AISI Test Procedures for Cold-formed Steel Structural Members and Connections

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Abstract

Over time the American Iron and Steel Institute (AISI) has developed a series of test procedures for determining the strength, stiffness and properties of cold-formed steel members and connections. These test procedures provide both an alternative for designing cold-formed steel members and structures and effective tools for research and development. Since 2001, four new test procedures have been developed and four previously published test procedures have been updated. For the convenience in document referencing, a new clarifying numbering system was established for all the AISI test procedures. In addition, all the published AISI test procedures have been approved by the American National Standards Institute (ANSI) as American National Standards (ANS).

This paper provides an overview for the new developed test procedures and summarizes the changes made to the previously published ones.

Introduction

The *North American Specification for the Design of Cold-Formed Steel Structural Members* (NASPEC) permits the use of test results to determine the strength and stiffness of cold-formed steel members and connections when their composition or configuration is such that calculation of strength and/or stiffness cannot be made using the provisions of the NASPEC. The AISI test procedures provide means for determining design data in these situations. Standardizing test

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procedures also establishe a common ground for researchers and manufacturers to share test results and ensure test quality.

In the 2002 edition of the AISI *Cold-Formed Steel Design Manual* (AISI 2002), an identifying numbering system was established as “AISI TS” followed by a sequence number and the year when the test procedure was published or updated. For all of the published test procedures prior to 2002, the year “2002” is assigned. A list of the current AISI test procedures, along with the corresponding identifying numbers, is found in Appendix 1.

Since 2001, four new test procedures, AISI TS-9 to AISI TS-12, were developed, and the existing test procedures, AISI TS-5 to AISI TS-8, were updated.

Summary of the Changes and Overview of the New Test Procedures

1. Updates of AISI TS-5, Test Methods for Mechanically Fastened Cold-Formed Steel Connections.

AISI TS-5 provides a series of methods for determining the strength and deformation of mechanically fastened connections for cold-formed steel building components. In the test procedure, the percentage difference between the maximum load and mean maximum load for requiring additional tests has been revised from 10 percent to 15 percent. This change is to bring this requirement into compliance with *Specification* Section F1.1, which allows for a 15 percent deviation.

2. Updates of TS-6, Standard Procedures for Panel and Anchor Structural Tests:

This test procedure extends and provides methodology for interpreting results of tests performed according to ASTM E1592, Standard Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference. In 2001, ASTM E1592 was updated with one of the major changes: the elimination of the option to test the boundary condition with both ends open. Reports from manufacturers using test results with the open-open end condition indicated that such tests formed the basis of adequate designs. As a result, AISI TS-6 was revised in 2004 to include the open-open end condition, in addition to the other end conditions in ASTM E1592-01. A table is added to the test procedure, which provides the minimum number of equal spans for both ends restraint, one end restraint and both ends open.

3. *Updates of AISI TS-7, Cantilever Test Method for Cold-Formed Steel Diaphragm*

This test procedure provides a cantilever test method for determining the shear strength and shear stiffness of a cold-formed steel diaphragm. Editorial changes were made to Figure 1 in the test procedure to better illustrate the simply supported boundary conditions of the deformed shape.

4. *Updates of AISI TS-8, Base Test Method for Purlins Supporting a Standing Seam Roof System*

Two approaches can be used to determine the strength of purlins supporting standing seam roof systems. One is to disregard the contribution of the lateral support provided by the roof system, and design the purlins considering only discrete lateral brace restraint. The second approach is to determine the strength with consideration of the contribution of the lateral bracing support from the standing seam roof system. The Base Test Method determines the degree of lateral support that the standing seam roof can provide by determining the strength reduction as compared to the strength of the fully braced purlin. The following changes and additions have been made to the test procedure:

a. If the test is performed with the purlin flanges opposed, they must be field installed with their flanges opposed as well.
b. A new figure was added, which shows how an intermediate brace that does not impede the vertical deflection during the test can be installed on the test specimen.
c. Rational procedures are permitted to reduce the number of Base Tests when an inventory consists of different clip types; a specific purlin depth and profile having different flange widths; and identical panel profiles except purlin thickness. The change is based on the research work performed by Trout and Murray (2000).
d. In a Base Test with purlins facing in the same direction and with the top flanges of the purlins not restrained, the term $2P_L(d/B)$ can only be added to the failure load, w_{ts}, when the downhill purlin is the first to fail, where P_L=required anchorage force; d=depth of purlin; and B=purlin spacing.

