ACI Standard

Preparation of Notation for Concrete (ACI 104-71) (Revised 1982) Reapproved 1997

Reported by ACI Committee 104 *

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Indicates how symbols shall be selected to represent quantities or terms. Principal symbols are upper and lower case Roman letters and Greek lower case letters. Roman lower case letters are used as subscripts and Greek upper case letters are reserved for mathematics.

Keywords: coding; concretes; definitions; nomenclature; notation; prestressed concrete; reinforced concrete; structural analysis; structural design; symbols; terminology.

PREPARATION OF NOTATION

Scope

All symbols used in defining any aspect of concrete construction shall be prepared using the guide outlined in Table 1.

Construction of symbols

The preparation of a symbol to represent a given quantity shall be conducted in the following manner.

(a) The leading or main letter of the symbol shall be selected from Table 1 based on

TABLE I-GUIDE FOR CONSTRUCTION OF SYMBOLS

(a) Roman capital letters (dimensions: force, force times length, area, area to a power, temperature)
1. Moments, shears, normal forces, concentrated loads, total loads
2. Area, first and second moments of area
3. Strain moduli (exception to dimensions)
4. Temperature

(b) Roman lower case letters (dimensions: length, length per time to a power, force per unit length, area, or volume, except where used as subscripts)
1. Unit moments, shears, normal forces, loads
2. Linear dimensions (length, width, thickness, etc.)
3. Unit strengths, stresses[1]
4. Velocity, acceleration, frequency
5. Descriptive letters (subscripts)

(c) Greek upper case letters
Reserved for mathematics

(d) Greek lower case letters (dimensionless)
1. Coefficients and dimensionless ratios
2. Strains
3. Angles
4. Specific gravity (ratio of densities)
5. Variable stresses (exception, CEB usage only)[1]

(e) Indices
' = compression

(f) Subscripts
Roman lower case letters may be used following the main symbol as required. Definitions assigned to subscripts include but are not limited to those listed below:

a	=	additional
b	=	bond
c	=	concrete
e	=	effective, elastic
i	=	initial
k	=	characteristic
l	=	longitudinal
m	=	average
p	=	prestress
r	=	tensile rupture
s	=	steel
t	=	transversal; total
u	=	ultimate
v	=	shear
x, y, z	=	axial directions

[1]Compatibility between ACI and CEB symbology for stresses to be achieved in the future.

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consideration of the dimensions of the quantity under consideration.

(b) An index representing compression shall be added to symbols representing geometrical quantities if required.

(c) Descriptive subscripts may be selected as desired. When subscripts other than those appearing in Table 1 are used, a clear written definition of their meaning shall be given.

(d) The sign of a computed stress is given by + (plus) for tension and - (minus) for compression.

COMMENTARY AND APPENDICES

The following commentary and appendices, while not a part of ACI 104-71, will assist the user in applying the standard and selecting notation which conforms to selections made by ACI committees, based on the standard.

Commentary on Application of Standard Notation

Need for standard notation

A "symbol" is here defined as a short grouping of letters and numerals to represent a written definition of some engineering concept. Thus, A_s is commonly used to define the cross-sectional area of reinforcing steel. The body of symbols used by an engineering discipline is further defined as the "notation" for that discipline. The sole function of a notation is to serve as a form of "shorthand" to aid in the communication of ideas among members of the discipline. A good notation then is one which best serves its masters. Hallmarks of a good notation are lack of ambiguity in determining the meaning of any given symbol, consistency of construction of symbols, and a common use of the notation by all members of the discipline.

Prior to the adoption of ACI Standard 104 in 1971, the notation for concrete in use in United States practice was the product of random evolution and not systematic planning. As a result, a single symbol was often used to represent a multiplicity of disparate concepts in a number of cases. For example, the symbol ***D*** was used to represent dead loads, bar diameter, column diameter, and wall length. Also a number of slightly different definitions of the same basic concept were represented by a single symbol, such as *t* to represent many kinds of thickness. With the rapid development of new knowledge and the corresponding continual need for new symbols, the need for a consistent method for the construction and definition of symbols was apparent.

In the 1977 Code, the subscript *u* has been reserved for load effects (shear force, bending moment) computed from factored loads. The subscript ***n*** is used for nominal strength which is the strength calculated using the nominal values of f_c', f_y, etc., and the standard calculation procedures.

