Nov 3rd, 12:00 AM

The 2008 AISI Cold-formed Steel Design Manual

Richard C. Kaehler

Helen Chen

Twentieth International Specialty Conference on Cold-Formed Steel Structures
St. Louis, Missouri, U.S.A., November 3 & 4, 2010

The 2008 AISI Cold-Formed Steel Design Manual

Richard C. Kaehler, P.E.[1] and Helen Chen, Ph.D., P.E.[2]

Abstract

The 2008 edition of the AISI Cold-Formed Steel Design Manual has been published. The new edition includes updated examples and design aids as well as newly developed example problems and design aids covering new material in the 2007 edition of the *North American Specification for the Design of Cold-Formed Steel Structural Members.* Also included are all current AISI structural Test Standards.

Introduction

The American Iron and Steel Institute (AISI) has published the 2008 edition of its Cold-Formed Steel Design Manual (manual). The manual was produced for AISI by Computerized Structural Design, S.C. under the direction of Subcommittee 26 – Design Manual of the AISI Committee on Specifications.

The manual is a companion to the 2007 edition of the *North American Specification for the Design of Cold-Formed Steel Structural Members* (*NA Specification*). As in earlier editions, the 2008 manual provides worked example problems, tabulated and graphed design aids, AISI test standards and other supplemental information for use by designers, students, educators and code officials.

[1] Vice President, Computerized Structural Design, S.C., Milwaukee, WI
[2] Manager, Construction Standards Development, American Iron and Steel Institute, Washington, D.C.

The 2008 edition of the manual is based on the 2007 *North American Specification for the Design of Cold-Formed Steel Structural Members*, a joint publication of AISI, the Canadian Standards Association and CANACERO. The 2007 *NA Specification* covers Load and Resistance Factor Design and Allowable Strength Design for use in the US and Mexico, and Limit State Design for use in Canada with equal emphasis. Country specific provisions applicable to Canada, Mexico and the U.S. are included for cases where joint provisions were not possible. New to the 2007 *NA Specification* are Appendices covering the Direct Strength Method and Second-Order Analysis. Provisions are provided in dimensionless terms where possible or in US customary units and two separate metric systems where that is not possible.

To keep the manual to a reasonable size and appeal to the majority of potential users, all example problems and other calculated values are presented in US customary units using the US country specific provisions. Manuals with Canadian or Mexican country specific provisions or metric units are not available at this time.

All of the previous tables and charts have been updated according to the provisions of the 2007 *NA Specification*. New tables were added to incorporate new design provisions wherever appropriate. A total of 50 illustrative examples are included in this manual. All example problems from the 2002 manual were reviewed and updated to improve presentation of the material and illustrate new and revised *NA Specification* provisions. Eleven new example problems were added to illustrate new and revised *NA Specification* provisions. To provide users with a better understanding of the design information included in each part of the manual, discussions on cold-formed member behavior and failure modes considered in design have been added to the relevant parts of the manual.

As in the 2002 edition, the *Specification* and *Commentary* are not included as chapters in the manual, due to space limitations. Both are available as part of the Cold-Formed Steel Design Manual Set. The 2007 *Specification* and the *Commentary* should be used in conjunction

with the manual. Highlights of the features and changes in the other sections of the manual follow.

Part I – Dimensions and Properties

The table of referenced ASTM steels has been updated to reflect recent changes in steels approved for cold-forming.

Many of the design aids and example problems are based on the "representative cross sections" that are tabulated in Part I. The cross section from the previous edition of the manual have been carried over, including industry standard Steel Stud Manufacturers Association (SSMA) and Light-Gage Steel Institute (LGSI) cross sections for such shapes as studs, C- and Z-sections.

The discussion of the calculation of effective section properties has been expanded to help clarify the procedure. Formulas for calculating distortional buckling properties have been added. The effective section property examples have been updated to reflect changes in Chapter B of the 2007 *NA Specification*.

Part II – Beam Design

To provide an overall understanding to cold-formed steel beam design, new discussions of cold-formed flexural member behavior and limit states, including distortional buckling, have been added to the introductory section.

Three new design tables have been added to aid in evaluation of the distortional buckling limit state. These tables provide design coefficients and nominal distortional buckling strengths for the C-shapes, SSMA studs and Z-shapes tabulated in Part I. A sample of one of these tables is shown in Figure 1. In addition, the smallest possible nominal distortional buckling strength is noted (with diamonded shape) on the each beam's nominal flexural strength curve in Charts II-1 to II-3. The lower bound of the available distortional buckling strength for a

given beam can be calculated via the value on the chart and be used to estimate whether the distortional buckling controls the beam design.