5. *New Test Procedure AISI TS-9, Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams*

The web crippling strength obtained from tests is related not only to the section profile and the loading condition, but also to specimen length, lateral restraints and configuration of the test setup. It is therefore important to have a standard test procedure, such as TS-9, for web crippling tests to ensure comparable test results. This performance test method establishes procedures for conducting tests to determine the web crippling strength of cold-formed steel flexural members for conditions of Interior-One-Flange Loading (IOF), End-One-Flange Loading (EOF), Interior-Two-Flange Loading (ITF) and End-Two-Flange Loading (ETF). Illustrations for these loading conditions are provided in Figure 1. The test method is applicable to single-web, multiple-web and built-up web sections as shown in Figure 2. The test procedure provides guidance on how to setup the test specimen, perform the test, evaluate the test results, and finally prepare the test report.

6. *New Test Procedure AISI TS-10, Test Method for Distortional Buckling of Cold-Formed Steel Hat Shaped Columns*

Cold-formed steel hat section members are susceptible to distortional buckling. This test method establishes procedures for determining the distortional buckling strength for hat section members subjected to compression. To ensure the distortional buckling occurs, the specimen length, L, must be determined either analytically or experimentally. For the analytical approach, the distortional buckling half wavelength can be obtained using the finite strip method (AISI 2006) or other numerical methods. The test specimen length, L, must be at least four times the half wavelength, and must be tested between the flat ends. If the distortional buckling is not observed experimentally, the specimen length must be adjusted to achieve the distortional buckling mode, i.e., an array of tests of differing specimen lengths must be performed until the distortional buckling mode is observed or it is shown that the distortional buckling mode is not a controlling limit state. In addition to how to properly select the test specimen length, the test procedure also provides guidance on specimen preparation, column test procedure, determination of the strength based on test results, preparation of test report, and required test precisions.

7. *New Test Procedure AISI TS-11, Method for Flexural Testing Cold-Formed Steel Hat Shaped Beams*

This test procedure provides a method to experimentally determine the nominal strength of cold-formed hat section members. As illustrated by Figure 3, the test setup, it is critical to select the appropriate length, b, such that the interested buckling mode will be in control. The test procedure recommends that for local buckling, length “b” must be taken as at least three times the maximum flat dimension of the section; for overall buckling, length “b” must be based on the maximum in-place unbraced length of the actual member; and for distortional buckling, length “b” is to be determined either analytically or experimentally.

For the analytical approach, length "b" must be at least the distortional buckling half wavelength. If the distortional buckling mode is not observed, the test specimen length must be adjusted to achieve the distortional buckling. For the experiment approach, an array of tests of differing lengths must be performed until distortional buckling is observed. In addition, the test procedure also provides requirements for conducting the test, and what test data is to be included in the report.

8. New Test Procedure AISI TS-12, Test Procedure for Determining a Strength Value for a Roof Panel-To-Purlin-To-Anchorage Device Connection

Metal building roof systems need to be anchored to rafters due to tendency of sliding caused by down-slope components of gravity and external loads, as well as overturning caused by the eccentricity of down-slope components and resistance as illustrated in Figure 4. Because of many different types and methods of steel roof construction, it is not practical to develop a generic method to predict the strength of the roof panel-to-purlin-to-anchorage device connections. The interaction of the three components to an anchorage location is a complex phenomenon and highly indeterminate and a test is the only feasible way to determine the strength of the connections in the load path. This test method provides designers with a means of establishing a lower bound on the strength of the roof panel-to-purlin-to-anchorage connections. The test procedure is applicable to either through-fastened or standing seam, multi-span, multi-purlin line roof systems. To obtain the lower bound strength, a test setup capable of supporting simulated gravity loading is required. No fewer than three tests must be conducted for each roof panel-to-purlin-to-anchorage device system. The setup may consist of any number of purlin lines and any number of purlin spans, but all purlin flanges must face in the same direction. The anchorage system must be located along an external purlin line and may consist of any of the anchorage combinations specified in Section D3.2.1 of the *North American Specification for the Design of Cold-Formed Steel Structural Members* (2001, 2004). The lower bound strength of each roof panel-to-purlin-to-anchorage device connection used in the test is determined by calculating the anchorage force, P_L, at that location using the provisions in Section D3.2.1 of the NASPEC. The lesser of the load corresponding to a measured deflection of ½ in. (13 mm) at the top of the anchorage device or the maximum applied load in the test is used for this calculation. The following example illustrates how the lower bound strength is obtained based on test results of a standing seam roof panel-to-purlin-to-anchorage connection system.

