List of Symbol Definitions

\( a \)
long dimension for a section subjected to torsion (in, mm);
acceleration due to gravity, 32.17 ft/sec\(^2\), 9.81 m/sec\(^2\);
unit area (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\));
distance used in beam formulas (ft, m);
depth of the effective compression block in a concrete beam (in, mm)

\( a \)
area bounded by the centerline of a thin walled section subjected to torsion (in\(^2\), mm\(^2\))

\( A \)
area, often cross-sectional (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_e \)
et effective area, equal to the total area ignoring any holes and modified by the lag factor, \( U \), (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\)) (see \( A_{net} \))

\( A_g \)
gross area, equal to the total area ignoring any holes (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_{gv} \)
gross area subjected to shear for block shear rupture (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_{net} \)
et effective area, equal to the gross area subtracting any holes (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\)) (see \( A_e \))

\( A_{nt} \)
et area subjected to tension for block shear rupture (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_{nv} \)
et area subjected to shear for block shear rupture (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_p \)
bearing area (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_{throat} \)
area across the throat of a weld (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_s \)
area of steel reinforcement in concrete beam design (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_{s'} \)
area of compression steel reinforcement in concrete beam design (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_v \)
area of concrete shear stirrup reinforcement (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_{web} \)
web area in a steel beam equal to the depth x web thickness (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_1 \)
area of column in spread footing design ((in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( A_2 \)
projected bearing area of column load in spread footing design ((in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\( ASD \)
Allowable Stress Design

\( b \)
width, often cross-sectional (in, ft, mm, m);
narrow dimension for a section subjected to torsion (in, mm);
number of truss members;
rectangular column dimension in concrete footing design (in, mm, m);
distance used in beam formulas (ft, m)

\( b_E \)
effective width of the flange of a concrete T beam cross section (in, mm)

\( b_f \)
width of the flange of a steel or concrete T beam cross section (in, mm)

\( b_o \)
perimeter length for two-way shear in concrete footing design (in, mm, m)

\( b_w \)
width of the stem of a concrete T beam cross section (in, mm)

\( B \)
spread footing dimension in concrete design (ft, m);
dimension of a steel base plate for concrete footing design (in, mm, m)

\( B_1 \)
factor for determining \( M_u \) for combined bending and compression

\( B_s \)
width within the longer dimension of a rectangular spread footing that reinforcement must be concentrated within for concrete design (ft, m)
$c$  distance from the neutral axis to the top or bottom edge of a beam (in, mm, m); rectangular column dimension in concrete footing design (in, mm, m); the distance from the top of a masonry or concrete beam to the neutral axis (in, mm, m) (see $x$); buckling and crushing interaction factor for wood columns (see $C_p$)

$c_i$  distance from the center of a circular shape to the inner surface under torsional shear strain (in, mm, m)

$c_o$  distance from the center of a circular shape to the outer surface under torsional shear strain (in, mm, m)

$c_1$  coefficient for shear stress for a rectangular bar in torsion

$c_2$  coefficient for shear twist for a rectangular bar in torsion

$CL, c_i$  center line

$C$  compression label; compression force (lb, kips, N, kN); dimension of a steel base plate for concrete footing design (in, mm, m)

$C_b$  modification factor for LRFD steel beam design

$C_c$  column slenderness classification constant for steel column design; compressive force in the concrete of a doubly reinforced concrete beam (lb, k, N, kN)

$C_D$  load duration factor for wood design

$C_F$  size factor for wood design

$C_f$  form factor for circular sections or or square sections loaded in plane of diagonal for wood design

$C_{fu}$  flat use factor for wood design

$C_F$  size factor for wood design

$C_H$  shear stress factor for wood design

$C_i$  incising factor for wood design

$C_L$  beam stability factor for wood design

$C_m$  modification factor for combined stress in steel design

$C_M$  wet service factor for wood design

$C_p$  column stability factor for wood design

$C_r$  repetitive member factor for wood design

$C_s$  compressive force in the compression steel of a doubly reinforced concrete beam (lb, k, N, kN)

