SYMBOLS

A cross-sectional area; area, in.^{2}

A_{BM} cross-sectional area of base metal for a welded joint, in.^{2}

A_I influence area, ft^2

A_{Ib} influence area of an interior beam, ft^2

A_{Ic} influence area of an interior column, ft^2

A_{Ig} influence area of an interior girder, ft^2

A_R cross-sectional area of a threaded rod based on the nominal diameter of the rod, in.^{2}

A_T tributary area, ft^2

A_{Tb} tributary area of an interior beam, ft^2

A_{Tc} tributary area of an interior column, ft^2

A_{Tg} tributary area of an interior girder, ft^2

A_b nominal unthreaded body area of bolt or threaded rod, in.^{2} ; cross-sectional area based upon the nominal diameter of bolt

A_c area of the compressive plastic zone, in a fully plastified section

$\mathrm{A_{ce}}$ area of the directly connected elements of a tension member, using transverse welds only, in.^{2}

A_e effective net area of tension member, in.^{2}; net tensile area of threaded rod, in.^{2}

A_f gross area of one flange, in.^{2}

A_{fe} effective area of tension flange, in.^{2}

A_{fg} gross area of tension flange, in.^{2}

A_{fn} net area of tension flange, in.^{2}

A_g gross area of a tension member, in.^{2}; gross area of a compression member, in.^{2}

A_{g1} gross area required to satisfy the limit state of yield on gross area of a tension member, in.^{2}

A_{g2} gross area required to satisfy the limit state of fracture on net area of a tension member, in.^{2}

A_{nk} net area along possible failure path k, for a tension member, in.^{2}

A_{gt} gross area subject to tension – limit state of block shear rupture, in.^{2}

A_{gv} gross area subject to shear – limit state of block shear rupture, in.^{2}

A_h area of cross section lost due to a bolt hole, in.^{2}

A_n net area of a tension member, in.^{2}

A_{nt} net area subject to tension – limit state of block shear rupture, in.^{2}

A_{nv} net area subject to shear – limit state of block shear rupture, in.^{2}

A_s stress area of bolt, in.^{2}

A_{st} cross-sectional area of stiffener or pair of stiffeners, in.^{2}

A_t area of the tensile plastic zone, in a fully plastified section

A_v net shear area per shear plane, ft^2

A_w area of beam web, in.^{2}; effective area of weld, in.^{2}

A_1 area of steel bearing plate (or, base plate), in.^{2}

A_2 effective concrete support area, below a bearing plate (or, base plate) and within the body of the footing, that is geometrically similar to and concentric with the area A_1, in.^{2}

B factor for bending stress in tees and double angles; base plate width, in.

B_d design strength of a bolt, kips

B_{dv} design shear strength of a bolt, kips

B_{db} design bearing strength of a bolt, kips

B_{dbo} design bearing strength of connected plate element for the limit state of ovalization of bolt hole, kips

B_{dbte} design bearing strength of an end bolt for the limit state of shear tear-out of connected plate element, kips

B_{dbti} design bearing strength of an interior bolt for the limit state of shear tear-out of connected plate element, kips

B_{dbe} design bearing strength of an end bolt, kips

B_{dbi} design bearing strength of an interior bolt, kips

B_{dt} design tensile strength of a bolt, kips

B_{dv} design shear strength of a bolt, kips

B_n nominal strength of a bolt, kips

B_{nb} nominal bearing strength of a bolt, kips

B_{nv} nominal shear strength of a bolt in a bearing type joint, kips

B_{tu} tensile component of applied factored load on a bolt for combined shear and tension loading

B_{vu} shear component of applied factored load on a bolt for combined shear and tension loading

B_1, B_2 magnification factors used in determining second-order moment for combined bending and axial compression when first-order analysis is employed

BF beam factor (a factor that can be used to calculate the flexural strength for unbraced length L_b between L_p and L_r)

C width across points of square or hex bolt head or nut

C coefficient for eccentrically loaded bolt and weld groups

C_a, C_b coefficients used in extended end-plate connection design

C_b bending coefficient dependent on the shape of moment diagram for lateral-torsional buckling strength of beam segments

C_d design strength of connectors in a joint, kips

C_{db} design bearing strength of connectors in a joint, kips

C_{dv} design shear strength of connectors in a joint, kips

C_e exposure coefficient

C_f resultant (force) of the stresses in the compressed flange of a beam

C_m coefficient applied to bending term in interaction formula for prismatic members and dependent on column curvature caused by applied moments

C_p external pressure coefficient

C_p, T_p compressive and tensile stress resultants of a fully plastified section in bending

C_y, T_y compressive and tensile stress resultants of a section in bending at the onset of yielding

C_t thermal factor

C_v ratio of critical web stress, according to linear buckling theory, to the shear yield stress of web material

C_w warping torsional constant of a cross section, in.^{6}

C_1 clearance for tightening of bolts, in.