Example for Determining the Lower Bound Strength of Roof Panel-to-Purlin-to-Anchorage Device:

A test setup with three continuous 25 ft spans, four Z-purlin lines, anchorage device connections at the rafters along one purlin line was loaded to failure using a vacuum test chamber to determine a lower bound strength for the standing seam roof panel-to-purlin-to-anchorage device connections. The AISI Test Procedure TS-12-05 is to be used to determine the ASD and LRFD lower bound strengths. The 8Z2.25x0.70 purlins failed at a load of 175 lb/ft. (2.55 kN/m). The deflection at the top of the anchorage devices did not exceed ½ in. (13 mm). The lower bound strength of the anchorage devices, P_{Ln}, are determined using the *North American Specification* Eq. D.3.2.1-5:

$$P_{Ln} = C_{tr}\left[\frac{0.053b^{1.85}L^{0.13}}{n_p^{0.95}d^{1.07}t^{0.94}}\cos\theta - \sin\theta\right]W$$

For the given example,

C_{tr}= 0.63 for end support devices and 0.87 for interior support devices;
d (depth of section) = 8 in. (203 mm);
b (flange width) = 2.25 in. (57.2 mm);
t (thickness) = 0.07 in. (1.78 mm);
L (span length) = 300 in. (7620 mm);
n_p (number of parallel purlin lines) = 4;
θ (angle between vertical and plane of web of Z-section) = 0 degree; and
W (total test load supported by purlin lines between adjacent supports = 175x25x4 = 17,500 lbs (77.84 kN).

Substituting the above values into the equation for P_L, the anchorage forces are 1939 lbs (8.62 kN) at the end supports and 2678 lbs (11.9 kN) for the interior supports. The ASD (Ω=1.67) allowable design strengths for the standing seam panel-to-purlin-anchorage device connections are computed to be 1160 lbs (5.16 kN) at the end supports and 1600 lbs (7.10 kN) for the interior supports. For LRFD (ϕ = 0.9), the design strengths for the standing seam panel-to-purlin-anchorage device connections are 1745 lbs (7.76 kN) at the end supports and 2400 lbs (10.7kN) for the interior supports.

Conclusion

Since the publication of the AISI test procedures in the 2002 Cold-Formed Steel Design Manual, some changes and additions have been made. This paper summarized these revisions to the previously published test procedures and provided an overview of the four new test procedures. The revised and the newly developed test procedures can be ordered through the AISI website at (www.steel.org).

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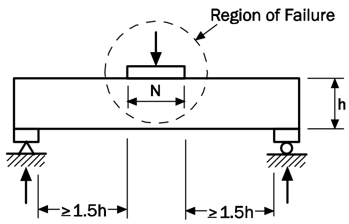
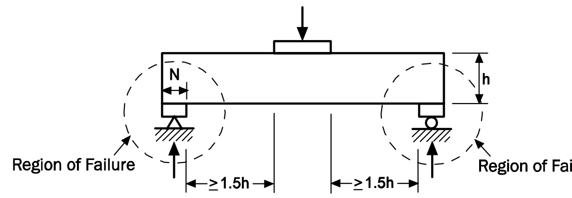
Appendix 1 AISI Test Procedures

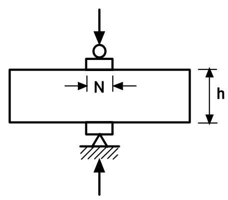
Designation	Title
AISI TS-1-02	Rotational-Lateral Stiffness Test Method for Beam-to-Panel Assemblies
AISI TS-2-02	Stub-Column Test Method for Effective Area of Cold-Formed Steel Column
AISI TS-3-02	Standard Method for Determination of Uniform and Local Ductility
AISI TS-4-02	Standard Test Methods for Determining the Tensile and Shear Strength of Screws
AISI TS-5-02	Test Methods for Mechanically Fastened Cold-Formed Steel Connections
AISI TS-6-02	Standard Procedures for Panel and Anchor Structural Tests
AISI TS-7-02	Cantilever Method for Cold-Formed Steel Diaphragm
AISI TS-8-04	Base Test Method for Purlins Supporting a Standing Seam Roof System
AISI TS-9-05	Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams
AISI TS-10-05	Test Method for Distortional Buckling of Cold-Formed Steel Hat Shaped Columns
AISI TS-11-05	Method for Flexural Testing Cold-Formed Steel Hat Shaped Beams
AISI TS-12-05	Test Procedure for Determining a Strength Value for a Roof Panel-To-Purlin-To-Anchorage Device Connection



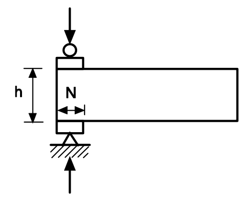
(a) Inter-One-Flange Loading (IOF)



(b) End-One-Flange Loading (EOF)

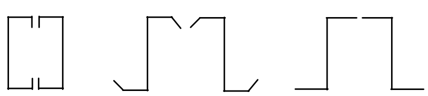


(c) Inter-Two-Flange Loading (ITF)

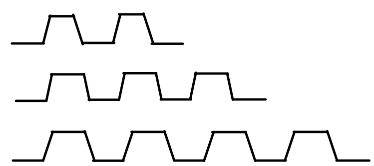


(d) End-Two-Flange Loading (ETF)

