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January 2022


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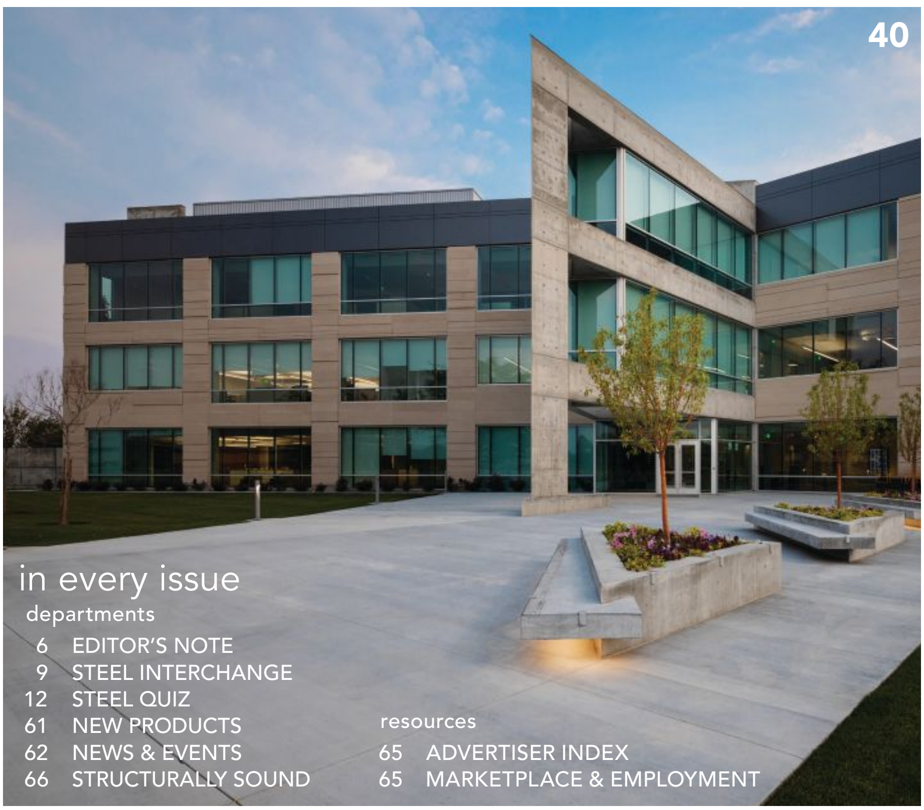

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ON THE COVER: Steel bracing is on full display at the the University of Rhode Island's Fascitelli Center, p. 32. (Photo: James Ewing)

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Let's talk about fried chicken for a minute.

I live in Chicago and commute to work via train. My local train station is right across the street from a Popeyes.

Here are two facts, which are in direct conflict with one another. One, I'm one of those people that prefers to patronize local restaurants and generally avoids chains. Two, I love Popeyes, which, of course, is a rather large restaurant chain (there are nearly 3,500 locations worldwide).

When I walk by this Popeyes location in the morning, it's closed. But in the evening, it smells magical, and every day, I almost dare myself to wander in the front door and get in line. Of course, I make excuses not to: I should save money, I should eat at home, there are better places to get fried chicken (and, let's be honest, fried chicken isn't exactly the healthiest food in the world anyway), and so on.

So the compromise is that we get chicken (and biscuits and other sides) from Popeyes twice a year: once on New Year's Day (a tradition that somehow started years ago) and once on some random day.

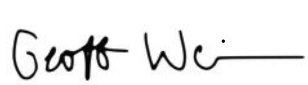
My point is that you can always talk yourself into or out of anything. Take work conferences, for example. They can seem expensive. They can take you or your employees away from work for a few days. And they can seem unnecessary (though ask yourself how many other "unnecessary" things you've talked yourself into doing or buying throughout your life and ended up being glad you did). But the best ones are investments in your livelihood.

Yes, this is the point where I remind you that NASCC: The Steel Conference is just around the corner. This year's show is taking place March 23-25 in Denver. Registration opens on January 10, and you can find out more—and register—at **aisc.org/nascc**. If you're already planning to attend, great, we'll see you there! If you haven't quite made up your might yet or are in the process of talking yourself into it, allow me to help. There will be 200 technical sessions delivered by the best minds in the steel design and construction industry. There will be a trade show floor with more than 250 exhibitors. There will be the exceedingly popular Thursday night Conference Dinner. There will be keynote addresses and the T.R. Higgins lecture. There will be opportunities to earn up to 21 PDHs. There will be multiple conferences within a conference: the World Steel Bridge Symposium, QualityCon, and the NISD Conference in Steel Detailing. There may or may not be fried chicken, but there will likely be green chile (a popular local addition to Mexican food and anything else you might want to slather it on; Google it). And one low registration fee gains you access to all of this.

And then there are the opportunities to catch up in person with colleagues and friends, see a new place (or a place you've been before and maybe visit some old haunts), or simply get a change of scenery that is fortuitously tied to an event geared toward making you better at what you do. And keep in mind that this will be the first in-person Steel Conference since 2019—all the more reason for those of us who are still working from home all or at part of the time to go.

And did I mention that it's in Denver? You may have heard that the Mile High City is rather fun and is located near lots and lots of mountains. Stick around after the conference and make a vacation out of it! As a former Colorado resident, I can assure you there's plenty to do in the area.

Happy new year, and we look forward to seeing you in Denver!



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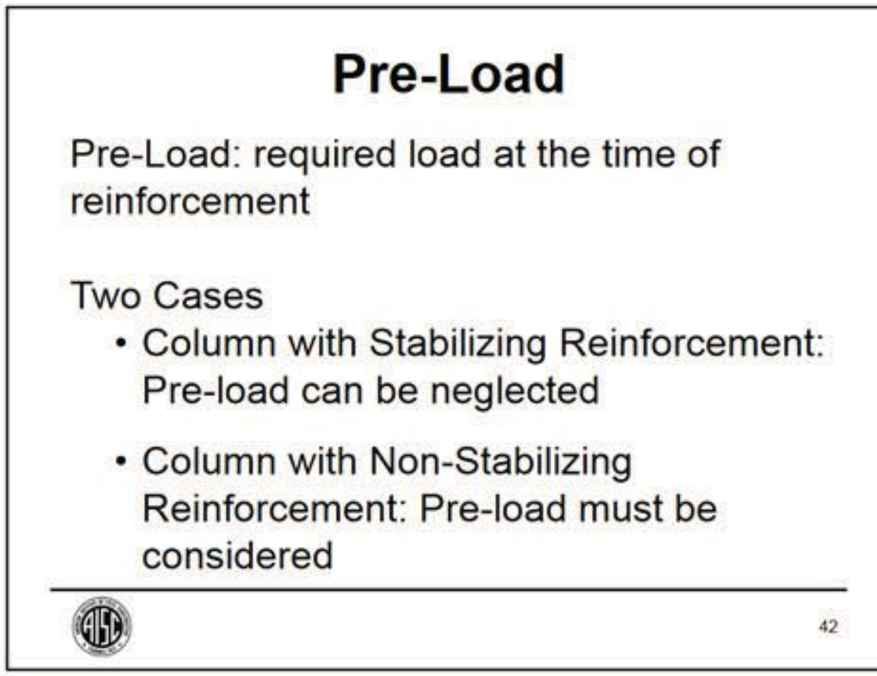
If you've ever asked yourself "Why?" about something related to structural steel design or construction, *Modern Steel*'s monthly Steel Interchange is for you! Send your questions or comments to **solutions@aisc.org**.

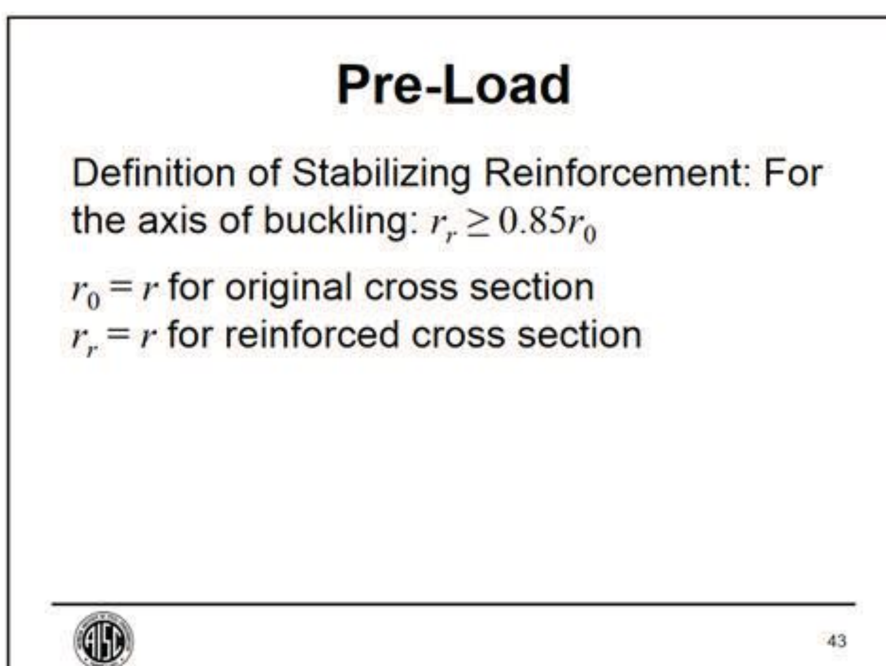
All mentioned AISC codes, standards, or manuals, unless noted otherwise, refer to the current version and are available at aisc.org/specifications.

Strengthening Existing Columns

I have a question about dealing with the pre-load in an existing column that is to be reinforced by adding plates. The AISC 2013 webinar "Design of Reinforcement for Steel Members" (which you can access at aisc.org/educationarchives; note that PDHs are available) indicates, on slides 42 and 43, that whether the reinforcement is stabilizing or non-stabilizing should be considered.

Is the concept of stabilizing and non-stabilizing reinforcement valid, and what is the source for the limit on the reinforced radius of gyration?





Pre-load does reduce the strength of columns. However, this detrimental effect can be partially or wholly offset by other beneficial effects. For some conditions, safe designs can be obtained with the equations in AISC *Specification* Section E3, which define the AISC Column Curve (curve expressing the relationship between flexural buckling and slenderness ratio). In this case, a safe design can be defined as the condition where the beneficial effects equal or exceed the detrimental effects. I developed the design guidance in the 2013 webinar based on an evaluation of the available research. (Although I am planning to write an AISC *Engineering Journal* article, it has taken longer than expected.)

Residual stresses are self-equilibrating stresses built into the member in the unstressed condition (no applied load). Due to uneven cooling after the rolling process, all steel shapes have residual stresses. I-shaped members usually have compression residual stresses at the flange tips. Although the magnitude can vary significantly, they are often assumed to be about 30% to 40% of the yield stress. Longitudinal fillet welds cause residual tension stresses in the connected members near the weld. These stresses are approximately equal to the yield stress of the base metal.

The locked-in stresses caused by the pre-load can be considered residual compression stresses acting on the original cross-section. Because the reinforcing plates are unstressed (excluding residual stresses) until an additional load is added to the reinforced column, the plates effectively have locked-in tension stresses caused by the pre-load. Conceptually, this is clearer if we think about the stresses in the reinforced member if the pre-load is removed after the reinforcing plates are welded.

If everything else is equal, including the initial out-of-straightness of the column, the beneficial and detrimental effects can be evaluated based on the locked-in stresses. The detrimental effects are the residual compression stresses and the locked-in stresses caused by the pre-load. The beneficial effects are the residual welding stresses and the locked-in tension stresses caused by the pre-load.

Pre-load does not affect buckling in the elastic range. However, the yield point in compression is dependent on the magnitude of the locked-in compression stresses. This is important because any yielding causes a significant reduction in buckling strength compared to the elastic section. For a given (non-slender) column geometry, the flexural stiffness about the buckling axis is the primary variable affecting the buckling strength. When a portion of the column yields, that yielded portion can be assumed to have a negligible contribution to the flexural stiffness of the cross-section. Therefore, inelastic columns are more efficient when the elastic areas are located farthest from the centroid of the reinforced section.

All steel shapes have different column curves that define the flexural buckling strength. For many shapes, the buckling curve is also dependent on the buckling axis. The differences are caused by shape factors, geometric imperfections, and material imperfections (including residual stresses). The AISC Column Curve is a lower-bound curve based on a statistical analysis of many shapes. Many of the shapes included in the analysis had residual compression stresses at the flange tips, which is the most detrimental location. For non-preloaded columns with welding residual stresses near the flange tips, the AISC Column Curve is conservative.

After reviewing the available research, I determined that when $r_r \leq 0.85r_o$, the AISC Column curve is appropriate for designing field-welded and pre-loaded columns. This applies only to doubly symmetric shapes with a controlling limit state of flexural buckling. In practice, I had used this method on several projects, even before it was presented in the 2013 webinar. Ultimately, you must use your judgment to determine what is appropriate for your situation.

Bo Dowswell, PE, PhD

Weak-axis Shear in a Wide Flange Member

I am using Equation G6-1 of the 2016 AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360), but I am not sure I am using it correctly. Even though the wide-flange member is doubly symmetric, the equation only seems to allow me to account for the shear strength of a single flange? Why can't we consider the strength of both flanges?

You have misunderstood the intent. Equation (G6-1) provides "…the nominal shear strength, V_n, for each shear resisting element…" It is not intended that you use "the strength of just one flange element" as you have interpreted the requirement. You can use both flange elements.

I believe the provision is presented the way it is because "doubly and singly symmetric shapes" could include one, two, three, or more "shear resisting elements," and each of these elements may or may not have identical dimensions (t_f, b_f).

Larry Muir, PE

G6. WEAK-AXIS SHEAR IN DOUBLY SYMMETRIC AND SINGLY SYMMETRIC SHAPES

For doubly and singly symmetric shapes loaded in the weak axis without torsion, the nominal shear strength, V_n, for each shear resisting element is:

$$V_n = 0.6F_y b_f t_f C_{v2} \qquad \text{(G6-1)}$$

where

C_{v2} = web shear buckling strength coefficient, as defined in Section G2.2 with $h/t_w = b_f/2t_f$ for I-shaped members and tees, or $h/t_w = b_f/t_f$ for channels, and $k_v = 1.2$

b_f = width of flange, in. (mm)

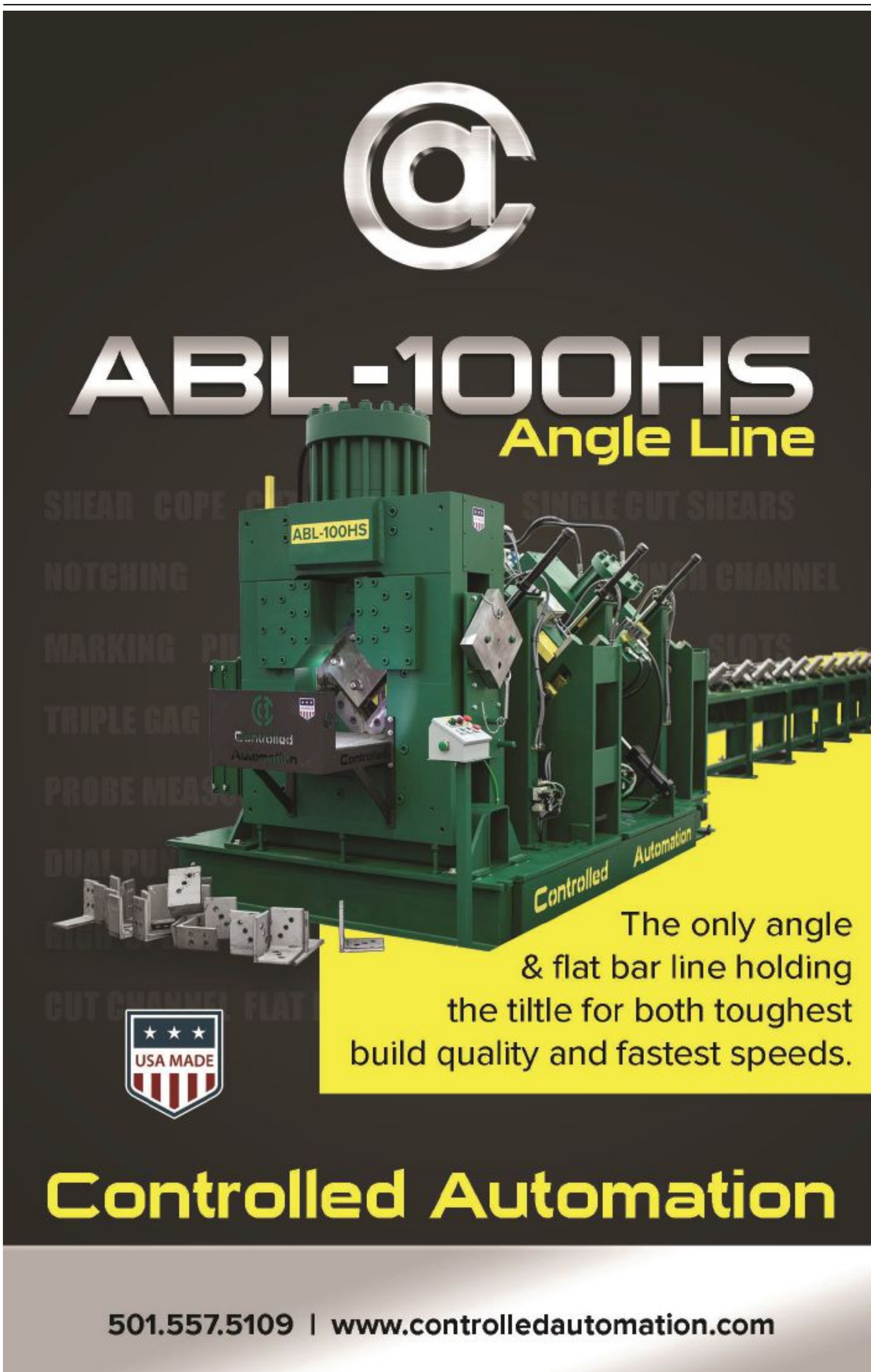
t_f = thickness of flange, in. (mm)

Bo Dowswell, principal with ARC International, LLC, and **Larry Muir** are both consultants to AISC.

AISC turned 100 in 2021, and this month's Steel Quiz takes a look at steel structures from the past century. Learn more at **aisc.org/legacy**.

1 Proving to be stronger and more weldable than its predecessor, A-7, what year was A-36 introduced?
a. 1962
b. 1966
c. 1960
d. 1964

2 What earthquake forever changed the way steel structures are designed and fabricated?
a. Loma Prieta
b. Northridge
c. El Centro
d. Napa



3 What building took the title from the Empire State Building as the world's tallest building?
a. World Trade Center
b. John Hancock Center (aka 875 North Michigan Avenue)
c. Sears Tower (now Willis Tower)
d. Salesforce Tower

4 What iconic steel structure was built for a World's Fair?
a. John Hancock Center
b. Space Needle
c. Citigroup Building
d. Sears Tower

5 Which U.S. President has their name on a bridge in Louisville? (Hint: Check the 1960s.)
a. Richard Nixon
b. Franklin Roosevelt
c. John F. Kennedy
d. Lyndon B. Johnson

6 What bridge has the 17th longest main span in the world and longest in the Americas?
a. Verrazano-Narrows Bridge
b. Rio Grande Gorge Bridge
c. Mackinac Bridge
d. Throgs Neck Bridge

7 What steel structure completed in 1969 contains striking X-shaped exterior bracing?
a. Sears Tower
b. World Trade Center
c. One Liberty Place
d. John Hancock Center

8 What issue endangered the Citigroup Center in New York? (Hint: Check the 1970s.)
a. Underestimated seismic loads
b. Miscalculated wind loads
c. Potential liquefaction
d. Faulty fabrication

9 What steel was adopted in 1999 as the new go-to material for rolled shapes?
a. ASTM A572 Grade 50
b. ASTM A500 Grade B
c. ASTM A992
d. ASTM A588

TURN TO PAGE 14 FOR THE ANSWERS


Chicago's John Hancock Center is known for its steel exterior X-bracing.

1 **c.** A-36 was introduced in 1960 at the National Engineering Conference.

2 **b.** The 1994 Northridge, Calif., earthquake spurred extensive research and work, leading to the development of the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341, **aisc.org/specifications**).

3 **a.** The World Trade Center in Manhattan used a novel system that relied on exterior walls to support the structure.

4 **b.** Seattle's Space Needle followed the theme of "The Age of Space" and was initially designed to withstand large earthquakes.

5 **c.** While still unnamed when President Kennedy was assassinated, the bridge was later named the John F. Kennedy Memorial Bridge in his honor.

6 **a.** New York's Verrazzano-Narrows Bridge's upper level opened in 1964, the lower level in 1969.

7 **d.** The John Hancock Center (now 875 North Michigan Avenue) is the fourth-tallest building in Chicago.

8 **b.** Wind loads were deemed an issue and corrected after a student raised a question to the building's chief engineer. (See the People to Know item "Delayed Reaction" in the October 2012 issue, available in the Archives section at **www.modernsteel.com**.)

9 **c.** ASTM A992 has been the preferred material specification for hot-rolled shapes since its adoption.

Everyone is welcome to submit questions and answers for the Steel Quiz. If you are interested in submitting one question or an entire quiz, contact AISC's Steel Solutions Center at 866.ASK.AISC or **solutions@aisc.org**.

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.

