendons may vary from that of members with continuously bonded prestressed reinforcement, bonded and unbonded prestressed concrete are combined with nonprestressed concrete under the generic term “reinforced concrete.” Provisions common to both prestressed and nonprestressed concrete are integrated to avoid overlapping and conflicting provisions.

concrete, reinforced—Includes members satisfying the requirements for nonprestressed and prestressed concrete.

concrete, sand-lightweight—By Code terminology, sand-lightweight concrete is lightweight concrete with all of the fine aggregate replaced by sand. This definition may not be in agreement with usage by some material suppliers or contractors where the majority, but not all, of the lightweight fines are replaced by sand. For proper application of the Code provisions, the replacement limits should be stated, with interpolation if partial sand replacement is used.

CODE

connection, strong—connection between one or more precast elements that remains elastic while adjoining members experience yielding as a result of earthquake design displacements.

construction documents—written and graphic documents and specifications prepared or assembled for describing the location, design, materials, and physical characteristics of the elements of a project necessary for obtaining a building permit and construction of the project.

contraction joint—formed, sawed, or tooled groove in a concrete structure to create a weakened plane and regulate the location of cracking resulting from the dimensional change of different parts of the structure.

contractor—an entity responsible for construction of the Work as required by construction documents.

cover, specified concrete—distance between the outermost surface of embedded reinforcement and the closest outer surface of the concrete.

crosstie—a continuous reinforcing bar having a seismic hook at one end and a hook not less than 90 degrees with at least a $6d_b$ extension at the other end. The hooks shall engage peripheral longitudinal bars. The 90-degree hooks of two successive crossties engaging the same longitudinal bars shall be alternated end for end.

curtain—grid of reinforcement, usually in a vertical orientation.

cutoff point—point where reinforcement is terminated.

D-region—portion of a member within a distance h of a force discontinuity or a geometric discontinuity.

design displacement—total calculated lateral displacement expected for the design-basis earthquake.

design information—project-specific information to be incorporated into construction documents by the licensed design professional, as applicable.

design load combination—combination of factored loads and forces.

design story drift ratio—relative difference of design displacement between the top and bottom of a story, divided by the story height.

development length, nonprestressed reinforcement—length of embedded reinforcement required to develop the specified yield strength f_y or, where specifically required in this Code, $1.25f_y$ at a critical section.

COMMENTARY

design displacement—The design displacement is an index of the maximum lateral displacement expected in design for the design-basis earthquake. In documents such as ASCE/SEI 7 and the International Building Code, the design displacement is calculated using static or dynamic linear elastic analysis under code-specified actions considering effects of cracked sections, effects of torsion, effects of vertical forces acting through lateral displacements, and modification factors to account for expected inelastic response. The design displacement generally is greater than the displacement calculated from design-level forces applied to a linear-elastic model of the building.

development length, nonprestressed reinforcement—development length provisions for nonprestressed reinforcement are generally calibrated to permit the achievement of the specified yield strength at the critical section. There are also sections of the code where it is required to develop the reinforcement for more than f_y, for example, 18.10.2.3(b)

CODE

development length, prestressed reinforcement—length of embedded reinforcement required to develop f_{ps} of prestressing reinforcement at a critical section.

discontinuity—abrupt change in geometry or loading.

distance sleeve—sleeve that encases the center part of an undercut anchor, a torque-controlled expansion anchor, or a displacement-controlled expansion anchor, but does not expand.

distributed plasticity (fiber) model—component model consisting of discrete fibers explicitly representing nonlinear stress-strain or force-deformation responses. (Appendix A)

dowel—a deformed reinforcing bar intended to transmit tension, compression, or shear through a construction joint.

drilled piers or caissons—cast-in-place concrete foundation elements with or without an enlarged base (bell), constructed by excavating a hole in the ground and filling with reinforcement and concrete. Drilled piers or caissons are considered as uncased cast-in-place concrete drilled or augered piles, unless they have permanent steel casing, in which case they are considered as metal cased concrete piles.

drop panel—projection below the slab used to reduce the amount of negative reinforcement over a column or the minimum required slab thickness, and to increase the slab shear strength.

duct—conduit, plain or corrugated, to accommodate prestressing reinforcement for post-tensioning applications.

ductile coupled structural wall—see **structural wall, ductile coupled**.

durability—ability of a structure or member to resist deterioration that impairs performance or limits service life of the structure in the relevant environment considered in design.

edge distance—distance from the edge of the concrete surface to the center of the nearest anchor.

effective depth of section—distance measured from extreme compression fiber to centroid of longitudinal tension reinforcement.

effective embedment depth, anchor—overall depth through which the anchor transfers force to or from the surrounding concrete.

effective embedment depth, reinforcing bar—overall depth from the critical section through which the reinforcing

COMMENTARY

and 18.10.2.5(a). If it is desired to achieve the expected yield strength of reinforcement, the embedment length may need to be increased beyond the development length. For some cases, sectional strength may be controlled by concrete breakout even though the reinforcing bars are embedded a distance at least equal to the development length in tension.

