List of Symbol Definitions

\(a\)  
- long dimension for a section subjected to torsion (in, mm);
- acceleration (ft/sec\(^2\), m/sec\(^2\));
- width of the base of a retaining wall for pressure calculation (ft, m);
- equivalent square column size in spread footing design (in, ft, mm, m);
- 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\(^2\))

\(A_b\)  
area of a bolt (in\(^2\), mm\(^2\))

\(A_e\)  
effective net area found from the product of the net area \(A_n\) by the shear lag factor \(U\) (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

\(A_g\)  
gross area, equal to the total area ignoring any holes or reinforcement (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\(^2\))

\(A_n\)  
net area, equal to the gross area subtracting any holes (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))  (see \(A_e\))

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

\(A_{nt}\)  
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\(^2\))

\(A_{req'd}\)  
area required to satisfy allowable stress (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

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

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

\(A_{st}\)  
area of steel reinforcement in concrete and masonry column design (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))

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

\(A_v\)  
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, ft, mm, m)

\(b_w\)  
width of the stem (web) of a concrete T beam cross section (in, mm)
$B$ spread footing or retaining wall base dimension in concrete design (ft, m); 
dimension of a steel base plate for concrete footing design (in, mm, m)

$B_s$ width within the longer dimension of a rectangular spread footing that reinforcement must be 
concentrated within for concrete design (ft, m)

$B_1$ factor for determining $M_u$ for combined bending and compression

c distance from the neutral axis to the top or bottom edge of a beam (in, mm, m); 
distance from the center of a circular shape to the surface under torsional shear strain (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)

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

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

$CL, C$ center line

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

$C_b$ lateral torsional buckling modification factor for moment in ASD & LRFD steel beam design, 
$C_b = 1$ for simply supported beams (0 moments at the ends)

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

$C_C$ curvature factor for laminated arch design

$C_D$ load duration 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 other than decks in wood design

$C_F$ size factor for wood design

$C_H$ shear stress factor for wood design

$c_l$ incising factor for wood design

$C_L$ beam stability factor for wood design

$C_m$ modification factor for combined stress in steel design; 
compression force in the masonry for masonry design (lb, k, N, kN)

$C_M$ wet service factor for wood design

$C_p$ column stability factor for wood design

$C_r$ repetitive member factor for wood design

$C_v$ web shear coefficient for steel design

$C_V$ volume factor for glue laminated timber 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

d  
depth, often cross-sectional (in, mm, m);  
diameter (in, mm, m);  
perpendicular distance from a force to a point in a moment calculation (in, ft, mm, m);  
effective depth from the top of a reinforced concrete or masonry beam to the centroid of the tensile steel (in, ft, mm, m);  
critical cross section dimension of a rectangular timber column cross section related to the profile (axis) for buckling (in, mm, m);  
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, ft, mm, m)

\( d_b \)  
bar diameter of a reinforcing bar (in, mm);  
nominal bolt diameter (in, mm)

\( d_f \)  
depth of a steel column flange (wide flange section) (in, mm)

\( d_x \)  
difference in the \( x \) direction between an area centroid (\( \bar{x} \)) and the centroid of the composite shape (\( \hat{x} \)) (in, mm)

\( d_y \)  
difference in the \( y \) direction between an area centroid (\( \bar{y} \)) and the centroid of the composite shape (\( \hat{y} \)) (in, mm)

D  
diameter of a circle (in, mm, m);  
dead load for LRFD design

DL  
dead load

e  
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)

\( E_s \)  
modulus of elasticity of steel (psi; ksi, kPa, MPa, GPa)

\( f \)  
symbol for stress (psi, ksi, kPa, MPa)

\( f_a \)  
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)

$f_s$ stress in the steel reinforcement for concrete or masonry design (psi, ksi, kPa, MPa)

$f'_s$ compressive stress in the compression reinforcement for concrete beam design (psi, ksi, kPa, MPa)

$f_t$ calculated tensile stress (psi, ksi, kPa, MPa)

$f_v$ calculated shearing stress (psi, ksi, kPa, MPa)

$f_x$ combined stress in the direction of the major axis of a column (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); symbol for allowable stress in design codes (psi, ksi, kPa, MPa); 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 combined stress for wood design (psi, ksi, kPa, MPa)

$F_c$ allowable compressive stress (psi, ksi, kPa, MPa)

