S136-12

North American specification for the design of cold-formed steel structural members

Approved in Canada by CSA Group and in the United States by the American Iron and Steel Institute, and endorsed in Mexico by CANACERO

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CSA Preface

This is the eighth edition of CSA S136, *North American specification for the design of cold-formed steel structural members* (NASPEC). It supersedes the previous editions published in 2007, 2001, 1994, 1989, 1984, 1974, and 1963. This edition is a harmonized Standard intended for use in Canada, the United States, and Mexico.

The NASPEC was developed jointly by CSA's Technical Committee on Cold-Formed Steel Structural Members and the American Iron and Steel Institute's Committee on Specifications. This effort was coordinated through the North American Specification Committee, which consisted of six members, three from the CSA Technical Committee and three from the AISI Committee. A detailed summary of the development of the Standard can be found in the joint preface to the North American Specification.

This Standard was reviewed for use in Canada by the CSA Technical Committee on Cold-Formed Steel Structural Members, under the jurisdiction of the CSA Strategic Steering Committee on Construction and Civil Infrastructure, and has been formally approved by the CSA Technical Committee.

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This Standard was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this Standard.*

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American Iron and Steel Institute

AISI STANDARD

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

2012 EDITION

Approved in Canada by the CSA Group

Endorsed in Mexico by CANACERO

CSA Group

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The material contained herein has been developed by a joint effort of the American Iron and Steel Institute (AISI) Committee on Specifications, CSA Group 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 2007 and previous editions 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 S136, *Cold Formed Steel Structural Members,* published by CSA Group.

The *Specification* was developed by a joint effort of the American Iron and Steel Institute (AISI) Committee on Specifications, CSA 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 the CSA 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 Appendices 1 and 2, that is intended for use in all three countries, and two country-specific appendices (A and B). Appendix A is for use in both the United States and Mexico, and Appendix B is for use in Canada. A symbol (☞A,B) 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 *ASD* and *LRFD* 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." In the *Specification*, the terms that are specifically applicable to *LSD* are included in square brackets.

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 Group.

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 Group, and CANACERO acknowledge the continuing dedication of the members of the specifications committees and their subcommittees. The membership of these committees follows this Preface.

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

Materials

- Material standard ASTM A1063 is added.
- All referenced ASTM material standards are reorganized in accordance with the ranges of the minimum specified elongation.

Elements

- Section B1.3, Corner Radius-to-Thickness Ratios, is added, which limits the applicability of the design provisions in Chapter B to members with corner radius-to-*thickness* ratio not exceeding 10.
- Section B2.5, Uniformly Compressed Elements Restrained by Intermittent Connections, is added, which determines the *effective widths* of multiple flute built-up members.

Members

- Country-specific provisions on tension member design (Section C2) are unified and moved from Appendices A and B to the main body of the *Specification*.
- Revisions are made in Section C3.1.1, such that the *resistance factor* for bending is the same for stiffened, partially stiffened, or unstiffened compression *flanges*.
- The simplified provisions for determining *distortional buckling strength* of C- or Z-section beams (Section C3.1.4) and columns (Section C4.2) are moved to the *Commentary*.
- The reduction factor, as given in Section C3.6, for combined bending and torsional loading is revised.

Built-Up Section Members

- Clarifications are made to Section D1.1, Flexural Members Composed of Two Back-to-Back C-Sections.

Member Bracing

- Sections D3 and D3.1 are revised for clarifications.
- Section D3.3 is revised to be consistent with the AISC bracing design provisions. The *second-order analysis* is now permitted to determine the *required bracing strength*.

Wall Stud and Wall Stud Assemblies

- Reference to nonstructural members is removed from Section D4.
- Reference to AISI S213, *North American Cold-Formed Steel Framing Standard–Lateral*, is moved from Section D4 in Appendix A to the main body of the *Specification*.

Metal Roof and Wall System

- The following applicability requirements in Section D6.1.1 are revised or added: member depth, depth to *flange* width ratio, *flange* width, and ratio of *tensile strength* to design *yield stress*.
- Clarification is made to Section D6.2.1a regarding the application of the 0.67 factor

specifically to clips, fasteners and standing seam roof panels.

Connections

- The whole chapter is reorganized with the rupture check consolidated to Section E6. In addition, the following provisions are added or revised:
    - New provisions (Section E2.2.4) on combined shear and tension on arc spot welds are added.
    - New provisions (Section E2.4) on top arc seam sidelap welds are added.
    - Section E2.6, Flare Groove Welds, is revised to be consistent with the provisions in AWS D1.1-2006.
    - Section E3, Bolted Connections, is revised with added provisions for alternative short-slotted holes, applicable to *connections* where the deformation of the hole is not a consideration and the bolt diameter equals 1/2 in.
    - Table E3.4-1, Nominal Tensile and Shear Strengths for Bolts, in Appendix A is revised to be consistent with the values provided in ANSI/AISC 360.
    - New provisions (Section E4.5) are added for screw combined shear and pull-over, combined shear and pull out, and combined shear and tension in screws.
    - New provisions (Section E5) on power-actuated fasteners are added.
    - The reduction factor due to staggered hole patterns is eliminated in Section E6.

Tests

- Determination of *available strength* [*factored resistance*] by evaluation of a *rational engineering analysis* model via verification tests is added.

