List of Symbol Definitions

\( a \)  
long dimension for a section subjected to torsion (in, mm);  
acceleration (ft/sec\(^2\), m/sec\(^2\));  
acceleration due to gravity, 32.17 ft/sec\(^2\), 9.81 m/sec\(^2\) \((also \ see \ g)\)  
unit area (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\))  
distance used in beam formulas (ft, m);  
deepth of the effective compression block in a concrete beam (in, mm);  
equivalent square column size in spread footing design (in, ft, mm, m)

\( a \)  
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\(^2\))

\( A_b \)  
nominal cross section bolt area (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 in shear, equal to the total area ignoring any holes (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\)) \((see \ A_e)\)

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

\( A_{nv} \)  
net area in shear of a bolted connection subject to shear rupture (in\(^2\), ft\(^2\), mm\(^2\), m\(^2\));  
net shear area for a masonry member (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\(^2\));  
seismic coefficient for acceleration

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

\( A_I \)  
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 \((also \ see \ n)\);  
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 of a concrete T beam cross section (in, mm)
$B$ spread footing dimension in concrete design (ft, m); dimension of a steel base plate (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); rectangular column dimension in concrete footing design (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

$CL, c$ center line

$C$ compression label; compression force (lb, kips, N, kN); dimension of a steel base plate for concrete footing design (in, mm, m); seismic design coefficient dependent on the building period of vibration; constant for moment calculation of plates with respect to boundary conditions; coefficient for eccentrically loaded bolt groups

$C_a$ constant for moment calculation of plates with respect to boundary conditions

$C_b$ modification factor for LRFD steel beam design; constant for moment calculation of plates with respect to boundary conditions

$C_d$ pressure coefficient for wind force calculation

$C_D$ load duration factor for wood design

$C_F$ size factor for wood design

$C_{fu}$ flat use 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

$C_s$ seismic design coefficient based on soil, response and acceleration

$C_v$ web shear coefficient for steel design

$C_V$ glulam volume factor for wood design

$C_t$ temperature factor for wood design; seismic coefficient based on structural system and number of stories to determine building period
\(d\) 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);
effective depth from the top of a reinforced concrete beam to the centroid of the steel (in, mm);
effective depth from the top of a reinforced masonry member to the centroid of the steel (in, mm);
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, mm)

\(d_b\) depth of a steel wide flange section (in, mm);
bar diameter of concrete reinforcement (in, mm)

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

\(d_s\) 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 (in, mm) (see s or \(\varepsilon\));
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);
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)

\(f_n\) natural frequency of a suspended cable (sec\(^{-1}\), Hz)

\(f_p\) calculated bearing stress (psi, ksi, kPa, MPa)

\(f_r\) calculated radial stress for a glulam timber (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)
\( f_v \)  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)
\( F \)  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 combined stress for wood design (psi, ksi, kPa, MPa)
\( F_c \)  allowable compressive stress (psi, ksi, kPa, MPa)
critical unfactored compressive stress for LRFD steel design
\( F_{cr} \)  flexural buckling (column) stress in ASD and LRFD (psi, ksi, kPa, MPa)
\( F_{c,\perp} \)  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)
\( F_{cr} \)  critical column stress due to buckling (psi, ksi, kPa, MPa)
\( F'_{c} \)  allowable compressive stress for ASD wood column design (psi, ksi, kPa, MPa)
\( F'_{c,E} \)  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 stress (psi, ksi, kPa, MPa)
\( F_{nv} \)  nominal shear stress (psi, ksi, kPa, MPa)
\( F_{nt} \)  nominal tensile stress (psi, ksi, kPa, MPa)
\( F_p \)  allowable bearing stress parallel to the wood grain (psi, ksi, kPa, MPa)
\( F_r \)  allowable radial stress for a curved glulam (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 (psi, ksi, kPa, MPa)
\( F_{vm} \)  allowable shear stress in the reinforced masonry (psi, ksi, kPa, MPa)
\( F_{vs} \)  allowable shear stress in the reinforcement for masonry (psi, ksi, kPa, MPa)
**Symbols**

