



AISI S100-2007



North American Specification for the Design of Cold-Formed Steel Structural Members

2007 EDITION

Approved in Canada by the
Canadian Standards Association
CSA S136-07

Endorsed in Mexico by CANACERO



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The material contained herein has been developed by a joint effort of the American Iron and Steel Institute Committee on Specifications, the Canadian Standards Association Technical Committee on Cold Formed Steel Structural Members (S136), and Camara Nacional de la Industria del Hierro y del Acero (CANACERO) in Mexico. The organizations and the Committees have made a diligent effort to present accurate, reliable, and useful information on cold-formed steel design. The Committees acknowledge and are grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. Specific references are included in the *Commentary* on the *Specification*.

With anticipated improvements in understanding of the behavior of cold-formed steel and the continuing development of new technology, this material may eventually become dated. It is anticipated that future editions of this specification will update this material as new information becomes available, but this cannot be guaranteed.

The materials set forth herein are for general information only. They are not a substitute for competent professional advice. Application of this information to a specific project should be reviewed by a registered professional engineer. Indeed, in most jurisdictions, such review is required by law. Anyone making use of the information set forth herein does so at their own risk and assumes any and all resulting liability arising therefrom.

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PREFACE

The *North American Specification for the Design of Cold-Formed Steel Structural Members*, as its name implies, is intended for use throughout Canada, Mexico, and the United States. This *Specification* supersedes the 2001 edition of the *North American Cold-Formed Steel Specification*, the previous editions of the *Specification for the Design of Cold-Formed Steel Structural Members* published by the American Iron and Steel Institute, and the previous editions of CSA Standard S136, *Cold Formed Steel Structural Members*, published by the Canadian Standards Association.

The *Specification* was developed by a joint effort of the American Iron and Steel Institute's Committee on Specifications, the Canadian Standards Association's Technical Committee on Cold Formed Steel Structural Members (S136), and Camara Nacional de la Industria del Hierro y del Acero (CANACERO) in Mexico. This effort was coordinated through the North American Specification Committee, which was made up of members from the AISI Committee on Specifications and CSA's S136 Committee.

Since the *Specification* is intended for use in Canada, Mexico, and the United States, it was necessary to develop a format that would allow for requirements particular to each country. This resulted in a main document, Chapters A through G and Appendix 1 and 2, that is intended for use in all three countries, and two country-specific appendices (A and B). In this edition of the *Specification*, what was previously Appendix C has been combined with Appendix A. The new Appendix A is for use in both the United States and Mexico, and Appendix B is for use in Canada. A symbol (➤ **AB**) is used in the main document to point out that additional provisions are provided in the corresponding appendices indicated by the letters.

This *Specification* provides an integrated treatment of Allowable Strength Design (ASD), Load and Resistance Factor Design (LRFD), and Limit States Design (LSD). This is accomplished by including the appropriate resistance factors (ϕ) for use with LRFD and LSD and the appropriate safety factors (Ω) for use with ASD. It should be noted that the use of LSD is limited to Canada and the use of LRFD and ASD is limited to the United States and Mexico.

The *Specification* also contains some terminology that is defined differently in Canada, the United States, and Mexico. These differences are set out in Section A1.3, "Definitions".

The *Specification* provides well-defined procedures for the design of load-carrying cold-formed steel members in buildings, as well as other applications, provided that proper allowances are made for dynamic effects. The provisions reflect the results of continuing research to develop new and improved information on the structural behavior of cold-formed steel members. The success of these efforts is evident in the wide acceptance of the previous editions of the *Specification* developed by AISI and CSA.

The AISI and CSA consensus committees responsible for developing these provisions provide a balanced forum, with representatives of steel producers, fabricators, users, educators, researchers, and building code regulators. They are composed of engineers with a wide range of experience and high professional standing from throughout Canada and the United States. AISI, CSA, and CANACERO acknowledge the continuing dedication of the members of the specifications committees and their subcommittees. The membership of these committees follows this Preface.

In this edition of the *Specification*, the terminology jointly used by AISC and AISI is applied. Terms defined in Section A1.3 are italicized when they appear for the first time in each section. A new standard numbering system has been introduced for standards developed by AISI: for example, this *Specification* will be referred as AISI S100-07, where the last two digits represent the year that this standard is updated. All AISI test procedures are referenced by a number with the format “S9xx-yy”, where “xx” is the sequence number, starting from “01”, and “yy” is the year the test standard is developed or updated.

In addition, design provisions are reorganized according to their applicability to wall studs and wall stud assemblies (Section D4), floor, roof, or wall steel diaphragm construction (Section D5), and metal roof and wall systems (Section D6). Accordingly, provisions under Chapters C and D of previous editions are relocated.

The other major technical changes made in this edition of the *Specification*, compared to the previous edition are summarized below.

Materials

- Provisions for applications of other steels (Section A2.2) have been rewritten.

Strength

- Strength reduction provisions (Section A2.3.2) are introduced for high-strength and low-ductility closed-box section members.

Elements

- The effective width equation (Eq. B2.2-2) for uniformly compressed stiffened elements with circular holes has been revised.
- New provisions for unstiffened elements and edge stiffeners with stress gradient (Section B3.2) are introduced.
- The provisions for determining the effective width of uniformly compressed elements with one intermediate stiffener (previously in Section B4.1) have been replaced by the provisions of B5.1.

Members

- Provisions for distortional buckling for beams (Section C3.1.4) and columns (C4.2) are introduced.
- The design provisions for bearing stiffeners (previously termed “transverse stiffeners”) have been revised.
- Provisions for web crippling strength for C- or Z-members with an overhang are added in Section C3.4.1.
- The equations for members subjected to combined bending and web crippling have been recalibrated.
- Provisions for considering combined bending and torsional loading (Section C3.6) are added.

Member Bracing

- Explicit equations for determining the required bracing force for members having neither

flange connected to sheathing are provided.

- Provisions for determining the required bracing force and stiffness of a compression member are introduced.

Wall Stud and Wall Stud Assemblies

- The sheathing braced design provisions have been removed.
- New framing standards are referenced.

Floor, Roof, or Wall Steel Diaphragm Construction

- The safety factors and the resistance factors for diaphragms (Section D5) have been revised.

Metal Roof and Wall System

- New provisions for Z-section compression members having one flange fastened to a standing seam roof (Section D6.1.4) are added for the United States and Mexico.
- For standing seam roof panel systems, a load reduction is permitted in the United States and Mexico for load combinations that include wind uplift.
- The provisions for determining the anchorage forces and required stiffness for a purlin roof system under gravity load with the top flange connected to metal sheathing have been revised.

Connections

- Provisions for shear strength determination of welded sheet-to-sheet connections are added.
- An interaction check for screws subjected to combined shear and pull-over is added.
- The design provisions for block shear rupture (Section E5.3) have been revised.

Appendix B

- The section for delivered minimum thickness for Canada is deleted.
- The specified loads (Section A3.1) and the load factors and load combinations for LSD (Section A6.1.2) for Canada have been revised.

New Appendices

- Appendix 1, Design of Cold-Formed Steel Structural Members Using the Direct Strength Method, is added. The Direct Strength Method provides alternative design provisions for several sections of Chapters C and D.
- Appendix 2, Second Order Analysis, is added. Appendix 2 provides alternative method for considering the second order effect in members subjected to compression and bending.

Users of the *Specification* are encouraged to offer comments and suggestions for improvement.

American Iron and Steel Institute
Canadian Standards Association
Camara Nacional de la Industria del Hierro y del Acero
July 2007

July 2007

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SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
A	Full unreduced cross-sectional area of member	A1.3, C3.1.2.1, C4.1.2, C5.2.1, C5.2.2, C4.1.5, D6.1.3, D6.1.4, 2.2.3
A	Area of directly connected elements or gross area	E2.7
A_b	$b_1t + A_s$, for bearing stiffener at interior support and or under concentrated load, and $b_2t + A_s$, for bearing stiffeners at end support	C3.7.1
A_b	Gross cross-sectional area of bolt	E3.4
A_c	$18t^2 + A_s$, for bearing stiffener at interior support or under concentrated load, and $10t^2 + A_s$, for bearing stiffeners at end support	C3.7.1
A_e	Effective area at stress F_n	A1.3, C3.7.1, C3.7.2, C4.1, C4.1.2, C5.2.1, C5.2.2, C4.1.5
A_e	Effective net area	E2.7, E3.2
A_f	Cross-sectional area of compression flange plus edge stiffener	C3.1.4
A_g	Gross area of element including stiffeners	B5.1
A_g	Gross area of section	A1.3, C2, C2.1, C4.2, E2.7, E3.2, 1.2.1.1
A_{gv}	Gross area subject to shear	E5.3
A_{nt}	Net area subject to tension	E5.3
A_{nv}	Net area subject to shear	E5.3
A_n	Net area of cross-section	A1.3, C2, C2.2, E3.2
A_o	Reduced area due to local buckling	C4.1.5
A_p	Gross cross-sectional area of roof panel per unit width	D6.3.1
A_s	Cross-sectional area of bearing stiffener	C3.7.1
A_s	Gross area of stiffener	B5.1
A_{st}	Gross area of shear stiffener	C3.7.3
A_t	Net tensile area	G4
A_w	Area of web	C3.2.1
A_{wn}	Net web area	E5.1
a	Shear panel length of unreinforced web element, or distance between shear stiffeners of reinforced web elements	C3.2.1, C3.7.3
a	Intermediate fastener or spot weld spacing	D1.2
a	Fastener distance from outside web edge	D6.1.3
a	Length of bracing interval	D3.2.1

