Modern
Steel Construction

October 2023

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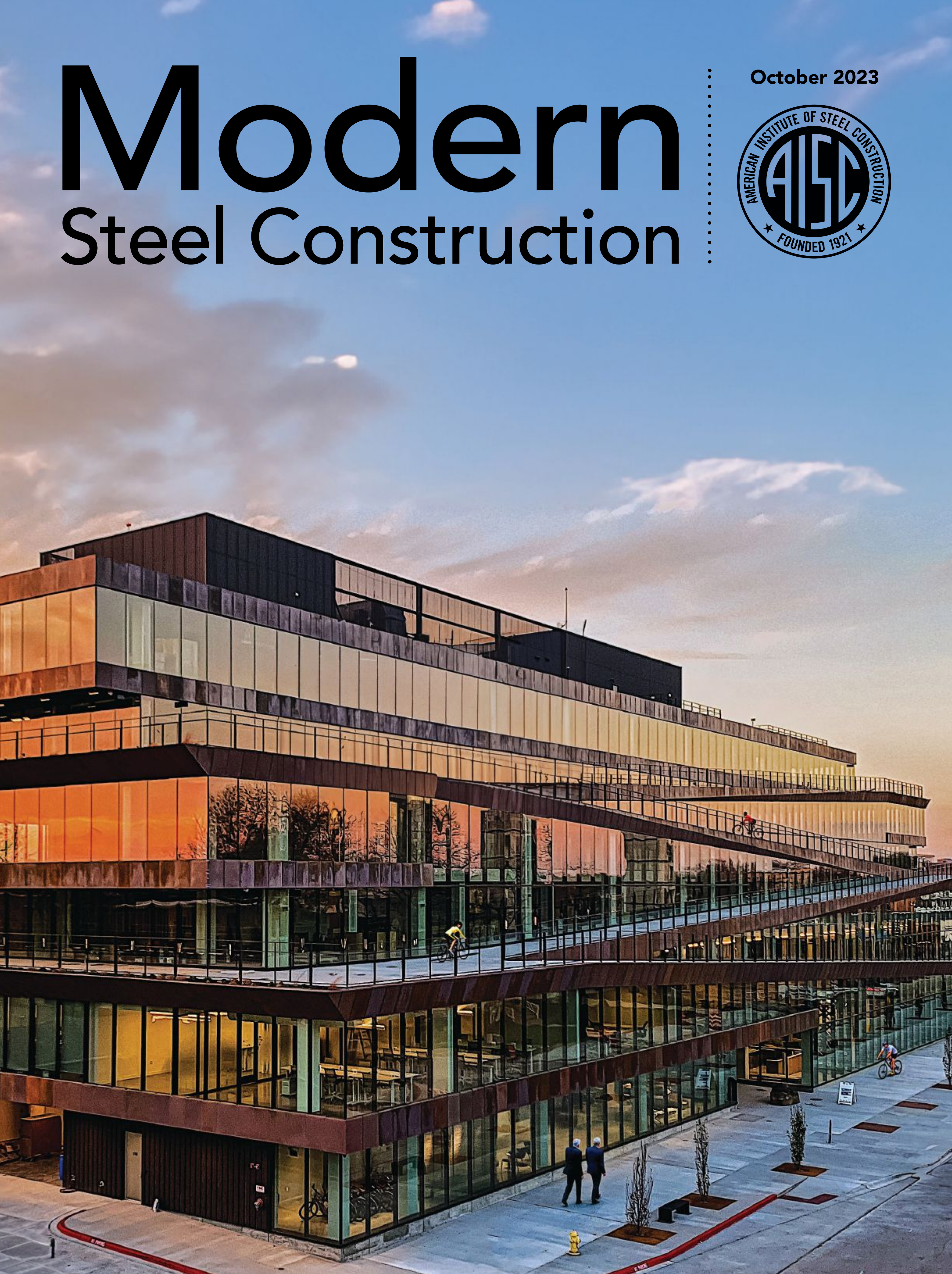


THINK BIG

Modern
Steel Construction

October 2023

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ON THE COVER: Workers are living on the edge—or rather the ledge—at the Ledger building in Bentonville, Ark. (p. 28. (Photo: W&W/AFCO)

MODERN STEEL CONSTRUCTION (Volume 63, Number 10) ISSN (print) 0026-8445: ISSN (online) 1945-0737. Published monthly by the American Institute of Steel Construction (AISC), 130 E Randolph Street, Suite 2000, Chicago, IL 60601. Single issues $8.00; 1 year, $60. Periodicals postage paid at Chicago, IL and at additional mailing offices. Postmaster: Please send address changes to MODERN STEEL CONSTRUCTION, 130 E Randolph Street, Suite 2000, Chicago, IL 60601.

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editor's note

I recently took a trip to Denver, the main goal of which was to drop my son off with my in-laws for a week (which also allowed me to take a trip within a trip to San Diego, but that's a story for another month).

While in the area, we paid a visit to one of the best live music venues anywhere, Red Rocks Amphitheatre. If you've never seen a concert there, I highly recommend putting it on your bucket list. It's such a neat venue that I'll go out on a limb and say it almost doesn't even matter who the performers are. The facility itself and its natural surroundings alone will make the trip worth it. And on top of that, as part of a renovation project, the roof for the stage was replaced a couple of years ago with a beautiful steel-framed structure (which you can't really make out in the photo, but trust me, it's there).

On the tail end of that trip, while we were all in the car on the way to the airport, we noticed a steel pedestrian bridge being transported via truck. My father-in-law commented that it looked rusty—which, of course, became an educational moment. I explained to him the wonders of weathering steel and its protective patina. I also told him that the trade name Corten is to weathering steel what Kleenex is to facial tissues.

If you want to learn your own lessons about bridges, simply keep turning the pages of this issue. You can start with SteelWise, which provides a look at the various steel plate lengths, widths, and thicknesses available for use in steel bridges. From there, you can turn to our Field Notes section and read an interview with Frank Russo, who received a lifetime achievement award at NASCC: The Steel Conference this past April for his work in advancing the state of the art in the analysis and design of bridge engineering, bridge inspection, forensics, and emergency rehab of complex bridge structures.

If you're looking for examples of and lessons learned from successful real-life steel bridge projects, check out the article on the Michigan Department of Transportation's (MDOT) pilot "bundling" project, which involved the rehabilitation or replacement of not one, not two, but 19 bridges across the state, ranging in length from 29 ft to 196 ft. Crucial to completing the pilot project on time was the use of galvanized steel press-brake-formed tub girders (PBFTGs). Tub girders were also the star of another article focusing on a curved steel flyover bridge near Orlando, Fla., that was fabricated with ten tub girder sections and two pier diaphragm box girders.

The issue also includes a look at a collaborative bridge life-cycle assessment (LCA) initiative between NSBA and the National Concrete Bridge Council (NCBC), as well as a new NSBA and Federal Highway Administration (FHWA) document that focuses on evaluating details for susceptibility to constraint-induced fracture.

There's plenty more in this issue, but if you're looking for useful information on bridges, rest assured that we've got you more than covered!

Geoff W

Geoff Weisenberger
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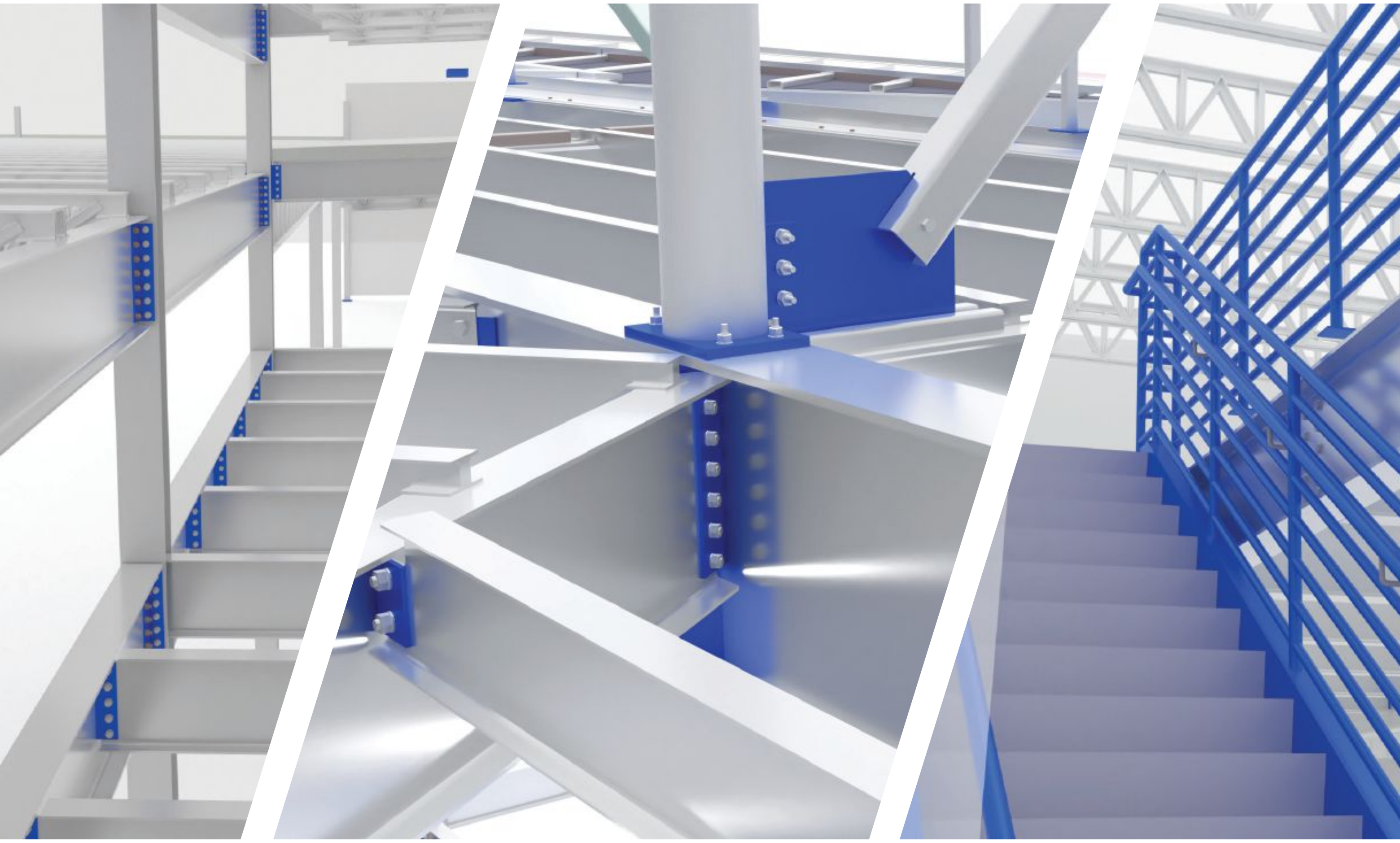


steel interchange

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**.

Sag in Rod Bracing

An architect is concerned about the amount of visible sag in a tension rod brace and is asking if the contractor can tighten the rod to minimize the sag. What guidance does AISC provide regarding tension rod braces, and what other considerations should be made?

Part 13 of the 16th Edition AISC *Steel Construction Manual* states, "Slender diagonal bracing members are relatively flexible and, thus, vibration and sag may be considerations. In slender tension-only bracing composed of light angles, these problems can be minimized with 'draw' or pretension created by shortening the fabricated length of the diagonal brace from the theoretical length, L, between member working points. In general, the following deductions will be sufficient to accomplish the required draw: no deduction for $L \le 10$ ft; deduct $\frac{1}{16}$ in. for 10 ft $< L \le 20$ ft; deduct $\frac{1}{8}$ in. for 20 ft $< L \le 35$ ft; and, deduct $\frac{3}{16}$ in. for $L > 35$ ft. This approach is not applicable to heavier diagonal bracing members, since it is difficult to stretch these members; vibration and sag are not usually design considerations in heavier diagonal bracing members…."

If the rods are detailed and the connections (turnbuckles) are turned to produce the sort of draw described above, then what has been done is consistent with the guidance in the *Manual*.

The magnitude of the draw will affect the tension in the rods, and greater tension in the rod will reduce the sag. However, if you find that the deduction required is going beyond what is recommended in the *Manual*, you may want to evaluate how much tension is being imparted on the structure.

Larry Muir, PE

Available Strengths of Floor Plates

Table 3-17 in the 16th Edition AISC *Steel Construction Manual* provides design information for floor plates and states in the table's discussion that the "tabulated values correspond to a maximum bending stress of 24 ksi in LRFD and 16 ksi in ASD." What safety factors are used to arrive at these values?

The basis for these values has to do with the material that is commonly used to manufacture floor plates. The 24 ksi and 16 ksi values are based on conservative assumptions due to an unknown grade of plate being used in a lot of instances.

Part 2 of the 16th Edition AISC *Steel Construction Manual* provides the following information on raised-pattern floor plates:

"ASTM A786/A786M (ASTM, 2021a) is the standard specification for rolled steel floor plates. As floor-plate design is seldom controlled by strength considerations, ASTM 786/A786M "commercial grade" is commonly specified. If so, per ASTM A786/A786M, Section 5.1.3, "the product will be supplied 0.33% maximum carbon by heat analysis, and without specified mechanical properties." Alternatively, if a defined strength level is desired, ASTM A786/A786M raised-pattern floor plate can be ordered to a defined plate specification, such as ASTM A36/A36M, A572/A572M, or A588/A588M; see ASTM A786/A786M, Sections 5.1.3, 7.1, and 8.1."

Carlo Lini, SE, PE

Two vs. Four Anchor Rods

When is it OK to have a column base plate with only two anchor rods?

Two anchor rods can be used for base plate connections for posts. Part 2 of the 16th Edition AISC *Steel Construction Manual* notes: "Posts (which weigh less than 300 lb) are distinguished from columns and excluded from the four-anchor-rod requirement." Otherwise, the *Manual* states: "All column base plates must be designed and fabricated with a minimum of four anchor rods." Part 2 also summarizes the relevant OSHA requirements.

AISC Design Guide 1: *Base Plate and Anchor Rod Design* (a free download for members at **aisc.org/dg**) provides some additional information on these requirements:

"Historically, two anchor rods have been used in the area bounded by column flanges and web. Recent regulations of the U.S. Occupational Safety and Health Administration (OSHA)—Safety Standards for Steel Erection (OSHA, 2001) (Subpart R of 29 CFR Part 1926)—require four anchor rods in almost all column-base-plate connections, and require all columns to be designed for a specific bending moment to reflect the stability required during erection with an ironworker on the column. This regulation has essentially eliminated the typical detail with two anchor rods except for small post-type structures that weigh less than 300 pounds (e.g., doorway portal frames)."

Carlo Lini, SE, PE

All mentioned AISC publications, unless noted otherwise, refer to the current version and are available at **aisc.org/publications**. *Modern Steel* articles can be found at **www.modernsteel.com**.

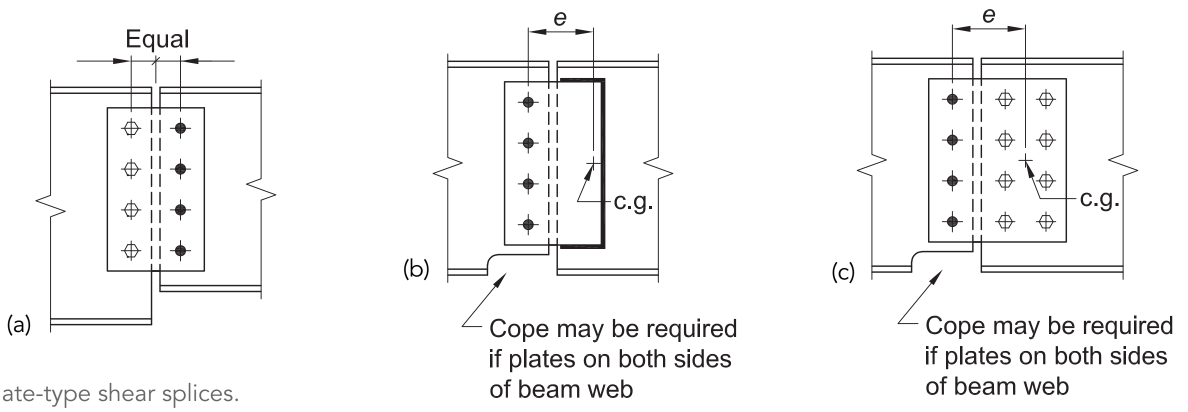


Fig. 10-17. Plate-type shear splices.

Beams Copes Aid Erection

In the 16th Edition AISC *Steel Construction Manual*, there is a note provided in Figure 10-17 (b and c) stating, "Cope may be required only if plates on both sides of beam web." Is this because of connection rigidity? What would happen if the bottom flange is not coped?

The cope shown in Figure 10-17 is required for erection. When the non-coped beam is erected first, the coped beam can be dropped between the two plates during erection.

Bo Dowswell, PE, PhD

Oversized Holes in all Plies (Part 1)

Part of a beam splice connection utilizes bolted web plates at the beam web splice location. The connection was designed as slip-critical to permit the use of oversized bolt holes. The erector is asking if the holes in both the beam webs and splice web plates can be oversized. Is this permitted per the 2022 AISC *Specification*?

Yes. *Specification* Section J3.3 states, "Oversized holes are permitted in any or all plies of slip-critical connections…" A quarter century ago, when it was more common to use oversize holes, joints with oversized holes in all plies were often used. So, it is not unusual for an erector to ask for oversized holes in both the beam webs and the splice web plates. Today, it is less common for erectors to request oversize holes because fabrication practices are much more precise than they once were.

With oversized holes in only one ply, there may be no way of placing a drift pin or larger bolt so that the erector can set the geometry. Thus, some erectors would rather live with standard holes than have oversized holes in only one ply. A compromise position that sometimes is used is to provide oversized holes for most of the bolts in only one ply and provide some (perhaps one or two) standard holes in all plies. The standard holes through all the plies can then be used to hold the geometry, while the oversize holes can allow for some adjustability in the fit-up. If the few standard holes prove to be a problem, these can be reamed until the proper geometry can be obtained. Of course, reaming is precisely what the erector is trying to avoid, but having the potential to ream only a couple of holes may be more acceptable, especially if the alternative is to have oversized holes only in one ply.

Larry Muir, PE

Oversized Holes in all Plies (Part 2)

Would your answer to my first question above change if this beam splice connection needed to meet the requirements of the 2022 AISC *Seismic Provisions*?

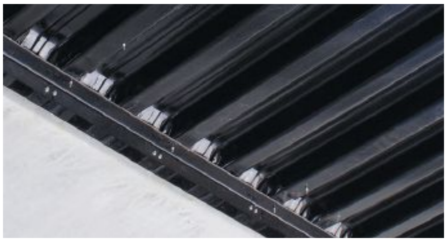
Yes. Section D2.2(c) in the 2022 AISC *Seismic Provisions* (a free download at **aisc.org/publications**) states, "Bolt holes shall be standard holes or short-slotted holes perpendicular to the applied load in bolted joints where the seismic load effects are transferred by shear in the bolts. Oversized (OVS) holes or short-slotted holes are permitted in connections where the seismic load effects are transferred by tension in the bolts but not by shear in the bolts." The seismic provisions provide the following exceptions to these requirements:

> "(1) For diagonal braces, OVS holes are permitted in one connection ply only when the connection is designed as a slip-critical joint.
>
> (2) Alternative hole types are permitted if designated in ANSI/AISC 358, or if otherwise determined in a connection prequalification in accordance with Section K1, or if determined in a program of qualification testing in accordance with Section K2 or Section K3."

Larry Muir, PE

Carlo Lini (**lini@aisc.org**) is the director of the AISC Steel Solution Center. **Bo Dowswell**, principal with ARC International, LLC, and **Larry Muir** are consultants to AISC.

STEEL SOLUTIONS CENTER



steel quiz

Lean on us and test your knowledge of lean-on bracing for steel bridges with this month's Steel Quiz. You can find clues in NSBA's *Lean-on Bracing Reference Guide*, available at **aisc.org/nsba/design-resources/lean-on-bracing-reference-guide**. This month's questions and answers were developed by Jack Zheng, an AISC intern and student at the University at Buffalo.

1 **True or False:** Compared to traditional cross frames, the initial cost of lean-on bracing is slightly higher, but the long-term cost is reduced.

2 The recommended limit of the number of girders per cross frame or diaphragm in a contiguous line, n_{gc}, is:

a. 1 **b.** 4 **c.** 5 **d.** 8

3 Which of the following is a component of the overall stability brace stiffness provided $(\beta_T)_{act}$, per the provisions of AASHTO *LRFD Bridge Design Specifications*, Article 6.7.4.2.2 (**store.transportation.org**)?

a. The brace stiffness of the diaphragm or cross frame
b. The cross-sectional distortion stiffness
c. The effective in-plane girder stiffness
d. a and b
e. All the above

4 **True or False:** Lean-on bracing is generally not recommended for horizontally curved bridges.

5 AASHTO *LRFD Bridge Design Specifications*, Article 6.7.4.2, recommends cross frames and diaphragms depth be at least what percentage of a girder's and rolled beam's depth, respectively?

a. 60% and 75% **b.** 80% and 25%
c. 75% and 50% **d.** 50% and 50%

6 Compared to a traditional cross frame, which of the following is a benefit of lean-on bracings?

a. Improved structural performance and long-term durability
b. Simplified inspections and lower cost
c. Easier fabrication and erection
d. All the above

7 **True or False:** Lean-on bracing provides more stiffness than traditional cross frames, which improves structural performance.

8 **True or False:** If a cross frame or diaphragm is at least 80% of the girder depth and connected to a full-depth connection plate, then the cross-sectional distortion stiffness may be ignored in the calculation of the overall stability brace stiffness provided, $(\beta_T)_{act}$.

TURN TO PAGE 14 FOR ANSWERS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1 **False.** One of the many reasons to adopt lean-on bracing over traditional methods is the reduced cost, both initial *and* long-term. Compared to traditional cross frames, lean-on bracing uses less material and reduces the time required for fabrication and steel erection. This means fewer members to maintain and inspect, yielding reduced long-term costs (*Lean-on Bracing Reference Guide*, Section 1.1).

2 **b.** 4. The number of girders per cross frame or diaphragm in a contiguous line is termed n_{gc}. NSBA recommends n_{gc} be limited to a maximum of 4—i.e., one cross frame/diaphragm per four girders (Section 2.1.3).

3 **e.** All the above. To determine the overall stability brace stiffness provided $(\beta_T)_{act}$, three components are required in the provisions of AASHTO *LRFD Bridge Design Specifications*, 6.7.4.2.2: the brace stiffness of the diaphragm or cross frame in a normal torsional brace system, β_{br}, the cross-sectional distortion stiffness for portions of the web or connection plate above and below the cross frame, β_{sec}, and the effective in-plane girder stiffness, β_g (Section 2.2).

4 **True.** The many benefits of lean-on bracing make it appropriate for straight steel girders with either normal or skewed supports. Lean-on bracing is generally not recommended for horizontally curved bridges or straight skewed bridges with staggered diaphragms or cross frames. The horizontal struts of lean-on bracing are not designed to resist the shear demands resulting from the horizontally curved girders (Section 2.1).

5 **c.** 75% and 50%. AASHTO *LRFD Bridge Design Specifications*, Article 6.7.4.2, recommends that a cross frame's and diaphragm's depth be at least 75% and 50% of a girder's and rolled beam's depth, respectively. A deeper bracing design results in reduced strength demand on the bracing members and improved stiffness in terms of the cross section distortion's (Section 2.1.4).