C_1 electrode coefficient for relative strength of electrodes where, for E70 electrodes , $C_1 = 1.00$

C_2 clearance for entering, in.

D dead load; outside diameter of circular hollow section, in.; number of sixteenths of an inch in the fillet weld size; slip probability factor for bolts

E earthquake load

E modulus of elasticity or Young's modulus (= 29,000 ksi for steel)

E_c modulus of elasticity of concrete, ksi

E_s strain hardening modulus, ksi

E_t tangent modulus, ksi

F width across flats of bolt head, in.

F clearance for tightening staggered bolts, in.

F_{BM} nominal strength of the base material to be welded, ksi

F_{EXX} classification number of weld metal (minimum specified ultimate tensile stress)

F_L smaller of (F_{yf} - F_r) or F_{yw}, ksi

F_{cr} critical stress, ksi; nominal compressive stress of an axially loaded column, ksi

F_e elastic buckling stress, ksi

F_{ex} elastic flexural buckling stress about the major axis, ksi

F_{ey} elastic flexural buckling stress about the minor axis, ksi

F_{ez} elastic torsional buckling stress, ksi

F_n nominal strength per unit area

F_{nb} nominal bearing strength per unit area, assumed to be uniform over the projected area of the bolt on the connected plate element, ksi

F_p nominal bearing stress on bolt, ksi

F_r compressive residual stress in flange (10 ksi for rolled shapes; 16.5 ksi for built-up shapes)

F_t nominal tensile strength per unit area of bolt shank, ksi

F_u specified minimum ultimate tensile stress of the type of steel being used, ksi

F_{ub} ultimate tensile stress of bolt material, ksi

F_{uBM} ultimate tensile stress of base material, ksi

F_{up} ultimate tensile stress of connected plate material, ksi

F_{uy} ultimate shear stress, ksi

F_{uw} ultimate tensile stress of the weld electrode material, ksi

F_v nominal shear strength per unit area of bolt shank, ksi

F_w nominal shear strength per unit area of the weld electrode material, ksi

F_y specified minimum yield stress of the type of steel being used, ksi

F_y''' The theoretical maximum yield stress (ksi) based on the web depth/thickness ratio (h/t_w) above which the web of a column is considered a slender element

Note: In the tables, – indicates $F_y''' > 65$ ksi.

F_{yb} F_y of a beam

F_{yBM} yield stress of base material, ksi

F_{yc} F_y of a column

F_{yf} specified minimum yield stress of the flange, ksi

F_{ypl} yield stress of the beam bearing plate or column base plate material, ksi

F_{yst} specified minimum yield stress of the stiffener material, ksi

F_{yw} specified minimum yield stress of the web, ksi

F_{yv} shear yield stress, ksi

G shear modulus of elasticity (= 11,200 ksi for steel) ; gust effect factor

G distance between the lines of bolts or welds connecting tie plates to the components of a built-up member, in.

G relative stiffness factor (ratio of the total stiffness of columns framing into a joint to that of the stiffening members framing into the same joint)

G_A, G_B relative stiffness factors at ends A and B of a column

G_{cpi} internal pressure coefficient

G_e elastic G factor assuming that both columns and girders behave elastically

G_i inelastic G factor assuming that the girders behave elastically while the columns behave inelastically

H horizontal force, kips; average story height; height of bolt head or nut, in.

H_{bt} height of a braced bent, ft

I impact factor; importance factor; moment of inertia, $in.^4$

I_c moment of inertia of column section about axis perpendicular to plane of buckling (bending), $in.^4$

I_g moment of inertia of girder section about axis perpendicular to plane of buckling (bending), $in.^4$

I_{g1}, I_{g2}, I_{g3}, I_{g4} moments of inertia of girders connected to ends A and B of column AB considered

I_p polar moment of inertia, $in.^4$

I_{pl} polar moment of inertia of a weld group with the weld treated as a line element, $in.^3$

I_s importance factor for snow loads

I_{st} moment of inertia of a stiffener, $in.^4$

I_w importance factor for wind loads

I_x, I_y moment of inertia of section about *x*- or *y*-axis, respectively, in.^{4}

I_{oi} moment of inertia of component, i, about its own center of gravity (parallel axis theorem), in.^{4}

J torsional constant for a section, in.^{4}

K effective length factor for a column

K_{LL} live load element factor

K_{LLb} live load element factor for an interior beam

K_{LLc} live load element factor for an interior column

K_{LLg} live load element factor for an interior girder

K_T theoretical K value for a column

K_d wind directionality factor

K_m modified effective length factor of a column to account for the presence of leaning columns in the frame