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
B_c	Term for determining tensile yield point of corners	A7.2
b	Effective design width of compression element	B2.1, B2.2, B3.1, B3.2, B4
b	Flange width	D6.1.3, D6.3.1
b_d	Effective width for deflection calculation	B2.1, B2.2, B3.1, B3.2, B4, B5.2
b_e	Effective width of elements, located at centroid of element including stiffeners	B5.1
b_e	Effective width	B2.3
b_e	Effective width determined either by Section B4 or Section B5.1 depending on stiffness of stiffeners	B5.2
b_o	Out-to-out width of compression flange as defined in Figure B2.3-2	B2.3, C3.1.4, C4.2
b_o	Overall width of unstiffened element as defined in Figure B3.2-3	B3.2
b_o	Total flat width of stiffened element	B5.1
b_o	Total flat width of edge stiffened element	B5.2, 1.1.1.1, 1.1.1.2
b_p	Largest sub-element flat width	B5.1
b_1, b_2	Effective widths	B2.3, B2.4
b_1, b_2	Effective widths of bearing stiffeners	C3.7.1
C	For compression members, ratio of total corner cross-sectional area to total cross-sectional area of full section; for flexural members, ratio of total corner cross-sectional area of controlling flange to full cross-sectional area of controlling flange	A7.2
C	Coefficient	C3.4.1
C	Bearing factor	E3.3.1
C_b	Bending coefficient dependent on moment gradient	C3.1.2.1, C3.1.2.2
C_f	Constant from Table G1	G1, G3, G4
C_h	Web slenderness coefficient	C3.4.1
C_m	End moment coefficient in interaction formula	C5.2.1, C5.2.2
C_{mx}	End moment coefficient in interaction formula	C5.2.1, C5.2.2, 2.1
C_{my}	End moment coefficient in interaction formula	C5.2.1, C5.2.2, 2.1
C_N	Bearing length coefficient	C3.4.1
C_p	Correction factor	F1.1
C_R	Inside bend radius coefficient	C3.4.1
C_s	Coefficient for lateral-torsional buckling	C3.1.2.1
C_{TF}	End moment coefficient in interaction formula	C3.1.2.1
C_v	Shear stiffener coefficient	C3.7.3

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
C_w	Torsional warping constant of cross-section	C3.1.2.1
C_{wf}	Torsional warping constant of flange	C3.1.4, C4.2
C_y	Compression strain factor	C3.1.1
$C_1, C_2,$ C_3	Axial buckling coefficients	D6.1.3
C_1 to C_6	Coefficients tabulated in Tables D6.3.1-1 to D6.3.1-3	D6.3.1
C_ϕ	Calibration coefficient	F1.1
c	Strip of flat width adjacent to hole	B2.2
c	Distance	C3.2.2
c_f	Amount of curling displacement	B1.1
c_i	Horizontal distance from edge of element to centerline of stiffener	B5.1, B5.1.2
D	Outside diameter of cylindrical tube	C6, C3.1.3, C4.1.5
D	Overall depth of lip	B1.1, B4, C3.1.4, C4.2, 1.1.1.1, 1.1.1.2
D	Shear stiffener coefficient	C3.7.3
D	Dead load	A3.1, A6.1.2
D_2, D_3	Lip dimension	1.1.1.1, 1.1.1.2
d	Depth of section	B1.1, C3.1.2.1, C3.4.2, C3.7.2, D3.2.1, D6.1.1, D6.1.3, D6.1.4, D6.3.1
d	Nominal screw diameter	E4, E4.1, E4.2, E4.3.1, E4.4.1, E4.5.1, E4.5.2
d	Flat depth of lip defined in Figure B4-1	B4
d	Width of arc seam weld	E2.3
d	Visible diameter of outer surface of arc spot weld	E2.2.1.1, E2.2.1.2, E2.2.1.3, E2.2.2
d	Diameter of bolt	E3a, E3.2, E3.3.1, E3.3.2, E3.4
d_a	Average diameter of arc spot weld at mid-thickness of t	E2.2.1.2, E2.2.1.3, E2.2.2
d_a	Average width of seam weld	E2.3
d_b	Nominal diameter (body or shank diameter)	G4
d_e	Effective diameter of fused area	E2.2, E2.2.1.2, E2.2.1.3, E2.2.2
d_e	Effective width of arc seam weld at fused surfaces	E2.3
d_h	Diameter of hole	B2.2
d_h	Depth of hole	B2.2, B2.4, C3.2.2, C3.4.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
d_h	Diameter of standard hole	E3a, E3.1, E3.2, E5.1
$d_{p_{i,j}}$	Distance along roof slope between the i th purlin line and the j th anchorage device	D6.3.1
d_s	Reduced effective width of stiffener	B4
d_s	Depth of stiffener	1.1.1.2
d'_s	Effective width of stiffener calculated according to B3.1	B4
d_{wx}	Screw head or washer diameter	E4.4
d_w	Larger value of screw head or washer diameter	E4, E4.4, E4.4.2, E4.5.1, E4.5.2
E	Modulus of elasticity of steel, 29,500 ksi (203,000 MPa, or 2,070,000 kg/cm ²)	A2.3.2, B1.1, B2.1, B4, B5.1, C3.1.1, C3.1.2.1, C3.1.2.2, C3.1.4, C3.2.1, C3.5.1, C3.5.2, C3.7.1, C3.7.3, C4.1.1, C4.2, C5.2.1, C5.2.2, C3.1.3, C4.1.5, D1.3, D6.1.3, D6.3.1, E2.2.1.2, 1.1.1.1, 1.1.1.2, 2.2.3
E	Live load due to earthquake	A3.1, A6.1.2, A6.1.2.1
E^*	twist of stud from initial, ideal, unbuckled shape Reduced modulus of elasticity for flexural and axial stiffness in second-order analysis	2.2.3
e	Distance measured in line of force from center of a standard hole to nearest edge of an adjacent hole or to end of connected part toward which force is directed	E3.1, E3.1a
e	Distance measured in line of force from center of a standard hole to nearest end of connected part	E4.3.2
e_{min}	Minimum allowable distance measured in line of force from centerline of a weld to nearest edge of an adjacent weld or to end of connected part toward which the force is directed	E2.2.1.1, E2.2.2
e_{sx}, e_{sy}	Eccentricities of load components measured from the shear center and in the x- and y- directions, respectively	D3.2.1
e_y	Yield strain = F_y/E	C3.1.1
F	Fabrication factor	F1.1
F_{SR}	Design stress range	G3
F_{TH}	Threshold fatigue stress range	G1, G3, G4
F_c	Critical buckling stress	B2.1, C3.1.2.1, C3.1.3

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Symbol	Definition	Section
F_{cr}	Plate elastic buckling stress	A2.3.2, B2.1, B5.1
F_d	Elastic distortional buckling stress	C3.1.4, C4.2
F_e	Elastic buckling stress	C3.1.2.1, C3.1.2.2, C4.1, C4.1.1, C4.1.2, C4.1.3, C4.1.4, C4.1.5
F_m	Mean value of fabrication factor	D6.2.1, F1.1
F_n	Nominal buckling stress	B2.1, C4.1, C5.2.1, C5.2.2
F_n	Nominal strength [resistance] of bolts	E3.4
F_{nt}	Nominal tensile strength [resistance] of bolts	E3.4
F_{nv}	Nominal shear strength [resistance] of bolts	E3.4
F'_{nt}	Nominal tensile strength [resistance] for bolts subject to combination of shear and tension	E3.4
F_{sy}	Yield stress as specified in Section A2.1, A2.2, or A2.3.2	A2.3.2, E2.2.1.1, E3.1
F_t	Nominal tensile stress in flat sheet	E3.2
F_u	Tensile strength as specified in Section A2.1, A2.2, or A2.3.2	A2.3.2, C2, C2.2, E2.2.1.1, E2.2.1.2, E2.2.1.3, E2.2.2, E2.3, E2.4, E2.5, E2.7, E3.1, E3.2, E3.3.1, E3.3.2, E4.3.2, E5.1, E5.3
F_{uv}	Tensile strength of virgin steel specified by Section A2 or established in accordance with Section F3.3	A7.2
F_{wy}	Lower value of F_y for beam web or F_{ys} for bearing stiffeners	C3.7.1
F_{xx}	Tensile strength of electrode classification	E2.1, E2.2.1.2, E2.2.1.3, E2.2.2, E2.3, E2.4, E2.5
F_{u1}	Tensile strength of member in contact with screw head	E4, E4.3.1, E4.4.2, E4.5.1, E4.5.2
F_{u2}	Tensile strength of member not in contact with screw head	E4, E4.3.1, E4.4.1
F_v	Nominal shear stress	E3.2.1
F_y	Yield stress used for design, not to exceed specified yield stress or established in accordance with Section F3, or as increased for cold work of forming in Section A7.2 or as reduced for low ductility steels in Section	A2.3.2, A7.1, A7.2, B2.1, C2, C2.1, C3.1.1, C3.1.2.1, C3.1.2.2, D6.1.1, C3.2.1, C3.4.1, C3.5.1, C3.5.2, A2.3.2, C3.7.1, C3.7.2, C3.7.3, C4.1, C4.1.2, C4.2, C5.1.1, C5.2.1, C5.2.2, C6, C3.1.3, C4.1.5, C5.1.2, D1.3, D6.1.2, D6.1.4, E2.1, E2.2.2, E5.2, G1, 1.1.1.1, 1.1.1.2, 1.2.1.1, 2.2.3
F_{ya}	Average yield stress of section	A7.2
F_{yc}	Tensile yield stress of corners	A7.2
F_{yf}	Weighted average tensile yield stress of flat portions	A7.2, F3.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
F_{ys}	Yield stress of stiffener steel	C3.7.1
F_{yv}	Tensile yield stress of virgin steel specified by Section A2 or established in accordance with Section F3.3	A7.2
f	Stress in compression element computed on basis of effective design width	B2.1, B2.2, B2.4, B3.1, B3.2, B4, B5.1, B5.1.1, B5.1.2, B5.2
f_{av}	Average computed stress in full unreduced flange width	B1.1
f_c	Stress at service load in cover plate or sheet	D1.3
$f_{bending}$	Normal stress due to bending alone at the maximum normal stress on the cross section due to combined bending and torsion	C3.6
$f_{torsion}$	Normal stress due to torsion alone at the maximum normal stress on the cross section due to combined bending and torsion	C3.6
f_d	Computed compressive stress in element being considered. Calculations are based on effective section at load for which deflections are determined.	B2.1, B2.2, B3.1, B4, B5.1.1, B5.1.2, B5.2
f_{d1}, f_{d2}	Computed stresses f_1 and f_2 as shown in Figure B2.3-1. Calculations are based on effective section at load for which serviceability is determined.	B2.3
f_{d1}, f_{d2}	Computed stresses f_1 and f_2 in unstiffened element, as defined in Figures B3.2-1 to B3.2-3. Calculations are based on effective section at load for which serviceability is determined.	B3.2
f_v	Required shear stress on a bolt	E3.4
f_1, f_2	Web stresses defined by Figure B2.3-1	B2.3, B2.4
f_1, f_2	Stresses on unstiffened element defined by Figures B3.2-1 to B3.2-3	B3.2
f_1, f_2	Stresses at the opposite ends of web	C3.1.4
G	Shear modulus of steel, 11,300 ksi (78,000 MPa or 795,000 kg/cm ²)	C3.1.2.1, C3.1.2.2, C3.1.4
g	Vertical distance between two rows of connections nearest to top and bottom flanges	D1.1
g	Transverse center-to-center spacing between fastener gage lines	E3.2
g	Gauge, spacing of fastener perpendicular to force	C2.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
H	A permanent load due to lateral earth pressure, including groundwater	A3.1, A3.2
h	Depth of flat portion of web measured along plane of web	B1.2, B2.4, C3.1.1, C3.2.1, C3.2.2, C3.4.1, C3.4.2, C3.5.1, C3.5.2, C3.7.3
h	Width of elements adjoining stiffened element	B5.1
h	Lip height as defined in Figures E2.5-4 to E2.5-7	E2.5
h_o	Out-to-out depth of web	B2.3, C3.1.4, C4.2, 1.1.1.1, 1.1.1.2
h_o	Overall depth of unstiffened C-section member as defined in Figure B3.2-3	B3.2
h_s	Depth of soil supported by the structure	A6.1.2
h_{wc}	Coped flat web depth	E5.1
h_x	x distance from the centroid of flange to the shear center of the flange	C3.1.4
I_E	Importance factor for earthquake	A6.1.2.2
I_S	Importance factor for snow	A6.1.2.2
I_W	Importance factor for wind	A6.1.2.2
I_a	Adequate moment of inertia of stiffener, so that each component element will behave as a stiffened element	B1.1, B4
I_{eff}	Effective moment of inertia	1.1.3
I_g	Gross moment of inertia	1.1.3
I_s	Actual moment of inertia of full stiffener about its own centroidal axis parallel to element to be stiffened	B1.1, B4, C3.7.3
I_{smin}	Minimum moment of inertia of shear stiffener(s) with respect to an axis in plane of web	C3.7.3
I_{sp}	Moment of inertia of stiffener about centerline of flat portion of element	B5.1, B5.1.1, B5.1.2
I_x, I_y	Moment of inertia of full unreduced section about principal axis	C3.1.2.1, C3.1.2.2, C5.2.1, C5.2.2, D3.2.1, D6.3.1
I_{xf}	x-axis moment of inertia of the flange	C3.1.4, C4.2
I_{xy}	Product of inertia of full unreduced section about major and minor centroidal axes	D3.2.1, D6.3.1
I_{xyf}	Product of inertia of flange about major and minor centroidal axes	C3.1.4, C4.2
I_{yc}	Moment of inertia of compression portion of section about centroidal axis of entire section parallel to web,	C3.1.2.1