$F_{c,L}$ 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)

$F^*_{c}$ 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

$F_{EXX}$ yield strength of weld material (psi, ksi, kPa, MPa)

$F_{horizontal-resist}$ 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)

$F_{tension}$ 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)

$F_s$ allowable tensile stress in reinforcement for masonry design (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

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

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

$F_{yw}$ yield stress in the web of a steel wide flange section (psi, ksi, kPa, MPa)

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

$F.S.$ factor of safety

$g$ acceleration due to gravity, 32.17 ft/sec$^2$, 9.807 m/sec$^2$; gage spacing of staggered bolt holes (in, mm)

$G$ shear modulus (psi; ksi, kPa, MPa); gigaPascals ($10^9$ Pa or 1 kN/mm$^2$); relative stiffness of columns to beams in a rigid connection (see Ψ); specific gravity (i.e. factor multiplied by density of water to get density)

$h$ 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 $\ell_o$)

$h_c$ height of the web of a wide flange steel section (in, ft, mm, m)

$h_f$ 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; height of retaining wall (ft, m)

$H_A$ horizontal force due to active soil 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$^4$)

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

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

$I_{transformed}$ 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, $j_d$ (see $d$)

$J, J_o$ polar moment of inertia (in$^4$, mm$^4$, m$^4$)

$k$ kips (1000 lb); shape factor for plastic design of 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
Symbols

klf  kips per linear foot (k/ft)
ksf  kips per square foot (k/ft²)
ksi  kips per square inch (k/in²)
kN   kiloNewtons (10³ N)
kPa  kiloPascals (10³ Pa)
K    effective length factor with respect to column end conditions  (also k); masonry mortar strength designation
Kce  material factor for wood column design
l    length (in, ft, mm, m); cable span (ft, m)
l_d  development length for reinforcing steel (in, ft, mm, m)  (also L_d)
l_de  development length for column dowels (in, ft, mm, m)
l_dh  development length for hooks (in, ft, mm, m)
l_θ  effective length that can buckle for wood column design (in, ft, mm, m)  (also L_θ)
l_n  clear span from face of support to face of support in concrete design (in, ft, mm, 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 (in, ft, mm, m)
L_c  clear distance between the edge of a hole and edge of next hole or edge of the connected steel plate in the direction of the load (in, ft, mm, m)
L_d  development length of reinforcement in concrete (ft, m)  (also l_d)
L_e  effective length that can buckle for column design (in, ft, mm, m)  (also l_θ)
L_m  projected length for bending in concrete footing design (ft, m)
L_p  maximum unbraced length of a steel beam in LRFD design for full plastic flexural strength (in, ft, mm, m)
L_r  roof live load in LRFD design; maximum unbraced length of a steel beam in LRFD design for inelastic lateral-torsional buckling (in, ft, mm, m)
L'   length of an angle in a connector with staggered holes (in, mm); 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)

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

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

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

\(M_n\) nominal flexure strength with the full section at the yield stress for LRFD steel beam design (lb-ft, kip-ft, N-m, kN-m);
nominal flexure strength with the steel reinforcement at the yield stress and compressive stress at the concrete design strength for reinforced beam design (lb-ft, kip-ft, N-m, kN-m)

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

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

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

\(M_u\) maximum moment from factored loads for LRFD beam design (lb-ft, kip-ft, N-m, kN-m)

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

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

\(M_1\) smaller end moment used to calculate \(C_m\) for combined stresses in a beam-column (lb-ft, kip-ft, N-m, kN-m)

\(M_2\) larger end moment used to calculate \(C_m\) for combined stresses in a beam-column (lb-ft, kip-ft, N-m, kN-m)

\(MPa\) megaPascals (10\(^6\) Pa or 1 N/mm\(^2\))

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

\(n.a.\) neutral axis (axis connecting beam cross-section centroids)

\(N\) Newtons (kg-m/sec\(^2\));
bearing-type connection with bolt threads included in shear plane;
normal load (lb, kip, N, kN);
masonry mortar strength designation;
bearing length on a wide flange steel section (in, mm);
number of stories