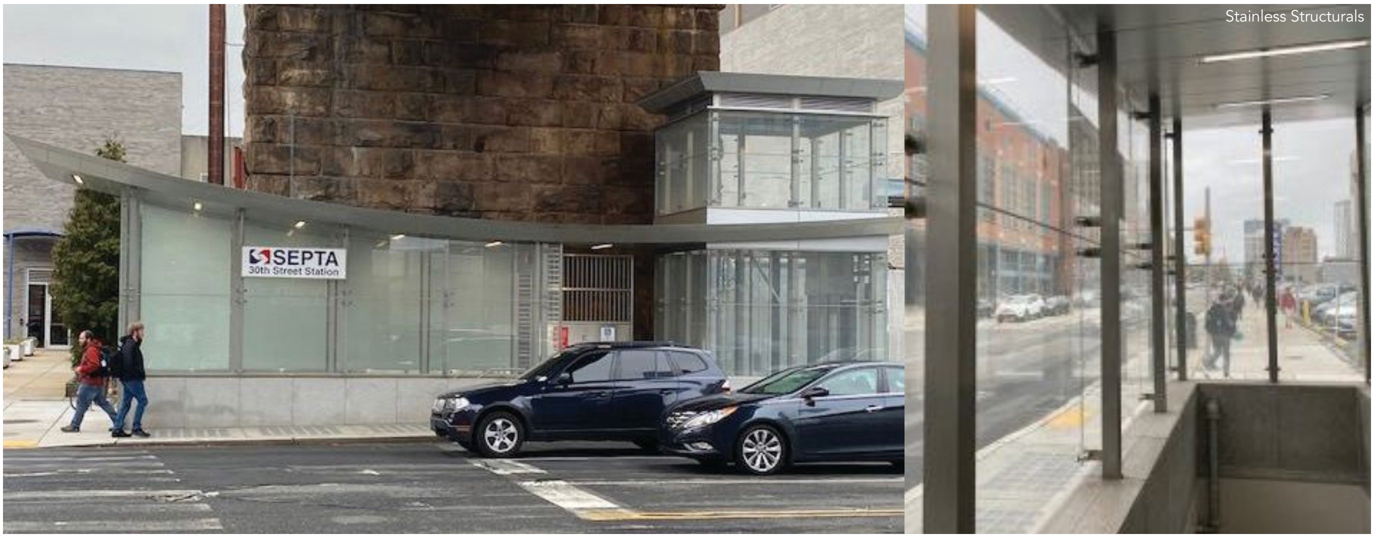
chemical, pharmaceutical, and food and beverage industries. In such applications, eliminating the need for coating maintenance or component replacement due to corrosion can result in significant long-term maintenance cost savings. Stainless steel structural components are also a popular choice for cladding 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.



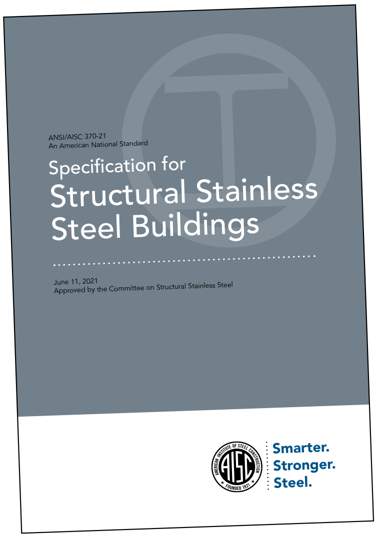
Stainless Structurals

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.

Mark Holland (**mholland@pvsteel.com**) is chief engineer at Paxton and Vierling Steel Co. and chairs the AISC 370 Committee for Structural Stainless Steel.

By the Book

INTERVIEW BY GEOFF WEISENBERGER

As one of AISC's longest-tenured employees, Cindi Duncan has wrangled countless committee members to keep publications on track and on schedule.

CINDI DUNCAN HAS SEEN a lot of changes to the steel construction industry over the years—not to mention a lot of standards.

AISC's longtime director of engineering has spent much of her nearly three decades here guiding the development of our many standards and manuals (and sometimes Design Guides and *Engineering Journal*), encouraging the process' evolution as well as being part of the evolution of the engineering profession itself.

As she nears retirement later this year, she reflects on how she got into the construction world (after taking a detour from an early pre-med path), how she's been able to bring disparate parties together on various committees to keep AISC's publications on schedule, her advice to the next generation of female engineers, and more.

Field Notes is *Modern Steel Construction*'s **podcast series**, where we interview people from all corners of the structural steel industry with interesting stories to tell. Listen in at **modernsteel.com/podcasts**.

Where are you from, and where did you grow up?

I grew up in Osceola, Iowa. I had a fairly modest upbringing in a blue-collar family, but my dad worked hard to move up to a sales position for a linen company and then eventually changed careers and owned his own business. My mom helped him and also sold real estate. Neither of my parents has a college degree. I'm the third of four children and ended up being the first in the family to get a college degree.

That's great! On that note, where did you go to school (college)?

Starting in middle school, when I took my first biology class, I wanted to be a doctor. So I started out at the University of Iowa in pre-med/liberal arts classes. After two years, I transferred to the University of Colorado-Boulder, mainly because my family moved to Colorado, and it was a good excuse to get out of Iowa. I ended up changing my direction to architectural engineering in the middle of my junior year.

What made you change your major/focus?

I'd taken a lot of liberal arts classes and really enjoyed that, but then one day I realized how expensive it was to go to medical school. My parents worked really hard for me to go to college. They always supported me even though they didn't have that same experience, and I knew they couldn't help support me through a medical school education. I really enjoyed the sciences, and my roommate's dad owned a structural engineering company in Denver, and I thought, "Oh, that sounds really interesting, designing buildings and constructing them." And I changed to architectural engineering at that point and ended up getting a bachelor of science in that field from CU. And then I went on to get a master of engineering degree (civil-structures) from Cornell University.

That's quite the change in direction! How did you get started at AISC?

After getting my bachelor's degree, I worked in Toledo, Ohio, as a project engineer at the Lathrop Company. I was working in a field trailer and joined the project when they were drilling caissons, and I remember wearing tall rubber boots and getting stuck in the mud trying to walk around to review the project. I was not excited about being in the field, nor the lack of respect I experienced due to being a female, so I went back to school after a year and a half, and that's when I got my master's degree in civil engineering/structures. And then I ended up in Chicago as my husband at the time took a job there. I actually answered a *Chicago Tribune* ad for a staff engineer position at AISC and interviewed with Dr. Geerhard Haaijer, who was the vice president of engineering and research at the time. I always say I got the job because he knew my steel professor, William McGuire, at Cornell.

How long have you been at AISC?

I started at AISC in 1985, left in 1992 to stay at home and raise my kids, and then returned in 1997 and basically picked up where I left off. Somewhere along the line, I was promoted to senior engineer and then director of engineering. I have had various roles through the years, including secretary of different task committees, from nuclear design to seismic design, and I currently serve as secretary of the Committee on Specifications, Committee on Manuals, and Committee on Structural Stainless Steel. I have also been editor of *Engineering Journal* and directly responsible for the development of AISC's Design Guides in the past.

Can you tell me one of your biggest success stories in terms of working on an AISC publication?

Most of my work has been involved in developing and preparing AISC standards and manuals for publication. There isn't any one story that stands out, but the fact that they come out on time (they're scheduled six years in advance) is a big success story every time it happens—especially since the AISC *Specification* and *Seismic Provisions*, in particular, have to be available by a specific time in order to be adopted in ASCE 7 and the *International Building Code*.

Have you witnessed some interesting or heated discussions when it comes to a committee or a particular publication?

This happens often. Our committees have a mix of industry folks, such as fabricators, producers, educators, and consulting engineers, so you can imagine the disagreements that may come up. When I first came to AISC in the mid-1980s, the big debate I recall was related to which column curve to adopt in the new *LRFD Specification*. This debate was primarily between educators, and you may be surprised how passionate they were about their related research. It is interesting what can cause a heated debate, from italicizing glossary terms in the specification to whether to remove ASD and have only the LRFD method of design. This has been the most recent debate.

I think in general, the technical debates have been less volatile in the past 15 years or so because most of the AISC standards are now ANSI-approved, meaning that the consensus bodies approving the standards have to be balanced with equal parts industry, general interest, academia, and consulting engineers, and they have to follow a very defined process, requiring 75% approval of a revision, and all negatives have to be fully vetted and responded to. If a negative is found non-persuasive and the voter doesn't wish to remove the objection, the negative comment/responses have to be circulated and the pertinent revision recirculated, allowing the full committee to vote again.

I'm glad the volatility has lessened. Back to your history at AISC, I understand that you were the first female engineer hired here. Can you talk a bit about that experience?

For the first seven years of my tenure at AISC, I am fairly sure I was the only female at the committee meetings. It is something I got used to and was already used to since most of my classmates were men. I have to admit there were occasional sexist or chauvinistic remarks from my male colleagues at AISC, as well as the committee members. I doubt that most of them were meant to be malicious, but I have never forgotten most of the comments. They stick with you.

I can imagine. Have things changed much in terms of women joining and being more accepted in engineering and construction in general?

After I returned to AISC in 1997, there seemed to be a change in direction and possibly a change in upper management so that finally, more women engineers were hired. At one point in the last ten years or so, I believe we have had more women engineers than men at AISC. It is good that AISC is now hiring women engineers regularly now—but I think the percentage of women going into civil engineering in general compared to men has stayed about the same since the mid-1980s for various reasons.

What advice do you have for young women looking to get into engineering or construction in general?

I suggest getting as much education in your field as you can, including a master's degree, then getting licensed as soon as you are eligible. I made the mistake of letting life get in the way and put off my registration, which made it very difficult to pass the licensure exams, especially since I have spent minimal time in my career doing design.

You're planning to retire later this year. What are you looking most forward to when it comes to retirement?

My time will be my own, *all* of the time! I can sit down and play the piano whenever I like and spend all day learning a new piece if I wish. I can help my aging parents out or spend the day with my grandson. I would also like to make more quilts. I made my first quilt for my grandson when he was born. And I'd like to help my mother write her memoirs and publish them. I have an interest in writing a book, too, just not sure what topic yet! ■

This column was excerpted from my conversation with Cindi. To hear more about her, including her musical skills, her thoughts on green and red chile, and her favorite things about Chicago and Santa Fe (she splits time between the two and will be spending a lot more time in one of them after she retires), check out the January Field Notes podcast at ***modernsteel.com/podcasts****.*

Geoff Weisenberger (**weisenberger@aisc.org**) is senior editor of *Modern Steel Construction*.

Looking Ahead

A group of construction professionals ponders the future of the industry and what can be done to ensure it's a bright one.

IT'S NEVER TOO EARLY to think about the future—and an unjaded perspective can help expand the range of possibilities.

That's the mindset of a new panel of young design and construction professionals. Initiated by AISC member fabricator Canam Group, the Future Leaders Program (FLP) gathers young leaders (under the age of 40) from various branches of the architecture, engineering, and construction (AEC) industry for open discussions about the state of the industry and where it is headed.

"The goal is to empower young leaders that are not yet fatally infected with the 'I-do-not-trust-you' bug to describe a desirable future state for the construction industry," summarized Marc Dutil, president and CEO of Canam Group, who helped launch the program.

Over the last two years, the group's participants have worked to identify the most challenging and frustrating issues in the construction process—many of which can be traced back to the early stages of projects—and have narrowed in specifically on challenges that can create resistance to change throughout the process. These include issues such as mistrust between team members, lack of transparency between owners and stakeholders, and short-term thinking. The group wholeheartedly believes these are solvable challenges and that now is the time for open dialogue, interdisciplinary trust, and collaboration, and the goal is to shift the collective mindset of the AEC industry to improve relationships and create better outcomes for clients and project teams.

A recent panel discussion facilitated by the FLP leaders featured four highly successful professionals representing various construction disciplines, with many years of industry experience and varied project types between them:

- Scott Erdy, Lead Design Principal, Erdy McHenry Architects
- Janis Vacca, Principal, The Harman Group
- Daniel Tessier, Vice President, AECOM Tishman
- Robert Frodyma, Vice President of Design and Construction, Canadian Tire Real Estate Limited

Together, they answered some key questions about where the industry is headed and how to drive positive change. The following feedback was summarized by members of the FLP team.

Should owners ask for more collaboration between designers and contractors (generals and subs) during design?

The panel was unanimous that owners should ask for more collaboration.

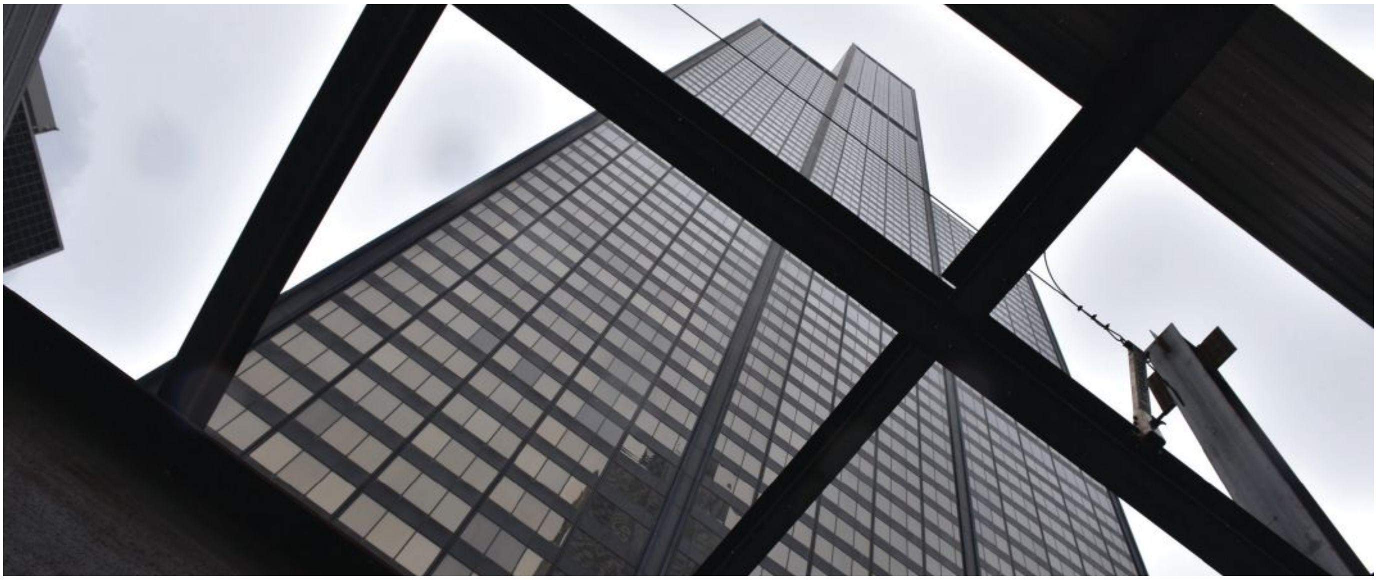
Frodyma said, "Yes, it's important and if you are not doing it, you should because you'll save time, you'll weed out mistakes in design and make your building more efficient, cost-effective, etc."

Collaboration early on is important, ideally with consultants, contractors, and client involvement, because trusting the team is the key, noted Vacca. "You can build that trust working together with the same purpose: doing what's best for the project and understanding the actual project priorities. When everyone works together from the start, communicates and listens to each other, you can understand their diverse perspectives."

According to Erdy, ''It's really about trust and how much you trust the team; that's the fundamental road to success."

Tessier also added that there is a problem in the construction industry: a lack of collaboration and communication. To improve collaboration, he stressed, the project team needs to create open lines of communication and make sure that everyone can bring their best ideas forward.

Do you think the emergence of new tools and technology—e.g., BIM, 4D scheduling (combining a traditional construction schedule with a 3D model), and modular construction—is enough to help the industry keep up with the fast pace of today's construction? What does the construction industry need to change to ensure quality and efficiency are maintained?




Scott Erdy


Janis Vacca

Again, there was unanimous agreement amongst the panel that technology will increase speed and agility to deliver construction projects more efficiently. Vacca pointed out, "Let's be honest, the number one stressor for everyone is money. Technology can impact the speed of delivery which ultimately correlates to financial savings."

Erdy suggested that the best option is where there is a collaborative relationship where models are shared in real time. However, the industry is very diverse in the technology used by different-sized companies as well as different trades. "Our schools need to do a better job in teaching the new generation the technology and tools that will provide a common language in the industry," he noted.

Tessier added, "From a field office perspective, our most critical tool has always been the paper version of the drawings, and in the last five years this critical tool has turned into the iPad. Technology, used the right way, can fast-track a building. The one thing we need to make sure is that all parties involved are on the same page as to how to use the programs, and that includes having access to adequate training."

The consensus amongst the panel was that capacity for change and elasticity of the mind is an individual phenomenon. As such, change starts with oneself, and we should learn these competencies as early as possible. They're applicable both in the professional realm and in personal lives. Students should also be trained and educated on soft skills in schools, with communication and people skills being a top priority. We should be pushing to integrate more of this training into our education programs. There is also the issue of fear: fear of not knowing and fear of asking questions. We need to cultivate a climate where people feel comfortable and safe in asking questions, in asking for help, and in looking to the younger generation to help answer technological questions.

What would be the best advice to an owner before selecting the project team and the type of contract/bidding for construction?

Tessier's advice was to be sure to select engineers, architects, and contractors who are good team players. "They should be able to collaborate respectfully and proactively with each other," he explained. "If possible, they would have collaborated previously together. There should be an open line of communication between these three and also with the client."

Vacca believes it's also best to bring key subcontractors on board earlier with the design team. Erdy recommends knowing the reputation of the people you will work with. Finally, Marc recommends that clients should pay their professionals well. "Contractors are not 'out to get' clients," he noted. "It's not just about the money; their pride is in a job well done." Overall, the lowest-bidder approach was not recommended as the end all, be all option.

How do you see your role in construction projects evolving over the next few years?

The panelists predicted that technology will continue to improve, changing the design process and allowing all stakeholders to understand projects more clearly. Erdy pointed out that we can use current technology to help everyone (from the client to the construction team) visualize the final product, and find potential conflicts before projects are physically constructed. However, technology has also allowed stakeholders to dehumanize aspects of construction, and the decades-long trend of society deemphasizing the importance of tradespeople has affected the quality of the trades today.

Tessier noted that construction was one of very few industries that didn't stop throughout the COVID pandemic because it is a critical service. Alongside technological advancements, he would like to see a change in the secondary school education system so that the trades are encouraged as a valued career, which contradicts his experience where kids were pushed into the trades when they were not considered "good enough" to do anything else.

What innovations in technology do you believe will impact your day-to-day work the most? What will this change offer the other project stakeholders?

The panelists highlighted cutting-edge technological advances, support for the skilled trades, and a cautious approach to adopting new technology. From Erdy's perspective, artificial intelligence (AI) will have a major impact on the industry. He pointed out that we already use AI tech saying, "At the most basic level, think of all the auto-correct your phone does, or jump into a fighter plane and start flying a jet that's auto-correcting to what it thinks you want. That's Revit in a nutshell."

While the potential impact of AI may be huge, both Erdy and Tessier think it's best to resist the urge to dive head-first into new technologies. Erdy cautioned, "I think that while our tools try to help us more, we must remain masters of our tools." Tessier added, "Technology has to be used correctly. I think that's the key point. If we're not using it correctly, whatever the program is, it's a waste of time or somebody could get hurt, whether hurt physically or financially."

The FLP is an ever-evolving organization of like-minded AEC industry professionals that are eager to engage in an impactful dialog and create a roadmap and strategy for disseminating ideas and future-oriented practices. Over the coming year, the group will continue its thought leadership approach, including industry talks, internal dialog, and public dissemination of forward-thinking ideas. Please join us in shaping the next generation of talent and moving the industry towards more open models of communication and collaboration. If our mission resonates with you, reach out via the LinkedIn page for "Future Leaders AEC" (**linkedin.com/groups/12478835**) to stay informed and discover ways to get involved. ■

Daniel Tessier


Robert Frodyma

Early to Rise

BY JIM FOREMAN AND WADE LEWIS

WORKING CLOSELY WITH A STEEL FABRICATOR is the best way to ensure your steel details are efficient and economical.

And the more complex a project, the greater the benefit.

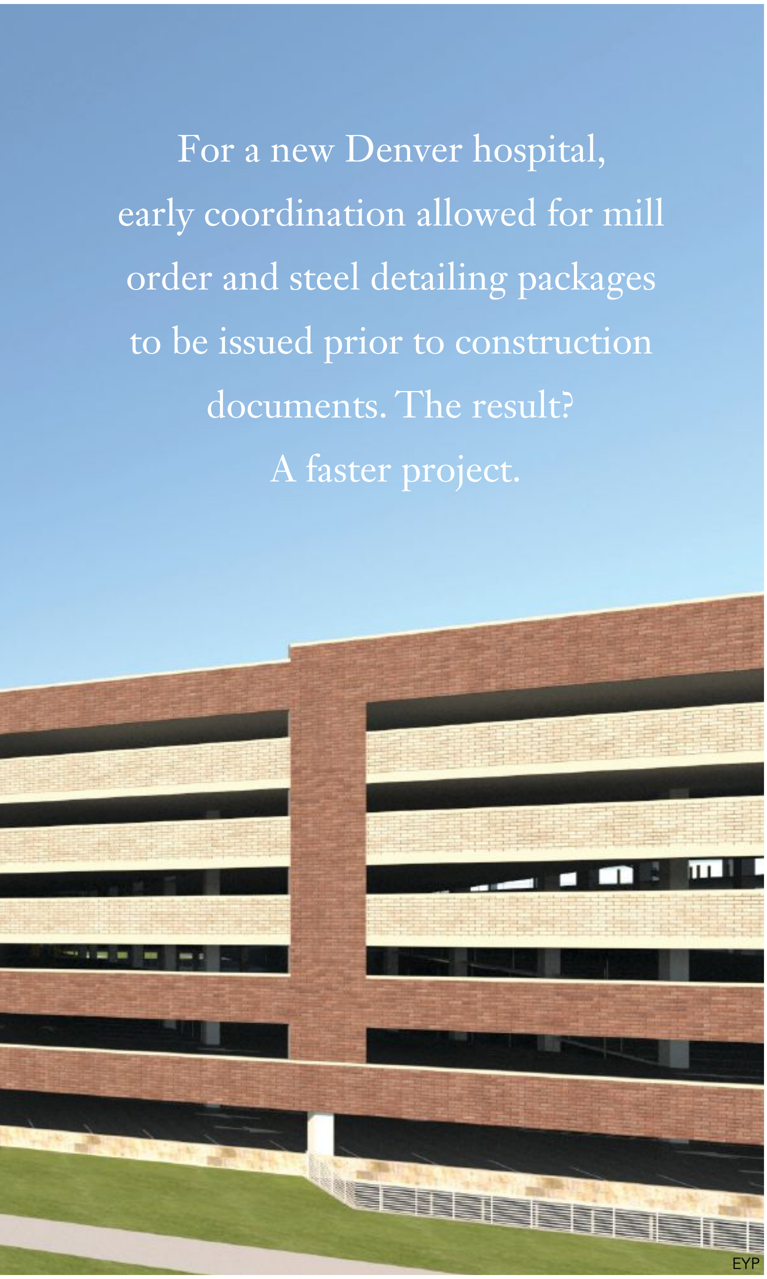
Tower 3, a 13-story addition to an existing inpatient pavilion at UCHealth University of Colorado Hospital on the Anschutz Medical Campus in Aurora, Colo., is one such complex project. Built to meet a growing demand for medical care, this new addition presented a variety of design challenges and goals. One of them—for the entire project team—was producing a structural design that facilitated an aggressive construction schedule. To accomplish this, the general contractor and steel trade partners were included early in the design process. Steel systems and details were designed specifically for the fabricator and erector's preferences and resulted in an efficient design that could be built on schedule. Steel for the project topped out in October 2021, and the new addition is expected to open this year.

