AISI Cold-Formed Steel Design Manual Updated

By Joshua Buckholt, S.E., P.E., Richard C. Kaehler, P.E. and Helen Chen, Ph.D., P.E., LEED AP-BD+C

Municipalities have, or are in the process of adopting, the 2015 edition of the *International Building Code* (IBC). The 2015 IBC incorporates by reference AISI S100-12, *North American Specification for the Design of Cold-Formed Steel Structural Members*, 2012 Edition. To facilitate the use of AISI S100-12, the American Iron and Steel Institute (AISI) developed the 2013 edition of its *Cold-Formed Steel Design Manual* (*Manual*).

The *Manual* includes 63 worked example problems, tabulated and graphical design aids, and supplemental information relevant to the design of cold-formed steel. In addition, AISI S100-12 and the *Commentary on the North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100-12-C) are included in the *Manual*. The *Manual* is presented in two volumes with eight parts. The following discussion highlights significant changes to the document.

Dimensions and Properties

The table of referenced ASTM steels has been updated to reflect recent changes in steels approved for cold-formed steel design. Information regarding steel deck products has been updated to reflect the latest requirements published by the Steel Deck Institute (SDI).

The cross-sections provided in Part I include: "representative cross-sections," such as purlins or girts and light-steel framing cross-sections (joists, studs, or track).

Similar to the previous edition of the *Manual*, formulas for calculating gross-section properties used for compression or flexure, and the properties for distortional buckling analysis, have been provided for commonly used C-, Z- and Hat-Sections. The effective section property examples have been updated to reflect changes in Chapter B of AISI S100-12.

Two new examples have been added:

1) **Effective section properties of a panel section with large radii**
   This example illustrates the effect of large corner radii on effective section properties by using the rational engineering method provided in Section B1.3 of the AISI S100-12-C *Commentary*.
2) **Effective section properties of cellular deck with intermittent fasteners between deck and cover plate**
   This example illustrates the application of the new design provisions of AISI S100-12 Section B2.5 for determining cellular deck effective section properties.

Beam Design

The introductory sections have been updated to include expanded discussions on cold-formed flexural member behavior and limit states, including distortional buckling, in order to assist in an overall understanding of cold-formed steel beam behavior and design.

The strength tables for joist/stud and track sections have been updated and reflect only the thicknesses readily available for each steel grade. Tabulated strengths for Grade 50 are provided for sections with a thickness greater than or equal to 54 mils. Similarly, tabulated strengths for Grade 33 are provided for sections with a thickness less than or equal to 43 mils. Table values based on Grade 50 material are differentiated with bold-faced type and shading.

Four new example problems have been added:

1) **Four span continuous standing seam roof system**
   This example outlines a comprehensive procedure for designing a standing seam roof system and applies to both the panel and its supporting purlins. This example illustrates the application of AISI S100-12 Section D6.1.2 to determine the flexural strength of purlins under gravity loads.
2) **Flexural strength of a C-Section with web perforations by the Direct Strength Method**
   This example shows how to determine the flexural strength of a perforated member using the Direct Strength Method (DSM).
3) **Shear strength by Direct Strength Method**
   This example illustrates how to calculate the shear strength and the combined bending and shear strength of a C-Section using the DSM.
4) **Inelastic reserve strength by Direct Strength Method**
   This example demonstrates how to use the DSM to evaluate the inelastic reserve strength of a flexural member.

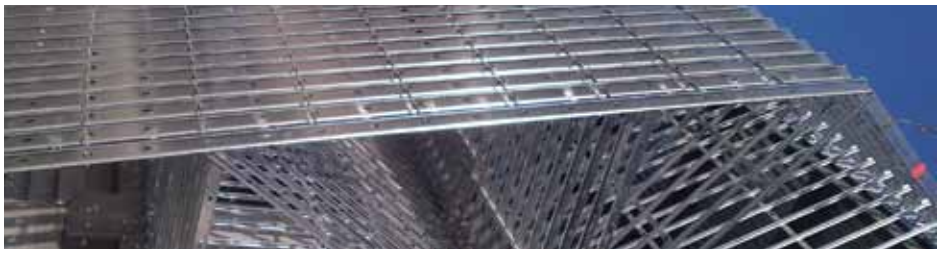
In addition to the four new design examples, the design example for a C-Section with combined bending and torsional loading has been expanded to include design calculations for flexural and torsional shear stresses.