6 **d.** All the above. The benefits of lean-on bracing include improved structural performance, improved long-term durability, simplified inspection, lower cost, and easier fabrication and erection. The improved structural performance of lean-on bracing is due to its ability to minimize unnecessary brace strength and stiffness. Lean-on brace struts are typically end-bolted to cross frame connection plates that are welded to girders instead of the Category E' details commonly used for most cross-frame ends, resulting in improved fatigue life and long-term durability. The inspection process is simplified thanks to fewer details prone to fatigue cracking and fewer places for corrosion to occur. Lean-on bracing removes multiple welding and handling steps needed for full cross frames, allowing for easier fabrication, and, due to the simplicity of the structural elements, easier erection. All of this factors into both lower initial and long-term costs (Section 1.1.2).

7 **False.** Using lean-on bracing minimizes stiff brace elements when compared to unnecessarily stiff traditional cross frames or diaphragms. Minimizing undesirable stiffness, which can attract undesirable forces, improves structural performance (Section 1.1.2).

8 **True.** For cross frames or diaphragms with a depth of at least 80% of the girder depth and connected to a full-depth connection plate, β_{sec} can be taken as infinity and may therefore be ignored in determining $(\beta_T)_{act}$ per AASHTO *LRFD Bridge Design Specifications*, Article 6.7.4.2.2 (Section 2.2).

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STEEL SOLUTIONS CENTER

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**.


It's a New Era in Detailing

Steel Plate Availability for Highway Bridges

BY CHRISTOPHER GARRELL, PE, AND TRAVIS HOPPER, PE

An overview of plate sizes commonly produced by domestic mills.

A QUESTION MANY ENGINEERS encounter when designing highway bridge structures is the availability of various plate lengths, widths, and thicknesses. The possibilities and options can seem infinite and overwhelming. However, understanding the availability of plate material while performing design iterations will ensure that the material specified can be readily sourced from domestic steel mills, which usually yields improved fabrication speed and better economy for the overall bridge superstructure.

The information listed in this article is not intended to be an all-encompassing summary of available plates that a mill may be able to produce. It is intended to provide an overview of where the thicknesses, widths, and lengths produced by each mill intersect with one another resulting in the greatest dimensional availability (Figure 1). Other widths, thicknesses, and lengths may be available from one or more of these producers. In cases where a dimension is not shown, one should consult the steel mill or a local steel bridge fabricator. More information can be found on the AISC Certification page under "Find a Certified Company" page (**aisc.org/certification**). Alternatively, feel free to contact an NSBA Regional Bridge Steel Specialist (see sidebar on page 19). The AISC Steel Solutions Center can also assist you by phone at 866.ASK.AISC and online at **aisc.org/solutions**.

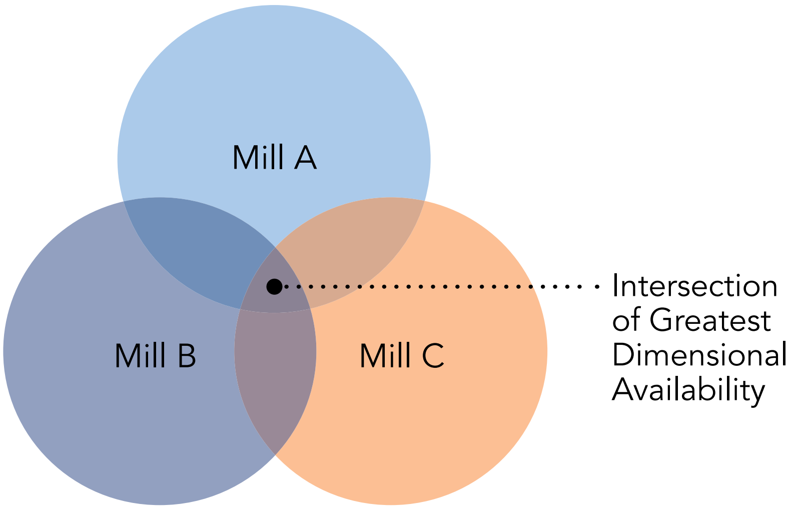


Fig. 1. Rationalization of plate thickness, width, and length availability.

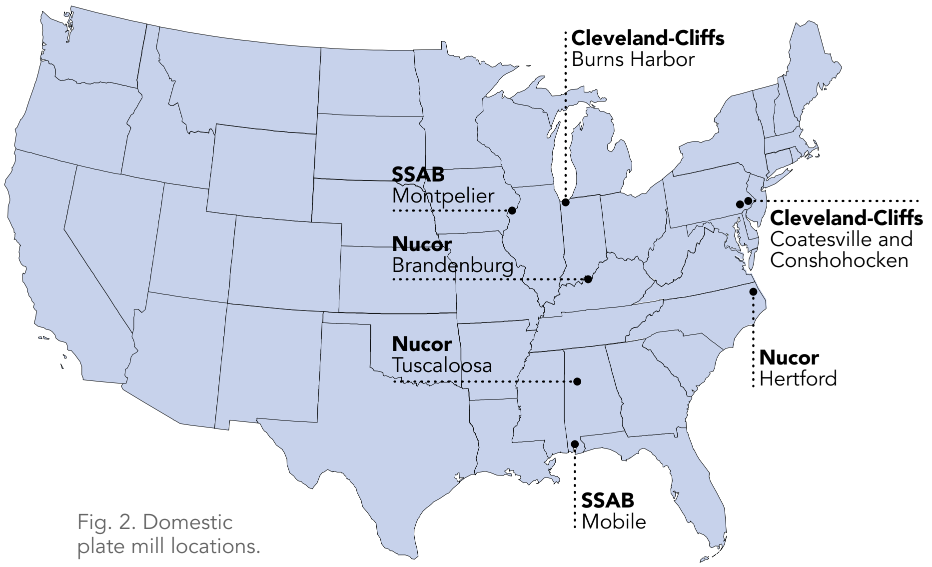


Fig. 2. Domestic plate mill locations.

Domestic Mills

Currently, there are three domestic plate producers in the United States: Cleveland-Cliffs, Nucor, and SSAB. While most steel plate mills are located within the eastern third of the United States, as shown in Figure 2, the proximity of a mill to a physical project bridge will not negatively influence availability or material cost.

Usable Area

The plate from which each component of a steel plate girder is cut and fabricated is sometimes referred to as a "source" plate. Steel plate may be received by the fabricator with a "mill edge"and have some variability of squareness. In this case, the source plate will be trued, and the fabricator reduces the net usable area. We surveyed several bridge fabricators to get a sense of how much material is typically removed from a source plate prior to fabricating a girder.

Keep in mind that these values can vary and depend on a fabricator's capabilities and equipment. All told, we found that the width of the plate will typically be reduced anywhere from ¾ in. to 2 in., while the length is reduced from 1 in. to 2 in, per edge.

When laying out pieces, fabricators must also account for "kerf"—the width of a cut or width of a material that is removed in the cutting process. The fabricators surveyed indicated that kerf is typically assumed to be a ¼ in. for each cut. It should be noted that fabricators will often err on the side of caution and may cut flanges anywhere from ¼ inch to 3⁄8 inch wider than specified by the engineer. See Figure 3 for a depiction of these fabrication losses.

When stripping flanges, a fabricator will optimize the layout to maximize the number that can be obtained from a single width of plate (Figure 3). However, the net available area in this case is reduced by the material lost to squaring the plate and *n*-1 cuts (where *n* represents the number of flange plates that can be cut from a single mother plate).

Not all bridge girders are straight, and some must be horizontally curved. In this case, a fabricator will take one of two approaches. They will build the girder to its final curved geometry by cut-curving the flanges or build it straight and introduce curvature with heat. A combination of strip heating and V-heating may be utilized to achieve the proper curvature (Figure 4). Heat curving is a well-established method, and it does not adversely affect the material properties of the girder when following maximum heat guidelines. It's often the more economical way to fabricate a steel bridge. Bans on heat curving should not eliminate horizontally curved girders entirely, as the girders can be fabricated using cut-curving techniques for the flanges instead (Figure 5). There is, though, potential for more wasted material when cut-curving.

Additional material may also need to be removed to create a haunch and camber. Consider a haunched girder. Assuming the designer did not want to introduce a horizontal splice in the web, the maximum haunch depth would be controlled by the width of the source plate it was fabricated from and the material loss due to the cutting and squaring process (Figure 6).

While it is not entirely necessary for an engineer to include optimization of plate usage into their design process, understanding how design decisions may affect the size and number of plates purchased by a fabricator to accommodate the design is important. At a minimum, an engineer should be conscious of how chosen sizes compare to the length and width boundaries of available steel plate, as a mere inch may force a fabricator to the next larger available plate size. In turn, this could increase material waste and reduce availability.

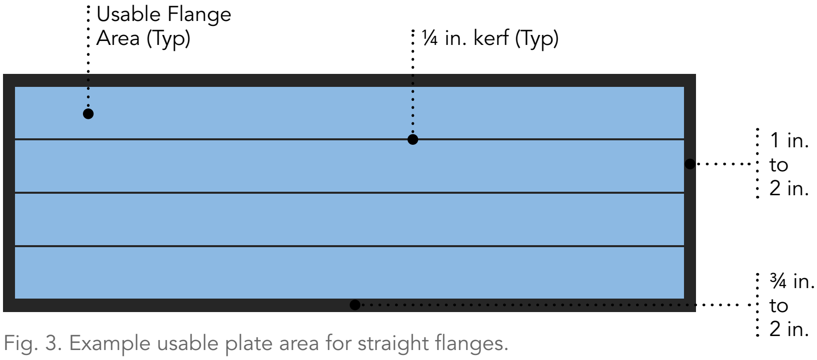


Fig. 3. Example usable plate area for straight flanges.

Fig. 4. Example Heat Curving Process.

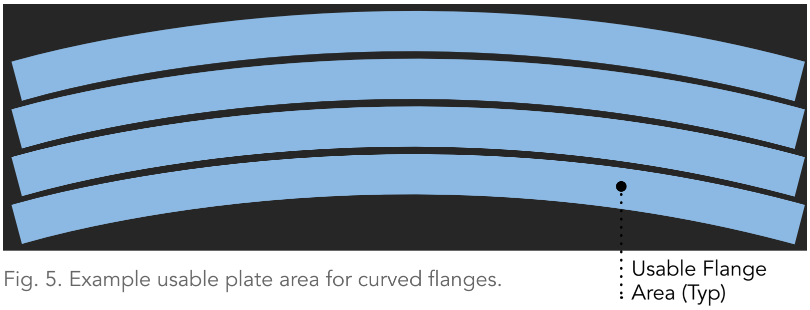


Fig. 5. Example usable plate area for curved flanges.

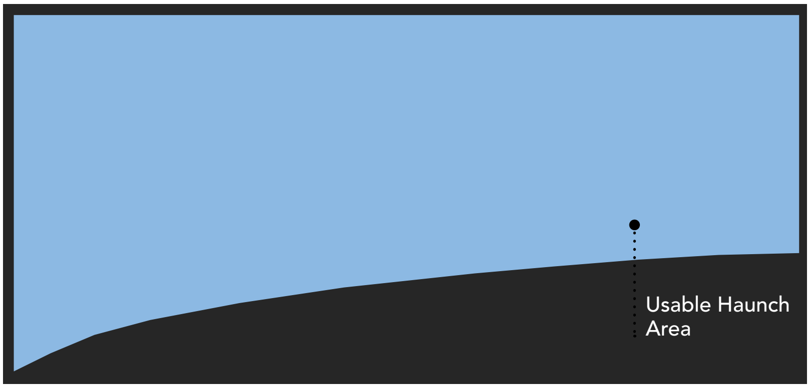


Fig. 6. Usable plate area for a haunch web.

A709 Availability

The plate availability for Cleveland-Cliffs, Nucor, and SSAB were compiled so that the common widths and thicknesses could be tabularized. While the capability of some steel mills exceeds what is shown, the main purpose is to summarize common sizes. Common grades of steel used for highway bridges include:

- ASTM A709/A709M Grade 50 and 50W
- ASTM A709/A709M Grade HPS 50W
- ASTM A709/A709M Grade HPS 70W
- ASTM A709/A709M Grade HPS 100W
- ASTM A709 Grade 50CR

Several of these grades are less common than others, some with only one domestic producer. However, providing information for less common grades is not to discourage their use, but rather to be transparent so that engineers can make informed decisions during design.

The information provided is for use in Load Path Redundant Members (LPRMs), or what have historically been referred to as non-Fracture Critical Members (non-FCMs). The availability of steel for System Redundant Members (SRMs), Internally Redundant Members (IRMs), and Nonredundant Steel Tension Members (NSTMs)—formerly Fracture Critical Members (FCMs)— is often similar to that of LPRMs, but this should be confirmed with a local steel bridge fabricator during design. To prevent brittle fracture of NSTMs, the steel used to fabricate NSTMs must demonstrate a higher fracture toughness at a higher testing frequency than that used for LPRMs by meeting the appropriate Charpy V-notch (CVN) impact energy requirements and test

Table 1
Plate Thickness Availability by Steel Grade (inches)

Thickness	A709 Grade 50 & 50W	A709 Grade HPS 50W	A709 Grade HPS 70W	A709 Grade HPS 100W
3⁄16	◐	◐	◐	◐
¼	●	●	◐	◐
5⁄16	●	●	◐	◐
⅜	●	●	◐	◐
7⁄16	●	●	◐	◐
½	●	●	◐	◐
9⁄16	●	●	◐	◐
⅝	●	●	◐	◐
11⁄16	●	●	●	◐
¾	●	●	●	◐
13⁄16	●	●	●	◐
⅞	●	●	●	◐
1	●	●	●	◐
1⅛	●	●	●	◐
1¼	●	●	●	◐
1⅜	●	●	●	◐
1½	●	●	●	◐
1¾	●	●	●	◐
2	●	●	●	◐
2¼	●	●	◐	◐
2½	●	●	◐	◐
2¾	●	●	◐	◐
3	●	●	◐	◐
3¼	◐	◐	◐	◐
3½	◐	◐	◐	◐
3¾	◐	◐	◐	◐
4	◐	◐	◐	◐

Table 2
Plate Width Availability by Steel Grade (inches)

Width	A709 Grade 50 & 50W	A709 Grade HPS 50W	A709 Grade HPS 70W	A709 Grade HPS 100W
48	◐	◐	◐	◐
54	◐	◐	◐	◐
60	◐	◐	◐	◐
66	◐	◐	◐	◐
72	●	●	●	◐
75	●	●	●	◐
78	●	●	●	◐
81	●	●	●	◐
84	●	●	●	◐
87	●	●	●	◐
90	●	●	●	◐
93	●	●	●	◐
96	●	●	●	◐
99	●	●	●	◐
102	●	●	●	◐
105	●	●	●	◐
108	●	●	●	◐
111	●	●	●	◐
114	●	●	●	◐
117	●	●	●	◐
120	●	●	●	◐
123	◐	◐	◐	◐
126	◐	◐	◐	◐
129	◐	◐	◐	◐
132	◐	◐	◐	◐
135	◐	◐	◐	◐
138	◐	◐	◐	◐

● Readily available from three domestic mills
◐ Readily available from two domestic mills
◔ Readily available from one domestic mill
○ Not readily available

ferquency defined in the AASHTO *LRFD Bridge Design Specifications* and ASTM A709. Special production processes and additional internal testing are often necessary for mills to produce steel that meets the more stringent CVN and other requirements for NSTMs, and those may have different plate size capabilities than what's used for LPRM plate production.

Thickness Availability

For the steel mills with information available at the time of printing, thicknesses range from $\frac{3}{16}$ in. through 4 in. The AASHTO *LRFD Bridge Design Specifications* limit the thickness of material used for structural applications to 4 in. Thickness availability is indicated in Table 1 on page 18 using a color scale corresponding to the number of domestic mills.

Width Availability

Similarly, widths from all the surveyed steel mills were tabulorized to compare availability. A range from 48 in. through 138 in. is shown in Table 2. While wider plates are available, the number of steel mills that can produce them decreases to a single provider. Like thickness, available widths are indicated by a color scale in Table 2 on page 18.

Standard industry widths are 72 in., 96 in. and 120 in. Outside these standard widths, the ability for a mill to supply the plate may become a consideration. When possible, consolidation will be performed to minimize the number of non-standard widths, which will make steel more economical. Otherwise, a special heat sequence, which can equate to a minimum order size, may be necessary to provide plate outside the standard industry widths.

NSBA Resources

NSBA's regional specialists are the primary liaisons between NSBA and the bridge design and construction community. They assist fabricators, designers, and owners in making the best bridge design selections possible. In addition, NSBA staff provide steel superstructure technical assistance and technical reviews at various stages of drawing completion. To view a list of NSBA staff members, please visit **aisc.org/nsba/about**.

Thickness, Width and Length Charts

The availability of different steel plate thicknesses and widths is important when choosing plate girder cross sections. However, the piece lengths and locations of splices will be affected by the length of plate that steel mills can provide. Maximum plate dimensions (i.e., thickness, width, length) are set by the maximum individual piece weight, which is a function of mill handling capabilities. In turn, the maximum plate length from a steel mill is a function of both plate width and thickness. Table 3 through Table 6 present maximum plate length availability for the common bridge steel grades.

In the tables, the associated lengths for

Table 3
Maximum Plate Length Availability (inches) – ASTM A709 Grade 50 & 50W

Plate Thickness	Plate Width—Grade 50 & 50W								
	72	78	84	90	96	102	108	114	120
⅜	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034
½	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034
9⁄16	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034
⅝	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034
¾	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034	1,034
⅞	1,034	1,034	1,034	1,034	1,034	1,034	1,026	972	923
1	1,034	1,034	1,034	1,034	1,034	1,030	980	680	680
1¼	1,034	1,034	1,034	1,034	1,034	1,034	790	680	680
1½	1,034	1,034	1,034	1,034	1,034	1,034	720	680	680
1¾	1,034	1,034	1,034	1,034	1,034	995	720	680	680
2	1,034	1,034	1,034	1,034	1,034	930	720	680	680
2¼	1,034	1,034	980	1,034	975	865	720	680	680
2½	1,034	1,034	975	925	875	825	720	680	680
2¾	1,034	975	900	850	800	720	700	650	625
3	970	900	825	775	725	675	650	600	575

Table 4
Maximum Plate Length Availability (inches) – ASTM A709 Grade HPS 50W

Plate Thickness	Plate Width—Grade HPS 50W								
	72	78	84	90	96	102	108	114	120
⅜	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224
½	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224
9⁄16	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,224
⅝	1,224	1,224	1,224	1,224	1,224	1,224	1,224	1,190	1,130
¾	1,224	1,224	1,224	1,224	1,224	1,224	1,197	1,134	1,070
⅞	1,224	1,224	1,224	1,224	1,154	1,086	1,026	972	923
1	1,224	1,224	1,154	1,077	1,010	950	897	850	808
1¼	1,224	994	923	861	808	760	718	680	646
1½	1,077	995	924	862	808	761	718	680	646
1¾	924	852	792	739	693	652	616	583	554
2	808	746	693	646	606	570	539	510	485
2¼	718	663	616	575	539	507	479	454	431
2½	646	597	554	517	485	456	431	408	388
2¾	588	542	504	470	441	415	392	371	353
3	539	497	462	431	404	380	359	340	323

The following key should be referenced when using Table 3 through Table 6:

- ● Readily available from three domestic mills
- ◐ Readily available from two domestic mills
- ◔ Readily available from one domestic mill
- ○ Not readily available

Table 5
Maximum Plate Length Availability (inches) – ASTM A709 Grade HPS 70W

Plate Thickness	Plate Width—Grade HPS 70W								
	72	78	84	90	96	102	108	114	120
⅜	600	600	600	600	600	600	600	600	600
½	600	600	600	600	600	600	600	600	600
9⁄16	600	600	600	600	600	600	600	600	600
⅝	600	600	600	600	600	600	600	600	600
¾	600	600	600	600	600	600	600	600	600
⅞	600	600	600	600	600	600	600	600	600
1	600	600	600	600	600	600	600	600	600
1¼	600	600	600	600	600	600	600	600	600
1½	600	600	600	600	600	600	600	600	600
1¾	600	600	600	600	600	600	600	583	554
2	600	600	600	600	600	570	539	510	485
2¼	600	600	600	575	539	507	479	454	431
2½	600	597	554	517	485	456	431	408	388
2¾	588	542	504	470	441	415	392	371	353
3	539	497	462	431	404	380	359	340	323

Table 6
Maximum Plate Length Availability (inches) – ASTM A709 Grade HPS 100W

Plate Thickness	Plate Width—Grade HPS 100W								
	72	78	84	90	96	102	108	114	120
⅜	540	540	540	540	540	540	540	540	540
½	540	540	540	540	540	540	540	540	540
9⁄16	540	540	540	540	540	540	540	540	540
⅝	540	540	540	540	540	540	540	540	540
¾	540	540	540	540	540	540	540	540	540
⅞	540	540	540	540	540	540	540	540	540
1	540	540	540	540	540	540	540	540	540
1¼	540	540	540	540	540	540	540	540	540
1½	540	540	540	540	540	540	540	540	540
1¾	540	540	540	540	540	540	540	540	540
2	540	540	540	540	540	540	540	540	540
2¼	540	540	540	540	540	540	540	540	540
2½	540	540	540	540	540	540	540	540	540
2¾	540	540	540	540	540	540	540	540	540
3	540	540	540	540	540	540	540	540	540

each mill at each common thickness and width were reviewed. The minimum length for the group was then used to create Table 3 through Table 6. While in some instances, mills can produce longer pieces, the length values shown above ensure that if one chooses from this table, a fabricator can obtain the plate from one of the mills, where available.

Closing

This summary of steel plate availability may help ease part of the process of designing steel plate girder highway bridges. Further information regarding best practices can be found in the AASHTO/NSBA Steel Bridge Collaboration document G12.1: *Guidelines to Design for Constructability and Fabrication*. That and other similar documents can be found at **aisc.org/nsba-collab-guidelines**. ■

Plate availability is expected to change in the future as mills expand their capabilities. This article represents capabilities at press time. For the most up-to-date information, refer to the NSBA plate availability page at ***aisc.org/nsba/design-and-estimation-resources/plate-availability****.*

The authors would like to thank David Stoddard with SSAB Americas, Julie Villarreal and Jeff Webb with Cleveland-Cliffs, and Jason Lloyd with Nucor for their assistance collecting plate information and providing review.

Chris Garrell (**garrell@aisc.org**) is NSBA's chief bridge engineer and **Travis Hopper** (**hopper@aisc.org**) is the bridge steel specialist in AISC's Steel Solutions Center.

The Big Picture

BY BRIAN RAFF

When it comes to the overall economy and the steel industry in particular, it's rarely all good or all bad news. The truth is always somewhere in between.

AS HUMANS, WE'RE HARDWIRED to pay more attention to negative rather than positive information.

"Many psychologists think that this has evolutionary roots," said Laura Carstensen, a psychology professor at Stanford University. "It's more important for people, for survival, to notice the lion in the brush than it is to notice the beautiful flower that's growing on the other side of the way."

Despite the headlines that you may have read over the past year about steel price increases, I'm here to counter your negativity bias and inform you that the steel industry announced its fourth wide-flange price reduction in nearly a year. Last summer, the price of a typical W14×68 section was $1,530 per ton. In just 13 months, the price of that same typical section has fallen more than 15% to $1,295 per ton.

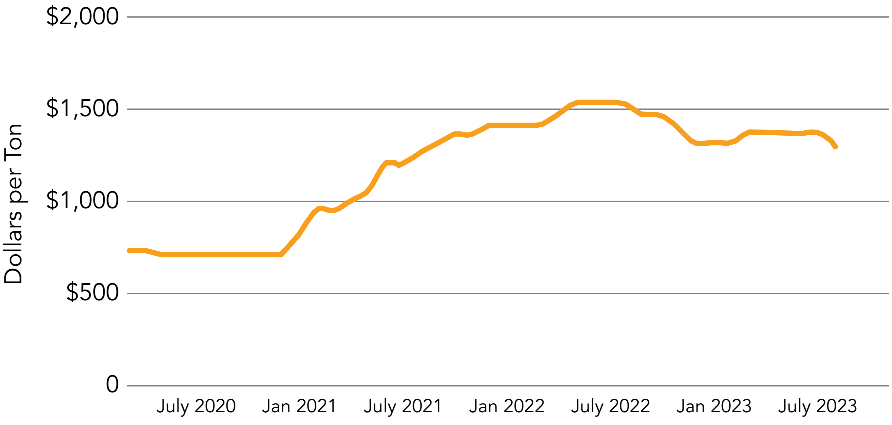
Now that I've told you the good news about steel prices, it's important that we consider the not-so-good things happening in the overall U.S. economy (which hopefully doesn't outweigh the good).

