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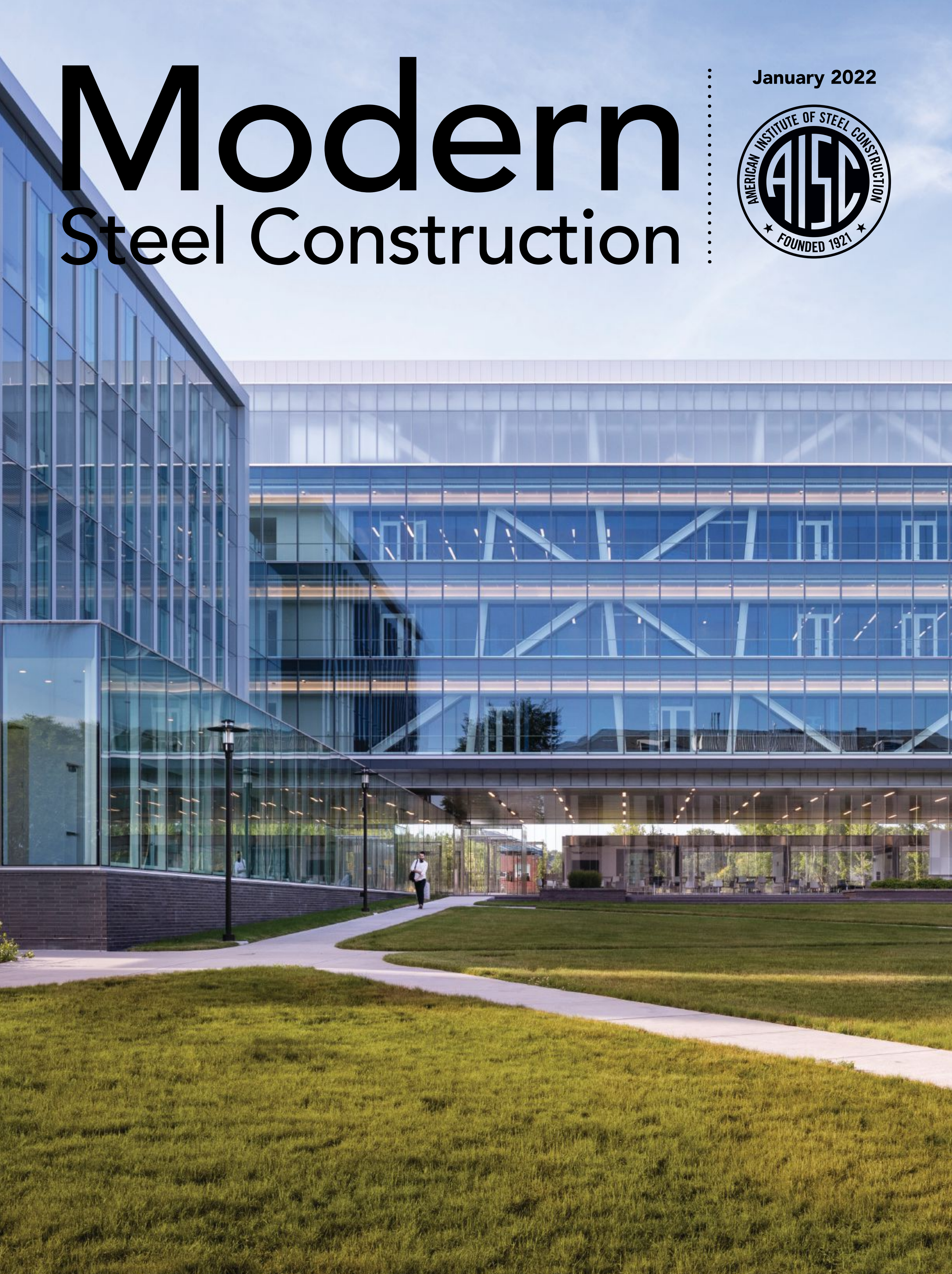


A New Shine on Steel Design

BY NANCY BADDOO, CENG, AND MARK HOLLAND, PE

A look at the new AISC *Specification for Structural Stainless Steel.*

Premier Industrial/Westinghouse

A stainless steel support structure was used for the passive cooling system in the containment structure at the Vogtle Nuclear Power Plant (Units 3 and 4) in Burke County, Ga. The tower is 30 ft tall and 11 ft square, and made from duplex stainless steel S32101 plate and HSS.