Early Engagement

The new tower, including mechanical penthouses, is 205 ft tall, and the structural system comprises steel columns, composite steel floor framing, and drilled pier foundations, with a concrete lateral system. A key feature of the building is its open ambulance bay on the north side, where a large, open space was critical to allow ambulance drivers direct access in and out of the drop-off zone. To accommodate this feature, two-story steel trusses were designed to keep a 160-ft by 130-ft area of the building free of interior columns at the lowest level and also support the 11 steel-framed floors above the ambulance bay.

Haselden Construction, the general contractor, was engaged at the start of the project to assist the design team, allowing for various structural systems and details to be studied, priced, and scheduled to determine the best approach for constructability and schedule. Steel fabricator Puma Steel, also brought on board early, was involved in the steel design and detailing process and helped

For a new Denver hospital, early coordination allowed for mill order and steel detailing packages to be issued prior to construction documents. The result? A faster project.



EYP

Steel for Tower 3 of the UCHealth University of Colorado Hospital on the Anschutz Medical Campus in Aurora, Colo., topped out this past October, and the addition is expected to open this year. Bringing fabricator and detailer Puma Steel on board early in the project helped optimize connection design and keep things on schedule.

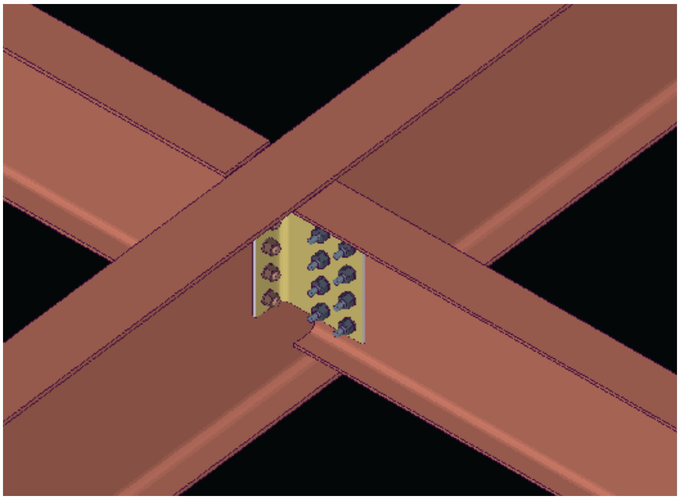
with connection type selection. For the most typical and complicated connections, the two companies assisted the design team with selecting connections that balanced material cost and labor with schedule.

To assist with the schedule, the design team issued several steel mill order and detailing packages before final structural design was complete. Mill order package and mill rolling schedules were coordinated for optimal efficiency, and the detailing package deadlines were coordinated with fabrication and erection schedules.

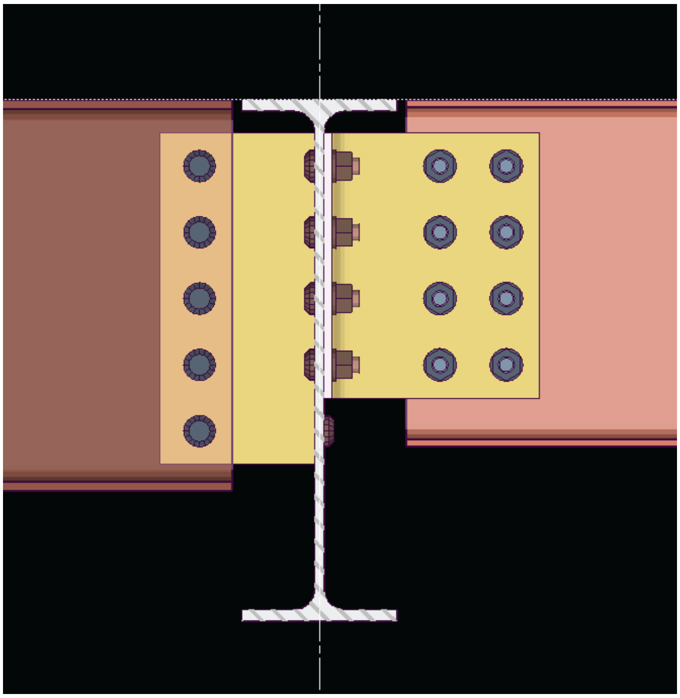
High-Strength Steel

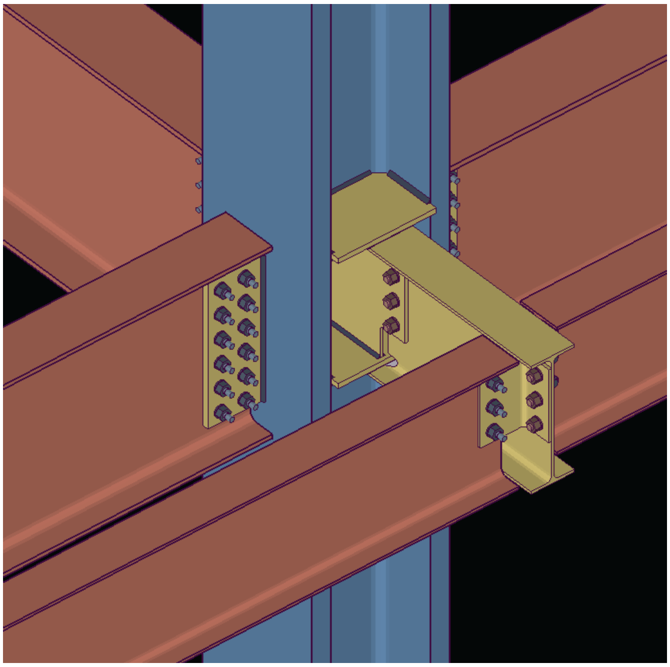
Grade 65 (A913) steel sections were chosen for the tower project. When comparing preliminary designs between 50-ksi members and 65-ksi

EYP

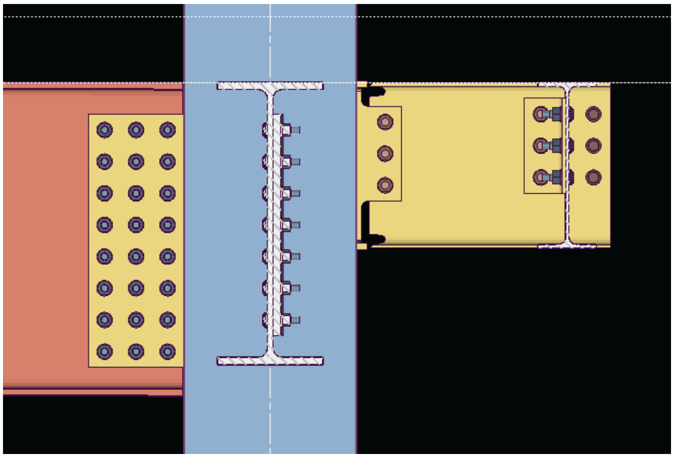


above and below: 3D model views of an extended bent connection.





above and below: 3D models of a cantilevered connection. In some cases, the cantilevered beam length was short enough to shop-weld the member to the column. For this detail, columns were oriented parallel to framing, and beam flanges were welded to column flanges.



members, high-strength steel offered an average material savings of 12%; compared to the approximate cost premium of 5% at the time, using high-strength steel was particularly beneficial to the project budget. Because high-strength steel was only available for heavier sections, typical beams and girders were designed as 50 ksi, while columns and truss members were designed as 65 ksi. The heaviest sections had to be specially ordered, including several W14×730s, and steel plates were designed as 50 ksi for the entire project.

Another advantage of using 65-ksi steel, especially when it came to the columns, was that it simplified shop welding. No preheating was required for welding many of the connection plates, thus significantly reducing labor hours (and the related costs) per ton.

Preliminary designs for steel-braced frame systems and concrete shear walls were developed and compared early in the design. Concrete shear walls were selected, but a hybrid option was implemented on the north side of the building to improve the construction schedule. For these "hybrid shear walls," steel columns were integrated into the concrete walls and were designed to carry temporary construction loads equivalent to six levels of steel and two concrete composite floors. Once the floor above was placed, the shear walls were infilled between the columns with shotcrete. Typically, concrete shear walls set the critical path for erection as the contractor waits for the concrete to gain strength before advancing erection to the level above, but the hybrid approach enabled steel erector LPR Construction to go full speed while the shotcrete installer trailed a few levels behind. The shear walls were designed to carry lateral loads and 100% of the tributary floor loads.

Steel Detailing

With Puma on board early, the design team coordinated every steel connection. For typical beam-to-girder and girder-to-column connections, the focus was on speed of erection and how the connections could be designed to make erection go as efficiently as possible. To minimize field welds, bolted connections were used when possible, and extended shear connections were used in lieu of coped beam flanges to simplify erection. More than 100,000 thousand structural bolts were used in all.

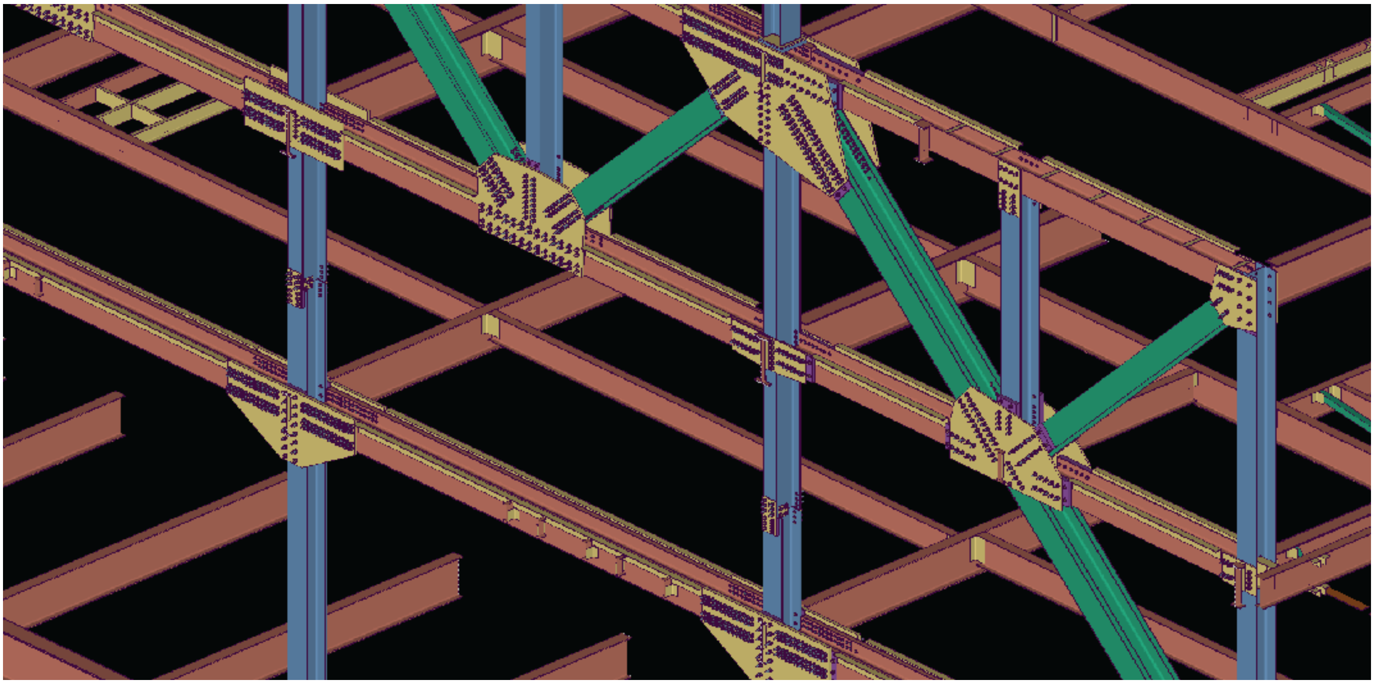
To achieve the architectural design, the exterior building columns were inset from the perimeter of the building, resulting in a typical condition of cantilevered floor framing around the perimeter of the floor plans. Again, the design team collaborated with Puma to design connections that would maximize erection efficiency. While interrupting every column for a continuous cantilevered floor beam is simple to detail and design, it increases the piece count for the erector and slows construction. Instead, columns were kept continuous, and bolted moment connections were used to support floor framing.

In some cases, the cantilevered beam length was short enough to shop-weld the member to the column. For this detail, columns were oriented parallel to framing, and beam flanges were welded to column flanges. To avoid continuity plates, columns were sized so that flange thickness was adequate for local cantilever forces.

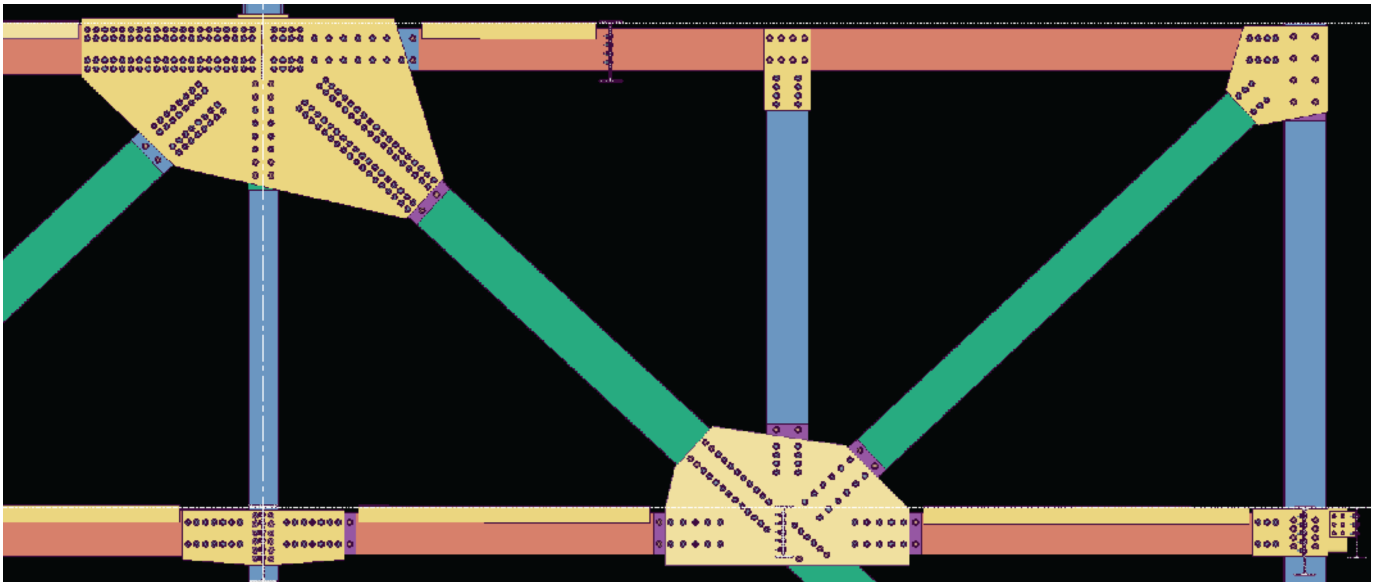
Trusses

The lowest level on the north side of the building footprint is the ambulance bay, which is open to the street. To keep this area unobstructed for easy ambulance driver access, again, the structure was designed without interior columns at the lowest level, and two-story trusses span the width of the building to the exterior columns.

Several truss configurations were considered during preliminary design. Early input from Haselden and Puma allowed the design team to better consider material cost and constructability during truss design. With a 120-ft span supporting 11 stories, truss stiffness was a key design criterion. Various configurations were considered, including one- and two-story options, and the final two-story configuration balances an efficient structural design with minimal disruption to the architectural floor plan. The trusses gained significant stiffness because the end diagonals were continuous for two stories



Truss connection design was highly collaborative, and the engineering and fabrication/erection teams spent many hours, over several meetings, brainstorming connection types and weighing the pros and cons of each.



With a 120-ft span supporting 11 stories, truss stiffness was a key design criterion. Various configurations were considered, including one- and two-story options, and the final two-story configuration balances an efficient structural design with minimal disruption to the architectural floor plan.

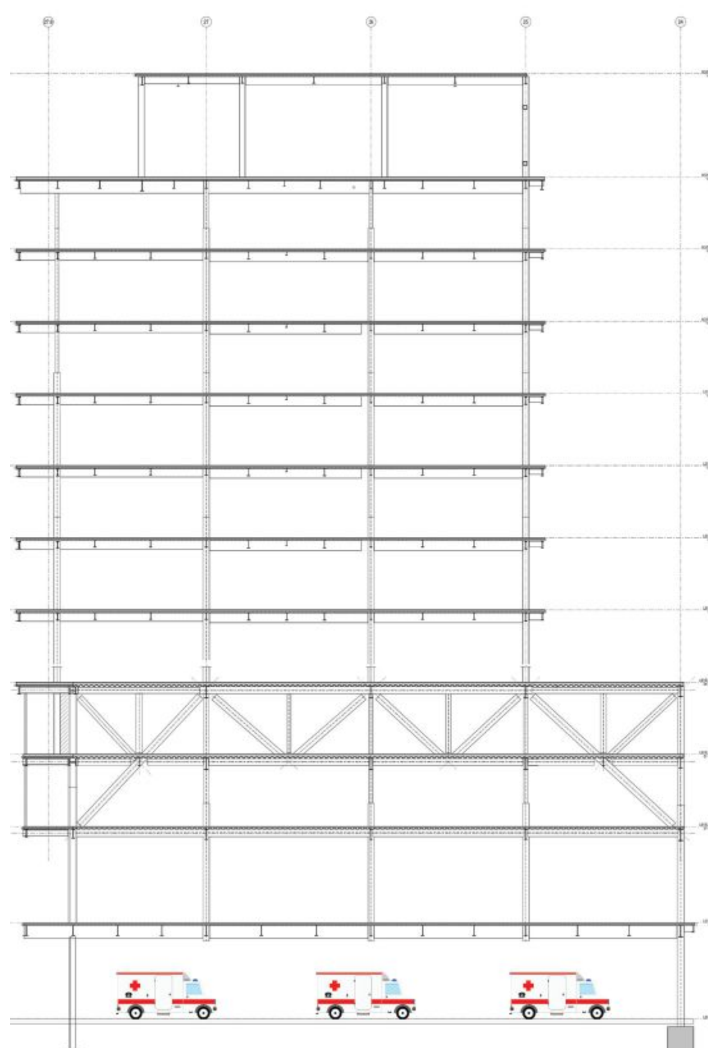
to exterior columns, but by confining the interior diagonals to a single story, the open floor space below was maximized.

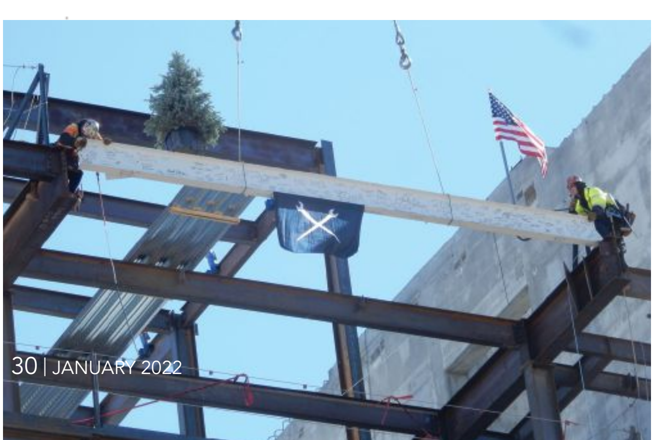
To erect the trusses, temporary columns and foundations were designed to support framing for the lower floors before each truss was completed. After truss placement, the column sections from Level 1 to Level 2 were removed and the foundations were abandoned.

Truss connection design was highly collaborative, and the engineering team and the fabrication/erection team spent many hours, over several meetings, brainstorming connection types and weighing the pros and cons of each. Ultimately, the two most favorable connection types were double-WT diagonals bolted to gussets aligned with the chord webs and wide-flange diagonals and chords rotated to web-horizontal with sandwich gusset plates. This second type was chosen because the wide-flange members were more efficient diagonal sections, considering the large axial forces in the trusses. Bolted connections using 1⅛-in.-diameter F2280-A490 slip-critical bolts were selected to avoid field welds.

right: A cross section of the tower. A large, open space was necessary to allow ambulance drivers direct access in and out of the drop-off zone.

below: Topping out!





The truss connections were shop-fabricated as much as possible, and Puma coordinated closely with LPR to understand the maximum assembly weights that could safely be lifted. While this tactic resulted in some heavy, challenging lifts (up to 27.5 tons), it was a benefit to the overall construction schedule thanks to fewer lifts being required.

Thanks to the collaborative effort of the design and steel teams, a total of 4,637 tons of steel (451 tons of which was Grade 65) was successfully designed, fabricated, and erected on schedule to meet the increased medical services demand of this growing metropolitan area. ■

Owner
UCHealth, Denver

General Contractor
Haselden Construction,
Centennial, Colo.