distributed plasticity (fiber) model—Force-controlled and deformation-controlled actions are classified in A.7 for design using nonlinear analysis of concrete structures. (Appendix A)

effective embedment depth, anchor— Effective embedment depth will normally be the depth of the concrete failure surface in tension applications; for cast-in headed anchor bolts and headed studs, the effective embedment depth is measured from the bearing contact surface of the head. Effective embedment depths for a variety of anchor types are shown in Fig. R2.1. For post-installed mechanical anchors, the value h_{ef} is obtained from the ACI CODE-355.2 product evaluation report provided by the manufacturer.

effective embedment depth, reinforcing bar—Figure R2.3 illustrates effective embedment depth for the purpose

CODE

bar transfers force to or from the surrounding concrete. For straight bars, the effective embedment depth is measured from the end of the bar; for hooked reinforcement, the effective embedment is measured from the outside end of the hook, point of tangency; for headed reinforcement, effective embedment depth is measured from the bearing contact surface of the head.

effective prestress—stress remaining in prestressed reinforcement after losses in 20.3.2.6 have occurred.

effective stiffness—stiffness of a structural member accounting for cracking, creep, and other nonlinear effects.

embedment length—length of embedded reinforcement provided beyond a critical section.

COMMENTARY

of determining concrete breakout strength for various types of reinforcing bar anchorage

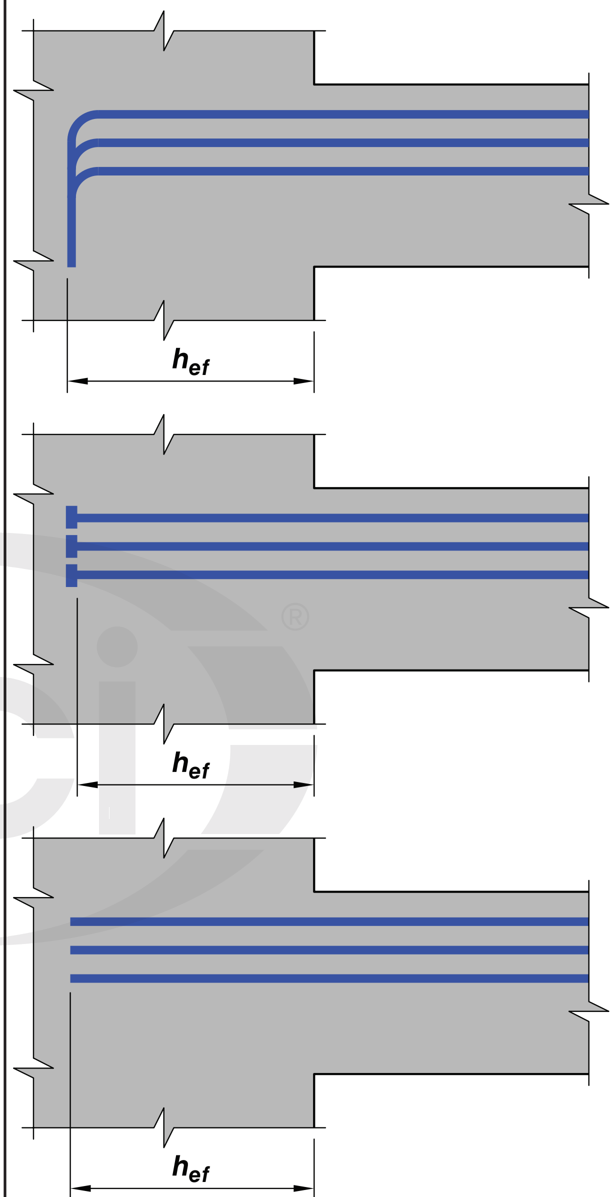


Fig. R2.3—Effective embedment depth for reinforcing bars for the purpose of determining concrete breakout strength.

CODE

embedments—items embedded in concrete, excluding reinforcement as defined in Chapter 20 and anchors as defined in Chapter 17. Reinforcement or anchors welded, bolted or otherwise connected to the embedded item to develop the strength of the assembly, are considered to be part of the embedment.

embedments, pipe—embedded pipes, conduits, and sleeves.

environmental product declaration (EPD)—declaration providing environmental data using predetermined parameters meeting the requirements of ISO 21930. (Appendix C)

equilibrium density—density of lightweight concrete determined in accordance with ASTM C567.

equivalent static wind load (ESWL)—wind load statically applied to the building, representing the wind-tunnel-determined combination of the background and resonant wind components. (Appendix B)

expansion sleeve—outer part of an expansion anchor that is forced outward by the center part, either by applied torque or impact, to bear against the sides of the predrilled hole. See also **anchor, expansion**.

expected strength, wind—strength of a member or cross section calculated in accordance with provisions and assumptions of this Code using expected material properties as contained in this Code. (Appendix B)

extreme tension reinforcement—layer of prestressed or nonprestressed reinforcement that is the farthest from the extreme compression fiber.

finite element analysis—a numerical modeling technique in which a structure is divided into a number of discrete elements for analysis.

five percent fractile—statistical term meaning 90% confidence that there is 95% probability of the actual strength exceeding the nominal strength.

foundation seismic ties—elements used to sufficiently interconnect foundations to act as a unit. Elements may consist of grade beams, slabs-on-ground, or beams within a slab-on-ground.

global warming potential (GWP)—index used to determine the energy absorption caused by the emissions of different gases associated with a product, normalized to an equivalent mass of carbon dioxide over a period of 100 years. (Appendix C)

hazard event—potential cause of damage to a structure and the magnitude or intensity associated with that cause. (Appendix C)