AS THE DEMAND for resilient, long-lasting structures with low maintenance requirements grows, so does the demand for stainless steel in construction—and AISC has recently released a specification dedicated to structural stainless steel.

Stainless steels are attractive and highly corrosion-resistant steel alloys with favorable strength, toughness, and fatigue characteristics. They can be fabricated using a wide range of commonly available engineering techniques and, like traditional structural steel, are fully recyclable at the end of their useful life.

While guidance for designing cold-formed structural stainless steel members—in the form of ASCE/SEI 8-02: *Specification for the Design of Cold-Formed Stainless Steel Structural Members*—has been around for decades, there wasn't a dedicated publication for welded and hot-rolled stainless steel products until AISC published the first edition of Design Guide 27: *Structural Stainless Steel* in 2013 (**aisc.org/dg**).

Subsequent interest from the industry spurred AISC to develop a specification dedicated to structural stainless steel. Work began with the establishment of the AISC Committee on Structural Stainless Steel, which includes stainless steel fabricators and welding experts, metallurgists, designers, and academics. And the new publication, *Specification for Structural Stainless Steel Buildings* (ANSI/AISC 370-21), is now available. The following is a brief look into the new publication and how it harmonizes with the 2016 AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360-16); both publications can be found at **aisc.org/specifications**.

Stainless Applications

First, it's important to consider where structural stainless steel can be most useful or make the most sense. Prominent stainless steel applications include external structural members that are in close proximity to saltwater, exposed to deicing salts, or in heavily polluted locations. Stainless steels are commonly used for platforms, barriers, and equipment supports for the water treatment, flood control, pulp and paper, nuclear, biomass,

Chattanooga Boiler and Tank Company

Stainless steel is increasingly being used for transit-related structures. Over the last 12 years, curved stainless steel and glass canopies have been installed over the entrances to 40 Washington, D.C., Metro stations. The canopies adopt a modular design and are made up of austenitic stainless steel S31603 rectangular HSS.

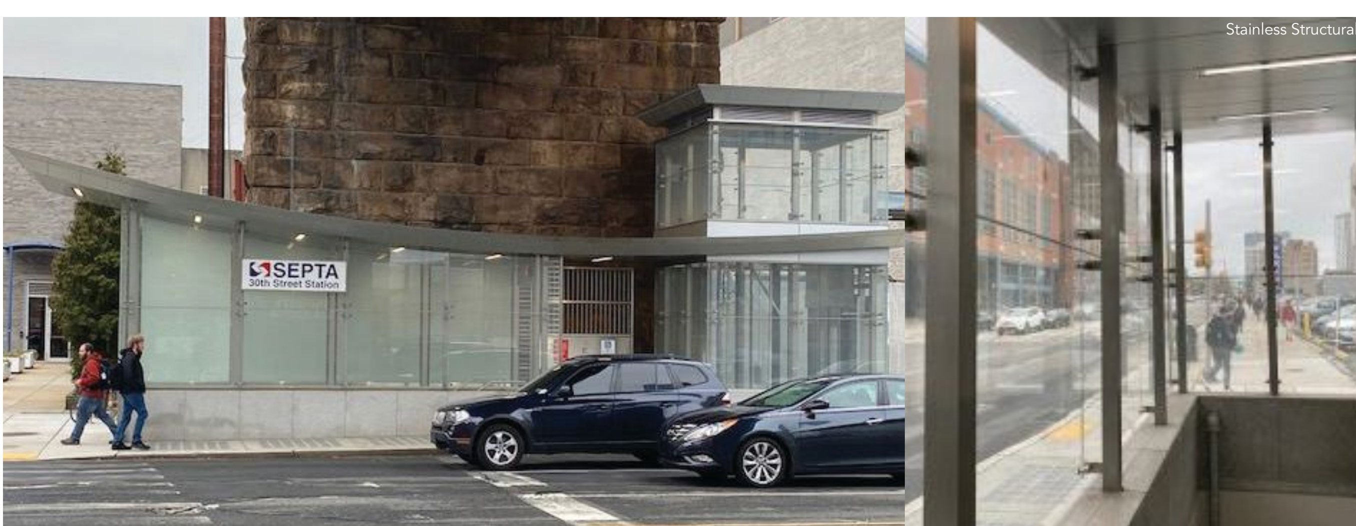
chemical, pharmaceutical, and food and beverage industries. In such applications, eliminating the need for coating maintenance or component replacement due to corrosion can result in significant long-term maintenance cost savings. Stainless steel structural components are also a popular choice for cladding supports, roofs, canopy supports, security barriers, and other applications that take advantage of the material's corrosion resistance, strength, and fire resistance to reduce maintenance requirements and improve safety.