The most recent U.S. Recession Probability (I:USRPEM) chart shown below, a financial indicator that measures the likelihood of a recession in the United States, is predicting a 66% chance that the U.S. economy will experience a recession by July 2024. This recession probability indicator calculated by the New York Fed uses a variety of economic data, including GDP growth, unemployment rates, and stock market performance.

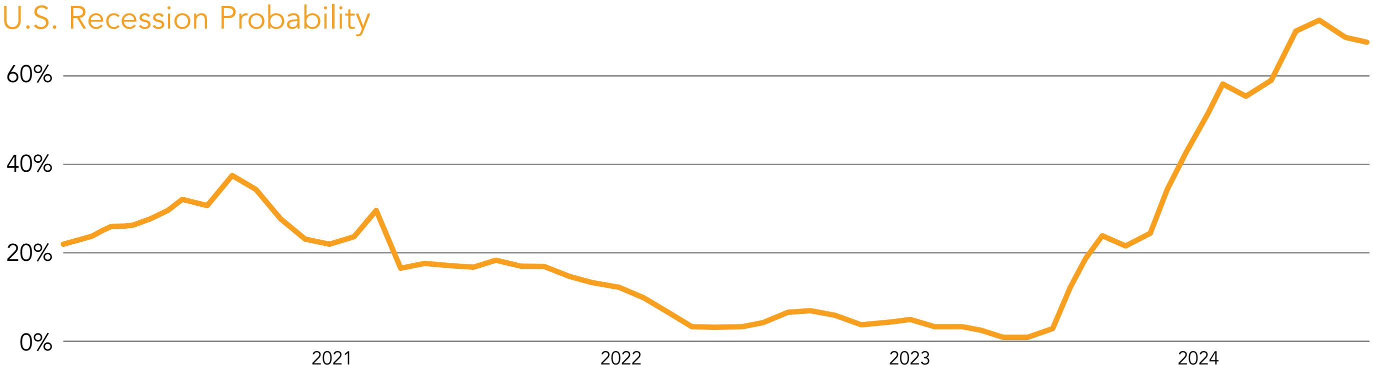
There are plenty of other predictive models, like the Leading Economic Index (LEI) from the Conference Board, that forecasts a short and shallow recession in the Q4 2023 to Q1 2024 timespan. Other sources, including the Associated General Contractors of America (AGC), don't anticipate a recession. But as we've seen in the past, consensus on such topics is exceedingly rare.

According to Justyna Zabinska-La Monica, senior manager of business cycle indicators at the Conference Board, "The US LEI—which tracks where the economy is heading—fell for the sixteenth consecutive month in July, signaling the outlook remains highly uncertain. On the other hand, the coincident index (CEI)—which tracks where economic activity stands right now—has continued to grow slowly but inconsistently, with three of the past six months not changing and the rest increasing. As such, the CEI is signaling that we are currently still in a favorable growth

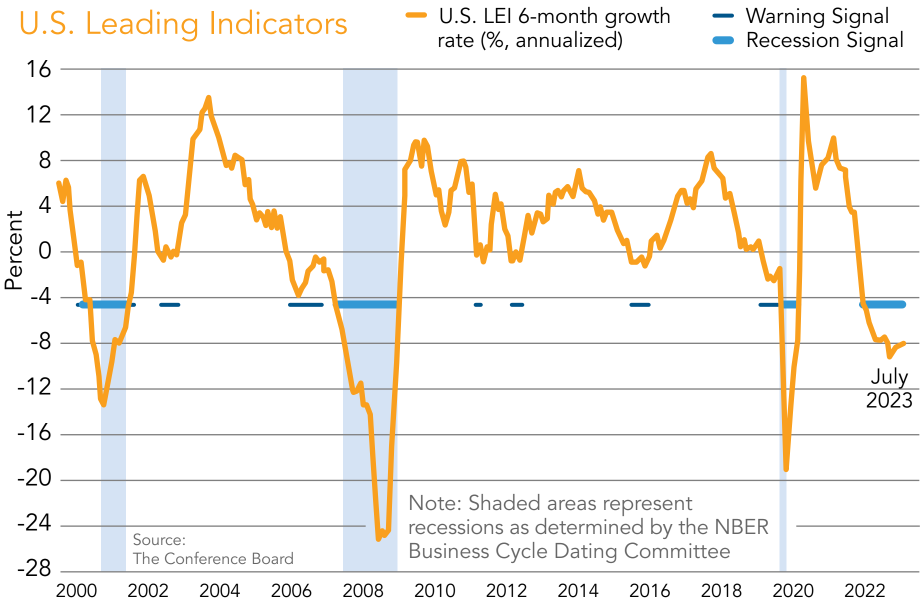
Typical Mill Pricing W14×68



U.S. Recession Probability



environment. However, in July, weak new orders, high interest rates, a dip in consumer perceptions of the outlook for business conditions, and decreasing hours worked in manufacturing fueled the leading indicator's 0.4% decline. The leading index continues to suggest that economic activity is likely to decelerate and descend into mild contraction in the months ahead.”

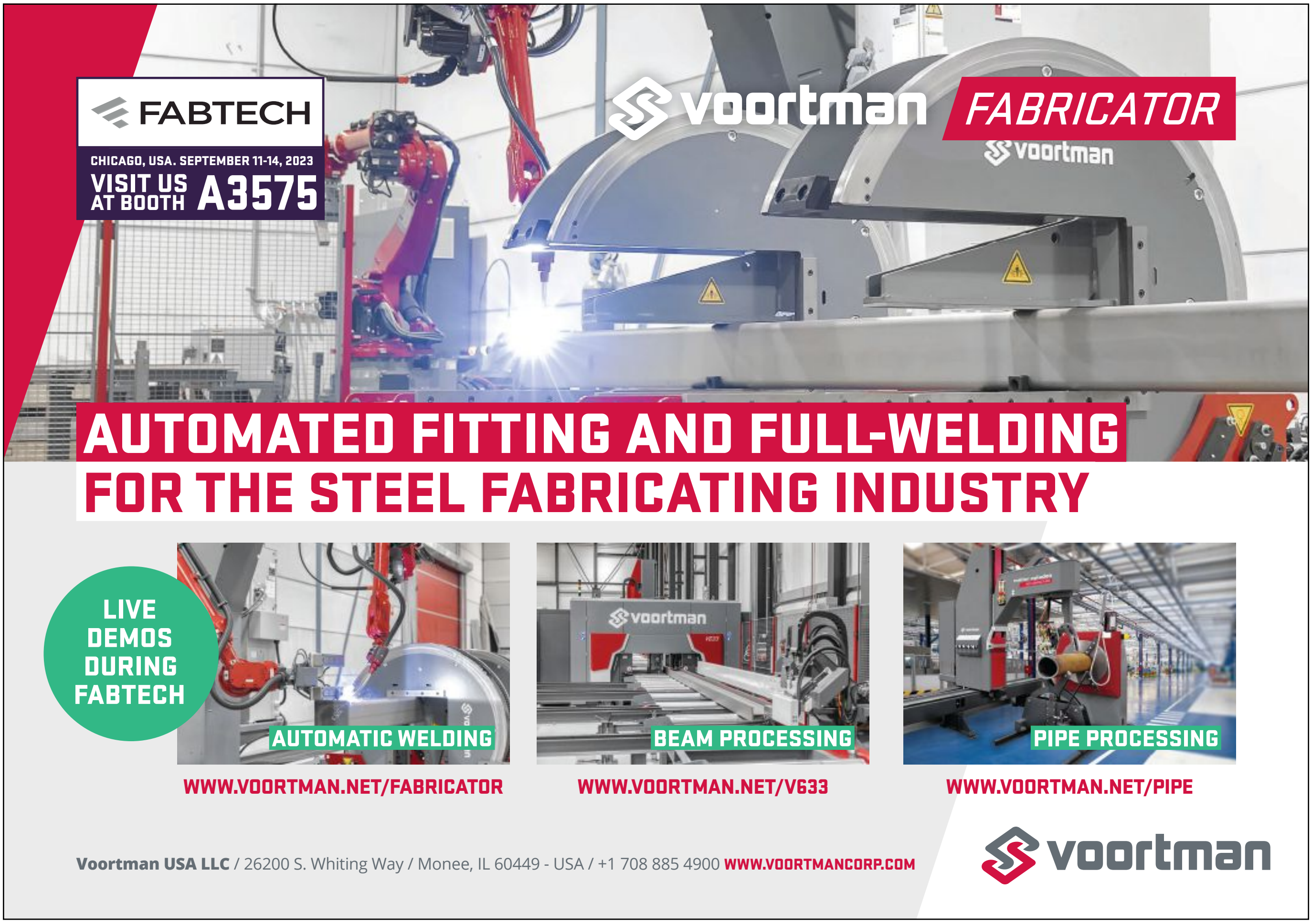


Source: The Conference Board

Note: Shaded areas represent recessions as determined by the NBER Business Cycle Dating Committee

All of this is to say that falling steel prices present a welcome change to the structural steel industry. And, of course, by the time you read this article, steel prices may have fluctuated greatly from what's printed here. Just be sure not to make any financial decisions based on the beautiful flower in front of you while ignoring the lion that remains hidden in the brush. ■

Brian Raff (**raff@aisc.org**) is AISC's vice president of market development, marketing communications, and government relations.



A Bridge Lifer

INTERVIEW BY GEOFF WEISENBERGER

Frank Russo has spent more than two decades in bridge design, rehabilitation, and construction. Now he's two years into his greatest challenge yet: starting and running his own company.

FRANK RUSSO bet on himself at age 50. He bet on nearly 30 years of structural engineering expertise and impressive credentials. On decades of experience rehabbing and building bridges. On his leadership skills and vision for a company that had yet to be tested.

Russo left his post at infrastructure engineering company Michael Baker in 2021 to start his own firm, called Russo Structural Services.

So far, the new venture has treated him well. Russo received a lifetime achievement award at NASCC: The Steel Conference this past April for his work in advancing the state of the art in the analysis and design of complex bridge engineering, bridge inspection, forensics, emergency rehab of complex bridge structures, and bridge education.

In a recent interview, we discussed his career path, how he became an expert in bridge rehabilitation projects, why he felt compelled to launch his own company, and more.

Russo (center) with AISC Board Chair Steve Knitter and AISC president Charlie Carter.

Chris Jenkins

What brought you into the world of engineering?

I grew up around it. My father was a civil engineer, a land surveyor, and a bridge engineer. As a kid, I remember working with him. It was one of those things that I didn't necessarily know exactly what I was going to do, but push comes to shove, and it was time to pick a major. Civil engineering it was!

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**.

But still, I didn't know what that was going to be. I thought I was going to be the guy that did high-rise buildings—sort of aspirational. Then things just evolved. You wind up working for your dad in the business, and it becomes a 30-year career in bridges.

When you got out of school, did you go directly to work for him?

While I was in college, I was summer help. I was his first employee at one of the regional offices we opened. I worked for him through the first two years of graduate school as well. Then I moved away, got my PhD at Iowa State University, came back, and have been in the private sector since March 2000.

After graduate school, did you start with your own firm right away?

I worked full-time for the Iowa Department of Transportation in the Office of Bridges while I got my PhD. It was really a formative five years of education and work at the same time. I had two kids along the way as well. It's not really the recipe for how to do it, but somehow we got through.

Then I went into the private sector and worked for URS for four years—they're now part of AECOM—HNTB for half a dozen years, then 11 years with Michael Baker. When I left, I was the national technical director of bridges. Then I started my own firm in September 2021.

What prompted you to strike out on your own, so to speak?

I wish there was a great idea. I wish there was a great story. It was just one of these things that I had thought about and thought about for a number of years. I got to be the ripe old age of 50, and my wife got tired of me talking about it. She put it in my head and said, "You better just go ahead and do this."

There was reluctance, of course, as the father and the supporter of the family.

You're always reluctant to walk away from a really good job and great people, which is what I had at Michael Baker, an absolutely wonderful group of collaborators and coworkers. But I just decided I was going to try it. It was either going to work and I'd be successful, or it wasn't going to work and I would go find a job someplace.

You definitely didn't want to not try it and regret that.

As I like to proverbially say, I actually did stand and look in the mirror and have thoughts and conversations. I didn't want to be the guy that stood and looked in the mirror and decided against trying it for much longer.

Were there challenges with starting up a brand-new company?

The advantage of working for a really large company is that you have people. You have support. There are people to handle things. The disadvantage of working for a big company is you get dragged into a whole bunch of things that are sometimes a distraction from the things you want to focus on. Now you go on your own, and the pluses and minuses are all of your own doing. The successes and the failures, the same guy in the mirror is responsible for both.

Throughout your career, you've had countless projects, but is there one that comes to mind right away that stands out as a good lesson?

I had the chance with my colleagues at Michael Baker to participate in a number of major steel bridge rehabilitation, repair, and emergency response projects. That includes the emergency response and rehabilitation of the Sherman Minton Bridge, which carries I-64 over the Ohio River and into Louisville. That was our first major response. That was back in 2011. Then we spent about a year and a half rehabilitating the Hoan Bridge in Milwaukee, famous for a near-collapse back around 2000.

We weren't involved in [the collapse], but we were involved in the major rehabilitation. I led the major rehabilitation and design of a couple of miles of all-steel structure right along the waterfront of Milwaukee, right across from the Summerfest property. That really raised the roof on Summerfest. Summerfest is right next to that big bridge that looms overhead.

Then I was involved in the emergency rehabilitation of the Delaware River Bridge for the Pennsylvania-New Jersey Turnpike. My last major project before leaving Michael Baker was the emergency response and rehabilitation of the Hernando de Soto Bridge, which crosses the Mississippi River in Memphis. Every one of those projects was taking a very important and critical lifeline steel structure that's essential to our communities nationwide, and demonstrating that we could either fix a problem or we could rehabilitate an existing structure to get many decades of future service life out of what are otherwise good structures in good shape.

The common thread through there is rehabilitation. How did you get into that side of bridge design?

It just comes to you. The phone call comes, and somebody needs some support. At that moment, you don't decide that you'd rather be designing another thing that might go on the cover of *Engineering News-Record* someday or grace the pages of *Modern Steel Construction*.

Our job as engineers is to be a steward of the taxpayers' dollars, at least in the part of the business that I work in—the transportation business. My own responsibility is to be responsible for your money. I look at it like it's my own money. Is this how I want to be spending my own money, my children's money, my friends and family's money? Very commonly, it comes down to that a really smart rehabilitation might be the most expedient thing to do. I just gravitated toward fixing and extending the service life of existing bridges.

I'm guessing you're starting to see more drones in inspection and rehabilitation?

That has definitely been a focus of increased attention over the past five years or so. It started out as, "Well, it's cute. Let's try it." Now what you really find is people are under the impression that a human being won't go inspect the bridge, that somebody else will just go out there, fly something around and take some pictures.

That's really not the way it goes, because our federal requirements that govern our inspection program really aren't set up to allow for a robotic drone to go out and do it. But they become really valuable assistance to the human beings that are doing the inspections. The way that the technology might be integrated into an inspection right now is that the drone goes out with the inspectors every two years and captures footage, captures pictures, and that can be used for archival and for tracking the change of conditions over time.

It's also used on really large structures to first get good eyeballs on the areas of the bridge that really need the inspectors' attention, because you're not likely going to crawl every inch of it if you don't have to. You catch it with the drone and then the inspector knows, "I have to go to this location on this cable, this location on the truss, put some hands on it and really figure out what's going on."

Not so much a replacement of human inspection, but just a supplement.

It becomes augmented. I grew up with my dad in the business, and I remember many, many years ago he and I talking about something and he pointed to a hammer. He said, "Frankie, what is that?" I said, "Well, it's a hammer."

He says, "It's not a carpenter, right? No, it's a hammer. Don't ever confuse the computer with the engineer." The same could be said of the drone. Let's not assume that one is a replacement for the other. One becomes a tool that allows the other to be more effective. ■

*This article was excerpted from my interview with Frank. To hear more from him, check out the October 2023 Field Notes podcast at **modernsteel.com/podcasts**.*

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

Put People First

BY DAN COUGHLIN

A good business constantly acknowledges that its employees and its customers are human beings first, not robots with a task.

PEOPLE OFTEN SEEM genuinely shocked when they are burned out at work. They almost feel bad about losing their mojo after 25 years of pounding away.

My response is to ask why. You're not a robot or a computer. You're a human being. You have the right to be burned out. The shocking part is that your boss was never clued into what was happening.

I'm amazed by the way bosses burn people out. I'll outline a common situation as an example. A person is grinding for long hours each week, and one of his or her team members quits on the spot. But instead of realizing the employees are getting seriously burned out and lightening the load on them, the boss shoulders the remaining employees with more work to make up for the one who left. Fairly soon after that happens, more employees leave due to unrealistic stress, pressure, and, yes, burnout.

The problem is sometimes compounded with entrepreneurs, because they can become even worse bosses to themselves than those they had when working for someone else.

Wear Common Sense to Avoid Careerburn

I've enjoyed going for three-mile walks several times a week for many years. For most of those years, I wore a negligible amount of sunscreen, if any. I laughed off the resulting red blotches on my face and said, "A little burn before the real suntan comes in never hurt anything." This went on for several years.

One day, my wife, Barb, talked about seeing a dermatologist, so I set up an appointment. My dermatologist needed merely 15 minutes to see a serious problem. Several of my sunspots needed to be burned off my face, and there was a very dark spot on my nose. She tested the area and found that I had skin cancer. It required a surgeon to slice my nose vertically from near the top to the tip, scrape out the cancer, and stitch my nose back up. Now, I faithfully wear SPF 70 every time I go outside for a walk.

I thought I could get away with a macho attitude that the sun couldn't hurt me. Similarly, entrepreneurs must avoid the trap of thinking they can work 70 to 100 hours a week and believing it will never hurt them or their personal relationships.

Unfortunately, they are wrong. Entrepreneurs are not robots, computers, or machines. They are human beings. They burn out. And burnout consequences can be harmful: heart attacks, mental breakdowns, nervous breakdowns, affairs, and divorces.

I urge all entrepreneurs to apply common sense to their lives. You are not the owner of a business. Your title is the owner of a business. You are a human being. You have a heart, a body, a brain, emotions, a soul, and relationships with other people outside of your work.

As you put things on your schedule, apply common sense. Yes, you will have to work hard in your business for a reasonable number of hours to build a surviving and thriving business. However, if that becomes the entire focus of your life, you will not survive and thrive as a human being. And then, of course, your business will suffer immeasurably. Put things on your daily, weekly, and monthly schedule that address your business, your mind, your heart, your emotions, your body, your soul, and your relationships with other people.

You are a human being with a business. You are not a business with an occasional human experience.

Businesses Are Relationships

Employees are humans, first and foremost. So are a business's customers.

A business is a relationship between a value provider and a value receiver.

It really is that simple.

High-tech companies, grocery stores, hospitals, schools, professional sports teams, management consultants, musicians, landscaping companies, medical device companies, film companies, TV shows, trucking companies, and on and on.

Value is anything that increases the

chances that the other person will achieve what he or she wants. Yes, there are technical differences between businesses and the value they create and deliver. At the core, though, businesses are built on the same principle: they're a relationship between a value provider and a value receiver.

No matter what value your business creates and delivers, you are still in a relationship with a value-receiver, otherwise known as a customer. You are a human being, and the person who is receiving value from you is a human being. You're both human beings. The essence of your business is a human relationship.

Now that we have that established, think about how you want to be treated as a human being. My hunch is you want to be talked with in a respectful way that enhances your personal dignity as a human being. You don't want to be upbraided or encounter rudeness.

Think about the human being who will be receiving value from your company. It's not just creating and delivering value in a transaction for money. A business, every business, is a relationship experience between you and the people who work for you and a human being paying for that value. The product or service must be great and of high quality. That's a given. Not a given, though, is the way human beings are being treated. But it's just as important as the product or service that you are selling.

The hidden key to long-term business success is to realize and remember that you are in a relationship business. That relationship is just as important as the revenues and profits you generate. Relationships are intangible and are not based on money. They are based on the endless subtleties that make up good human relationships: kindness, caring, compassion, forgiveness, forgetfulness, patience, respect, empathy, gentleness, hospitality, sense of humor, smiles, and on and on.

Go to work seeking to do more than build a better widget. Go there with the intention of strengthening relationships every single day. ■

Since 1998, **Dan Coughlin** has worked with business leaders to consistently deliver excellence, providing coaching and seminars to executives and groups, as well as guiding strategic decision-making meetings. And now he is also focused on helping people on their inner journey to excellence. Visit his free *Business Performance Idea Center* at **www.thecoughlincompany.com**. Dan has also given multiple presentations at NASCC: The Steel Conference. To hear recordings of them, visit **aisc.org/education-archives** and search for "Coughlin."

Bike right up to your workspace in this steel-framed office building with six stories of exterior cycling ramps.

Shifting Gears

BY KEVIN REYNOLDS, PE, AND ALEX FONT, PE

A TOWN WHERE COFFEE SHOP CONVERSATION often centers around the newest mountain bike trail was a fitting location to build the world's first bikeable office building.

Ledger is a six-story, 230,000-sq.-ft mixed-use office structure that provides fixed and flexible co-working space, located in Bentonville, Ark., just a few blocks south of the city's historic square. The building features a community-centric design focused on public gathering areas and outdoor access. All told, Ledger is Bentonville's latest project geared toward solidifying the title as the mountain biking capital of the world, and steel is its backbone.

Six stories of bikeable ramps take cyclists from the ground to the roof. Anyone can bike or walk the ramp, which provides access to all floors of the building. The trip from the first floor to the roof is approximately ¾ mile. The building features bike-friendly amenities, including indoor lockers on each floor for secure bike storage, eBike charging stations, onsite showers on each floor, and a bikers' lounge. Its outdoor communal terraces allow occupants to be part of the downtown Bentonville experience.

General contractor Nabholz and the project developer engaged steel fabricator W&W|AFCO Steel in a design-assist role during the initial design phase, which allowed the design and construction teams to work together to develop positive solutions to the many challenges the project presented.

Chief among those hurdles was Bentonville's 100-ft maximum height restriction on building structures, which required the teams to develop a steel design alternate that would be more economical than the originally proposed concrete structure.