Appendix 1

- The geometric and material limitations of pre-qualified columns and beams for using the *safety* and *resistance factors* defined in Sections 1.2.1 and 1.2.2 are expanded.
- Provisions for determining the flexural and compressive strength of perforated members are added in Sections 1.2.1 and 1.2.2.1.
- Provisions for determining the *web* shear strength using the *Direct Strength Method* approach are added as Section 1.2.2.2.
- Provisions for considering beam or column reserve capacity are added in Section 1.2.2.1.

Appendix 2

- For braced members, the requirement to meet the specified maximum-out-of-straightness is added.

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

American Iron and Steel Institute
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November 2012

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T. B. Peköz	Consultant
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J. J. Pote	New Millennium Building Systems
N. A. Rahman	The Steel Network, Inc.
G. Ralph	ClarkDietrich Building Systems
C. Rogers	McGill University
V. E. Sagan	Wiss, Janney, Elstner Associates, Inc.
H. Salim	University of Missouri-Columbia
T. Samiappan	ITW Building Component Group, Inc.
B. W. Schafer	Johns Hopkins University
N. Schillaci	ArcelorMittal Dofasco
K. Schroeder	DEVCO Engineering Inc.
W. E. Schultz	Nucor Vulcraft
R. M. Schuster	Consultant
J. Sears	Kirkpatrick Forest Curtis PC
M. Seek	Old Dominion University
F. Sesma	California Expanded Metal Products
Y. Shifferaw	Drexel University
W. L. Shoemaker	Metal Building Manufacturers Association
K. S. Sivakumaran	McMaster University
M. Sommerstein	M&H Engineering
T. Sputo	Steel Deck Institute
M. Tancredi	Ferroeng Group Inc.
N. A. Tapata	Simpson Strong-Tie
C. R. Taraschuk	National Research Council Canada
D. D. Tobler	American Buildings Company
T. W. J. Trestain	T. W. J. Trestain Structural Engineering
C. M. Uang	University of California at San Diego
P. Versavel	Behlen Industries LP
L. Vieira	University of New Haven
R. B. Vincent	Consultant
D. P. Watson	B C Steel Buildings
M. Winarta	New Millennium Building Systems
K. L. Wood	K. L. Wood Engineering
L. Xu	University of Waterloo
C. Yu	University of North Texas
R. Zadeh	Steel Stud Manufacturers Association

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_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*	E6.2
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 cross-section	A1.3, C2.1, C4.2, E6.2, 1.2.1.1.1
A_{gv}	*Gross area* subject to shear	E6.3
A_{nt}	*Net area* subject to tension	E6.2, E6.3
A_{nv}	*Net area* subject to shear	E6.1, E6.3
A_n	*Net area* of cross-section	A1.3, C2.2
A_{net}	*Net area* of cross-section at the location of a hole	1.2.1.2.2
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, 1.2.2.2
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
a	Major diameter of the tapered *PAF* head	E5, E5.2.3
B_c	Term for determining tensile *yield stress* of corners	A7.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
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
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_t	Hat or trapezoid shape stiffener over all width	1.1.1.2
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, 1.1.1.1
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
C_w	Torsional warping constant of cross-section	C3.1.2.1

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
C_{wf}	Torsional warping constant of *flange*	C3.1.4, C4.2
C_y	Compression strain factor	C3.1.1
C_{yd}	Compression strain factor	1.2.2.1.3.2
$C_{y\ell}$	Compression strain factor	1.2.2.1.2.2
C_{yt}	Ratio of maximum tension strain to yield strain	1.2.2.1.2.2
C_1, C_2, C_3	Axial *buckling* coefficients	D6.1.3
C1 to C6	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	C3.1.3, C4.1.5
D	Overall depth of lip	B1.1, B2.5, B4, 1.1.1.1, 1.1.1.2
D	Shear stiffener coefficient	C3.7.3
D	Dead load	A3.1, A6.1.2
DS	Width of *web* stiffener	1.1.1.2
D_2, D_3	Lip dimension	1.1.1.1, 1.1.1.2
d	Depth of section	B1.1, B2.5, C3.1.2.1, C3.4.1, C3.4.2, C3.7.2, D3.2.1, D6.1.1, D6.1.3, D6.1.4, D6.3.1, D6.3.2
d	Nominal screw diameter	E4, E4.1, E4.2, E4.3.1, E4.4.1, E4.5.1.1, E4.5.1.2, E4.5.2.1, E4.5.2.2
d	Flat depth of lip defined in Figure B4-1	B4
d	Visible width of arc seam weld	E2.3.1, E2.3.2.1, E2.3.2.2
d	Visible diameter of outer surface of arc spot weld	E2.2.1, E2.2.2.1, E2.2.2.2, E2.2.4
d	Nominal bolt diameter	E3, E3.1, E3.2, E3.3.1, E6.2
d	Fastener diameter measured at near side of embedment or d_s for *PAF* installed such that entire point is located behind far side of the embedment material	E5, E5.2.1, E5.3.1
d_a	Average diameter of arc spot weld at mid-thickness of t	E2.2.2.1, E2.2.2.2, E2.2.3, E2.2.4
d_a	Average width of seam weld	E2.3.2.1, E2.3.2.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
d_{ae}	Average embedded diameter, computed as average of installed fastener diameters measured at near side and far side of embedment material or d_s for *PAF* installed such that entire point is located behind far side of embedment material	E5, E5.3.3
d_b	Nominal diameter (body or shank diameter)	G4
d_e	Effective diameter of fused area	E2.2, E2.2.2.1, E2.2.2.2, E2.2.3
d_e	*Effective width* of arc seam weld at fused surfaces	E2.3.2.1
d_h	Diameter of hole	B2.2, E6.1, E6.2
d_h	Depth of hole	B2.2, B2.4, C3.2.2, C3.4.2
d_h	Screw head diameter or hex washer head integral washer diameter	E4, E4.4, E4.4.2
$d_{p_{i,j}}$	Distance along roof slope between the ith *purlin* line and the jth anchorage device	D6.3.1
d_s	Reduced *effective width* of stiffener	B2.5, B4
d_s	Depth of stiffener	1.1.1.2
d_s	Nominal shank diameter	E5, E5.1, E5.2.3, E5.3.2, E5.3.3, E5.3.4, E5.3.4
d'_s	*Effective width* of stiffener calculated according to B3.1	B4
d_w	Steel washer diameter	E4, E4.4, E4.4.2
d_w	Larger value of screw head or washer diameter	E4.5.1.1, E4.5.1.2
d'_w	Effective pull-over resistance diameter	E4, E4.4.2
d'_w	Actual diameter of washer or fastener head in contact with retained substrate	E5, E5.2.3
d_1,d_2	Weld offset from flush condition	E2.6
E	Modulus of elasticity of steel, 29,500 ksi (203,000 MPa, or 2,070,000 kg/cm^2)	A2.3.2, A2.3.3, B1.1, B2.1, B2.5, B4, B5.1, C3.1.1, C3.1.2.1, C3.1.2.2, C3.1.3, C3.1.4, C3.2.1, C3.5.1, C3.5.2,C3.7.1, C3.7.3, C4.1.1, C4.1.5, C4.2, C5.2.1, C5.2.2, D1.3, D6.1.3, D6.3.1, E2.2.2.1, E5.3.3, 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*	Reduced modulus of elasticity for flexural and axial stiffness in *second-order analysis*	2.2.3
e	*Flat width* between first line of connector and edge stiffener	B2.5