Choosing the correct stainless steel alloy for a specific application is crucial, and the first stage of the design process should involve characterizing the service environment. The publication's Commentary provides guidance in this area, and AISC Design Guide 27 also advises on the durability of different stainless steel alloys in various environments.

Synching Up

The scope of the *Stainless Specification* generally matches the scope of the AISC *Specification*. Although structural stainless steel has some promising properties for seismic applications, there are currently no supplemental seismic provisions available for stainless steel. The new publication's provisions apply to austenitic and duplex stainless steels, and some provisions are also given on the use of precipitation hardening stainless steels for tension members, fittings, and fasteners.

Chapters A through N of the *Stainless Specification* mirror the equivalent chapters in the AISC *Specification*. The one exception is Chapter I, which currently serves as a placeholder to retain the same chapter letters as the AISC *Specification* while design rules are developed for inclusion in a later edition.



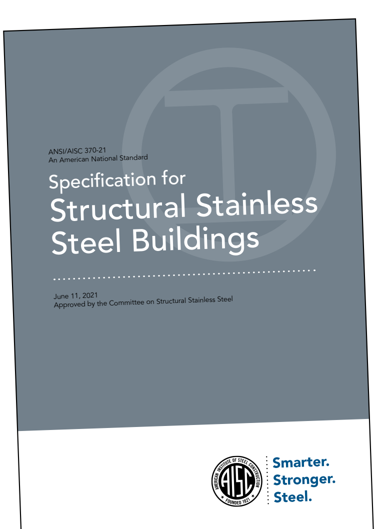
Stainless Structurals

Stainless steel S31603 laser-welded sharp-cornered HSS, wide-flange beams, and angles were used as structural members for the glazed entrance structures and elevator shafts as part of the renovation of the Southeastern Pennsylvania Transportation Authority (SEPTA) station at 30th Street in Philadelphia.

The high-strength duplex stainless steel S32205 mullions in the glazed façade of the 60-ft-tall three-sided atrium to 3 World Trade Center are sharp-cornered profiles of built-up structural tube, which was selected for its resilient design characteristics and excellent corrosion resistance.

Although the necessary steps to determine the structural capacity of stainless steel members and connections are very similar to those of carbon steel, the nonlinear stress-strain characteristics of stainless steel impact certain aspects of structural behavior—e.g., local and global buckling response. A comparison of the *Stainless Specification* and the AISC *Specification* is summarized here:

- In addition to applicable material specifications, Chapter A of the *Stainless Specification* provides product order requirements, as well as minimum assessment requirements for specifying corrosion resistance.
- In Chapter B, the limiting width-to-thickness ratios are generally lower than the equivalent values in the AISC *Specification* and are organized into fewer categories. A method is provided for determining the strength increase in stainless steel cold-formed hollow structural sections (HSS) due to strain hardening.
- There are some differences in the rules for stability in Chapter C.
- In Chapter D, the provisions are generally the same as the AISC *Specification*, although there is specific guidance for stainless steel members where deformation needs to be limited.
- The Chapter E expressions for determining the flexural buckling strength differ from those in the AISC *Specification.*
- The Chapter F expressions for determining the lateral-torsional buckling strength differ from those in the AISC *Specification*.
- In Chapter G, the provisions for shear are generally the same as those in the AISC *Specification*, apart from the expression for calculating the web shear strength coefficients. Provisions for torsion are given in Chapter G, as opposed to Chapter H.
- Chapter H gives the same interaction expressions as those in the AISC *Specification.*
- The Chapter J rules for determining the available strength of connections are generally the same as those in the AISC *Specification*, apart from the provisions for bearing strength and slip-critical connections.
- The Chapter K provisions are the same in both specifications, except the scope of this chapter in the *Stainless Specification* is limited to square or round HSS and box sections of uniform wall thickness.
- In Chapter L, the nonlinear characteristics of stainless steels mean it is necessary to use the secant modulus, as opposed to the modulus of elasticity, for estimating deflections.
- Chapter M contains some different provisions that are necessary due to the different chemical compositions of stainless steels compared to carbon steel. Storage and handling measures to avoid surface-finish damage are also given.
- In Chapter N, the requirements for inspection and testing of welding in accordance with AWS D1.6/D1.6M replace those for carbon steel, where AWS D1.1/D1.1M is referenced in the AISC *Specification*.



- There are some differences in the rules for design by advanced analysis given in Appendix 1.
- Appendix 2 gives a deformation-based design method for determining the strength of stainless steel cross sections, considering the benefits of strain hardening. It offers an alternative and less conservative way of determining member available strengths to the traditional methods given in Chapters D, E, F, and H of the *Stainless Specification*.
- The provisions regarding fatigue in Appendix 3 are the same as those in the AISC *Specification*, although certain detail classes are removed as they fall outside the scope.
- For fire design in Appendix 4, the strength and stiffness degradation factors and the expressions for determining the nominal compressive and flexural strength for design by simple methods of analysis are different from those in the AISC *Specification*.
- In Appendix 5, the same procedures apply to evaluating existing structures as those in the AISC *Specification*.
- The provisions in Appendix 6 for the required strength of bracing members are different than those in the AISC *Specification*.
- Appendix 7 gives the expressions for modeling material behavior for stainless steel at room temperature and elevated temperatures.

Note that the *Stainless Specification* is a standalone document with its own code of standard practice, *Code of Standard Practice for Structural Stainless Steel* (AISC 313-21); next month's SteelWise will provide information on this forthcoming publication. In addition, the second edition of Design Guide 27 will be published at the same time as the *Stainless Specification* to serve as its "handbook," providing examples and section property and member capacity tables for a range of structural sections. (At present, there is no U.S. specification giving a standard library of sizes of stainless steel sections for structural applications, so the tables cover the range of practical section sizes in typical use.)

With the new stainless steel standard, its related code, and the updated stainless design guide at their fingertips, designers will be able to design economic stainless steel structures with long service lives and low maintenance requirements and, generally, get the most out of their stainless steel projects. ■

Inside Stainless Steel

Stainless steels are a family of corrosion- and heat-resistant steels containing a minimum of 10.5% chromium and a maximum of 1.2% carbon. There is a wide range of stainless steels with varying levels of corrosion resistance, strength, and weldability. This array of properties is the result of controlled alloying element additions, each affecting specific mechanical properties and the ability to resist different corrosive environments.

With a combination of a minimum chromium content of 10.5%, a clean surface, and exposure to air, a transparent and tightly adherent layer of chromium-rich oxide forms spontaneously on the surface of stainless steel. If scratching or cutting damages the film, it reforms immediately in the presence of oxygen. As long as the stainless steel alloy is corrosion-resistant enough for the service environment, it will not react further with the atmosphere. No applied coatings are necessary throughout the lifetime of a component.

Stainless steel components are available in a range of finishes, from a standard mill finish suitable for applications where cosmetic appearance is less important to brushed, polished, and even colored finishes for architectural applications.

Stainless Structurals

Nancy Baddoo (**n.baddoo@steel-sci.com**) is an associate director with the Steel Construction Institute in the United Kingdom. She and her SCI colleague Francisco Meza prepared the first draft of the AISC *Specification for Structural Stainless Steel Buildings* and are also joint authors of the second edition of AISC Design Guide 27: *Structural Stainless Steel*, which is expected to be published later this year.

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