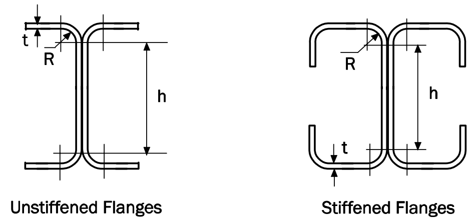
Figure 1 Loading Conditions



(a) Single-Web Cross Sections



(b) Multi-Web Cross Sections



(c) Built-Up Cross Sections

Figure 2 Cold-Formed Steel Cross Sections

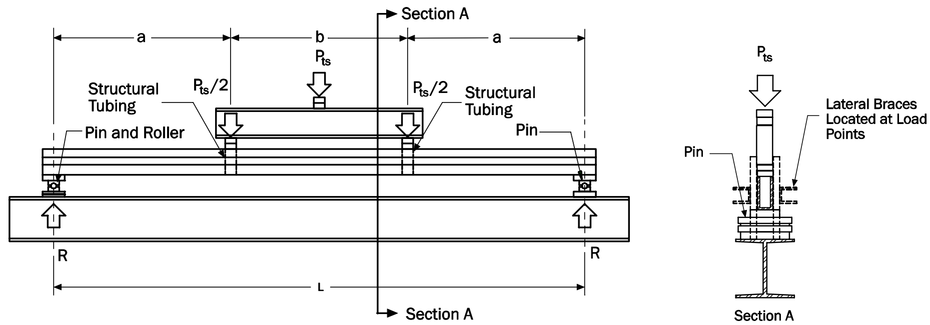


Figure 3 Simply Supported Beam Test

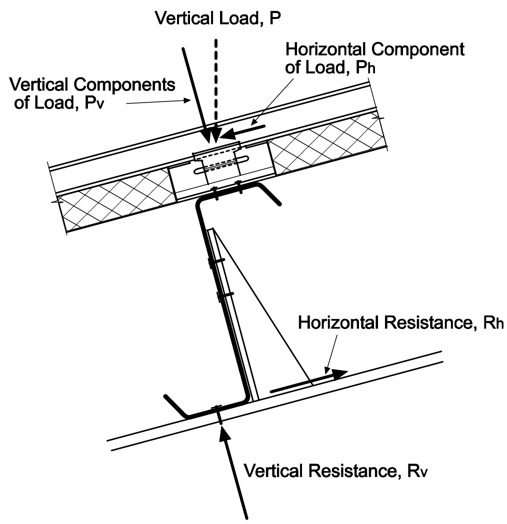


Figure 4 Force and Resistance on Panel-to-Purlin-to-Anchorage Connection

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Organizations and the Move Toward Standardization in the North American Cold-Formed Steel Framing Industry

Don Allen[1]

Abstract

Over the past decade, the once fragmented steel framing industry in North America has realized the importance of standardizing their products and unifying their efforts in the code and regulation arena. Also, by collaborating across boarders, Canada, Mexico, and the United States have developed the first of several North American standards to take advantage of these standard products. This paper will cover a brief history of the standardization, the reasons for the standardization, some of the obstacles encountered, what the current state of framing manufacturing and standardization is in North America, and what some of the next steps are in the process. This paper will include some of the regulatory and manufacturing barriers encountered, the development and coordination of industry organizations to address these barriers, and a forecast of what lies ahead for steel framing standardization in North America.

Introduction

Specifications for cold-formed steel framing have been around, in one form or another, in North America since the mid 19th century. As manufacturers discovered new ways to process and bend sheet steel, new products came on the market and became commercially viable, especially in areas where straight, strong, non-combustible, and termite-resistant construction was needed. With the development of these new products, it became difficult to regulate the market: building officials, builders, architects, and even engineers were having difficulty specifying a standard product and getting what they expected on the delivery truck and on the job. Several companies advertised steel-framed systems, but would only warranty their systems when their specific types of products were used: not only for the framing, but for fasteners and cladding as

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well. The steel industry saw a great opportunity in commercial and especially residential framing. Industry leaders realized that a major barrier to the market was standardization. Before looking at how this process was addressed, it may be helpful to take a brief look at the history of codes and standards in the Western world, leading up to the current regulatory environment in North America.

A Brief History of Standards

Throughout history, codes and standards have been developed to help ensure safety and quality of structures. The first known building code language was contained in the Code of Hammurabi, written around 1780 BC. After that, it often took major disasters to move civic groups and governments to action in developing and implementing building codes on a large scale. Examples include the burning of Rome around 64 AD, and the "London Building Act," written and implemented after the great London fire of 1666. In Rome, Emperor Nero had long advocated a master plan for the layout of the city. After Rome burned, Nero's plan was quickly implemented, and included some of the first fire codes. The "London Building Act," on the other hand, took two years of legislative wrangling to develop, and many of the 15,000 buildings that had been destroyed (almost two-thirds of the city) were rebuilt before the act's implementation, using many of the same poor construction practices as the structures that were destroyed. In North America, the Chicago Fire of 1871 and the San Francisco Earthquake of 1906 both led to development of building regulations to help prevent both loss of life and costly damage to structures.