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
e_{net}	Clear distance between end of material and edge of fastener hole or weld	E6.1
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_{bs}	Base *stress* parameter (66,00 psi (455 MPa))	E5, E5.2.1
F_{SR}	Design *stress* range	G3
F_{TH}	Threshold *fatigue stress* range	G1, G3, G4
F_c	Critical *buckling stress*	B2.1, B2.5, C3.1.2.1, C3.1.3
F_{cr}	Plate elastic *buckling stress*	A2.3.2, B2.1, B2.5, 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* of bolts	E3.4
F_{nt}	*Nominal tensile strength* of bolts	E3.4
F_{nv}	*Nominal shear strength* of bolts	E3.4
F'_{nt}	*Nominal tensile strength* for bolts subject to combination of shear and tension	E3.4
F_{sy}	*Yield stress* as specified in Section A2.1 or A2.2	A2.3.2, A2.3.3, A2.3.4, E2.4.1
F_u	*Tensile strength* as specified in Section A2.1 or A2.2	A2.3.2, A2.3.3, C2.2, 2.2.2.1, E2.2.2.2, E2.2.3, E2.2.4, E2.3.2.1, E2.3.2.2,E2.4.1, E2.6, E3.3.1, E3.3.2, E4.5.2.1, E4.5.2.2, E6.1, E6.2, E6.3
F_{uh}	*Tensile strength* of hardened *PAF* steel	E5, E5.2.1, E5.3.1
F_{uv}	*Tensile strength* of *virgin steel* specified by Section A2 or established in accordance with Section F3.3	A7.2
F_{ut}	*Tensile strength* of non-hardened *PAF* steel	E5
F_{u1}, F_{u2}	*Tensile strengths* of connected parts corresponding to *thicknesses* t_1 and t_2	E2.5
F_{u1}	*Tensile strength* of member in contact with screw head	E4, E4.3.1, E4.4.2, E4.5.1.1, E4.5.1.2
F_{u1}	*Tensile strength* of member in contact with *PAF* head or washer	E5, E5.2.3, E5.3.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
F_{u2}	*Tensile strength* of member not in contact with screw head	E4, E4.3.1, E4.4.1, E4.5.2.1, E4.5.2.2
F_{u2}	*Tensile strength* of member not in contact with *PAF* head or washer	E5
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, E2.2.2.1, E2.2.2.2, E2.2.3, E2.2.4, E2.3.2.1, E2.3.2.2, E2.4.1, E2.5, E2.6
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	A2.3.3, A2.3.4, A7.1, A7.2, B2.1, B2.5, C2.1, C3.1.1, C3.1.2.1, C3.1.2.2, C3.1.3, C3.2.1, C3.4.1, C3.5.1, C3.5.2, C3.7.1, C3.7.2, C3.7.3, C4.1, C4.1.2, C4.1.5, C C4.2, 5.1.2, C5.1.1, C5.2.1, C5.2.2, D1.3, D6.1.1,D6.1.2, D6.1.4, E2.1, E2.2.4, E4.5.2.1, E4.5.2.2, E6.3, G1, 1.1.1.1, 1.1.1.2, 1.2.1.1.1, 1.2.1.2.2, 1.2.2.1.1.1.1, 1.2.2.1.1.2, 1.2.2.1.2.1.2, 1.2.2.2, 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
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_{y2}	*Yield stress* of t_2 sheet steel	E5, E5.3.3
f	*Stress* in compression element computed on basis of *effective design width*	B2.1, B2.2, B2.4, B2.5, B3.1, B3.2, B4, B5.1, B5.1.1, B5.1.2, B5.2
f′	*Stress* used in Section B4(a) for determining *effective width* of edge stiffener	B2.5
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
$f_{bending}$	Bending stress at location in cross section where combined bending and torsion *stress* is maximum	C3.6
$f_{bending\_max}$	Bending stress at extreme fiber, taken on same side of neutral axis as $f_{bending}$	C3.6