K_o effective length factor of a column determined from the nomograph, not accounting for the presence of leaning columns in the frame

K_{oi} effective length factor of restraining column i obtained from the monograph

K_x, K_y effective length factor for flexural buckling about *x* axis and *y* axis

$(K_xL_x)_y$ effective length with respect to the minor axis, equivalent in load carrying capacity to the actual effective length about the major axis, ft

K_z effective length factor for torsional buckling; velocity pressure exposure coefficient that accounts for terrain and height above ground

K_{zt} topographic factor

L nominal live load due to occupancy (also known as reduced live load, or design live load), psf

L story height or panel spacing; span; span of portal frame; length of tension member, in. or ft, as indicated

L unbraced length of member, in. or ft, as indicated

L_b laterally unbraced length; length between points which are either braced against lateral displacement of compression flange or braced against twist of the cross section; span of beams

L_{bt} width of a braced bent, ft

L_c clear distance for a bolt, in.; unsupported length of a column section

L_{ce} clear distance for an end bolt, in.

L_{ci} clear distance for an interior bolt, in.

L_{con} length of connection in the direction of loading, in.

L_e end distance of a bolt measured in direction of line of force, in.; edge distance, in.

L_e effective length of a column, in. or ft, as indicated

L_{eh} horizontal edge distance, in.

L_{ev} vertical edge distance, in.

$L_{e,\text{ full}}$ limiting value of end distance above which limit state of bolt ovalization controls bearing strength, in.

L_g span length of a girder, ft; unsupported length of a girder or other restraining member, ft; gross length of a fillet weld, in.

$L_{g1}, L_{g2}, L_{g3}, L_{g4}$ length of girders connected to ends A and B of column AB considered (for columns in rectangular frames, $L_{g3} = L_{g1}$, $L_{g4} = L_{g2}$)

L_{iw} length of a segment of intermittent fillet weld, in.

L_{lw} length of a longitudinal weld, in.

L_o basic, or unreduced live load

L_p limiting laterally unbraced length for full plastic bending capacity, uniform moment case (C_b = 1.0), in.

L_p^* limiting laterally unbraced length for full plastic flexural strength ($C_b > 1.0$ and $L_p < L_b \leq L_r$)

L_p^{**} limiting laterally unbraced length for full plastic flexural strength ($C_b > 1.0$ and $L_b > L_r$)

L_p' limiting laterally unbraced length for the maximum design flexural strength for noncompact shapes, uniform moment case ($C_b = 1.0$)

L_p' limiting laterally unbraced length for the maximum design flexural strength for noncompact shapes, uniform moment case ($C_b = 1.0$)

L_{pd} limiting laterally unbraced length for plastic analysis

L_r limiting laterally unbraced length for inelastic lateral-torsional buckling, in. or ft, as indicated

L_r roof live load, psf

L_s side distance of a bolt measured perpendicular to line of force, in.

L_{st} length of stiffener, in.

L_{sw} length of slot for a slot weld, in.

L_t thread length of a bolt, in.

L_{tp} length of tie plate, measured parallel to the length of the member, in.

L_{tw} effective length of a transverse weld, in.

L_w effective length of a fillet weld, in.

$L_{w,\,\min}$ minimum effective length of a fillet weld, in.

L_w^* maximum length of end-loaded fillet weld below which the effective length equals the actual length, in.

M number of possible failure paths for a tension member

M bending moment

M_{A} absolute value of moment at quarter point of the unbraced beam segment, in.-kips

M_{B} absolute value of moment at centerline of the unbraced beam segment, in.-kips

M_{C} absolute value of moment at three-quarter point of the unbraced beam segment, in.-kips

M_T applied torsional moment, in.-kips

M_{cr} elastic lateral-torsional buckling moment of a beam or a beam segment, in.-kips or ft-kips, as indicated

M_{cr}^o elastic lateral-torsional buckling moment of a beam or a beam segment under uniform moment

M_d design bending strength of a member

M_{dI} design bending strength of a beam segment, when $L_p < L_b \le L_r$

M_{dE} design bending strength of a beam segment, when $L_b > L_r$

$M_{dI}^{\,o}$ design bending strength of a beam segment under uniform moment, when $L_p < L_b \le L_r$

$M_{dE}^{\,o}$ design bending strength of a beam segment under uniform moment, when $L_b > L_r$

M_{dx} design bending strength about the major axis, in.-kips or ft-kips, as indicated

M_{dy} design bending strength about the minor axis, in.-kips or ft-kips, as indicated

M_{ep} resisting moment of a partially plastified section

M_{ez} resisting moment of the elastic zone of a partially plastified section

M_{eu} required flexural strength for extended end-plate connection, in.-kips

M_{lt} maximum first-order factored moment in a beam-column due to lateral frame translation only