Five new example problems have been added.

1. Distortional Buckling of C-Section illustrates the calculation in detail of the distortional buckling strength of a C-Section braced by OSB per *NA Specification* Section C3.1.4.

2. Tubular Section – Rectangular illustrates the calculation of the flexural strength of a square HSS using *NA Specification* Section C3.1.2.2, including a comparison between the AISI and AISC methods.

3. C-Section with Combined Bending and Torsional Loading illustrates the calculation of the combined flexural and torsional strength of a C-section subject to an eccentric transverse loading per *NA Specification* Section C3.6.

4. Web Crippling illustrates the calculation of the available bearing strength of a stud with a reinforcing bearing stiffener attached according to *NA Specification* Section C3.7.

5. Web-Stiffened C-Section by the Direct Strength Method – Flexure illustrates the computation of the strength of a flexural member having a complex cross section using the Direct Strength procedure from *NA Specification* Appendix 1.

Part III – Column Design

New discussions of cold-formed compression member behavior and limit states have been added to the introductory section.

Three new design tables have been added to aid in evaluation of the distortional buckling limit state. These tables provide design coefficients and nominal distortional buckling strengths for the C-

shapes, SSMA studs and Z-shapes tabulated in Part I. A sample of one of these tables is shown in Figure 2.

Five new example problems have been added.

1. C-Section Subject to Distortional Buckling – Compression illustrates the new distortional buckling provisions for columns included in *NA Specification* Section C4.2.

2. Stiffened Z-Section with One Flange Fastened to a Standing Seam Roof – Compression illustrates the calculation of the axial strength of a Z-purlin in a standing seam roof system per the provisions of *NA Specification* Section D6.1.4.

3. Square HSS Section – Bending and Compression illustrates the calculation of compression strengths and combined compressive and flexural strengths of a square HSS according to *NA Specification* Sections C4 and C5, including a comparison between the AISI and AISC methods.

4. Frame Design by Second-Order Analysis illustrates the new second-order analysis and design provisions given in *NA Specification* Appendix 2.

5. Web-Stiffened C-Section by the Direct Strength Method – Compression illustrates the computation of the strength of a compression member having a complex cross section using the Direct Strength procedure from *NA Specification* Appendix 1.

Part IV – Connection Design

New discussions of connection design limit states were added to the introductory sections for welded, bolted and screwed connections.

A new design table, Arc Spot Welds – Shear of Sheet Welded to an Identical Sheet has been added, in which the nominal strength is based

on the sheet strength. Each of the six screw strength tables from the last edition has been duplicated using the typical SSMA design thicknesses, to allow convenient use with SSMA shapes without the need for interpolation.

The design examples have been revised to reflect technical and editorial changes in the 2007 *NA Specification*.

Part V – Supplemental Information

There is once again a cross reference table showing where each illustrated provision of the *NA Specification* can be found in the example problems.

The material previously published as Section 2 – Laterally Unbraced Compression Flanges has been removed. The long published "9 step" or "10 step" method provided a means of calculating the combined flange and web buckling strength of sections such as hats. This mode of buckling is now recognized as "distortional buckling" and can now be evaluated using the provisions of the Direct Strength method in Appendix 1 of the 2007 *NA Specification*.

The previously published Section 4 – Suggested Cold-Formed Steel Structural Framing, Engineering, Fabrication, and Erection Procedures for Quality Construction has been removed. The information in this document has been superseded by the 2006 Edition of the *AISI Code of Standard Practice for Cold-Formed Steel Structural Framing*.

Part VI – Test Methods

All existing and new test standards have been given new identifying numbers consistent with the new AISI document numbering standard. For example, the test method Rotational-Lateral Stiffness Test Method for Beam-To-Panel Assemblies which was referenced as AISI TS-1-02, is now AISI S901-08, where the 'S901' is the unique designation for this standard and '08' indicates the year of the edition. A cross

reference table is included in the beginning of Part VI, which lists the old and new numbering for each standard.

Several previously included standards have been updated and six new test standards have been added to this edition:

1. *AISI S909-08: Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams*. This test standard establishes procedures for conducting tests to determine the web crippling strength of single-web, multiple-web and built-up web flexural members.

2. *AISI S910-08: Test Method for Distortional Buckling of Cold-Formed Steel Hat Shaped Compression Members*. This test standard establishes procedures for determining the distortional buckling strength of cold-formed steel compression members with a hat shaped cross section.

3. *AISI S911-08: Method for Flexural Testing Cold-Formed Steel Hat Shaped Beams*. This test standard establishes procedures for determining the nominal flexural strength of cold-formed steel compression members with a hat shaped cross section subject to negative bending moment.