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Symbol	Definition	Section
I_{yf}	using full unreduced section y-axis moment of inertia of flange	C3.1.4, C4.2
i	Index of stiffener	B5.1, B5.1.2
i	Index of each purlin line	D6.3.1
J	Saint-Venant torsion constant	C3.1.2.1, C3.1.2.2
J_f	Saint-Venant torsion constant of compression flange, plus edge stiffener about an x-y axis located at the centroid of the flange	C3.1.4
j	Section property for torsional-flexural buckling	C3.1.2.1
j	Index for each anchorage device	D6.3.1
K	Effective length factor	A2.3.2, C4.1.1, D1.2
K'	A constant	D3.2.1
K_a	Lateral stiffness of anchorage device	D6.3.1
K_{af}	Parameter for determining axial strength of Z-Section member having one flange fastened to sheathing	D6.1.4
$K_{eff,i,j}$	Effective lateral stiffness of j th anchorage device with respect to i th purlin	D6.3.1
K_{req}	Required stiffness	D6.3.1
K_{sys}	Lateral stiffness of roof system, neglecting anchorage devices	D6.3.1
K_t	Effective length factor for torsion	C3.1.2.1
$K_{total,i}$	Effective lateral stiffness of all elements resisting force P_i	D6.3.1
K_x	Effective length factor for buckling about x-axis	C3.1.2.1, C5.2.1, C5.2.2, 2.1
K_y	Effective length factor for buckling about y-axis	C3.1.2.1, C3.1.2.2, C5.2.1, C5.2.2, 2.1
k	Plate buckling coefficient	B2.1, B2.2, B2.3, B3.1, B3.2, B4, B5.1, B5.2
k_d	Plate buckling coefficient for distortional buckling	B5.1, B5.1.1, B5.1.2, C3.1.4, C4.2
k_{loc}	Plate buckling coefficient for local sub-element buckling	B5.1, B5.1.1, B5.1.2
k_v	Shear buckling coefficient	C3.2.1, C3.7.3,
k_ϕ	Rotational stiffness	C3.1.4, C4.2
$k_{\phi fe}$	Elastic rotational stiffness provided by the flange to the flange/web juncture	C3.1.4, C4.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
$\tilde{k}_{\phi fg}$	Geometric rotational stiffness demanded by the flange from the flange/web juncture	C3.1.4, C4.2
$k_{\phi we}$	Elastic rotational stiffness provided by the web to the flange/web juncture	C3.1.4, C4.2
$\tilde{k}_{\phi wg}$	Geometric rotational stiffness demanded by the web from the flange/web juncture	C3.1.4, C4.2
L	Full span for simple beams, distance between inflection point for continuous beams, twice member length for cantilever beams	B1.1
L	Span length	D6.3.1, D1.1
L	Length of weld	E2.1, E2.5
L	Length of longitudinal welds	E2.7
L	Length of seam weld not including circular ends	E2.3
L	Length of fillet weld	E2.4
L	Length of connection	E3.2
L	Unbraced length of member	C4.1.1, D1.2, C5.2.1, C5.2.2
L	Overall length	A2.3.2
L	Live load	A3.1, A6.1.2, A6.1.2.1
L	Minimum of L_{cr} and L_m	C3.1.4, C4.2
L_b	Distance between braces on one compression member	D3.3
L_{br}	Unsupported length between brace points or other restraints which restrict distortional buckling of element	B5.1, B5.1.1, B5.1.2
L_c	Summation of critical path lengths of each segment	C2.2
L_{cr}	Critical unbraced length of distortional buckling	C3.1.4, C4.2
L_{gv}	Gross failure path length parallel to force	C2.2
L_h	Length of hole	B2.2, B2.4, C3.2.2, C3.4.2
L_m	Distance between discrete restraints that restrict distortional buckling	C3.1.4, C4.2
L_{nv}	Net failure path length parallel to force	C2.2
L_o	Overhang length measured from the edge of bearing to the end of member	C3.4.1
L_s	Net failure path length inclined to force	C2.2
L_{st}	Length of bearing stiffener	C3.7.1
L_t	Unbraced length of compression member for torsion	C3.1.2.1
L_t	Net failure path length normal to force due to direct tension	C2.2

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Symbol	Definition	Section
L_u	Limit of unbraced length below which lateral-torsional buckling is not considered	C3.1.2.2
L_x	Unbraced length of compression member for bending about x-axis	C3.1.2.1, C5.2.1, C5.2.2
L_y	Unbraced length of compression member for bending about y-axis	C3.1.2.1, C3.1.2.2, C5.2.1, C5.2.2
L_0	Length at which local buckling stress equals flexural buckling stress	A2.3.2
l	Distance from concentrated load to a brace	D3.2.1
M	Required allowable flexural strength, ASD	C3.3.1, C3.5.1
M	Bending moment	1.1.3
M_{crd}	Distortional buckling moment	C3.1.4, 1.1.2, 1.2.2.3
M_{cre}	Overall buckling moment	1.1.2, 1.2.2.1
$M_{cr\ell}$	Local buckling moment	1.1.2, 1.2.2.2
M_d	Nominal moment with consideration of deflection	1.1.3
M_f	Factored moment	C3.3.2
M_{fx}, M_{fy}	Moments due to factored loads with respect to centroidal axes	C4.1, C5.1.2, C5.2.2
M_m	Mean value of material factor	D6.2.1, F1.1
M_{max}, M_A, M_B	Absolute value of moments in unbraced segment, used for determining C_b	C3.1.2.1
M_C		
M_n	Nominal flexural strength [resistance]	B2.1, C3.1, C3.1.1, C3.1.2.1, C3.1.2.2, C3.1.3, C3.1.4, C3.3.1, C3.3.2, D6.1.1, D6.1.2, 1.1.1, 1.1.3, 1.2.2, 1.2.2.2, 1.2.2.3
M_{nd}	Nominal flexural strength for distortional buckling	1.2.2, 1.2.2.1, 1.2.2.2
M_{ne}	Nominal flexural strength for overall buckling	1.2.2, 1.2.2.1, 1.2.2.2
$M_{n\ell}$	Nominal flexural strength for local buckling	1.2.2, 1.2.2.2
M_{nx}, M_{ny}	Nominal flexural strengths [resistances] about centroidal axes determined in accordance with Section C3	C5.1.1, C5.1.2, C5.2.1, C5.2.2
M_{nxo}, M_{nyo}	Nominal flexural strengths [resistances] about centroidal axes determined in accordance with Section C3.1 excluding provisions of Section C3.1.2	C3.3.1, C3.3.2, C3.5.1, C3.5.2
M_{nxt}	Nominal flexural strengths [resistances] about	C5.1.1, C5.1.2