$M_{\max}$ maximum bending moment; required bending strength under factored loads

$M_{\max}$ absolute value of maximum moment in the unbraced beam segment (including the end points)

M_n nominal bending strength of a member

M_n' nominal flexural strength for noncompact shapes, when $L_b \leq L_p'$

M_{nt} maximum first-order factored moment in a beam-column assuming there is no lateral translation of the frame

M_p plastic bending moment of a section, in.-kips or ft-kips, as indicated

$\mathrm{M_{pc}}$ reduced plastic moment of a section, in the presence of an axial compressive load P

M_{pcx} reduced plastic moment of an I-shape bent about its major axis

M_{pcy} reduced plastic moment of an I-shape bent about its minor axis

M_{px} plastic moment of an I-shape bent about its major axis

M_{py} plastic moment of an I-shape bent about its minor axis

M_{pz} resisting moment of the plastic zones of a partially plastified section

M_r bending moment in a section when the extreme fiber stress reaches (F_y - F_r)

M_u required bending strength of a member under factored loads , in.-kips or ft-kips, as indicated

M_u^* required flexural strength of a beam-column under factored loads, including second-order effects

M_{ueq}^{o} equivalent factored uniform moment capacity for the segment considered

M_y moment corresponding to onset of yielding at the extreme fiber from an elastic stress distribution (= F_y S for homogeneous sections), in.-kips

M_1 smaller moment at end of unbraced length of a beam or beam-column segment

M_2 larger moment at end of unbraced length of a beam or beam-column segment

N number of bolts in a joint

N length of bearing, in.; length of beam bearing plate, in.; length of column base plate, in.; number of bolts in a joint

N_s number of shear planes in a bearing-type joint; number of slip planes in a slip-critical joint

P axial load on column, kips

P_E Euler load; elastic buckling load of a pin-ended column, kips

P_{Ei} Euler load of restraining column i

P_{Ex}, P_{Ey} Euler load for buckling about the x- and y- axis of an I-shape, respectvely

P_{bf} applied factored beam flange force in moment connections, kips

P_{cr} critical load of a column

P_d design strength of an axially loaded column, kips

P_{dx} design strength of an axially loaded column for buckling about its major axis, kips

P_{dy} design strength of an axially loaded column for buckling about its minor axis, kips

P_{dp} design bearing load on concrete, kips

P_{dps} design load on bracket corresponding to the limit state of separation of plates at the top edge

P_{dsf} design load on bracket corresponding to the limit state of slip

P_e elastic buckling load of a column, kips

P_{eoi} elastic flexural buckling load of restraining column*i* based on the nomograph

P_{ex} elastic buckling load of a column for buckling about the major axis, kips

P_{ey} elastic buckling load of a column for buckling about the minor axis, kips

P_{ez} elastic torsional buckling load of a column, kips

P_{e1} elastic buckling load used in the determination of magnification factor B_1, kips

P_{e2} elastic buckling load used in the determination of magnification factor B_2, kips

P_{fb} resistance to flange local bending at a concentrated tensile force centrally applied across the flange, kips

P_{max} maximum strength of an axially loaded column (stability limit load)

P_n nominal strength of an axially loaded column, kips

P_{np} nominal bearing load on concrete, kips

P_r reduced modulus load of a column, kips

P_t tangent modulus load of a column, kips

P_{req} required axial compressive strength of column, kips

P_u axial force under factored loads; required axial strength of a column, kips

P_{ueq} equivalent axial load used in selecting a trial shape for design of a beam column

P_{uf} factored beam flange force, tensile or compressive, kips

P_{ui} factored axial load on restraining column *i*

P_{wb} resistance to web compression buckling under a pair of compressive concentrated forces, applied at both flanges of an I-shaped member at the same location

P_y yield load of a section (also known as squash load), $(= F_y A_g)$, kips

Q concentrated transverse load on a member, kips

Q' first moment of area in shear flow formula, in.^{3}

Q_o nominal load effect

Q_D unfactored dead load, kips

Q_{Db} dead load transmitted from beams to an interior girder, lbs

Q_E unfactored earthquake load, kips

Q_L unfactored live load, kips

Q_{Lb} live load transmitted from beams to an interior girder, lbs

Q_S unfactored snow load, kips

Q_i load effects

Q_u factored concentrated beam load, kips

Q_{ug} factored concentrated load transmitted from beams to an interior girder, lbs

Q_{uj} factored axial load on leaning column j

R rain load; nominal reaction, kips

R earthquake response modification coefficient

R_d design strength, kips

R_{dc} design strength of bearing plate corresponding to the limit state of beam web crippling, kips