Development of standard notation

Recognizing the need for a standard, the Technical Activities Committee of ACI organized Committee 104, Notation, in 1964. Initially, the committee examined the notation* prepared by Commission VII, Notation and Terminology, of the Comite Europeen du Beton (European Concrete Committee) to see if it could be adopted in toto since one of the goals was the attainment of a universal standard. However, the first version of the notation prepared by CEB VII was felt to be unacceptable since it involved the use of a large number of sub- and superscripts and Greek letters. Hence, it was necessary for ACI 104 to develop an independent notation which was, however, modeled as closely as possible on that of the CEB. The first version of the ACI 104. notation was published in the May 1968 ACI JOURNAL.[2]

Close liaison between ACI 104 and CEB VII was maintained by having several persons serve simultaneously as members of each committee. The possibility of arriving at a common ACI-CEB notation was continuously explored but appeared unlikely until about 1969, since the CEB notation had already been adopted by several countries for use in their national building codes. However, at the 13th biennial meeting of the CEB, held at Scheveningen, Netherlands, in September 1969, discussions of a common ACI-CEB Standard for notation were held. Extensive discussions were conducted jointly by ACI 104 and CEB VII and also the general assembly discussed notation during two meetings. The point was repeatedly made that several major codes, including the ACI, the CEB, the British, the Scandinavian, and others, were soon to appear in new editions and that the Scheveningen meeting represented the last chance to arrive at a common standard for perhaps decades. During the discussions numerous compromises were made and a proposed standard was developed. The standard was adopted by the CEB general assembly contingent upon its acceptance by the ACI. The standard was then presented to ACI membership vote and adopted as an ACI standard in 1971. The new standard for preparation of notation for concrete thus became the first universal standard in any profession.

The logic of the system described in Table 1 of the standard lies in the selection of the leading letter of a symbol based on a consideration of the units of the physical quantity involved. One exception occurs in the case of strain moduli. The symbols *E* and G are retained for Young's modulus and the shear modulus since these are now universally in use. One divergence between CEB and ACI usage is the retention by CEB of sigma and tau for normal and shear stresses.

A detailed description of the usage of each Roman and Greek letter based upon the standard is given in Appendix A. Definitions which are not italicized were jointly adopted. Italicized definitions have been adopted by ACI.

Appendix B is a listing of the notation used in ACI Standard 3 18.

References

1. ***International Recommendations for the Design and Construction of Concrete Structures,*** Comite Europeen du Beton/Federation Intemationale de la Precontrainte, Paris, 1970. (English translation, Cement and Concrete Association, London, 1970, 80 pp.)

2. Vanderbilt, M. D., "Notation-The Case for a New System," ACI JOURNAL, ***Proceedings V. 65, No. 5,*** May 1968, pp. 357-361.

3. "Bases for Design of Structures: Notations, General Symbols," (ISO 3898-1976), International Standards Organization/American National Standards Institute, New York, 1976, 4 pp.

Appe ndice s

APPENDIX A-DETAILED DESCRIPTION OF USAGE OF ROMAN AND GREEK LETTERS*

Typical notation for reinforced concrete cross sections is shown in Fig. 1.

Capital Roman letters

A = area
B =
c = torsional constant
D = *dead load*
E = modulus of elasticity; *earthquake load*
F = force; load; *liquid pressure*
G = modulus of shear
H = *lateral force; lateral earth pressure*
I = moment of inertia
J =
K = any coefficient with proper dimensions
L = *live load ,*
M = bending moment
N = normal force
0 = (VOID)†
P = prestressing force; *axial load*
Q =
R =
S = first moment of an area; internal forces; load effects
T = torsional moment; temperature
U = *required strength*
V = shear force
W = wind load
X = reactions or forces in general, parallel to axis *x*
Y = reactions or forces in general, parallel to axis y
Z = reactions or forces in general, parallel to axis *z*

Lower case Roman letters

a = deflection; distance; *depth of rectangular stress block*
b width
= distance from compression fiber to neutral axis
d = effective depth; diameter (see also *h)*
e = eccentricity, base of Napierian logarithms (mathematical usage)
f = unit strength *or stress* (f_C *for concrete in compression,* f_r for concrete in tension, and f_s for steel)
g = acceleration due to gravity
h = total depth; thickness; diameter
i =
j =
k = any coefficient with proper dimensions
1 = span; length of member or element
m = bending moment per unit length
n = unit normal force; number
0 = (VOID)
p = (VOID)
q =
r = *radius of gyration*
s = standard deviation; spacing
t = time; unit torsional moment per unit length
u =
v = shear; *stress*
w = crack width; *total load per unit length or area*
x = coordinate
y = coordinate
z = coordinate; *reinforcement distribution factor*

***Italicized words indicate ACI usage.**
All other definitions are common ACI-CEB-FIP usage.
A blank space indicates an unassigned letter.
†Void indicates the letter shall not be used.