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Symbol	Definition	Section
M_{nyt}	centroidal axes determined using gross, unreduced cross-section properties	
M_x ,	Required allowable flexural strength with respect to	C4.1, C5.1.1, C5.2.1
M_y	centroidal axes for ASD	
M_u	Required flexural strength for LRFD	C3.3.2, C3.5.2
M_{ux} ,	Required flexural strength with respect to	C4.1, C5.1.2, C5.2.2
M_{uy}	centroidal axes for LRFD	
M_y	Moment causing maximum strain ϵ_y	B2.1, C3.1.2
M_y	Yield moment ($=S_y F_y$)	C3.1.4, 1.1.3, 1.2.2.1, 1.2.2.3
M_1	Smaller end moment in an unbraced segment	C3.1.2.1, C3.1.4, C5.2.1, C5.2.2
M_2	Larger end moment in an unbraced segment	C3.1.2.1, C3.1.4, C5.2.1, C5.2.2
$\bar{M}$	Required flexural strength [factored moment]	C3.3.2, C3.5.2
$\bar{M}_x$,	Required flexural strengths [factored moments]	C4.1, C5.1.2
$\bar{M}_y$		
M_z	Torsional moment of required load P about shear center	D3.2.1
m	Degrees of freedom	F1.1
m	Term for determining tensile yield point of corners	A7.2
m	Distance from shear center of one C-section to mid-plane of web	D1.1, D3.2.1, D6.3.1
m_f	Modification factor for type of bearing connection	E3.3.1
N	Actual length of bearing	C3.4.1, C3.4.2, C3.5.1, C3.5.2
N	Number of stress range fluctuations in design life	G3
N_a	Number of anchorage devices along a line of anchorage	D6.3.1
N_i	Notional lateral load applied at level i	2.2.4
N_p	Number of purlin lines on roof slope	D6.3.1
n	Coefficient	B4
n	Number of stiffeners	B5.1, B5.1.1, B5.1.2, 1.1.1.2
n	Number of holes	E5.1
n	Number of tests	F1.1
n	Number of equally spaced intermediate brace locations	D3.3
n	Number of anchors in test assembly with same tributary area (for anchor failure), or number of panels with identical spans and loading to failed span (for non-anchor failure)	D6.2.1
n	Number of threads per inch	G4

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Symbol	Definition	Section
n_b	Number of bolt holes	E3.2
n_c	Number of compression flange stiffeners	1.1.1.2
n_w	Number of web stiffeners and/or folds	1.1.1.2
n_t	Number of tension flange stiffeners	1.1.1.2
P	Required allowable strength for concentrated load reaction in presence of bending moment for ASD	C3.5.1
P	Required allowable strength (nominal force) transmitted by weld for ASD	E2.2.1.1
P	Required allowable compressive axial strength for ASD	A2.3.1, C5.2.1
P	Professional factor	F1.1
P	Required concentrated load [factored load] within a distance of $0.3a$ on each side of a brace, plus $1.4(1-l/a)$ times each required concentrated load located farther than $0.3a$ but not farther than $1.0a$ from the brace	D3.2.1
P	Required nominal brace strength [resistance] for a single compression member	D3.3
P_{Ex}	Elastic buckling strengths [resistances]	C5.2.1, C5.2.2
P_{Ey}		
P_{L1}, P_{L2}	Lateral bracing forces	D3.2.1
P_{Lj}	Lateral force to be resisted by the j th anchorage device	D6.3.1
P_{crd}	Distortional buckling load	C4.2, 1.1.2, 1.2.1.3
P_{cre}	Overall buckling load	1.1.2, 1.2.1.1
$P_{cr\ell}$	Local buckling load	1.1.2, 1.2.1.2
P_f	Axial force due to factored loads	A2.3.1, C5.2.2
P_f	Concentrated load or reaction due to factored loads	C3.5.2
P_f	Factored shear force transmitted by welding	E2.2.1.1
P_i	Lateral force introduced into the system at the i th purlin	D6.3.1
P_m	Mean value of the tested-to-predicted load ratios	F1.1
P_n	Nominal web crippling strength [resistance]	C3.4.1, C3.5.1, C3.5.2, A2.3.1,
P_n	Nominal axial strength [resistance] of member	C4.1, C4.2, C5.2.1, C5.2.2, D3.3, D6.1.3, D6.1.4, 1.1.1, 1.2.1, 2.1
P_n	Nominal axial strength [resistance] of bearing stiffener	C3.7.1, C3.7.2
P_n	Nominal strength [resistance] of connection component	E2.1, E2.2.1.2, E2.2.1.3, E2.2.2, E2.3, E2.4, E2.5, E2.6, E3.1, E3.2
P_n	Nominal bearing strength [resistance]	E3.3.1, E3.3.2
P_n	Nominal tensile strength [resistance] of welded member	E2.7

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Symbol	Definition	Section
P_n	Nominal bolt strength [resistance]	E3.4
P_{nc}	Nominal web crippling strength [resistance] of C- or Z-Section with overhang(s)	C3.4.1
P_{nd}	Nominal axial strength for distortional buckling	1.2.1, 1.2.1.3
P_{ne}	Nominal axial strength for overall buckling	1.2.1, 1.2.1.1, 1.2.1.2
$P_{n\ell}$	Nominal axial strength for local buckling	1.2.1, 1.2.1.2
P_{no}	Nominal axial strength [resistance] of member determined in accordance with Section C4 with $F_n = F_y$	C5.2.1, C5.2.2
P_{not}	Nominal pull-out strength [resistance] per screw	E4, E4.4.1, E4.4.3
P_{nov}	Nominal pull-over strength [resistance] per screw	E4, E4.4.2, E4.4.3, E4.5.1, E4.5.2
P_{ns}	Nominal shear strength [resistance] per screw	E4, E4.2, E4.3.1, E4.3.2, E4.3.3, E4.5.1, E4.5.2
P_{nt}	Nominal tension strength [resistance] per screw	E4, E4.4.3
P_r	Required axial compressive strength [resistance]	2.2.3
P_s	Concentrated load or reaction	D1.1
P_{ss}	Nominal shear strength [resistance] of screw as reported by manufacturer or determined by independent laboratory testing	E4, E4.3.3
P_{ts}	Nominal tension strength [resistance] of screws as reported by manufacturer or determined by independent laboratory testing	E4, E4.4.3
P_u	Required axial strength for LRFD	A2.3.1, C5.2.2
P_u	Factored force (required strength) transmitted by weld, for LRFD	E2.2.1.1
P_u	Required strength for concentrated load or reaction in presence of bending moment for LRFD	C3.5.2
P_{wc}	Nominal web crippling strength [resistance] for C-Section flexural member	C3.7.2
P_x, P_y	Components of required load P parallel to x and y axis, respectively	D3.2.1
P_y	Member yield strength	C4.2, 1.2.1.1, 1.2.1.3, 2.2.3
$\bar{P}$	Required strength for concentrated load or reaction [concentrated load or reaction due to factored loads] in presence of bending moment.	C3.5.2
$\bar{P}$	Required compressive axial strength [factored compressive force]	C5.2.2
p	Pitch (mm per thread for SI units and cm per thread for MKS units)	G4

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
Q	Required allowable shear strength of connection	E4.5.1
$\overline{Q}$	Required shear strength [factored shear force] of connection	E4.5.2
Q_i	Load effect	F1.1
q	Design load in plane of web	D1.1
q_s	Reduction factor	C3.2.2
R	Required allowable strength for ASD	A4.1.1
R	Modification factor	B5.1
R	Reduction factor	C3.6
R	Reduction factor	D6.1.1
R	Reduction factor determined in accordance with AISI S908	D6.1.2
R	Reduction factor determined from uplift tests in accordance with AISI S908	D6.1.4
R	Coefficient	C4.1.5
R	Inside bend radius	A7.2, C3.4.1, C3.5.1, C3.5.2
R	Radius of outside bend surface	E2.5
R_I	I_s/I_a	B4
R_a	Allowable design strength	F1.2
R_b	Reduction factor	A2.3.2
R_c	Reduction factor	C3.4.2
R_f	Effect of factored loads	A6.1.1
R_n	Nominal strength [resistance]	A4.1.1, A5.1.1, A6.1.1, F2
R_n	Nominal block shear rupture strength [resistance]	E5.3
R_n	Average value of all test results	F1.1, F1.2
R_r	Reduction factor	A2.3.2
R_u	Required strength for LRFD	A5.1.1
r	Correction factor	D6.1.1
r	Least radius of gyration of full unreduced cross-section	A2.3.2, C4.1.1, C4.1.2, D1.2
r	Centerline bend radius	1.1.1.1, 1.1.1.2
r_i	Minimum radius of gyration of full unreduced cross-section	D1.2
r_o	Polar radius of gyration of cross-section about shear center	C3.1.2.1, C4.1.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
r_x, r_y	Radius of gyration of cross-section about centroidal principal axis	C3.1.2.1
S	$1.28\sqrt{E/f}$	B4, B5.2
S	Variable load due to snow, including ice and associated rain or rain	A3.1, A6.1.2, A6.1.2.1
S_c	Elastic section modulus of effective section calculated relative to extreme compression fiber at F_c	B2.1, C3.1.2.1
S_e	Elastic section modulus of effective section calculated relative to extreme compression or tension fiber at F_y	C3.1.1, D6.1.1, D6.1.2
S_f	Elastic section modulus of full unreduced section relative to extreme compression fiber	B2.1, C3.1.2.1, C3.1.2.2, C3.1.3, C3.1.4
S_{ft}	Section modulus of full unreduced section relative to extreme tension fiber about appropriate axis	C5.1.1, C5.1.2
S_{fy}	Elastic section modulus of full unreduced section relative to extreme fiber in first yield	C3.1.4
S_n	In-plane diaphragm nominal shear strength [resistance]	D5
s	Center-to-center hole spacing	B2.2
s	Spacing in line of stress of welds, rivets, or bolts connecting a compression cover plate or sheet to a non-integral stiffener or other element	D1.3
s	Sheet width divided by number of bolt holes in cross-section being analyzed	E3.2
s	Weld spacing	D1.1
s	Pitch, spacing of fastener parallel to force	C2.2
s'	Longitudinal center-to-center spacing of any consecutive holes	E3.2
s_{end}	Clear distance from the hole at ends of member	B2.2
s_{max}	Maximum permissible longitudinal spacing of welds or other connectors joining two C-sections to form an I-section	D1.1
T	Required allowable tensile axial strength for ASD	C5.1.1
T	Required allowable tension strength of connection	E4.5.1
T	Load due to contraction or expansion caused by temperature changes	A3.1, A3.2
T_f	Tension due to factored loads for LSD	C5.1.2
T_f	Factored tensile force of connection for LSD	E4.5.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
T_n	Nominal tensile strength [resistance]	C2, C2.1, C2.2, C5.1.1, C5.1.2
T_s	Design strength [factored resistance] of connection in tension	D1.1
T_u	Required tensile axial strength for LRFD	C5.1.2
T_u	Required tension strength of connection for LRFD	E4.5.2
$\bar{T}$	Required tensile axial strength [factored tensile force]	C5.1.2
$\bar{T}$	Required tension strength [factored tensile force] of connection	E4.5.2
t	Base steel thickness of any element or section	A1.3, A2.3.2, A2.4, A7.2, B1.1, B1.2, B2.1, B2.2, B2.4, B3.2, B4, B5.1, B5.1.1, B5.1.2, B5.2, C2.2, C3.1.1, C3.1.3, C3.1.4, C3.2.1, C3.2.2, C3.4.1, C3.4.2, C3.5.1, C3.5.2, C3.7.1, C3.7.3, C4.2, C6, C4.1.5, D1.3, D6.1.3, D6.1.4, D6.3.1, E3.3.1, E3.3.2, E4.3.2, 1.1.1.1, 1.1.1.2
t	Thickness of coped web	E5.1
t	Total thickness of two welded sheets	E2.2.1.1, E2.2.1.2, E2.2.1.3, E2.2.2, E2.3
t	Thickness of thinnest connected part	E2.4, E2.5, E2.6, E3.1, E3.2, E3.3.2
t_c	Lesser of depth of penetration and t_2	E4, E4.4.1
t_e	Effective throat dimension of groove weld	E2.1
t_i	Thickness of uncompressed glass fiber blanket insulation	D6.1.1
t_s	Thickness of stiffener	C3.7.1
t_w	Effective throat of weld	E2.4, E2.5
t_1, t_2	Based thicknesses connected with fillet weld	E2.4
t_1	Thickness of member in contact with screw head	E4, E4.3.1, E4.4.2, E4.5.1, E4.5.2
t_2	Thickness of member not in contact with screw head	E4, E4.3.1, E4.5.1, E4.5.2
U	Reduction coefficient	E2.7, E3.2
V	Required allowable shear strength for ASD	C3.3.1
V_F	Coefficient of variation of fabrication factor	D6.2.1, F1.1
V_f	Shear force due to factored loads for LSD	C3.3.2
V_f	factored shear force of connection for LSD	E4.5.2
V_M	Coefficient of variation of material factor	D6.2.1, F1.1

