The 2013 AISI Cold-Formed Steel Design Manual

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Abstract

The 2013 edition of the AISI Cold-Formed Steel Design Manual has been published. The new edition includes updated and newly developed example problems and design aids covering new material in the 2012 edition of the AISI North American Specification for the Design of Cold-Formed Steel Structural Members (NA Specification). Also published with the Manual are the NA Specification and the Commentary.

Introduction

The American Iron and Steel Institute (AISI) has published the 2013 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 the Education Subcommittee of the AISI Committee on Specifications. AISI has dedicated this Manual 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.

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The Manual includes worked example problems, tabulated and graphical design aids, and supplemental information relevant to the design of cold-formed steel. In addition, the 2012 edition of the North American Specification for the Design of Cold-Formed Steel Structural Members (NA Specification) and the Commentary to the NA Specification are published as part of the Manual.

The 2013 edition of the Manual is based on the 2012 North American Specification for the Design of Cold-Formed Steel Structural Members, a joint publication of the American Iron and Steel Institute (AISI), the Canadian Standards Association (CSA), and Camara Nacional de la Industria del Hierro y del Acero (CANACERO). The 2012 NA Specification covers Load and Resistance Factor Design (LRFD) and Allowable Strength Design (ASD) for use in the United States and Mexico, and Limit States Design (LSD) for use in Canada, with equal emphasis. Provisions specific to Canada, Mexico, and the United States are included as appendices for cases where joint provisions were not possible. Provisions are provided in dimensionless terms where possible or in U.S. customary units and two separate metric systems where that is not possible.

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

All previous tables and charts have been updated according to the provisions of the 2012 NA Specification. Additional tables were added to incorporate new design provisions wherever appropriate. A total of 63 illustrative examples are included in this Manual. All example problems from the 2008 Manual were
reviewed and updated to improve presentation of the material and to illustrate new and revised NA Specification provisions. Thirteen new example problems were added to illustrate new and revised NA Specification provisions.

In this edition of the Manual, all AISI test standards are removed from the Manual because they are now available free to download from the AISI website (www.steel.org).

Part I – Dimensions and Properties

The table of referenced ASTM steels has been updated to reflect recent changes in steels approved for cold-forming. 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, for illustration purposes; and stock cross-sections, that are named joists, studs, or track. Standard joist, stud, and track sections are identified using the product designator given in AISI S201 (AISI, 2012).

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 the 2012 NA Specification.

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 the AISI S100-C Commentary Section B1.3.

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 *Specification* Section B2.5 in determining cellular deck effective section properties. In addition, this example shows how to check the spacing of connections in cellular deck cover plates per *Specification* Section D1.3.

**Part II – 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 design. In this *Manual*, the strength tables for joist/stud and track sections have been updated to include 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 *Specification* 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) included in *Specification* Appendix 1.

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 outlined above, 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.

**Part III – Column Design**

Discussions of cold-formed compression member behavior and limit states located in the introductory sections have 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 applies the Direct Strength Method to a compression member with 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 verifies the strength and stiffness of a lateral bracing member (tension strap) against given design criteria applicable for a second-order analysis using *Specification Appendix 2.*

**Part IV - Connection Design**

The introductory discussions of design limit states were updated for welded, bolted, screwed, and power-actuated fastened connections. The design examples have been revised to reflect technical and editorial changes in the 2012 *NA Specification.* The following new examples are added:

1. **Flare bevel groove weld with t>0.10 in.**
   This example illustrates how to apply the newly added design provisions for flare bevel groove welds in *Specification Section E2.6.*

2. **Flare V groove weld**
   This example illustrates how to apply the newly added design provisions for flare V groove welds in *Specification Section E2.6.*

3. **Top arc seam sidetap weld**
   This example illustrates how to apply the newly added design provisions in *Specification Section E2.4 for top arc seam sidetap welds that are used in diaphragm 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.

**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.

In addition, 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* (AISI, 2011).

**Part VI – Test Procedures**

All fourteen AISI test standards included in previous editions of the *Manual* have been removed because they are published by AISI online free to download (www.steel.org). The Bibliography of test procedures has been updated, and a new example is added:

1. **Computing $\phi$ and $\Omega$ factors from test data using Section F1.1(b)**
   This example shows how to apply *Specification* Section F1.1(b) to determine the resistance and safety factors for a derived design equation.
Part VII: 2012 Edition of the North American Specification for the Design of Cold-Formed Steel Structural Members

In this edition of the Cold-Formed Steel Design Manual, the NA Specification is included as an integral part of the Manual. The changes and additions in the 2012 edition of the NA Specification as compared to the 2007 edition are provided in Appendix 1 of this paper. The Manual provides direct references to the NA Specification section and equation numbers in the examples and descriptions.

Part VIII: 2012 Edition of the Commentary on the North American Specification for the Design of Cold-Formed Steel Structural Members

The Commentary on the NA Specification is also included in the Manual, which provides background information and reasoning for the provisions provided in the NA Specification.

Availability

The 2013 edition of the Cold-Formed Steel Design Manual can be obtained from the AISI e-store at: http://www.steel.org.

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.

References

American Iron and Steel Institute, Cold-Formed Steel Design Manual, Washington, D.C., 2013.


Appendix 1, Major Technical Changes in AISI S100-12

The major technical changes made in the 2012 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. 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 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.