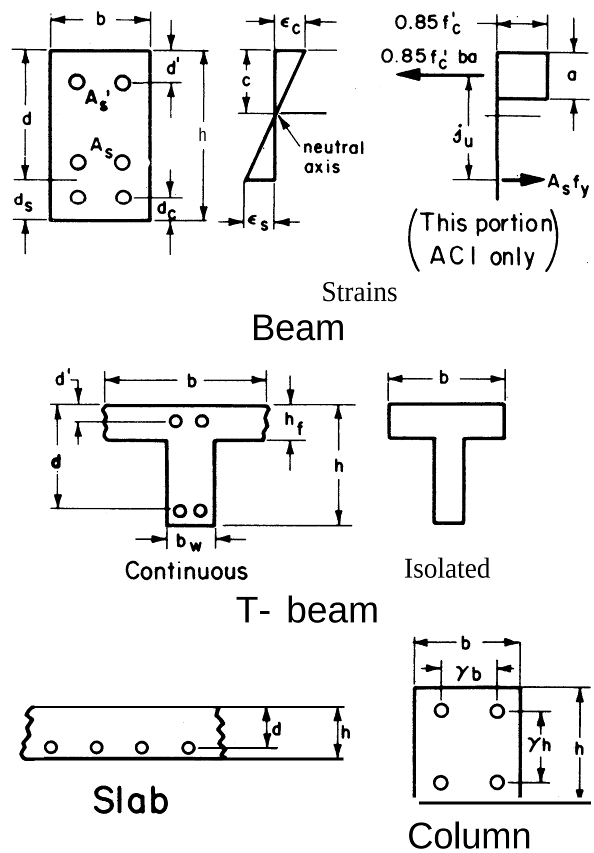

Fig. I - Typical notation for reinforced concrete cross sections

Lower case Greek letters

Alpha *α* = angle; ratio; coefficient
Beta *β* = angle; ratio; coefficient
Gamma *γ* = specific gravity; ratio
Delta *δ* = coefficient; coefficient of variation
Epsilon *ϵ* = strain
Zeta *ζ* = coefficient
Eta *η* = (VOID)
Theta *θ* = rotation
Iota *ι* = (VOID)
Kappa *κ* = (VOID)
Lambda *λ* = slenderness ratio; coefficient
Mu *μ* = coefficient of friction
Nu *ν* = Poisson's ratio
Xi *ξ* = coefficient
Omicron *o* = (VOID)
Pi *π* = reserved for mathematics, 3.14159
Rho *ρ* = geometrical ratio of reinforcement

$$\rho = \frac{A_s}{A_c}, \rho' = \frac{A_s'}{A_c}$$

Sigma *σ* = normal stress (CEB only)
Tau *τ* = shear or transverse stress (CEB only)
Upsilon *ν* = (VOID)
Phi . *ϕ* = *strength reduction factor; creep coeficient*

Chi χ = (VOID)
Psi ψ =
Omega ω = reinforcing strength index

Subscripts

= additional
b = bond; bar; beam; balanced
= concrete; column; compression; ***critical***
d = design; ***dead load***
e = effective; elastic
f = flange; flexure; friction; fatigue
g = gross
h = horizontal; hook; ***hoop***
i = initial
j =
k = characteristic
l = longitudinal; ***live load***
m = average values; ***moment***
n = number; ***net; nominal***
o = a particular value of a quantity
p = prestress; ***pile***
q =
r = tensile rupture
s = steel; slab
t = transversal; torsion; tension; total; ***tubing;*** time
u = ***unsupported;*** factored load effect at ultimate
v = shear; vertical
w = wind; ***wire; web; wall***
x = axial direction
y = axial direction; yield
z = axial direction
0, 1, 2 . . . = particular values of quantities

Subscripts formed from abbreviations

bal = ***balanced***
cr = ***cracked,*** critical
max = maximum
min = minimum
sp = ***spiral***
vert = ***vertical***

Subscripts for loads

d = ***dead load***
l = ***live load***
eq = earthquake
h = ***earth pressure***
te = temperature; creep; shrinkage; prestrain effects
wl = wind load

APPENDIX B- NOTATION FOR ACI 318-83

Reproduced below, in separate lists, is the notation selected for "Building Code Requirements for Reinforced Concrete (ACI 3 18-83)" and for the Commentary on the Code. These lists should be useful to committees and other authors in selecting notation for their use. Note that while ACI 3 18-83, and all preceding discussion, is independent of any system of units such as metric, English, etc., many of the symbols given below contain English units since they appear in empirical equations.

The notation used in the code and commentary follows "ACI Standard for Preparation of Notation for Concrete (ACI 104-71, Revised 1982)" with very few exceptions and also follows the principles adopted by the Comite Euro-International du Beton.