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
V_n	Nominal shear strength [resistance]	C3.2.1, C3.3.1, C3.3.2, E5.1
V_P	Coefficient of variation of tested-to-predicted load ratios	D6.2.1, F1.1
V_Q	Coefficient of variation of load effect	D6.2.1, F1.1
V_u	Required shear strength for LRFD	C3.3.2
V_u	Required shear strength of connection for LRFD	E4.5.2
$\bar{V}$	Required shear strength [factored shear]	C3.3.2
W	Wind load, a variable load due to wind	A3.1, A6.1.2, A6.1.2.1
W	Required strength from critical load combinations for ASD, LRFD, or LSD	D3.2.1
W_{pi}	Total required vertical load supported by i th purlin in a single bay	D6.3.1
W_x, W_y	Components of required strength W	D3.2.1
w	Flat width of element exclusive of radii	A2.3.2, B1.1, B2.1, B2.2, B3.1, B3.2, B4, C3.1.1, C3.7.1
w	Flat width of beam flange which contacts bearing plate	C3.5.1, C3.5.2
w	Flat width of narrowest unstiffened compression element tributary to connections	D1.3
w_f	Width of flange projection beyond web for I-beams and similar sections; or half distance between webs for box- or U-type sections	B1.1
w_i	Required distributed gravity load supported by the i th purlin per unit length	D6.3.1
w_o	Out-to-out width	B2.2
w_1	Leg of weld	E2.4, E2.5
w_2	Leg of weld	E2.4, E2.5
x	Non-dimensional fastener location	D6.1.3
x	Nearest distance between web hole and edge of bearing	C3.4.2
x_o	Distance from shear center to centroid along principal x-axis	C3.1.2.1, C4.1.2
x_o	Distance from flange/web junction to the centroid of the flange	C3.1.4, C4.2
$\bar{x}$	Distance from shear plane to centroid of cross-section	E2.7, E3.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
Y	Yield point of web steel divided by yield point of stiffener steel	C3.7.3
Y_i	Gravity load from the LRFD or LSD load combinations or 1.6 times the ASD load combinations applied at level i	2.2.3, 2.2.4
y_o	y distance from flange/web junction to the centroid of the flange	C3.1.4
α	Coefficient for purlin directions	D6.3.1
α	Coefficient for conversion of units	D6.1.3, E3.3.2, G3
α	Load factor	A1.2a
α	Coefficient for strength [resistance] increase due to due to overhang	C3.4.1
α	Coefficient accounts for the benefit of an unbraced length, L_{mv} shorter than L_{cr} .	C4.2
α	Second-order amplification coefficient	2.2.3
$1/\alpha_x$, $1/\alpha_y$	Magnification factors	C5.2.1, C5.2.2, 2.1
β	Coefficient	B5.1.1, B5.1.2, C4.1.2
β	A value accounting for moment gradient	C3.1.4
$\beta_{br,1}$	Required brace stiffness for a single compression member	D3.3
β_o	Target reliability index	D6.2.1, F1.1
Δ_{tf}	Lateral displacement of purlin top flange at the line of restraint	D6.3.1
δ, δ_{iv} , γ, γ_{iv} , ω, ω_i	Coefficients	B5.1.1, B5.1.2
ξ_{web}	Stress gradient in web	C3.1.4
γ_i	Load factor	F1.1
θ	Angle between web and bearing surface $>45^\circ$ but no more than 90°	C3.4.1
θ	Angle between vertical and plane of web of Z-section,	D6.3.1

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
	degrees	
θ	Angle between an element and its edge stiffener	B4, C3.1.4, C4.2, 1.1.1.1, 1.1.1.2
θ_2, θ_3	Angle of segment of complex lip	1.1.1.1, 1.1.1.2
λ, λ_c	Slenderness factors	B2.1, B2.2, B3.2, B5.1, C3.5.1, C3.5.2, C4.1, 1.2.1.1
$\lambda_1, \lambda_2,$ λ_3, λ_4	Parameters used in determining compression strain factor	C3.1.1
λ_ℓ	Slenderness factor	1.2.1.2, 1.2.2.2
λ_d	Slenderness factor	C3.1.4, C4.2, 1.2.1.3, 1.2.2.3
μ	Poisson's ratio for steel = 0.30	B2.1, C3.2.1, C3.1.4, C4.2
ρ	Reduction factor	A7.2, B2.1, B3.2, B5.1, F3.1
σ_{ex}	$(\pi^2 E)/(K_x L_x/r_x)^2$ $(\pi^2 E)/(L/r_x)^2$	C3.1.2.1
σ_{ey}	$(\pi^2 E)/(K_y L_y/r_y)^2$ $(\pi^2 E)/(L/r_y)^2$	C3.1.2.1
σ_t	Torsional buckling stress	C3.1.2.1, C4.1.2, C4.1.3
ϕ	Resistance factor	A1.2, A1.3, A5.1.1, A6.1.1, D6.2.1, C3.5.2, C3.7.2, D6.1.3, D6.3.1, E2.1, E2.2.2, E2.3, E2.4, E2.5, E2.6, E2.2.1.1, E2.2.1.2, E2.2.1.3, E2.7, E3.1, E3.2, 3.3.1, E3.3.2, E3.4, E4, E4.3.2, E4.4, E4.4.3, E4.5.2, E5.1, E5.3, F1.1, F1.2, 1.1.1, 1.1.1.1, 1.1.1.2, 1.2.1, 1.2.2
ϕ_b	Resistance factor for bending strength	C3.1.1, C3.1.2, C3.1.3, C3.1.4, C3.3.2, C4.2, C3.5.2, C5.1.2, C5.2.2, D6.1.1, D6.1.2, 1.2.2
ϕ_c	Resistance factor for concentrically loaded compression strength	A2.3.1, C3.7.1, C4.1, C5.2.2
ϕ_d	Resistance factor for diaphragms	1.2.1 D5
ϕ_t	Resistance factor for tension strength	C2, C2.1, C5.1.2
ϕ_u	Resistance factor for fracture on net section	C2.2
ϕ_v	Resistance factor for shear strength	C3.2.1, C3.3.2
ϕ_w	Resistance factor for web crippling strength	C3.4.1, C3.5.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
ψ	$ f_2/f_1 $	B2.3, B3.2, C3.1.1
τ_b	Parameter for reduced stiffness using second-order analysis	2.2.3
Ω	Safety factor	A1.2, A1.3, A4.1.1, D6.2.1, C3.5.1, C3.7.2, D6.1.3, D6.3.1, E2.1, E2.2.1.1, E2.2.1.2, E2.2.1.3, E2.2.2, E2.3, E2.4, E2.5, E2.6, E2.7, E3.1, E3.2, E3.3.1, E3.3.2, E3.4, E4, E4.3.2, E4.4, E4.4.3, E4.5.1, E5.1, E5.3, F1.2, 1.1.1, 1.1.1.1, 1.1.1.2, 1.2.1, 1.2.2
Ω_b	Safety factor for bending strength	C3.1.1, C3.1.2, C3.1.3, 3.1.4, C3.3.1, C4.2, C3.5.1, C5.1.1, C5.2.1, D6.1.1, D6.1.2, 1.2.2
Ω_c	Safety factor for concentrically loaded compression strength	A2.3.1, C4.1, C5.2.1, 1.2.1
Ω_c	Safety factor for bearing strength	C3.7.1
Ω_d	Safety factor for diaphragms	D5
Ω_t	Safety factor for tension strength	C2, C5.1.1
Ω_v	Safety factor for shear strength	C3.2.1, C3.3.1
Ω_w	Safety factor for web crippling strength	C3.4.1, C3.5.1

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NORTH AMERICAN SPECIFICATION FOR THE DESIGN OF COLD-FORMED STEEL STRUCTURAL MEMBERS

A. GENERAL PROVISIONS

A1 Scope, Applicability, and Definitions

A1.1 Scope

This *Specification* applies to the design of *structural members* cold-formed to shape from carbon or low-alloy steel sheet, strip, plate, or bar not more than 1 in. (25.4 mm) in *thickness* and used for load-carrying purposes in

- (a) buildings; and
- (b) structures other than buildings provided allowances are made for dynamic effects.