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
$f_{torsion}$	Torsional warping stress at location in cross section where combined bending and torsion stress effect is maximum	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, B2.5, 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
GS	Center-to-center spacing of flat widths plus two interior stiffeners	1.1.1.2
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	E6.2
H	A *permanent load* due to lateral earth pressure, including groundwater	A3.1, A3.2
HRC_p	Rockwell C hardness of *PAF* steel	E5, E5.2.1
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, 1.2.2.2
h	Width of elements adjoining stiffened element	B5.1
h	Height of lip	E2.6
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

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
h_s	Depth of soil supported by the structure	A6.1.2
h_{st}	Nominal seam height	E2.4.1
h_{wc}	Coped flat *web* depth	E6.1
h_{xf}	x distance from centroid of *flange* to *flange*/*web* junction	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, B2.5, 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*, using full unreduced section	C3.1.2.1
I_{yf}	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

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
K	Effective length factor	C4.1.1, D1.2
K′	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 jth anchorage device with respect to ith *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
KL	Effective length	A2.3.2
k	Plate *buckling* coefficient	B2.1, B2.2, B2.3, B2.5, 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
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 *flange* to *flange*/*web* juncture	C3.1.4, C4.2
$\tilde{k}_{\phi fg}$	Geometric rotational stiffness demanded by *flange* from *flange*/*web* juncture	C3.1.4, C4.2
$k_{\phi we}$	Elastic rotational stiffness provided by *web* to *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	D1.1, D6.3.1, D6.3.2
L	Length of weld	E2.1, E2.6
L	Length of longitudinal weld or length of *connection*	E6.2
L	Length of seam weld not including circular ends	E2.3.2.1

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
L	Length of fillet weld	E2.5
L	Unbraced length of member	C4.1.1, C5.2.1, C5.2.2, D1.2
L	Overall length	2.2.1
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 individual concentrically loaded compression member to be braced	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_{cr}	Critical unbraced length of *distortional buckling*	C3.1.4, C4.2
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_o	Overhang length measured from the edge of bearing to the end of member	C3.4.1
L_{st}	Length of bearing stiffener	C3.7.1
L_t	Unbraced length of compression member for torsion	C3.1.2.1
L_u	Limit of unbraced length below which lateral-torsional buckling is not considered	C3.1.2.2
L_w	Length of *top arc seam sidelap weld*	E2.4.1
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
ℓ_{dp}	*PAF* point length	E5, E5.2.1, E5.2.2, E5.3.1, E5.3.2
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, 1.2.2.1.3.1.1, 1.2.2.1.3.1.2
M_{cre}	Overall buckling moment	1.1.2, 1.2.2.1, 1.2.2.1.1.1.1, 1.2.2.1.1.1.2, 1.2.2.1.1.2
$M_{cr\ell}$	*Local buckling* moment	1.1.2, 1.2.2.1.2.1.1, 1.2.2.1.2.2
M_d	Nominal moment with consideration of deflection	1.1.3