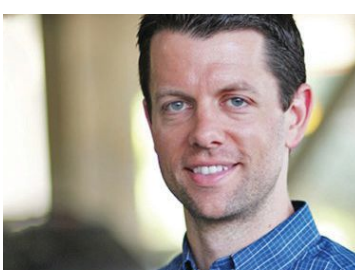
Architects
EYP, Denver
Pact Studios, Denver

Structural Engineer
Martin/Martin, Inc., Lakewood, Colo.

Steel Team

Fabricator and Detailer
Puma Steel (AISC Certified Fabricator), Cheyenne, Wyo.

Erector
LPR Construction (AISC Associate), Loveland, Colo.



Jim Foreman
(**jforeman@martinmartin.com**)
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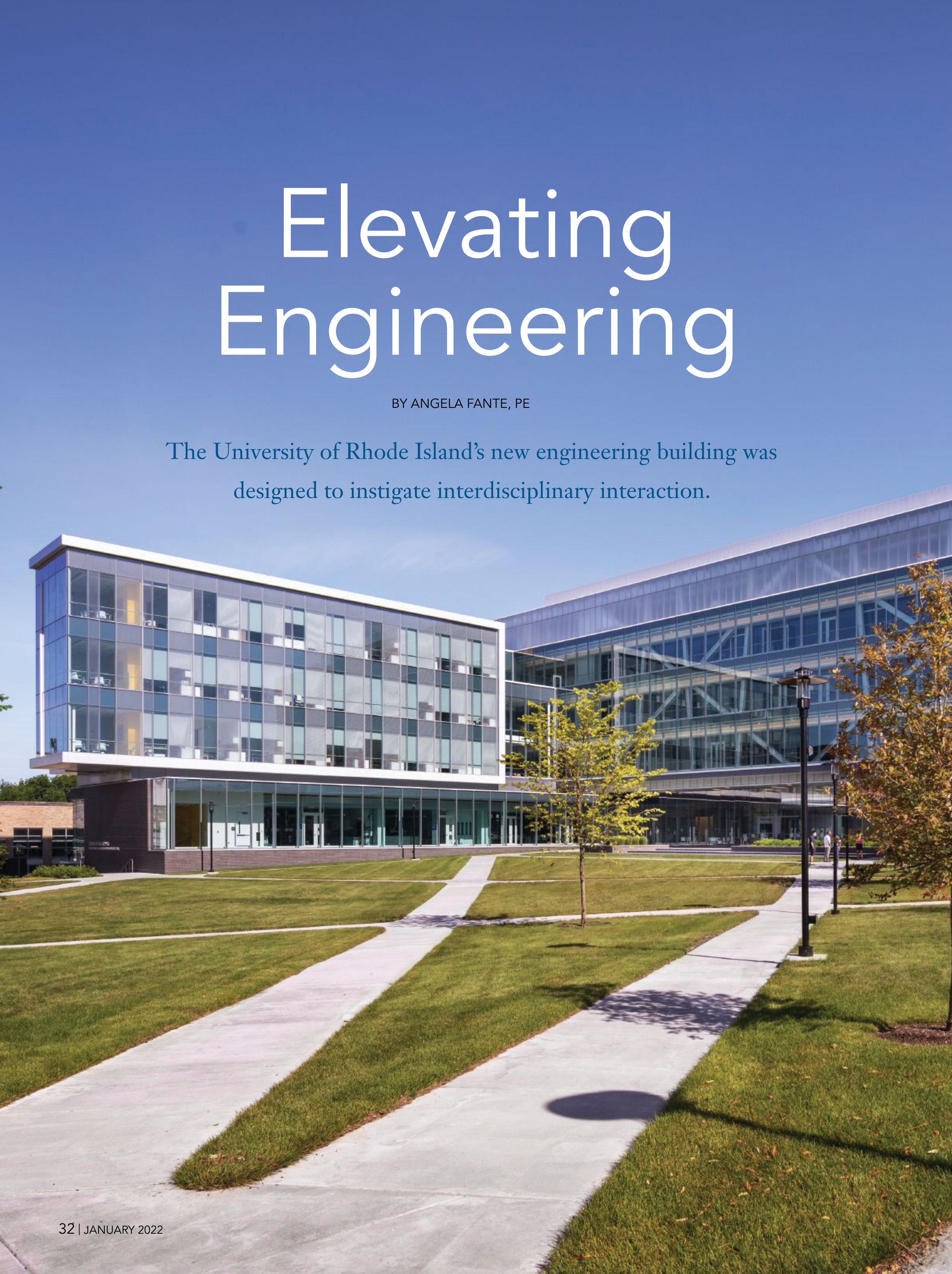
Martin/Martin, and **Wade Lewis**
(**wade.lewis@pumasteel.com**)
is the vice president of Puma Steel.



Elevating Engineering

BY ANGELA FANTE, PE

The University of Rhode Island's new engineering building was designed to instigate interdisciplinary interaction.

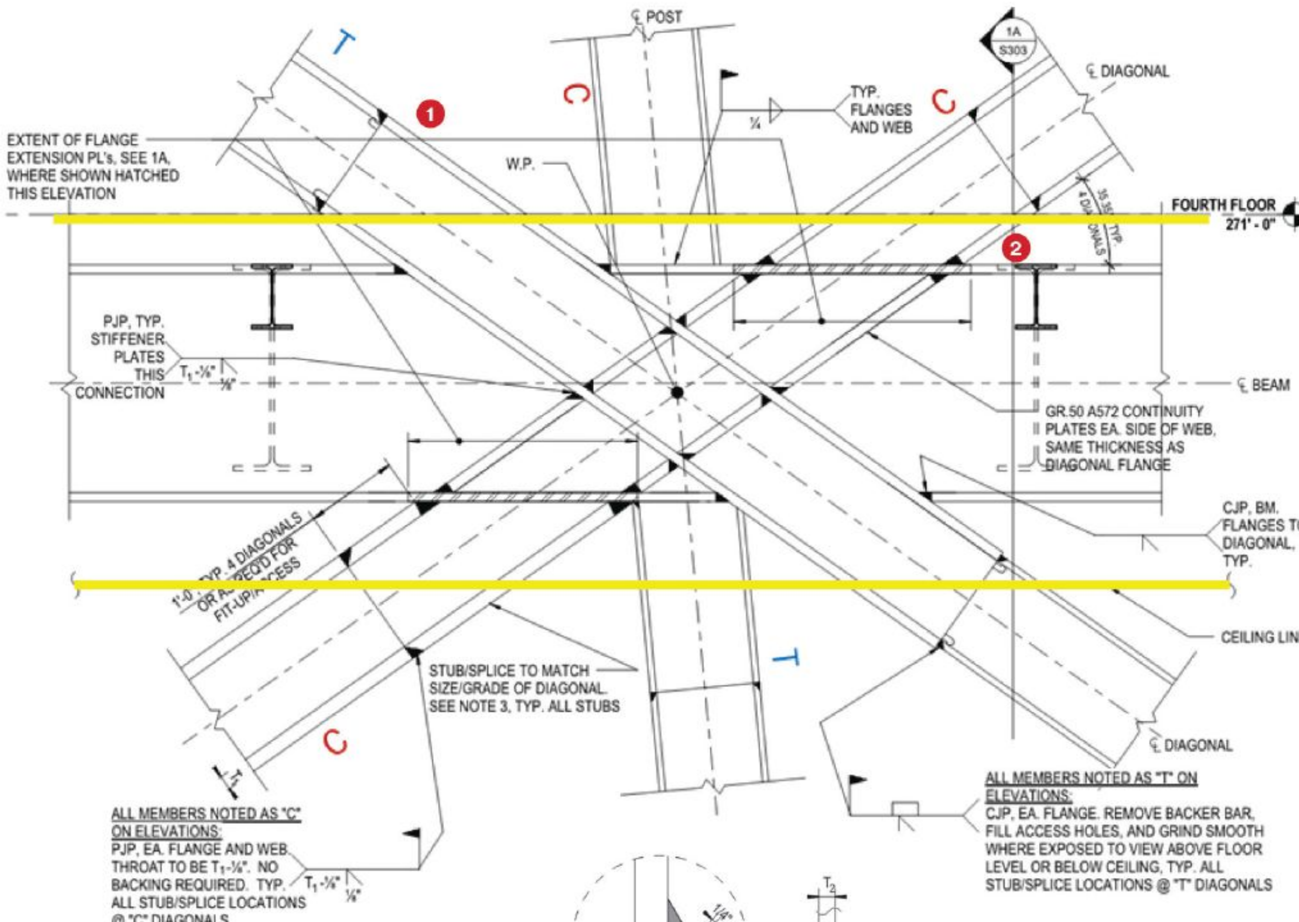
James Ewing

ENGINEERING IS ROOTED IN PRACTICALITY AND PRINCIPLES, but its promise is transformational and inspiring.

This was the mindset of University of Rhode Island's College of Engineering Dean Raymond Wright when it came to the school's new Fascitelli Center for Advanced Engineering. The project represents Wright's ambitious mission to create a "transformational building that fosters a vibrant and innovative environment by attracting the best faculty, students, and industry partners."

Constructed on the former site of five demolished engineering buildings on the university's main South Kingstown campus, the new engineering building serves as a "bridge" between the liberal arts programs at campus south and the basic sciences at campus north. The design goal of the project was for the building—specifically, its first-floor commons space—to transform the College of Engineering into a hub of activity, encouraging not only interaction between the engineering disciplines housed within its walls but also chance encounters between students and faculty in the sciences, humanities, and engineering programs. As such, a large, transparent, uninterrupted column-free commons space was designed to invite students of all disciplines to enter, linger, converse, and discover cross-disciplinary synergies.

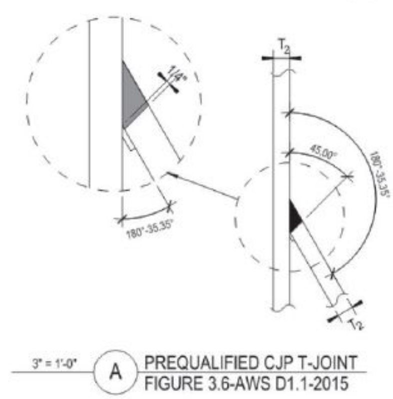
To meet the university's design, budget, and schedule requirements, steel was the only viable option for the framing system (which uses approximately 2,200 tons of structural steel). A reinforced concrete building—post-tensioned or otherwise—would not have been economically viable for framing the long-span laboratory spaces while still meeting laboratory floor vibration criteria, and the tension members in the trusses would have been excessively large visually if formed of rebar and concrete (in fact, even if a concrete solution had been implemented, structural steel probably would have been used as the truss reinforcement in lieu of rebar due to the high loading to be resisted). In addition, a concrete frame would have increased the size of the foundations. Timber and other materials such as cold-formed metal framing and precast concrete would not have been capable of resisting the high loads in the trusses without substantial increases in cross-sectional areas, defeating the architectural intent and structural expression.



Ballinger

1 Tension member continuous through joint, CJP weld adjacent lengths together as required for load.

2 Maintain load path for compression members, PJP welds adequate for bearing.



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above and left: A node connection detail and an actual node.

below: The project incorporates approximately 2,200 tons of structural steel.

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13	Tee Stem Up	MEAN DIA.	22" x $142\frac{1}{2}$# Tee
14	Angle Heel In	INSIDE DIA.	8" x 8" x 1" Angle
15	Angle Heel Out	OUTSIDE DIA.	8" x 8" x 1" Angle
16	Angle Heel Up	MEAN DIA.	8" x 8"x1" Angle
17	Square Tube	INSIDE DIA.	24" x $\frac{1}{2}$" Tube
18	Rectangular Tube The Easy Way (Y-Y Axis)	INSIDE DIA.	20" x 12" x $\frac{5}{8}$" Tube
19	Rectangular Tube The Hard Way (X-X Axis)	INSIDE DIA.	20" x 12" x $\frac{5}{8}$" Tube
20	Square Tube Diagonally	MEAN DIA.	12" x $\frac{5}{8}$" Square Tube
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Transformational Trusses

To create a literal bridge and provide an architectural expression of the engineering programs housed within it, the central "bar" of the building is supported by three 260-ft-long by 55-ft-tall (four-story) exposed structural steel trusses, each with 160-ft center spans plus cantilevers at each end. This layout allows for a column-free commons area and unobstructed pass-through from campus south to north. The highly visible trusses are spaced 41 ft on center, with 8-ft cantilevered corridors on both exterior walls; they support four stories of laboratory program and mechanical penthouse.

Doubling as a teaching application of "engineering in sight," the major truss members are comprised of W14 diagonals and W36 top and bottom chords, which also serve as floor girders. Unfactored diagonal loads range from 2,200 kips in tension in the most highly loaded diagonals, 1,600 kips in the compression diagonals, and 900 kips to 1,500 kips in tension and compression in the top and bottom chords.

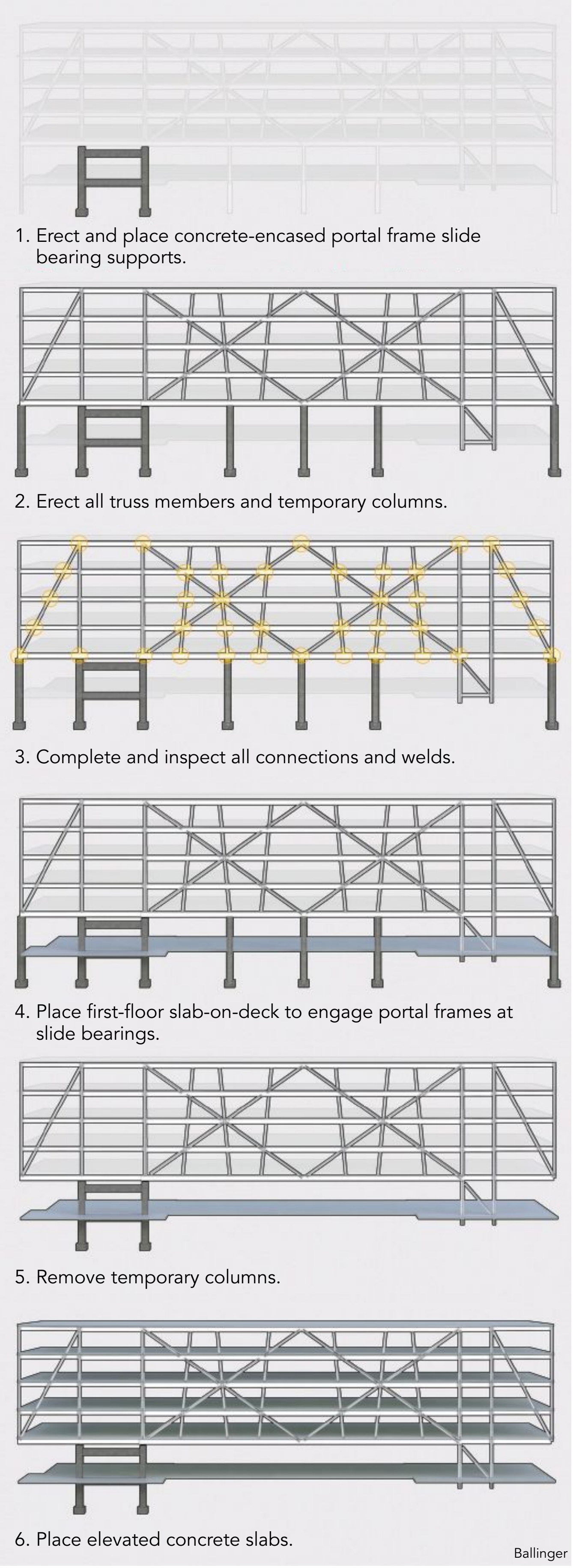
From the outset, the design team was challenged with a prevailing owner and construction manager mindset that the project could not be economically delivered if the trusses remained an element of the design. Repeated requests for the addition of commons level columns were made as part of the value engineering effort, and the design team was tasked with proving the viability of the bold design—and proving that it could be constructed within budget and schedule—if the project was to proceed into the design development phase.

Specific Sequence

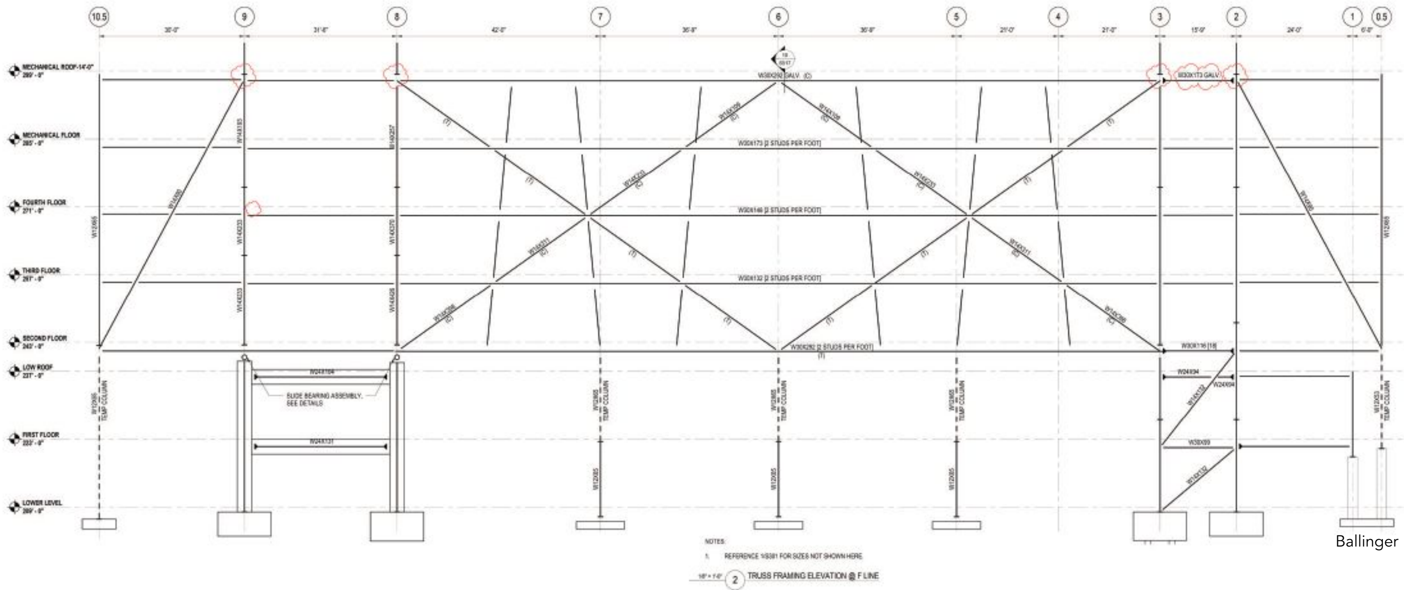
As the construction schedule was a top priority, Ballinger, the project's architect and structural engineer of record, met with Berlin Steel, the project's steel fabricator and erector, immediately after Berlin was awarded the project. The two companies reviewed the sequence of erection, detailing schedule, approval of submittals, and unique challenges associated with this level of exposed-to-view structural steel. For the trusses to be built within budget, the construction documents were developed with this sequence defined as its basis of design. Because the 260-ft by 55-ft truss dimensions far exceeded transportation limits, Ballinger provided the sequence of erection on the contract documents and worked closely with Berlin to determine member splice points, with the goal of maximizing shop fabrication and ensuring proper field fit-up.

The gravity load members in the 41-ft span laboratory loft spaces were designed to mitigate the effects of floor vibration on sensitive lab equipment. To accommodate thermal expansion and contraction, the west ends of the trusses bear on six ConServ disc bearings that were customized for the specific design load at each location. The slide bearing assemblies range from 24 in. to 40 in. square and 8 in. to 12 in. high. Because the site's grade varies by one full story from the west to east ends of the truss, a concrete-encased steel portal frame supports the slide bearing assemblies, designed to resist the lateral force imparted by the slide bearing assembly prior to it slipping into service at the design load. The governing load case was the force caused by the elongation of the trusses due to thermal expansion, as the trusses were erected in the winter, and the building not being thermally enclosed until after the following summer.

Ballinger also produced truss deflection diagrams as part of the contract documents for the use of exterior wall manufacturer and mechanical, electrical, and plumbing subcontractors in understanding the tolerances and movements that their respective

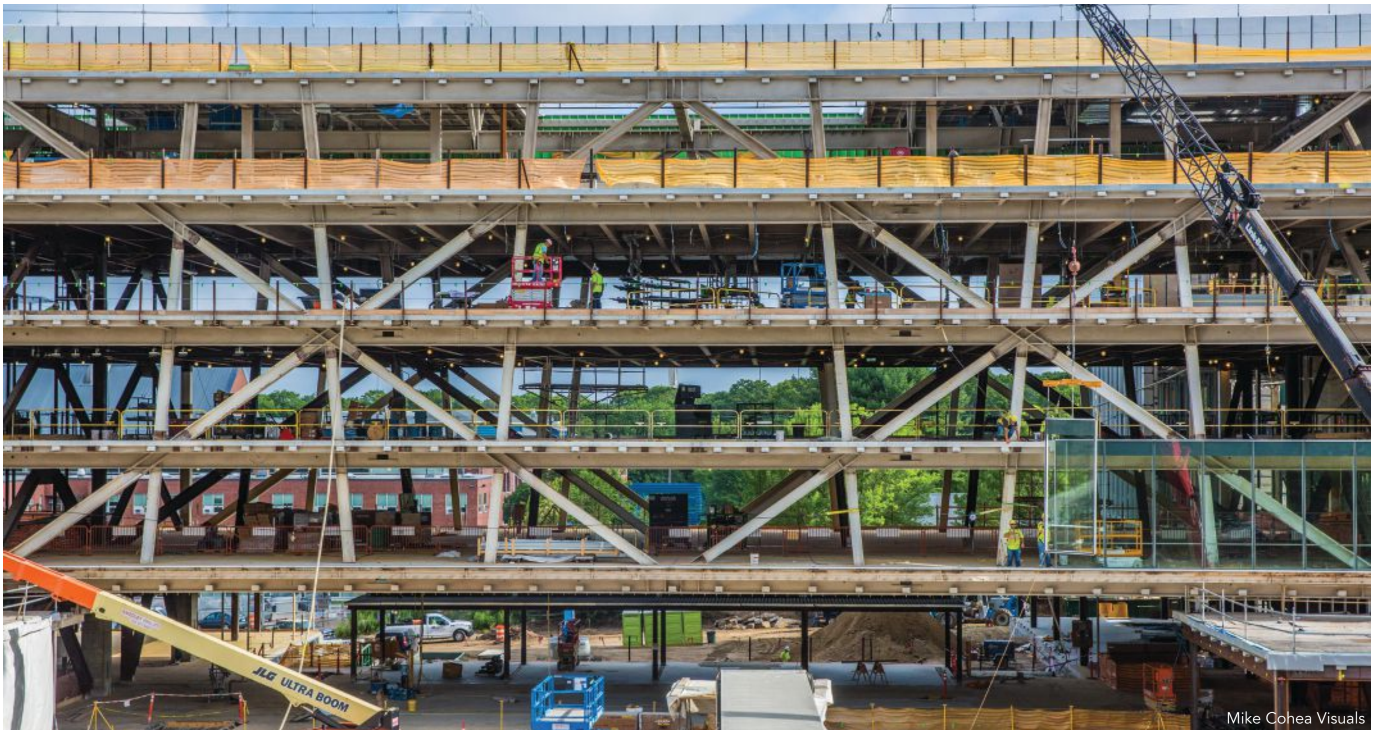


The erection sequence.