→A

A1.2 Applicability

This *Specification* includes Symbols and Definitions, Chapters A through G, Appendices A and B, and Appendices 1 and 2 that shall apply as follows:

- Appendix A — the United States and Mexico,
- Appendix B — Canada,
- Appendix 1 — alternative design provisions for several sections of Chapter C, and
- Appendix 2 — second-order analysis.

Symbol ^x is used to point out that additional provisions are provided in the appendices indicated by the letter(s).

This *Specification* includes design provisions for *Allowable Strength Design (ASD)*, *Load and Resistance Factor Design (LRFD)*, and *Limit States Design (LSD)*. These design methods shall apply as follows:

- ASD and LRFD — United States and Mexico, and
- LSD — Canada

In this *Specification*, bracketed terms are equivalent terms that apply particularly to LSD.

The *nominal strength* [*nominal resistance*] and stiffness of cold-formed steel elements, members, assemblies, *connections*, and details shall be determined in accordance with the provisions in Chapters B through G, Appendices A and B, and Appendices 1 and 2 of the *Specification*.

Where the composition or configuration of such components is such that calculation of strength [*resistance*] and/or stiffness cannot be made in accordance with those provisions, structural performance shall be established from either of the following:

- (a) *Available strength* [*factored resistance*] or stiffness by tests, undertaken and evaluated in accordance with Chapter F,
- (b) Available strength [*factored resistance*] or stiffness by *rational engineering analysis* based on appropriate theory, related testing if data is available, and engineering judgment. Specifically, the available strength [*factored resistance*] is determined from the calculated nominal strength [*nominal resistance*] by applying the following *safety factors* or *resistance factors*:

For members

$$\Omega = 2.00 \quad (\text{ASD})$$

$$\phi = 0.80 \quad (\text{LRFD})$$

$$= 0.75 \quad (\text{LSD})$$

For connections

$$\Omega = 2.50 \quad (\text{ASD})$$

$$\phi = 0.65 \quad (\text{LRFD})$$

$$= 0.60 \quad (\text{LSD})$$

When rational engineering analysis is used to determine the nominal strength [nominal resistance] for a *limit state* already provided in this *Specification*, the safety factor shall not be less than the applicable safety factor (Ω) nor shall the resistance factor exceed the applicable resistance factor (ϕ) for the prescribed limit state.

A1.3 Definitions

In this *Specification*, “shall” is used to express a mandatory requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the *Specification*; and “shall be permitted” is used to express an option or that which is permissible within the limits of the *Specification*. In Standards developed by the Canadian Standards Association, “shall be permitted” is expressed by “may”.

The following terms are italicized when they appear for the first time in a sub-section of the *Specification*. Terms listed under the ASD and LRFD Terms sections shall apply to the USA and Mexico, while definitions listed under the LSD Terms section shall apply in Canada.

Terms designated with + are common AISC-AISI terms that are coordinated between the two standards developers.

General Terms

Applicable Building Code⁺. Building code under which the structure is designed.

Bearing⁺. In a *connection*, *limit state* of shear forces transmitted by the mechanical fastener to the connection elements.

Bearing (Local Compressive Yielding)⁺. Limit state of *local compressive yielding* due to the action of a member bearing against another member or surface.

Block Shear Rupture⁺. In a *connection*, limit state of tension rupture along one path and shear yielding or shear rupture along another path.

Braced Frame⁺. Essentially vertical truss system that provides resistance to lateral *loads* and provides stability for the structural system.

Buckling⁺. Limit state of sudden change in the geometry of a structure or any of its elements under a critical loading condition.

Buckling Strength. Nominal strength [nominal resistance] for *instability* limit states.

Cold-Formed Steel Structural Member⁺. Shape manufactured by press-braking blanks sheared from sheets, cut lengths of coils or plates, or by roll forming cold- or hot-rolled coils or sheets; both forming operations being performed at ambient room temperature, that is, without manifest addition of heat such as would be required for hot forming.

Confirmatory Test. Test made, when desired, on members, *connections*, and assemblies designed in accordance with the provisions of Chapters A through G, Appendices A and B, and Appendices 1 and 2 of this *Specification* or its specific references, in order to

compare actual to calculated performance.

Connection⁺. Combination of structural elements and *joints* used to transmit forces between two or more members.

Cross-Sectional Area:

Effective Area. Effective area, A_e , calculated using the *effective widths* of component elements in accordance with Chapter B. If the effective widths of all component elements, determined in accordance with Chapter B, are equal to the actual *flat widths*, it equals the *gross* or *net area*, as applicable.

Full, Unreduced Area. Full, unreduced area, A , calculated without considering *local buckling* in the component elements, which equals either the gross area or net area, as applicable.

Gross Area. Gross area, A_g , without deductions for holes, openings, and cutouts.

Net Area. Net area, A_n , equal to gross area less the area of holes, openings, and cutouts.

Curtain Wall Stud. A member in a steel framed exterior wall system that transfers transverse (out-of-plane) loads and is limited to a superimposed axial load, exclusive of sheathing materials, of not more than 100 lb/ft (1460 N/m or 1.49 kg/cm), or a superimposed axial load of not more than 200 lbs (890 N or 90.7 kg) per stud.

Diaphragm⁺. Roof, floor, or other membrane or bracing system that transfers in-plane forces to the lateral force resisting system.

Direct Strength Method. An alternative design method detailed in Appendix 1 that provides predictions of member strengths [resistances] without the use of effective widths.

Distortional Buckling. A mode of *buckling* involving change in cross-sectional shape, excluding local buckling.

Doubly-Symmetric Section. A section symmetric about two orthogonal axes through its centroid.

Effective Design Width (Effective Width). Flat width of an element reduced for design purposes, also known simply as the effective width.

Factored Load⁺. Product of a *load factor* and the *nominal load* [specified load].

Fatigue⁺. Limit state of crack initiation and growth resulting from repeated application of live loads.

Flange of a Section in Bending (Flange). Flat width of flange including any intermediate stiffeners plus adjoining corners.

Flat Width. Width of an element exclusive of corners measured along its plane.

Flat-Width-to-Thickness Ratio (Flat Width Ratio). Flat width of an element measured along its plane, divided by its thickness.

Flexural Buckling⁺. Buckling mode in which a compression member deflects laterally without twist or change in cross-sectional shape.

Flexural-Torsional Buckling⁺. Buckling mode in which a compression member bends and twists simultaneously without change in cross-sectional shape.

Girt⁺. Horizontal *structural member* that supports wall panels and is primarily subjected to bending under horizontal loads, such as wind load.

In-Plane Instability⁺. Limit state involving buckling in the plane of the frame or the member.

Instability⁺. Limit state reached in the loading of a structural component, frame, or structure in which a slight disturbance in the loads or geometry produces large displacements.

Joint⁺. Area where two or more ends, surfaces, or edges are attached. Categorized by type of fastener or weld used and the method of force transfer.

Lateral-Torsional Buckling⁺. Buckling mode of a flexural member involving deflection out of

the plane of bending occurring simultaneously with twist about the shear center of the cross-section.

Limit State⁺. Condition in which a structure or component becomes unfit for service and is judged either to be no longer useful for its intended function (*serviceability* limit state) or to have reached its ultimate load-carrying capacity (strength [resistance] limit state).

Load⁺. Force or other action that results from the weight of building materials, occupants and their possessions, environmental effects, differential movement, or restrained dimensional changes.

Load Effect⁺. Forces, stresses, and deformations produced in a *structural component* by the applied loads.

Load Factor⁺. Factor that accounts for deviations of the nominal load from the actual load, for uncertainties in the analysis that transforms the load into a *load effect*, and for the probability that more than one extreme load will occur simultaneously.

Local Bending⁺. Limit state of large deformation of a flange under a concentrated transverse force.

Local Buckling. Limit state of buckling of a compression element where the line junctions between elements remain straight and angles between elements do not change.

Local Yielding⁺. Yielding that occurs in a local area of an element.

Master Coil. One continuous, weld-free coil as produced by a hot mill, cold mill, metallic coating line or paint line and identifiable by a unique coil number. In some cases, this coil is cut into smaller coils or slit into narrower coils; however, all of these smaller and/or narrower finished coils are said to have come from the same master coil if they are traceable to the original master coil number.

Moment Frame⁺. Framing system that provides resistance to lateral loads and provides stability to the structural system primarily by shear and flexure of the framing members and their connections.

Multiple-Stiffened Element. Element stiffened between webs, or between a web and a stiffened edge, by means of intermediate stiffeners parallel to the direction of stress.

Notional Load. Virtual load applied in a structural analysis to account for destabilizing effects that are not otherwise accounted for in the design provisions.

Out-of-Plane Buckling⁺. Limit state of a beam, column or beam-column involving lateral or lateral-torsional buckling.

Performance Test. Test made on structural members, connections, and assemblies whose performance cannot be determined in accordance with Chapters A through G of this *Specification* or its specific references.

Permanent Load⁺. Load in which variations over time are rare or of small magnitude. All other loads are *variable loads*.

Point-Symmetric Section. Section symmetrical about a point (centroid) such as a Z-section having equal flanges.

Published Specification. Requirements for a steel listed by a manufacturer, processor, producer, purchaser, or other body, which (1) are generally available in the public domain or are available to the public upon request, (2) are established before the steel is ordered, and (3) as a minimum, specify minimum mechanical properties, chemical composition limits, and, if coated sheet, coating properties.

Purlin⁺. Horizontal structural member that supports roof deck and is primarily subjected to bending under vertical loads such as snow, wind, or dead loads.