The earliest example of a code regulation favoring or prohibiting certain construction materials in North America came as early as 1630, when the city of Boston in the colony of Massachusetts mandated that "no man shall build his chimney with wood nor cover his roof with thatch." In 1905, the first "model building code" was developed in the United States (USA) by the National Board of Fire Underwriters. This began a trend that continues to this day: model codes are developed by private organizations, and adopted by political jurisdictions. Sometimes the codes are adopted across an entire state or province; sometimes just by certain cities or counties. As the Europeans are discovering in their efforts to implement Eurocode, having multiple independent states makes consensus difficult, to say the least.

Cold-formed steel had not been widely used as a construction and framing material at the times of these code implementations or disasters. The American Iron and Steel Institute, (AISI,) had been promoting iron and structural steel products since 1855, and in 1939 they began sponsoring research on cold-formed members at Cornell University under the direction of George Winter. AISI sponsored research has continued since that time with the first specification on cold-formed steel design published in 1946.

In 1941 in Canada, when the Canadian federal government published the first Canadian National Building Code, there was a patchwork of local and regional building codes. It took almost 20 years for this code to be adopted by most of the provinces and local jurisdictions. In 1961, the Canadian Sheet Steel Building Institute, or CSSBI, was formed. The Canadian building code relies in part on standards developed by the Canadian Standards Association (CSA,) to develop consensus standards for adoption into the building code. CSA Standard S136, *Cold-Formed Steel Structural Members*, was the code-accepted standard for cold-formed steel design before the development of the North American Specification [CSA, 1994].

In Mexico, cold-formed steel construction did not become widely accepted until the early 1960s. The AISI specification had been used in Mexico before that time, and in 1965 a translated version of this reference was published. Mexican cold-formed steel research became more robust in the 60s, and in 1969 the Engineering Institute of the National University of Mexico published a theoretical and experimental study of the structural behavior of cold-formed steel members. The trade association for the steel industry in Mexico is Camara Nacional de la Industria del Hierro y del Acero (CANACERO.) Founded in 1949, CANACERO represents the Mexican steel industry, and played a vital role in the development of a unified North American specification.

Why standardization across borders?

Markets and marketing, for many products and product sectors, has become more global than local. With the increased use of the internet, international trade agreements, cross-border outsourcing and expansion of markets, it makes economic sense to standardize larger geographic regions. Manufacturers need only comply with one set of regulations to sell into multiple-country markets; specifiers, designers, and engineers need only specify one type of product to cover construction in multiple countries; inventories, product tracking, and logistics are easier to develop and maintain. New product development and implementation is easier and faster.

The opportunity for multi-national standardization became clear in 1993, with the ratification of the North American Free Trade Agreement, (NAFTA,) by Canada, Mexico, and the United States. With this agreement, it became clear that multi-national standardization of the steel design specification could be the first step in the development of additional multi-national standards, as standards specific to the framing market were being developed.

In 1995, the first technical meetings took place between all North American countries to initiate the move to common standards. There were several obstacles to this process, however. Each country used a different set of units: U.S. Customary Units in the United States, Système International d'Unités (SI) in Canada, and meter-kilogram-second (MKS) system in Mexico. Also, multiple design methodologies were used: Load and Resistance Factor design (LRFD,) Allowable Strength Design (ASD,) and Limit State Design (LSD.) Each country had its own accepted factors of safety, and methods of incorporating these factors into their steel codes. After years of work, bargaining, and negotiations, CANACERO, CSA, and AISI released the 2001 "North American Specification for the Design of Cold-Formed Steel Structural Members," referred to herein as the "*Specification.*" Hailed as "The First Tri-National Construction Standard," the publication was able to incorporate country-specific provisions in appendices [Urquiza, 2003]. A symbol is used in the main document to point out that additional provisions are provided in the corresponding appendices indicated by the letters. The Specification accomplishes the different types of safety factors by including the appropriate resistance factors (Φ) for use with LRFD and LSD, and the appropriate factors of safety (Ω) for use with ASD [AISI, 2001, p.3] (Figure 1).

