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What's New in the 2007 Edition of the North American Cold-formed Steel Specification

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What's New in the 2007 Edition of the North American Cold-Formed Steel Specification?

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Abstract

The 2007 edition of the *North American Specification for the Design of Cold-Formed Steel Structural Members* (*Specification*) was published recently by AISI (2007a). As the name indicates, the *Specification* is intended for use throughout Canada, Mexico and the United States. The *Specification* has been approved in the United States by the American National Standards Institute as the American National Standard, in Canada by the Canadian Standards Association, and has been endorsed in Mexico by Camara Nacional de la Inductria del Hirrro y del Acero (CANACERO).

In the 2007 edition, many new design provisions were adopted and significant editorial and technical changes were made. This paper provides an overview of the major changes and additions.

Introduction

The first edition of the *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI, 2001) was published in 2001 as the result of a joint effort of the American Iron and Steel Institute's Committee on Specifications (AISI COS), the Canadian Standard Association's Committee on Cold-Formed Steel Structural Members (CSA S136), and Mexico's Camara Nacional del la Industria del Hierro y del Acero (CANACERO). A Supplement

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to the 2001 edition of the *Specification* (AISI, 2004) was published in 2004. In 2007, a new edition of the *North American Specification* was published, which includes all the changes and new design provisions approved since the publication of the 2001 edition of the *Specification*.

The 2007 edition of the *North American Specification* consists of a main document, Chapters A through G and several appendices. The numbered appendices, Appendices 1 and 2 are applicable to all three countries. The lettered appendices are country specific, Appendix A for the United States and Mexico and Appendix B for Canada. To make the *Specification* more user-friendly, some contents have been reorganized according to their application. Light frame construction is covered in Section D4*; floor, roof or wall steel diaphragm construction is covered in Section D5; and metal roof and wall systems are covered in Section D6. In addition, the definitions of commonly used terminologies are standardized as a result of a joint effort of AISI and the American Institute of Steel Construction (AISC) (AISI, 2007b).

In the following sections, an overview of the major technical changes and added provisions will be provided.

Technical Changes and Additions of the Design Provisions

1. Materials.

In addition to updating all the standards for applicable steels, a new standard was added, ASTM A1039 for hot-rolled carbon steel sheet produced by the twin-roll casting process.

The North American Specification permits applications of steels that are produced to other than the listed specifications, provided that certain requirements are satisfied. In the 2007 edition, these requirements in chemical and mechanical properties, coating properties, ductility and weldability have been clarified (Appendix A, Section A2.2).

2. Elements.

Previously, the effective width of an unstiffened compression element in bending was determined assuming a uniform stress distribution. A new provision adopted in 2004 (AISI, 2004) was included in the 2007 *Specification*,

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* Section numbers referred to herein are those in the 2007 edition of the *North American Specification*, unless otherwise indicated.

which enables one to consider stress gradient effects. This design provision was based on research work by Bambach and Rasmussen (2002a, 2002b, and 2002c). The new design provision will result in an improved assessment of the buckling performance of an unstiffened compression element in bending (Section B3.2).

In the 2007 *Specification*, the design of uniformly compressed elements with multiple or single intermediate stiffeners was merged. This is based on the finding that the method for multiple intermediate stiffeners provides the same reliability as the previous provision for a single intermediate stiffener.

3. Members

It has been recognized that cold-formed steel members may be subjected to distortional buckling, an instability that may occur in members with edge stiffened flanges, such as C- and Z-sections. Illustrated in Figures 1 and 2 are the various buckling modes for a flexural member. Distortional buckling is characterized by instability of the entire compression flange, as the flange along with the edge stiffener rotates about the junction of the compression flange and the web. However, until the 2007 edition, the *Specification* had been silent on the evaluation of the structural performance of members subject to distortional buckling. In this edition, explicit equations are provided (in Section C3.1.3 for flexural members and in Section C4.2 for compression members) for determining the distortional buckling strengths of C- and Z- shaped members. For any other shaped members, rational analysis approaches are permitted.

Since cold-formed steel members are often singly-symmetric sections, additional stresses normal to the cross section can occur if the applied forces do not pass through the shear center. As a result, unless negated by bracing, the member flexural strength can be reduced due to torsion. This reduction can now be considered by a reduction factor, which is determined by the ratio of the nominal stress due to bending alone to the combined stresses due to both bending and torsional warping at the point of maximum combined stress on the cross-section (Section C3.6).