a = depth of equivalent rectangular stress block as defined in Section 10.2.7. Chapters 10 and 12
a = shear span, distance between concentrated load and face of support. Chapter 11
a = maximum deflection under test load of member relative to a line joining the ends of the span, or of the free end of a cantilever relative to its support, in. Chapter 20
A = effective tension area of concrete surrounding the flexural tension reinforcement and having the same centroid as that reinforcement, divided by the number of bars or wires, sq in. When the flexural reinforcement consists of different bar or wire sizes the numbers of bars or wires shall be computed as the total area of reinforcement divided by the area of the largest bar or wire used. Chapter 10
A = area of that part of cross section between flexural tension face and center of gravity of gross section, sq in. Chapter 18
A_b = area of an individual bar, sq in. Chapter 12
A_c = area of core of spirally reinforced compression member measured to outside diameter of spiral, sq in. Chapter 10
A_c = area of concrete section resisting shear transfer. Chapter 11
A_c = area of contact surface being investigated for horizontal shear, sq in. Chapter 17
A_c = area of concrete at cross section considered, sq in. Chapter 18
A_{ch} = cross-sectional area of a structural member measured out-to-out of transverse reinforcement, sq in. Appendix A
A_{cp} = area of concrete section, resisting shear, of an individual pier or horizontal wall segment, sq in. Appendix A
A_{cv} = net area of concrete section bounded by web thickness and length of section in the direction of shear force considered, sq in. Appendix A
A_f = area of reinforcement in bracket or corbel resisting factored moment, $[V_{u}a + N_{uc}(h - d)]$, sq in. Chapter 11
A_g = gross area of section, sq in. Chapters 9, 10, 11, 14, and Appendixes A and B
A_h = area of shear reinforcement parallel to flexural tension reinforcement, sq in. Chapter 11
A_j = minimum cross-sectional area within a joint in a plane parallel to the axis of the reinforcement generating the shear in the joint. Where a girder frames into to a support of larger width, effective width of the joint shall be assumed not to exceed the width plus the overall depth of the joint, sq in. Appendix A
A_n = area of reinforcement in bracket or corbel resisting tensile force N_{uc}, sq in. Chapter 11
A_ℓ = total area of longitudinal reinforcement to resist torsion, sq in. Chapter 11

A_{ps} = area of prestressed reinforcement in tension zone, sq in. Chapters 11 and 18

A_s = area of nonprestressed tension reinforcement, sq in. Chapters 8, 9, 10, 11, 12, and 18

A'_s = area of compression reinforcement, sq in. Chapters 8, 9, and 18

A_{sh} = total cross-sectional area of transverse reinforcement (including cross-ties) within spacing s and perpendicular to dimension h_c Appendix A

A_{st} = total area of longitudinal reinforcement, (bars or steel shapes), sq in. Chapter 10

A_t = area of structural steel shape, pipe, or tubing in a composite section, sq in. Chapter 10

A_t = area of one leg. of a closed stirrup resisting torsion within a distance s, sq in. Chapter 11

A_v = area of shear reinforcement within a distance s, or area of shear reinforcement perpendicular to flexural tension reinforcement within a distance s for deep flexural members, sq in. Chapters 11, 12, and Appendix B

A V = total cross-sectional area of shear reinforcement within spacing s and perpendicular to longitudinal axis of structural member, sq in. Appendix A

A_{vf} = area of shear-friction reinforcement, sq in. Chapter 11

A_{vh} = area of shear reinforcement parallel to flexural tension reinforcement within a distance s_2, sq in. Chapter 11

A_w = area of an individual wire to be developed or spliced, sq in. Chapter 12

A_1 = loaded area. Chapter 10 and Appendix B

A_2 = maximum area of the portion of the supporting surface that is geometrically similar to and concentric with the loaded area. Chapter 10 and Appendix B

b = width of compression face of member, in. Chapters 8, 9, 10, 11, 18, and Appendix B

b = effective compressive flange width of a structural member, in. Appendix A

b_o = perimeter of critical section for slabs and footings, in. Chapter 11 and Appendix B

b_t = width of that part of cross section containing the closed stirrups resisting torsion. Chapter 11

b_v = width of cross section at contact surface being investigated for horizontal shear. Chapter 17

b_w = web width, or diameter of circular section, in. Chapters 11, 12, and Appendix B

c = distance from extreme compression fiber to neutral axis, in. Chapter 10

c_1 = size of rectangular or equivalent rectangular column, capital, or bracket measured in the direction of the span for which moments are being determined, in. Chapters 11 and 13

c2 = size of rectangular or equivalent rectangular column, capital, or bracket measured transverse to the direction of the span for which moments are being determined, in. Chapters 11 and 13

C = cross-sectional constant to define torsional properties. See Eq. (13-7) Chapter 13

C_m = a factor relating actual moment diagram to an equivalent uniform moment diagram. Chapter 10

C_t = factor relating shear and torsional stress properties. Chapter 11

$$= \frac{b_w d}{\Sigma x^2 y}$$

d = distance from extreme compression fiber to centroid of tension reinforcement: in. Chapters 7, 8, IO, 12, 13, and Appendix B

d = distance from extreme compression fiber to centroid of nonprestressed tension reinforcement, in, Chapter 18

d = distance from extreme compression fiber to centroid of longitudinal tension reinforcement, but need not be less than 0.80h for prestressed members, in. (For circular sections, d need not be less than the distance from extreme compression fiber to centroid of tension reinforcement in opposite half of member). Chapter 11

d = distance from extreme compression fiber to centroid of tension reinforcement for entire composite section, in. Chapter 17

d = effective depth of section. Appendix A

d' = distance from extreme compression fiber to centroid of compression reinforcement, in. Chapters 9 and 18

d_b = nominal diameter of bar, wire, or prestressing strand, in. Chapters 7 and 12

d_b = nominal diameter of bar, in. Chapter 3 and Appendix A

d_c = thickness of concrete cover measured from extreme tension fiber to center of bar or wire located closest thereto, in. Chapter 10

d_p = diameter of pile at footing base. Chapter 15

d_p = distance from extreme compression fiber to centroid of prestressed reinforcement. Chapter 18.