COMMENTARY

five percent fractile—The determination of the coefficient K_{05} associated with the 5% fractile, $\bar{x} - K_{05}s_s$ depends on the number of tests, n, used to calculate the sample mean, $\bar{x}$, and sample standard deviation, s_s. Values of K_{05} range, for example, from 1.645 for $n = \infty$, to 2.010 for $n = 40$, and 2.568 for $n = 10$. With this definition of the 5 percent fractile, the nominal strength in Chapter 17 is the same as the characteristic strength in ACI CODE-355.2 and ACI CODE-355.4.

global warming potential (GWP)—This index was developed as a single parameter to estimate the global warming impact of different gaseous emissions. (Appendix C)

hazard event—Selecting the demands for which a structure will be designed requires establishing the hazards to which the structure may be subjected and the intensities of those hazards for target risk levels. For example, a structure might be subjected to frequent earthquakes with small intensities and very infrequent earthquakes with large intensities. (Appendix C)

CODE

headed bolt—cast-in steel anchor that develops its tensile strength from the mechanical interlock provided by either a head or nut at the embedded end of the anchor.

headed deformed bars—deformed bars with heads attached at one or both ends.

headed shear stud reinforcement—reinforcement consisting of individual headed studs or groups of studs, with anchorage provided by a head at each end, or by a head at one end and a common base rail consisting of a steel plate or shape at the other end.

headed stud—a steel anchor conforming to the requirements of AWS D1.1 and affixed to a plate or similar steel attachment by the stud arc welding process before casting; also referred to as a **welded headed stud**.

hooked bolt—cast-in anchor anchored mainly by bearing of the 90-degree bend (L-bolt) or 180-degree bend (J-bolt) against the concrete, at its embedded end, and having a minimum e_h equal to $3d_a$.

hoop—continuous closed tie or continuously wound tie having seismic hooks at both ends.

inspection—observation, verification, and required documentation of the materials, installation, fabrication, erection, or placement of components and connections to determine compliance with construction documents and referenced standards.

inspection, continuous—the full-time observation, verification, and required documentation of construction being performed.

inspection, periodic—the part-time or intermittent observation, verification, and required documentation of construction being performed.

isolation joint—separation between adjoining parts of a concrete structure, usually a vertical plane at a designed location such as to interfere least with performance of the structure, yet such as to allow relative movement in three directions and avoid formation of cracks elsewhere in the concrete, and through which all or part of the bonded reinforcement is interrupted.

jacking force—in prestressed concrete, temporary force exerted by a device that introduces tension into prestressing reinforcement.

joint—portion of structure common to intersecting members

COMMENTARY

headed deformed bars—The bearing area of a headed deformed bar is, for the most part, perpendicular to the bar axis. In contrast, the bearing area of the head of headed stud reinforcement is a nonplanar spatial surface of revolution, as shown in Fig. R20.4.1. The two types of reinforcement differ in other ways. The shanks of headed studs are smooth, not deformed as with headed deformed bars. The minimum net bearing area of the head of a headed deformed bar is permitted to be as small as four times the bar area. In contrast, the minimum stud head area is not specified in terms of the bearing area, but by the total head area which must be at least 10 times the area of the shank.

hoop—Refer to 25.7.4.

joint—The effective cross-sectional area of a joint of a special moment frame, A_j, for shear strength calculations is given in 15.5.2.2.

CODE

joint, corner—joint where two non-colinear members transfer moment and terminate at the joint.

licensed design professional—an individual who is licensed to practice structural design as defined by the statutory requirements of the professional licensing laws of the state or jurisdiction in which the project is to be constructed, and who is in responsible charge for all or part of the structural design.

life cycle assessment (LCA)—compilation and evaluation of the inputs, outputs, and potential environmental impacts of a product throughout its life cycle. (Appendix C)

load—forces or other actions that result from the weight of all building materials, occupants, and their possessions, environmental effects, differential movement, and restrained dimensional changes; permanent loads are those loads in which variations over time are rare or of small magnitude; all other loads are variable loads.

load, dead—(a) the weights of the members, supported structure, and permanent attachments or accessories that are likely to be present on a structure in service; or (b) loads meeting specific criteria found in the general building code; without load factors.

load effects—forces and deformations produced in structural members by applied loads or restrained volume changes.

load, factored—load, multiplied by appropriate load factors.

load, live—(a) load that is not permanently applied to a structure, but is likely to occur during the service life of the structure (excluding environmental loads); or (b) loads meeting specific criteria found in the general building code; without load factors.

load path—sequence of members and connections designed to transfer the factored loads and forces in such combinations as are stipulated in this Code, from the point of application or origination through the structure to the final support location or the foundation.

load, roof live—a load on a roof produced: (a) during maintenance by workers, equipment, and materials, and (b) during the life of the structure by movable objects, such as planters or other similar small decorative appurtenances that are not occupancy related; or loads meeting specific criteria found in the general building code; without load factors.

load, self-weight dead—weight of the structural system, including the weight of any bonded concrete topping.