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
M_{d2}	*Nominal flexural strength* [*resistance*] of *distortional buckling* at λ_2	1.2.2.1.3.2
M_f	Moment due to *factored loads*	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, M_C	Absolute value of moments in unbraced segment, used for determining C_b	C3.1.2.1
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
M_{nd}	*Nominal flexural strength* [*resistance*] for *distortional buckling*	1.2.2.1, 1.2.2.3, 1.2.2.1.3.1.1, 1.2.2.1.3.1.2, 1.2.2.1.3.2
M_{ne}	*Nominal flexural strength* [*resistance*] for overall *buckling*	1.2.2.1, 1.2.2.1, 1.2.2.1.1, 1.2.2.1.1.1.1, 1.2.2.1.1.1.2, 1.2.2.1.1.2, 1.2.2.1.2.1.1, 1.2.2.1.2.2, 1.2.2.3
$M_{n\ell}$	*Nominal flexural strength* [*resistance*] for *local buckling*	1.2.2.1, 1.2.2.1.2, 1.2.2.1.2.1.1, 1.2.2.1.2.1.2, 1.2.2.1.2.2
$M_{n\ell o}$	*Nominal flexural strength* [*resistance*] for *local buckling* with M_{ne}=M_y	1.2.2.3
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, 1.2.2.3
M_{nxt}, M_{nyt}	*Nominal flexural strengths* [*resistances*] about centroidal axes determined using gross, unreduced cross-section properties	C5.1.1, C5.1.2
M_p	Plastic moment	1.2.2.1.1.2, 1.2.2.1.2.2, 1.2.2.1.3.2
M_x, M_y	*Required allowable flexural strength* with respect to centroidal axes for *ASD*	C4.1, C5.1.1, C5.2.1
M_u	*Required flexural strength* for *LRFD*	C3.3.2, C3.5.2
M_{ux},M_{uy}	*Required flexural strength* with respect to centroidal axes for *LRFD*	C4.1, C5.1.2, C5.2.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
M_y	Moment causing maximum strain e_y	B2.1
M_y	Yield moment ($=S_fF_y$)	C3.1.4, 1.1.3, 1.2.2.1.1.1.1, 1.2.2.1.2.1.2, 1.2.2.1.2.2, 1.2.2.1.3.1.1, 1.2.2.1.3.1.2, 1.2.2.1.3.2, 1.2.2.3
M_{yc}	Moment at which yielding initiates in compression (after yielding in tension).	1.2.2.1.2.2, 1.2.2.1.3.2
M_{ynet}	Yield moment of net cross-section	1.2.2.1.2.1.2, 1.2.2.1.3.1.2
M_{yt3}	Yield moment at maximum tensile strain	1.2.2.1.2.1.2, 1.2.2.1.3.1.2
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
$\overline{M}$	*Required flexural strength* [moment due to *factored loads*]	C3.3.2, C3.5.2
$\overline{M}_x$, $\overline{M}_y$	*Required flexural strengths* [moments due to *factored loads*]	C4.1, C5.1.2
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 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 fasteners on critical cross-section	E6.1
n	Number of threads per inch	G4
n_b	Number of fasteners along failure path being analyzed	E6.1, E6.2
n_c	Number of compression *flange* stiffeners	1.1.1.2
n_w	Number of *web* stiffeners and/or folds	1.1.1.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
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 compressive axial strength* for *ASD*	A2.3.5, C5.2.1
P	Professional factor	F1.1, 1.1.1.1
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_{d2}	*Nominal axial strength* [*resistance*] of *distortional buckling* at λ_2	1.2.1.3.2
P_{Ex}, P_{Ey}	Elastic *buckling* strengths	C5.2.1, C5.2.2
P_{L1}, P_{L2}	Lateral bracing forces	D3.2.1
P_{L_j}	Lateral force to be resisted by the jth anchorage device	D6.3.1
P_{crd}	*Distortional buckling* load	C4.2, 1.1.2, 1.2.1.3.1
P_{cre}	Overall *buckling* load	1.1.2, 1.2.1.1.1, 1.2.1.1.2
$P_{cr\ell}$	*Local buckling* load	1.1.2, 1.2.1.2.1
P_f	Axial force due to *factored loads*	A2.3.5, C5.2.2
P_f	Concentrated load or reaction due to *factored loads*	C3.5.2
P_i	Lateral force introduced into system at ith *purlin*	D6.3.1
P_m	Mean value of tested-to-predicted load ratios	F1.1, 1.1.1.1
P_n	*Nominal web crippling strength* [*resistance*]	C3.4.1, C3.5.1, C3.5.2,
P_n	*Nominal axial strength* [*resistance*] of member	A2.3.5, C4.1, C4.2, C5.2.1, C5.2.2, 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, E2.2.2.1, E2.2.2.2, E2.2.3 E2.3.2.1, E2.3.2.2, E2.4.1, E2.5, E2.6, E2.7
P_n	*Nominal bearing strength* [*resistance*]	E3.3.1, E3.3.2
P_n	*Nominal bolt strength* [*resistance*]	E3.4
P_{nbp}	*Nominal bearing* and *tilting strength* [*resistance*] per *PAF*	E5, E5.3.2
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, 1.2.1.3.1, 1.2.1.3.2
P_{ne}	*Nominal axial strength* [*resistance*] for overall *buckling*	1.2.1, 1.2.1.1.1, 1.2.1.1.2, 1.2.1.2.1
$P_{n\ell}$	*Nominal axial strength* [*resistance*] for *local buckling*	1.2.1, 1.2.1.2.1, 1.2.1.2.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
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_{nos}	*Nominal pull-out strength* [*resistance*] in shear per *PAF*	E5, E5.3.3
P_{not}	*Nominal pull-out strength* [*resistance*] of sheet per screw	E4, E4.4.1, E4.5.2.1, E4.5.2.2
P_{not}	*Nominal pull-out strength* [*resistance*] in tension per *PAF*	E5
P_{nov}	*Nominal pull-over strength* [*resistance*] of sheet per screw	E4, E4.4.2, E4.5.1.1, E4.5.1.2
P_{nov}	*Nominal pull-over strength* [*resistance*] per *PAF*	E5
P_{ns}	*Nominal shear strength* [*resistance*] of sheet per screw	E4, E4.3.1, E4.5.1.1, E4.5.1.2, E4.5.2.1, E4.5.2.2
P_{ns}	*Nominal shear strength* [*resistance*] given by Section E2.2.2	E2.2.4.1, E2.2.4.2
P_{nsp}	*Nominal shear strength* [*resistance*] per *PAF*	E5, E5.3.1
P_{nt}	*Nominal tension strength*[*resistance*] given by Section E2.2.3	E2.2.4.1, E2.2.4.2
P_{ntp}	*Nominal tensile strength* [*resistance*] per *PAF*	E5, E5.2.1
P_{n1}, P_{n2}	*Nominal shear strength* [*resistance*] corresponding to connected *thicknesses* t_1 and t_2	E2.5
P_{ra}	*Required axial compressive strength* [compressive axial force due to *factored loads*] using *ASD*, *LRFD* or *LSD load combinations*	2.2.3
P_{ra}	*Required compressive axial strength* [compressive axial force due to *factored loads*] of individual concentrically loaded compression member to be braced, which is calculated in accordance with *ASD*, *LRFD*, or *LSD load combinations* depending on the design method used	D3.3
P_{rb}	*Required brace strength* [brace force due to *factored loads*] to brace a single compression member with an axial *load* P_{ra}	D3.3
P_s	Concentrated load or reaction	D1.1
P_{sp}	*Nominal shear strength* [*resistance*] of *PAF*	E5
P_{ss}	*Nominal shear strength* [*resistance*] of screw as reported by manufacturer or determined by independent laboratory testing	E4, E4.3.2, E4.5.3.1, E4.5.3.2
P_{tp}	*Nominal tensile strength* [*resistance*] of *PAF*	E5
P_{ts}	*Nominal tension strength* [*resistance*] of screws as reported by manufacturer or determined by independent laboratory testing	E4, E4.4.3, E4.5.3.1, E4.5.3.2
P_u	*Required axial strength* for *LRFD*	A2.3.5, C5.2.2
P_u	*Required strength* for concentrated load or reaction in presence of bending moment for *LRFD*	C3.5.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
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, 1.2.1.3.1, 1.2.1.3.2, 2.2.3
P_{ynet}	Member yield strength on net cross-section	1.2.1.2.2, 1.2.1.3.2
$\overline{P}$	*Required strength* for concentrated load or reaction [concentrated load or reaction due to *factored loads*] in presence of bending moment	C3.5.2
$\overline{P}$	*Required compressive axial strength* [compressive axial force due to *factored loads*]	C5.2.2
PAF	Power-actuated fasteners	E5, E5.1, E5.2, E5.2.1, E5.2.2, E5.2.3, E5.3, E5.3.1, E5.3.2, E5.3.3, E5.3.4, E5.4, E6
p	Pitch (mm per thread for SI units and cm per thread for MKS units)	G4
Q	*Required allowable shear strength* per *connection* fastener	E2.2.4.1, E4.5.1.1, E4.5.3.1
$\overline{Q}$	*Required shear strength* [shear force due to *factored loads*] per *connection* fastener	E2.2.4.2, E4.5.1.2, E4.5.3.2
Q_f	Shear force due to *factored loads* per *connection* fastener for *LSD*	E2.2.4.2
Q_i	*Load effect*	F1.1
Q_u	*Required shear strength* per *connection* fastener for *LRFD*	E2.2.4.2
q	*Design load* [factored load] on beam for determining longitudinal spacing of connections	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