R_{dy} design strength of bearing plate corresponding to the limit state of beam web local yielding, kips

R_{dp} design strength of bearing plate corresponding to the limit state of bearing of plate on concrete or masonry, kips

R_{df} design strength of bearing plate corresponding to the limit state of plate flexural strength, kips

R_{dw} design strength of weld corresponding to the limit state of weld metal failure, kips

R_{dBM} design strength of weld corresponding to the limit state of base material failure, kips

R_{dBM1} design shear rupture strength of the adjacent base material, kips

R_{dBM2} design shear yielding strength of the adjacent base material, kips

R_n nominal strength, kips

R_{req} required strength, kips

R_1 an expression consisting of the first portion of LRFDS Eq. K1-3, kips

R_2 an expression consisting of terms from the second portion of LRFDS Eq. K1-3, kli

R_3 an expression consisting of the first portion of LRFDS Eq. K1-5*a*, kips

R_4 an expression consisting of terms from the second portion of LRFDS Eq. K1-5*a*, kli

R_5 an expression consisting of the first portion of LRFDS Eq. K1-5*b*, kips

R_6 an expression consisting of terms from the second portion of LRFDS Eq. K1-5*b*, kli

S elastic section modulus, $\mathrm{in.}^3$; snow load; in. or ft, as indicated

S_{S} spacing of sag rods, ft

S_{T} spacing of trusses, ft

S_b spacing of roof or floor beams, ft

S_{tp} spacing of tie plates, in. or ft, as indicated

S_x elastic section modulus about major axis, $\mathrm{in.}^3$

S_{xe} effective section modulus about major axis, $\mathrm{in.}^3$

S_{xt}, S_{xb} elastic section modulus referred to tension and compression flanges, respectively, $\mathrm{in.}^3$

S_{xb}, S_{xt} elastic section modulus referred to bottom and top fibers, respectively, $\mathrm{in.}^3$

SRF stiffness reduction factor, for use with alignment charts

T change in temperature, ° F; distance between web toes of fillets at top and bottom of web, in.; axial load in a tension member, kips

T unfactored tensile force on slip-critical connections designed at service loads, kips

T_S tension in the top sag rod, kips

T_T tension in tie rod, kips

T_b, T_m specified pretension load in high-strength bolt, kips

T_d design strength of a tension member, kips

T_{dbs} design block shear rupture strength, kips

T_{d1} design strength of a tension member corresponding to the limit state of yielding in the gross section, kips

T_{d2} design strength of a tension member corresponding to the limit state of fracture in the net section, kips

T_{d3} design strength of a tension member corresponding to the limit state of block shear failure, kips

T_{d4} design strength of a tension member corresponding to the limit state of connector failure, kips

T_d design strength of a tension rod, kips

T_{d1} design strength of a tension rod corresponding to the limit state of yielding in the gross section in the unthreaded part (body) of the rod, kips

T_{d2} design strength of a tension rod corresponding to the limit state of fracture in the net section in the threaded part of the rod, kips

T_{d3} design strength of a tension rod corresponding to the limit state of the nut stripping the threaded portion of the rod, kips

T_{d4} design strength of a tension rod corresponding to the limit state of the nut stripping the threaded portion of the nut, kips

T_{d5} design strength of a tension rod corresponding to the limit state of bearing of the nut on the support, kips

$T_{d\mathrm{R}}$ design strength of a uniform tension rod (i.e., without upset ends), kips

T_{fnt} tension rupture component – limit state of block shear rupture, kips

T_{fnv} shear rupture component – limit state of block shear rupture, kips

T_n nominal strength of a tension member, kips

T_{n1} nominal strength of a tension member corresponding to the limit state of yielding in the gross section, kips

T_{n2} nominal strength of a tension member corresponding to the limit state of fracture in the net section, kips

T_{n3} nominal strength of a tension member corresponding to the limit state of block shear failure, kips

T_{n4} nominal strength of a tension member corresponding to the limit state of connector failure, kips

T_{req} required strength of a tension member, kips

T_u factored tension load, required tensile strength due to factored loads, kips

T_{ygt} tension yielding component – limit state of block shear rupture, kips

T_{ygv} shear yielding component – limit state of block shear rupture, kips

U reduction coefficient, used in calculating effective net area of a tension member

V shear force, kips; basic wind speed, mph;

V_d design shear strength, kips

V_n nominal shear strength, kips

V_{req} required shear strength, kips

V_u shear force under factored loads, kips; required shear strength, kips

W wind load; width across flats of nut, in.

W_d design shear strength of a 1 in. long fillet weld, kli

W_{tp} width of tie plate, measured normal to the length of the member, in.