Column Design

Discussion of cold-formed compression member behavior and limit states located in the introductory section has been updated. In addition, two new example problems have been added:

1) **Compressive strength of C-Section members with openings using the Direct Strength Method**
   This example illustrates the Direct Strength Method for a compression member with web holes. A methodology, utilizing manual calculations, is outlined that determines the compressive strength of the member including the influence of the holes based on local, distortional, and global buckling.
2) **Braced frame design with consideration of second-order analysis**
   This example demonstrates the verification of the strength and stiffness of a lateral bracing member (tension strap) against given design criteria applicable for a second-order analysis using AISI S100-12 Appendix 2.

continued on next page



Connection Design

The introductory discussions of design limit states were updated for welded, bolted, screwed, and power-actuated fastened connections. The following new example problems were added:

1) **Flare bevel groove weld with t>0.10 in.**
   This example illustrates how to apply the new design provisions for flare bevel groove welds in AISI S100-12 Section E2.6.
2) **Flare V groove weld**
   This example illustrates how to apply the new design provisions for flare V groove welds in AISI S100-12 Section E2.6.
3) **Top arc seam sidelap weld**
   This example illustrates how to apply the new design provisions in AISI S100-12 Section E2.4 for top arc seam sidelap welds that are used in diaphragm deck systems.
4) **Power-actuated fasteners in shear and tension**
   This example presents a comprehensive procedure for determining the shear and tension strengths of power-actuated fasteners (PAF) and how to check the interaction of PAFs subject to shear and uplift loads. The calculations utilize the provisions of Section E5 of AISI S100-12.

Supplemental Information

Section 4, "Suggested Cold-Formed Steel Structural Framing, Engineering, Fabrication, and Erection Procedures for Quality Construction," has been updated to reflect the 2011 Edition of the *AISI Code of Standard Practice for Cold-Formed Steel Structural Framing* which can be downloaded from **www.aisistandards.org**.

Test Procedures

The fourteen AISI test standards included in previous editions of the *Manual* have been removed and are available online as free PDF downloads at **www.aisistandards.org**. The Bibliography of test procedures has been updated, and a new example problem was added:

1) **Computing ϕ and Ω factors from test data using Section F1.1(b)**
   This example shows how to apply AISI S100-12 Section F1.1(b) to determine the resistance and safety factors for a derived design equation.

2012 Edition of AISI S100-12

AISI S100-12 is included as an integral part of the *Manual*. The major technical changes contained in AISI S100-12 are:

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 *Manual*.
- 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. 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 ½ 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 prequalified 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 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.

2012 Edition of the *Commentary*

The *Commentary* on AISI S100-12, which provides background information and reasoning for the provisions, is also included in the *Manual*.

Conclusion

The 2013 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.

This *Manual* has been dedicated to Richard (Dick) Kaehler, P.E., who has produced each edition of the AISI *Cold-Formed Steel Design Manual* since 1996. As a highly respected professional in structural analysis, design, and testing, Dick is noted for his expertise in developing design manuals, design guides, and computer programs. Engineers, students, and general users have greatly benefited from his many contributions.▪

Joshua Buckholt, S.E., P.E., is an associate at Computerized Structural Design and assisted with the development of the 2013 AISI Cold-Formed Steel Design Manual. Joshua may be reached at ***jbuckholt@csd-eng.com****.*

Richard Kaehler, P.E., ***in memoriam****, was a Vice President at Computerized Structural Design and was responsible for the production of the 2013 AISI Cold-Formed Steel Design Manual.*

Helen Chen, Ph.D, P.E., LEED AP-BD+C, is manager of the Construction Standards Development of the American Iron and Steel Institute. She is directly involved in the development and update of AISI construction standards. Helen may be reached at ***hchen@steel.org****.*

APPENDIX 1 – AISI Cold-Formed Steel Design Manual Complete List of Design Examples