\(o\) point of overturning of a retaining wall, commonly at the “toe”
on-center

point of origin; masonry mortar strength designation

pitch of nail or bolt spacing (in, ft, mm, m); pressure (lb/ft², kips/ft², N/m², Pa, MPa)

active soil pressure (lb/ft², kips/ft², N/m², Pa, MPa)

pounds per linear foot (lb/ft)

pounds per square foot (lb/ft²)

pounds per square inch (lb/in²)

force, concentrated (point) load (lb, kip, N, kN); axial load in a column or beam-column (lb, kip, N, kN)

allowable axial load (lb, kip, N, kN);
required axial force in ASD steel design (unified) (lb, kip, N, kN)

allowable axial load (lb, kip, N, kN)

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

critical (failure) load in column calculations (lb, kip, N, kN)

nominal capacity of dowels from concrete column to footing in concrete design (lb, kip, N, kN)

Euler buckling strength in steel unified design (lb, kip, N, kN)

nominal column or bearing load capacity in LRFD steel and concrete design (lb, kip, N, kN);
nominal axial load for a tensile member or connection in LRFD steel (lb, kip, N, kN)

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

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

factored column load calculated from load factors in LRFD steel and concrete design (lb, kip, N, kN);
factored axial load for a tensile member or connection in LRFD steel (lb, kip, N, kN)

Pascals (N/m²)

shear flow (lb/in, kips/ft, N/m, kN/m); soil bearing pressure (lb/ft², kips/ft², N/m², Pa, MPa)

allowable soil bearing pressure (lb/ft², kips/ft², N/m², Pa, MPa)

gross allowed soil pressure (lb/ft², kips/ft², N/m², Pa, MPa)

net allowed soil bearing pressure (lb/ft², kips/ft², N/m², Pa, MPa)

ultimate soil bearing strength in allowable stress design (lb/ft², kips/ft², N/m, Pa, MPa);
factored soil bearing pressure in concrete design from load factors (lb/ft², kips/ft², N/m, Pa, MPa)

first moment area used in shearing stress calculations (in³, mm³, m³);
generic axial load quantity for LRFD design (also see R)

first moment area used in shearing stress calculations for built-up beams (in³, mm³, m³)

first moment area about an x axis (using y distances) (in³, mm³, m³)
$Q_y$  
first moment area about an $y$ axis (using $x$ distances) (in$^{3}$, mm$^{3}$, m$^{3}$)

$r$  
radius of a circle or arc (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;
generic load quantity (force, shear, moment, etc.) for LRFD design *(also see $Q$)*;
radius of curvature of a laminated arch (ft, m)

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

$R_n$  
concrete beam design ratio $= M_u/\text{bd}^2$ (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 $\Omega$

$R_u$  
design value for LRFD design based on load factors *(also see $P_u$, $M_u$)*

$R_x$  
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)

$s$  
length of a segment of a thin walled section (in, mm);
spaceing 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 per length 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

$S4S$  
surface-four-sided

$t$  
thickness (in, mm, m)

$t_f$  
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, k-ft, N-m, kN-m);
throat size of a weld (in, mm);
effect of thermal load for LRFD design;
period of vibration (sec)
$T_s$ tension force in the steel reinforcement for masonry design (lb, kip, N, kN)

$U$ shear lag factor for steel tension member design (see $A_e$ and $A_{net}$)

$U_{ho}$ reduction coefficient for block shear rupture

$v$ shear force per unit length (lb/ft, k/ft, N/m, kN/m) (see $q$)

$V$ volume (in$^3$, ft$^3$, mm$^3$, m$^3$); shear force (lb, k, N, kN); wind speed (mi/hr, m/hr)

$V_a$ 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 strength capacity for LRFD beam design (lb, kip, N, kN)

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

$V_u$ maximum shear from factored loads for LRFD design (lb, kip, N, kN); shear at a distance $d$ away from the face of support for reinforced concrete beam design (lb, kip, N, kN)

$V_{u1}$ maximum one-way shear from factored loads for LRFD beam design (lb, kip, N, kN)

$V_{u2}$ maximum two-way shear from factored loads for LRFD beam design (lb, kip, N, kN)

$w$ load per unit length on a beam (lb/ft, kip/ft, N/m, kN/m) (also $\omega$); load per unit area (lb/ft$^2$, kips/ft$^2$, N/m$^2$, Pa, MPa); width dimension (in, ft, mm, m)

$w_{adjusted}$ adjusted distributed load for equivalent live load deflection limit (lb/ft, kip/ft, N/m, kN/m)

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

$w_{equivalent}$ the equivalent distributed load derived from the maximum bending moment (lb/ft, kip/ft, N/m, kN/m)