Ballinger

above and below: The highly visible trusses are spaced 41 ft on center, with 8-ft cantilevered corridors on both exterior walls.



Mike Cohea Visuals

systems would need to accommodate. The movements described on these drawings were the basis for the exterior wall mock-up testing to ensure that the exterior wall jointing, mullions, and glass could withstand the unique motion of this sliding long-span structure supporting the façade.

As proper implementation of the exposed truss connections was critical to the aesthetic, Ballinger designed and documented each custom connection intersection as the truss diagonals passed through the floor levels and did not delegate connection design to the fabricator's engineer. Bolted connections with large gusset plates were out of the question, as each connection point would be visible through the glass façade. Especially at night, large gussets would create oversized shadow spots when illuminated from within, detracting from the visual intent of continuous, uninterrupted members supporting the glass frame.

Snowflake Stubs

To provide an economical yet fully welded design, the horizontal truss members and floor girders were shop fabricated with "snowflake" stubs at all connection points where a truss diagonal intersected with the floor members. This method maximized shop fabrication and welding and increased the quality control of these critical welded connections, with the third-party inspector being present in the fabrication shop for all complete-joint-penetration (CJP) and partial-joint-penetration (PJP) truss connection welds. Because cost was a major concern for this state-owned project, rather than simply specifying a CJP weld at all connections, each member and weld was sized to support only the load required. Wherever possible, PJP welds were specified to eliminate the requirement for weld access holes requiring infill.

above and below: The central "bar" of the building is supported by three 260-ft-long by 55-ft-tall (four-story) exposed structural steel trusses, each with 160-ft center spans plus cantilevers at each end.

Given the quantity of CJP and PJP welds at the truss connections, the substantial amount of shop fabrication, and the critical nature of each connection node, a detailed inspection plan was developed to ensure the quality and soundness of each weld. Upon the return of each sequence of erection drawings, Ballinger provided a color-coded set of plans and details indicating which connections required shop versus field ultrasonic testing (UT), magnetic testing (MT), and visual inspection. The inspector used these plans to cross-check their plans and provide a complete inspection report for each sequence.

A New Approach to Fire Engineering

In the hopes of eliminating fire protection from the exposed-to-view trusses for cost savings, Jensen Hughes was engaged to provide a full thermal load analysis of a design fire on the building's four-story trusses. Ballinger and Jensen Hughes attended the state Building Code Commission meeting to seek approval to proceed with the performance-based design of the trusses as set forth in Appendix E of ASCE 7-16: *Minimum Design Loads and Associated Criteria for Buildings and Other Structures,* which at the time had not yet been adopted by the state—and permission was granted. However, the thermal load of the design fire would have required a substantial increase to the steel member sizes, and intumescent paint proved more economical in the end. Regardless of the outcome, this process was an important and proactive example of how state building code commissions, architects, and engineers can interface to provide safe yet innovative buildings for their constituents and points to a bright future for the field of structural fire engineering.


James Ewing

Constructed on the former site of five demolished engineering buildings on the university's main South Kingstown campus, the new engineering building serves as a "bridge" between the liberal arts programs at campus south and the basic sciences at campus north.

To ensure successful field fit-up of the splices, the stubs and diagonal truss members were cut from the same member with end orientation labeled in the shop. Temporary erection bolts were provided for fit-up, and the diagonal lengths between connection stubs were field-welded to the stubs at the splices. Once all welds were completed and inspections were passed, the erection bolt holes and CJP weld access holes were filled with weld material. The use of PJP welds greatly reduced field and material costs in the compression members, as well as the time associated with the removal and infill of backing bars and access holes. All welds and infilled holes were then ground smooth. The truss members were then coated with intumescent paint (CAFCO SprayFilm WB 5 with a top coat of finish paint) as fireproofing to retain the visual shape of the wide-flanges.

Because of the importance of these members, a full-scale on-site mock-up of the central "node"—where eight members intersect—was provided to confirm the feasibility of the welds selected and to approve aesthetics of the final ground-down and painted condition. This mock-up served as a visual guide of the workmanship required for all aspects of the truss aesthetics, including the filling of weld access and bolt holes, the quality of the weld grinding, and the application of the intumescent paint.

Since neither the full 160-ft center span nor the full four-story height could be erected at one time, 15 temporary columns were provided in Ballinger's design, each with its own foundation to temporarily support the building during erection. The truss and floor members were then erected floor by floor in economical fashion. Once all final inspections were performed and all truss connections were completed, the temporary columns were removed in the sequence defined on the contract documents. After the columns were removed, the concrete slabs on deck were placed to a level surface elevation (the weight of additional concrete having been accounted for


Mike Cohea Visuals


James Ewing

Long-span steel framing allows for large column-free spaces throughout the building.

in the truss design) such that the deflection of the main span of the truss did not produce undue deflections in the center of the lab bar.

A Connected Team

Berlin produced 2,654 unique steel fabrication piece drawings for the project and held weekly team meetings with Ballinger, from steel contract award through the end of shop drawing production, to review truss member splice points, connection detailing, and coordination items. Several piece drawings were three sheets long to capture the detailing at each unique condition along the truss member lengths.

This project showcases structural steel as the premier material of choice and is a testament to the sheer will and perseverance required to deliver such a bold project for a motivated client. The teamwork between the architect, engineer, steel fabricator/erector, and third-party inspector is an inspiring story of successful teamwork bringing together a beautiful project under the highest levels of complexity and scrutiny. ■

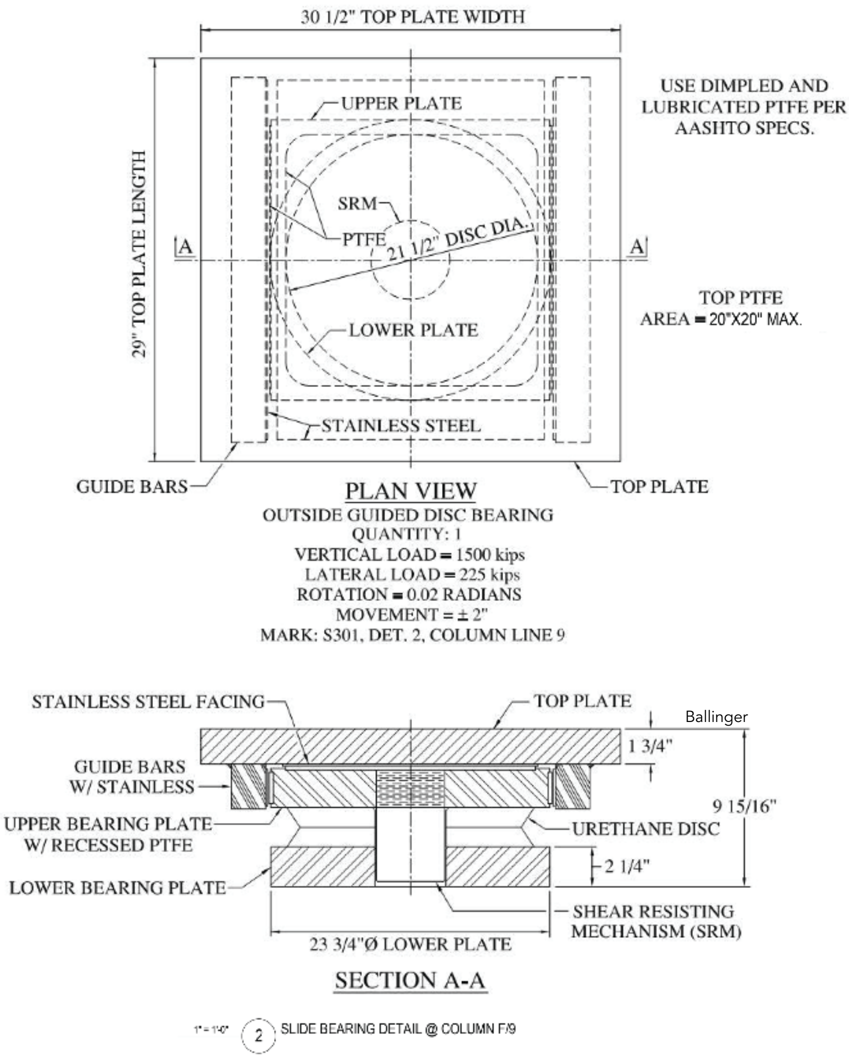
Owner
University of Rhode Island, Kingston, R.I.

General Contractor
Dimeo Construction Co., Providence, R.I.

Architect and Structural Engineer
Ballinger, Philadelphia

Associate Structural Engineer
Odeh Engineers, North Providence, R.I.

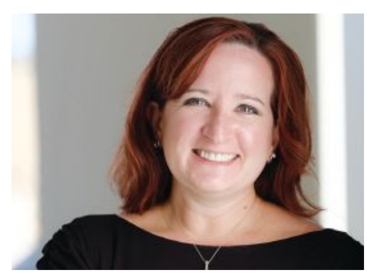
Steel Fabricator, Erector, and Detailer
The Berlin Steel Construction Co., Kensington, Conn.



A slide bearing detail.

The exposed steel framing doubles as a teaching application of "engineering in sight."

James Ewing



Angela Fante (**afante@ballinger.com**) is a principal and chief structural engineer with Ballinger.

Building for the Future

BY BEN LOCKHART

THE OLD SAYING "The cobbler's children have no shoes" would probably find an understanding audience with past generations of Jacobsen Construction Company employees.

Jacobsen has been Utah's skyline and expanding its clientele far and wide for nearly a century. But until very recently, the company had not turned inward to build its own new home from the ground up. That finally changed during the general contracting company's 97th year in business, in 2019, when it announced it would construct a 63,000-sq.-ft modernized headquarters in northwest Salt Lake City.

"You don't construct a headquarters like this unless you're planning on being around for the long haul," said Jacobsen project manager Stan Burke, who led the effort. "This building is a stake in the ground saying, 'Hey, we're going to be here for a long time.'"

With these long-term aspirations for a new company home, it was immediately apparent that structural steel's exceptional performance would play an important role in making Jacobsen's office space the gold standard among Utah construction firms. More than 23,000 fabricated steel pieces and 250 tons of structural steel later, the headquarters is a dazzling and iconic home base for another century of impactful construction projects for the company. Jacobsen employees celebrated the ribbon cutting of the new building in September, an event highlighted by remarks from Utah's governor and the mayors of both Salt Lake City and Salt Lake County.

A general contractor known for self-performing concrete work looks to steel to frame its new headquarters building in Salt Lake City.

Dana Sohm

"We've been on many jobs together, but this wasn't just a Jacobsen job—it was their headquarters," said Dale Parrish project manager JT Steel, the project's steel fabricator. "From the get-go, we wanted to make sure that that we went the extra mile for our trade partner. And we told them if it's put on paper, it can be built. We can do it. It might take a little bit of ingenuity, but we're going to be able to build the kind of structure you're looking for."

"We knew that doing our job right and doing it per the design would be extremely important to Jacobsen's vision for their new offices because we knew what the most integral part of that building would be: steel."

Expertise on Display and Behind the Scenes

With Jacobsen overseeing construction of its own building, there inevitably arose a special urgency to ensure that the processes and craftsmanship used on the project would demonstrate the very best that the firm can offer to clients on their own projects. But to the process-oriented Burke and his team, it was just as critical that the project could showcase Jacobsen's more abstract but also most crucial capabilities: problem-solving, collaboration, advance planning, value engineering, and good old-fashioned persistence and resilience. Early on and throughout the project, these important planning frameworks and principles led the project team to rely heavily on the many uses of structural steel throughout the building.

A framing model of Jacobsen's new headquarters building.

Jacobsen Construction

The opening of Jacobsen's new 63,000-sq.-ft headquarters in northwest Salt Lake City marks the beginning of its second century in business.

Dana Sohm

"In order to reduce weight, optimize erection, and balance costs, composite steel-framed floors and a steel roof were used as the primary gravity structural system," explained Cameron Empey, an engineering professional and associate with Reaveley Engineers, the project's structural engineering firm.

The roof employs open-web steel joists to minimize tonnage while also comfortably meeting all loading requirements. For the walls, the interplay of the aesthetically featured concrete and the supportive tied-in, behind-the-scenes structural steel highlighted the best qualities of both types of materials, Burke said.

"One of the quality-related goals of our work was to showcase Jacobsen's self-perform concrete crews' ability to install exceptional architectural concrete walls," he explained. "It was determined in design that the most visually compelling way to do that would be to leave the concrete shear walls exposed. Using embeds in the concrete walls to tie to the walls to the structural steel—plus using rebar inside the walls themselves—really amplified the structural benefits of multiple materials while also giving us the ability to very visually and very tangibly show off what our own builders can do with their concrete craftsmanship."

Although exposed steel has become a more popular aesthetic in recent years, JT Steel is still accustomed to their structural work remaining behind the scenes, explained JT Steel quality control manager Brian Stephenson.

"We knew it was critical to do everything on our part to make sure the material we created for this important project was exactly per the design so that there would be very few problems if any on the job site when putting it all together," Stephenson said. "We knew that if we did our job right, the framers, sheetrock installation people would thank us for minimizing any workarounds and ensuring everything could come into place."

No significant snags were hit in the placement of the fabricated steel components, which Parrish chalked up to working out issues early by raising any questions or concerns with the engineer at the beginning stages rather than waiting for the erectors to approach them later to say a specific piece wasn't working as intended on the job site.

Kai Ton

"You don't construct a headquarters like this unless you're planning on being around for the long haul," said Jacobsen project manager Stan Burke, who led the project.

"It's always amazed me that you can have so many different subcontractors on a single project who are putting a building together, and 99% of the time, everything is within a tolerance of $\frac{1}{8}$ in.," Parrish said. "To have everybody come together and make it all fit like that without major adjustments, you need to pride yourself on being able to resolve issues early—because sometimes, you're going to have problems on a project. But they're much smaller problems if you deal with them as quickly as possible."

A thorough inspection of every piece, precisely documented and rechecked for good measure, does wonders for the peace of mind of the whole project team, Stephenson added.

"Not one piece of steel got out our door without being looked at, and the key to that was having each person who worked on any one certain piece documenting their review and their confirmation that everything was up to code and up to expectations," he said.

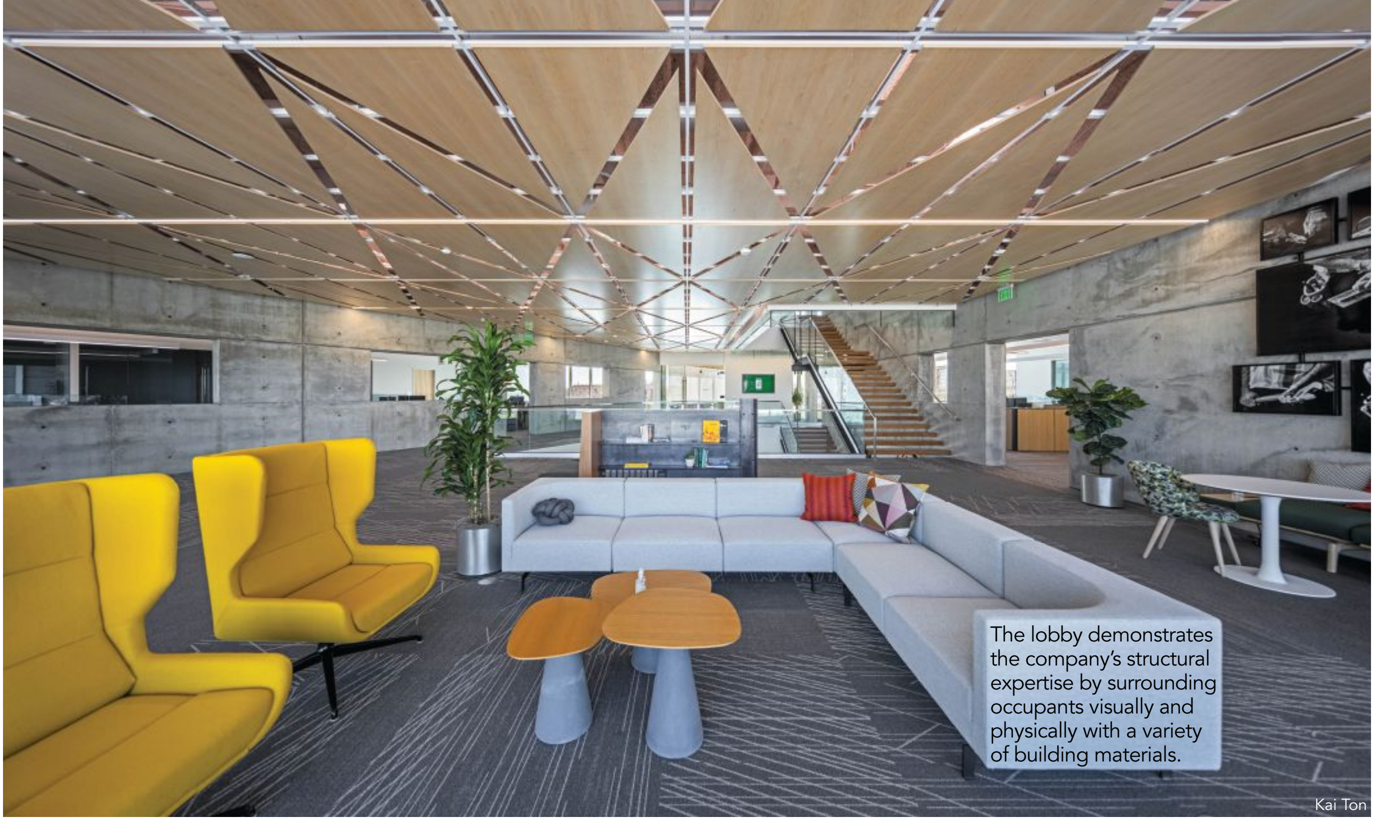
One particularly ambitious stretch goal on this project, Burke noted, was to run each enormous concrete shear wall all the way up the building's three-and-a-half-story height.

"As we studied the supports required to run them all the way up, we realized we would need to brace the walls more than was physically possible," Burke explained. "So we had to readjust, bring them up two stories, then install the steel to act as a brace to tie the wall back to the steel so that it was solid. Then we did the same for the last one and a half stories."

This strategy required a much more stop-and-start effort when it came to steel erection than an all-steel project would, requiring the erection crew to demobilize from the job site after the first phase was completed and then return when the final one and a half stories of concrete shear walls were being put up.

"It took a little bit of coordinating and rearranging of work sequences," Burke said, "but the erection team proved to be very flexible in shifting from their standard process."

Even when the concrete walls took close to eight months to complete, keeping the project at a methodical pace, the stop-and-start of the steelwork proved to be no problem for the erection team members, who only needed 30 total days on-site to complete all of their work.



The lobby demonstrates the company's structural expertise by surrounding occupants visually and physically with a variety of building materials.

Kai Ton

Kai Ton

Looking up at the signature steel stair, which provides a striking focal point for the building's lobby.

Installing the wood-tread/steel-framed grand staircase, the visual centerpiece of the building's open, community-oriented atrium

Jacobsen Construction

An early rendering of the building, which had its grand opening this past September.

Jacobsen Construction

"Having a trusted subcontractor customizing everything according to the design and doing all the calculations and fabrication off-site sped up the entire steel erection process and helped us to move quickly despite all of the other non-steel scheduling challenges that we faced," said Burke. "Receiving our materials from JT Steel was almost like getting a life-sized Erector Set. Each piece is clearly labeled and has its place."

For Parrish, turning unpredictable and wholly unique designs into predictable and reliable results is what gets him up in the morning.