VOLUME 1

Part I – Dimensions and Properties

Example I-1 C-Section With Lips – Gross Section Properties
Example I-2 C-Section Without Lips – Gross Section Properties
Example I-3 Z-Section With Lips – Gross Section Properties
Example I-4 Equal Leg Angle With Lips – Gross Section Properties
Example I-5 Equal Leg Angle Without Lips – Gross Section Properties
Example I-6 Hat Section Without Lips – Gross Section Properties
Example I-7 Wall Panel Section With Intermediate Stiffeners – Gross Section Properties
Example I-8 C-Section With Lips – Effective Section Properties
Example I-9 C-Section Without Lips – Effective Section Properties
Example I-10 Z-Section With Lips – Effective Section Properties
Example I-11 Equal Leg Angle With Lips – Effective Section Properties
Example I-12 Equal Leg Angle Without Lips – Effective Section Properties
Example I-13 Hat Section – Effective Section Properties Using Inelastic Reserve Capacity
Example I-14 Wall Panel Section With Intermediate Stiffeners – Effective Section Properties
Example I-15 Strength Increase From Cold Work of Forming
Example I-16 Shear Lag
Example I-17 Flange Curling
Example I-18 Section Properties of Cross-Sections With Large Corner Radii
Example I-19 Cellular Deck With Intermittent Fasteners

Part II – Beam Design

Example II-1 Four Span Continuous C-Purlins Attached to Through-Fastened Roof – LRFD
Example II-2 Four Span Continuous Z-Purlins Attached to Through-Fastened Roof – ASD
Example II-3 Four Span Continuous Standing-Seam Roof System – ASD
Example II-4 C-Section Without Lips Braced at Mid-Span
Example II-5 Distortional Buckling of C-Section
Example II-6 C-Section Without Lips in Weak Axis Bending
Example II-7 Fully Braced Hat Section
Example II-8 Tubular Section – Round
Example II-9 Tubular Section – Rectangular
Example II-10 C-Section With Openings
Example II-11 C-Section With Combined Bending and Torsional Loading
Example II-12 Web Crippling
Example II-13 Web-Stiffened C-Section by the Direct Strength Method – Flexure
Example II-14 Lipped C-Section With Web Perforations by the Direct Strength Method – Flexure
Example II-15 C-Section With Lips: Shear Strength by the Direct Strength Method
Example II-16 C-Section With Lips: Inelastic Reserve Strength by the Direct Strength Method

Part III – Column Design

Example III-1 Braced C-Section With Lips – Bending and Compression
Example III-2 C-Section With Lips With Holes – Compression
Example III-3 C-Section Subject to Distortional Buckling – Compression
Example III-4 C-Section With Lips With Holes – Compression – Direct Strength Method
Example III-5 Unbraced Equal Leg Angle With Lips – Compression
Example III-6 Tubular Section – Round – Bending and Compression
Example III-7 Stiffened Z-Section With One Flange Through-Fastened to Deck or
Sheathing – Compression
Example III-8 Stiffened Z-Section With One Flange Fastened to a Standing Seam Roof –
Compression
Example III-9 Hat Section – Bending and Compression
Example III-10 I-Section – Built-Up From Channels
Example III-11 Square HSS Section – Bending and Compression
Example III-12 Unbraced Frame Design by Second-Order Analysis
Example III-13 Braced Frame Design by Second-Order Analysis
Example III-14 Web-Stiffened C-Section by the Direct Strength Method – Compression

Part IV – Connection Design

Example IV-1 Flat Section With Fillet Welded Lap Connection
Example IV-2 Flat Section With Arc Spot Welded Connection
Example IV-3 Flat Section With Arc Seam Welded Connection
Example IV-4 Flat Section With Flare Bevel Groove Weld
Example IV-5 Flat Section With Flare Bevel Groove Weld, t > 0.10 in.
Example IV-6 Flat Section With Flare V Groove Weld
Example IV-7 Flat Section With Groove Welded Butt Joint
Example IV-8 Top Arc Seam Sidelap Weld
Example IV-9 Bolted Flat Section
Example IV-10 Bolted Angle Connection
Example IV-11 Screwed Connection
Example IV-12 Power-Actuated Fasteners in Shear and Tension

Part V – Supplementary Information

Part VI – Test Procedures

Example VI-1 Computing ϕ and Ω Factors From Test Data Using AISI S100 Section F1.1(a)
Example VI-2 Computing ϕ and Ω Factors From Test Data Using AISI S100 Section F1.1(b)