COMMENTARY

joint, corner—Roof level corner joints are sometimes referred to as knee joints.

licensed design professional—May also be referred to as “registered design professional” in other documents; a licensed design professional in responsible charge of the design is often referred to as the “engineer of record” (EOR).

load—A number of definitions for loads are given as the Code contains requirements that are to be met at various load levels. The terms “dead load” and “live load” refer to the unfactored, sometimes called “service” loads specified or defined by the general building code. Service loads (loads without load factors) are to be used where specified in the Code to proportion or investigate members for adequate serviceability. Loads used to proportion a member for adequate strength are defined as factored loads. Factored loads are service loads multiplied by the appropriate load factors for required strength except wind and earthquake which are already specified as strength loads in ASCE/SEI 7. The factored load terminology clarifies where the load factors are applied to a particular load, moment, or shear value as used in the Code provisions.

load effects—Stresses and strains are directly related to forces and deformations and are considered as load effects.

CODE

load, service—all loads, static or transitory, imposed on a structure or element thereof, during the operation of a facility, without load factors.

load, superimposed dead—dead loads other than the self-weight that are present or are considered in the design.

Manufacturer's Printed Installation Instructions (MPII)—published instructions for the correct installation of a post-installed anchor under all covered installation conditions as supplied in the product packaging.

mechanical splice—region along lengths of two reinforcing bars joined by a mechanical splicing device, including the device.

mechanical splicing device—system used to mechanically join two reinforcing bars for the purpose of transferring axial compression, axial tension, or both from one bar to the other.

metal cased concrete piles—thin-walled steel pipe, steel shell, or spiral-welded metal casing with a closed end that is driven for its full length in contact with the surrounding soil, left permanently in place, and subsequently filled with reinforcement and concrete.

modulus of elasticity—ratio of normal stress to corresponding strain for tensile or compressive stresses below proportional limit of material.

moment frame—frame in which beams, slabs, columns, and joints resist forces predominantly through flexure, shear, and axial force; beams or slabs are predominantly horizontal or nearly horizontal; columns are predominantly vertical or nearly vertical.

moment frame, intermediate—cast-in-place beam-column frame or two-way slab-column frame without beams complying with 18.4.

moment frame, ordinary—cast-in-place or precast concrete beam-column or slab-column frame complying with 18.3.

moment frame, special—cast-in-place beam-column frame complying with 18.2.3 through 18.2.8; and 18.6 through 18.8. A precast beam-column frame complying with 18.2.3 through 18.2.8 and 18.9.

net tensile strain—the tensile strain at nominal strength exclusive of strains due to effective prestress, creep, shrinkage, and temperature.

nodal zone—volume of concrete around a node that is assumed to transfer strut-and-tie forces through the node.

node—point in a strut-and-tie model where the axes of the struts, ties, and concentrated forces acting on the joint intersect.

node, curved-bar—the bend region of a continuous reinforcing bar (or bars) that defines a node in a strut-and-tie model.

COMMENTARY

mechanical splicing device—Mechanical splicing devices are most often commercially-marketed products. Features vary with the particular nature of the mechanical splicing device and may include but are not limited to coupling sleeves, filler materials of various types (such as flowable grouts), bolts, nuts, and threaded studs. Preparation of reinforcing bar ends by threading or other processes, application of friction welds, or other measures, may be required when manufacturing, fabricating, or installing the device.

CODE

one-way construction—members designed to resist out-of-plane loads through bending in a single direction. See also **two-way construction**.

panel, shotcrete mockup—a shotcrete specimen that simulates the size and detailing of reinforcement in a proposed structural member for preconstruction evaluation of the nozzle operator's ability to encase the reinforcement.

panel, shotcrete test—a shotcrete specimen prepared in accordance with ASTM C1140 for evaluation of shotcrete.

pedestal—member with a ratio of height-to-least lateral dimension less than or equal to 3 used primarily to support axial compressive load; for a tapered member, the least lateral dimension is the average of the top and bottom dimensions of the smaller side.

performance-based wind design (PBWD)—alternative design procedure to the prescriptive provisions in the general building code and referenced standards, which considers direct evaluation of the wind demand on the structure, and evaluates the building performance as it relates to occupant comfort, operational performance, and continuous occupancy, limited interruption performance objectives. (Appendix B)

performance objective—specific desired outcome for an action, element, or system of a building during or following a wind event as chosen by the project stakeholders and licensed design professionals. (Appendix B)

performance objective, continuous occupancy, limited interruption—specific desired outcome in which damage to the main wind-force-resisting system does not significantly disrupt or impair the continued operation and functionality of the structure. (Appendix B)

performance objective, occupant comfort—specific desired outcome in which the accelerations from wind-induced sway motions remain within acceptable limits for occupant comfort and for equipment to maintain the functionality of the building. (Appendix B)

performance objective, operational—specific desired outcome in which the main wind-force-resisting system remains essentially elastic and the building systems remain operational during the designated risk-category-based event. (Appendix B)

plastic hinge region—length of frame element over which flexural yielding is intended to occur due to earthquake design displacements, extending not less than a distance h from the critical section where flexural yielding initiates.

post-installed reinforcing bar—deformed bar installed with adhesive or grout in a hole drilled in hardened concrete.