Members		
USA and Mexico		Canada
Ω (ASD)	φ (LRFD)	φ(LSD)
2.00	0.80	0.75

Connections		
USA and Mexico		Canada
Ω (ASD)	φ (LRFD)	φ(LSD)
2.50	0.65	0.60

Figure 1: typical tables of safety and resistance factors from the *North American Specification for the Design of Cold-Formed Steel Structural Members* [AISI, 2001, p. 33]

Framing-specific standards and products

The Specification covered all types of cold-formed steel members up to 1" (25.4 mm) thick. This included not only members for framing, but metal decks, purlins, girts, siding, and roofing in metal buildings, loadbearing metal racks, rails, and other structural members. The specification was not limited to building structures either. The cold-formed steel framing industry had developed systems of wall stud, floor joist, and roof truss and rafter framing that were, for the most part, proprietary. Engineers and architects developed and used cross-reference sheets, so they could determine equivalency between manufacturers. Some engineers would use the weakest member in a specific classification, to ensure that material supplied on a project would meet these minimums, no matter which manufacturer was used. This was not good for the industry, since it added construction costs and time to sort out and identify material specified versus material used. It was very difficult for the inspection and enforcement community as well.

Two organizations began efforts at standardization of material types and profiles. The Metal Lath and Steel Framing Association (ML/SFA,) a division of the National Association of Architectural Metal Manufacturers, had worked with other organizations such as the American Society of Testing and Materials (now ASTM International) to develop manufacturing and marking standards, but did not agree upon a manufacturing standard. On the west coast of the United States, the Metal Stud Manufacturers Association (MSMA) did develop a consensus on manufacturing standards, and in the 1990s published a standard catalog, showing members produced by all of their member companies. This was regional only, and did not include Canada, Mexico, or the Eastern United States.

In 2000, MSMA and ML/SFA began talks to work together on a national USA standard for framing members. They were encouraged and supported by the recently formed North American Steel Framing Alliance (NASFA), sanctioned by the AISI and CSSBI. MSMA and ML/SFA formed a new, nationwide organization for the USA: the Steel Stud Manufacturers Association (SSMA,) and published their first catalog in 2001 [SSMA, 2001]. This included the new, standard nomenclature, developed jointly by SSMA and NASFA, which was to be used in the code-adopted framing standards being developed simultaneously by AISI [Appendix C.]

Framing standards development was taking a parallel track to what the manufacturers were doing in SSMA. The AISI saw the need for the development of standards specific to framing, to help the code and regulators understand and accept steel framing in the building and housing construction markets. In the early 90s, AISI and the USA Department of Housing and Urban Development contracted with the National Association of Home Builders Research Center to develop a Prescriptive Method for steel home construction. The first version of this document was published in May, 1996 [National, 1996]. Also in 1996, the AISI decided to form a special committee to develop framing standards, and in February 1997, the AISI Committee on Framing Standards (AISI/COFS) held their first meeting in Tucson, Arizona.

This group had an aggressive schedule for standards development: to have four standards published through the consensus process of the American National Standards Institute by 2001, in time for adoption into the 2003 versions of the model building codes. The first of these was an updated version of the 1996 Prescriptive Method [AISI-PM, 2001]. This would include the jointly developed nomenclature for members, and reference other AISI standards. The second would be a base document, the General Provisions Standard, to include basic information and definitions, describing systems covered by the Prescriptive Method and other framing standards. The General Provisions Standard would describe the basic c-shaped member (Figure 2), permitted sheet steel thickness and coating, system installation, and special provisions for connection, installation of utilities, and insulation [AISI-GP 2001]. The third and fourth documents were for system-specific built-up configurations: the Header Standard (Figure 3) and the Truss Standard (Figure 4.) Each of these contained provisions specific to these unique configurations of systems of members that were not completely addressed in the *Specification*.

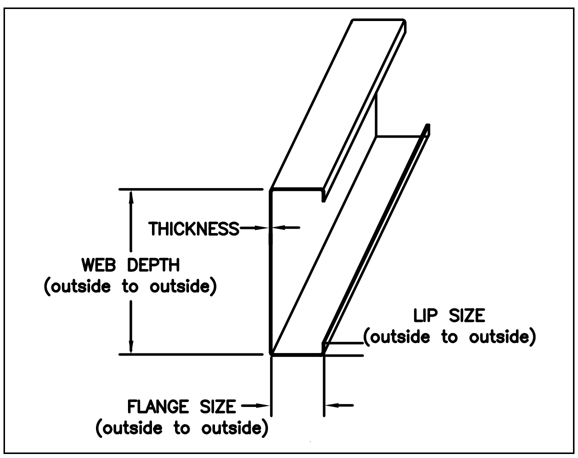


Figure 2: Basic configuration of the standard C-shaped section, as shown in Figure A2-1 of the General Provisions Standard [AISI-GP 2001, p. 2].