P- δ Effect. Effect of loads acting on the deflected shape of a member between joints or nodes.

P-Δ Effect. Effect of loads acting on the displaced location of joints or nodes in a structure. In tiered building structures, this is the effect of loads acting on the laterally displaced location of floors and roofs.

Rational Engineering Analysis⁺. Analysis based on theory that is appropriate for the situation, any relevant test data, if available, and sound engineering judgment.

Resistance Factor, ϕ ⁺. Factor that accounts for unavoidable deviations of the nominal strength from the actual strength and for the manner and consequences of failure.

Rupture Strength⁺. Strength limited by breaking or tearing of members or connecting elements.

Second-Order Analysis. Structural analysis in which equilibrium conditions are formulated on the deformed structure; second-order effects (both $P-\delta$ and $P-\Delta$, unless specified otherwise) are included.

Second-Order Effect. Effect of loads acting on the deformed configuration of a structure; includes $P-\delta$ effect and $P-\Delta$ effect.

Serviceability Limit State⁺. Limiting condition affecting the ability of a structure to preserve its appearance, maintainability, durability, or the comfort of its occupants or function of machinery, under normal usage.

Shear Buckling⁺. Buckling mode in which a plate element, such as the web of a beam, deforms under pure shear applied in the plane of the plate.

Shear Wall⁺. Wall that provides resistance to lateral loads in the plane of the wall and provides stability for the structural system.

Singly-Symmetric Section. Section symmetric about only one axis through its centroid.

Specified Minimum Yield Stress⁺. Lower limit of *yield stress* specified for a material as defined by ASTM.

Stiffened or Partially Stiffened Compression Elements. Flat compression element (i.e., a plane compression flange of a flexural member or a plane web or flange of a compression member) of which both edges parallel to the direction of stress are stiffened either by a web, flange, stiffening lip, intermediate stiffener, or the like.

SS (Structural Steel). ASTM designation for certain sheet steels intended for structural applications.

Stress. Stress as used in this *Specification* means force per unit area.

Structural Analysis⁺. Determination of load effects on members and connections based on principles of structural mechanics.

Structural Members. See the definition of Cold-Formed Structural Steel Structural Members.

Structural Component⁺. Member, connector, connecting element, or assemblage.

Sub-Element of a Multiple Stiffened Element. Portion of a multiple stiffened element between adjacent intermediate stiffeners, between web and intermediate stiffener, or between edge and intermediate stiffener.

Tensile Strength (of Material)⁺. Maximum tensile stress that a material is capable of sustaining as defined by ASTM.

Tension and Shear Rupture⁺. In a bolt or other type of mechanical fastener, limit state of rupture due to simultaneous tension and shear force.

Thickness. The thickness, t , of any element or section is the base steel thickness, exclusive of coatings.

Torsional Buckling⁺. Buckling mode in which a compression member twists about its shear center axis.

Unstiffened Compression Elements. Flat compression element stiffened at only one edge

parallel to the direction of stress.

Unsymmetric Section. Section not symmetric either about an axis or a point.

Variable Load⁺. Load not classified as *permanent load*.

Virgin Steel. Steel as received from the steel producer or warehouse before being cold worked as a result of fabricating operations.

Virgin Steel Properties. Mechanical properties of virgin steel such as yield stress, *tensile strength*, and elongation.

Web. In a member subjected to flexure, the portion of the section that is joined to two flanges, or that is joined to only one flange provided it crosses the neutral axis.

Web Crippling⁺. Limit state of local failure of web plate in the immediate vicinity of a concentrated load or reaction.

Yield Moment⁺. In a member subjected to bending, the moment at which the extreme outer fiber first attains the yield stress.

Yield Point⁺. First stress in a material at which an increase in strain occurs without an increase in stress as defined by ASTM.

Yield Strength⁺. Stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain as defined by ASTM.

Yield Stress⁺. Generic term to denote either *yield point* or *yield strength*, as appropriate for the material.

Yielding⁺. Limit state of inelastic deformation that occurs when the *yield stress* is reached.

Yielding (Plastic Moment)⁺. Yielding throughout the cross section of a member as the bending moment reaches the *plastic moment*.

Yielding (Yield Moment)⁺. Yielding at the extreme fiber on the cross section of a member when the bending moment reaches the *yield moment*.

ASD and LRFD Terms (USA and Mexico):

ASD (Allowable Strength Design)⁺. Method of proportioning *structural components* such that the *allowable strength* equals or exceeds the *required strength* of the component under the action of the *ASD load combinations*.

ASD Load Combination⁺. Load combination in the *applicable building code* intended for *allowable strength design* (allowable stress design).

Allowable Strength⁺. Nominal strength divided by the *safety factor*, R_n/Ω .

Available Strength⁺. Design strength or allowable strength as appropriate.

Design Load⁺. Applied load determined in accordance with either *LRFD load combinations* or *ASD load combinations*, whichever is applicable.

Design Strength⁺. Resistance factor multiplied by the nominal strength, ϕR_n .

LRFD (Load and Resistance Factor Design)⁺. Method of proportioning structural components such that the design strength equals or exceeds the required strength of the component under the action of the LRFD load combinations.

LRFD Load Combination⁺. Load combination in the applicable building code intended for strength design (*Load and Resistance Factor Design*).

Nominal Load⁺. The magnitudes of the load specified by the applicable building code.

Nominal Strength⁺. Strength of a structure or component (without the *resistance factor* or *safety factor* applied) to resist the *load effects*, as determined in accordance with this *Specification*.

Required Strength⁺. Forces, stresses, and deformations acting on a structural component, determined by either *structural analysis*, for the LRFD or ASD load combinations, as

appropriate, or as specified by this *Specification*.

Resistance. See the definition of Nominal Strength.

Safety Factor, Ω^+ . Factor that accounts for deviations of the actual strength from the nominal strength, deviations of the actual load from the nominal load, uncertainties in the analysis that transforms the load into a load effect, and for the manner and consequences of failure.

Service Load⁺. Load under which serviceability limit states are evaluated.

Strength Limit State⁺. Limiting condition, in which the maximum strength of a structure or its components is reached.

LSD Terms (Canada):

Limit States Design (LSD). A method of proportioning *structural components* (members, connectors, connecting elements, and assemblages) such that no applicable *limit state* is exceeded when the structure is subjected to all appropriate *load combinations*.

Factored Resistance. Product of *nominal resistance* and appropriate *resistance factor*.

Nominal Resistance. The capacity of a structure or component to resist the *effects of loads*, determined in accordance with this *Specification* using specified material strengths and dimensions.

Specified Loads. The magnitudes of the *loads* specified by the *applicable building code*, not including *load factors*. B

A1.4 Units of Symbols and Terms

Any compatible system of measurement units shall be permitted to be used in the *Specification*, except where explicitly stated otherwise. The unit systems considered in those sections shall include U.S. customary units (force in kilopounds and length in inches), SI units (force in Newtons and length in millimeters), and MKS units (force in kilograms and length in centimeters).

A2 Material

A2.1 Applicable Steels

This *Specification* requires the use of steels intended for structural applications as defined in general by the specifications of the American Society for Testing and Materials listed in this Section. The term SS shall designate sheet material and the terms HSLAS and HSLAS-F shall designate high-strength low-alloy steels.

ASTM A36/A36M, Standard Specification for Carbon Structural Steel

ASTM A242/A242M, Standard Specification for High-Strength Low-Alloy Structural Steel

ASTM A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates

ASTM A500, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A529/A529M, Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality

ASTM A572/A572M, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel

with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100 mm] Thick
 ASTM A606, Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
 ASTM A653/A653M (SS Grades 33 (230), 37 (255), 40 (275), 50 (340) Class 1, Class 3 and Class 4, and 55 (380); HSLAS and HSLAS-F, Grades 40 (275), 50 (340), 55 (380) Class 1 and 2, 60 (410), 70 (480) and 80 (550)), Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
 ASTM A792/A792M (Grades 33 (230), 37 (255), 40 (275), and 50 (340) Class 1 and Class 4)), Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
 ASTM A847/A847M, Standard Specification for Cold-Formed Welded and Seamless High Strength, Low Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance
 ASTM A875/A875M (SS Grades 33 (230), 37 (255), 40 (275), and 50 (340) Class 1 and Class 3; HSLAS and HSLAS-F, Grades 50 (340), 60 (410), 70 (480), and 80 (550)), Standard Specification for Steel Sheet, Zinc-5% Aluminum Alloy-Coated by the Hot-Dip Process
 ASTM A1003/A1003M (ST Grades 50 (340) H, 40 (275) H, 37 (255) H, 33 (230) H), Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members
 ASTM A1008/A1008M (SS Grades 25 (170), 30 (205), 33 (230) Types 1 and 2, and 40 (275) Types 1 and 2; HSLAS Classes 1 and 2, Grades 45 (310), 50 (340), 55 (380), 60 (410), 65 (450), and 70 (480); HSLAS-F Grades 50 (340), 60 (410), 70 (480), and 80 (550)), Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
 ASTM A1011/A1011M (SS Grades 30 (205), 33 (230), 36 (250) Types 1 and 2, 40 (275), 45 (310), 50 (340), and 55 (380); HSLAS Classes 1 and 2, Grades 45 (310), 50 (340), 55 (380), 60 (410), 65 (450), and 70 (480); HSLAS-F Grades 50 (340), 60 (410), 70 (480), and 80(550)), Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
 ASTM A1039/A1039M (SS Grades 40 (275), 50 (340), 55 (380), 60 (410), 70 (480), and 80 (550)), Standard Specification for Steel, Sheet, Hot Rolled, Carbon, Commercial and Structural, Produced by the Twin-Roll Casting Process. Thicknesses of Grades 55 (380) and higher that do not meet the minimum 10% elongation requirement are limited per Section A2.3.2.

→ **B**

A2.2 Other Steels

See Section A2.2 of Appendix A or B.