- \( F_x \): force component in the x coordinate direction (lb, kip, N, kN)
- \( F_y \): force component in the y coordinate direction (lb, kip, N, kN)
- \( F_{yw} \): 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 (also see SF)
- \( g \): acceleration due to gravity, 32.17 ft/sec\(^2\), 9.81 m/sec\(^2\) (also see \( a \))
- \( G \): 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 \( \Psi \))
- \( h \): depth, often cross-sectional (in, ft, mm, m); sag of a cable structure (ft, m); height (in, ft, mm, m); effective height of a wall or column, (see \( \ell_o \))
- \( h_c \): height of the web in a wide flange 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)
- \( h_n \): building height for determination of period for seismic design
- \( H \): hydraulic soil load for LRFD design; height of retaining wall (ft, m)
- \( H_A \): horizontal load from active soil or water pressure (lb, k, N, kN)
- \( I \): moment of inertia (in\(^4\), mm\(^4\), m\(^4\)); seismic importance factor based on building occupancy
- \( I \): moment of inertia about the centroid (in\(^4\), mm\(^4\), m\(^4\))
- \( \bar{I} \): moment of inertia about the centroid of a composite shape (in\(^4\), mm\(^4\), m\(^4\)) (also see \( \hat{I} \))
- \( \bar{I}_T \): moment of inertia about the centroid of a composite shape (in\(^4\), mm\(^4\), m\(^4\)) (also see \( I_c \))
- \( I_c \): 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\(^4\))
- \( I_{net} \): moment of inertia of plate area excluding bolt holes (in\(^3\), mm\(^3\), m\(^3\))
- \( I_o \): 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\(^4\))
- \( j \): number of connections in a truss (also see \( n \)); multiplier by effective depth of concrete or 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 plastic design of steel beams, \( M_p/M_y \);  
- effective length factor for columns (also \( K \));  
- distance from outer face of flange to the web toe of fillet of a wide flange section (in, mm);  
- spring constant (lb/in, N/mm);  
- multiplier by effective depth of masonry section for neutral axis, \( kd \)

\( kg \)  
- kilograms

\( kN \)  
- kiloNewtons \( (10^3 \text{ N}) \)

\( kPa \)  
- kiloPascals \( (10^3 \text{ Pa}) \)

\( K \)  
- effective length factor with respect to column end conditions (also \( k \));  
- masonry mortar strength designation

\( K_A \)  
- empirically derived coefficient based on soil properties

\( K_{cE} \)  
- material factor for wood column design

\( \ell \)  
- length (in, ft, mm, m);  
- cable span (ft, m)

\( \ell_d \)  
- development length of concrete reinforcement (in, ft, mm, m)

\( \ell_{dc} \)  
- development length of compression reinforcement in concrete footing design (in, ft, mm, m)

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

\( \ell_a \)  
- effective length that can buckle for wood column design (in, ft, mm, m)

\( \ell_n \)  
- effective clear span for concrete one-way slab design (ft, m)

\( lb \)  
- pound force

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

\( L_{ub} \)  
- unbraced length of a steel beam in LRFD design (ft, m)

\( L_c \)  
- clear distance between the edge of a bolt hole and the edge of the next hole or edge of the connected steel plate in the direction of the load (in, mm)

\( L_{rd} \)  
- development length of reinforcement in concrete (ft, m)

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

\( L_{om} \)  
- projected length for bending in concrete footing design (ft, m)

\( L_{rp} \)  
- 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 the one-way shear area in concrete footing design (ft, m)

\( LL \)  
- live load

**LRFD**  
- Load and Resistance Factor Design
mass (lb-mass, g, kg);  
meters;  
moment per unit width (lb-ft/ft, kN-m/m);  
edge dimension in a steel base plate (in, mm)

millimeters

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

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

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

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

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

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

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

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

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

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

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

internal bending moment when all fibers in a cross section reach the yield stress (lb-ft, kip-ft, N-m, kN-m)  
(also see $M_p$)

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

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

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

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

number of truss joints or members, nails or bolts;  
modulus of elasticity transformation coefficient for steel to concrete;  
edge dimension in a steel base plate (in, mm)

neutral axis (axis connecting beam cross-section centroids)

equivalent edge dimension in a steel base plate for design (in, mm)
\(N\) Newtons (kg-m/sec^2);

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);

dimension of a steel base plate (in, mm, m);

masonry mortar strength designation

\(N_\phi\) meridional in-plane internal force per unit length in a shell (lb/ft, N/m, kN/m)

\(N_\theta\) hoop in-plane internal force per unit length in a shell (lb/ft, N/m, kN/m)

\(o.c.\) on-center

\(O\) point of origin;

masonry mortar strength designation

\(p\) pitch of nail spacing (in, mm) \((also\ see\ s)\);

pressure (lb/in^2, lb/ft^2, kip/in^2, kip/ft^2, Pa, MPa):

unit weight of soil for determining active lateral pressure (lb/ft^3, kN/m^3)

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

\(p_r\) internal pressure (lb/in^2, lb/ft^2, kip/in^2, kip/ft^2, Pa, MPa)

\(P\) 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);

nominal axial load for a tensile member or connection in LRFD steel (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);

factored axial load for a tensile member or connection in LRFD steel (lb, kip, N, kN)

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

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

soil bearing pressure (lb/ft^2, kips/ft^2, N/m^2, Pa, MPa)

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

\(q_h\) static wind velocity pressure for wind force calculation (lb/ft^2, kips/ft^2, N/m, Pa, MPa)

\(q_{net}\) 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)

\(Q_{connected}\) 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 or arc (in, mm, m);  
radius of gyration (in, mm, m)

$r_o$  
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 or radius of a shell (ft, m);  
rainwater or ice load for LRFD design;  
seismic response modification based on structural type;  
calculated reduction in live load limited to 60% (in percent);  
generic load quantity (force, shear, moment, etc.) for LRFD design

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

$R_n$  
cement beam design ratio = $M_u/bd^2$ (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* $P_u$, $M_u$)

$R_w$  
seismic response modification based on structural type

$R_x$  
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* $p$);  
longitudinal center-to-center spacing of any two consecutive holes (in, mm);  
spacing of stirrups in reinforced concrete beams (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)  
seismic soil profile;  
masonry mortar strength designation

$S_{net}$  
section modulus of plate area excluding bolt holes ($in^3$, $mm^3$, $m^3$)

$S_{required}$  
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 (*also 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;
seismic building period (sec);
deepth in web of wide flange section from fillet to fillet (in, mm)

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

\( U_{bs} \) reduction coefficient for block shear rupture

\( v \) velocity (ft/sec, m/sec, mi/h);
shear force per unit length (lb/ft, k/ft, N/m, kN/m) (see \( q \))

\( V \) shearing force (lb, kip, N, kN);
seismic base 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\(^2\)) (see \( w' \));
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\(^2\))

\( w' \) load per unit area on a surface (lb/ft\(^2\), kip/ft\(^2\), N/m\(^2\), kN/m\(^2\)) (see \( w \))

\( W \) weight (lb, kip, N, kN);
total load from a uniform distribution (lb, kip, N, kN);
wind load for LRFD design;
seismic building weight (lb, kip, N, kN);
wide flange shape designation (i.e. W 21 x 68)

\( x \) a distance in the x direction (in, ft, mm, m)

\( \bar{x} \) 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;
design constant for steel base plate design based on concrete bearing capacity
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)

\bar{y}_r the distance in the y direction from a reference axis to the centroid of a composite shape (in, mm)  \textit{(also see } \hat{y} \text{)}

\hat{y} the distance in the y direction from a reference axis to the centroid of a composite shape (in, mm)  \textit{(also see } \bar{y}_r \text{)}

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

Z plastic section modulus of a steel beam (in$^3$, mm$^3$);
seismic geographic factor based on zone

^\prime symbol for feet

^\prime 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

\alpha coefficient of thermal expansion (°C, °F);
angle, in a math equation (degrees, radians)

\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 for determining stress block height, \( a \), based on concrete strength, \( f'_c \)

\delta elongation (in, mm) \textit{(also see } e \text{)}

\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);
story drift (in, mm);
an increment

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

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

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

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

\varepsilon strain (no units)

\varepsilon_t thermal strain (no units)
Symbols

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

\( \kappa \)  
- limit of timber slenderness for intermediate length columns (no units)

\( \lambda \)  
- design constant for steel base plate design

\( \mu \)  
- Poisson’s ratio (also see \( \nu \));  
- coefficient of static friction

\( \nu \)  
- Poisson’s ratio (also see \( \mu \))

\( \gamma \)  
- 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 (no units);  
- load factor in LRFD design

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

\( \gamma_L \)  
- live load factor in LRFD steel 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 = \( \frac{A_s}{bd} \) (or possibly \( \frac{A_s}{bt} \), \( \frac{A_s}{bh} \)) (no units)

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

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

\( \rho_{max} \)  
- 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)

\( \omega' \)  
- 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 \( G \))