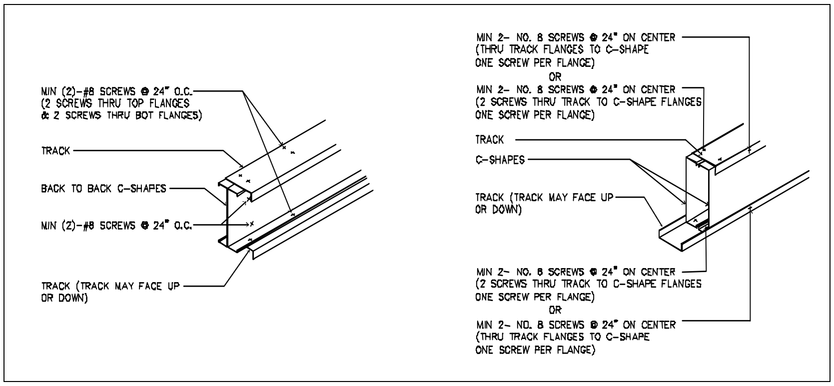


Figure 3: Two of the three types of headers referenced in the Header Standard [AISI-HEADER, figures A1.1.1-1 and A1.1.1-2, p. 1]

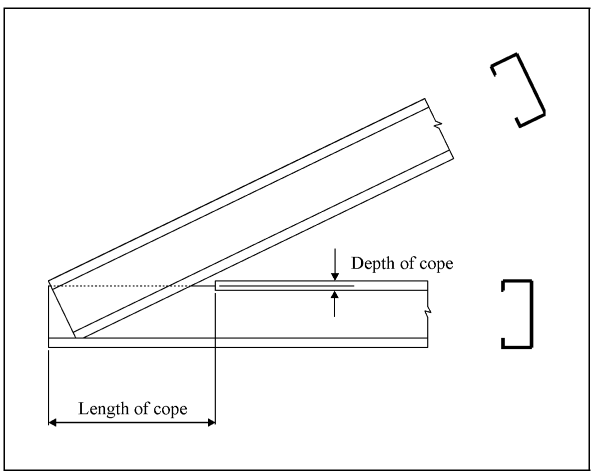


Figure 4: Coping detail (figure D5.2-1) from the Truss Standard commentary [AISI-TC, 2001, p. 8]

The AISI Committee on Framing Standards was able to meet their goal, and their publications were adopted into the model building codes for 2003: the International Building Code, the International Residential Code, and the NFPA 5000 Building Code. However, not being true North American standards, the AISI/COFS documents had not been set up in a format adoptable into the National Building Code of Canada, or the Mexican building codes. In 2004, the AISI/COFS began discussions with the CSSBI and SSMA on development of a series of North American standards. This would start with a North American

Product Standard, which would contain much of the same type of information that was in the SSMA Product Technical Information Catalog: dimensions, thicknesses, product nomenclature, minimum tensile strengths, and member section properties [SSMA, 2001, pp. 5-11]. Eventually, a North American Quality Standard would be developed, for consistent quality in the manufacture of the products referenced in the Product Standard, and a North American standard set of load and span tables, based on the design requirements of the *Specification*.

Highlights of current and new standards

Two key principals were considered and adopted early on in the development of the first North American Specification that have been helpful for the development of this and other documents.

- Non-Dementional: permitting any consistent set of units, such as U.S. Customary, SI, MKS, or other consistent set of units may be used. The product designator is non dimensional: although dimensions are expressed in fractions of an inch, the actual product designator has no units, and is being used successfully in both the CSSBI and SSMA publications.
- Unified LRFD and ASD: Academia and practicing engineers have grappled over the past two decades to make the transition from allowable stress design to limit states design. The *Specification*, as well as other design documents, uses the concept of development of a nominal design value, then dividing by a safety factor or multiplying by a resistance factor. This same premise, first incorporated into the 1996 AISI *Specification*, has been adopted in the United States by the American Institute of Steel Construction, in their hot-rolled steel specification.

In 2004, revisions to the General Provisions, Header, and Truss standards were issued, along with new standards for wall stud design and lateral design. Standards being developed now include a Product Standard, Quality Standard, and Span and Load tables. These tables will cover most of the same sections that are currently in the SSMA Product Technical Information Catalog.

The Future of North American Steel Framing

The author of this paper predicts that by the end of 2015, most steel framing products produced and used in North America will not be standard members. The reason is clear: new technologies, from both North America and abroad, have brought innovative new framing products that are lighter, more durable, and less expensive to produce and use. These products address issues that are common to many types of framing construction, as well as some that are unique to steel framing: sound transmission, heat transmission, cost, corrosion, and constructability. There are several joist and stud products now on the market with lip-reinforced holes, which allow for less weight, less thermal transfer, and passage of utilities such as ductwork and plumbing. Several stud products with slit or perforated webs are now either available or in development, to specifically address heat transfer in building envelopes. Products for specific applications, such as jamb studs, headers, and truss webs and chords, have special shapes and configurations rather than the standard C-shape shown in North American framing standards. Built-up and boxed members are in development using new fastening techniques: such as specially formulated adhesives for steel or clinched, pinned, and riveted connections. Traditional fastening techniques from other markets, such as resistance spot welds, are being tried in new framing applications, such as factory forming of boxed members and built-up sections. Builders have developed clips, connectors, fastening devices and other accessories that make their work faster and easier. Metallurgists have developed new formulations for new types of steel, and even chemists have developed coatings and adhesives for protecting and fastening framing members. The possibilities for innovation are endless, and many manufacturers from around the world are up to the challenge. Products from Australia, Finland, New Zealand, the United Kingdom, and other locations already have a strong presence in North America.