d_s = distance from extreme tension fiber to centroid of tension reinforcement in. Chapter 9

D = dead loads, or related internal moments and forces. Chapters 9, 18, and 20

e = base of Napierian logarithms. Chapter 18

E = load effects of earthquake, or related internal moments and forces. Chapter 9 and Appendix A

E_c = modulus of elasticity of concrete, psi. See Section 8.51. Chapters 8, 9, 10, 19, and Appendix B

E_{cb} = modulus of elasticity of beam concrete. Chapter 13

E_{cc} = modulus of elasticity of column concrete. Chapter 13

E_{cs} = modulus of elasticity of slab concrete. Chapter 13

EI = flexural stiffness of compression member. See Eq. (10-10) and (10-11). Chapter 10

E_s = modulus of elasticity of reinforcement, psi. See Section 85.2 or 8.5.3. Chapters 8, 10, and Appendix B

f'_c = specified compressive strength of concrete, psi. Chapters 4, 8, 9, 10, 11, 12, 14, 18, 19, and Appendixes A and B

f'_{cr} = required average compressive strength of concrete used as the basis for selection of concrete proportions, psi. Chapter 4

$\sqrt{f'_c}$ = square root of specified compressive strength of concrete, psi. Chapters 9, 11, 12, 15, 18, 19, and Appendix B

f'_{ci} = compressive strength of concrete at time of initial prestress, psi. Chapter 18

$\sqrt{f'_{ci}}$ = square root of compressive strength of concrete at time of initial prestress, psi. Chapter 18

f_{ct} = average splitting tensile strength of lightweight aggregate concrete, psi. Chapters 4, 9, 11, 12, and Appendix B

f_d = stress due to unfactored dead load, at extreme fiber of sectionwhere tensile stress is caused by externally applied loads, psi. Chapter 11

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 when the centroid lies within the flange, psi. (In a composite member, f_{pc} is resultant compressive stress at centroid of composite section, or at junction of web and flange when the centroid lies within the flange, due to both prestress and moments resisted by precast member acting alone). Chapter 11

f_{pc} = average compressive stress in concrete due to effective prestress force only (after allowance for all prestress losses), psi. Chapter 18

f_{pe} = compressive stress in concrete due to effective prestress forces only (after allowance for all prestress losses) at extreme fiber of section where tensile stress is caused by externally applied loads, psi. Chapter 11

f_{ps} = stress in prestressed reinforcement at nominal strength. See text for units. Chapters 12 and 18

f_{pu} = specified tensile strength of prestressing tendons, psi. Chapters 11 and 18

f_{py} = specified yield strength of prestressing tendons, psi. Chapter 18

f_r = modulus of rupture of concrete, psi. Chapters 9 and 18

f_s = calculated stress in reinforcement at service loads, ksi. Chapter 10

f_s = permissible tensile stress in reinforcement, psi. Appendix B

f_{se} = effective stress in prestressed reinforcement (after allowance for all prestress losses). See text for units. 'Chapters 12 and 18

f i = specified yield strength of nonprestressed reinforcement, psi. Chapters 3, 7, 8, 9, IO, 11, 12, 18, 19, and Appendixes A and B

f_{yh} = specified yield strength of transverse reinforcement, psi. Appendix A

F = loads due to weight and pressures of fluids with well-defined densities and controllable maximum heights, or related internal moments and forces. Chapter 9

h = overall thickness of member, in. Chapters 9, 10, 11, 12, 13, 14, 18, 20, and Appendix A

h = thickness of shell or folded plate, in. Chapter 19

h_c = cross-sectional dimension of column core measured center-to-center of confining reinforcement. Appendix A

h_v = total depth of shearhead cross section, in. Chapter 11

h_w = total height of wall from base to top, in. Chapter 11

h_w = height of entire wall (diaphragm) or of the segment of wall (diaphragm) considered. Appendix A

H = loads due to weight and pressure of soil, water in soil, or other materials, or related internal moments and forces. Chapter 9

I = moment of inertia of section resisting externally applied factored loads. Chapter 11

I_b = moment of inertia about centroidal axis of gross section of beam as defined in Section 13.2.4. Chapter 13

I_c = moment of inertia of gross section of column. Chapter 13

I_{cr} = moment of inertia of cracked section transformed to concrete. Chapter 9

I_e = effective moment of inertia for computation of deflection. Chapter 9

I_g = moment of inertia of gross concrete section about centroidal axis, neglecting reinforcement. Chapters 9 and 10

I_s = moment of inertia about centroidal axis of gross section of slab
= $h^3/12$ times width of slab defined in notations α and β_t. Chapter 13

I_{se} = moment of inertia of reinforcement about centroidal axis of member cross section. Chapter 10