$C_t$  temperature factor for wood design

$C_T$  buckling stiffness factor for wood truss design

$C_v$  web shear coefficient for steel design

$C_V$  glulam volume factor for wood design
\(d\) diameter of a circle (in, mm, m);
depth, often cross-sectional (in, mm, m);
perpendicular distance from a force to a point in a moment calculation (in, mm, m);
critical cross section dimension of a rectangular timber column cross section related to the
profile (axis) for buckling (in, mm, m);
effective depth from the top of a reinforced concrete beam to the centroid of the tensile steel
(in, mm);
symbol in calculus to represent a very small change (like the greek letters for \(d\), see \(\delta\) & \(\Delta\))
\(d'\) effective depth from the top of a reinforced concrete beam to the centroid of the compression steel (in, mm)
\(d_b\) depth of a steel W beam section (in, mm);
bar diameter of concrete reinforcement (in, mm)
nominal bolt diameter (in, mm)
\(d_f\) depth of a steel W column flange (in, mm)
\(d_x\) difference in the \(x\) direction between an area centroid and the centroid of the composite shape
(in, mm)
\(d_y\) difference in the \(y\) direction between an area centroid and the centroid of the composite shape
(in, mm)
\(D\) diameter of a circle (in, mm, m);
dead load for LRFD design
\(DL\) dead load
\(e\) dimensional change to determine strain (\(see\ s\ or\ \varepsilon\)) (in, mm);
eccentric distance of application of a force (\(P\)) from the centroid of a cross section (in, mm)
\(E\) modulus of elasticity (psi, ksi, kPa, MPa, GPa);
earthquake load for LRFD design
\(E_c\) modulus of elasticity of concrete (psi, ksi, kPa, MPa, GPa)
\(E_{min}\) reference modulus of elasticity for stability (psi, ksi, kPa, MPa, GPa)
\(E_{min\ n}\) reference nominal modulus of elasticity for stability with LRFD (psi, ksi, kPa, MPa, GPa)
\(E_s\) modulus of elasticity of steel (psi, ksi, kPa, MPa, GPa)
\(E'_{min}\) adjusted modulus of elasticity for stability (psi, ksi, kPa, MPa, GPa)
\(E'_{min\ n}\) adjusted nominal modulus of elasticity for stability with LRFD (psi, ksi, kPa, MPa, GPa)
\(f\) symbol for stress (psi, ksi, kPa, MPa)
symbol for function with respect to some variable; ie. \(f(t)\)
\(f_a\) calculated axial stress (psi, ksi, kPa, MPa)
\(f_b\) calculated bending stress (psi, ksi, kPa, MPa)
\(f_c\) calculated compressive stress (psi, ksi, kPa, MPa)
\(f'_c\) concrete design compressive stress (psi, ksi, kPa, MPa)
\(f_{cr}\) calculated column stress based on the critical column load \(P_{cr}\) (psi, ksi, kPa, MPa)
\(f_m\) calculated compressive stress in masonry (psi, ksi, kPa, MPa)
\( f'_m \) masonry design compressive stress (psi, ksi, kPa, MPa)
\( f_p \) calculated bearing stress (psi, ksi, kPa, MPa)
\( f_s \) calculated steel stress for reinforced masonry (psi, ksi, kPa, MPa)
\( f_t \) calculated tensile stress (psi, ksi, kPa, MPa)
\( f_x \) combined stress in the direction of the major axis of a column (psi, ksi, kPa, MPa)
\( f_v \) calculated shearing stress (psi, ksi, kPa, MPa)
\( f_y \) yield stress (psi, ksi, kPa, MPa)
\( f_{yt} \) yield stress of transverse reinforcement (psi, ksi, kPa, MPa)
\( F \) force (lb, kip, N, kN); capacity of a nail in shear (lb, kip, N, kN); hydraulic fluid load for LRFD design
\( F_a \) allowable axial stress (psi, ksi, kPa, MPa)
\( F_b \) allowable bending stress (psi, ksi, kPa, MPa)
\( F'_b \) allowable bending stress for ASD wood design (psi, ksi, kPa, MPa)
\( F_{in} \) nominal bending stress for LRFD wood design (psi, ksi, kPa, MPa)
\( F_c \) allowable compressive stress (psi, ksi, kPa, MPa); critical unfactored compressive stress for LRFD steel design
\( F_{cl} \) allowable compressive stress perpendicular to the wood grain (psi, ksi, kPa, MPa)
\( F_{connector} \) resistance capacity of a connector (lb, kips, N, kN)
\( F'_{c,E} \) intermediate compressive stress for ASD wood column design dependant on material (psi, ksi, kPa, MPa)
\( F_{cr} \) flexural buckling (column) stress in ASD and LRFD (psi, ksi, kPa, MPa)
\( F'_c \) allowable compressive stress for ASD wood column design (psi, ksi, kPa, MPa)
\( F_{cn} \) nominal compressive stress for LRFD wood design (psi, ksi, kPa, MPa)
\( F'_{ct} \) intermediate compressive stress for ASD wood column design dependant on load duration (psi, ksi, kPa, MPa)
\( F_e \) elastic critical buckling stress is steel design
\( F_h \) force component in the horizontal direction (lb, kip, N, kN)
\( F_{horizontal-resist} \) resultant frictional force resisting sliding in a footing or retaining wall (lb, kip, N, kN)
\( F_n \) nominal strength in LRFD steel design (psi, ksi, kPa, MPa)
\( F_{ns} \) nominal tension or shear strength of a bolt (psi, ksi, kPa, MPa)
\( F_p \) allowable bearing stress parallel to the wood grain (psi, ksi, kPa, MPa)
\( F_{sliding} \) resultant force causing sliding in a footing or retaining wall (lb, kip, N, kN)
\( F_t \) allowable tensile stress (psi, ksi, kPa, MPa)
$F_v$ allowable shear stress (psi, ksi, kPa, MPa); allowable shear stress in a welded connection; force component in the vertical direction (lb, kip, N, kN)

$F'_v$ allowable shear stress for ASD wood beam design (psi, ksi, kPa, MPa)

$F''_w$ nominal shear stress for LRFD wood beam design (psi, ksi, kPa, MPa)

$F_x$ force component in the x coordinate direction (lb, kip, N, kN)

$F_w$ allowable weld stress (psi, ksi, kPa, MPa)

$F_y$ force component in the y coordinate direction (lb, kip, N, kN); yield stress (psi, ksi, kPa, MPa)

$F_u$ ultimate stress a material can sustain prior to failure (psi, ksi, kPa, MPa)

$F.S.$ factor of safety (also see SF)

$g$ acceleration due to gravity, 32.17 ft/sec^2, 9.807 m/sec^2; transverse center-to-center spacing (gage) between fastener gage lines (in, mm,)

$G$ shear modulus (psi, ksi, kPa, MPa, GPa); relative stiffness of columns to beams in a rigid connection (see $\Phi$)

$h$ depth, often cross-sectional (in, ft, mm, m); height (in, ft, mm, m); sag of a cable structure (ft, m); effective height of a wall or column (see $\ell_e$)

$h'$ effective height of a wall or column (see $\ell_e$)

$h_c$ height of the web in a W section (in, ft, mm, m) (also see $t_w$)

$h_f$ depth of a flange in a T section (in, ft, mm, m); height of a concrete spread footing (in, ft, mm, m)

$H$ hydraulic soil load for LRFD design

$H_A$ horizontal load from active soil or water pressure (lb, k, N, kN)

$I$ moment of inertia (in^4, mm^4, m^4)

$\bar{I}$ moment of inertia about the centroid (in^4, mm^4, m^4)

$\hat{I}$ moment of inertia about the centroid of a composite shape (in^4, mm^4, m^4)

$I_c$ moment of inertia about the centroid of a composite shape (in^4, mm^4, m^4)

$I_{min}$ minimum moment of inertia of $I_x$ and $I_y$ (in^4, mm^4, m^4)

$I_o$ moment of inertia about the centroid (in^4, mm^4, m^4)

$I_{transformed}$ moment of inertia of a multi-material section transformed to one material (in^4, mm^4, m^4)

$I_x$ moment of inertia with respect to an x-axis (in^4, mm^4, m^4)

$I_y$ moment of inertia with respect to a y-axis (in^4, mm^4, m^4)

$j$ multiplier by effective depth of masonry section for moment arm, jd (see $d$)

$J, J_o$ polar moment of inertia (in^4, mm^4, m^4)
$k$  kips (1000 lb); shape factor for steel beams, $M_p/M_y$:
effective length factor for columns (also $K$):
distance from outer face of W flange to the web toe of fillet (in, mm);
multiplier by effective depth of masonry section for neutral axis, $kd$

$kg$  kilograms

$k\text{lf}$  kips per linear foot (k/ft)

$ksf$  kips per square foot (k/ft$^2$)

$ksi$  kips per square inch (k/in$^2$)

$kN$  kiloNewtons (10$^3$ N)

$kPa$  kiloPascals (10$^3$ Pa)

$K$  effective length factor with respect to column end conditions;
masonry mortar strength designation

$K_{cE}$  material factor for wood column design

$K_F$  format conversion factor for timber LRFD design

$l$  length (in, ft, mm, m);
cable span (ft, m)

$l_d$  development length of concrete reinforcement (in, ft, mm, m)

$l_{dc}$  development length of compression reinforcement in concrete footing design (in, ft, mm, m)

$l_{dh}$  development length for hooks (in, ft, mm, m)

$l_e$  effective length that can buckle for wood column design (in, ft, mm, m)

$l_n$  effective clear span for concrete one-way slab design (ft, m)

$l_{sc}$  lap splice length in compression for reinforcement (in, ft, mm, m)

$lb$  pound force

$L$  length (in, ft, mm, m);
live load for LRFD design;
spread footing dimension in concrete design (ft, m)

$L_b$  unbraced length of a steel beam in LRFD design (ft, m)

$L_c$  maximum unbraced length of a steel beam in ASD design for compression buckling limit (ft, m);
clear distance between the edge of a hole and edge of next hole or edge of the connected steel plate (in, ft, mm, m)

$L_d$  development length of reinforcement in concrete (ft, m)

$L_e$  effective length that can buckle for column design (ft, m)

$L_m$  projected length for bending in concrete footing design (ft, m)

$L_p$  limiting length of a steel beam in LRFD design for full plastic strength (ft, m)

$L_r$  roof live load in LRFD design;
limiting length of a steel beam in LRFD design for inelastic lateral-torsional buckling (ft, m)

$L_u$  maximum unbraced length of a steel beam in ASD design for stress limit of 0.6$F_y$
\( L' \)  
length of the one-way shear area in concrete footing design (ft, m)

\( LL \)  
live load

\( LRFD \)  
Load and Resistance Factor Design

\( m \)  
mass (lb-mass, g, kg); meters

\( mm \)  
millimeters

\( M \)  
moment of a force or couple (lb-ft, kip-ft, N-m, kN-m); bending moment (lb-ft, kip-ft, N-m, kN-m); masonry mortar strength designation

\( M_a \)  
required bending moment in steel ASD beam design (unified) (lb-ft, kip-ft, N-m, kN-m)

\( M_A \)  
moment value at quarter point of unbraced beam length for LRFD beam design (lb-ft, kip-ft, N-m, kN-m)

\( M_B \)  
nominal moment capacity of a reinforced concrete beam at the balanced steel ratio (\( \rho_b \)) for limiting strains in both concrete and steel (lb-ft, kip-ft, N-m, kN-m)

\( M_c \)  
nominal moment capacity of a reinforced concrete beam based on compression force in a concrete section (lb-ft, kip-ft, N-m, kN-m) \( \text{(also see } M_n) \)

\( M_C \)  
moment value at three quarter point of unbraced beam length for LRFD beam design (lb-ft, kip-ft, N-m, kN-m)

\( M_m \)  
nominal moment capacity of a reinforced masonry beam (lb-ft, kip-ft, N-m, kN-m)

\( M_n \)  
nominal moment capacity of a reinforced concrete beam based on steel yielding and concrete design strength (lb-ft, kip-ft, N-m, kN-m)

\( M_{overturning} \)  
resulting moment from all forces on a footing or retaining wall causing overturning (lb-ft, kip-ft, N-m, kN-m)

\( M_p \)  
internal bending moment when all fibers in a cross section reach the yield stress (lb-ft, kip-ft, N-m, kN-m) \( \text{(also see } M_{ult}) \)

\( M_r \)  
required nominal moment capacity based on design moment for reinforced concrete (lb-ft, kip-ft, N-m, kN-m) \( \text{(also see } M_n) \)

\( M_{resis} \)  
resulting moment from all forces on a footing or retaining wall resisting overturning (lb-ft, kip-ft, N-m, kN-m)

\( M_t \)  
nominal moment capacity of a reinforced concrete beam based on tensile force in the steel reinforcement (lb-ft, kip-ft, N-m, kN-m) \( \text{(also see } M_n) \)

\( M_u \)  
factored moment calculated in concrete design from load factors (lb-ft, kip-ft, N-m, kN-m)

\( M_{ult} \)  
internal bending moment when all fibers in a cross section reach the yield stress (lb-ft, kip-ft, N-m, kN-m) \( \text{(also see } M_p) \)

\( M_y \)  
internal bending moment when the extreme fibers in a cross section reach the yield stress (lb-ft, kip-ft, N-m, kN-m)

\( n \)  
number of truss joints, nails or bolts; modulus of elasticity transformation coefficient from steel to concrete

\( n.a. \)  
neutral axis (axis connecting beam cross-section centroids)
\( N \)  Newtons;
bearing-type connection with bolt threads included in shear plane;
normal load (lb, kip, N, kN);
bearing length on a wide flange steel section (in, mm)
masonry mortar strength designation

\( o.c. \)  on-center

\( O \)  point of origin;
masonry mortar strength designation

\( p \)  pitch of nail or bolt spacing (in, mm) (also see \( s \));
pressure (lb/in\(^2\), lb/ft\(^2\), kip/in\(^2\), kip/ft\(^2\), Pa, MPa);
reinforcement ratio in concrete beam design = \( A_s/\text{bd} \) (or possibly \( A_s/\text{bt}, A_s/\text{bh} \)) (no units) (see \( \rho \))

\( p_A \)  active soil pressure (lb/ft\(^2\), kN/m\(^3\))

\( p_b \)  balanced reinforcement ratio in concrete beam design (see \( \rho_b \))

\( plf \)  pounds per linear foot (lb/ft)

\( psf \)  pounds per square foot (lb/ft\(^2\))

\( psi \)  pounds per square inch (lb/in\(^2\))

\( P \)  force, concentrated (point) load (lb, kip, N, kN)

\( P_a \)  required axial force in ASD steel design (unified) (lb, kip, N, kN)

\( P_c \)  available axial strength for steel unified design (lb, kip, N, kN)

\( P_{cr} \)  critical (failure) load in column calculations (lb, kip, N, kN)

\( P_{el} \)  Euler buckling strength in steel unified design (lb, kip, N, kN)

\( P_n \)  maximum column load capacity in LRFD steel and concrete design (lb, kip, N, kN)

\( P_o \)  maximum axial force with no concurrent bending moment in a reinforced concrete column (lb, kip, N, kN)

\( P_r \)  required axial force in steel unified design (lb, kip, N, kN)

\( P_u \)  factored column load calculated from load factors in LRFD steel and concrete design (lb, kip, N, kN)

\( Pa \)  Pascals (N/m\(^2\))

\( q \)  shear flow (lb/in, kips/ft, N/m, kN/m)

\( q_{\text{allowed}} \)  allowable soil bearing pressure (lb/ft\(^2\), kips/ft\(^2\), N/m\(^2\), Pa, MPa)

\( q_{\text{net}} \)  net allowed soil bearing pressure (lb/ft\(^2\), kips/ft\(^2\), N/m, Pa, MPa)

\( q_u \)  factored soil bearing pressure in concrete design from load factors (lb/ft\(^2\), kips/ft\(^2\), N/m, Pa, MPa)

\( Q \)  first moment area used in shearing stress calculations (in\(^3\), mm\(^3\), m\(^3\))

\( Q_{\text{connected}} \)  first moment area used in shear calculations for built-up beams (in\(^3\), mm\(^3\), m\(^3\))

\( Q_x \)  first moment area about an x axis (using \( y \) distances) (in\(^3\), mm\(^3\), m\(^3\))

\( Q_y \)  first moment area about an y axis (using \( x \) distances) (in\(^3\), mm\(^3\), m\(^3\))

\( r \)  radius of a circle (in, mm, m);
radius of gyration (in, mm, m)
$r_n$  nominal capacity per bolt in a connection (k/bolt or k/bolt/in.)

