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The 1999 Supplement to the AISI Design Specification

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Abstract

The AISI Committee on Specifications for Cold-Formed Steel recently developed Supplement No. 1 to the 1996 *Specification for the Design of Cold-Formed Steel Structural Members*. The *Supplement* reflects new information developed through research projects, brings provisions in agreement with other specifications where appropriate, and also provides certain clarifications and corrections. The *Supplement* and the *Specification* have both been recently accepted as ANSI standards. The present paper reviews the major items included in the *Supplement*. The Committee continues to sponsor research projects aimed at developing a better understanding of particular areas of cold-formed steel behavior and more comprehensive design rules. Projects currently underway or recently completed are listed. As a result of a collaborative effort with representatives from Canada and Mexico, it is anticipated that the next edition of the specification will be referred to as the AISI *North American Specification for the Design of Cold-Formed Steel Members*.

Introduction

In 1999 the AISI Committee on Specifications for Cold-Formed Steel approved Supplement No. 1 (AISI, 1999) to the 1996 *Specification for the Design of Cold-Formed Steel Structural Members* (AISI, 1996). The *Supplement* was issued as an update to reflect the results of various research projects, to coordinate with provisions of other specifications where appropriate, and to provide clarifications and corrections. A preview of the *Supplement* was published previously as a CCFSS Technical Bulletin (CCFSS, 1999). The *Supplement* and the *Specification* have both been recently accepted as ANSI standards. This paper presents a review of the main items included in the *Supplement*. Additional information may be found in the *Commentary* (AISI, 1996a) to the *Specification* and the text by Wei-Wen Yu (Yu, 2000).

Summary of Main Items in the AISI *Supplement*

Section A3.1 Applicable Steels

This section lists steels that meet the requirements of the AISI *Specification*. References for all ASTM standards were updated and two were added: (1.) A847, "Standard Specifications for Cold-Formed Welded and Seamless High Strength, Low Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance," and (2.) A875/A875M, "Standard Specification for Steel Sheet, Zinc-5% Aluminum Alloy-Coated by the Hot-Dip Process." For A875/A875M, only the following designations were recognized: SS Grades 33, 37, 40, 50-Class 1, and 50-Class 3; HSLA Types A and B, Grades 50, 60, 70, and 80.

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Section A3.3 Ductility

Steels not listed in A3.1 can be used under certain conditions if they comply with requirements set forth in A3.3. Section A3.3.1 provides alternative ductility requirements related to local and uniform elongation. Section A3.3.2 provides for usage of Grade 80 or Grade E steels for multiple web configurations such as roofing, siding, and floor decking. In the past, this restricted the yield point to 75 percent of specified minimum (60 ksi or 414 MPa if lower) and the tensile strength to 75 percent of specified minimum (62 ksi or 427 MPa if lower). In the *Supplement* an exception was added that allowed an alternative means for calculation of a reduced yield point for determining nominal flexural strength. The equations for the reduction factor, which are based on research at the University of Missouri – Rolla (Wu, Yu, and LaBoube, 1996), typically result in a design strength greater than the 75 percent limit.

Section A5.1.3 Wind or Earthquake Loads

The exception clause for evaluating diaphragms was deleted from this Section; appropriate factors for diaphragms subjected to earthquake loads are included in the section on diaphragm construction, Section D5.

Section A9 Reference Documents

References to all documents were updated and references to ASTM A847 and A875/A875M steels were added.

Section B 1.1 Flange Flat-Width-to-Thickness Considerations

The conditions for some maximum w/t limits for compression elements were revised.

Section B2.4 C-Section Webs with Holes Under Stress Gradient

A new section was added to provide a method for determining the effective width of web elements of C-sections adjacent to web openings. This section, along with other sections added to deal with shear strength and crippling strength of webs with holes, is based on research at the University of Missouri – Rolla (Shan et al, 1994).