I_t = moment of inertia of structural. steel shape, pipe, or tubing about centroidal axis of composite member cross section. Chapter 10

k = effective length factor for compression members. Chapter 10

k = effective length factor. Chapter 14

K = wobble friction coefficient per foot of prestressing tendon, Chapter 18

K_b = flexural stiffness of beam; moment per unit rotation. Chapter 13

K_c = flexural stiffness of column; moment per unit rotation. Chapter 13

K_s = flexural stiffness of slab; moment per unit rotation. Chapter 13

K_t = torsional stiffness of torsional member; moment per unit rotation. Chapter 13

ℓ = span length of beam or one-way slab, as defined in Section 8.7; clear projection of cantilever, in. Chapter 9

ℓ = length of span of two-way flat plates in direction parallel to that of the reinforcement being determined, in. See Eq. (18-8). Chapter 18

ℓ_a = additional embedment length at support or at point of inflection, in. Chapter 12

ℓ_c = vertical distance between supports, in. Chapter 14

ℓ_d = development length, in. Chapters 7,12, and Appendix A

ℓ_{dh} = development length of standard hook in tension, measured from critical section to outside end of hook (straight embedment length between critical section and start of hook [point of tangency] plus radius of bend and one bar diameter), in.
= $\ell_{hb} \times$ applicable modification factors. Chapter 12

ℓ_{dh} = development length for a bar with a standard hook as defined in Eq. (A-5). Appendix A

ℓ_{hb} = basic development length of standard hook in tension, in. Chapter 12

ℓ_n = clear span for positive moment or shear and average of adjacent clear spans for negative moment. Chapter 8

ℓ_n = clear span measured face-to-face of supports, Chapter 11

ℓ_n = length of clear span in long direction of two-way construction, measured face-to-face of supports in slabs without beams and face-to-face of beams or other supports in other cases. Chapter 9

ℓ_n = length of clear span in direction that moments are being determined, measured face-to-face of supports. Chapter 13

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

ℓ_t = span of member under load test (shorter span of flat slabs and of slabs supported on four sides). Span of member, except as provided in Section 20.4.9, is distance between centers of supports or clear distance between supports plus depth of member, whichever is smaller, in. Chapter 20

ℓ_u = unsupported length of compression member. Chapter 10

ℓ_v = length of shearhead arm from centroid of concentrated load or reaction, in. Chapter 11

ℓ_w = horizontal length of wall, in. Chapter 11

ℓ_w = length of entire wall (diaphragm) or a segment of wall (diaphragm) considered in direction of shear force. Appendix A

ℓ_x = length of prestressing tendon element from jacking end to any point x, ft. See Eq. (18-l) and (18-2). Chapter 18

ℓ_1 = length of span in direction that moments are being determined, measured center-to-center of supports. Chapter 13

ℓ_2 = **length of span transverse to ℓ_1, measured center-**to-center of supports. See also Sections 13.6.2.3 and 13.6.2.4. Chapter 13

L = live loads, or related internal moments and forces. Chapters 9, 18, and 20

M = design moment. Appendix B

M_a = maximum moment in member at stage deflection is computed. Chapter 9

M_c = factored moment to be used for design of compression member. Chapter 10

M_{cr} = cracking moment. See Section 9.5.2.3. Chapter 9

M_{cr} = moment causing flexural cracking at section due

Chapter 11

M_m = modified moment. Chapter 11

M_{max} = maximum factored moment at section due to externally applied loads. Chapter 11

M_o = total factored static moment. Chapter 13

M_n = nominal moment strength at section, in.-lb Chapter 12

= $A_s f_y(d - a/2)$.

M_p = required plastic moment strength of shearhead cross section. Chapter 11

M_s = portion of slab moment balanced by support moment. Appendix A

M_u = factored moment at section. Chapter 11

M_v = moment resistance contributed by shearhead reinforcement. Chapter 11

M_{1b} = value of smaller factored end moment on compression member due to the loads that result in no appreciable sidesway, calculated by conventional elastic frame analysis, positive if member is bent in single curvature, negative if bent in double curvature. Chapter 10

M_{2b} = value of larger factored end moment on compression member due to loads that result in no appreciable sidesway, calculated by conventional elastic frame analysis. Chapter 10

M_{2s} = value of larger factored end moment on compression member due to loads that result in appreciable sidesway calculated by conventional elastic frame analysis. Chapter 10

n = modular ratio of elasticity. Appendix B.

= E_s/E_c

N = design axial load normal to cross section occurring simultaneously with V; to be taken as positive for compression, negative for tension, and to include effects of tension due to creep and shrinkage. Appendix B

N_c = tensile force in concrete due to unfactored dead load plus live load (D + L). Chapter 18

N_u = factored axial load normal to cross section occurring simultaneously with V_u; to be taken as positive for compression, negative for tension, and to include effects of tension due to creep and shrinkage. Chapter 11

N_{uc} = factored tensile force applied at top of bracket or corbel acting simultaneously with V_u, to be taken as positive for tension. Chapter 11

Pb = nominal axial load strength at balanced strain conditions. See Section 10.3.2. Chapters 9 and 10

P_c = critical load. See Eq. (1 O-9). Chapter 10

P_n = nominal axial load strength at given eccentricity. Chapters 9 and 10

P, = nominal axial load strength at zero eccentricity. Chapter 10

P_s = prestressing tendon force at jacking end. Chapter 18

P" = **factored axial load at given eccentricity $\le \phi P_n$.** Chapters 9 and 10

P_{nw} = nominal axial load strength of wall designed by Section 14.4. Chapter 14

P_x = prestressing tendon force at any point *x*. Chapter 18

r = radius of gyration of cross section of a compression member. Chapter 10

s = standard deviation, psi. Chapter 4

s = spacing of shear or torsion reinforcement in direction parallel to longitudinal reinforcement, in. Chapter 11

s = spacing of stirrups or ties, in. Chapter 12

s = spacing of transverse reinforcement measured along the longitudinal axis of the structural member.. in. Appendix A

s = spacing of shear reinforcement in direction parallel to longitudinal reinforcement, in. Appendix B

s_o = maximum spacing of transverse reinforcement, in. Appendix A

sw = spacing of wire to be developed or spliced, in. Chapter 12

s_1 = spacing of vertical reinforcement in wall, in. Chapter 11

52 = spacing of shear or torsion reinforcement in direction perpendicular to longitudinal reinforcement-or spacing of horizontal reinforcement in wall, in. Chapter 11

T = cumulative effects of temperature, creep, shrinkage, and differential settlement. Chapter 9

T_c = nominal torsional moment strength provided by concrete. Chapter 11

T_n = nominal torsional moment strength. Chapter 11

T_s = nominal torsional moment strength provided by torsion reinforcement. See Section 11.6.8.3. Chapter 11

T_u = factored torsional moment at section. Chapter 11

U = required strength to resist factored loads or related internal moments and forces. Chapter 9

v = design shear stress. Appendix B

v_c = permissible shear stress carried by concrete, psi. Chapter 11 and Appendix B

vh = permissible horizontal shear stress, psi. Appendix B

V = design shear force at section. Appendix B

V_c =; nominal shear strength provided by concrete. Chapters 8, 11, and Appendix A

V_{ci} = nominal shear strength provided by concrete when diagonal cracking results from combined shear and moment. Chapter 11

V_{cw} = nominal shear strength provided by concrete when diagonal cracking results from excessive principal tensile stress in web. Chapter 11

Kf = shear force at section due to unfactored dead load. Chapter 11

V_e = design shear force determined from Section A.7.1.1 or A.7.1.2. Appendix A

V_i = factored shear force at section due to externally applied loads occurring simultaneously with M_{max}. Chapter 11

V" = nominal shear strength. Chapter 11 and Appendix A

V_{nh} = nominal horizontal shear strength. Chapter 17

V_p = vertical component of effective prestress force at section. Chapter 11

V_s = nominal shear strength provided by shear reinforcement. Chapter 11

V_u = factored shear force at section. Chapters 11, 12, and 17, and Appendix A

wc = weight of concrete, lb per cu ft. Chapters 8 and 9

w_d = factored dead load per unit area. Chapter 13

w_t = factored live load per unit area. Chapter 13

w_u = factored load per unit length of beam or per unit area of slab. Chapter 8

w_u = factored load per unit area. Chapter 13

W = wind load, or related internal moments and forces. Chapter 9

x = shorter overall dimension of rectangular part of cross section. Chapters 11 and 13.

x_1 = shorter center-to-center dimension of closed rectangular stirrup. Chapter 11

y = longer overall dimension of rectangular part of cross section. Chapters 11 and 13

y_t = distance from centroidal axis of gross section, neglecting reinforcement, to extreme fiber in tension. Chapters 9 and 11

y_1 = longer center-to-center dimension of closed rectangular stirrup. Chapter 11

z = quantity limiting distribution of flexural reinforcement. See Section 10.6. Chapter 10

α **(alpha)** = angle between inclined stirrups and longitudinal axis of member. Chapter 11 and Appendix B

α = total angular change of prestressing tendon profile in radians from tendon jacking end to any point x. Chapter 18

α = 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. Chapters 9 and 13

$$= \frac{E_{cb}I_b}{E_{cs}I_s}$$

% = ratio of flexural stiffness of columns above and below the slab to combined flexural stiffness of the slabs and beams at a joint taken in the direction of the span for which moments are being determined. Chapter 13

$$= \frac{\Sigma K_c}{\Sigma(K_s + K_b)}$$

α_c = coefficient defining the relative contribution of concrete strength to wall strength. See Eq. (A-6) Appendix A

α_f = angle between shear-friction reinforcement and shear plane. Chapter 11

α_m = average value of all for all beams on edges of a panel. Chapter 9

α_{min} = **minimum α_c to satisfy Section 13.6.10(a). Chapter 13**

α_t = **coefficient as a function of y_1/x_1. See Section** 11.6.10.1. Chapter 11