$r_o$  polar radius of gyration (in, mm, m)

$r_x$  radius of gyration with respect to an $x$-axis (in, mm, m)

$r_y$  radius of gyration with respect to a $y$-axis (in, mm, m)

$R$  force, reaction or resultant (lb, kip, N, kN);
radius of curvature of a beam (ft, m);
rainwater or ice load for LRFD design

$R_a$  required strength (ASD-unified) *(also see $V_a$, $M_a$)*

$R_n$  concrete beam design ratio = $M_o/\text{bd}^2$ (lb/in$^2$, MPa)
nominal value for LRFD design to be multiplied by $\phi$ *(also see $P_n$, $M_n$)*
nominal value for ASD design to be divided by the safety factor $\Omega$

$R_x$  reaction or resultant component in the $x$ coordinate direction (lb, kip, N, kN)

$R_y$  reaction or resultant component in the $y$ coordinate direction (lb, kip, N, kN)

$s$  strain (change in length divided by length (no units);
displacement with respect to time (ft, m);
length of a segment of a thin walled section (in, mm);
pitch of nail spacing (in, mm) *(also see $p$)*;
spacing of stirrups in reinforced concrete beams (in, mm);
longitudinal center-to-center spacing of any two consecutive holes (in, mm)

$s.w.$  self-weight

$S$  section modulus (in$^3$, mm$^3$, m$^3$);
snow load for LRFD design;
allowable strength of a weld for a given size (lb/in, kips/in, N/mm, kN/m);
masonry mortar strength designation

$S_{\text{required}}$  section modulus required to not exceed allowable bending stress (in$^3$, mm$^3$, m$^3$)

$S_x$  section modulus with respect to the $x$-centroidal axis (in$^3$, mm$^3$, m$^3$)

$S_y$  section modulus with respect to the $y$-centroidal axis (in$^3$, mm$^3$, m$^3$)

$SC$  slip critical bolted connection

$SF$  safety factor *(see F.S.)*

$S4S$  surface-four-sided

$t$  thickness (in, mm, m);
time (sec, hrs)

$t_f$  thickness of the flange of a steel beam cross section (in, mm, m)

$t_w$  thickness of the web of a steel beam cross section (in, mm, m)

$T$  tension label;
tensile force (lb, kip, N, kN);
torque (lb-ft, kip-ft, N-m, kN-m);
throat size of a weld (in, mm);
effect of thermal load for LRFD design

$U$  shear lag factor for bolted connections

$U_{hs}$  reduction coefficient for block shear rupture
\( \nu \) velocity (ft/sec, m/sec, mi/h); shear force per unit length (lb/ft, k/ft, N/m, kN/m) \((\text{see } q)\)

\( V \) shear force (lb, kip, N, kN)

\( V_a \) required shear in steel ASD design (unified) (lb, kip, N, kN)

\( V_c \) shear force capacity in concrete (lb, kip, N, kN)

\( V_n \) nominal shear force capacity for concrete design (lb, kip, N, kN)

\( V_s \) shear force capacity in steel (lb, kip, N, kN)

\( V_u \) factored shear calculated in concrete design from load factors (lb, kip, N, kN)

\( V_{u1} \) factored one-way shear calculated in concrete footing design from load factors (lb, kip, N, kN)

\( V_{u2} \) factored two-way shear calculated in concrete footing design from load factors (lb, kip, N, kN)

\( w \) load per unit length on a beam (lb/ft, kip/ft, N/m, kN/m); load per unit area on a surface (lb/ft\(^2\), kip/ft\(^2\), N/m\(^2\), kN/m\(^2\)); width dimension (in, ft, mm, m)

\( w_c \) weight of reinforced concrete per unit volume (lb/ft\(^3\), N/m\(^3\))

\( w_u \) factored load per unit length on a beam from load factors (lb/ft, kip/ft, N/m, kN/m); factored load per unit area on a surface from load factors (lb/ft\(^2\), kip/ft\(^2\), N/m\(^2\), kN/m\(^2\))

\( W \) weight (lb, kip, N, kN); total load from a uniform distribution (lb, kip, N, kN); wind load for LRFD design

\( x \) a distance in the x direction (in, ft, mm, m); the distance from the top of a masonry or concrete beam to the neutral axis (in, mm, m) \((\text{see } c)\)

\( \bar{x} \) the distance in the x direction from a reference axis to the centroid of a shape (in, mm)

\( \hat{x} \) the distance in the x direction from a reference axis to the centroid of a composite shape (in, mm)

\( X \) bearing-type connection with bolt threads excluded from shear plane

\( y \) a distance in the y direction (in, ft, mm, m); distance from the neutral axis to the y-level of a beam cross section (in, mm)