Section B6.1 Transverse Stiffeners

The limiting w/t ratio for unstiffened elements of transverse stiffeners was revised from $0.37\sqrt{E/F_{ys}}$ to $0.42\sqrt{E/F_{ys}}$ for consistency with other parts of the *Specification.*

Section C2 Tension Members

The nominal strength of axially loaded tension members was revised to agree with other specifications. The limit states for determining nominal tensile strength now include (a) yielding in the gross section, (b) fracture in the net section away from connections, and (c) fracture in the effective net section at the connection.

Section C3.1 Strength for Bending Only

A footnote was added to Section C3.1 to clearly state that the provisions of this section do not consider torsional effects, such as may result from loads that do not pass through the shear center of the cross section. Such effects must be considered separately or negated through appropriate bracing.

Section C3.1.2. Lateral-Torsional Buckling Strength

This section was revised to include subsections on open cross section members and closed box members. In Section C3.1.2.1, Lateral Torsional Strength for Open Cross Section Members, the design equations for critical moments were changed to critical stress equations with some editorial revisions. New Section C3.1.2.2, Lateral Torsional Strength of Closed Box Members, provides expressions for maximum unbraced length to develop full section strength and for calculating the critical stress with greater spacings. Based on relationships given in the SSRC *Guide* (Galambos, 1998) it replaces a simplification previously in Section D3.3.

Section C3.1.3 Beams Having One Flange Through-Fastened to Deck or Sheathing

For beams having the tension flange attached to deck or sheathing and the compression flange unbraced, such as a roof purlin or wall girt subjected to wind suction, the bending capacity is less than that of a fully braced member, but greater than an unbraced member. Accordingly, this section provides reduction factors (R values) that can be multiplied by the nominal bending strength to determine the strength of simple span C- and Z- sections, when certain specified conditions are met. It also applies to the portion of continuous spans between inflection points, exclusive of regions adjacent to a support. In the *Supplement*, the R-values were revised to reflect a more rational basis that classified sections according to their depth and profile type (C or Z). The R-values are based on structural tests by numerous investigators, with the most recent study being done by Fisher (Fisher, 1996).

Section C3.1.4 Beams Having One Flange Fastened to a Standing Seam Roof System

For beams supporting a standing seam roof system, the bending capacity is greater than that of an unbraced member and may be equal to that of a fully braced member. The 1996 AISI *Specification* permitted an R-value to be determined using a defined Base Test Method, but only for the gravity load condition. For the *Supplement*, the Base Test Method was revised and the use of this method was extended to systems under uplift load as well as gravity load. The revised method is included in the *Supplement* as Appendix A.

Section C3.1.5 Strength of Standing Seam Roof Panel Systems

The strength of panels in standing seam roof systems is usually established by tests, but numerous questions often arise as to the interpretation of results. Therefore, the *Supplement* provides a new section that specifies a methodology of interpreting test results obtained using ASTM Standard Test Method E1592.

Section C3.2 Shear Strength of Beam Webs

This section was revised to include subsections on webs with and without holes. Section C3.2.1, Shear Strength of Webs Without Holes, contains the same design provisions previously included in Section C3.2. New Section C3.2.2, Shear Strength of C-Section Webs with Holes, provides design equations for computing a shear strength reduction factor based on web and hole dimensions.

Section C3.4 Web Crippling Strength

This section was also revised to include subsections on webs with and without holes. Section C3.4.1, Web Crippling Strength of Webs Without Holes, contains the same design provisions previously included in Section C3.4. New Section C3.4.2, Web Crippling Strength of C-Section Webs with Holes, provides design equations for computing a crippling strength reduction factor based on web and hole dimensions. Also, based on new research showing the effect of higher yield points on crippling strength (Wu, Yu, and LaBoube, 1997), the constant C3 was replaced by C1 in Equations C3.4.1-1, C3.4.1-2, and C3.4.1-6.

Section C4 Concentrically Loaded Compression Members

The *Specification* has traditionally indicated that the slenderness ratio, KL/r, of compression members preferably should not exceed 200, or 300 during construction. In the Supplement, this non-mandatory recommendation was moved to the *Commentary*.