α_v = ratio of stiffness of shearhead arm to surrounding **composite slab section. See Section 11.11.4.5.** Chapter 11

α_1 = **α in direction of ℓ_1. Chapter 13**

α_2 = **α in direction of ℓ_2. Chapter 13**

β **(beta)** = ratio of clear spans in long to short direction of two-way slabs. Chapter 9

β = ratio of long side to short side of footing. Chapter 15

Pa = ratio of dead load per unit area to live load per unit area (in each case without load factors). Chapter 13

β_b = ratio of area of reinforcement cut off to total area of tension reinforcement at section. Chapter 12

β_c = ratio of long side to short side of concentrated load or reaction area. Chapter 11 and Appendix B

β_d = absolute value of ratio of maximum factored dead load moment to maximum factored total load moment, always positive. Chapter 10

β_s = ratio of length of continuous edges to total perimeter of a slab panel. Chapter 9

β_t = ratio of torsional stiffness of edge beam section to flexural stiffness of a width of slab equal to span length of beam, center-to-center of supports. Chapter 13

$$= \frac{E_{cb}C}{2E_{cs}I_s}$$

β_1 = factor defined in Sections 10.2.7.3. Chapters 8 and 10

β_1 = factor defined in Section 10.2.7.1. Chapter 18

γ_f **(gamma)** = fraction of unbalanced moment transferred by flexure at slab-column connections. See Section 13.3.3.2. Chapters 11 and 13

YP = factor for type of prestressing tendon. Chapter 18
= 0.40 for f_{py}/f_{pu} not less than 0.85
= **0.28 for f_{py}/f_{pu} not less than 0.90**

γ_v = fraction of unbalanced moment transferred by eccentricity of shear at slab-column connections. See Section 11 .12.2.3. Chapter 11
= **$1 - \gamma_f$**

6 6 **(delta)** = moment magnification factor for frames braced against sidesway, to reflect effects of member curvature between ends of compression member. Chapter I0

δ_s = moment magnification factor for frames not braced against sidesway, to reflect lateral drift resulting from lateral and gravity loads. Chapter 10

s . = factor defined by Eq. (13-5). See Section 13.6.10. Chapter 13

η **(eta)** = number of identical arms of shearhead Chapter 11

λ **(lambda)** = multiplier for additional long-time deflection as defined in Section 9.52.5. Chapter 9

λ = correction factor related to unit weight of concrete. Chapter 11

μ **(mu)** = coefficient of friction. See Section 11.7.4.3. Chapter 11

μ = curvature friction coefficient. Chapter 18

ξ = time-dependent factor for sustained load. See

(xi) Section 9.5.2.5. Chapter 9

ρ **(*rho*)** = ratio of nonprestressed tension reinforcement. Chapters 8, 10, **11,** 18, and Appendixes A and B
= A_s/bd.

ρ' = ratio of nonprestressed compression reinforcement. Chapter 8
= A'_s/bd.

ρ' = reinforcement ratio for nonprestressed compression reinforcement, A'_s/bd. Chapter 9

ρ' = ratio of compression reinforcement. Chapter 18
= A'_s/bd.

ρ_b = reinforcement ratio producing balanced strain conditions. See Section 10.3.2. Chapters 8 and 10

ρ_g = ratio of total reinforcement area to cross-sectional area of column. Appendix A

ρ_h = ratio of horizontal shear reinforcement area to gross concrete area of vertical section. Chapter 11

ρ_n = ratio of vertical shear reinforcement area to gross concrete area of horizontal section. Chapter 11

ρ_n = ratio of distributed shear reinforcement on a plane perpendicular to plane of A_{cv}. Appendix A

ρ_p = ratio of prestressed reinforcement. Chapter 18
= A_{ps}/bd.

ρ_s = ratio of volume of spiral reinforcement to total volume of core (out-to-out spirals) of a spirally reinforced compression member. Chapter 10

ρ_s = ratio of volume of spiral reinforcement to the core volume confined by the spiral reinforcement (measured out-to-out). Appendix A

ρ_v = A_{sv}/A_{cv}; where A_{sv} is the projection on A_{cv} of area of distributed shear reinforcement crossing the plane of A_{cv}. Appendix A

ρ_w = A_s/b_wd. Chapter 11

ϕ **(*phi*)** = strength reduction factor. See Section 9.3. Chapters 8, 9, 10, 11, 14, 15, 17, 18, 19, and Appendix A

ϕ = strength reduction factor. See Section B.2.1. Appendix B

ω **(*omega*)** = $\rho f_y/f'_c$. Chapter 18

ω' = $\rho' f_y/f'_c$. Chapter 18

ω_p = $\rho_p f_{ps}/f'_c$. Chapter 18

$\omega_w, \omega_{pw}, \omega'_w$ = reinforcement indices for flanged sections computed as for ω, ω_p, and ω' except that b shall be the web width, and reinforcement area shall be that required to develop compressive strength of web only. Chapter 18

Σx^2y = torsional section properties. See Section 11.6.1.1 and 11.6.1.2. Chapter 11