4. Structural Assemblies and Systems

As indicated previously, one of the major changes in the 2007 edition of the *Specification* was to reorganize the design provisions according to applications. These applications were divided into Light Frame Construction; Floor, Roof or Wall Diaphragm Construction; and Metal Roof and Wall Systems. The reorganized provisions and changes are outlined as follows:

- Cold-Formed Steel Light-Frame Construction (Section D4)
  In this section, only the All Steel Design approach is included. The sheathing braced design approach for wall stud assemblies has been removed from the *Specification*. Design for sheathing braced design and other light-frame construction design is now included in a separate set of documents, the North American Standards for Cold-Formed Steel Framing -:
  - General Provisions;
  - Floor and Roof System Design;
  - Wall Stud Design;
  - Header Design;
  - Truss Design; and
  - Lateral Design (note: this standard is only applicable in the United States and Mexico).

  A detailed review of the above standards can be found in the paper, <title> by Jay Larson (2008).

- Floor, Roof, or Wall Steel Diaphragm Construction (Section D5)
  The safety and resistance factors have been recalibrated based on the full-scale test data summarized in the Steel Deck Institute Diaphragm Design Manual, First edition (1987).

- Metal Roof and Wall Systems (Section D6)
  This section is designated for design provisions related to metal roof and wall systems:
  - Flexural Members Having One Flange Through-Fastened to Deck or Sheathing. In these provisions, the applicable panel depth has been reduced from 1-1/4 in. (32 mm) to 1-1/8 in. (29 mm).Also, purlin systems with adjacent span lengths varying more than 20 percent are permitted to use the reduction factor, R, for the simply supported condition.
  - Flexural Members Having One Flange Fastened to a Standing Seam Roof System.
  - Compression Members Having One Flange Through-Fastened to Deck or Sheathing.
  - Strength [Resistance] of Standing Seam Roof Panel Systems.
    In the 2007 *Specification*, a reduction factor, 0.67, is permitted to be applied to nominal wind loads for certain standing seam roof systems in Zone 2 (edge zone) or Zone 3 (corner zone) as defined in ASCE/SEI 7-05 (2005). The adoption of the reduction factor is based on research conducted by Surry et. al. (2007), which correlated the static upload capacity and the behavior of wind on a standing seam roof system.

This wind load reduction is only applicable in the United States and Mexico.

- Compression of Z-Section Members Having One Flange Fastened to a Standing Seam Roof. This new design provision is to determine the strength of strut purlins that are connected to a standing seam roof system. The provision is only applicable in the United States and Mexico.
- Anchorage of Bracing for Purlin Roof Systems Under Gravity Load with Top Flange Connected to Metal Sheathing.
  This design provision has been revised based on new research by Seek and Murray (2006, and 2007) and Sears and Murray (2007). The new provision provides better estimates for required anchorage forces and specifies the stiffness requirements for anchorage systems. A design guide, sponsored by AISI and MBMA, will be available in 2009 to assist engineers in applying this provision.
- Alternate Lateral and Stability Bracing for Purlin Roof Systems.
  As an alternate method for anchorage of purlin roof systems, torsional bracing is permitted, which prevents twist about the longitudinal axis of a member, in combination with lateral restraints that resist lateral displacement of the top flange at the frame line.

Another addition related to stability of structural assemblies is the design provision for determining the required brace strength and stiffness. The required brace strength to restrain lateral translation at a brace point for an individual compression member is given in Section D3.3 as:

$$P_{br,1} = 0.01P_n \qquad (Eq.\ 1)$$

The required brace stiffness to restrain lateral translation at a brace point for an individual compression member is calculated from:

$$\beta_{br,1} = \frac{2[4-(2/n)]P_n}{L_b} \qquad (Eq.\ 2)$$

where

P_n = Axial compression strength of the member to be braced

$P_{br,1}$ = Required nominal brace strength for a single compression member

P_n = Nominal axial compression strength of a single compression member

$\beta_{br,1}$ = Required brace stiffness for a single compression member

n = Number of equally spaced intermediate brace locations

L_b = Distance between braces on one compression member

The above requirements for brace strength and stiffness for a single compression member were developed from a study by Green et al (2004) and are similar to the provisions for compression member nodal bracing in the AISC *Specification for Structural Steel Buildings* with the exception that in the stiffness requirement, AISC assumes n equals infinity, thus, the required brace stiffness is $8P_n/L_b$. For the calculation of brace strength and stiffness, the nominal axial strength of the member, P_n, is used rather than the required strength because the equations for member strength assume the brace enables the development of the full member strength.