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
R	Inside bend radius	A7.2, C3.4.1, C3.5.1, C3.5.2
R	Radius of outside bend surface	E2.6
R_I	I_s/I_a	B4
R_a	*Allowable design strength*	F1.2
R_b	Reduction factor	A2.3.3
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*]	E6.3
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_1, R_2	Radius of outside bend surface	E2.6
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
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	Stiffener spacing	1.1.1.2
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, 1.2.2.1.1.1.1
S_{fnet}	Net section modulus referenced to the extreme fiber in first yield	1.2.2.1.2.1.2
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 cross-section relative to extreme fiber in first yielding	C3.1.4

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
S_n	In-plane *diaphragm nominal shear strength* [*resistance*]	D5
s	Center-to-center hole spacing	B2.2
s	Center-to-center spacing of connectors in line of compression *stress*	B2.5
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	E6.2
s	Weld spacing	D1.1
s′	Longitudinal center-to-center spacing of any consecutive holes	E6.2
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* per *connection* fastener	E2.2.4.1, E4.5.1.1, E4.5.2.1, E4.5.3.1
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 per *connection* fastener for *LSD*	E2.2.4.2, E4.5.1.2, E4.5.3.2
T_n	*Nominal tensile strength* [*resistance*]	C2.1, C2.2, C5.1.1, C5.1.2
T_n	*Nominal tensile rupture strength* [*resistance*]	E6.2
T_r	*Required strength* [force due to *factored loads*] for *connection* in tension	D1.1
T_u	*Required tensile axial strength* for *LRFD*	C5.1.2
T_u	*Required tension strength* per *connection* fastener for *LRFD*	E2.2.4.2, E4.5.1.2
$\overline{T}$	*Required tensile axial strength* [tensile force due to *factored loads*]	C5.1.2
$\overline{T}$	*Required tension strength* [tensile force due to *factored loads*] per *connection* fastener	E2.2.4.2, E4.5.1.2, E4.5.2.2, E4.5.3.2
t	Base steel *thickness* of any element or section	A1.3, A2.3.3, A2.4, A7.2, B1.1, B1.2, B2.1, B2.2, B2.4, B2.5, B3.2, B4, B5.1, B5.1.1, B5.1.2, B5.2, 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,