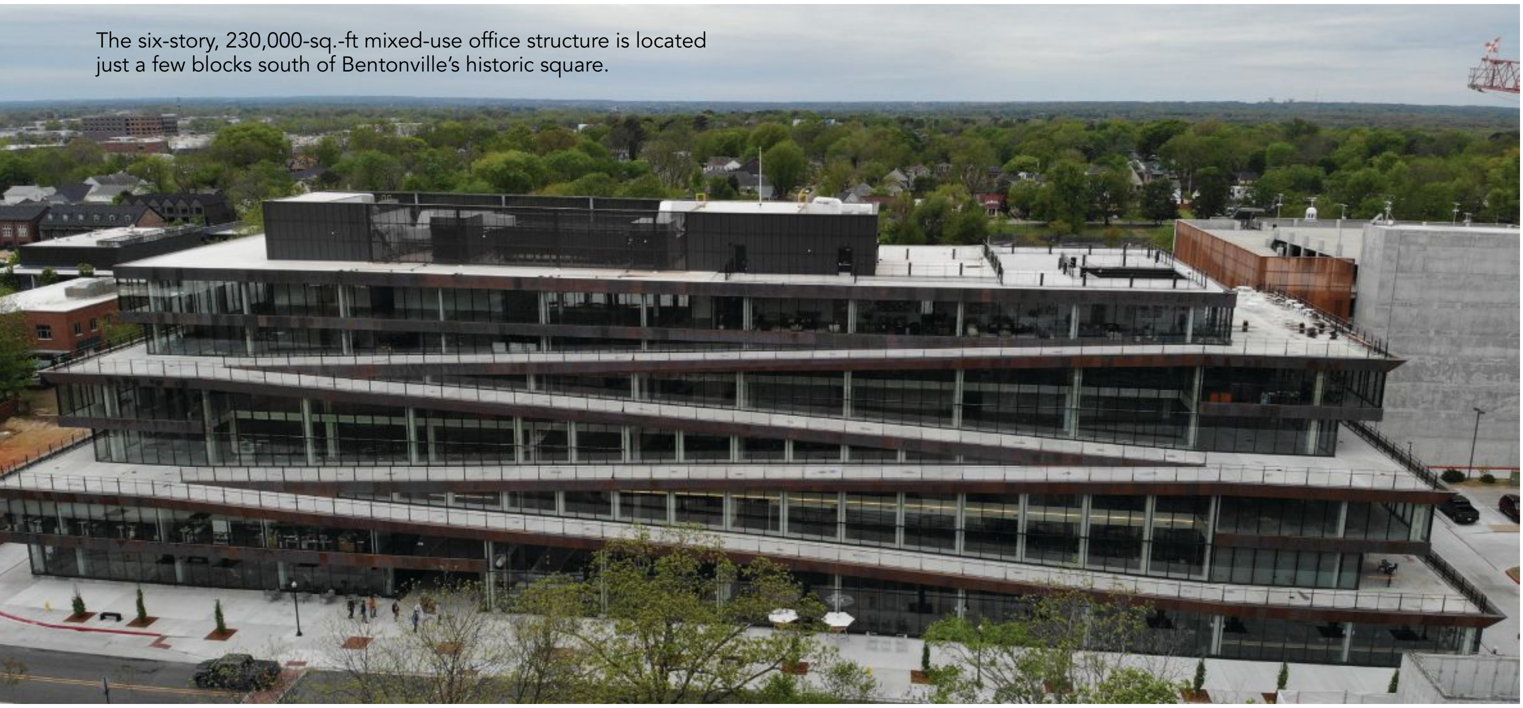
The teams collaborated to develop and perform cost analysis on numerous conventional and unconventional steel framing options that minimized the floor-to-floor spacing, and they determined that a conventional steel moment frame system using composite floor slab over shallow floor members was the best option. On top of that, Nabholz's comprehensive cost analysis concluded the proposed steel framing system would be more economical than the originally planned concrete building frame.

Maximizing Floor-to-Floor Heights

In response to the height restriction, the teams sized the typical girders and floor beams to minimize depth, with the steel members sized about 6 in. shallower than typical framing on an office building with the same structural grid. The building columns are laid out on a 30-ft by 30-ft grid with W18×97 primary floor girders and W10×54 infill beams spaced at 10 ft on centers. Cambers measuring 1¼ in. were specified for the W10 infill beams to help offset the estimated dead load deflection. The typical W18 girders were also raised 2 in. to the top of floor deck elevation, further reducing the overall structure depth. For the typical framing, the overall floor depth (with a 6-in. floor slab) was 22⅝ in. at the girders and 16⅛ in. at the infill beams. This allowed space for MEP and sprinklers with headroom to spare over the open office floor plan.

Six stories of bikeable ramps take cyclists from the ground to the roof of the Ledger building.

A combination of shallow steel framing, framing steps, cantilevers, and built-up trusses support the exterior ramps and terraces without inhibiting the interior spaces below.



The six-story, 230,000-sq.-ft mixed-use office structure is located just a few blocks south of Bentonville's historic square.

A Lateral System with Erection Efficiency

As with any building project, the schedule was a concern from the beginning. Due to the limited laydown space available on site, an efficient structural system and thoroughly planned erection sequence were focal points early during the design stage. A consistent system of moment frames throughout the structure in lieu of braced frames or shear walls appeared to offer the most advantages for the erection of the building, and welded moment connections were not considered due to the schedule. Instead, all moment connections were designed as extended end plate bolted connections, as per AISC Design Guides 4 (*Extended End-Plate Moment Connections Seismic and Wind Applications*) and 16 (Flush and Extended Multiple-Row Moment End-Plate Connections), both available at **aisc.org/dg**. Not only did the moment frames provide instant stability and plumbness of the structure upon erection, therein eliminating the need for temporary guy cables, but also the erection sequence was not influenced by having to plan around the erection of braced cores. Each column line of the building provides stability, ultimately allowing for more flexibility with the erection sequence planning.

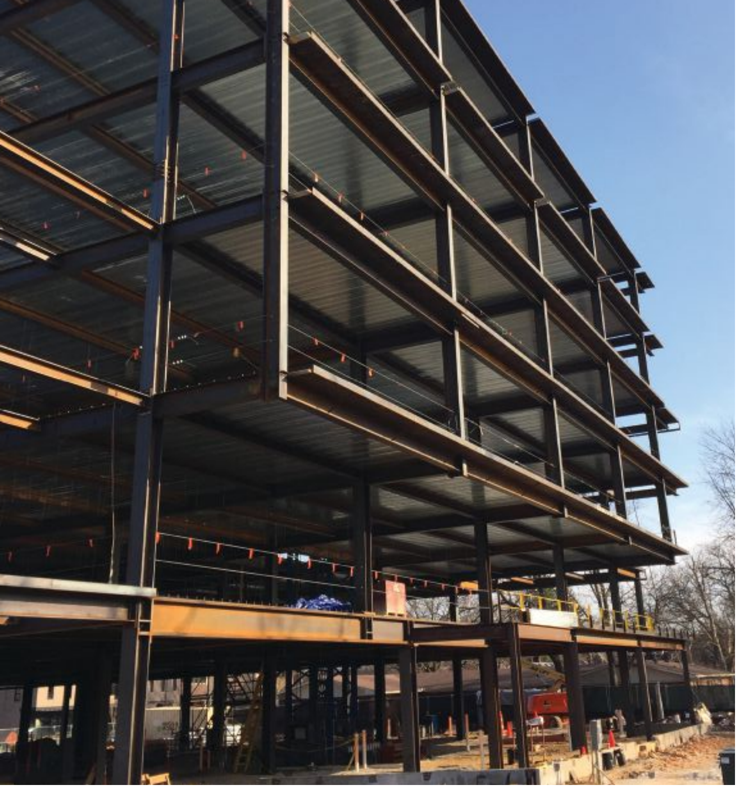
Minimizing the "Junk"

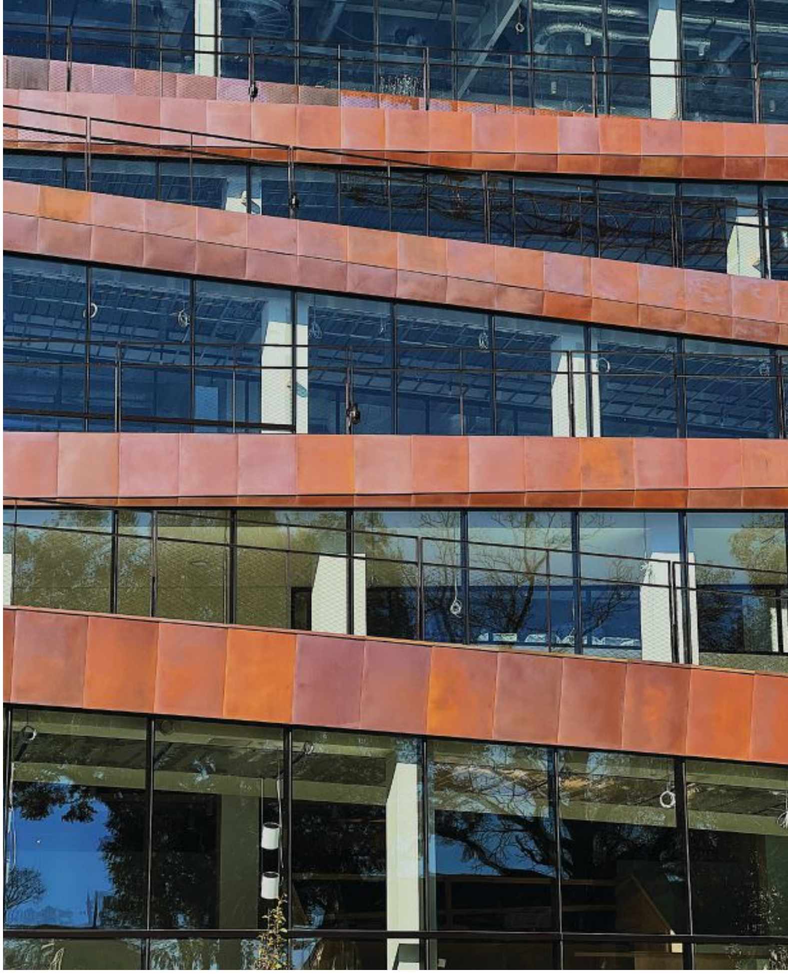
Bolted moment connections are framed into the column web

In response to Bentonville's 100-ft height restriction for buildings, the teams sized the typical girders and floor beams to minimize depth, with the steel members sized about 6 in. shallower than typical framing on an office building with the same structural grid.

and flanges from all sides at many of the column locations. It was important to design the moment connections in a way that did not require column web stiffeners or doubler plates. Eliminating the column web stiffeners and doubler plates enabled the extended end plate bolted moment connections to fit consistently and cleanly into the webs of the columns. The typical column size of W14×120 was selected to carry the typical floor girder moment connections without additional reinforcement required to the column. When considering the cost of extra material and fabrication time for added web stiffeners and doubler plates to the columns at the floor framing, increasing the column sizes to eliminate the additional reinforcement is often the more economical solution.

Architectural requirements necessitated the perimeter slab edge extending 1 ft, 4 in. from the centerline of the spandrel beam. The metal floor deck was extended over the bent plate slab edge to eliminate the need for kicker bracing at the slab edges, and Nelson studs were welded through the deck to the bent plate below to create a composite steel section to carry the weight of the slab and floor. Temporary angle kickers were installed to steady the bent plate during the floor slab pours and removed later prior to installation of the building envelope. The absence of kickers outside the perimeter beams offered an ideal space for running mechanical ducts along the perimeter glass façade.





above: On one side of the building, the floors from Level 3 to the roof cantilever almost 12 ft.

right: Copper paneling visually highlights the trail.

below: The building trail's switchbacks mimic those of a mountain biking or hiking trail.

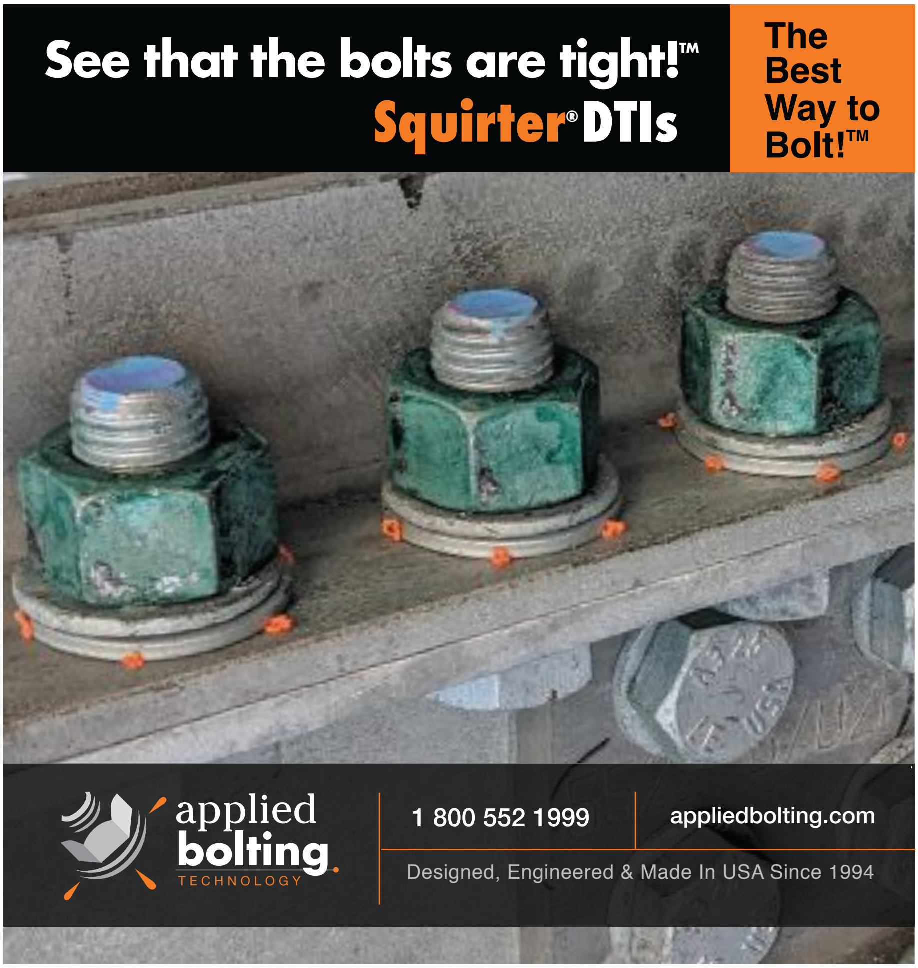
Standing Out

Structural steel also served as the perfect solution to support the undulating ramps and terraces that traverse the perimeter of the building. A combination of shallow steel framing, framing steps, cantilevers, and built-up trusses support the ramps and terraces without inhibiting the interior spaces below.

In addition to the exterior climbing ramp to the roof, the building expresses itself with some eye-catching cantilevers. On its west side, the floors from Level 3 to the roof cantilever almost 12 ft. Bolted moment connections through the perimeter column webs support the west side cantilever, effectively cantilevering the typical W18×97 floor girders at each column line. At the end of the cantilever beam, a continuous vertical W16 column is attached with bolted moment connections at each floor level. The moment-connected vertical columns stiffened the individual cantilever beams and tied each level together, redistributing the floor live loads along the height of the building and holding a uniform deflection at the end of the cantilever.

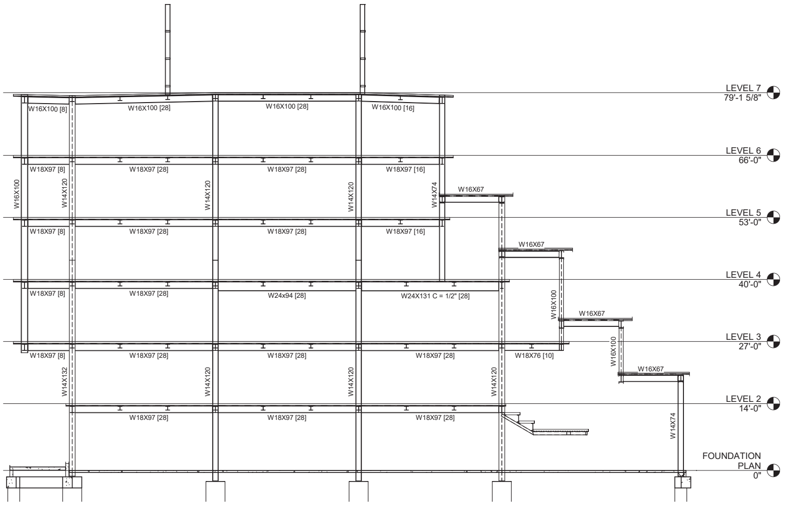
On each end of the building the floors cantilever from 14 ft to 19 ft to provide column-free cover to the terraces below. The 14-ft cantilevers on the terraces work similarly to the west side cantilevers, with bolted moment connections through the perimeter columns. However, at the terrace levels, the cantilevered beams make a vertical step down at the column to accommodate the roof build-up needed at the exterior terraces. For the nearly 19-ft cantilever on the north end, custom plate girder shapes were designed to carry the Level 3 floor plate and roof terrace above. The plate girders supporting Level 3 were also tapered to reduce the depth toward the end of the cantilever and provide greater clear height to the exterior terrace below. These girders were constructed with 2-in. thick steel plates, 16-in. wide flanges, and a maximum depth of 26 in., with the tapered plate girders reducing to a minimum 19 in. depth.

All cantilever members were sized to produce an estimated ½ in. deflection under dead load. A tip camber of $\frac{3}{8}$ in. to ½ in. was specified for all cantilevers, with the goal of leveling the floors as much as possible once the floor slabs were placed and cured. Through collaboration between structural engineer



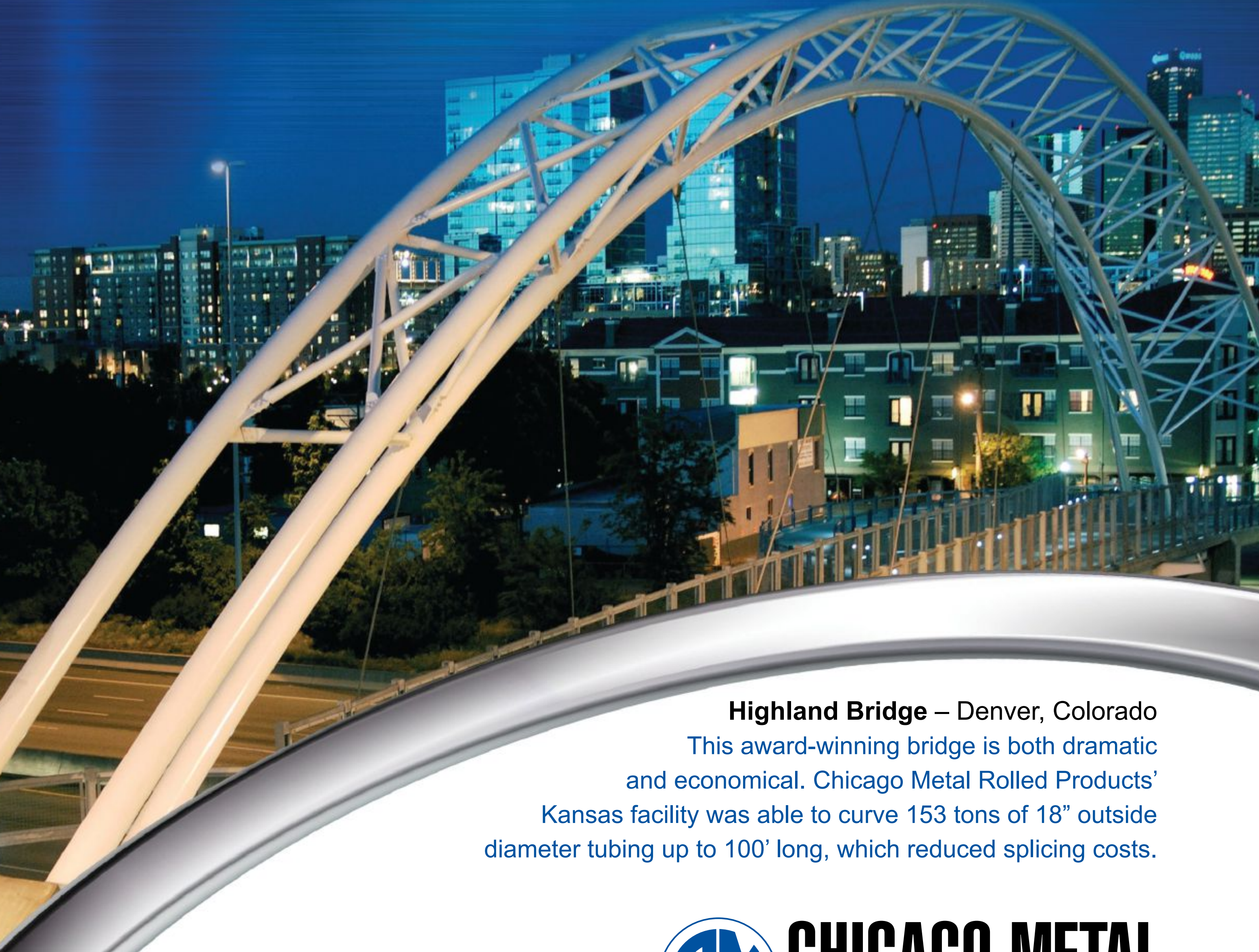
above: On each end of the building, where the ramps merge into terraces, the floors above cantilever from 14 ft to 19 ft to provide column-free cover to the terraces below.

below: A building section view at the atrium.



Engineering Consultants, W&W | AFCO, and the steel erector, the team determined that shop installation of a $^{1}/_{16}$-in. steel shim near the low side of the bolted moment connections where the cantilever beams attach to the perimeter columns would produce the specified tip camber at the end of each cantilever. A $^{1}/_{16}$-in. steel shim was also added near the top side of the bolted moment connection at the end of the cantilever. The shim solution proved to be more efficient for the fabricator than alternate methods of producing camber, such as heat-treating or rolling of the steel beams.