COMMENTARY

one-way construction—Joists, beams, girders, and some slabs and foundations are considered one-way construction.

panel, shotcrete mockup—Shotcrete mockup panels are used for preconstruction evaluation and are either sawed or cored, or both, to evaluate if the reinforcement has been adequately encased.

panel, shotcrete test—Shotcrete test panels are typically used to evaluate a shotcrete mixture, to qualify a nozzle operator, to verify surface finish, and to provide specimens for compressive or flexural strength testing.

performance objective, continuous occupancy, limited interruption—Continued operation and functionality of the structure is implicitly achieved when the main wind-force-resisting system is designed for a wind event corresponding to the designated building risk category to achieve the target reliability for structural stability that is consistent with the building code. (Appendix B)

performance objective, occupant comfort—Although the occupant comfort performance objective is part of performance-based wind design, it is outside of the scope of Appendix B. (Appendix B)

performance objective, operational—Members in reinforced concrete structures are considered cracked when concrete tensile stresses exceed the stress corresponding to the tensile strength. Even though the force-deformation relationship becomes nonlinear immediately after cracking, when performing the lateral analysis for the operational performance objective, it is assumed that the structure is essentially elastic, and its behavior is adequately represented using the secant stiffness for peak response for the risk category-based event. (Appendix B)

CODE

post-tensioning—method of prestressing in which prestressing reinforcement is tensioned after concrete has hardened.

precast concrete piles—driven piles that may be either prestressed concrete or conventionally reinforced concrete.

precompressed tension zone—portion of a prestressed member where flexural tension, calculated using gross section properties, would occur under service loads if the prestress force was not present.

pretensioning—method of prestressing in which prestressing reinforcement is tensioned before concrete is cast.

projected area—area on the free surface of the concrete member that is used to represent the greater base of the assumed rectilinear failure surface.

projected influence area—rectilinear area on the free surface of the concrete member that is used to calculate the bond strength of adhesive anchors.

pryout strength, concrete—strength corresponding to formation of a concrete spall behind short, stiff anchors displaced in the direction opposite to the applied shear force.

reinforcement—steel element or elements embedded in concrete and conforming to 20.2 through 20.4. Prestressed reinforcement in external tendons is also considered reinforcement.

reinforcement, anchor—reinforcement used to transfer the design load in tension from the anchors into the structural member

reinforcement, bonded prestressed—pretensioned reinforcement or prestressed reinforcement in a bonded tendon.

reinforcement, deformed—deformed bars, welded bar mats, deformed wire, and welded wire reinforcement conforming to 20.2.1.3, 20.2.1.5, or 20.2.1.7, excluding plain wire.

reinforcement, nonprestressed—bonded reinforcement that is not prestressed.

reinforcement, plain—bars or wires conforming to 20.2.1.4 or 20.2.1.7 that do not conform to definition of deformed reinforcement.

reinforcement, prestressed—prestressing reinforcement that has been tensioned to impart forces to concrete.

reinforcement, prestressing—high-strength reinforcement such as strand, wire, or bar conforming to 20.3.1.

reinforcement, supplementary—reinforcement that acts to restrain the potential concrete breakout but is not designed to transfer the design load from the anchors into the structural member.

COMMENTARY

reinforcement, anchor—Anchor reinforcement is designed and detailed specifically for the purpose of transferring anchor loads in tension from the anchors into the member. Hairpins are generally used for this purpose (refer to 17.5.2.1(a) and 17.5.2.1(b)); however, other configurations that can be shown to effectively transfer the anchor load are acceptable.

reinforcement, deformed—Deformed reinforcement is defined as that meeting the reinforcement specifications in the Code. No other reinforcement qualifies. This definition permits accurate statement of development lengths. Bars or wire not meeting the deformation requirements or welded wire reinforcement not meeting the spacing requirements are "plain reinforcement," for code purposes, and may be used only for spirals.

reinforcement, supplementary—Supplementary reinforcement has a configuration and placement similar to anchor reinforcement but is not specifically designed to transfer loads from the anchors into the member. Stirrups, as used for shear reinforcement, may fall into this category.

CODE

reinforcement, welded deformed steel bar mat—mat conforming to 20.2.1.5 consisting of two layers of deformed bars at right angles to each other welded at the intersections.

reinforcement, welded wire—plain or deformed wire fabricated into sheets or rolls conforming to 20.2.1.7.

reinforcing bar group—parallel reinforcing bars connecting two members, or a member and a joint, and developed in an anchorage region defined by $A_{c,eff}$.

COMMENTARY

reinforcing bar group—Some examples are shown in Fig. R2.4.