5. Connections

As a new addition, a provision for determining the shear strength of sheet-to-sheet arc spot weld connections has been adopted from the Steel Deck Design Manual (SDI, 1987), which stipulates that the shear strength for a sheet-to-sheet arc spot weld connection is taken as 75% of the strength of a sheet-to-structural connection.

Since screw connections are frequently subjected to combined shear and pull-over, a new provision for checking the interaction of screw shear and pull-over was adopted. This design provision is based on the initial research at West Virginia (Luttrell, 1999) and further verification by Zwick and LaBoube (2002).

For bolted connections, the equations for determining the bolt tensile stress subjected to combined shear and tension have been consolidated for provisions applicable to the US and Mexico. The following single equation is used to determine the modified tensile strength:

For ASD, $$F'_{nt} = 1.3F_{nt} - \frac{\Omega F_{nt}}{F_{nv}} f_v \le F_{nt} \quad (Eq.\ 3a)$$

For LRFD, $$F'_{nt} = 1.3F_{nt} - \frac{F_{nt}}{\phi F_{nv}} f_v \le F_{nt} \quad (Eq.\ 3b)$$

where

F'_{nt} = Nominal tensile stress modified to include the effects of required shear stress

F_{nt} = Nominal tensile stress

F_{nv} = Nominal shear stress

F_v = Required shear stress

Ω = Safety factor

ϕ = Resistance factor

The equations for determining the block shear rupture strength have also been revised based on the work by Kulak and Grondin (2001) and confirmed by LaBoube and Sokol (2002).

6. Appendix 1, Design of Cold-Formed Steel Structural Members Using the Direct Strength Method.

Adopted in the 2004 Supplement (AISI, 2004), the Direct Strength Method (DSM) provides an alternative approach for determining the flexural and compressive strengths and stiffness of cold-formed members. Different from the conventional "Effective Width Approach", the DSM determines member strengths without discretizing the member cross-section into elements. This ensures that compatibility and equilibrium are maintained between junctions of the elements and the interactions between the elements are taken into consideration. In addition, the DSM provides a rational approach for determining the member strengths of cold-formed members with unconventional cross sections. To assist designers to better understand and fully utilize this method, a Direct Strength Method Design Guide (2006) has been published by AISI. The design guide can be ordered from the AISI online store at www.steel.org.

7. Appendix 2, Second-Order Analysis

This new Appendix provides an alternative approach for frame analysis that considers both the effect of loads acting on the deflected shape of a member between joints or nodes (P-δ effect) and the effect of loads acting on the displaced location of joints or nodes in a structure (P-Δ effect). The analysis approach is consistent with the AISC Direct Analysis method (AISC, 2005) with differences as stipulated in the Commentary to Appendix 2.

8. Conclusion

The major technical changes and additions to the *Specification* have been outlined in this paper. The *Commentary on the 2007 North American Specification for the Design of Cold-Formed Steel Structural Members* contains a more detailed discussion of the design provisions. Also, the *Commentary* provides a comprehensive bibliography for the background of the Specification provisions. For a more complete compilation of the changes to the 2007 *North American Specification for the Design of Cold-Formed Steel Structural Members* refer to Wei-Wen Yu Center for Cold-Formed Steel Structures' Technical Bulletin Vol. 16, No. 2, Fall 2007 (www.mst.edu/~ccfss).