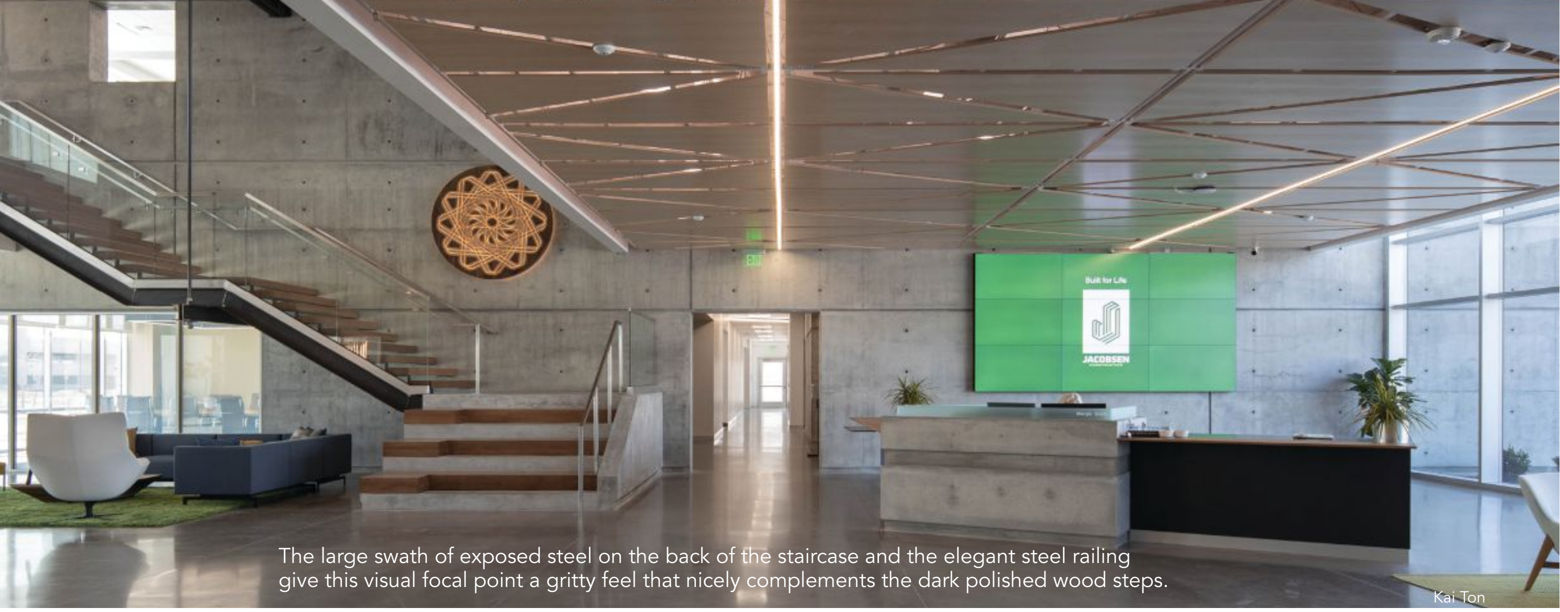
"The beauty of it is, in this line of work, every project is going to look a little different," he said. "Every client wants people to notice their building. So when we're doing our custom fabricating here in our shop, we expect the unexpected, and we love to see what makes each building stand out. And Jacobsen's headquarters certainly stands out."

According to Empey, the decision to use composite steel-framed floors was both an engineering choice and budget-conscious choice. Beautiful and durable, but not very labor-intensive, these floors proved to be the best fit by far for the project.

"Structural steel was clearly the most practical solution for supporting floor decks for the building and resulted in a cost-efficient floor framing system that could be tuned to the specific vibration needs of a modern office building," Empey said. "The combination of steel and concrete in the composite steel floors was a perfect match, allowing both materials to play to their inherent strengths."

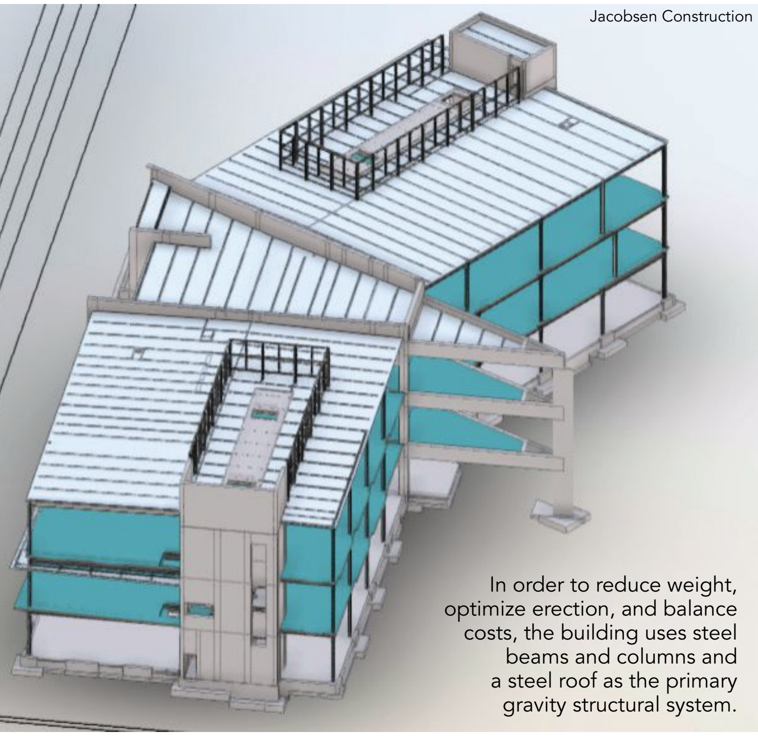
Even so, he noted, Jacobsen Construction's desire for premier office space could have been compromised by consideration of static gravity loads only.

"Lack of attention to floor vibration could have created a serious and disruptive serviceability issue," Empey said. "So the design team took deliberate efforts, performing parametric vibration studies on the composite concrete/metal deck/steel wide-flange beams, to develop a design that not only met all applicable code provisions for strength but also provided sufficient stiffness to prevent floor vibration from becoming a serviceability issue." He also noted that Reaveley Engineers consulted AISC Design Guide 11: *Vibrations of Steel-Framed*



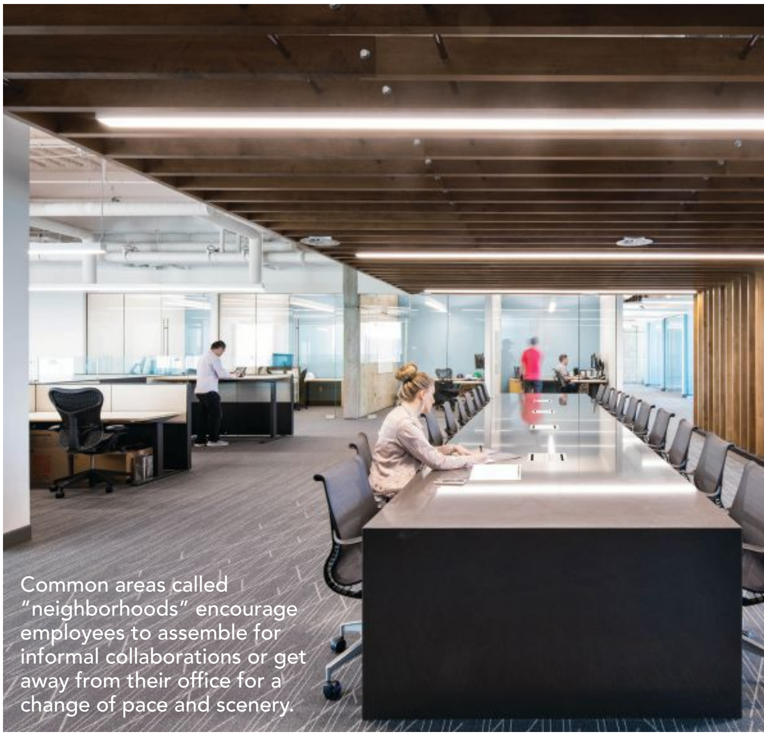
The large swath of exposed steel on the back of the staircase and the elegant steel railing give this visual focal point a gritty feel that nicely complements the dark polished wood steps.

Kai Ton



Jacobsen Construction

In order to reduce weight, optimize erection, and balance costs, the building uses steel beams and columns and a steel roof as the primary gravity structural system.



Common areas called "neighborhoods" encourage employees to assemble for informal collaborations or get away from their office for a change of pace and scenery.

Structural Systems Due to Human Activity (**aisc.org/dg**) to steer their decision-making.

Despite much of the steel framing being hidden from view, exposed steel elements add a sleek, clean, modern look in some key areas. For example, the wood-tread/steel-framed grand staircase is the visual centerpiece of the building's open, community-oriented atrium core throughout its full height.

"The large swath of exposed steel on the back of the staircase and the elegant steel railing give this visual focal point a gritty feel that nicely complements the dark polished wood steps," Burke said.

Beautiful and plainly noticeable exposed steel columns also run up the side of reading nook bookshelves in common areas of the building called "neighborhoods," where employees can assemble for informal collaborations or get away from their office for a change of pace and scenery.

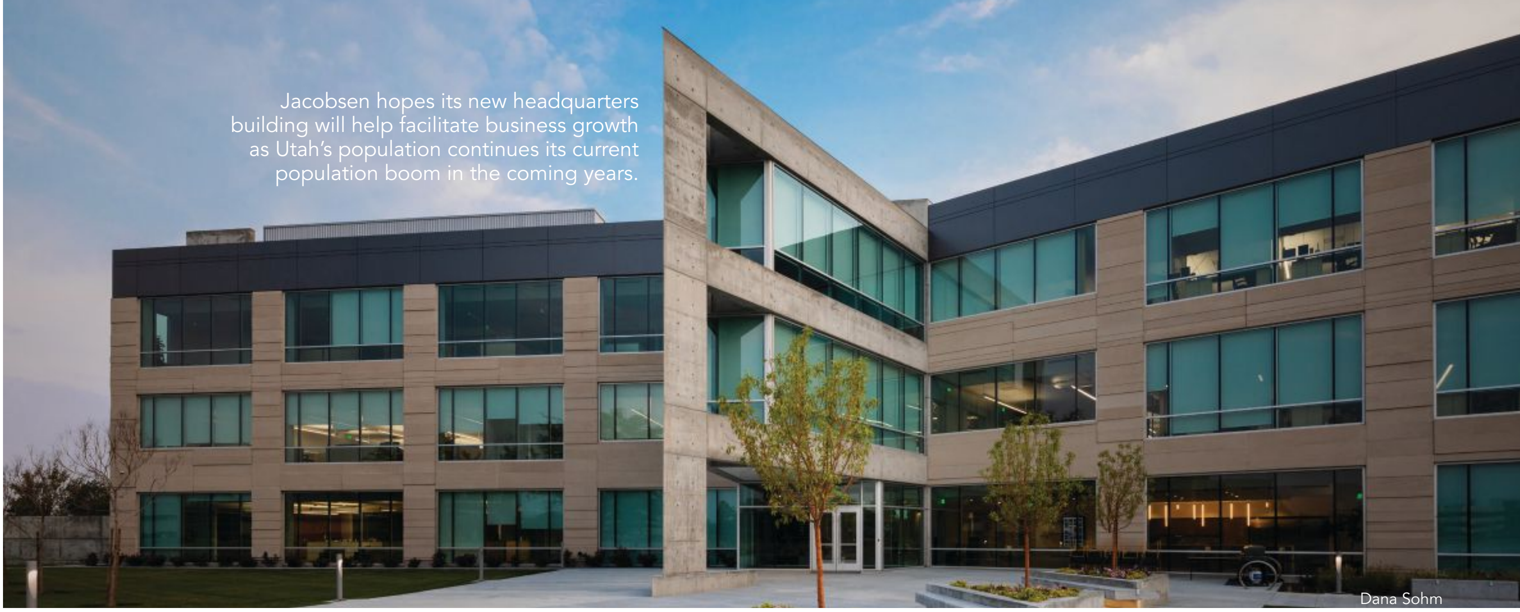
Environmentally sustainable construction remains a profound need in the industry. Steel, being the most recyclable material used in construction, contributed significantly to the priority of sustainable building on this project, as Stephenson was keen to point out.

"Almost 99% of the leftover steel from what we cut in the shop can be recycled," he explained. The cost-effectiveness of that outpaces other materials by leaps and bounds—not only that, but we're also not having an impact on landfills."

Hidden from View but Standing Tall

The new headquarters building represents one of Jacobsen's most significant milestones as a company and will help facilitate business growth as Utah's population continues its nation-leading population boom in the coming years, opening the door for all kinds of fascinating new building projects.

"Jacobsen's new headquarters is a tangible, powerful way for the company to chart its own path ahead and innovate and invest in its people and the community as never before," Jacobsen president and CEO Gary Ellis said. "This building is an investment in our people, our future, and our community."


Jacobsen hopes its new headquarters building will help facilitate business growth as Utah's population continues its current population boom in the coming years.

Dana Sohm


Kai Ton


Jacobsen Construction

The new facility incorporates roughly 250 tons of structural steel in all.

"We owe a lot of thanks to the many generations of Jacobsen workers who never wavered from their passion for building the enduring communities made possible by their craftsmanship," he continued. "With this beautiful new workplace, we are honoring and elevating the work of those who came before us and the community that we've called home for the last century."

While Jacobsen's people stand on the shoulders of giants, the building itself stands because of steel. Hidden from view but standing proud and tall, the steel upholds everything Jacobsen aspires to be in its second 100 years. ■

Owner and General Contractor
Jacobsen Construction Co.

Architect
VCBO Architecture

Structural Engineer
Reaveley Engineers, Salt Lake City

Steel Fabricator
JT Steel, Inc. AISC CERTIFIED FABRICATOR, West Jordan, Utah

Ben Lockhart (**blockhart@jbuild.com**) is Jacobsen Construction's corporate communications manager.

A steel producer for which sizable facilities are the norm goes bigger than ever with its new sheet mill in Texas.

Texas-Sized Steel

BY GEORGE R. BATCHA, IV, AND MICHAEL T. KEMPFERT

Steel Dynamics, Inc.

STEEL DYNAMICS, INC. (SDI) has built a Texas-sized new facility.

The AISC member producer's new steel mill in Sinton, Texas, roughly 10 miles north of Corpus Christi, is a sprawling complex that produces flat-rolled steel coils. At a cost of $1.9 billion, the new campus represents the largest construction project the company has ever undertaken. Consisting of a melt shop, hot mill, and cold mill complex, the mill was designed to greatly expand SDI's capacity to manufacture sheet steel.

When SDI approached CSD Structural Engineers to design the structures that would house and support their cranes and equipment, the latter's experienced team saw the project as an exciting opportunity.

"Engineers in our field have the chance to work on a project like this maybe once or twice in a career," said Mike Ryer, CSD's president. "It's a very interesting project full of big, complicated stuff—like putting a puzzle together in record time."

The project represented a collaboration of steel experts, both on the producing side and the structural design side. While SDI and CSD had collaborated on several projects in the past, the new mill presented an unprecedented challenge that pushed the engineering and project coordination expertise of the combined team to its limits. With a high level of complexity and an extremely aggressive schedule, it would take expertise, ingenuity, and the exceptional capabilities of structural steel to ensure the success of the project.

Building Geometry and Loads

With over two million sq. ft under roof and building heights approaching 175 ft, the scale of the buildings alone is staggering. Mill buildings are essentially shells to support crane runways and provide shelter for the manufacturing process. As a result, they are largely open with no interior columns and open aisles typically over 100 ft wide. For this project, the cranes travel on elevated runways up to 125 ft above the mill floor, with crane bridge spans up to 115 ft.

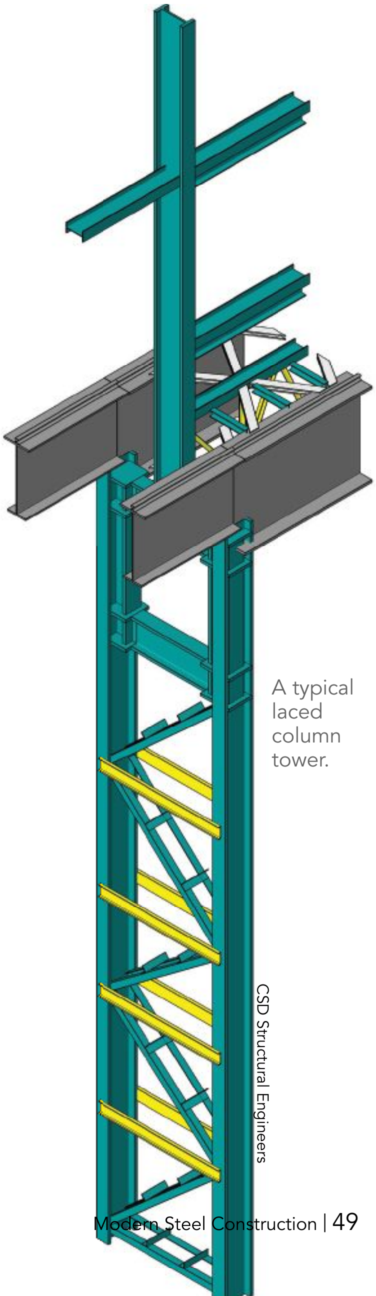
The new mill contains more than six miles of runway girders and rail.

Steel Dynamics, Inc.

CSD Structural Engineers

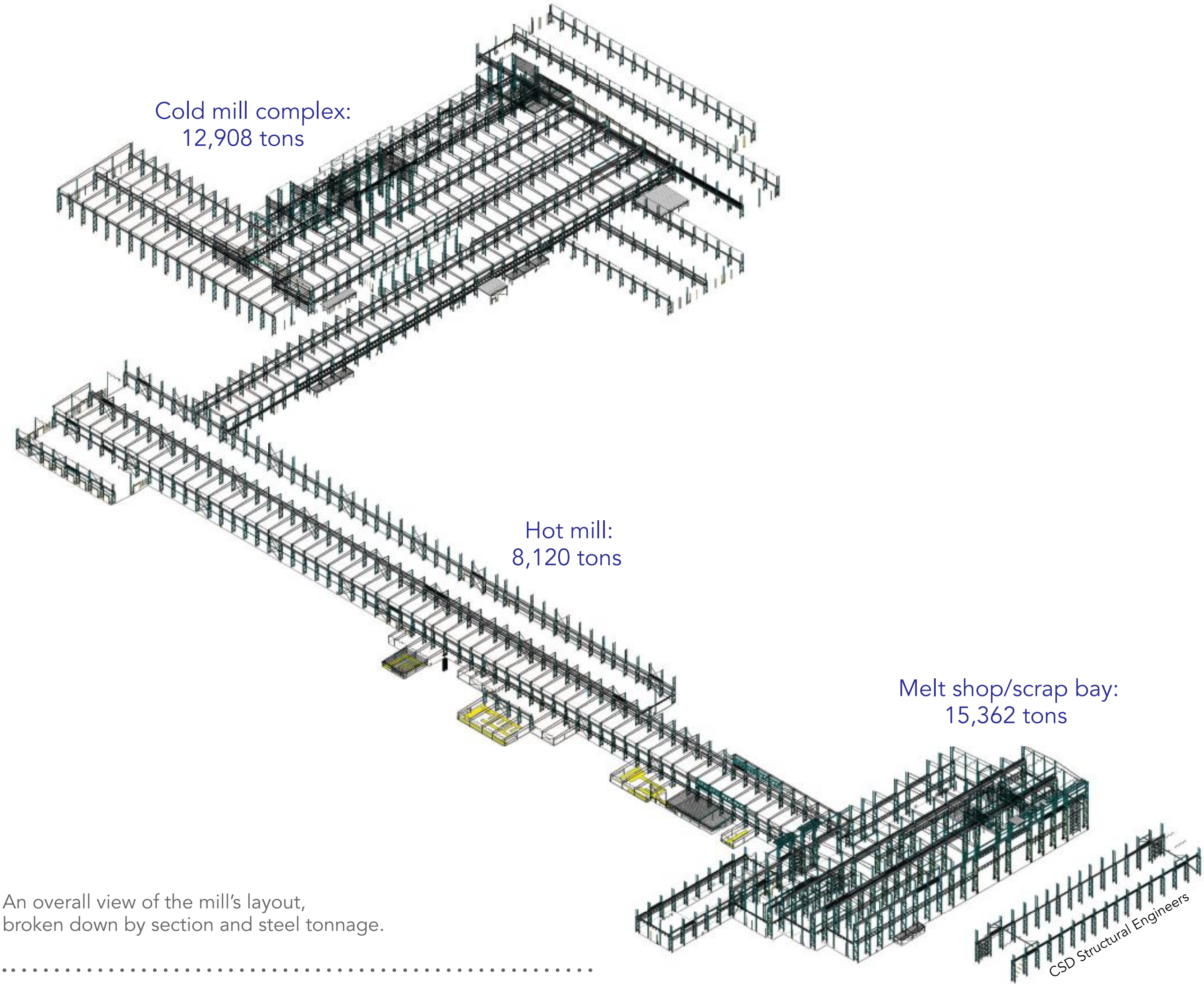
Steel Dynamics, Inc.

The entire mill is framed by more than 36,000 tons of structural steel.



A typical laced column tower.

CSD Structural Engineers



An overall view of the mill's layout, broken down by section and steel tonnage.

There are nearly 50 cranes in the complex, ranging from 10-ton maintenance cranes up to 500-ton capacity cranes in the melt shop, the latter being capable of lifting the entire lower section of an electric arc furnace (EAF). In such facilities, crane runways must be designed for vertical loads from the weight of the crane and lifted loads, dynamic lifting forces, side thrusts transverse to the structural framing, and horizontal forces along the length of the runway. Deflection and drift requirements for crane runway structures are generally more restrictive than standard buildings, both to protect operations and to prevent maintenance issues with the cranes and runway structures. In addition, the exposure to hurricane-force winds inherent in the facility's location near the Gulf of Mexico presented unique loading challenges to the design of the buildings.

Also unique to this type of project are the design considerations for the extreme environment. Molten steel, hot gas, corrosive elements, and heavy mobile equipment are just a few of the items that cause damage and deterioration in the structures. While deterioration can't be avoided completely, the facility's design must help prevent such issues as much as possible.

Crane Runways

The project contains over six miles of crane runway girders and rail. Typical runway girder spans were 40 ft, but in some cases ranged up to 90 ft to accommodate the requirements of the steelmaking process. For lighter cranes (less than 50-ton capacity) in the 40-ft bays, rolled wide-flange shapes (W27 to W36 weighing up to 178 lb per ft) were used for the runway beams, although in many cases, reinforcing angles were required at the beam top flange. This combination of wide-flange beams with reinforcing angles allowed SDI to construct a large percentage of the crane runways using steel shapes produced at its Columbia City, Ind., steel mill.