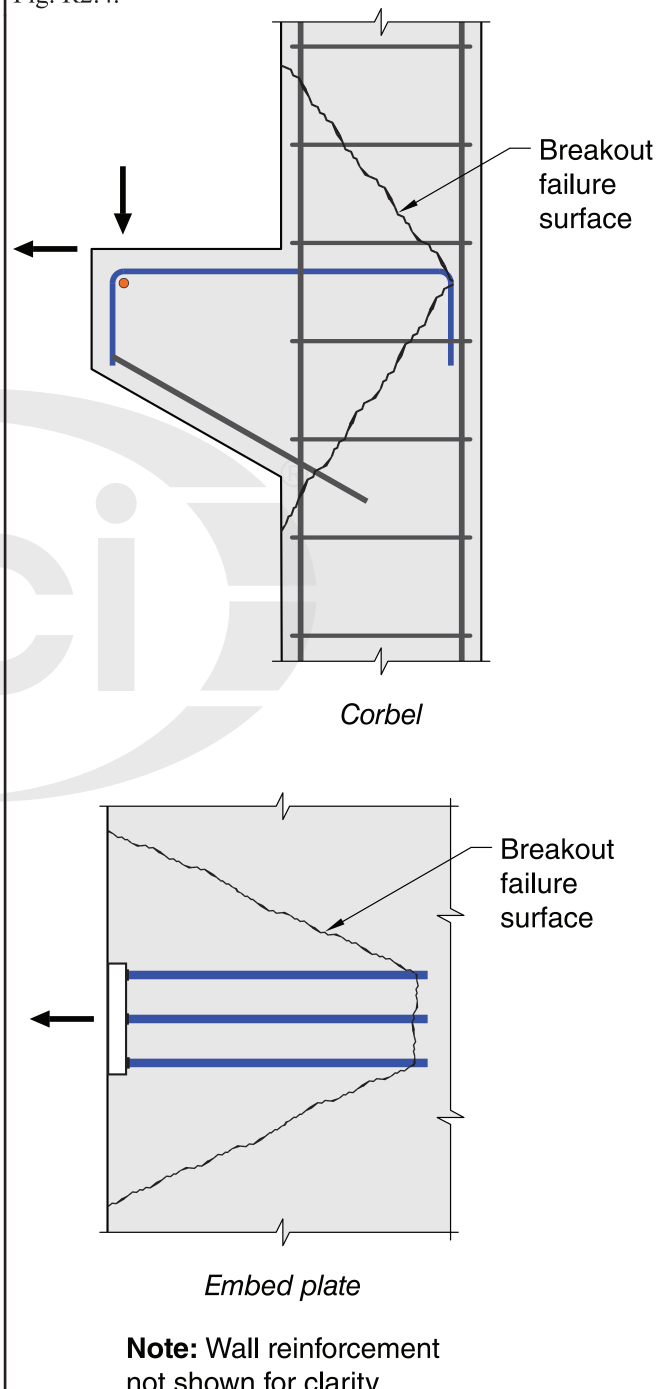


Fig. R2.4—Breakout failure of bar groups.

CODE

resilient design—design process that anticipates, addresses, and mitigates risks associated with known natural or human-caused hazards by balancing construction cost, material consumption, recovery of functionality, and potential financial loss should a particular hazard event occur. (Appendix C)

COMMENTARY

resilient design—The design of resilient concrete structural systems includes:

(a) Assessing the importance of the structure with respect to its functional, social, and economic roles in the community

(b) Evaluating the hazards to which the structure may be exposed (such as flood or earthquake) and the estimated magnitudes associated with target risk levels in the present and in the future

(c) Assessing the vulnerability and sensitivity of the structure to damage

(d) Assessing the consequences of damage to the structure caused by the hazard event(s)

(e) Evaluating the interdependent effects of the structure on other physical and social systems

In the context of the community of which individual structures are a part, resilience may include the community's ability to absorb disturbances while retaining the same basic structure and functionality, the capacity for self-organization, and the capacity to adapt to stress and change. The hazard design criteria and required recovery time following a hazard event should be based on the use, importance, and occupancy of the structure. (Appendix C)

CODE

Seismic Design Category—classification assigned to a structure based on its occupancy category and the severity of the design earthquake ground motion at the site, as defined by the general building code. Also denoted by the abbreviation SDC.

seismic-force-resisting system—portion of the structure designed to resist earthquake effects required by the general building code using the applicable provisions and load combinations.

seismic hook—hook on a stirrup, hoop, or crosstie having a bend not less than 135 degrees, except that circular hoops shall have a bend not less than 90 degrees; hooks shall have an extension of at least $6d_b$, but not less than 3 in. The hooks shall engage the longitudinal reinforcement and the extension shall project into the interior of the stirrup or hoop.

shear cap—projection below the slab used to increase the slab shear strength.

shear lug—a steel element welded to an attachment base plate to transfer shear to concrete by bearing.

sheathing—material encasing prestressing reinforcement to prevent bonding of the prestressing reinforcement with the surrounding concrete, to provide corrosion protection, and to contain the corrosion-inhibiting coating.

shotcrete—concrete placed pneumatically by high velocity projection from a nozzle onto a surface.

shotcrete, dry-mix—shotcrete in which most of the mixing water is added to the concrete ingredients at the nozzle.

shotcrete, wet-mix—shotcrete in which the concrete ingredients, including water, are mixed before introduction into the delivery hose.

COMMENTARY

sheathing—Typically, sheathing is a continuous, seamless, high-density polyethylene material extruded directly on the coated prestressing reinforcement.

shotcrete—Terms such as gunite and sprayed concrete are sometimes used to refer to shotcrete.