X_1, X_2 beam buckling factors defined by LRFDS Eqs. F1-8 and F1-9, respectively

Z plastic section modulus, in.^{3}

Z_e effective plastic section modulus, in.^{3}

$Z_{x\,\mathrm{req}}$ required plastic section modulus, in.^{3}

a clear distance between transverse stiffeners, in.; coefficient for eccentrically loaded weld group; depth of bracket plate, in.; length of a rectangular plate measured in the direction of main longitudinal stress in the plate, in.;

a distance from bolt centerline to edge of fitting subjected to prying action, but not greater than 1.25b, in.

b compression element width perpendicular to load direction, in.; width of a rectangular section, in.; minimum shelf dimension for deposition of fillet weld, in.; width of bracket plate, in.; width of bracket flange plate, in.; distance from bolt centerline to face of fitting subjected to prying action, in.

b coefficient related to axial compressive strength for beam-column design, $(\text{kips})^{-1}$

b_e effective width of the compression block of a bracket flange plate, in.

b_f flange width of rolled beam or plate girder, in.

b_s width of extended end-plate, in.

b_{st} width of transverse or diagonal plate stiffener, in.

c distance from neutral axis to extreme fiber where flexural stress is computed, in.

c_b distance from neutral axis to extreme bottom fiber

c_t distance from neutral axis to extreme top fiber

d nominal diameter of a bolt, in.; overall depth of member, in. ; pin diameter, in.; roller diameter, in.

d_R nominal diameter of a threaded rod, in.

d_b depth of beam, in.

d_c depth of column, in.

d_{cope} depth of cope, in.

d_{dp} width of doubler plate, in.

d_e effective width of bolt hole, in.

d_h diameter of bolt hole (STD or OVS holes), in.

d_i distance between the center of gravity of an element, *i* of a cross section to the center of gravity of the cross section (for use in parallel axis theorem)

d_{fp} moment arm between the center lines of flange plates of a flange-plated moment connection, in.

d_{dp} width of doubler plate, in.

d_{pw} diameter of plug weld, in.

$d_{pw,\,\max}$ maximum diameter of hole for a plug weld, in.

$d_{pw,\,\min}$ minimum diameter of hole for a plug weld, in.

d_{sw} width of slot for a slot weld, in.

$d_{sw,\,\max}$ maximum width of hole for a slot weld, in.

$d_{sw,\,\min}$ minimum width of hole for a slot weld, in.

e base of natural logarithm = 2.71828...; eccentricity of load; elongation

e_o horizontal distance from the outer edge of channel web to its shear center, in.

e_y lever arm between the forces C_y and T_y

e_p lever arm between the forces C_p and T_p

f stress; computed compressive stress; average stress in a stub column test

f_E Euler stress (elastic buckling stress of a pin-ended column), ksi

f_a average compressive stress in a plate, ksi

f_b maximum bending stress, ksi

f_c' specified 28-day compressive strength of concrete, ksi

f_{cr} critical stress of a compressed member or element, ksi

f_{pl} proportional limit; proportional limit from stub column test

f_r residual stress

f_{rc} residual compressive stress

f_{rt} residual tensile stress

f_u ultimate stress of a plate, including any post-buckling strength

f_v nominal shear stress, ksi

g transverse center-to-center spacing (gage) between bolt gage lines, in.; acceleration due to gravity (= 32.2 ft/sec^2)

g_A gage used in leg *A* of framing angle, in.

g_B gage used in leg *B* of framing angle, in.

g_a, g_b gage distances to lines of bolt holes located in two adjacent elements of a tension member, measured from the heel, in.

g_a', g_b' gage distances to lines of bolt holes located in two adjacent elements of a tension member, measured along the center line of those elements, in.

g_{ab} distance between two lines of bolt holes, in two adjacent elements of a tension member, measured along the center line of those elements

g_j gage for *j*th diagonal segment along possible failure path *k,* for a tension member, in.

g_1 gage distance in angle leg when only one line of bolts is used in that leg, in.

g_2, g_3 gage distances in angle leg when two lines of bolts are used in that leg, in.

h clear distance between flanges less the fillet or corner radius for rolled shapes; and for built-up welded sections, the clear distance between flanges, in.

h mean roof height of a building, ft; height of a portal frame, in. or ft, as indicated

h rise of a roof truss or gable, ft

h_c twice the distance from the centroid to the following: the inside face of the compression flange less the fillet or corner radius, for rolled shapes; the inside face of the compression flange when welds are used, or the nearest line of bolts at the compression flange, for built-up sections, in.

h_{dp} height of doubler plate, in.

k distance from outer face of flange to web toe of fillet; plate buckling coefficient

k_c plate buckli9ng coefficient

k_v web plate buckling coefficient

k_1 distance from web centerline to flange toe of fillet, in.