4. *AISI S912-08: Test Procedure for Determining a Strength Value for a Roof Panel-to-Purlin-to Anchorage Device Connection*. This test standard establishes procedures for determining lower bound strength values for roof panel-to-purlin-to-anchorage device connections in through-fastened and standing seam, multi-span, multi-purlin line roof systems, with or without intermediate braces.

5. *AISI S913-08: Test Standard for Hold-Downs Attached to Cold-Formed Steel Structural Framing*. This test standard establishes procedures for determining the strength and deformation behavior of hold-downs used in cold-formed steel light-frame construction.

6. *AISI S914-08: Test Standard for Joist Connectors Attached to Cold-Formed Steel Structural Framing*. This test standard establishes procedures for determining the strength and deformation behavior of joist connections used in cold-formed steel light-frame construction.

Availability

The 2008 Edition of the Cold-Formed Steel Design Manual Set, which includes the 2008 Cold-Formed Steel Design Manual, the 2007 *NA Specification* and the *Commentary*, can be obtained from the AISI e-store at: http://www.steel.org.

Conclusion

The 2008 AISI Cold-Formed Steel Design Manual represents a refinement and updating of the previous edition. The changes will make the manual both more convenient and useful to the range of users it serves.

Appendix - References

American Iron and Steel Institute, *Cold-Formed Steel Design Manual*, Washington, D.C., 2008.

American Iron and Steel Institute, AISI S100-07, *North American Specification for the Design of Cold-Formed Steel Structural Members*, Washington, D.C., 2007.

American Iron and Steel Institute, *Code of Standard Practice*, Washington, D.C., 2007.

Figure 1 – Example Flexural Distortional Buckling Table

Table II - 8

Distortional Buckling Properties
SSMA Studs – Flexural Strength
C-Sections With Lips

Ω_b = 1.67 (ASD)
ϕ_b = 0.90 (LRFD)

	L_{cr} in.	$k_{\phi fe}$ kips	$\tilde{k}_{\phi fg}$ in.^{2}	$k_{\phi we}$ kips	$\tilde{k}_{\phi wg}$ in.^{2}	F_d/β ksi	$M_n^1{}_{(\beta=1)}$ F_y=33 ksi kip-in.	$M_n^1{}_{(\beta=1)}$ F_y=50 ksi kip-in.
1200S250-97	17.9	1.05	0.0256	1.06	0.0142	53.2	171	226
1200S250-68	21.7	0.328	0.0128	0.326	0.00698	33.1	105	136
1200S250-54*	24.5	0.156	0.00811	0.154	0.00441	24.7	75.9	97.5
1200S200-97	15.7	1.07	0.0189	1.18	0.0180	60.9	159	212
1200S200-68	19.0	0.334	0.00953	0.352	0.00889	37.2	98.2	128
1200S200-54*	21.5	0.158	0.00606	0.164	0.00562	27.5	70.9	91.4
1200S162-97	12.1	1.15	0.0162	1.54	0.0292	59.1	140	186
1200S162-68	14.5	0.359	0.00845	0.435	0.0146	34.5	85.1	110
1200S162-54*	16.4	0.169	0.00543	0.196	0.00925	24.9	60.7	78.1

Figure 2 – Example Axial Compression Distortional Buckling Table

Table III – 4

Distortional Buckling Properties
Axial Strength
C-Sections With Lips

Ω_c = 1.80 (ASD)
ϕ_c = 0.85 (LRFD)

Section	Per Section 4.2(b)							
	L_{cr} in.	$k_{\phi fe}$ kips	$\tilde{k}_{\phi fg}$ in.^{2}	$k_{\phi we}$ kips	$\tilde{k}_{\phi wg}$ in.^{2}	F_d ksi	$P_n^1{}_{(Lm\geq Lcr)}$ F_y=33 ksi kips	$P_n^1{}_{(Lm\geq Lcr)}$ F_y=55 ksi kips
12CS4x105	32.7	0.712	0.0322	0.521	0.0280	20.5	44.3	57.6
12CS4x085	35.2	0.363	0.0223	0.277	0.0195	15.3	31.2	40.2
12CS4x070	37.8	0.196	0.0158	0.154	0.0139	11.8	22.6	28.9
12CS3.5x105	30.2	0.721	0.0267	0.521	0.0328	20.9	42.5	55.4
12CS3.5x085	32.5	0.367	0.0184	0.277	0.0229	15.6	30.0	38.6
12CS3.5x070	35.0	0.198	0.0130	0.154	0.0162	12.0	21.7	27.8
12CS2.5x105	24.6	0.750	0.0175	0.521	0.0492	19.1	36.7	47.6