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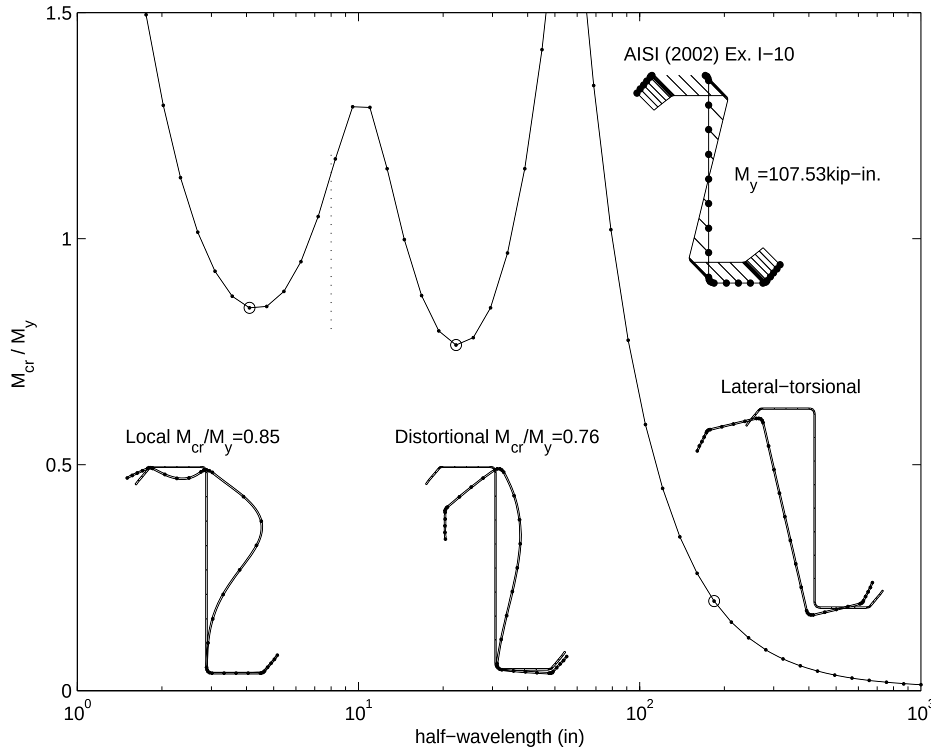

Figure 1 Buckling Modes for a Z-section

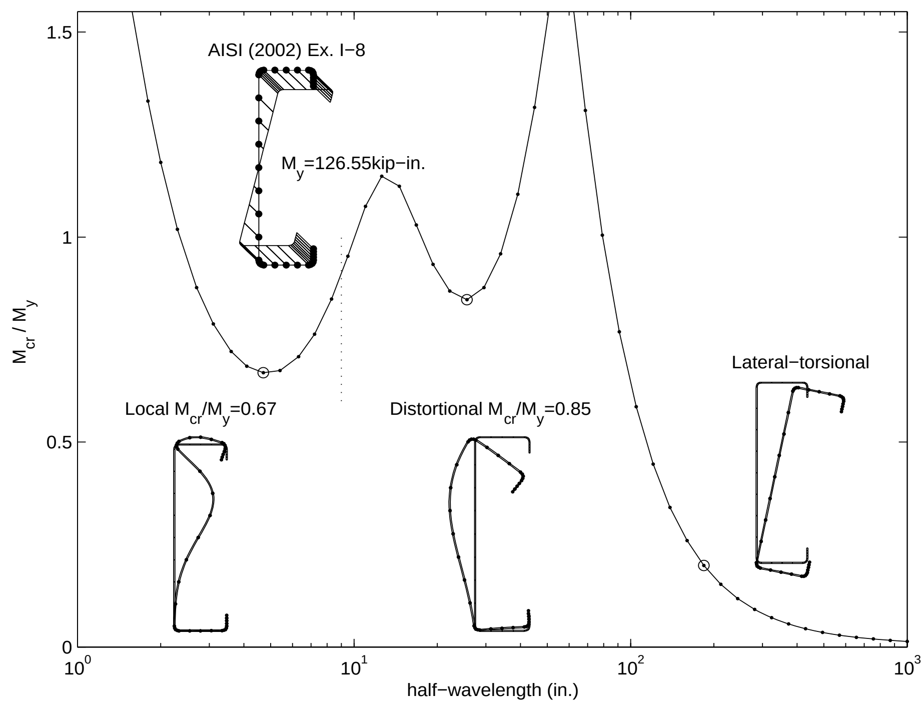

Figure 2 Buckling Modes for a C-section