The typical building column spacing was spread out to 60 ft to create the interior open atrium and lobby space. Steel Vierendeel trusses were designed to support the 60-ft spans of the exterior ramps above. The Vierendeel design was chosen for its simplicity and lack of diagonal members, which allow for more uninterrupted light to enter the building. The truss members consist of W16×100 verticals and W18×130 or W18×175 chords. The connections, both between truss verticals to truss chords and truss chords to support columns, are made with bolted moment connections. The team worked to



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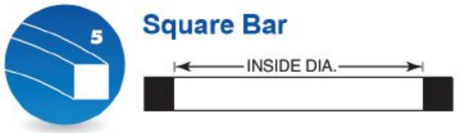
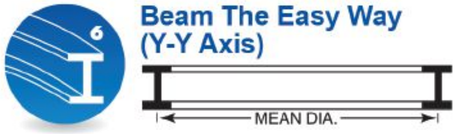


18" Square

Beam The Easy Way (Y-Y Axis)



44" x 335#,
36" x 925#

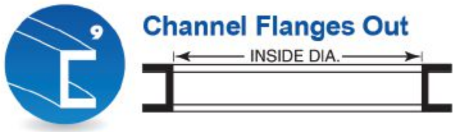
Beam The Hard Way (X-X Axis)

44" x 285#

Channel Flanges In

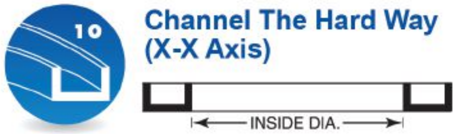
All Sizes

Channel Flanges Out



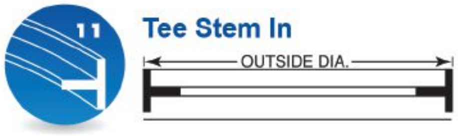
All Sizes

Channel The Hard Way (X-X Axis)



All Sizes

Tee Stem In



22" x 142½# Tee

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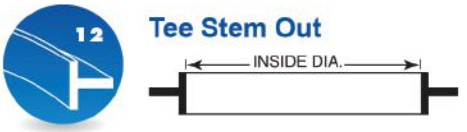
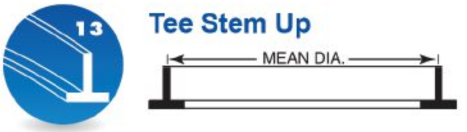
Tee Stem Out



22" x 142½# Tee

Tee Stem Up



22" x 142½# Tee

Angle Heel In

8" x 8" x 1" Angle

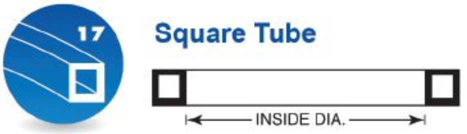
Angle Heel Out

8" x 8" x 1" Angle

Angle Heel Up

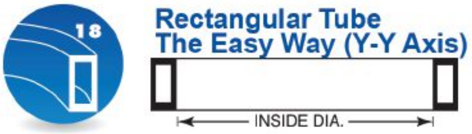
8" x 8"x1" Angle

Square Tube



24" x ½" Tube

Rectangular Tube The Easy Way (Y-Y Axis)

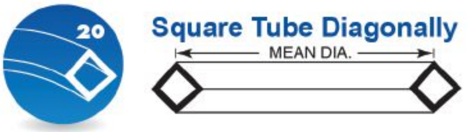


20" x 12" x ⅝" Tube

Rectangular Tube The Hard Way (X-X Axis)

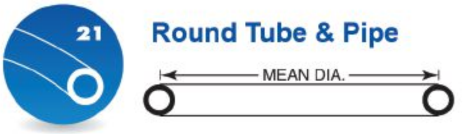
20" x 12" x ⅝" Tube

Square Tube Diagonally



12" x ⅝" Square Tube

Round Tube & Pipe



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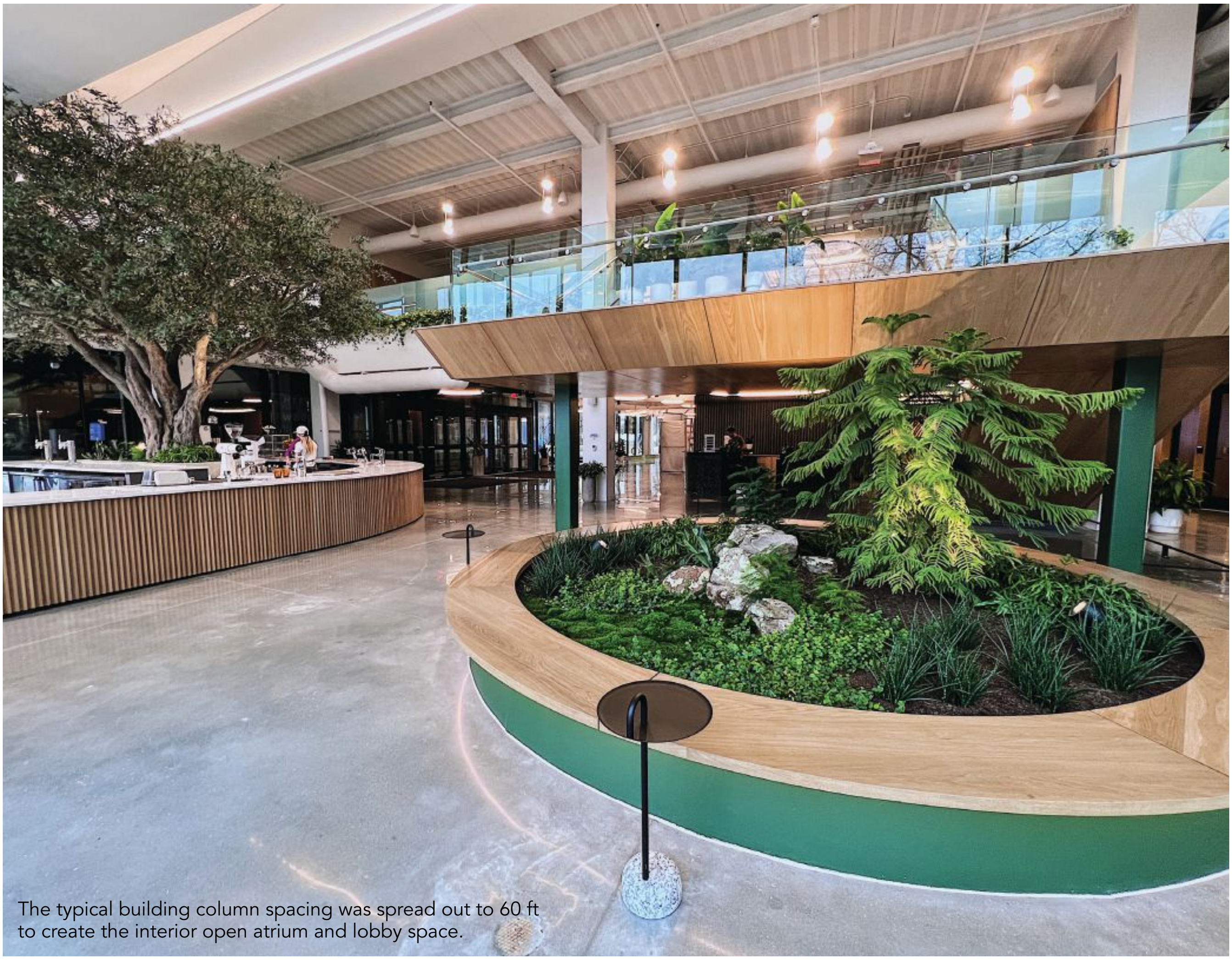


The typical building column spacing was spread out to 60 ft to create the interior open atrium and lobby space.

incorporate bolted moment connections in lieu of field welding as much as possible to ease and speed up the steel erection.

The design team also found a solution in steel to the project's acoustical challenges. W&W|AFCO and metal decking supplier New Millennium proposed a cellular acoustical metal deck, which eliminated the originally planned spray-on acoustical treatment. The metal decking option proved to be more economical and provided a clean, flat surface that the developer and architect desired for the interior ceilings.

The final design incorporated approximately 2,200 tons of structural steel and 230,000 sq. ft of metal decking. Fabrication began in September 2020 and was completed in April 2021. Erection began in November 2020 and was largely complete by July 2021. Now open, Ledger serves as a new symbol for Bentonville that walks the walk (and rides the ride) as an employee-centric building that encourages wellness and activity. ■

Owner
Center City, LLC

Architect
Michel Rojkind and Callaghan Horiuchi + Marlon Blackwell Architects

General Contractor
Nabholz

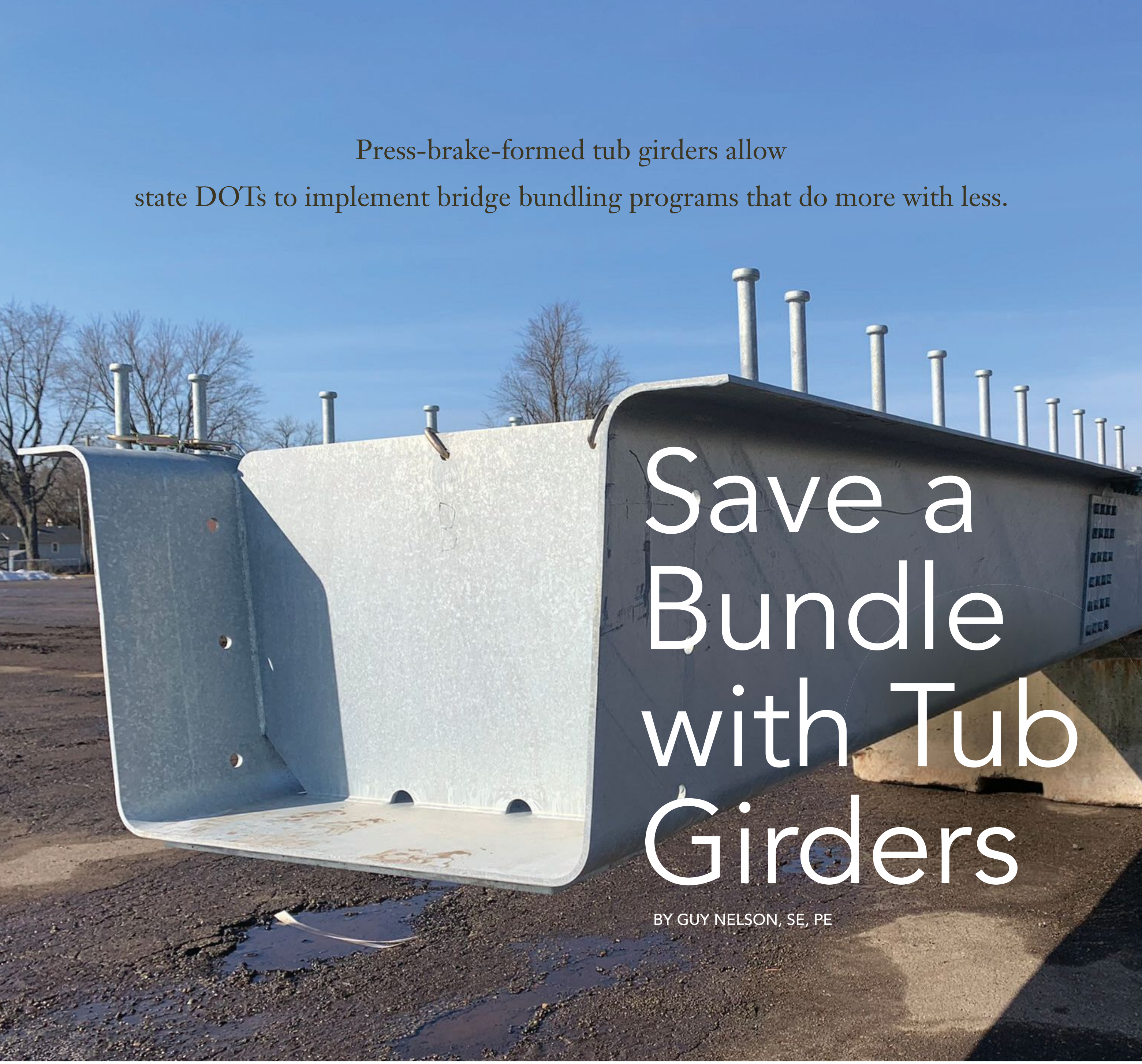
Structural Engineer
Engineering Consultants, Inc.

Steel Team

Fabricator
W&W|AFCO Steel AISC CERTIFIED FABRICATOR

Detailer
S. P. International, Inc. AISC DETAILER

Kevin Reynolds (kreynolds@wwafcosteel.com) is the Executive Vice President of W&W|AFCO Steel, and **Alex Font** (alex.font@ecilr.com) is a principal engineer with Engineering Consultants, Inc.



Press-brake-formed tub girders allow state DOTs to implement bridge bundling programs that do more with less.

Save a Bundle with Tub Girders

BY GUY NELSON, SE, PE

GRETCHEN WHITMER BECAME MICHIGAN'S GOVERNOR in 2018 with a platform that included a pledge to "fix the damn roads." She and her administration soon learned, though, that a state tax hike would not fund this infrastructure upgrade. The Michigan legislature voted against an increase in the gas tax, necessitating an innovative and less expensive method for repairing decaying bridges.

Their solution: Combine the reconstruction of several bridges into a single contract.

In 2019, the Michigan Department of Transportation (MDOT) launched a design-build pilot "bundling" project called Rebuilding Our Bridges. Preserving, maintaining, rehabilitating, or replacing bridges in groups, referred to as bundling, allows agencies to save time and money by expediting project delivery and reducing design and construction costs. Bundling has become a tool for DOTs to capitalize on available funding and introduce new and innovative financing options. In addition, they can maximize available labor, save time and money, and reduce public disruption by simultaneously starting (and completing) multiple bridges.

MDOT Chief Bridge Engineer Matt Chynoweth said the pilot project included 19 local agency-owned bridges around the state—ranging from 29 ft to 196 ft long—with major elements in serious or critical condition. They had contract requirements calling for completion in 60 or 90 days each.

"This is the most supportive program from the state of Michigan for local bridges that I've ever seen," said Wayne Harrall, Deputy Managing Director for Engineering at the Kent County

opposite page: A close-up view of a tub girder used on one of 19 Michigan bridge repair and rebuild projects.

below: One of 19 bridges in Michigan that were rebuilt or repaired using tub girders.

Road Commission. “The MDOT Bureau of Bridges has engaged with local agencies from the beginning before there was even funding allocated to the effort.”

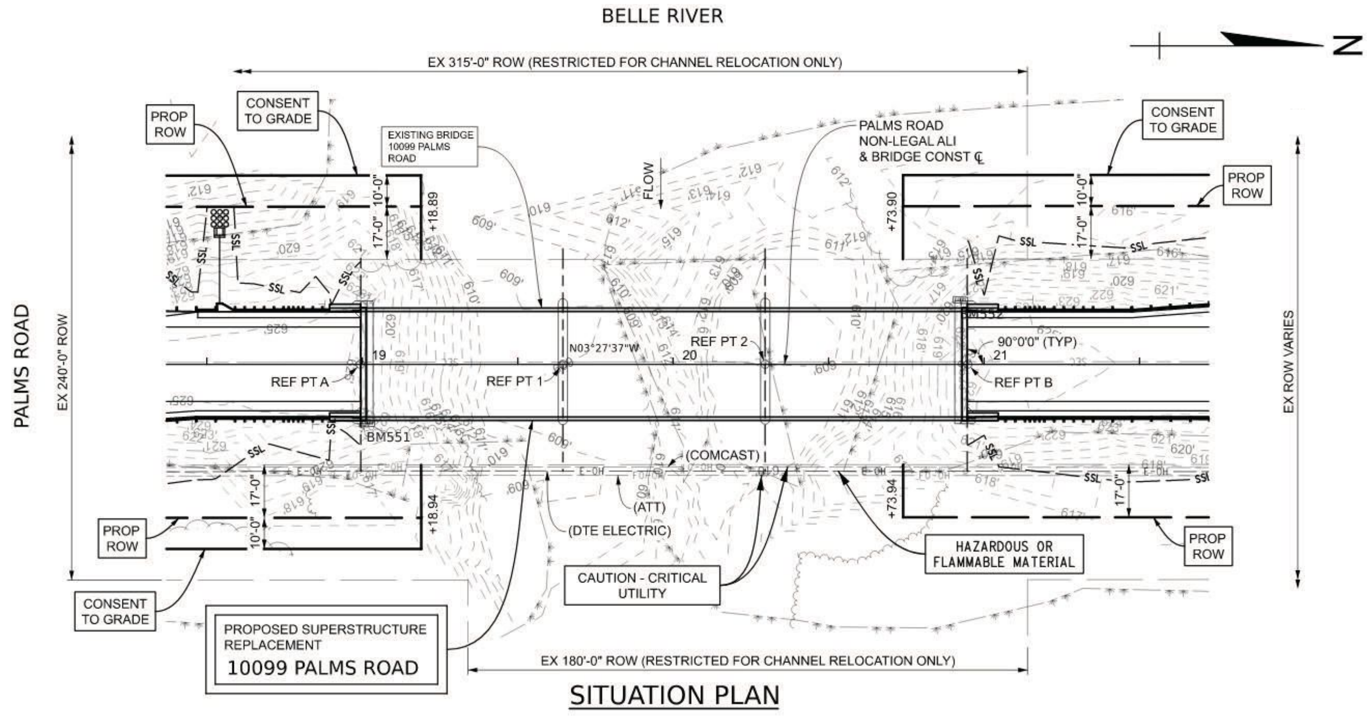
The project, Harrall said, has kept millions of dollars in local coffers, “where they can fix other structures [and] hopefully get us into a position where we can better preserve and maintain the local bridge system.”

In late 2022, Whitmer announced that the final five bridges marked for repair under the Rebuilding Our Bridges program were beginning construction. “We are setting up orange barrels at record pace as we make the largest investment in state roads and bridges in Michigan’s history,” Whitmer said in a press release. “Let’s keep fixing our roads with the right mix and materials, so they stay fixed.”

Ready to Go

MDOT bid out the Pilot Design-Build Bridge Bundling project to local contractors in February 2021, and the awarded team of builders and design consultants selected Valmont’s U-BEAM™ galvanized steel press-brake-formed tub girders (PBFTGs). The girders are $^3/_8$ in. thick AASHTO M270 GR 50 Plates. Sizes ranging from U12, U18, and U24 were all used on the project.

In the past, side-by-side box beam bridges have been a popular choice for short- to medium-span due to their ease of construction, favorable span-to-depth ratios, aesthetic appeal, and high torsional stiffness. However, they have major deficiencies, including a short service life in extreme conditions, early deterioration of joints, and limited corrosion protection. These performance problems persist despite amendments to the design during the last 70 years. An MDOT study of current inventory shows



above: An overhead view of the Palms Road bridge in St. Clair County, Mich.

left: A tub girder being galvanized at Valmont's shop.

pre-stressed concrete box beam service life of less than 50 years.

Those performance issues prompted MDOT to place a moratorium on using side-by-side box beam bridges. Introduced into MDOT's bridge beam market 20 years ago, the press-brake-formed tub girder filled this need by achieving similar advantages while also offering a longer service life.

A PBFTG is a single steel plate that is cold-formed into a U shape, with each bend occurring along the plate's longitudinal axis. The first PBFGT bridge installation was completed in 2004 in Michigan for the Monroe County Road Commission. Now almost 20 years old, that instillation shows no signs of deterioration of the concrete driving surface or corrosion in the galvanized steel PBFGTs.

U-BEAMs can achieve a 100-year service life, if specified with a hot-dip galvanized coating, with the first 60 years completely maintenance-free. (Valmont is also a coatings company and can provide any protective coating system specified, though it recommends hot-dip galvanizing for its long maintenance-free service life). For the MDOT project, Valmont's Engineering Support Services division provided specific design solutions and prices for each of the 19 bridges prior to the bid. All 19 used galvanized U-BEAMS. These included the most economical U-BEAM solutions, construction accessories, stamped design and shop drawings, and stamped load rating.

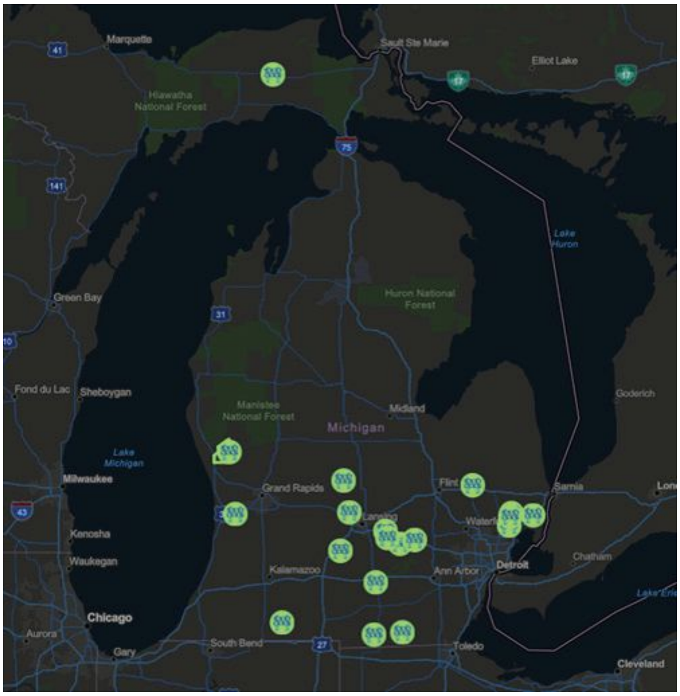
The Palms Road Bridge over the Belle River in St. Clair County, for example, was 196 ft long with three 65-ft spans. It featured a U24 Beam, which is 24 in. deep, and replaced an existing 27-in. deep prestressed concrete box beam. Construction began on August 22, 2022 and finished on

October 28 of the same year. All told, the rehabbed bridge used 77 tons of steel, which cost $268,445.

The U-BEAMs on all 19 bridges have several time-saving features, including shop-welded shear studs and pre-welded forming hardware that eliminates field welding. The bridge deck forming system can also be set directly atop the flanges without welding or surveying before the formwork is placed, rendering fall-safety equipment to access the bridge beams after installation unnecessary. Workers can walk on the bottom of the tub girders safely and easily because of their shape.

The system also improved safety by allowing laborers to work and walk inside of the beam and tie off directly to the internal bracing angles for fall protection, rather than installing expensive and time-consuming fall safety horizontal lifelines. No special training is required to install the girders. In fact, county maintenance crews have installed them with no prior bridge-building experience.

The system has been accepted by the Army Corps of Engineers, the U.S. Forest Service, state DOTs, and county agencies throughout the United States, and, if desired, can be delivered as a Prefabricated Bridge Unit (PBU) with a precast concrete driving surface already installed. These units are delivered fully fabricated and can be quickly placed, tied together, and opened to traffic. They can replace bridge superstructures in a single day.

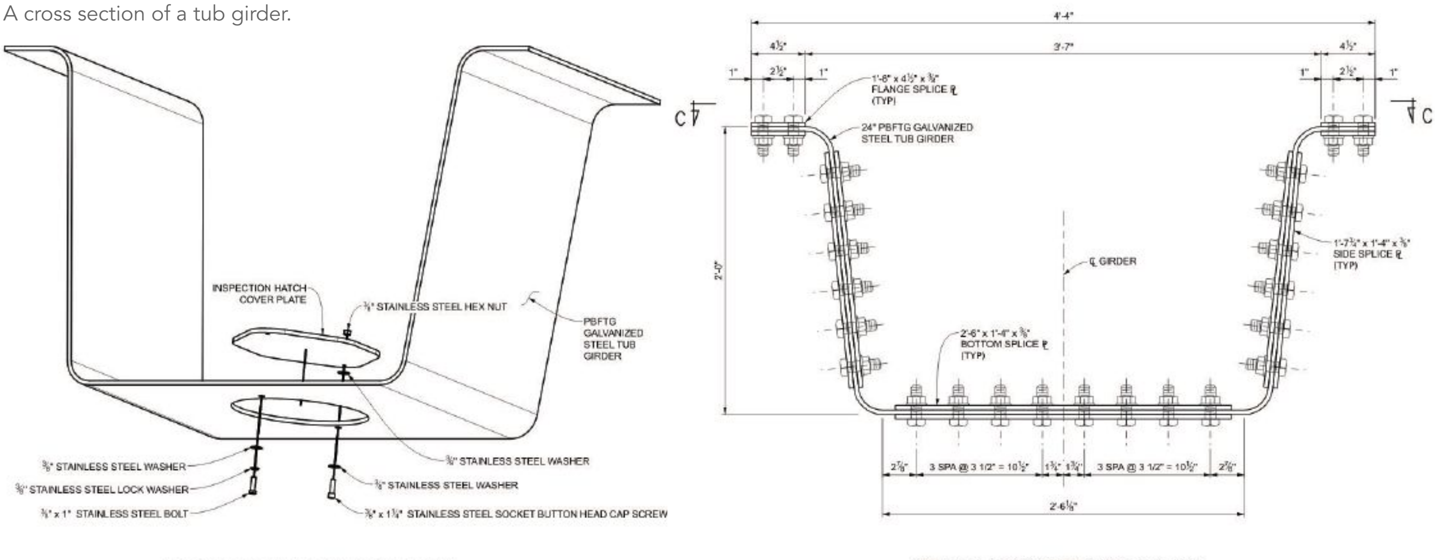


above: A map of the 19 Michigan bridges that were repaired or rebuilt using tub girders.

below: Tub girders being transported to one of the Michigan projects

A top-side view of a completed Michigan tub girder project.

A cross section of a tub girder.



INSPECTION HATCH ASSEMBLY

GIRDER SECTION THRU SPLICE

One of the Michigan bridge projects incorporated 12 tub girders.


Crews setting formwork in place.

Fast Finish

The U-BEAM's short lead time and large production capacity allowed MDOT to shave an entire year off its three-year schedule, and it all started with the early purchase of 500 tons of steel plates before bridge construction plans were finalized and approved. The average tonnage per bridge is 25, with a low of nine and high of 77. Due to steel plate shortages in early 2021 and material price increases during the project, this early procurement saved approximately $1 million and expedited the fabrication of the U-BEAMs because the material was on hand when shop drawings were approved. Valmont fabricated and delivered all 157 U-BEAMs for the 19 bridges in a single eight-month construction season, including providing the hot-dip galvanized coating, which ensured seamless coordination between fabrication, coating, and delivery.