$w_u$ 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; wide flange shape designation (i.e. W 21 x 68)

$x$ 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) (see $c$)

$\tilde{x}$ 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)

$\tilde{y}$ 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)
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Z$</td>
<td>plastic section modulus of a steel beam (in³, mm³); lateral design value for a single fastener in a timber connection (lb/nail, k/bolt)</td>
</tr>
<tr>
<td>$Z_x$</td>
<td>plastic section modulus of a steel beam with respect to the x axis (in³, mm³)</td>
</tr>
<tr>
<td>$'$</td>
<td>symbol for feet</td>
</tr>
<tr>
<td>$''$</td>
<td>symbol for inches</td>
</tr>
<tr>
<td>$#$</td>
<td>symbol for pounds</td>
</tr>
<tr>
<td>$=$</td>
<td>symbol for equal to</td>
</tr>
<tr>
<td>$\approx$</td>
<td>symbol for approximately equal to</td>
</tr>
<tr>
<td>$\propto$</td>
<td>symbol for proportional to</td>
</tr>
<tr>
<td>$\leq$</td>
<td>symbol for less than or equal to</td>
</tr>
<tr>
<td>$\int$</td>
<td>symbol for integration</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>coefficient of thermal expansion ($^\circ$C, $^\circ$F); angle, in a math equation (degrees, radians); method factor for $B_f$ for steel beam-column design</td>
</tr>
<tr>
<td>$\beta$</td>
<td>angle, in a math equation (degrees, radians); ratio of long side to short side of the column in concrete footing design</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>coefficient for determining stress block height, $a$, based on concrete strength, $f'_c$; coefficient for determining stress block height, $c$, in masonry LRFD design</td>
</tr>
<tr>
<td>$\delta$</td>
<td>elongation (in, mm)</td>
</tr>
<tr>
<td>$\delta_p$</td>
<td>elongation due to axial load (in, mm)</td>
</tr>
<tr>
<td>$\delta_s$</td>
<td>shear deformation (in, mm)</td>
</tr>
<tr>
<td>$\delta_T$</td>
<td>elongation due to change in temperature (in, mm)</td>
</tr>
<tr>
<td>$\Delta$</td>
<td>beam deflection (in, mm); an increment</td>
</tr>
<tr>
<td>$\Delta_{LL}$</td>
<td>beam deflection due to live load (in, mm)</td>
</tr>
<tr>
<td>$\Delta_{\text{max}}$</td>
<td>maximum calculated beam deflection (in, mm)</td>
</tr>
<tr>
<td>$\Delta_{tL}$</td>
<td>beam deflection due to total load (in, mm)</td>
</tr>
<tr>
<td>$\Delta_x$</td>
<td>beam deflection in beam diagrams and formulas (in, mm)</td>
</tr>
<tr>
<td>$\Delta T$</td>
<td>change in temperature ($^\circ$C, $^\circ$F)</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>strain (no units)</td>
</tr>
<tr>
<td>$\varepsilon_t$</td>
<td>thermal strain (no units)</td>
</tr>
<tr>
<td>$\varepsilon_y$</td>
<td>yield strain (no units)</td>
</tr>
<tr>
<td>$\phi$</td>
<td>diameter symbol; angle of twist (degrees, radians); resistance factor in LRFD steel design and reinforced concrete design</td>
</tr>
</tbody>
</table>
\( \phi_b \) resistance factor for flexure in LRFD design

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

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

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

\( \lambda \) modification factor for reinforced concrete shear for lightweight materials

\( \mu \) Poisson’s ratio;
coefficient of static friction

\( \gamma \) 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;
load factor in LRFD design

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

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

\( \theta \) angle, in a trig equation, ex. \( \sin \theta \) (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 = \( \frac{A_s}{bd} \)

\( \rho_b \) balanced reinforcement ratio in masonry design

\( \rho_{balanced} \) balanced reinforcement ratio in concrete beam design

\( \rho_g \) reinforcement ratio in concrete column design = \( \frac{A_s}{A_g} \)

\( \rho_{max} \) 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

\( \nu_c \) shear strength in concrete design

\( \omega \) 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)

\( \omega' \) load per unit volume (lb/ft, kip/ft, N/m, kN/m) \( (see \ \gamma) \)

\( \Sigma \) summation symbol

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

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