l length of the reference segment of weld group considered, in.

m number of floors supported by a column, at a level considered

m coefficient related to strong-axis flexural strength for beam-column design, $(\text{ft-kips})^{-1}$

m cantilever dimension for base plate, used to determine plate thickness, in.

n number of component parts in a built-up section; number of bolts in a vertical row; number of threads per inch on threaded fasteners

n coefficient related to weak-axis flexural strength for beam-column design, $(\text{ft-kips})^{-1}$

n cantilever dimension for base plate, used to determine plate thickness, in.

n' number of bolts above the neutral axis (in tension)

n_d number of gage spaces with a diagonal segment along failure path k of a tension member

n_e number of end bolts in a bolted joint ; number of elements in the cross section of a tension member

n_i number of interior bolts in a bolted joint

n_r number of bolts in a horizontal row

n_t number of threads per inch

p distance center-to-center of two adjacent bolt holes on a given gage line (pitch of bolts), in.;

longitudinal center-to-center spacing (pitch) of intermittent fillet welds, in.

p wind pressure, psf; length of supporting flange parallel to stem or leg of hanger tributary to each bolt in determining prying forces, in.

p_{Db} dead load per unit area on the tributary area of an interior beam, psf

p_{Lb} design live load intensity on the tributary area of an interior beam, psf

p_{Lc} design live load intensity on the tributary area of an interior column, psf

p_{Lg} design live load intensity on the tributary area of an interior girder, psf

p_e external wind pressure, psf; effective span used to compute M_{eu} for extended end-plate connections, in.

p_f distance from centerline of bolt to nearer surface of tension flange in extended end-plate connections, in.

p_i internal wind pressure, psf

p_g ground snow load, psf

p_f flat roof snow load, psf

p_s sloped-roof snow load, psf

p_{full} limiting value of pitch above which limit state of bolt ovalization controls bearing strength, in.

p_{ui} intensity of unbalanced snow load on the leeward side, psf

p_{uw} intensity of unbalanced snow load on the windward side, psf

q uniformly distributed transverse load on a member, klf

q_b self-weight per unit length of an interior beam, plf

q_c self-weight per unit length of an interior column, plf

q_{Db} dead load per unit length of an interior beam, plf

q_g self-weight per unit length of an interior girder, plf

q_h velocity pressure evaluated at height *h*

q_{Lb} live load per unit length of an interior beam, plf

q_{sv} shear flow, kli

q_u additional tension per bolt resulting from prying action produced by deformation of the connected parts, kips/bolt

q_{ub} factored uniformly distributed load on a beam, plf

q_{ug} factored uniformly distributed load on a girder, plf

q_z velocity pressure

r radius of gyration, in.; governing radius of gyration about the axis of buckling, in.; radial distance, in.

r_L live load reduction multiplier

$r_{L\min}$ minimum value to be used for the live load reduction multiplier, r_L

r_i minimum radius of gyration of individual component in a built-up member, in.

r_{ib} radius of gyration of individual component relative to centroidal axis parallel to member axis of buckling, in.

$r_{\min}$ least radius of gyration, in.

r_n nominal strength per bolt from LRFDS

r_x, r_y radius of gyration about *x* and *y* axes, respectively, in.

r_{yC} radius of gyration of a channel with respect to its *y*-axis, in.

r_z radius of gyration of an angle with respect to *z*-axis, in.

r_o polar radius of gyration about the shear center, in.

s staggered pitch (or, stagger), in.; bolt spacing, in.; length of stub column

s back-to-back spacing of angles in built-up double angle members, in.

s_j staggered pitch for the *j*th diagonal segment along possible failure path *k,* for a tension member, in.

s_{lpw} longitudinal spacing of plug welds, in.

s_{tpw} transverse spacing of plug welds, in.

s_{lsw} longitudinal spacing of slot welds, in.

s_{tsw} transverse spacing of slot welds, in.

t thickness of element, in.; HSS design wall thickness, in.; thickness of a plate, in.

t thickness of bearing plate, in.; thickness of column base plate, in.

t_o thickness of the base plate to be ordered, in.

t_a thickness of framing angle, in.

t_{dp} thickness of doubler plate, in.

t_e effective throat thickness of a fillet weld, in.

t_f flange thickness, in.

t_{fin} finishing allowance for base plate thickness, in.

$\mathrm{t_i}$ thickness of element Ii of a tension member, in.

t_j average element thickness corresponding to the *j*th diagonal segment, along failure path *k* of a tension member

t_p thickness of plate, in.

t_{p1} thickness of thinner part joined

t_{p2} thickness of thicker part joined

t_{tp} thickness of tie plate, in.

t_w web thickness, in.

t_{wb} beam web thickness, in.

t_{wc} column web thickness, in.

t_{wg} girder web thickness, in.

t_{wz} panel zone web thickness, in.

u deflection in the major axis plane (bending or buckling about minor axis)

v deflection in the minor axis plane (bending or buckling about major axis)

w leg size of fillet weld, in.; thickness of plug or slot weld, in.; width of plate, in.

w unit weight of concrete, pcf

w_e effective leg size of fillet weld, in.