The company achieved these fast production rates due to its investment in a dedicated U-BEAM fabrication facility, which can cut production time by 70%. The facility houses an automated 60-ft press brake, roll forming for camber, an automated stud welding machine, and a dedicated welding station for the sole plates, end diaphragms, and angle braces.

Adam Newton, project engineer with the Macomb County Department of Roads (MCDR), said the bridge bundling program was a great resource because it provided a sustainable balance of bridge replacement, improvements, and preventive maintenance.

"Having a few of the bridge superstructures that are in critical condition replaced within the bridge bundle pilot project has given the MCDR an opportunity to focus on implementing a mix of fixes for the remainder of our bridge inventory with traditional resources and funding," he said.

In the end, MDOT's Pilot Bridge Bundling project was deemed a major success, with 19 bridges replaced and opened to traffic ahead of schedule. In response, Whitmer announced plans to proceed with Phase II of the Rebuilding Our Bridges program, in which MDOT will replace 60 bridges over four years. ■

*See "Fast-Acting Tub Girders" in the July 2023 issue (**www.modernsteel.com**) to read about a U-BEAM project in Tennessee.*

Owner
Michigan Department of Transportation

General Contractor
CA Hull Construction, Anlaan Construction

Structural Engineer
Alfred Benesch Consulting

Steel Fabricator
Valmont, Inc., AISC CERTIFIED FABRICATOR, Jasper, Tenn.

Guy Nelson (**guy.nelson@valmont.com**) is a product development engineer with Valmont Industries.

Innovation on the Fly

BY JUAN VALENZUELA, PE AND EDWARD SEVERINO, PE

WEKIVA PARKWAY fills a gap of sorts.

The 25-mile expressway, also known as State Road 429 (S.R. 429), is well on its way to completing Central Florida's beltway. Weather permitting, the final link in what will ultimatley be a 54-mile beltway around greater Orlando will open in December. The parkway will provide travel options while also helping protect the natural resources surrounding the Wekiva River, a National Wild and Scenic River and Florida Outstanding Waterway.

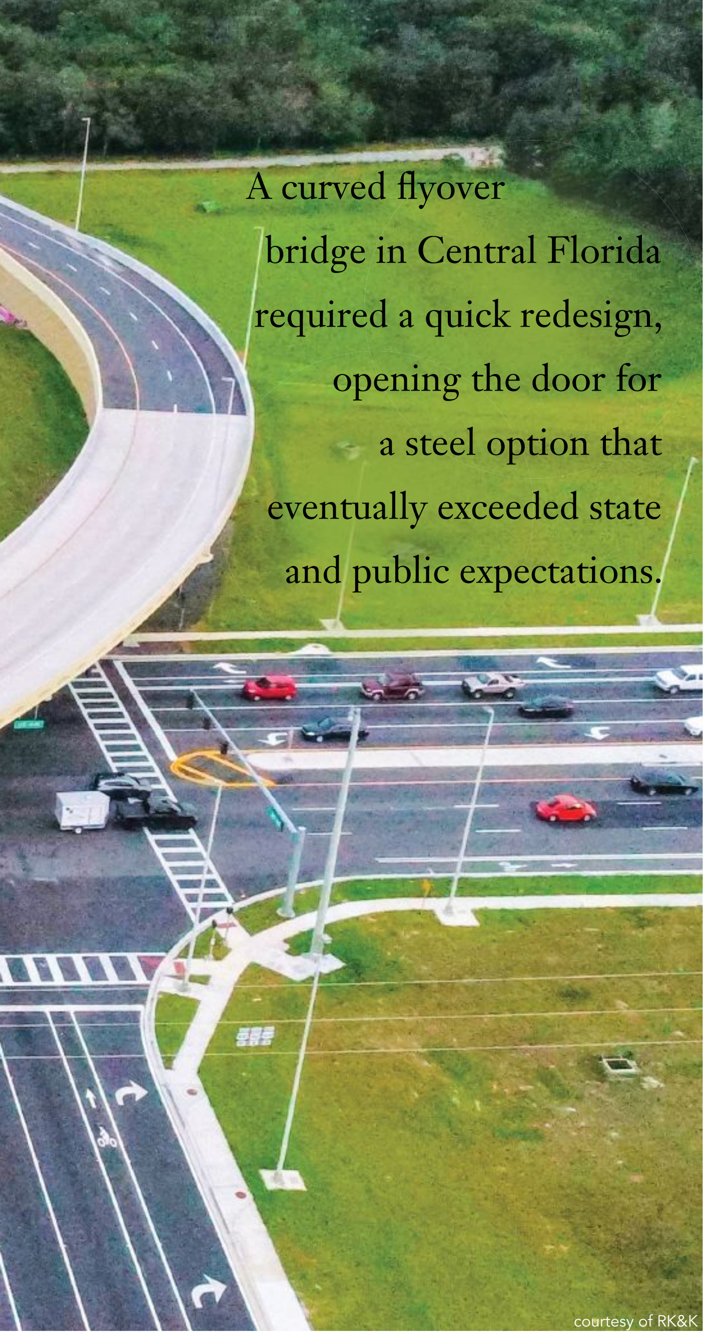
Developing and building the 25-mile stretch of road has been a forward-thinking collaborative effort led by the Florida Department of Transportation (FDOT), the Central Florida Expressway Authority (CFX), and Florida's Turnpike Enterprise, with the latter handling the toll operations for the FDOT sections. The vision for the project grew from 30 years of extensive engagement with national, state, and local government leaders, advisory committees made up of environmentalists, community and business leaders, and thousands of area citizens.

The parkway has been heralded as a shining example of transportation planning through an environmentally sensitive area, and its development includes more than 3,400 acres of land for conservation set aside to protect the Wekiva River Basin and new wildlife bridges for improved habitat connectivity. It also alleviates traffic congestion in the vicinity and provides improved evacuation time during severe weather emergencies such as hurricanes.

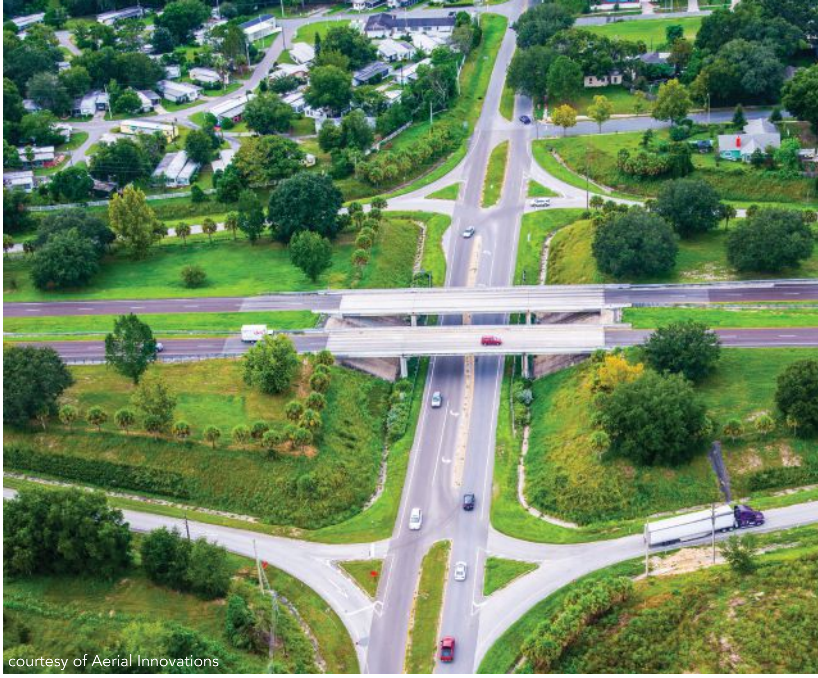
Realigned and Reconstructed

One of the crucial steel-framed components of the parkway is Section 3B—the westernmost portion of the project—which includes the realignment and reconstruction of S.R. 46 in Lake County. The project converted the previous diamond interchange at U.S. 441 over S.R. 46 to an at-grade intersection by providing a new flyover bridge, which opened in September 2020, to accommodate the heavy traffic volumes from southbound U.S. 441 as vehicles enter the S.R. 46 corridor and connect to the Wekiva Parkway.

The project's role as a gateway to the City of Mount Dora necessitated innovative considerations regarding the layout and aesthetics of the interchange. Mount Dora's height restrictions required the lowest possible profile for the proposed interchange, A curved flyover bridge in Central Florida required a quick redesign, opening the door for a steel option that eventually exceeded state and public expectations.



courtesy of RK&K

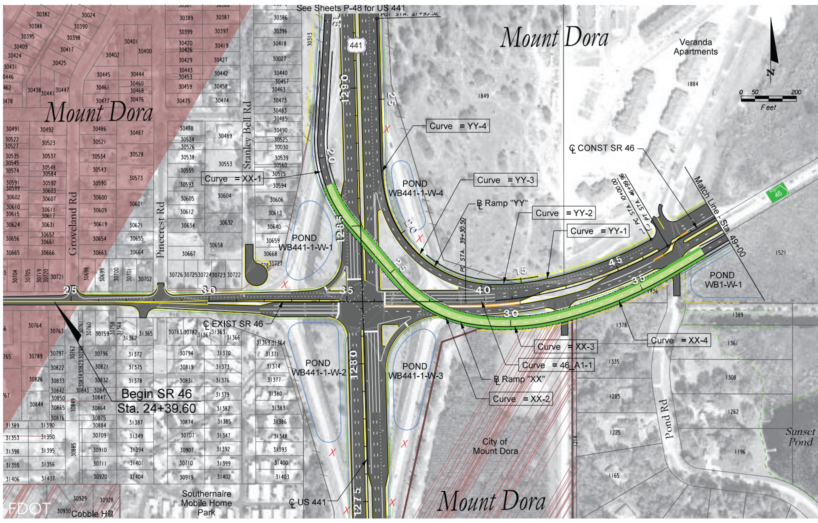


courtesy of Aerial Innovations

above: The previous diamond interchange.

left: A view of the completed structure.

below: The original flyover configuration from the study phase (the bridge is shown in green).



and in adhering to them, the project avoided the typical three-level version. The concept plans from the study phase called for a 1,593-ft-long flyover eccentric to the at-grade intersection.

In the diamond interchange configuration prior to construction, U.S. 441 was at the original grade atop a hill and S.R. 46 was in a cut section under U.S. 441. The long flyover from the study phase crossed over U.S. 441 and S.R. 46 at a higher elevation. In the final design phase, though, the engineering team proposed spanning directly over the intersection to shorten the flyover bridge's length rather than be eccentric to the intersection. Then U.S. 441 was sunk to match S.R. 46, which lowered the bridge's profile to minimize impacts on adjacent residences and businesses. A steel trapezoidal box (tub) girder option with integral pier diaphragms further reduced the structure depth.

courtesy of Aerial Innovations

The original bridge demolition and traffic on at-grade ramps.

The construction sequence required removing the previous diamond interchange bridges, with traffic detoured onto one of the previous at-grade ramps. This significantly improved the safety of the construction workers and provided more opportunities for temporary shoring tower locations.

Traffic modeling showed a single-lane flyover bridge would provide a satisfactory level of service in the design year (20 years after construction), but FDOT agreed a two-lane bridge would better provide for future growth beyond the design year when considering how site constraints would impact future bridge widening. As such, the bridge was designed with two 12-ft lanes superelevated at 2.6% for the 35-mph vehicle design speed. The outside shoulder is 10 ft wide, and the inside shoulder is 11 ft wide due to the sight distance around the inside of the curve. The inside shoulder is wider than the standard 6-ft width to increase horizontal sight distance on this flyover ramp bridge.

The bridge has 42-in.-tall TL-5 traffic barriers on both sides in lieu of the standard 32-in.-tall TL-4 barriers used on most bridges in the state. This was due to the tight 500-ft radius and projected truck traffic of 10%, which warranted taller barriers. In addition, the taller barriers required the cantilevered portions of the bridge deck to be thicker and more robust when compared to the TL-4 barriers.

Structural Design Considerations

Curved concrete and steel box girder alternatives were developed during the design phase, but the concrete box girder alternative was ultimately removed from the bid documents due to a shift in FDOT policy on post-tensioning corrosion-protection methods. The policy change occurred during right-of-way acquisition, which did not leave adequate time to redesign the concrete alternative.

Since the project constraints included a tight radius and the profile necessitated integral diaphragms on the single-column piers, it was clear from the start the bridge's deck area would have a higher pounds of steel per square foot than more traditional bridges without integral pier diaphragms. With the added consideration of the bid documents—including the curved post-tensioned concrete superstructure alternative—the net differences were evaluated between using more traditional end span lengths (75% to 80% of the 231-ft main span) for the steel alternative versus matching the end span lengths from the concrete superstructure option (50% of the main span length). Because the bridge superstructure constraints already required a high degree of torsional and longitudinal stiffness, there would not be a significant increase in member sizes and fabrication costs if the end span lengths were shortened to match the concrete alternative.

The bridge has 60 lb of steel per sq. ft (about 683 tons total), and the cost for the structural steel pay item in the bid documents (which included only fabricated structural steel elements) was about $4,000 per ton, based on the winning bid. The total cost for the flyover bridge was $4.2 million, which amounts to about $186 per sq. ft of bridge deck when the project was bid in June 2017.

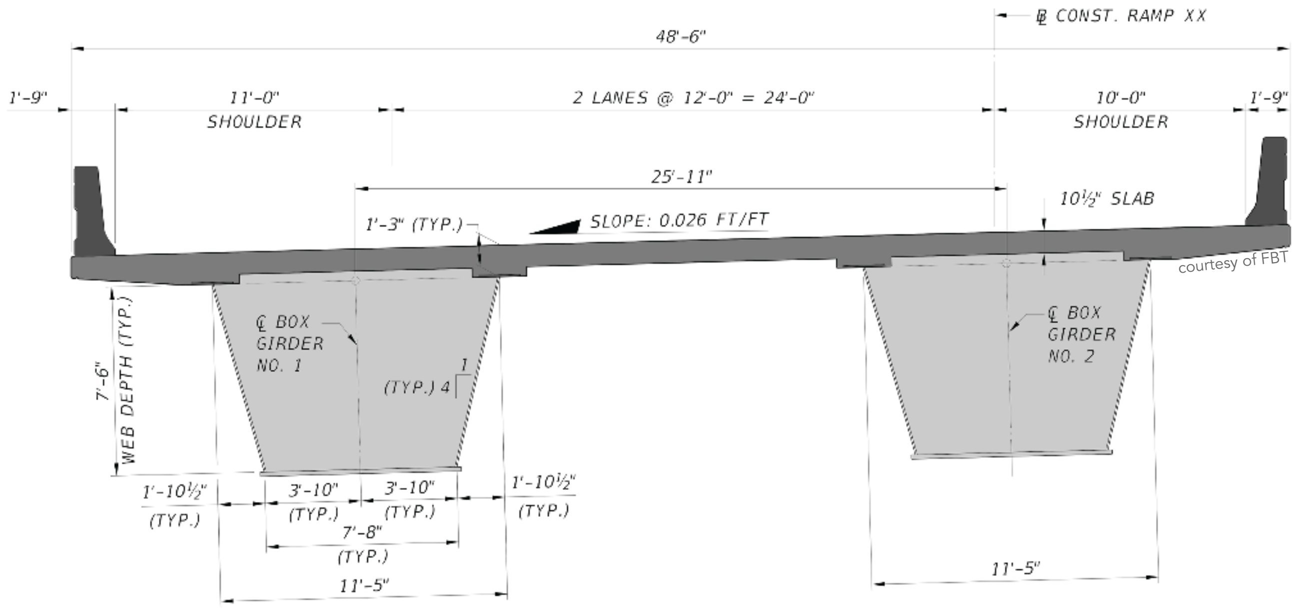
The steel bridge's stiffness was sufficient to avoid any uplift on the bridge by the inherent stiffness of the external bracing and internal longitudinal girder quasi-box bracing behavior, along with the integral box-shaped pier diaphragms. The reduced long-term maintenance costs associated with the longer end spans was also considered. Therefore, the final design phase proceeded with the steel superstructure alternative matching the bridge length of the concrete superstructure option (120-ft-long end spans and a 231-ft-long main span for a total bridge length of 471 ft), which allowed just one set of roadway plans to accompany the two bridge options (the structure depth of both options was the same, resulting in one profile for both alternatives).

The innovative design demonstrated that the end span lengths of a bridge can be reduced by using the torsional and longitudinal stiffness when the bridge has similar constraints. Grade 50W weathering steel was used throughout most of the superstructure, resulting in reduced maintenance needs, and HPS 50W steel was used for the integral diaphragm members, which were designated as Nonredundant Steel Tension Members (formerly fracture-critical members, or FCM) in the plans due to the higher toughness and improved weldability.

The challenging internal and external flexural, warping, torsional, distortional, shear, and St. Venant torsion shear stresses were resisted by internal cross bracing and stout lateral WT section horizontal truss bracing, contributing to the system stiffness. The transverse integral diaphragms were designed to be composite with the deck in two-way bending with principal stress checks, even within the negative moment region as required per AASHTO *LRFD Bridge Design Specifications* (**store.transportation.org**), and were supported on two eccentric polytetrafluoroethylene (PTFE)/pot bearings as part of a system of fixed and guided bearings for translations and rotations in the direction of movement. The movement was further accommodated by the strip seal expansion joints at the beginning and end bridge.

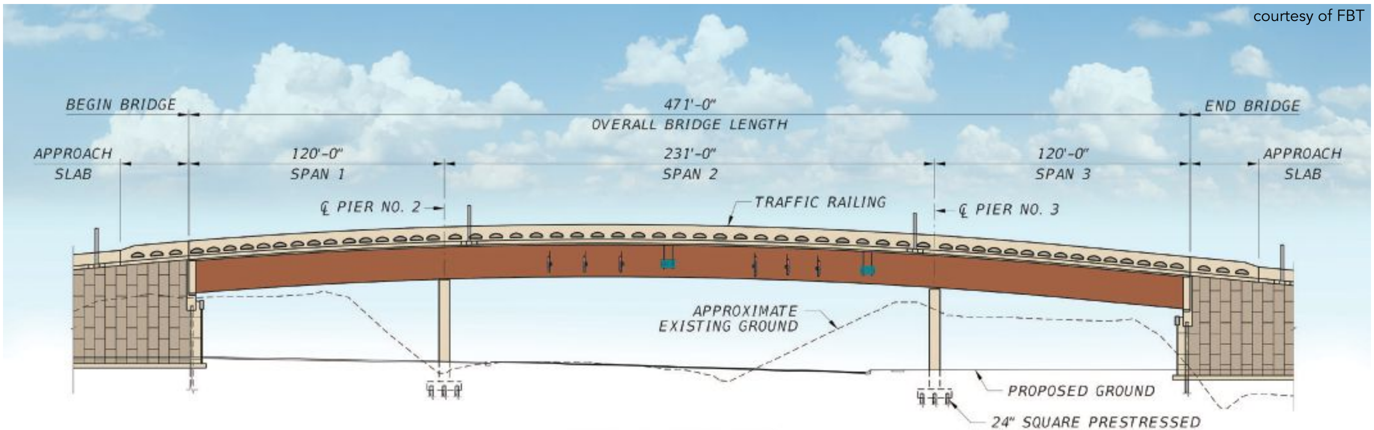
The integral steel box pier diaphragms required the longitudinal box girders to align geometrically and provide continuous access for maintenance and inspection throughout the limits of the structure. Therefore, the walls of the pier diaphragm box girder required 2⅔-ft-wide by 3½-ft-tall openings at the intersections with the longitudinal tub girders and along the length of the pier diaphragms. The openings were strategically located so they could be reinforced by the jacking stiffeners at the sides in case the bearings ever needed to be replaced.

The box girder internal cross bracing and horizontal truss members required accommodating the interruption for the continuous diaphragm top flange, the jacking and bearing stiffeners, as well as the adjacent field splices that allowed the diaphragm boxes to be shipped in one piece. The internal stresses from the shortened end span arrangement were balanced by the stiffness of the integral box diaphragm, where longitudinal and transverse bending necessitated the need to check the principal two-way stresses in the diaphragm top flange. The connections, often with eccentric bolt groups, were designed for applicable limits states: tension and shear yielding and rupture, bearing and tearout, block shear rupture, and Whitmore sections for tension member gusset plates, among others. The integral diaphragms were designed by hand, while the longitudinal girders were modeled using a 3D grid model.



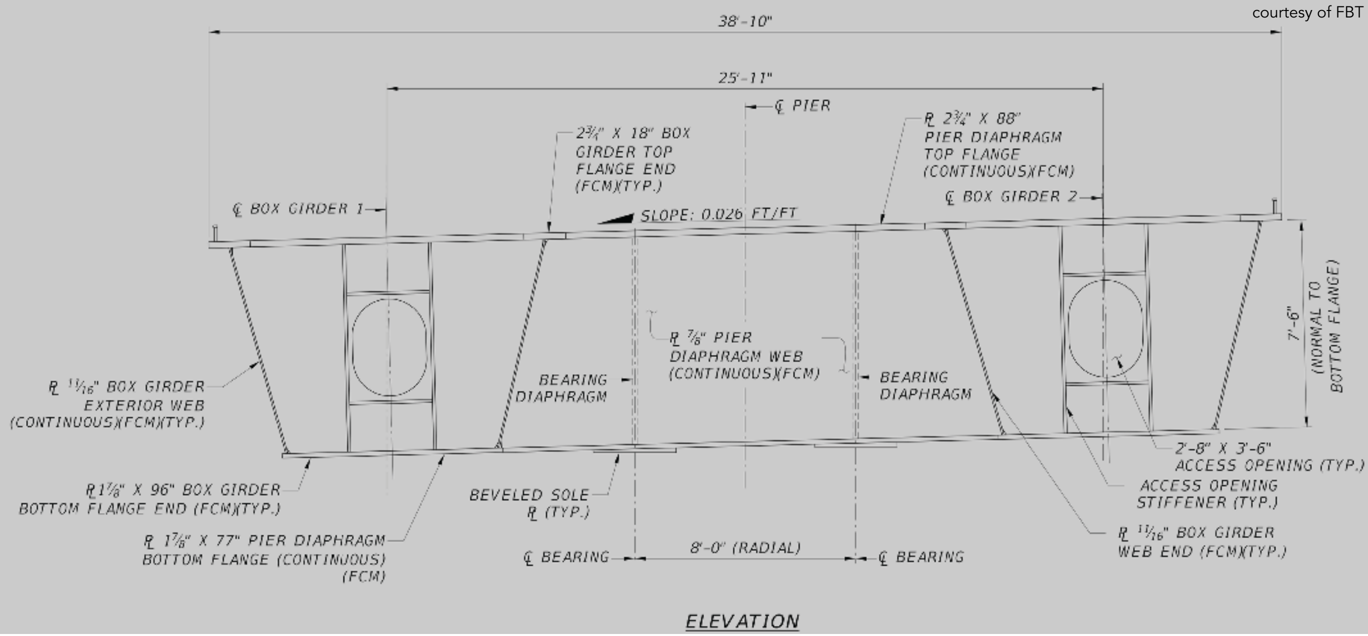
courtesy of FBT

A typical tub girder section.



courtesy of FBT

The bridge elevation view from plans.



courtesy of FBT

A detail of the integral pier diaphragms.


courtesy of FBT

above: A typical pier segment supported by a single concrete column.

below: A pier segment integral with a steel diaphragm.


courtesy of FBT


The girder shop assembly for fabrication fit-up.

courtesy of Robert Clark, Jr (Tampa Steel)

FDOT classifies the flyover as a “major bridge,” which required an independent peer review with oversight and review from the FDOT Central Office. The peer review’s intent was to produce an independent design using different 3D modeling software than the original design to verify the adequacy of the modeling methods and the assumptions used to create the models.