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Symbol	Definition	Section
		C4.1.5, C4.2, D1.3, D6.1.3, D6.1.4, D6.3.1, E3.3.1, E3.3.2, E6.1, E6.2,1.1.1.1, 1.1.1.2
t	*Thickness* of coped *web*	E6.1
t	Total *thickness* of two welded sheets	E2.2.2.1, E2.2.2.2, E2.2.3, E2.2.4, E2.3.2.1, E2.3.2.2
t	*Thickness* of thinner connected sheet	E2.4.1
t	*Thickness* of thinnest connected part	E2.5, E2.7
t	*Thickness* of flare-bevel groove welded member	E2.6
t_c	Lesser of depth of penetration and t_2	E4, E4.4.1, E4.5.2.1, E4.5.2.2
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	E2.5, E2.6
t_w	Steel washer thickness	E4.4.2, E5, E5.1
t_{wf}	Effective throat of groove weld that is filled flush to surface, determined in accordance with Table E2.6-1	E2.6
t_1	*Thickness* of member in contact with screw head	E4, E4.3.1, E4.4, E4.4.2, E4.5.1.1, E4.5.1.2
t_1	*Thickness* of member in contact with *PAF* head or washer	E5, E5.2.3, E5.3.2
t_2	*Thickness* of member not in contact with screw head	E4, E4.3.1, E4.5.1.1, E4.5.1.2, E4.5.2.1, E4.5.2.2
t_2	*Thickness* of member not in contact with *PAF* head or washer	E5, E5.3.2, E5.3.3
t_1, t_2	Based *thicknesses* connected with fillet weld	E2.5
U_{bs}	Non-uniform block shear factor	E6.3
U_{s1}	Shear lag factor determined in Table E6.2-1	E6.2
V	*Required allowable shear strength* for *ASD*	C3.3.1
V_{cr}	Shear buckling load	1.1.2, 1.2.2.2
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	Shear force due to *factored loads* per *connection* fastener for *LSD*	E4.5.1.2, E4.5.3.2
V_M	Coefficient of variation of material factor	D6.2.1, F1.1
V_n	*Nominal shear strength* [*resistance*]	C3.2.1, C3.3.1, C3.3.2, E6.1, 1.1.1, 1.2.2.2, 1.2.2.3

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
V_P	Coefficient of variation of tested-to-predicted load ratios	D6.2.1, F1.1, 1.1.1.1
V_Q	Coefficient of variation of *load effect*	D6.2.1, F1.1
V_y	Yield shear force of section	1.2.2.2
V_u	*Required shear strength* for *LRFD*	C3.3.2
V_u	*Required shear strength* per *connection* fastener for *LRFD*	E4.5.1.2, E4.5.3.2
$\overline{V}$	*Required shear strength* [shear force due to *factored loads*]	C3.3.2
W	Wind load, a *variable load* due to wind	A3.1, A6.1.2, A6.1.2.1
W	*Required strength* [*factored load*] from critical *load combinations* for *ASD*, *LRFD*, or *LSD*	D3.2.1
W_{pi}	Total required vertical load supported by ith *purlin* in a single bay	D6.3.1
W_x, W_y	Components of *required strength* [*factored load*] W	D3.2.1
WS	Depth of stiffeners	1.1.1.2
w	*Flat width* of element exclusive of radii	A2.3.3, B1.1, B2.1, B2.2, B3.1, B3.2, B4, C3.1.1, C3.7.1
w	*Flat width* of element measured between longitudinal connection lines and exclusive of radii at stiffeners	B2.5
w′	Equivalent *flat width* for determining *effective width* of edge stiffener	B2.5
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_f	Face width of weld	E2.6
w_i	Required distributed gravity load supported by ith *purlin* per unit length	D6.3.1
w_o	Out-to-out width	B2.2
w_1	Leg of weld	E2.5
w_1	Transverse spacing between first and second line of fasteners in compression element	B2.5
w_2	Leg of weld	E2.5
x	Non-dimensional fastener location	D6.1.3
x	Nearest distance between *web* hole and edge of bearing	C3.4.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
x_o	Distance from shear center to centroid along principal x-axis	C3.1.2.1, C4.1.2
x_{of}	x distance from centroid of *flange* to shear center of *flange*	C3.1.4, C4.2
$\bar{x}$	Distance from shear plane to centroid of cross-section	E6.2
Y	Yield stress of *web* steel divided by yield stress 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_{of}	y distance from centroid of *flange* to shear center of *flange*	C3.1.4
Z_f	Plastic section modulus	1.2.2.1.1.1.2
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 increase due to overhang	C3.4.1
α	Second-order amplification coefficient	2.2.3
α	Coefficient	E5.2.3
α_b	Coefficient	E5.3.2
$1/\alpha_x$, $1/\alpha_y$	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
β_o	Target reliability index	D6.2.1, F1.1
β_{rb}	Minimum required brace stiffness to brace a single compression member	D3.3
γ, γ_i,	Coefficients	B5.1.1, B5.1.2
γ_i	*Load factor*	F1.1
δ, δ_i,	Coefficients	B5.1.1, B5.1.2
η	Variable	E2.6
θ	Angle between vertical and plane of *web* of Z-section, degrees	D6.3.1
θ	Angle between an element and its edge stiffener	B4, 1.1.1.1, 1.1.1.2