$w_{\max}$ maximum size of fillet weld along the edge of a plate element, in.

$\bar{x}$ x-coordinate of center of gravity; horizontal distance from the outer edge of a channel web to its centroid, in.

$\bar{x}_{con}$ connection eccentricity, in.

$\bar{y}$ y-coordinate of center of gravity

x_o, y_o coordinates of the shear center with respect to the centroid, in.

z height above ground level, ft

α shape factor; coefficient of expansion, in./in.; column parameter (Eq. 8.4.5)

α ratio of moment at bolt line to moment at stem line for determining prying action in hanger connections

α_m coefficient for calculating M_{eu} for extended end-plate connections

β member relative stiffness factor for a portal frame; confinement coefficient for concrete under bearing plate or base plate

γ load factor

δ deflection, in.; central deflection of a simple beam; deflection at the free end of a cantilever beam; ratio of net area at bolt line to gross area at face of stem or angle leg used to determine prying action for hanger connections

δ_{all} allowable deflection, in.

δ_{e} percentage elongation

Δ sway, in.; elongation of a tension member, in.

Δ_{oh} translation deflection of the story under consideration, in.

ϵ strain

ϵ_{m} strain corresponding to F_u, in./in.

ϵ_{st} strain at the onset of strain hardening range, in./in.

ϵ_{u} fracture strain, in./in.

ϵ_y yield strain (also known as, elastic strain), in./in.

ϵ_x, ϵ_y, ϵ_z strain in the x-, y-, and z-direction, respectively

ζ exponent for alternate beam-column interaction equation

η exponent for alternate beam-column interaction equation

θ roof slope; inclination of a diagonal brace with the horizontal; inclination of diagonal stiffener with the horizontal; angle of loading measured from the weld longitudinal axis

λ slenderness parameter

λ_c column slenderness parameter

λ_e equivalent slenderness parameter

λ_p limiting slenderness parameter for compact element

λ_{pf} limiting slenderness parameter for the flange of a compact I-shape

λ_{pw} limiting slenderness parameter for the web of a compact I-shape

λ_r limiting slenderness parameter for noncompact element

λ_{rf} limiting slenderness parameter for the flange of a noncompact I-shape

λ_{pv} limiting slenderness of the web below which shear yielding rather than shear buckling controls the design

λ_{rw} limiting slenderness parameter for the web of a noncompact I-shape

μ Poisson's ratio (= 0.3 for steel); coefficient of static friction; mean slip coefficient for slip-critical connections

τ stiffness reduction factor (SRF)

τ shear stress at a point on a given cross section of a beam, located at a distance y from the ENA

Φ curvature

ϕ resistance factor

ϕ_b resistance factor for flexure (= 0.90)

ϕ_c resistance factor for compression (= 0.85)

ϕ_r resistance factor for compression, used in web crippling calculations

ϕ_t resistance factor for tension

ϕ_{t1} resistance factor for tension, limit state of yield on gross area (= 0.90)

ϕ_{t2} resistance factor for tension, limit state of fracture in net area (= 0.75)

ϕ_v resistance factor for shear (= 0.90)

Ω factor of safety

Subscripts

BM base metal

C channel

D direct component

E elastic domain

FLB flange local buckling

I I-shape; instantaneous center of rotation; inelastic domain

L angle

LTB lateral torsional buckling

PC pseudo-channel

PL plate; pseudo-angle

PT pseudo-tee

T T-shape; torsional component

WLB web local buckling

WT WT-shape

a axial; average; seat angle

avg average

b beam; bending; bolt; bearing; bottom

c column; compression; clear; concrete con end connection of a tension member

cr critical

d design

dp doubler plate

e elastic; end; effective

el elastic limit state

f flange

l weld considered as a line element

lt lateral translation

lw longitudinal weld

min minimum

max maximum

n nominal

nt no-translation

p plastic; polar

pl plate; plastic limit state

pw plug weld

r reinforcement (panel zone); reduced modulus

req required

st stiffener; strain hardening

sw slot weld

t tension; top; tangent modulus

tw transverse weld

u ultimate; under factored load; required

v shear

w web; weld

x subscript relating symbol to member strong axis

y yield

y subscript relating symbol to member weak axis

z subscript relating symbol to member longitudinal axis

z subscript relating symbol to week principal axis of angle

z related to panel zone