For longer spans and heavier cranes, it was necessary to use fabricated plate girders for the runway. Many of these were asymmetrical sections with different top and bottom flange sizes to provide an efficiently designed section while still ensuring that performance demands were met. Even so, the largest runway girders were 11 ft deep, used plates up to 3 in. thick, and weighed over 1,600 lb per ft.

The tolerances for crane runways are much more stringent than those typical for structural steel construction. This is necessary to minimize crane maintenance issues that can be caused by a runway structure with too much variation from theoretical horizontal and vertical alignment. Strict fabrication and erection controls are necessary, starting from the ground up to ensure that a crane runway can be properly aligned. Industry documents such as AIST Technical Report #13: *Guide for the Design and Construction of Mill Buildings* and AISC Design Guide 7: *Industrial Building Design* can supplement the AISC *Code of Standard Practice for Buildings and Bridges* (ANSI/AISC 303) for certain tolerances to help achieve this goal. (CSD Engineers served on the committee for AIST TR#13 and authored AISC Design Guide 7. Both mentioned AISC publications can be found at **aisc.org/publications**).

Building Framing

Mill buildings require open access throughout their length so that the overhead cranes can travel freely along the runways. As a result, there is no opportunity to brace across the building width, and the buildings are too long to only brace at the end walls. As such, frame lines for the SDI project were typically spaced at 40 ft, and the frames were comprised of a double-column on each side. The inside column supports the crane runway gravity loads along with part of the building loads, while the outside column supports building loads, and both columns are laced together to provide lateral support for the crane and building horizontal loads. These columns are spaced with a gauge equal to approximately 8% to 10% of the building height, and being laced together allows the whole system to act as a fixed-base cantilever from the foundation.

In the hot mill and cold mill buildings with medium heights and lighter cranes, the laced column towers were built using W24 shapes in the 12-in.-flange series. The melt shop building has the most severe loading conditions as it contains the 500-ton capacity cranes operating at 100 ft above the mill floor, with runway spans extending to 80 ft. In addition, this building structure provided support for piping and electrical utilities, alloy storage and conveying systems, and emission control ductwork up to 22 ft in diameter. These loads required one of the heaviest rolled shapes produced in the U.S. today: W36×652. In some cases, the loads were so high that even these massive columns required the addition of 4-in.-thick cover plates to provide additional strength. CSD coordinated with SDI to use reinforcing plates on available steel wide-flange shapes to avoid more expensive fabricated built-up columns from plates.

Platform Structures

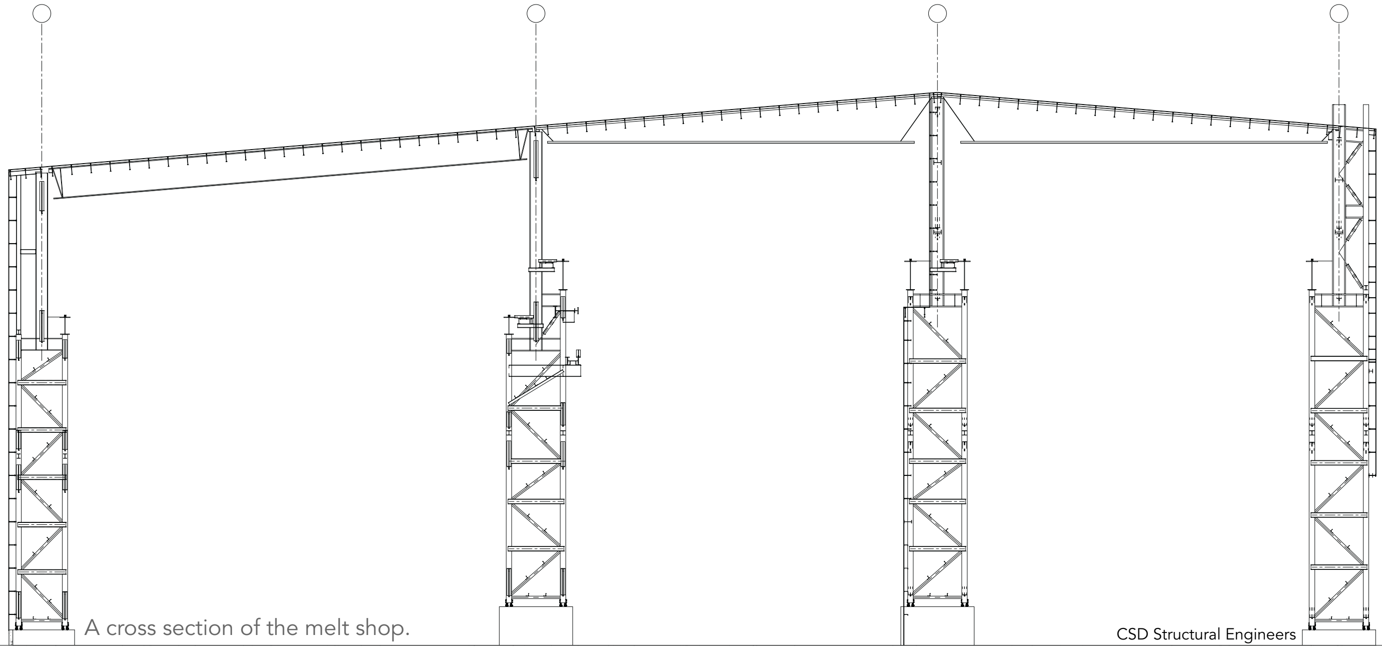
Another prominent use of structural steel can be seen in the dozens of platform structures throughout the facility. While most primary equipment is supported directly on concrete foundations, many pieces of equipment that support the process, such as control pulpits and maintenance equipment, are supported on steel platforms. In addition, steel walkways and stairways can be seen in almost every area of the mill.

In the melt shop, large multi-level platforms provide access around the furnaces as well as support for the many materials and processes necessary to operate these key pieces of equipment. The combination of heavy floor loading (up to 750 psf), in conjunction with depth restrictions on framing members (due to clearances with processing equipment), required complex framing schemes with heavy, relatively shallow members.

In the cold mill complex, coating lines that apply paint or galvanizing to finished coils employ numerous large platform structures to support the dozens of pieces of equipment. These platform structures are of a scale similar to typical buildings but are deliberately kept independent from the main structure so that environmental loads do not affect the stringent tolerances necessary to meet the quality requirements of the process lines. The layout and design of all platform structures had to be closely coordinated to meet SDI's and all equipment vendors' requirements to precisely support the equipment and provide necessary clearance around both it and the foundations that penetrated through multiple levels.

Connection Design

CSD's expertise in steel connection design was also showcased at the new Sinton mill. By providing a complete structural design, which included all connection designs, CSD ensured that the project's fabricators and erectors had accurate information from the bid stage until steel erection began. Using standard AISC connection designs while also incorporating fabricator preferences allowed for a streamlined process for shop drawing review and fabrication in the shop. CSD's experience in both heavy industrial crane buildings and connection design provided an additional advantage when it came to developing what would be considered non-standard connections. These include connections of heavily loaded members, laced columns, crane runway girders, and crane runway girder tiebacks to the columns.



A cross section of the melt shop.

CSD Structural Engineers

CSD Structural Engineers

With over two million sq. ft under roof and building heights approaching 175 ft, the scale of the mill buildings is staggering. The cranes travel on elevated runways up to 125 ft above the mill floor, with crane bridge spans of up to 115 ft. Frame lines for the project were typically spaced at 40 ft, and the frames are comprised of a double-column on each side.

CSD Structural Engineers

CSD Structural Engineers

CSD Structural Engineers

The complex contains nearly 50 cranes, ranging from 10-ton maintenance cranes to 500-ton cranes in the melt shop, the latter being capable of lifting the entire lower section of an electric arc furnace (EAF).

Structures of this size supporting loads of this magnitude and built within this schedule are only possible with steel. A steel producer expanding its capability to produce more steel with the help of a team of expert structural engineers makes for a great case study for structural steel design, detailing, fabrication, erection, and end performance—and, given the industrial nature of a mill, also puts it on full display. SDI's new flat roll steel mill stands as one of the world's premier steel production facilities and is supported, protected, and enabled by the very material the company produces. ■

*Visit the Project Extras section at **www.modernsteel.com** for drone footage of the project during construction.*

Owner and General Contractor
Steel Dynamics, Inc.

Structural Engineer and Connection Designer
CSD Structural Engineers

Steel Team

Fabricator
FabArc Steel Supply, Oxford, Ala. (Hot Mill)

Erector
Bracken Construction Company, Inc., Ridgeland, Miss.

Detailer
S. P. International, Inc., Kansas City

George R. Batcha, IV, and **Michael T. Kempfert** are both vice presidents with CSD Structural Engineers in Milwaukee.

Of Codes and Contracts

BY JASON COPLEY, ESQ, AND MATTHEW SKAROFF, ESQ

Tips on understanding the interplay between contracts and the AISC *Code of Standard Practice*.

ALL STEEL CONSTRUCTION project owners know the overall importance of contracts.

But understanding the details, particularly how the various trades and players can affect contract interpretation and legal obligations, is crucial to a successful project.

A business with a strong understanding of the trade practices that set the legal playing field—as well as an understanding of the relationship between those practices and contract formation and interpretation—will have greater value when it comes to contracting for work and handling disputes. And when it comes to successful, mutually beneficial steel projects, a big part of achieving this value is having a good grasp on the interplay between the law of contracts and the most relevant trade practices—namely, those contained in the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303, **aisc.org/specifications**).

Setting the Foundation

The *Code* sets forth a common understanding of the acceptable standards of custom and usage when contracting for structural steel, including the fabrication and erection of steel on a project. It addresses standard practices for design documents and specifications, shop fabrication and delivery, quality control, and contracting, among other things. The *Code* is intended to be useful for all parties involved with structural steel, including owners, architects, engineers, general contractors, construction managers, fabricators, detailers, and erectors so as to ensure that everyone is on the same page.

Functionally, the *Code* establishes an objective baseline for interactions relating to the use of structural steel on projects. It is a consensus document developed by a fair and balanced committee process of various stakeholders and, unlike many contracts, the *Code* is not "skewed" toward any particular role—rather, it is a reflection of all participants in the industry from designers to erectors.

Incorporating the *Code*

In contract law, the concept of "incorporation" refers to the process of making a secondary document a part of a contract. Design documents, which can be drawings or models, for example, are often incorporated into a purchase order or agreement by explicitly listing "design documents" or the document or drawing numbers in the purchase order or agreement itself. The act of incorporating a secondary document into a primary contract will have the effect of making the terms of the secondary document legally binding. In fact, several states will not even recognize secondary documents in many circumstances unless they are incorporated explicitly into the primary contract.

Given the legal concept of incorporation, the best way to ensure that the *Code* applies to a project to the extent desired is to explicitly include it in an agreement. This can be as simple as including a statement that "all work shall be performed in accordance with the AISC *Code of Standard Practice*" in the agreement or in any incorporated documents. When a dispute arises, incorporating the *Code* can save significant hassle by sparing arguments about whether it otherwise applies.

Be Explicit

Every state has different laws regarding the interpretation of contracts, so parties should always consult a lawyer about how to interpret them for contract formation and handling disputes. However, educational commentary on contract law generally addresses how trade practices should apply to contract interpretation when a contract does not otherwise incorporate such practices. Many state laws often follow such commentary. Specifically, the 1981 version of the U.S. legal document *Restatement (Second) of the Law of Contracts* states (with emphasis added): "**Unless otherwise agreed, a usage of trade** in the vocation or trade in which the parties are engaged or a usage of trade of which they know or have reason to know **gives meaning to or supplements or qualifies their agreement.**"

Similarly, the *Uniform Commercial Code (UCC)*, which governs sale transactions and in certain circumstances can apply to structural steel, provides that trade practices may supplement a written agreement and that they should be interpreted harmoniously with explicit agreement terms. Though the *UCC* itself is not legally binding, most states have adopted portions, if not all, of it.

In light of the above, when the *Code* is not explicitly incorporated into a contract, it likely still applies, though in most cases, it will not trump any contradictory provisions in the contract. Instead, it will most likely serve as a gap filler. Therefore, the *Code* becomes a powerful reference when a contract is silent on a particular issue and when there is a disagreement between the parties. In such cases, the provisions of the *Code* should usually apply.

Interplay between *Code* and Contracts

To use the *Code* to its full potential, structural steel industry players not only need to understand its crucial provisions but also how and when it applies, and how to resolve conflicts between the *Code* and a contract—or add language to avoid the conflict altogether. Our session will not only cover the above but will also delve into specific examples to help you sharpen your understanding of when the *Code* applies, as well as help you take advantage of its benefits regardless of your role on a steel project. ■

This article is a preview of the 2022 NASCC: The Steel Conference session "Understanding How the Code of Standard Practice *Impacts Your Work." The conference takes place in Denver, March 23-25. For more information and to register, visit* ***aisc.org/nascc****.*

Jason Copley (**jcopley@cohenseglias.com**) and **Matthew Skaroff** (**mskaroff@cohenseglias.com**) are both attorneys in the Construction Department at Cohen Seglias Pallas Greenhall and Furman PC, AISC's general counsel.

Thoughts on how to improve erection planning and execution.

Plan the Work, Work the Plan

BY BILL BORCH

MANY OF US in the industry have at times struggled with putting together what we deem to be the perfect steel erection plan.

We all look at the 2020 AISC *Standard for Certification Programs* (AISC 207-20) requirements and try to incorporate element 5.20: ERECTION PLAN language into our plans, with the idea of avoiding a plan that's onerous or cumbersome for field staff to implement.

Meeting the Requirements

A solid erection plan starts with addressing the items in the General Notes and the Division 5 specifications, identifying any erection requirements outside the normal. The first relevant item to address is beam and joist elevations and anchor rod surveys. At times, these items can be challenging, as many general contractors and construction managers continue to push them onto erectors even though they are embodied in their project specifications. In addition, the AISC *Code of Standard Practice for Buildings and Bridges* (ANSI/AISC 303), in Section 7: Erection, states the following. "The *owner's designated representative for construction* shall be responsible for the accurate location of lines and benchmarks at the job site and shall furnish the *erector* with a plan that contains all such information. The *owner's designated representative for construction* shall establish offset lines and reference elevations at each level for the *erector's* use in the positioning of *adjustable items* (see Section 7.13.1.3), if any."

The *Code* also states, in Section 7.5.1: "*Anchor rods*, foundation bolts, and other embedded items shall be set by the *owner's designated representative for construction* in accordance with *embedment drawings* that have been approved by the *owner's designated representatives for design and construction*. The variation in location of these items from the dimensions shown in the approved *embedment drawings* shall be as follows: (a) The vertical variation in location from the specified top of *anchor rod* location shall be equal to or less than plus or minus ½ in. (13 mm). (b) The horizontal variation in location from the

A solid erection plan starts with addressing the items in the General Notes and the Division 5 specifications of the AISC *Certification Standard*, identifying any erection requirements outside the normal.

There are specific items in Section 5.20: Erection Plan of the *Certification Standard* that are to be embodied in our plans, which, when done correctly, can be valuable to even the most seasoned raising gang foreman.

specified position of each *anchor rod* centerline at any location along its projection above the concrete shall be equal to or less than the dimensions given for the *anchor rod* diameters listed…"

And in the Commentary to this section: "The tolerances established in this Section have been selected for compatibility with the hole sizes that are recommended for base plates in the AISC *Steel Construction Manual*. If special conditions require more restrictive tolerances, such as for smaller holes, the required tolerances should be stated in the *contract documents*. When the *anchor rods* are set in sleeves, the adjustment provided may be used to satisfy the required *anchor-rod* setting tolerances."

Once we meet the aforementioned requirements, we then must procure the requirements of OSHA 1926.752(a): Approval to begin steel erection. Before authorizing the commencement of steel erection, the controlling contractor shall ensure that the steel erector is provided with the following written notifications in this OSHA standard:

1926.752(a)(1): The concrete in the footings, piers and walls and the mortar in the masonry piers and walls has attained, on the basis of an appropriate ASTM standard test method of field-cured samples, either 75 percent of the intended minimum compressive design strength or sufficient strength to support the loads imposed during steel erection.

1926.752(a)(2): Any repairs, replacements and modifications to the anchor bolts were conducted in accordance with OSHA 1926.755(b).

1926.752(b): Commencement of steel erection. A steel erection contractor shall not erect steel unless it has received written notification that the concrete in the footings, piers and walls or the mortar in the masonry piers and walls has attained, on the basis of an appropriate ASTM standard test method of field-cured samples, either 75% of the intended minimum compressive design strength or sufficient strength to support the loads imposed during steel erection.

These requirements are critical prior to steel erection, and their acquisition helps to facilitate the successful implementation of our erection plans.

Writing the Plan

Now, let's write that erection plan. Note that there are specific items in Section 5.20: Erection Plan of the *Certification Standard* that are to be embodied in our plans, which, when done correctly, can be a valuable tutorial or guide to even the most seasoned raising gang foreman. Let's review those components as listed and explore their value to our plan. Section 5.20 starts with the following requirements (and remember that every instance of "shall" denotes a mandatory requirement:

"The *erector* shall prepare an *erection plan* for every project. The *erection plan*, in whole or in part, may be described graphically or in text. The *erection plan* shall include the following information as appropriate for the project: (a) Project name and location. (b) Indication of access for material delivery and equipment delivery, including lay-down, shake-out, and field-*assembly* areas. (c) Sequence of *erection*. (d) Dimensions and locations of cranes or other lifting equipment. (e) Required site conditions for the crane location and confirmation of adequate base support for the crane. (f) Sizes, model names or numbers, and capacity charts for lifting equipment. (g) Information regarding the heaviest lift and its radius, the longest radius and its lift weight, and the boom configuration for each at every location of the lifting equipment. (h) Indicate critical lifts, if any, and include the critical lift protocol or *procedure*. (i) Requirements for multi-lift rigging. (j) Types of slings to be used and, if more than one type, the locations in which they will be used. (k) Rigging information for atypical lifts (weight, geometry, center of gravity, etc.) such as slings and hardware, rated lifting beams, beam clamps (including catalog cuts), as applicable to the lift. (l) Designation of crane paths from position to position, indicating load travel paths, swing restrictions, and personnel exclusion zones. (m) Designation of space required for field *assembly* prior to *erection*. (n) Identification of special fastening sequences and/or methods. (o) Identification of special or atypical connections. (p) Traffic control notes. (q) Identification of specification requirements for *erection*, such as plumbing tolerances smaller than those stipulated in the AISC *Code of Standard Practice*. (r) Provisions for temporary supports as required by the AISC *Code of Standard Practice* Section 7.10.3. (s) Falsework requirements and corresponding design calculations. (t) Jacking layout and jacking *procedure*. (u) Notation of special problems due to overhead restrictions, underground utilities, barriers to crane tail swing, etc.

The *erection plan* shall be reviewed before the start of *erection* by the *erector's* project management team and be available to all employees assigned to the project. All revisions shall be approved by the site superintendent and communicated to affected personnel at the time of the revision."

The above language can be daunting at first glance. Join us at NASCC: The Steel Conference in Denver this March, and we'll break these requirements down for ease of implementation and incorporation into your erection plans. ■

All mentioned AISC publications can be found at ***aisc.org/specifications****. This article is a preview of the 2022 NASCC: The Steel Conference session "Erection Planning Made Easy." The conference takes place in Denver, March 23-25. For more information and to register, visit* ***aisc.org/nascc****.*

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Notes on delegated design and the role of the design professional of record.

Avoiding Surprises

BY BRUCE F. BROTHERSEN, PE

Fig. 1. A surprise hole in a structural member.

SURPRISES ARE GREAT— depending on the type and context. Whereas a "surprise" in the sense of bearing good fortune is greatly appreciated by most, surprises in the construction process almost never bear good fortune and are not appreciated.

One way to eliminate construction surprises is to pay close attention to items where the structural engineer of record (EOR) delegates the design of structural products or services. In even the simplest of buildings, there are numerous suppliers of products and services that rely on the EOR to clearly define the design that is delegated to them. Some obvious specialty products where the design is delegated in part or whole include:

- open web steel joist and deck
- fire suppression
- building cladding
- structural framing
- connections

A proven best practice for the EOR is found in the applicable provisions of the building codes. Also, knowing and following the codes of standard practice for specialty products simplifies communication, resulting in clearly defining the requirements in terms of loads, geometry, and serviceability. In turn, the design engineer for the specialty products can meet the requirements and intent of the EOR. The design boundaries may seem black and white, but gray areas always seem to surface, so open lines of communication are a necessity.

Subcontractor surprises. I would hate to think that a subcontractor would "surprise" the EOR with a hole in a structural member, as shown in Figure 1. In this case, the EOR delegates the design of the fire suppression system to a subcontractor. The specialty product (fire suppression) engineer would design the system to meet applicable codes for which they should be an expert (the EOR would likely not have the level of expertise that the specialty product engineer does concerning their product). Consequently, the delegation of design expands the knowledge base for the project, resulting in a better overall design and valuable intuition for future projects.

The specialty engineer's design likely will include additional loads to the structure and, as shown in the figure, modification to structural elements. The EOR is responsible for the overall building, so their design should include the loads and possible modifications for the specialty products. Clearly noting the design accommodations or boundaries that a specialty engineer should operate within can help limit the possibility of surprises.

Connection coordination. Coordinating design aspects is essential to delegated design. For example, the connection in Figure 2 requires coordination of design aspects between the EOR

left: Fig. 2. This connection requires coordination of design aspects between the EOR and the open-web joist manufacturer's engineer.

above: In even the simplest of buildings, there are numerous suppliers of products and services that rely on the EOR to clearly define the design that is delegated to them.

and the open-web joist manufacturer's engineer. In most cases, the EOR does not design the entire connection but needs to perform enough design to know the size and quantity of bolts that are needed and/or preferred. The joist engineer would design the size of the plates and welds for the material they are providing. Generally, the joist manufacturer uses a 1-in. end plate. If a 1-in. plate is used, the minimum bolt size is 1 in. due to fabrication safety requirements. If the EOR is unaware of the plate requirement and ¾-in. bolts are specified, there will be a problem that may lead to an unwanted surprise. The eccentricity of this connection may be a gray area and should be coordinated by both parties. The eccentricity may also be more than what was considered in the design of the bolts.