When it came to the deck pour, the sequence was designed to minimize the potential for cracking in the deck caused by subsequent pours. The first three deck pour limits were within the positive moment regions at the ends and in the middle of span 2, away from the tension and stress reversal regions, and enough deck area was poured in the first two end pours to anchor the end spans and avoid uplift. The subsequent pours were the negative moment regions.

Fabrication and Shop Assembly

The flyover bridge was fabricated with ten tub girder sections and two pier diaphragm box girders. Since it uses weathering steel, all complete joint penetration (CJP) welds were required to have the last two layers of the weld made with a weathering consumable. The CJP butt splice welds were internally filled with typical non-weathering Lincoln Electric's L61/960 SAW (submerged arc welding) weld wire and flux combination. All CJP welds were then capped with two passes welded with Lincoln Electric's Lincolnweld LA75/960 SAW wire flux combination—the weathering welding consumable—to ensure that the welds would have the same corrosion resistance and aesthetic patina as the base metal on the rest of the bridge.

The construction specifications in the contract documents specifically required a full bridge fit-up. To assemble the individual steel girder components as they would be configured in final erected position, fabricator Tampa Steel Erecting Company altered its typical standard shop assembly procedures to accommodate the integral pier diaphragms.

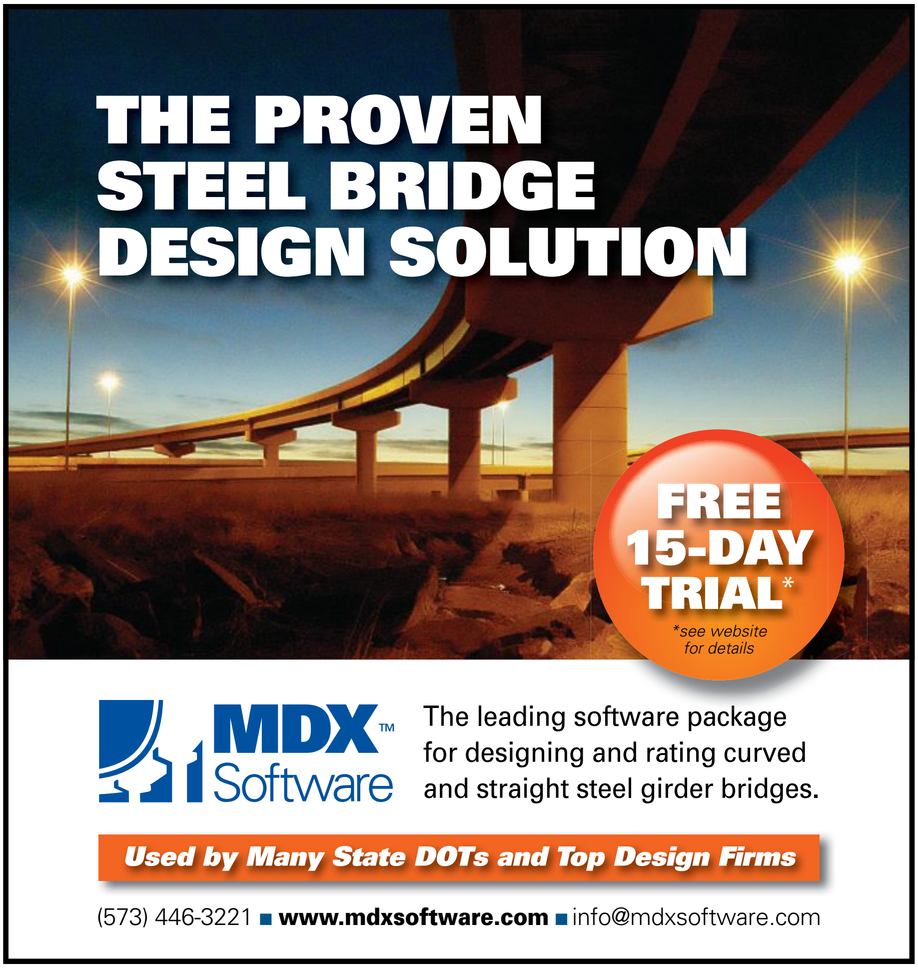
In lieu of starting the laydown process at one of the end bents and progressing to the other, the laydown started with each one-piece pier diaphragm section and progressed towards the end bents. Careful staging of components was essential for proper tub girder-to-pier diaphragm fit-up. The gap between the ends of abutting girders and pier diaphragm stubs was held to no more than ¼ in. A 100-ton Mi-Jack travel lift maneuvered the tub girders and pier diaphragms into the correct positions.

The tub girder weights ranged from approximately 36.5 tons to 78 tons, with lengths ranging from 51 ft to 123 ft. Pier diaphragms weighed about 59 tons each, with an overall length of 38.8 ft. Each pier diaphragm had two bearings, located 8 ft apart. These bearing points were set first, then girders were brought in from each side, trimmed to length, and bolted together with match-drilled splice plates. The final survey tolerances of the bearing locations had to be within ⅛ in. for each direction.

Coating Process

After the laydown assembly, the components were disassembled and prepared for blasting and coating. The entire exterior and interior of all the girders and pier diaphragm boxes were blasted to an SSPC SP10 near white metal blast, removing mill scale and contaminants and achieving an even patina of the weathering steel.

The bridge's exterior was left bare, and the interior was coated with a single layer of Carboline's Carboguard 893 Epoxy coating. In lieu of the standard FDOT



requirement for a two-coat system (inorganic zinc and epoxy) for the interior of steel tub girders, this project was approved by FDOT for a single coat of the 893 Epoxy. That provided an illumination-friendly surface to assist maintenance teams with future inspections and select the proper coating that would provide the best value to Florida residents. Removing the requirement for the inorganic zinc coating and allowing a single interior coat saved time, labor cost, and material.

Girder Handling and Delivery

The tight 500-ft radius required careful planning for lifting, handling, and shipping of the highly curved tub girders to avoid rollover. It was critical to determine the longitudinal centerline of gravity for establishing rigging pick points and trucking bolster support points so the girders would stay balanced during lifting and shipping operations. Tampa Steel created temporary supports at the shop, including free-moving tilt tables, and then set the ends of each girder on the tilt tables with its 100-ton Mi-Jack mobile crane. Each end of the girder sections was then shifted transversely until the balance points were found and marked on the girders. The points were used to center the girder sections under the crane hooks and on the trucking equipment.

The increased lengths and weights of the oversized loads required the trucking routes to be carefully planned and coordinated with FDOT, whose analysis explored clearances, structures to be crossed, and load-limit restrictions. Both lead and follow escort vehicles were required for each load that was delivered. Gross vehicle weights, axle spacings, widths, heights, and travel times were planned in detail by Gator Transport, Inc., and then coordinated with FDOT, which ultimately granted the oversize load permits to ship each of the fabricated sections.

Social and Economic Considerations

The structure incorporated intersection signing and signals on the bridge to supplement the mast arms for the intersection beneath the bridge. A permanent bat abode was mounted between the box girders to be inhabited by the environmentally protected bats that were present in the previous bridge. The bats were humanely excluded from the original bridge prior to construction, and the abode had to be located in a portion of the bridge with reduced live load vibrations (near a support). It consists of 4-ft by 8-ft sheets of plywood with ¾-in. spacers, which provide the bats with crevices for roosting.

As far as aesthetics, the box girders met Mount Dora's requirements and have a rustic weathering steel look that met the Wekiva Parkway Aesthetic Master Plan requirements. The color schemes and textures with recessed form liners were also a requirement on the columns and the scallops on the outside face of the traffic railings.

The Mount Dora City Commission and FDOT did not want the interchange to feel like an interstate roadway in residents' backyards. Not only did this structure eliminate the need for a three-level interchange, but it also further reduced the profile by up to 10 ft with the use of an innovative integral diaphragm with trapezoidal box girders when compared with a more traditional use of steel plate girders supported on top of hammerhead concrete pier caps. The shorter and more compact bridge is significantly less intrusive to the adjacent residents, yet still provides full functionality of the original concept from a traffic perspective.

The completed project represents an elegant solution that satisfies the many different project constraints. All told, the construction cost was $32.8 million, the estimated construction duration was 850 days, and the total continuous structure length of 471 ft is nearly 70% shorter than the 1,593-ft flyover eccentric to the at-grade intersection from the study phase concept plans.

The project will serve as a valuable case study that illustrates a better solution than more traditional interchange configurations when the level of service is acceptable. The revised geometry from the study phase simplified the project and allowed the use of a simpler mechanically stabilized earth (MSE) embankment, which


courtesy of FBT

The white interior coating provides improved inspectability.


courtesy of FBT

The bat abode under the bridge.

Traffic signals are actually mounted on the bridge.

courtesy of FBT

shaved nine months off the construction schedule, saved roughly $3 million, and greatly reduced impacts on the adjacent residential properties in Mount Dora. ■

The opinions, findings, and conclusions expressed in this article are those of the authors and not necessarily those of the Florida Department of Transportation or the U.S. Department of Transportation.

Owner
Florida Department of Transportation

General Contractor
GLF Construction Corporation, Miami

Bridge Prime Designer and Structural Engineer
Florida Bridge and Transportation, Orlando

Bridge Independent Peer Review Engineer
BCC Engineering, Miami

Prime Design Consultant and Design Project Manager
Moffatt and Nichol, Lake Mary, Fla.

Construction Engineering Inspection (CEI)
RK&K (Rummel, Klepper and Kahl), Orlando

Erection Plan Drawings
McElhanney Consulting Services, Tampa

Steel Team

Fabricator and Erector
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Tensor Engineering AISC DETAILER, Indian Harbour Beach, Fla.

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Joining Forces

BY JOHN CROSS, PE AND EMILY B. LORENZ, PE, F-ACI

Steel and concrete bridge champions collaborate to develop thorough bridge life-cycle assessments and lower embodied carbon material procurement requirements

ON THE SURFACE, two recent federal initiatives of increasing infrastructure spending and reducing carbon emissions seem mutually exclusive, which raises the question of whether more bridges can be built while simultaneously lowering the carbon emissions associated with their construction.

Those two can coexist, though, but only if a consistent and robust technical framework is in place for evaluating the embodied carbon impacts of the materials used in their construction.

To address this task, the steel and concrete industries have joined together to develop fair and technically robust life cycle assessment (LCA) requirements for the bridge market that will address the need. The National Concrete Bridge Council (NCBC) and the National Steel Bridge Alliance (NSBA) are working to craft a guidance document for properly conducting an LCA specifically applicable to bridges. The guidance will also address the procurement of lower embodied carbon materials.

The guidance document will be especially valuable to state departments of transportation that are increasing their infrastructure investments but must operate within recent legislation designed to reduce the embodied carbon impact of construction materials.

Some of the recent federal, state, and local initiatives that are driving this push toward more sustainable solutions include the following actions:


CHA Consulting

- FHWA issued a vision for pavements: "To advance the knowledge and practice of designing, constructing, and maintaining more-sustainable pavements through stakeholder engagement, education, and development of guidance and tools." (Ram et al., 2017)
- The White House has set economy-wide CO_2 targets: 50% reduction by 2030, 100% reduction by 2050 (based on 2005 baseline). (White House, 2023)
- A Federal Buy Clean initiative was announced in September 2022. (White House, 2022)
- Creation of a carbon reduction program through the Bipartisan Infrastructure Law. (FHWA, 2023)
- California, New York, Colorado, Minnesota, and Oregon are among the states to enact Buy Clean legislation that established embodied carbon thresholds for purchasing construction materials for buildings and infrastructure projects. (Carbon, 2022)

These initiatives can only be successful if the embodied carbon impacts they seek to reduce can be accurately and consistently measured and quantified.

Design decisions need to be based on numerous analytical factors, including the environmental effects of alternative scenarios. Today, properly evaluating the embodied carbon impacts of the project in terms of its global warming potential (GWP) is critical. A bridge LCA is necessary for measuring GWP and must be based on

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Carbon Leadership Forum, 2022. "Implementing Buy Clean." Seattle, WA. **tinyurl.com/clforum22**

FHWA. 2023. "Fact Sheets: Carbon Reduction Program (CRP)." Washington, DC. **tinyurl.com/fhwacrp**

Ram, P.V. et al. 2017. *Sustainable Pavements Program Road Map.* Washington, DC: Federal Highway Administration (FHWA). **tinyurl.com/fhwaspr**

The White House. 2023. "National Climate Task Force." Washington, DC. **whitehouse.gov/climate/**

The White House. 2022. "FACT SHEET: Biden-Harris Administration Announces New Buy Clean Actions to Ensure American Manufacturing Leads in the 21st Century." Washington, DC. **tinyurl.com/buyclean22**

© Alex Menendez/courtesy of TranSystems

a consistent and sound technical methodology.

But the effort to reduce embodied carbon must not stop there. The same product from different producers will have different embodied carbon impacts associated with the producer's manufacturing and production processes. Procurement guidelines are necessary to ensure that any differences in the manufacturing process from company to company still lead to producing low embodied carbon products.

Today's bridge market lacks comprehensive tools to quantify and reduce negative environmental impacts. The first step in developing the tools is the LCA guidance document.

Why a Consistent LCA Framework Is Needed

Current Buy Clean legislation and embodied-carbon-reduction specifications for steel and concrete materials used in bridges are technically insufficient and developed without industry input. Legislation or specifications sometimes disagree with ISO standard requirements that have established the methods for measuring, evaluating, and reporting environmental impacts. Without technically accurate requirements, departments of transportation cannot know if they are truly accomplishing the mandated goal of reducing

the environmental impact of concrete and steel bridges.

What Will Be Developed

The steel and concrete industries have been conducting LCAs for more than 20 years and have the longest history of evaluating and reporting the environmental impacts associated with structural materials. Representatives of these industries are well-versed in the ISO standards used during assessments and frequently serve on the committees that develop them.

Together, a joint effort of the steel and concrete industries will provide the best opportunity for crafting technically sound language that can be used to accurately determine real reductions in environmental impacts, including embodied carbon. By joining together to develop resources, the concrete and steel bridge industries can ensure that the requirements that will be implemented are fair and technically robust.

Goals

The steel-concrete collaboration aims to develop a guidance document for conducting LCAs for bridge projects and addressing the procurement of materials. This guidance document will:

- Maintain technical accuracy and adherence to ISO standards.
- Emphasize the importance of performance in conjunction with reducing environmental impacts.
- Frame decision-making from a whole life cycle context and evaluate a full set of environmental impacts.
- Be mindful of existing DOT requirements and the Envision Rating System (similar to LEED but for infrastructure projects) to harmonize with current industry practices, where possible.
- Solicit feedback from bridge engineers, DOTs, and other agencies during work product development.

It is anticipated that draft guidelines will be available for review in mid-2024.

"NCBC looks forward to the collective efforts between the concrete and steel industry groups on a scientific-based approach to aid bridge practitioners in assessing and reducing the embodied carbon in the design and execution of their projects," said NCBC chair Gregg Freeby.

"NSBA is thrilled to work on this collaborative effort to standardize the environmental assessment of steel and concrete bridges, and we're confident that the marketplace will benefit from this unified approach," said NSBA chief bridge engineer Chris Garrell, PE. ■

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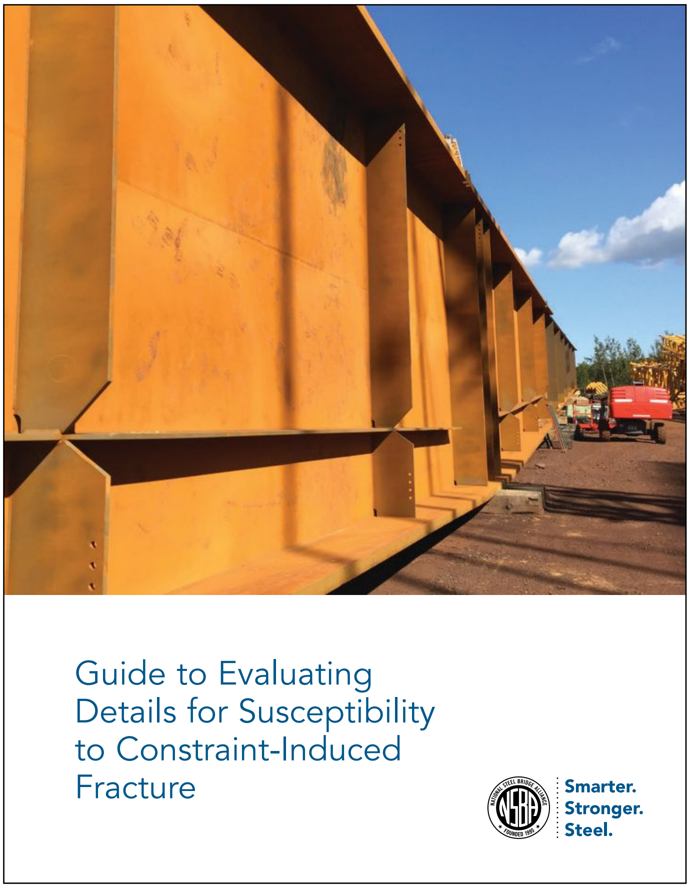
Intersecting Welds in Bridges—Myth or Monster?

BY DOMENIC COLETTI, PE

FHWA and NSBA guidance dispels long-standing notions about welding details and their susceptibility to constraint-induced fracture.



Guide to Evaluating Details for Susceptibility to Constraint-Induced Fracture

Smarter.
Stronger.
Steel.

AMONG THE MANY MYTHS associated with welding is the idea that details with intersecting welds are problematic or failure-prone and should be avoided. This is not true, though, and details with intersecting welds are not necessarily subject to elevated susceptibility to failure. Recently published guidance from the Federal Highway Administration (FHWA) and the National Steel Bridge Alliance (NSBA) helps dismiss that myth, as well as clarify some misconceptions about welds and constraint-induced fracture (CIF).

Historically, few significant problems have been tied to steel bridge details with intersecting welds. There have been few notable instances of bridges suffering from CIF. Perhaps the most famous is the Hoan Bridge, which suffered fractures in all three girders in one of the approach spans. After a detailed forensic investigation, the FHWA published a technical memorandum about the incident.

The memo stated the fractures occurred at details that exhibited excessive triaxial constraint, where a welded lateral bracing system gusset plate and a welded cross-frame connection plate framed into the girder web, with minuscule gaps between the two plates. It also included some recommended actions intended to help owners and inspectors identify conditions that might be susceptible to triaxial constraint—which is often associated with the intersection of three or more welded steel elements—suggesting that further evaluation might be warranted if "intersecting or touching welds are identified or suspected."

With that, the myth was born. Bridge designers and owners took the guidance to watch for details where three or more welded steel elements intersected with small gaps in areas subject

Evaluation of Steel Bridge Details for Susceptibility to Constraint-Induced Fracture

FINAL REPORT

Publication No. FHWA-HIF-21-046
Office of Bridges and Structures

September 2021

U.S. Department of Transportation
Federal Highway Administration

to tension as "intersecting welds are bad and can lead to fracture."

That's an incorrect interpretation of the lessons from the Hoan Bridge, and it has led to the implementation of some misinformed policies and questionable repair and rehabilitation actions. To correct these misconceptions and provide clearer guidance on CIF, the FHWA commissioned a report that reviewed the pertinent literature and developed consensus guidance based on input from a team of industry experts.

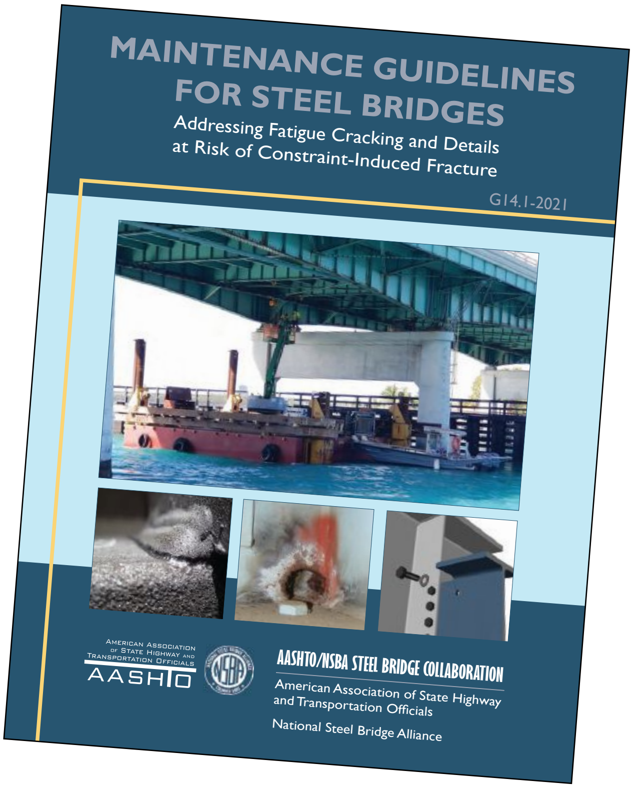
The report provides a simple, generalized scorecard procedure that can be used to evaluate any steel bridge detail for susceptibility to CIF. It includes 18 examples of using the procedure to assess a wide range of common steel bridge details, with suggestions for protocols after finding a particular detail that may have elevated susceptibility. Subsequently, the NSBA produced an abridged version of the FHWA report that can be used as a design guide for steel bridge engineers. That guide includes some background information, but mostly focuses on the evaluation procedure and the 18 examples.

The risks associated with elevated susceptibility to CIF could be significant, but modern bridges do not feature details subject to elevated susceptibility (thanks to some simple provisions and prohibitions in the AASHTO *LRFD Bridge Design Specifications*). Furthermore, evaluating whether a particular detail in older bridges may be worth a closer look is easy, and if a detail is found to have elevated susceptibility, the retrofit actions that can provide relief of the triaxial constraint are not hard to implement. NSBA can help with that too, thanks to a recently published AASHTO/NSBA *Steel Bridge Collaboration Guideline* that presents retrofit details for various situations.

Want to learn more?

Here are some free resources that can help:

- **aisc.org/fhwa-steel**, Publication No. FHWA-HIF-21-046, Federal Highway Administration, September 2021
- **aisc.org/nsba-technical-resources**, *Guide to Evaluating Details for Susceptibility to Constraint-Induced Fracture*, National Steel Bridge Alliance, June 2023
- **aisc.org/nsba-collab-guidelines**, Guideline G14.1-2021, AASHTO/NSBA Steel Bridge Collaboration, 2022



MAINTENANCE GUIDELINES FOR STEEL BRIDGES
Addressing Fatigue Cracking and Details at Risk of Constraint-Induced Fracture

G14.1-2021

American Association of State Highway and Transportation Officials
AASHTO

AASHTO/NSBA STEEL BRIDGE COLLABORATION
American Association of State Highway and Transportation Officials
National Steel Bridge Alliance

Designers can use the new NSBA guide to learn how to spot details in new designs that may warrant evaluation for susceptibility to CIF and can use the simple scorecard procedure to perform the evaluation. Likewise, owners can use the NSBA guide to evaluate details quickly and easily in existing bridges for elevated susceptibility and make more informed decisions about possible retrofit actions. ■

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Making Connections

BY PATRICK ENGEL

AISC's 14th annual celebration of steel has outgrown one day and is now a weeklong event known as SteelDays.

AISC'S FLAGSHIP FALL EVENT outgrew its name.

Last year, a mere day couldn't accommodate all the conferences, tours, and hands-on experiences planned as part of SteelDay, requiring expansion to an entire week.

The 2023 version is also one week long and, appropriately, has been rebranded as SteelDays. But the goal is still the same as always: to serve as an annual celebration of the structural steel industry, sponsored by AISC and its partners. It gives AEC professionals, faculty, students, and the public firsthand experience in the U.S. structural steel world through events across the country. Participants can learn about the latest technologies and trends in steel, as well as network with people in the industry. The 14th edition of the event runs October 16–20 and begins with the fully virtual Flash Steel Conference, which is comprised of 20 half-hour-long sessions on various industry topics.

Here's a look at some of the in-person SteelDays events happening across the country.