\( \bar{y} \) the distance in the y direction from a reference axis to the centroid of a shape (in, mm)

\( \hat{y} \) the distance in the y direction from a reference axis to the centroid of a composite shape (in, mm)

\( z \) the distance from a unit area to a reference axis (in, ft, mm, m) \((\text{also see } d_x \text{ and } d_y)\)

\( Z \) plastic section modulus of a steel beam (in\(^3\), mm\(^3\)) lateral design value for a single fastener in a timber connection (lb/nail, k/bolt)

\( ' \) symbol for feet

\( " \) symbol for inches

\# symbol for pounds

\( = \) symbol for equal to

\( \approx \) symbol for approximately equal to

\( \propto \) symbol for proportional to

\( \leq \) symbol for less than or equal to

\( \int \) symbol for integration
Symbols

\( \alpha \)  coefficient of thermal expansion (°C, °F);
angle, in a math equation (degrees, radians)
method factor for \( B_I \) for steel beam-column design

\( \beta \)  angle, in a math equation (degrees, radians)

\( \beta_c \)  ratio of long side to short side of the column in concrete footing design

\( \beta_1 \)  coefficient to determine the stress block height in concrete beam design

\( \delta \)  elongation (in, mm)  \((also \ see \ e)\)

\( \delta_p \)  elongation due to axial load (in, mm)

\( \delta_s \)  shear deformation (in, mm)

\( \delta_T \)  elongation due to change in temperature (in, mm)

\( \Delta \)  beam deflection (in, mm);
an increment

\( \Delta_{LL} \)  beam deflection due to live load (in, mm)

\( \Delta_{max} \)  maximum calculated beam deflection (in, mm)

\( \Delta_{IL} \)  beam deflection due to total load (in, mm)

\( \Delta_s \)  beam deflection in beam diagrams and formulas (in, mm)

\( \Delta T \)  change in temperature (°C, °F)

\( \varepsilon \)  strain \((also \ see \ s)\)

\( \varepsilon_t \)  thermal strain

\( \phi \)  diameter symbol;
angle of twist (degrees, radians);
resistance factor in LRFD steel design and reinforced concrete design

\( \phi_b \)  resistance factor for flexure in LRFD design

\( \phi_c \)  resistance factor for compression in LRFD design

\( \phi_s \)  resistance factor for stability in timber LRFD design

\( \phi_t \)  resistance factor for tension in LRFD design

\( \phi_v \)  resistance factor for shear in LRFD design

\( \lambda \)  time effect factor in LRFD timber design;
modification factor for reinforced concrete shear for lightweight materials

\( \lambda_c \)  design constant for slenderness evaluation for steel columns in LRFD design

\( \mu \)  Poisson’s ratio;
coefficient of static friction
Specific gravity of a material (lb/in^3, lb/ft^3, N/m^3, kN/m^3);
angle, in a math equation (degrees, radians);
shearing strain (no units);
load factor in LRFD design
ratio of reinforcement width to width of column

\( \gamma_D \) dead load factor in LRFD steel design

\( \gamma_L \) live load factor in LRFD steel design

\( \theta \) angle, in a trig equation (degrees, radians);
slope of the deflection of a beam at a point (degrees, radians)

\( \pi \) pi (180°)

\( \rho \) radial distance (in, mm);
radius of curvature in beam deflection relationships (ft, m);
reinforcement ratio in concrete beam design = \( A_s / bd \) (or possibly \( A_s / bt, A_s / bh \)) (no units)

\( \rho_b \) balanced reinforcement ratio in concrete beam design

\( \rho_g \) reinforcement ratio in concrete column design = \( A_{st} / A_g \)

\( \rho_{max} \) maximum reinforcement ratio allowed in concrete beam design for ductile behavior

\( \sigma \) engineering symbol for normal stress (axial or bending)

\( \tau \) engineering symbol for shearing stress

\( \nu_c \) shearing stress capacity in concrete design (psi, ksi, kPa, MPa)

\( \omega \) load per unit length on a beam (lb/ft, kip/ft, N/m, kN/m) (see \( w \));
load per unit area (lb/ft^2, kips/ft^2, N/m^2, Pa, MPa)

\( \Sigma \) summation symbol

\( \Omega \) safety factor for ASD of steel (unified)

\( \Psi \) relative stiffness of columns to beams in a rigid connection (see \( G \))