Conclusions

Although North America has a standards development process in place, there is still much work to be done. While current standards address the decades-old C-shaped members, standard writers and manufacturers must grapple with how to address new products, while protecting the intellectual properties of the inventors and manufacturers. Good arguments have been made to make standards more open to innovation, and in fact the scope statement for the General Provisions Standard includes the following: "These General Provisions shall not preclude the use of other materials, assemblies, structures or designs not meeting the criteria herein, when the other materials, assemblies, structures or designs demonstrate equivalent performance for the intended use to those specified in these General Provisions." [AISI-GP 2001] With all of this innovation, the next generation of standards will work to incorporate as much as possible, while simultaneously permitting new innovation in the marketplace and allowing the protection of proprietary designs and systems.

Appendix A: References

American Iron and Steel Institute (AISI). (2001). *North American Specification for the Design of Cold-Formed Steel Structural Members*, Washington, D.C.

American Iron and Steel Institute (AISI-GP). (2001). *Standard for Cold-Formed Steel Framing - General Provisions*, Washington, D.C.

American Iron and Steel Institute (AISI-GPC). (2001). *Commentary on the Standard for Cold-Formed Steel Framing - General Provisions*, Washington, D.C.

American Iron and Steel Institute (AISI-PM). (2001). *Standard for Cold-Formed Steel Framing - Prescriptive Method*, Washington, D.C.

American Iron and Steel Institute (AISI-HEADER). (2001). *Standard for Cold-Formed Steel Framing – Header Design*, Washington, D.C.

American Iron and Steel Institute (AISI-TC). (2001). *Commentary on the Standard for Cold-Formed Steel Framing – Truss Design*, Washington, D.C.

Canadian Standards Association (CSA). (1994). *Cold-formed Steel Structural Members S136-94*, Ontario, Canada.

National Association of Home Builders Research Center, for the U. S. Department of Housing and Urban Development – Office of Policy, Development and Research. (1996). *Prescriptive Method for Residential Cold-Formed Steel Framing,* Upper Marlboro, Maryland.

Steel Stud Manufacturers Association (SSMA). (2001) *Product Technical Information Catalog*, Chicago, Illinois

Urquiza, J. A. G., "The First Tri-National Construction Standard", *ASTM Standardization News,* January 2003

Appendix B: Organizations Referenced

AISI	American Iron and Steel Institute
AISI/COFS	American Iron and Steel Institute Committee on Framing Standards
ANSI*	American National Standards Institute
ASTM	ASTM International (formerly American Society for Testing and Materials)
CSSBI	Canadian Sheet Steel Building Institute
CANACERO	Camara Nacional de la Industria del Hierro y del Acero
CSA	Canadian Standards Association
ML/SFA	Metal Lath and Steel Framing Association (formerly part of the National Association of Architectural Metal Manufacturers; now part of SSMA)
MSMA	Metal Stud Manufacturers Association (now part of SSMA)
NAHB*	National Association of Home Builders
NASFA	North American Steel Framing Alliance (now the Steel Framing Alliance)
SSMA	Steel Stud Manufacturers Association

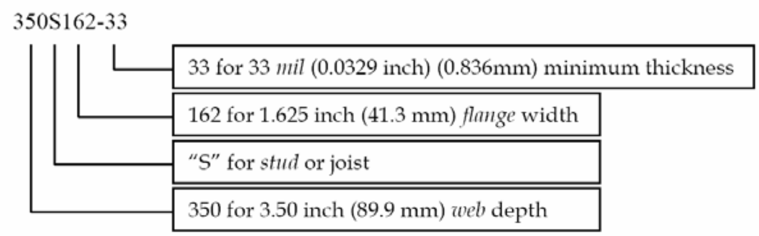
*Abbreviation not used in this document, but organization is referenced.

Appendix C: North American Standard Member Nomenclature

From the General Provisions Standard Commentary [AISI-GPC 2001, p.3]

The following presents an example of the standard designator for a steel stud:

350S162-33 represents a member with the following:



From the SSMA Product Technical Information Catalog [SSMA, p.2]

EXAMPLE: