**List of Symbol Definitions**

\( a \)  
long dimension for a section subjected to torsion (in, mm);  
acceleration (ft/sec\(^2\), m/sec\(^2\))

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

\( A_{e} \)  
net effective area, equal to the total area ignoring any holes (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\(^2\))

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

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

\( A_{web} \)  
web area in a steel beam equal to the depth \( \times \) web thickness (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

\( b_{f} \)  
width of the flange of a steel beam cross section (in, mm)

\( c \)  
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)

\( c_{i} \)  
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

\( CL, \ell \)  
center line

\( C \)  
compression label;  
compression force (lb, kips, N, kN)

\( C_{b} \)  
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

\( C_{D} \)  
load duration factor for wood design

\( C_{F} \)  
size 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

\( C_{t} \)  
temperature factor for wood design
\(d\) depth, often cross-sectional (in, mm, m);
  perpendicular distance from a force to a point in a moment calculation (in, mm, m)
\(d_x\) 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
\(f\) 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)
\(f_{cr}\) calculated column stress based on the critical column load \(P_{cr}\) (psi, ksi, kPa, MPa)
\(f_t\) calculated tensile stress (psi, ksi, kPa, MPa)
\(f_p\) calculated bearing 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)
\(F\) 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)
\(F_a\) 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)
\(F_{connector}\) 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)
\(F'_{c}\) 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)
\( F_{o}' \) allowable buckling stress for combined bending steel design (psi, ksi, kPa, MPa)

\( F_t \) 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)

\( F_u \) 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\(^2\)

\( G \) shear modulus (psi; ksi, kPa, MPa, GPa)

\( h \) depth, often cross-sectional (in, ft, mm, m); sag of a cable structure (ft, m)

\( I \) 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 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\(^4\))

\( I_x \) 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\(^4\))

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

\( k \) kips (1000 lb); shape factor for plastic design of steel beams, \( M_p/M_y \)

\( kg \) kilograms

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

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

\( K \) effective length factor with respect to column end conditions

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

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

\( lb \) pound force

\( L \) length (in, ft, mm, m); live load for LRFD design

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

\( L_c \) maximum unbraced length of a steel beam in ASD design for maximum allowed bending stress (in, ft, mm, m)

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

\( L_r \) roof live load in LRFD design
\( L_p \)  
maximum unbraced length of a steel beam in LRFD design for full plastic flexural strength (in, ft, mm, m)

\( L_r \)  
maximum unbraced length of a steel beam in LRFD design for inelastic lateral-torsional buckling (in, ft, mm, m)

\( L_u \)  
maximum unbraced length of a steel beam in ASD design for reduced allowed bending stress (in, ft, mm, m)

\( LL \)  
live load

\( L_{RFD} \)  
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)

\( M_A \)  
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)

\( M_n \)  
nominal flexure strength with the full section at the yield stress for LRFD beam design (lb-ft, kip-ft, N-m, kN-m)

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

\( M_{ult} \)  
(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 \((10^6 \text{ Pa} \text{ or } 1 \text{ N/mm}^2)\)

\( n \)  
number of truss joints, nails or bolts

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

\( N \)  
Newtons \((\text{kg-m/sec}^2)\); bearing-type connection with bolt threads included in shear plane

\( O \)  
point of origin

\( p \)  
pitch of nail spacing (in, ft, mm, m)

\( P \)  
force, concentrated (point) load (lb, kip, N, kN); axial load in a column or beam-column (lb, kip, N, kN)
$P_{cr}$ critical (failure) load in column calculations (lb, kip, N, kN)
$P_n$ nominal load strength capacity for LRFD design (lb, kip, N, kN)
$P_u$ maximum load from factored loads for LRFD design (lb, kip, N, kN)
$Pa$ Pascals (N/m$^2$)
$q$ shear flow (lb/in, kips/ft, N/m, kN/m)
$Q$ first moment area used in shearing stress calculations (in$^3$, mm$^3$, m$^3$)
$Q_{connected}$ first moment area used in shearing stress 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)
$r_o$ 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 design quantity (force, shear, moment, etc.) for LRFD design
$R_n$ generic nominal capacity (force, shear, moment, etc.) for LRFD design
$R_u$ generic maximum quantity (force, shear, moment, etc.) from factored loads for LRFD design
$R_x$ 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)
$s.w.$ 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)
$S_{required}$ 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
$S4S$ 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, kip-ft, N-m, kN-m); throat size of a weld (in, mm)
\( V \) shearing force (lb, kip, N, kN)
\( V_n \) nominal shear strength capacity for LRFD beam design (lb, kip, N, kN)
\( V_u \) maximum shear from factored loads for LRFD beam design (lb, kip, N, kN)
\( w \) (also \( \omega \)) load per unit length on a beam (lb/ft, kip/ft, N/m, kN/m)
\( W \) 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)
\( \bar{x} \) 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)
\( Z \) plastic section modulus of a steel beam (in\(^3\), mm\(^3\))
\( ' \) symbol for feet
\( " \) symbol for inches
\( # \) symbol for pounds
\( \alpha \) coefficient of thermal expansion (\( ^\circ\text{C}, ^\circ\text{F} \)); angle, in a math equation (degrees, radians)
\( \beta \) angle, in a math equation (degrees, radians)
\( \delta \) elongation (in, mm)
\( \delta_p \) 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)
\( \Delta_{TL} \) beam deflection due to total load (in, mm)
\( \Delta T \) change in temperature (\( ^\circ\text{C}, ^\circ\text{F} \))
\( \varepsilon \) strain (no units)
\( \varepsilon_t \) thermal strain (no units)
\( \phi \) diameter symbol;
   angle of twist (degrees, radians);
   resistance factor in LRFD steel design

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

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

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

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

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

\( \mu \) Poisson’s ratio

\( \gamma \) 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 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

\( \rho \) radial distance (in, mm)

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

\( \tau \) engineering symbol for shearing stress

\( \Sigma \) summation symbol

\( \omega \) (also w) load per unit length on a beam (lb/ft, kip/ft, N/m, kN/m)