→ **A,B**

A2.3 Ductility

Steels not listed in Section A2.1 and used for *structural members* and *connections* in accordance with Section A2.2 shall comply with ductility requirements in either Section A2.3.1 or Section A2.3.2:

A2.3.1 The ratio of *tensile strength* to *yield stress* shall not be less than 1.08, and the total elongation shall not be less than 10 percent for a two-inch (50 mm) gage length or 7 percent for an eight-inch (200 mm) gage length standard specimen tested in accordance with ASTM A370. If these requirements cannot be met, the following criteria shall be satisfied: (1) local elongation in a 1/2 in. (12.7 mm) gage length across the fracture shall

not be less than 20 percent, and (2) uniform elongation outside the fracture shall not be less than 3 percent. When material ductility is determined on the basis of the local and uniform elongation criteria, the use of such material shall be restricted to the design of *purlins, girts, and curtain wall studs* in accordance with Sections C3.1.1(a), C3.1.2, D6.1.1, D6.1.2, D6.2.1, and country-specific requirements given in A2.3.1a of the Appendix A or B. For purlins, girts, and curtain wall studs subject to combined axial load and bending moment (Section C5), $\frac{\Omega_c P}{P_n}$ shall not exceed 0.15 for ASD, $\frac{P_u}{\phi_c P_n}$ shall not exceed 0.15 for LRFD, and $\frac{P_f}{\phi_c P_n}$ shall not exceed 0.15 for LSD. ⇒ AB

A2.3.2 Steels conforming to ASTM A653/A653M SS Grade 80 (550), A1008/A1008M SS Grade 80 (550), A792/A792M Grade 80 (550), A875/A875M SS Grade 80 (550), thicknesses of ASTM A1039 Grades 55 (380), 60 (410), 70 (480), and 80 (550) that do not meet the minimum 10 percent elongation requirement in Section A2.3.1, and other steels that do not meet the provisions of Section A2.3.1 shall be permitted for concentrically loaded closed box section compression members as given in Exception 2 below and for multiple-web configurations such as roofing, siding, and floor decking as given in Exception 1 provided that:

- (1) the *yield stress*, F_y , used for determining *nominal strength* [nominal resistance] in Chapters B, C, D, and E is taken as 75 percent of the *specified minimum yield stress* or 60 ksi (410 MPa or 4220 kg/cm²), whichever is less, and
- (2) the *tensile strength*, F_u , used for determining *nominal strength* [nominal resistance] in Chapter E is taken as 75 percent of the *specified minimum tensile strength* or 62 ksi (427 MPa or 4360 kg/cm²), whichever is less.

Alternatively, the suitability of such steels for any multi-web configuration shall be demonstrated by load tests in accordance with the provisions of Section F1. *Available strengths* [factored resistances] based on these tests shall not exceed the available strengths [factored resistances] calculated in accordance with Chapters B through G, Appendices A and B, and Appendices 1 and 2, using the specified minimum yield stress, F_{sy} , and the specified minimum tensile strength, F_u .

Exception 1: For multiple-web configurations, a reduced specified minimum yield stress, $R_b F_{sy}$, shall be permitted for determining the nominal flexural strength [moment resistance] in Section C3.1.1(a), for which the reduction factor, R_b , shall be determined in accordance with (a) or (b):

- (a) For stiffened and partially stiffened compression flanges

For $w/t \leq 0.067E/F_{sy}$

$$R_b = 1.0$$

For $0.067E/F_{sy} < w/t < 0.974E/F_{sy}$

$$R_b = 1 - 0.26[wF_{sy}/(tE) - 0.067]^{0.4}$$

(Eq. A2.3.2-1)

For $0.974E/F_{sy} \leq w/t \leq 500$

$$R_b = 0.75$$

- (b) For unstiffened compression flanges

For $w/t \leq 0.0173E/F_{sy}$

$$R_b = 1.0$$

For $0.0173E/F_{sy} < w/t \leq 60$

$$R_b = 1.079 - 0.6\sqrt{wF_{sy}/(tE)} \quad (\text{Eq. A2.3.2-2})$$

where

w = Flat width of compression flange

t = Thickness of section

E = Modulus of elasticity of steel

F_{sy} = Specified minimum yield stress determined in accordance with Section A7.1
 ≤ 80 ksi (550 MPa, or 5620 kg/cm²)

The above Exception shall not apply to the use of steel deck for composite slabs, for which the steel deck acts as the tensile reinforcement of the slab.

Exception 2: For concentrically loaded compression members with a closed box section, a reduced yield stress, $0.9F_{sy}$, shall be permitted to be used in place of F_y in Eqs. C4.1-2, C4.1-3, and C4.1-4 for determining the axial strength in Section C4. A reduced radius of gyration (R_r)(r) shall be used in Eq. C4.1.1-1 when the value of the effective length KL is less than $1.1L_0$, where L_0 is given by Eq. A2.3.2-3, and R_r is given by Eq. A2.3.2-4.

$$L_0 = \pi r \sqrt{\frac{E}{F_{cr}}} \quad (\text{Eq. A2.3.2-3})$$

$$R_r = 0.65 + \frac{0.35(KL)}{1.1L_0} \quad (\text{Eq. A2.3.2-4})$$

where

L_0 = Length at which *local buckling* stress equals *flexural buckling* stress

r = Radius of gyration of full unreduced cross section

F_{cr} = Minimum critical *buckling* stress for section calculated by Eq. B2.1-5

R_r = Reduction factor

KL = Effective length

A2.4 Delivered Minimum Thickness

The uncoated minimum steel *thickness* of the cold-formed steel product as delivered to the job site shall not at any location be less than 95 percent of the thickness, t , used in its design; however, lesser thicknesses shall be permitted at bends, such as corners, due to cold-forming effects.

A3 Loads

Loads and *load combinations* shall be as stipulated by the applicable country-specific provisions in Section A3 of Appendix A or B.

➡ **A.B**

A4 Allowable Strength Design

A4.1 Design Basis

Design under this section of the *Specification* shall be based on *Allowable Strength Design* (ASD) principles. All provisions of this *Specification* shall apply, except for those in Sections A5 and A6 and in Chapters C and F designated for *LRFD* and *LSD*.

A4.1.1 ASD Requirements

A design satisfies the requirements of this *Specification* when the *allowable strength* of each *structural component* equals or exceeds the *required strength*, determined on the basis of the *nominal loads*, for all applicable *load combinations*.

The design shall be performed in accordance with Equation A4.1.1-1:

$$R \leq R_n / \Omega \quad (\text{Eq. A4.1.1-1})$$

where

R = Required strength

R_n = *Nominal strength* specified in Chapters B through G and Appendix 1

Ω = *Safety factor* specified in Chapters B through G and Appendix 1

R_n / Ω = *Allowable strength*

A4.1.2 Load Combinations for ASD

Load combinations for ASD shall be as stipulated by Section A4.1.2 of Appendix A.

→A

A5 Load and Resistance Factor Design**A5.1 Design Basis**

Design under this section of the *Specification* shall be based on *Load and Resistance Factor Design (LRFD)* principles. All provisions of this *Specification* shall apply, except for those in Sections A4 and A6 and in Chapters C and F designated for ASD and LSD.

A5.1.1 LRFD Requirements

A design satisfies the requirements of this *Specification* when the *design strength* of each *structural component* equals or exceeds the *required strength* determined on the basis of the *nominal loads*, multiplied by the applicable *load factors*, for all applicable *load combinations*.

The design shall be performed in accordance with Equation A5.1.1-1:

$$R_u \leq \phi R_n \quad (\text{Eq. A5.1.1-1})$$

where

R_u = Required strength

ϕ = *Resistance factor* specified in Chapters B through G and Appendix 1

R_n = *Nominal strength* specified in Chapters B through G and Appendix 1

ϕR_n = *Design strength*

A5.1.2 Load Factors and Load Combinations for LRFD

Load factors and *load combinations* for LRFD shall be as stipulated by Section A5.1.2 of Appendix A.

→A

A6 Limit States Design**A6.1 Design Basis**

Design under this section of the *Specification* shall be based on *Limit States Design (LSD)* principles. All provisions of this *Specification* shall apply, except for those in Sections A4 and

A5 and Chapters C and F designated for *ASD* and *LRFD*.

A6.1.1 LSD Requirements

Structural members and their connections shall be designed to have *resistance* such that the *factored resistance* equals or exceeds the effect of *factored loads*. The design shall be performed in accordance with Equation A6.1.1-1:

$$\phi R_n \geq R_f \quad (\text{Eq. A6.1.1-1})$$

where

ϕ = Resistance factor specified in Chapters B through G and Appendix 1

R_n = Nominal resistance specified in Chapters B through G and Appendix 1

ϕR_n = Factored resistance

R_f = Effect of factored loads

A6.1.2 Load Factors and Load Combinations for LSD

Load factors and load combinations for LSD shall be as stipulated by Section A6.1.2 of Appendix B. 

A7 Yield Stress and Strength Increase from Cold Work of Forming

A7.1 Yield Stress

The *yield stress* used in design, F_y , shall not exceed the *specified minimum yield stress* of steels as listed in Section A2.1 or A2.3.2, as established in accordance with Chapter F, or as increased for cold work of forming in Section A7.2.

A7.2 Strength Increase from Cold Work of Forming

Strength increase from cold work of forming shall be permitted by substituting F_{ya} for F_y , where F_{ya} is the average *yield stress* of the full section. Such increase shall be limited to Sections C2, C3.1 (excluding Section C3.1.1(b)), C4, C5, D4, and D6.1. The limits and methods for determining F_{ya} shall be in accordance with (a), (b) and (c).

(a) For axially loaded compression members and flexural members whose proportions are such that the quantity ρ for strength determination is unity as determined in accordance with Section B2 for each of the component elements of the section, the design yield stress, F_{ya} , of the steel shall be determined on the basis of one of the following methods:

- (1) full section tensile tests [see paragraph (a) of Section F3.1],
- (2) stub column tests [see paragraph (b) of Section F3.1],
- (3) computed in accordance with Eq. A7.2-1.

$$F_{ya} = CF_{yc} + (1 - C) F_{yf} \leq F_{uv} \quad (\text{Eq. A7.2-1})$$

where

F_{ya} = Average yield stress of full unreduced section of compression members or full flange sections of flexural members

C = For compression members, ratio of total corner *cross-sectional area* to total cross-sectional area of full section; for flexural members, ratio of total corner cross-sectional area of controlling flange to full cross-sectional area of