Section D3.2.1 Anchorage of Bracing for Roof Systems Under Gravity Load with Top Flange Connected to Sheathing

In metal roof systems, external restraint must be provided to prevent the system from moving laterally. This restraint typically consists of members attached to the purlin at discrete points along the span. The required restraint force depends upon the type of cross section and the member orientation. For the *Supplement*, a new equation was added for C-section purlins to determine the restraint force when all compression flanges face in the same direction. For Z-sections, the equation for determining the restraint force was revised. These changes are based on research at Virginia Tech.

Section E2.6 Resistance Welds

A design equation was added for determining the nominal shear strength of resistance welds. This equation replaces the tabulated values given previously.

Section E2.7 Shear Lag Effect in Welded Connections of Members Other Than Flat Sheets

This is a new section for considering the shear lag effect in welded connections of structural members. Design equations are given for fracture and/or yielding in the effective net section of the connected parts. These are patterned after provisions in the AISC specifications. The equations for the reduction coefficient U for angles and channels are based on research at the University of Missouri – Rolla (LaBoube and Yu, 1995).

Section E3.2 Shear Lag Effect in Bolted Connections

The section title was revised to reflect the shear lag effect in bolted connections. Design equations were added for determining the effective net area of angles and channels and for considering the effect of staggered holes in flat sheet connections (LaBoube and Yu, 1995).

Section E3.3 Bearing

New equations were added for determining the nominal bearing strength of bolted connections when deformation around the bolt holes is a design consideration (LaBoube and Yu, 1995). Also, the lower thickness limit for the equations that apply when deformation around the bolt holes is a design consideration, was revised from 0.024 in. (0.61 mm) to 0.036 in. (0.91 mm). This was done because research at the University of Sydney had shown that the bearing strength coefficient for thinner sheets might be lower (Rogers and Hancock, 1998).

Section E5 Rupture

This section now covers shear rupture (Section E5.1), tension rupture (new Section E5.2), and block shear rupture (new Section E5.3). The new design provisions in E5.2 and E5.3 parallel those in AISC specifications.

Section E6.1 Bearing

This section was simplified by deleting all design equations for determining the nominal bearing strength with a concrete support. Provisions for nominal bearing strength on concrete should be derived from ACI specifications.

Section Fl Tests for Determining Structural Performance

Where the configuration is such that strength calculations cannot be made in accordance with the provisions of the Specification, structural performance must be established from tests. Section F1 provides a statistical basis for evaluating such tests and includes statistical data (material factor, fabrication factor, and coefficients of variation of those factors) for different types of components. In the *Supplement*, such statistical data were added to provide for structural members and connections not specifically listed.

Future Developments

The AISI Committee on Specifications continues to sponsor research projects aimed at developing a better understanding of particular areas of cold-formed steel behavior and developing more comprehensive design rules. Table 1 lists projects that are currently underway or recently completed. Each year the committee goes through a detailed process to determine the most needed projects so that the best use can be made of available funds. The results of these projects are carefully reviewed and used to improve the *Specification.*

Also of interest is the possible use of steels such as Grade 80 or Grade E steels for expanded applications. In Australia, where these steels are used more extensively, research has indicated that the present provisions for their use in the *Specification* may be conservative (Rogers and Hancock, 1997). Likewise inspired by research in Australia, the Committee continues to search for a practical means of including the effects of distortional buckling of beams and columns (Hancock et al, 1994).

Currently the Committee is working with representatives from Canada and Mexico to develop a new specification applicable to all of North America. To facilitate this activity, three representatives from each of these two countries have become members of the Committee. Despite the inherent difficulties in achieving this goal, the work is progressing well. As a result, it is anticipated that the next edition of the specification will be referred to as the AISI *North American Specification for the Design of Cold-Formed Steel Members.*

Table 1

Current Research Project Areas

Transverse Stiffeners for Beams
Bolted Connections
Purlin Bracing Systems
Web Crippling Test Methods
Steel Framing Manual
Strut Purlin Design
Improved State-of-the-Art Design Methods
Base Test Method for Purlins Supporting Standing Seam Roof
Beam Column Design
Distortional Buckling of Beams and Columns
Channels Without Lips Under Axial load and Bending
Edge Stiffeners Other Than Simple Lips

Acknowledgments

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