Deferred submittals and the *IBC*. The *International Building Code (IBC)* addresses delegated design of specialty products with deferred submittals in Section 107. For common products where the design is not performed by the EOR, a deferred submittal process is an acceptable and common practice for the building official. In this process, the EOR must note items that fall under deferred approval and then review the items for compatibility with the overall design of the building. This review may include drawings and/or calculations from a specialty products design engineer. In the case of open-web steel joists, *IBC* Section 2207 provides the information that should be on the construction documents as well as the information that should be on the submittal from the joist manufacturer's design engineer. Hopefully, no surprises here. (The *IBC* is available at **www.iccsafe.org**.)

Is value engineering actually valuable? One area where surprises often occur is in scenarios involving "value engineering." For example, a specialty engineer may be doing some sort of delegated design and is tasked with finding ways to reduce cost and/or shorten the schedule. While this can be considered a "value" to the owner or general contractor, the EOR is still responsible for the design of the overall building, and potential savings must be coordinated with them to ensure the design intent is met. If coordination doesn't occur, the expected value may be lost. In short, true value engineering can't merely be dictated; it can only come to fruition if all parties have a voice and are on the same page.

Avoid surprises—but not good fortune. As with most things, one solution does not fit every circumstance; and each project may have its own special requirements. But it's best to keep in mind that good coordination and communication, perhaps even over-communication, is the key to reducing surprises. When surprises do arise—and they will—swift action can resolve the effects. And in the best-case scenario, you may even find that good fortune is not a surprise because you planned for it ahead of time. ■

This article is a preview of the 2022 NASCC: The Steel Conference session "Delegated Design and the Engineer of Record." The conference takes place in Denver, March 23-25. For more information and to register, visit ***aisc.org/nascc****.*

Bruce Brothersen (**bbrothersen@vulcraft-ut.com**) is a senior research engineer with Vulcraft/Verco Group.

This month's New Products section takes a (safe) stroll through the fabrication shop, focusing on welding and drilling operations, and includes a drill with a new magnet design geared toward drilling thin steel plate, a new gas-shielded flux-cored wire, and a new lithium-ion battery-powered respirator with a wider viewing area.

SteelMax D1-TS for Thin Steel

The D1-TS for Thin Steel drill features a new magnet design that allows for optimal magnetic field distribution on very thin steel plates with comparable holding force to drills with standard magnets. This allows the drill to safely work on material down to ⅛ in. where most other drills would be deemed unsafe or not work at all. It features a 1⅜-in.-diameter by 2-in.-deep cut, a 14¾-in. working height (with coolant bottle), a weight of only 22 lb, an adjustable cutter guard with a built-in chip breaker, a through-spindle coolant system with a removable reservoir, and a maintenance-free rail guide system for long life, minimal run-out, and extreme accuracy. For more information, visit **www.steelmax.com**.

ESAB Savage A40 PAPR

ESAB Welding and Cutting Products has launched its new Savage A40 PAPR with Powered Air Purifying Respirator (PAPR) technology. The helmet is essential for workers in situations where welding fumes and particulates are a concern, confined or poorly ventilated spaces, and in operations where hexavalent chromium fumes are present. The unit has three settings that adjust airflow between 170 and 230 l/minute to suit the environment and application. It operates at a quiet 70 dB and features a high-capacity, lithium-ion rechargeable battery that offers up to eight hours of performance between charges. It also has a two-stage replaceable filtration cartridge that meets NIOSH certification and removes 99.9% of airborne particles. With a design inspired by the company's Sentinel A50 helmet, the Savage A40 PAPR offers a 3.93-in. by 1.96-in. viewing area for a wider field of vision, and its 1/1/1/2 optical-class lens features ESAB's ultra-clear true-color technology for increased weld pool clarity and enhanced definition. For more information, visit **www.esabna.com**.

Hobart FabCO 912K-M

The new FabCO 912K-M gas-shielded flux-cored wire was introduced to accompany Hobart's reformulated FabCO 91K2-C wire. Both wires provide robust mechanical properties when welding within a wide range of heat inputs and are ideal for single- or multi-pass operations and all-position welding on structural steel fabrication applications. The 91K2-M wire is classified to the American Welding Society (AWS) A5.29 *Specification for Low-Alloy Steel Electrodes for Flux-Cored Arc Welding* as an E91T1-K2M J H4 wire for use with 75% to 80% argon/balance CO_2 shielding gas mixtures. Both wires feature an H4 designation, indicating they produce a weld deposit with a very low diffusible hydrogen content, which is desirable when welding higher-strength steels. Both wires also feature a "J" designation that indicates enhanced low-temperature toughness requirements. However, FabCO 91K2-C and FabCO 91K2M have been developed to exceed classification requirements for test temperature and absorbed energy; users can typically expect good toughness at temperatures as low as -76 °F. For more information, visit **www.hobartbrothers.com**.

NASCC

2022 NASCC Registration Opens January 10

Get ready. For the first time in nearly three years, NASCC: The Steel Conference will take place in person.

Scheduled for March 23-25 in Denver, NASCC is the premier educational and networking event for the structural steel industry, bringing together structural engineers, structural steel fabricators, erectors, detailers, and architects. In addition to more than 200 practical seminars on the latest design concepts, construction techniques, and cutting-edge research, the conference also features 250 exhibitors showcasing products ranging from structural design software to machinery for cutting steel beams, as well as plentiful networking opportunities. One low registration fee gains you access to all of the technical sessions, the keynote addresses, the T.R. Higgins Lecture, and the exhibitor showcase.

NASCC is your once-a-year opportunity to learn from leading experts in the steel community and earn PDHs. Also included are multiple conferences within a conference: the World Steel Bridge Symposium, QualityCon, and the NISD Conference in Steel Detailing. One low registration fee gains you access to all of these conferences/sessions, the keynote sessions, and the exhibition hall.

For more information and to register (registration opens January 10), visit **aisc.org/nascc**.

NEED FOR SPEED

AISC Offering $5,000 Prize for the Next Great Idea in Column Splices

AISC's Column SpeedConnection Challenge is looking for the next great idea in column splice connections—and there is $5,000 on the line for the best concept!

Column splices haven't changed much over time, typically using bolts, welds, or a combination of the two. But what if there is a better way to splice a column?

The keywords are FAST and EASY—to design, fabricate, and erect safely. We welcome all participants with a spark of inspiration and "back of a napkin" idea that we can help develop into a revolutionary concept.

To register for the challenge, visit **herox.com/SpeedConnectionColumn** and click the "SOLVE THIS CHALLENGE" button. The deadline for entry is January 14.

The SpeedConnection project—part of AISC's Need for Speed initiative, geared toward increasing the speed of steel construction by 50% by 2025—aims to provide speed improvements for how buildings can be erected related to connections. This transformative effort's overarching goal is to develop a solution that "changes the world" for steel connections.

People & Companies

Walter P Moore announced that **Jessalyn Nelson, PE**, has been named the 2021 recipient of the Javier F. Horvilleur Outstanding Young Professional Award. The Horvilleur Award is presented annually to one young professional at the firm who has exemplified excellence in technical design, client service, and business acumen. The award is named for and is in appreciative memory of Javier F. Horvilleur, PE (1954–2002), who was an inspirational leader-engineer at the firm for over two decades. Nelson is a senior associate and senior project manager in the company's Houston office and has worked on a wide variety of project types, including higher education buildings, aquariums, and hospitals.

The **American Iron and Steel Institute (AISI)** presented its 2021 Market Development Achievement Awards to **Richard (Rick) Haws, PE**, engineer, **RBH Consulting LLC**, and **David Stoddard**, senior applications engineer at AISC member producer **SSAB Americas**, and its Market Development Industry Leadership Award to **Dajun Zhou, PhD**, manufacturing specialist, **Stellantis North America**. The market development awards were established in 2007 to recognize individuals who have made significant contributions to advancing the competitive use of steel in the marketplace.

Specialized structural engineering firm **Zabik Turner Engineering (ZTE)** of Orlando is joining forces with **Bennett and Pless**, strengthening the latter's capabilities in central Florida. Combined, the firms will bring an added level of expertise to the structural engineering services offered across the Southeast, U.S., and internationally.

STANDARDS

New AISC 2022 Standards Available for Public Review

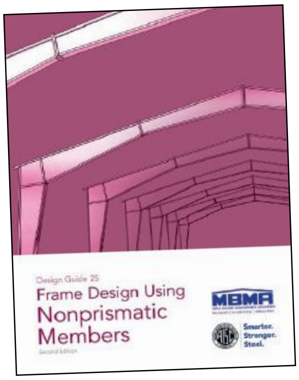
Drafts of the 2022 AISC *Specification for Structural Steel Buildings*, 2022 AISC *Seismic Provisions for Structural Steel Buildings*, and 2022 AISC *Seismic Provisions for Evaluation and Retrofit of Existing Structural Steel Buildings* will be available for public review from January 7 to February 21. Please see **aisc.org/publicreview** for more information and the draft specifications, along with the review forms. (You can also request a hard copy—for a $35 charge—by contacting Martin Downs at **downs@aisc.org**.)

Please submit comments to Cynthia J. Duncan, director of engineering, at **duncan@aisc.org** by February 21. (And if you want to learn more about Cindi and her role in making AISC's various standards and specifications come to fruition, check out this month's Field Notes column "By the Book" on page 23).

DESIGN GUIDES

Second Edition of Design Guide 25 on Nonprismatic Members Now Available

The second edition of AISC's Design Guide 25: *Frame Design Using Nonprismatic Members* is now available. Developed in conjunction with the Metal Building Manufacturers Association (MBMA), this updated guide presents a comprehensive approach to the design of frames using nonprismatic members within the context of the 2016 AISC *Specification* and includes extensive design examples. You can find Design Guide 25 and the rest of AISC's Design Guides at **aisc.org/dg**.



BRIDGES

American Steel Can Be On-Site for Bridge Projects Faster than Other Materials

Recent media reports have bemoaned extended delivery schedules for raw steel. But is this accurate—and is it impacting steel bridge projects?

"Steel projects are still being delivered on schedule," according to Charles J. Carter, SE, PE, PhD, executive director of the National Steel Bridge Alliance (NSBA), AISC's bridge division, and president of AISC.

Carter added that during the past year, lead times have become extended for all construction materials. "Typical lead times for steel plate are in the eight- to 10-week range, while lately we're more likely to see 10 to 12 weeks. However, this shouldn't have a substantial impact on bridge projects, which are usually planned months and even years in advance. In addition, the longer lead times reflect when steel is available directly from mills, but some steel, especially on smaller projects, is actually purchased from steel service centers, which are large warehouses throughout the nation that often stock more than 10,000 tons each and that together stock millions of tons of product and can deliver steel quickly."

Mill sources report that lead times are rapidly returning to pre-pandemic levels, with various mills now quoting lead times between six and 10 weeks depending on the specific product needed.

Recent cases amplify the speed at which the steel industry can respond. For example, when a truck accident and resulting fire damaged the Brent Spence Bridge between Ohio and Kentucky last year, many feared the bridge would be closed for months, if not permanently. But service centers were able to deliver steel to the fabricator in just six days to help get the bridge back in service in just seven weeks. In another well-publicized example, steel was quickly obtained to enable a fast repair on the Hernando de Soto Bridge this year.

Similar extended schedules for concrete and rebar have been reported. Fortunately, thanks to Buy America provisions, steel plate and other structural steel for bridges are widely available from domestic steel mills, so it's not subject to the current delays at ports. And to accommodate the expected increased demand from the recently passed infrastructure bill, the steel industry is rapidly adding capacity, such as the 1.2 million-ton plate mill now under construction in Kentucky and additional upgrades from multiple steel producers. According to steel mill representatives, the industry has sufficient capacity to support both the current and expected future demand for steel.

AISC and its bridge subsidiary, NSBA, recommend talking directly with your regional fabricator. Proper pre-planning and project coordination will often mitigate any supply chain issues, and fabricators can provide reliable timetables for how long a bridge project will take to complete.

Visit **aisc.org/economics** and **aisc.org/nsba** for more information about current economic conditions or talk with an AISC or NSBA steel specialist.


Courtesy of Kentucky Transportation Cabinet

Crews work to repair the Brent Spence Bridge.

ENGINEERING JOURNAL

First Quarter 2022 *Engineering Journal* Now Available

The first quarter 2022 issue of AISC's *Engineering Journal* is now available. (You can access this issue as well as past issues at **aisc.org/ej**.)

Closure: Investigation on the Performance of a Mathematical Model to Analyze Concentrically Braced Frame Beams with V-Type Bracing Configurations
Alireza Asgari Hadad and William Thornton

Comparison of Simple and Advanced Methods of Analysis in the AISC *Specification* for Fire-Resistant Structural Design
Rachel Chicchi and Amit H. Varma

AISC *Specification* Appendix 4 provides criteria to aid in structural design for fire conditions. It includes an advanced method of analysis and a simple method of analysis. A comparison of these methods will be articulated through the analysis of a 10-story steel office building with perimeter moment frames. To conduct the advanced analyses, a three-dimensional finite element method building model was developed using ABAQUS. The simple analyses were conducted using SAP2000, a commercially available structural analysis and design software. A comparison of results from each method of analysis shows that for gravity framing members, the advanced method produced the longest fire-resistance rating. The fire-resistance rating determined from the simple method was more conservative, resulting in a shorter resistance rating. The simple method was also found to be the most conservative approach for the moment-resisting frame members, making it a less desirable method for designing the lateral system for fire than the prescriptive approach. The simple method may be most advantageous for gravity framing applications only and may be overly conservative for considerations of the lateral framing system.

Steel-Plate Composite (SC) Wall–to–Reinforced Concrete (RC) Wall Mechanical Connection, Part 1: Out-of-Plane Flexural Strength
Jungil Seo, Hassan S. Anwar, Amit H. Varma, and Yoonho Nam

In safety-related nuclear structures, steel-plate composite (SC) walls are often used in combination with reinforced concrete (RC) walls or foundations. Appropriate connections are required to transfer force demands from the SC walls to the RC components without the connection failure that is often associated with brittle failure mode. This paper presents a design procedure developed for mechanical connections between SC and RC walls. This procedure implements the full-strength connection design approach in ANSI/AISC N690-18, *Specification for Safety-Related Steel Structures for Nuclear Facilities* (AISC, 2018), which requires connections to be stronger than the weaker of the connected walls. This paper also presents the results from experimental and analytical investigations conducted to verify the structural performance of the full-strength SC-to-RC connection. The focus of this paper is on the evaluation of the performance, strength, and ductility of SC wall–to–RC wall mechanical connections subjected to out-of-plane flexure. The experimentally observed and analytically predicted results verify the conservatism of the proposed design procedure.

Practice-Accessible Methodology for Nonlinear Refined Analysis of Gusset Plate Connections of Steel Truss Bridges
Alireza Mohammadi and Walid S. Najjar

A new approach is proposed for estimating the structural capacity of gusset plate connections of steel truss bridges. The approach involves refined nonlinear analysis of a truss model, consisting of a single truss made of shell elements for two gusset plates at a subject connection and frame elements for truss members. Connectors (bolts or rivets) are excluded from the proposed model to simplify the model, with the knowledge that their associated failure modes can be addressed by simplified design calculations. Only yielding and buckling failure modes of gusset plates are considered. The new approach is calibrated by comparison with laboratory test data from NCHRP Project 12-84. The primary intent of this paper's approach is to reduce the complexity of the refined analysis developed under this NCHRP project and make it more user-friendly to load rating engineers seeking accurate estimation of gusset plate capacity. Based on a limited case study, the proposed refined analysis provides an estimate of gusset plate capacity that is approximately equal to capacity calculated by the truncated Whitmore method of the AASHTO *Manual for Bridge Evaluation* (2018). In other words, the proposed approach validates the truncated Whitmore method as compared to the more conservative partial shear method of the AASHTO *Manual*.

Review of Local Buckling Width-to-Thickness Limits
Ben W. Schafer, Louis F. Geschwindner, Tom Sabol, and Chia-Ming Uang

This paper provides a review of local buckling width-to-thickness limits employed in the ANSI/AISC 360-16 *Specification for Structural Steel Buildings* and ANSI/AISC 341-16 *Seismic Provisions for Structural Steel Buildings*. The review was conducted by a task group formed to address potential changes in the next and/or future editions of the AISC *Specifications*. A comprehensive review of existing local buckling limits was completed, including detailing the underlying assumptions and the objectives of the existing limits. Particular attention was given to the potential impact of adopting newer steel materials. It was found that in AISC 360, some λ_r limits for flexure may not be well aligned with intended objectives, and while all λ_p limits for flexure ensure the plastic moment may be achieved, rotation objectives are not consistently implemented. Review of λ_{md} and λ_{hd} in AISC 341 reveals complications with implementing expected yield stress in the slenderness parameters and highlights the large number of varied objectives for these limits in seismic design, as well as a need for improvements—particularly for deep wide-flange columns. In general, it is found that only minor changes are potentially needed to current *w/t* limits. In most cases, it is expected that AISC design can continue unchanged, with the exception of the improved criteria for deep columns. To minimize change while still expanding opportunity, newer local buckling cross-section classification methods could be permitted as alternatives rather than used as replacements to current *w/t* limits so that advantages of the newer approaches can be utilized when beneficial.

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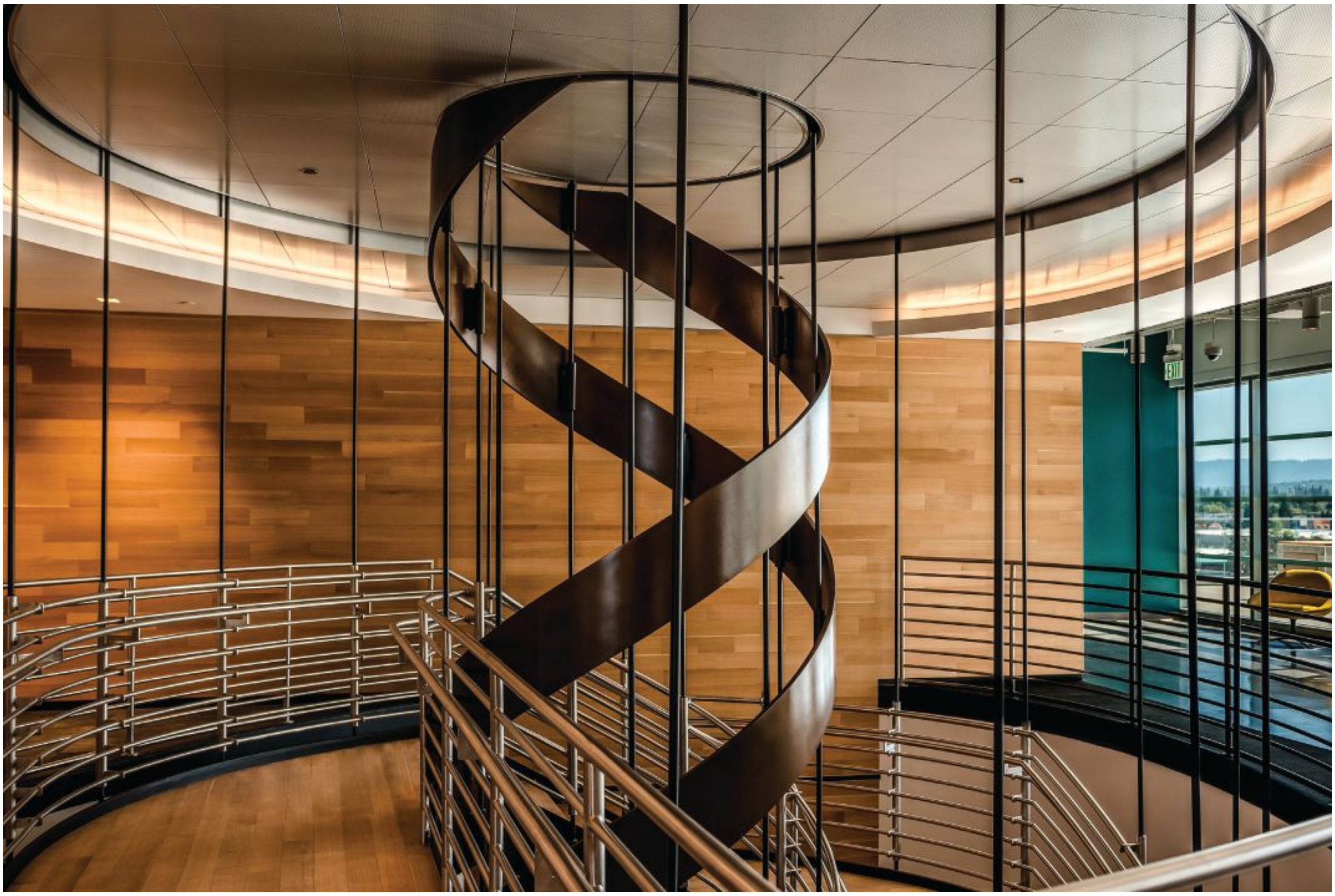

Steel Genetics

WHEN ENVISIONING ITS new San Carlos, Calif., headquarters, biopharmaceutical company ChemoCentryx wanted an eye-catching element with steel in its DNA.

The prescription? A spiraling steel stair wrapped with a double-helix steel ribbon feature, connecting the sixth-floor main entry lobby with the fifth-floor laboratory spaces and offices.

Designed by architect DGA and KPW Structural Engineers, the stair's railing elements are stainless steel while the supporting structural elements are painted black to contrast with the tan/gold color of the ribbon, with curved elements provided by AISC member bender-roller Albina Co, Inc. The flooring on the stair is clad with recycled wood, which is also featured on the wall behind the stair.

Fabricated and erected by AISC member WeSTco Iron Works, the stair accounts for inter-story drift and is fully fixed to the building's fifth-floor framing, extending up to a bridge that frames out of an opening in the sixth floor. This bridge is a rigid truss that supports the top of the stair, laterally tying it into the sixth floor. The entire stair/bridge structure is hung from above with 1-in.-diameter rods located at the inner and outer stringers. ■