CODE

side-face blowout strength, concrete—strength of anchors with deep embedment and thin side-face cover such that spalling occurs on the side face around the embedded head without breakout occurring at the top concrete surface.

slab beam strip—in two-way prestressed slabs, the width of the floor system, including both the slab and beam if applicable, bounded laterally by adjacent panel centerlines for an interior slab-beam strip, or by adjacent panel centerline and slab edge for an exterior slab-beam strip.

spacing—center-to-center distance between adjacent items, such as longitudinal reinforcement, transverse reinforcement, prestressing reinforcement, or anchors.

spacing, clear—least dimension between the outermost surfaces of adjacent items.

span length—distance between supports.

special seismic systems—structural systems that use special moment frames, special structural walls, or both.

specialty engineer—a licensed design professional to whom a specific portion of the design has been delegated.

specialty insert—predesigned and prefabricated cast-in anchors specifically designed for attachment of bolted or slotted connections.

spiral reinforcement—continuously wound reinforcement in the form of a cylindrical helix.

steel element, brittle—element with a tensile test elongation of less than 14%, or reduction in area of less than 30% at failure.

steel element, ductile—element with a tensile test elongation of at least 14 percent and reduction in area of at least 30 percent; steel element meeting the requirements of ASTM A307 shall be considered ductile; except as modified by for earthquake effects, deformed reinforcing bars meeting the requirements of ASTM A615, A706, or A955 shall be considered as ductile steel elements.

stirrup—reinforcement used to resist shear and torsion in a member; deformed bar, deformed wire, or welded wire reinforcement,typically in the form of a single leg or bent into L, U, or rectangular shapes, oriented perpendicular to, or at an angle to, longitudinal reinforcement, and anchored near the extreme compression and tension surfaces of the section by bends, heads, or cross wires. See also **tie**.

structural wall panel zone—portion of a structural wall common to intersecting wall segments where forces from adjacent wall segments are resolved. (Appendix A)

strength, design—nominal strength multiplied by a strength reduction factor ϕ.

strength, nominal—strength of a member or cross section calculated in accordance with provisions and assumptions of the strength design method of this Code before application of any strength reduction factors.

COMMENTARY

specialty insert—Specialty inserts are devices often used for handling, transportation, erection, and anchoring elements; specialty inserts are not within the scope of the Code.

steel element, brittle—The 14% elongation should be measured over the gauge length specified in the appropriate ASTM standard for the steel.

steel element, ductile—The 14 percent elongation should be measured over the gauge length specified in the appropriate ASTM standard for steel. Due to concerns over fracture in cut threads, it should be verified that threaded deformed reinforcing bars satisfy the strength requirements of 25.5.7.1.

stirrup—The term “stirrup” is usually applied to transverse reinforcement in beams or slabs and the term “ties” or “hoops” to transverse reinforcement in compression members.

strength, nominal—Nominal or specified values of material strengths and dimensions are used in the calculation of nominal strength. The subscript n is used to denote the nominal strengths; for example, nominal axial load strength P_n, nominal moment strength M_n, and nominal shear strength V_n. For additional discussion on the concepts and nomenclature for strength design, refer to the Commentary of Chapter 22.

CODE

strength, required—strength of a member or cross section required to resist factored loads or related internal moments and forces in such combinations as stipulated in this Code.

stretch length—length of anchor, extending beyond concrete in which it is anchored, subject to full tensile load applied to anchor, and for which cross-sectional area is minimum and constant.

structural concrete—concrete used for structural purposes, including plain and reinforced concrete.

structural diaphragm—member, such as a floor or roof slab, that transmits forces acting in the plane of the member to vertical elements of the lateral-force-resisting system. A structural diaphragm may include chords and collectors as part of the diaphragm.

structural integrity—ability of a structure through strength, redundancy, ductility, and detailing of reinforcement to redistribute stresses and maintain overall stability if localized damage or significant overstress occurs.

structural system—interconnected members designed to meet performance requirements.

structural truss—assemblage of reinforced concrete members subjected primarily to axial forces.

structural wall—wall proportioned to resist combinations of moments, shears, and axial forces in the plane of the wall; a shear wall is a structural wall.

structural wall, ductile coupled—a seismic-force-resisting-system complying with 18.10.9.

structural wall, intermediate precast—a wall complying with 18.5.

structural wall, ordinary plain concrete—a wall complying with Chapter 14.

structural wall, ordinary reinforced concrete—a wall complying with Chapter 11.

structural wall, special—a cast-in-place structural wall in accordance with 18.2.3 through 18.2.8 and 18.10; or a precast structural wall in accordance with 18.2.3 through 18.2.8 and 18.11.

strut—compression member in a strut-and-tie model representing the resultant of a parallel or a fan-shaped compression field.

strut, boundary—strut located along the boundary of a member or discontinuity region.

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strength, required—The subscript u is used only to denote the required strengths; for example, required axial load strength P_u, required moment strength M_u, and required shear strength V_u, calculated from the applied factored loads and forces. The basic requirement for strength design may be expressed as follows: design strength ≥ required strength; for example, $\phi P_n \geq P_u$; $\phi M_n \geq M_u$; $\phi V_n \geq V_u$. For additional discussion on the concepts and nomenclature for strength design, refer to the Commentary of Chapter 22.

stretch length—Length of an anchor over which inelastic elongations are designed to occur under earthquake loadings. Examples illustrating stretch length are shown in Fig. R17.2.3.4.3.

structural wall, intermediate precast—Requirements of 18.5 are intended to result in an intermediate precast structural wall having minimum strength and toughness equivalent to that for an ordinary reinforced concrete structural wall of cast-in-place concrete. A precast concrete wall not satisfying the requirements of 18.5 is considered to have ductility and structural integrity less than that for an intermediate precast structural wall.