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
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, B2.5, B3.2, B5.1, C3.1.1, C4.1, 1.2.1.1.1
λ_1, λ_2, λ_3, λ_4	Parameters used in determining compression strain Factor	C3.1.1
λ_ℓ	Slenderness factor	1.2.1.2.1, 1.2.2.1.2.1.1, 1.2.2.1.2.2
λ_d	Slenderness factor of column or beam	C3.1.4, C4.2, 1.2.1.3.1, 1.2.1.3.2, 1.2.2.1.3
λ_{d1}, λ_{d2}	Slenderness factors of column or beam	1.2.1.3.2, 1.2.2.1.3
λ_t	Slenderness factor	B2.5
λ_v	Slenderness factor	1.2.2.2
μ	Poisson's ratio of steel = 0.30	B2.1, C3.2.1, C3.1.4, C4.2
ξ_{web}	*Stress* gradient in *web*	C3.1.4
ρ	Reduction factor	A7.2, B2.1, B2.5, B3.2, B5.1, F3.1
ρ_m	Reduction factor	B2.5
ρ_t	Reduction factor	B2.5
σ_{ex}	$(\pi^2E)/(K_xL_x/r_x)^2$ $(\pi^2E)/(L/r_x)^2$	C3.1.2.1
σ_{ey}	$(\pi^2E)/(K_yL_y/r_y)^2$ $(\pi^2E)/(L/r_y)^2$	C3.1.2.1
σ_t	*Torsional buckling stress*	C3.1.2.1, C4.1.2, C4.1.3
τ_b	Parameter for reduced stiffness using second-order analysis	2.2.3
ϕ	*Resistance factor*	A1.2, A1.3, A5.1.1, A6.1.1, D6.2.1, C3.5.2, C3.7.2, D3.3, D6.1.3, D6.3.1, D6.3.2, E2.1, E2.2.2.1, E2.2.2.2, E2.2.3, E2.3.2.1, E2.3.2.2, E2.4.1, E2.5, E2.6, E2.7, E3.3.1, E3.3.2, E3.4, E4, E4.3.2, E4.4.3,

SYMBOLS AND DEFINITIONS

Symbol	Definition	Section
		E4.5.1.2, E4.5.2.2, E4.5.3.2, E5.2.1, E5.2.2, E5.2.3, E5.3.1, E5.3.2, E5.3.3, E6, F1.1, F1.2, 1.1.1, 1.1.1.1, 1.1.1.2, 1.2.1, 1.2.2.1
ϕ_b	*Resistance factor* for bending strength	C3.1, C3.1.1, C3.1.2, C3.1.3, C3.1.4, C3.3.2, C3.5.2, C5.1.2, C5.2.2, D6.1.1, D6.1.2, 1.2.2.1
ϕ_c	*Resistance factor* for concentrically loaded compression strength	A2.3.5, C3.7.1, C4.1, C4.2, C5.2.2, 1.2.1
ϕ_d	*Resistance factor* for *diaphragms*	D5
ϕ_s	*Resistance factor* for shear strength	E2.2.4.2
ϕ_t	*Resistance factor* for tension strength	C2.1, C2.2, C5.1.2, E2.2.4.2
ϕ_u	*Resistance factor* for *rupture*	E6
ϕ_v	*Resistance factor* for shear strength	C3.2.1, C3.3.2, 1.2.2.2
ϕ_w	*Resistance factor* for *web crippling* strength	C3.4.1, C3.5.2
ω_i	Coefficient	B5.1.2
ψ	$\|f_2/f_1\|$	B2.3, B3.2, C3.1.1
Δ_{tf}	Lateral displacement of *purlin* top *flange* at the line of restraint	D6.3.1
Ω	*Safety factor*	A1.2, A1.3, A4.1.1, D6.2.1, C3.5.1, C3.7.2, D3.3, D6.1.3, D6.3.1, D6.3.2, E2.1, E2.2.2.1, E2.2.2.2, E2.3.2.1, E2.3.2.2, E2.4.1, E2.5, E2.6, E2.7, E3.3.1, E3.3.2, E3.4, E4, E4.3.2, E4.4.3, E4.5.1.1, E4.5.2.1, E4.5.3.1, E5.2.1, E5.2.2, E5.2.3, E5.3.1, E5.3.2, E5.3.3, E6, F1.2, 1.1.1, 1.1.1.1, 1.1.1.2, 1.2.1, 1.2.2.1
Ω_b	*Safety factor* for bending strength	C3.1, C3.1.1, C3.1.2, C3.1.3, C3.1.4, C3.3.1, C3.5.1, C5.1.1, C5.2.1, D6.1.1, D6.1.2, 1.2.2.1
Ω_c	*Safety factor* for concentrically loaded compression	A2.3.5, C4.1, C4.2, C5.2.1, 1.2.1

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Symbol	Definition	Section
	strength	
Ω_c	*Safety factor* for *bearing* strength	C3.7.1
Ω_d	*Safety factor* for *diaphragms*	D5
Ω_s	*Safety factor* for shear strength	E2.2.4.1
Ω_t	*Safety factor* for tension strength	C2.1, C2.2, C5.1.1, E2.2.4.1
Ω_v	*Safety factor* for shear strength	C3.2.1, C3.3.1, 1.2.2.2
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 2012 EDITION

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.

The symbol ☜x is used to point out that additional provisions that are specific to a certain country are provided in the corresponding appendices indicated by the letter(s) "x."

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* — The United States and Mexico, and
- *LSD* — Canada.

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

The *nominal strength* [*resistance*] and stiffness of cold-formed steel components such as 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 the components is such that calculation of *available strength* [*factored resistance*] or stiffness cannot be made in accordance with those provisions, structural performance shall be established from one of the following:

(a) *Available strength* [*factored resistance*] or stiffness by tests only. Specifically, the *available strength* [*factored resistance*] is determined from tested *nominal strength* [*resistance*] by applying the *safety factors* or the *resistance factors* evaluated in accordance with Section F1.1(a);
(b) *Available strength* [*factored resistance*] by *rational engineering analysis* with verification tests. Specifically, the *available strength* [*factored resistance*] is determined from the calculated *nominal strength* [*resistance*] by applying the *safety factors* or *resistance factors* evaluated in