structural wall, special—Requirements of 18.2.3 through 18.2.8 and 18.11 are intended to result in a special precast structural wall having minimum strength and toughness equivalent to that for a special reinforced concrete structural wall of cast-in-place concrete.

strut, boundary—A boundary strut is intended to apply to the flexural compression zone of a beam, wall, or other

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strut, interior—strut not located along the boundary of a member or discontinuity region.

strut-and-tie model—truss model of a member or of a D-region in such a member, made up of struts and ties connected at nodes and capable of transferring the factored loads to the supports or to adjacent B-regions.

sustainable design—design process that considers the balance among social, economic, and environmental principles from the Work's conception through the end of its service life (Appendix C).

tendon—in post-tensioned members, a tendon is a complete assembly consisting of anchorages, prestressing reinforcement, and sheathing with coating for unbonded applications or ducts filled with grout for bonded applications.

tendon finishing—the trimming of tendons, installing watertight encapsulation cap, and filling stressing pockets; for bonded post-tensioning systems, it also includes installing grout caps and closure of grout vents.

tendon, bonded—tendon in which prestressed reinforcement is continuously bonded to the concrete through grouting of ducts embedded within the concrete cross section.

tendon, external—a tendon external to the member concrete cross section in post-tensioned applications.

tendon, unbonded—tendon in which prestressed reinforcement is prevented from bonding to the concrete. The prestressing force is permanently transferred to the concrete at the tendon ends by the anchorages only.

tensile strength, reinforcement—specified minimum tensile strength of reinforcement.

tension-controlled section—a cross section in which the net tensile strain in the extreme tension steel at nominal strength is greater than or equal to ε_{ty} + 0.003.

tie—(a) reinforcing bar or wire enclosing longitudinal reinforcement; a continuously wound transverse bar or wire in the form of a circle, rectangle, or other polygonal shape without reentrant corners enclosing longitudinal reinforcement; see also **stirrup, hoop**; (b) tension element in a strut-and-tie model.

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member. Boundary struts are not subject to transverse tension and are therefore stronger than interior struts (Fig. R23.2.1).

strut, interior—Interior struts are subject to tension, acting perpendicular to the strut in the plane of the model, from shear (Fig. R23.2.1).

sustainable design—The design of sustainable concrete structural systems seeks to achieve balance between the production of concrete elements and the required performance characteristics in all phases of the structural system's life cycle. This approach includes measures to reduce the consumption of resources, including but not limited to water, aggregates, cementitious materials, reinforcing steel, and fuels; considers economic value and societal and cultural impacts; and minimizes impacts on the environment. When considering sustainable design, the Code places emphasis on the environmental impacts. Users should also consider social and economic principles of sustainable design that are not directly addressed by the Code. The principles of resilience and resilient design should be considered in sustainable design (Appendix C).

tendon, external—In new or existing post-tensioned applications, a tendon totally or partially external to the member concrete cross section, or inside a box section, and attached at the anchor device and deviation points.

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transfer—act of transferring stress in prestressing reinforcement from jacks or pretensioning bed to concrete member.

transfer length—length of embedded pretensioned reinforcement required to transfer the effective prestress to the concrete.

two-way construction—members designed to resist out-of-plane loads through bending in two directions; some slabs and foundations are considered two-way construction. See also **one-way construction**.

uncased cast-in-place concrete drilled or augered piles—piles with or without an enlarged base (bell) that are constructed by either drilling a hole in the ground, or by installing a temporary casing in the ground and cleaning out the soil, and subsequently filling the hole with reinforcement and concrete.

wall—a vertical element designed to resist axial load, lateral load, or both, with a horizontal length-to-thickness ratio greater than 3, used to enclose or separate spaces.

wall pier—a vertical wall segment within a structural wall, bounded horizontally by two openings or by an opening and an edge, with ratio of horizontal length to wall thickness (ℓ_w/b_w) less than or equal to 6.0, and ratio of clear height to horizontal length (h_w/ℓ_w) greater than or equal to 2.0.

wall segment—portion of wall bounded by vertical or horizontal openings or edges.

wall segment, horizontal—segment of a structural wall, bounded vertically by two openings or by an opening and an edge.

wall segment, vertical—segment of a structural wall, bounded horizontally by two openings or by an opening and an edge; wall piers are vertical wall segments.

water-cementitious materials ratio—ratio of mass of water, excluding that absorbed by the aggregate, to the mass of cementitious materials in a mixture, stated as a decimal.

Whole Building Life Cycle Assessment (WBLCA)—life cycle assessment (LCA) of the complete building (Appendix C).

Work—the entire construction or separately identifiable parts thereof that are required to be furnished under the construction documents.

yield strength, reinforcement—specified minimum yield strength of reinforcement.

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wall pier—Wall piers are vertical wall segments with dimensions and reinforcement intended to result in shear demand being limited by flexural yielding of the vertical reinforcement in the pier.

wall segment, horizontal—A horizontal wall segment is shown in Fig. R18.10.4.5.

Work—Work is capitalized throughout the Code when used in accordance with this definition.

yield strength, reinforcement—specified yield strength differs from actual yield strength, which is the measured yield strength of the reinforcement

Notes