Costa Mesa, Calif. (October 17): John A. Martin Associates and Morphosis Architects are leading a tour of the Orange County Museum of Art, a 2023 IDEAS^2 Award-winning structural steel project.

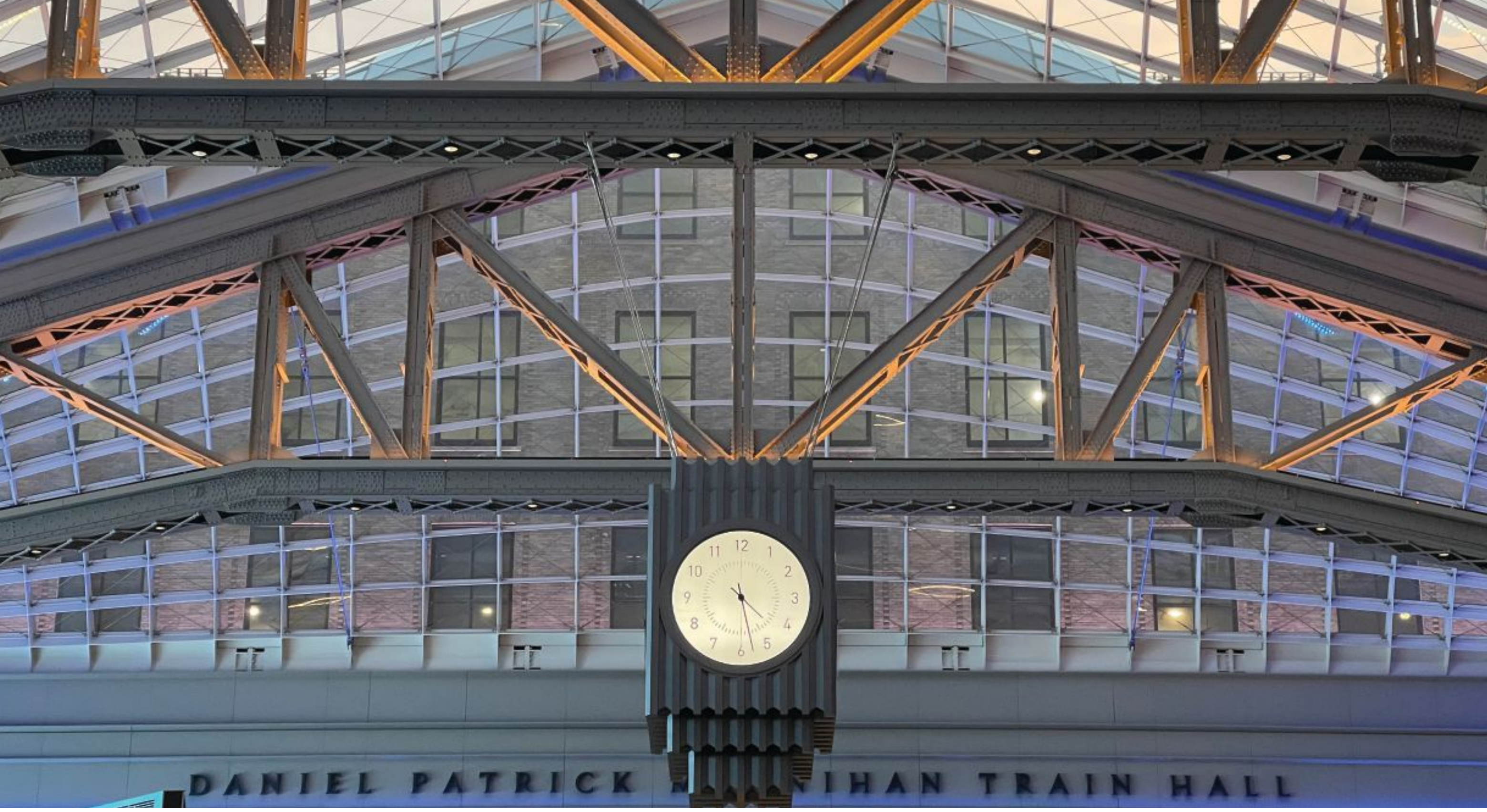
Aurora, Ill. (October 20): Garbe Iron Works, one of the Midwest's top fabricators, is hosting a tour of its shop and will offer a look at how it takes design and makes structural steel a reality for the Chicagoland area. A reception with food and drinks and an AISC-sponsored raffle will follow.

Denver (October 17): Puma Steel, Total Welding, Inc., and Hensel Phelps are joining to hold a site tour of the largest Class A office project to break ground in Denver in 40 years. Designed with the latest technology, sustainability, and health and wellness standards in mind, this project will soon become an anchor of an active mixed-use neighborhood centered around Union Station.

Lancaster, Pa. (October 19): Join High Steel Structures for a full-day event that includes a morning technical session, barbeque lunch, guided facility tours, and welding demonstrations. Registration is required, and the technical session is offsite.

Multiple locations nationwide (October 16–20): Iron Workers Local chapters are hosting visitors at locations across the country to give a firsthand experience of an ironworker's daily duties at a job site. Attendees will have the opportunity to weld, flame-cut, rig a beam, and climb a column—all while learning how to make the most of Ironworker Management Progressive Action Cooperative Trust (IMPACT) and AISC resources.

Training facility tours are planned in Atlanta, Boston, Denver, Phoenix, San Diego, Kansas City, Mo., La Palma, Calif., and Astoria, N.Y.



New York (TBD): Severud Associates is offering a chance to tour Moynihan Train Hall, a 2023 IDEAS^2 winner and the latest exciting development that connects New York City to the rest of the region. The project team will share some words about their experience and accept their awards. A design team member will give the tour, and a cocktail reception will follow.

Philadelphia (October 20): The Owen Steel design team that is working on the under-construction Life Science Building will give a tour of the job site.

Arlington, Texas (October 19): W&W|AFCO, Bosworth Steel Erectors, and Linbeck Group are co-hosting an event in the Dallas-Fort Worth Area. The day will include a tour of the National Medal of Honor Museum and a video that catalogs steel's journey on the project. Participants will also hear from the teams that brought the project to life.

Vineland, N.J. (TBD): Prove your welding skills and aim to win big prizes at the Student Welding Competition, hosted by Southern New Jersey Steel Company. Contestants will showcase their welding skills, and the winners will walk away with exciting prizes. This competition is the perfect platform for budding welders to showcase their potential and prove themselves in front of a large audience of fellow classmates and future employers.

Other SteelDays events are not open to all, but fabricator shops and Iron Workers local chapters are open to hosting public on-site tours at any time. Here's a look at some closed events.

Washington, D.C. (October 18): Students at Phelps ACE High School in Washington will tour the Iron Workers Local 5 Training Facility, learning about the ironworker trade, actively participating in welding, cutting plate with a torch, rigging and connecting beams, tightening and untightening bolts with a spud wrench, and climbing a steel column. A lunchtime Q&A session with university students in the ACE fields will follow.

Multiple locations nationwide (several dates): High school students in career and technical education programs can tour a local fab shop and get the inside scoop on the fascinating world of structural steel fabrication. Among the fab shops hosting tours are Capone Iron (Berlin, N.H. and Rowley, Mass), Basden Steel (Burleson, Texas), SteelFab Inc. of Alabama (Roanoke, Ala.), Hancock Steel (Findlay, Ohio), SL Chasse (Hudson, N.H.), STS Steel (Schenectady, N.Y.), Novel Iron (New Boston, N.H.), and Tarrier Steel (Columbus, Ohio).

Pittsburgh (October 19–21): AISC is hosting the three-day Steel City excursion's opening night kick-off dinner at the Grand Concourse, a historic, steel-framed train station in downtown Pittsburgh that was adapted into a high-end restaurant and bar. AIA Tampa Bay and AIA Pittsburgh members will attend. All told, the event includes tours of the Grand Concourse, downtown Pittsburgh (the Steel City), Frank Lloyd Wright's Fallingwater, the Andy Warhol Museum, and the steel-framed Phipps Conservatory.

SteelDays participation need not be in person, though. The fourth Flash Steel Conference is comprised entirely of webinars and can be accessed from any computer. The conference features five tracks that cover adaptive reuse, connections, detailing, seismic design, and more. Participants can earn up to 10 PDHs.

To view a list of the above and other events, register for an event, and learn more about SteelDays, visit aisc.org/steeldays. We'll see you in October! ■

Patrick Engel (engel@aisc.org) is associate editor of *Modern Steel Construction*.

MAKING CONNECTIONS

SteelDays 2023

October 17–20

One day just isn't enough!

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to fit your busy life.

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at welding.

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to network
with existing
and potential
customers.

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that show you
how steel is
prepared for
your project.

A free
national webinar.

aisc.org/steelday

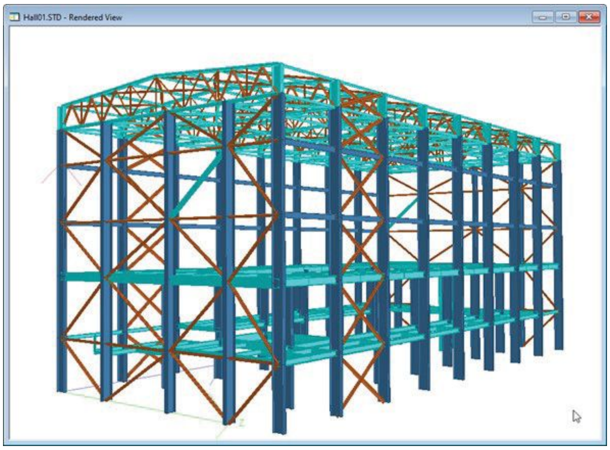
Smarter.
Stronger.
Steel.

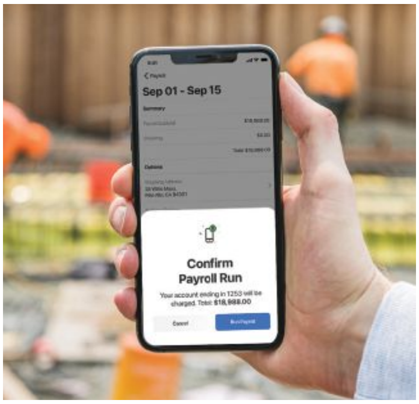
new products

This month's New Products section features an updated design software package, a workers' comp software package that uses real data to calculate premiums, and a Bluetooth hearing protector designed for work environments with harsh noises.

Bentley STAAD.Pro 2023

STAAD.Pro 2023 offers several new structural analysis and design features. Structural engineers can work side-by-side with a previous version of STAAD.Pro CONNECT Edition, allowing them to use all the latest benefits of STAAD.Pro 2023 on new projects, but still complete older jobs with the CONNECT Edition. With enclosed zone loading, STAAD.Pro 2023 can handle more complex shapes, including openings and members within the zone that are not designed to attract the loading directly (such as bracing members). The user report system is now built on a database platform, which enables a higher level of customization. The application's standard profile database system offers greater flexibility, allowing new databases to be created, shared, and employed without needing to redefine existing database assignments. For more complex types of analysis, such as transient dynamic or collapse analysis, a new export option enables model data to be generated in the ADINA format. For more information, visit **www.bentley.com/software/staad/**.





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Savox Noise-COM 500

Savox Noise-COM 500 is a Bluetooth hearing protector designed for use in extremely harsh and noisy operations. The ability to communicate with clarity is of equally high importance, and these robust and durable hearing protectors combine excellent ambient sound quality with an outstanding noise-cancelling microphone for clear speech. The Savox Noise-COM 500 can be connected to various Bluetooth two-way radios or mobile phones, allowing users to comfortably listen to audio as well as make and receive phone calls. Additionally, the ambient sound feature allows users to clearly hear speech or warning signals while blocking high-level, harmful noises out. There is also an easily accessible rotary button for push-to-talk and ambient sound volume adjustment. Another version, the Savox Noise-COM 500XP model, has an added option to define ambient sound audio profiles for different occasions, enabling the best possible audio for every operational situation. Both devices also have a voice-prompted menu, a built-in rechargeable battery, a low battery warning with an automatic switch-off, and casting technique that protects the electronics for maximum reliability. For more information, visit **www.savox.com**.

MANUAL

AISC Releases 16th Ed. *Steel Construction Manual*

The 16th edition of AISC's *Steel Construction Manual* is now available at **aisc.org/publications**. The *Manual* is the authoritative reference for professionals who design, fabricate, and build with structural steel.

The 16th edition includes:

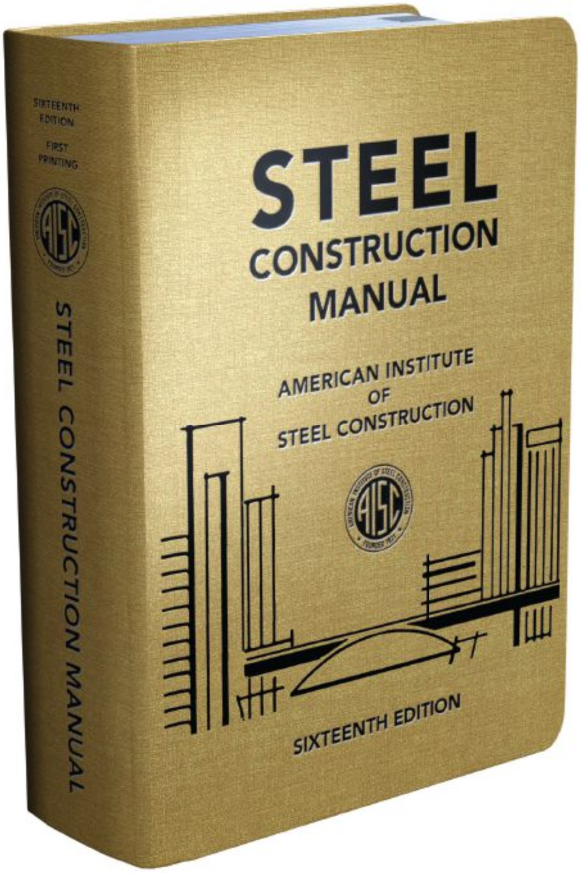
- New 50-ksi steel design tables
- Properties and dimensions for 210 new hollow structural section (HSS) shapes
- Revised and expanded discussion of prying action
- New and revamped tables for design of double-angle connections, single-plate connections, single-angle connections, and shear end-plate connections
- New section on the design of simple connections for combined forces
- Updated discussion on the chevron effect, as well as new information and a new table on wrap-around gusset plates

The *Manual* also features the 2022 editions of the AISC *Specification for Structural Steel Buildings* and the AISC *Code of Standard Practice*.

AISC released several new free resources to complement the *Manual*'s publication, including the v16.0 Manual Companion, v16.0 Shapes Database, v16.0 Historic Shapes Database, Basic Design Values Cards, and an Interactive References List.

"The *Steel Construction Manual* has been the gold standard for structural steel design and construction for almost a century—and the 16th edition's gleaming cover just underscores its role as the go-to reference for industry professionals around the world," said AISC director of manuals, Margaret Matthew. "Since the first edition's publication in 1927, the *Manual* has defined codes and standards worldwide and established a shared language and knowledge base for everyone who works with structural steel. We're honored to continue that tradition with the gold edition."

The *Manual* is priced at $250 for AISC members and $500 for nonmembers. A digital edition will be available this fall. Visit **aisc.org/publications** for more information.



People & Companies

AISC's director of workforce development **Jennifer Traut-Todaro, SE**, will take on additional leadership responsibilities next year: president of the **Structural Engineers Association of Illinois (SEAOI)**.

Traut-Todaro began her tenure as president-elect in July 2023 and will officially begin her term as president July 1, 2024.

"As we continue to transition out of social distancing and acclimate to the state of remote work and collaboration, it is becoming more and more important to engage our members and the profession in new ways," she said. "I plan to work on this specifically this year, drawing on ideas from others as well as testing out a few of my own. I am committed to reaching as many SEAOI members as we can, through a variety of programming that meets their needs."

Traut-Todaro has served on the Executive Committee since 2021, first as secretary and then as treasurer, and is currently the co-chair of the Equity, Diversity, and Inclusion ad-hoc committee.

She is particularly proud of co-founding (with Christine Freisinger of Wiss, Janney, Elstner Associates) the Women in Structural Engineering committee. Since its inception in 2010, the WiSE program has provided vital support for SEAOI's members. It is now one of the organization's most engaged committees, connecting female engineers with mentors, valuable contacts, and other resources.

"I'm particularly honored to follow in the footsteps of former AISC director of education Nancy Gavlin, who was the first female SEAOI president," said Traut-Todaro, who will be the fourth female president in the organization's 59-year history.

ENVIRONMENT

Steel Associations Push American Steel for Wind and Solar Projects Receiving IRA Bonus Credits

Five trade associations representing the American steel industry urged the U.S. Treasury Department to ensure that certain wind and solar components use U.S.-produced steel to qualify for the domestic content bonus tax credits under the Inflation Reduction Act (IRA). The agency is responsible for implementing the guidance for clean electricity production and investment tax credits from the IRA.

In a letter to Treasury Secretary Janet Yellen, AISC, the American Iron and Steel Institute (AISI), Steel Manufacturers Association (SMA), Committee on Pipe and Tube Imports (CPTI), and Specialty Steel Industry of North America (SSINA) expressed concern that the current guidance allows the use of imported steel in place of available domestic steel products in three areas: monopiles for offshore wind facilities, steel components with structural functions in photovoltaic tracking systems (including torque tubes, foundations, and rails), and steel fasteners.

"We believe that the agency should take appropriate action to fix... errors in the recently issued guidance," the letter stated. "It is critical to ensuring that the clear intent of Congress to incentivize the use of domestic steel and iron in clean energy projects is realized. It also ensures that the guidance does not unwittingly benefit China and other countries that have repeatedly exported dumped and subsidized steel into the U.S. market, injuring domestic steel producers and their workers. The domestic steel industry has made significant investments to expand its capacity to satisfy demand for these products. There are no constraints on domestic supply that would justify removing them from the scope of the IRA's domestic iron and steel requirement."

ENGINEERING JOURNAL

Fourth-Quarter 2023 *Engineering Journal* Now Available

The fourth-quarter 2023 issue of AISC's *Engineering Journal* is now available. It includes papers on the strength of I-girders subjected to concentrated loads, the post-single component fracture behavior of two-channel mechanically fastened axial members, tests on embedded column base connections, and research on adhesive steel-to-steel connections.

To access this issue and all past issues of *EJ*, visit **aisc.org/ej**.

Strength of I-Girders with Narrow Panels Subjected to Concentrated Loads

Rolando Chacón and Luis B. Fargier-Gabaldon

This technical note deals with the strength of web panels under concentrated loads, with emphasis on girders with closely spaced transverse stiffeners (commonly referred to as narrow panels). A review of experimental data and data from simulations suggest that girders with closely spaced panels exhibit substantially higher strength to concentrated loads than that calculated in accordance with the AISC *Specification for Structural Steel Buildings*. A simple equation to account for a fraction of the excess in strength is proposed.

Internal Redundancy of Mechanically Fastened Built-Up Steel Axially Loaded Two-Channel Members

Jason B. Lloyd, Francisco J. Bonachera Martin, Cem Korkmaz, and Robert J. Connor

Previous research on large-scale fracture tests on mechanically fastened built-up steel members subjected to flexural or axial loads demonstrated resistance to complete member fracture due to cross-boundary fracture resistance (CBFR). This paper builds on and expands that work through additional experimental and analytical research into the behavior of two-channel mechanically fastened built-up axial steel members following fracture of a single component.

Seismic Performance of Embedded Column Base Connections with Attached Reinforcement: Tests and Strength Models

Ahmad S. Hassan and Amit M. Kanvinde

Embedded column base (ECB) connections used in mid- to high-rise steel moment frames derive moment resistance through bearing of the embedded column and base plate against the concrete footing. Five large-scale tests on ECB connections are presented; these feature cantilever columns subjected to axial compression and cyclic lateral loading.

The addition of vertical reinforcement in the form of stirrups mitigates this issue to an extent. A strength model considering these effects is proposed and shown to predict strength with good accuracy across a range of configurations, encompassing the different configurations of horizontal and vertical reinforcement. Limitations of the approach are discussed.

Steel Structures Research Update Adhesive Steel-To-Steel Connections

Judy Liu

Ongoing research on adhesive steel-to-steel connections is highlighted in this study, currently underway at the University of Massachusetts-Amherst and led by Dr. Kara Peterman, Associate Professor in the Department of Civil and Environmental Engineering. Dr. Peterman's research interests include the behavior of cold-formed and hot-rolled steel structures under service loads and extreme loads due to natural hazards. Among Dr. Peterman's accolades for her teaching and research are the University of Massachusetts-Amherst College of Engineering Outstanding Teacher Award, the McGuire Award for Junior Researchers from the Structural Stability Research Council (SSRC), the AISC Terry Peshia Early Career Faculty Award, and the AISC Milek Fellowship.

The four-year Milek Fellowship is supporting this research on the holistic design and behavior of adhesive steel-to-steel connections. The research team is partway through year two of the four-year study. Selected highlights from the work to date are presented, along with a preview of future research tasks.

FORGE PRIZE

AISC's Forge Prize Now Accepting Entries, Expands Eligibility Requirements for 2024 Competition

For the last five years, AISC's Forge Prize has challenged emerging architects to dream up an inspiring vision of the future—and the 2024 competition is now accepting entries from a broader pool of designers than previous iterations.

The basic questions are simple: What will the future look like? What will people build with? Where will they live, work, and play? This year, AISC is asking not only practicing architects—as was the case in the past—but also educators and graduate students to consider their answers.

"The future truly belongs to those who create it, and the Forge Prize offers a unique opportunity to dream big and envision something ground-breaking," said Jeanne Homer, AIA, senior architect with AISC's University Relations department. "I spent 20 years teaching architecture, and I've watched countless students come up with amazing concepts in the studio. I'm thrilled to invite the next generation of big thinkers and the educators who both guide and are inspired by them to enter the Forge Prize."

Established by AISC in 2018, the Forge Prize recognizes visionary emerging architects, architecture faculty, and graduate students for design concepts that embrace innovations in steel as a primary structural component.

The competition is open to designers or teams of designers based in the U.S. who are:

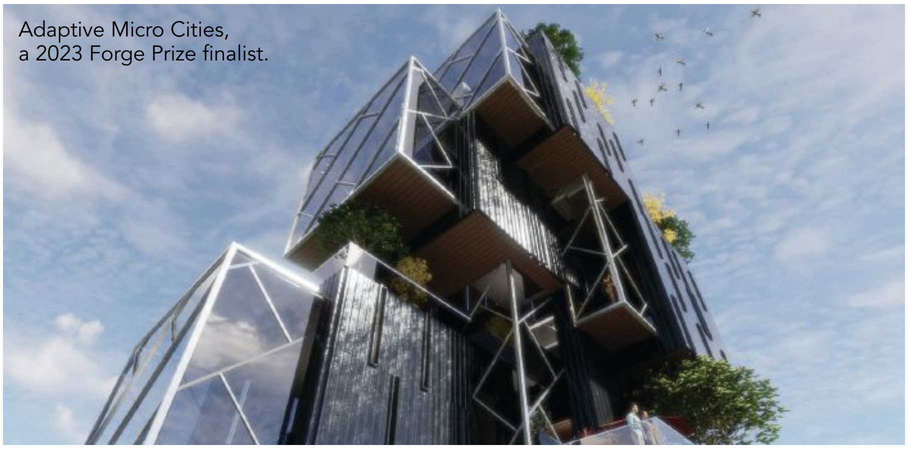
- Emerging practicing architects (those licensed for less than ten years or on the path to licensure)
- Tenured or tenure-track educators who have taught for less than ten years in a university-level architecture program in the U.S.
- Adjunct architecture educators who have taught for less than ten years and have been licensed for less than ten years or are on the path to licensure
- Graduate-level architecture students enrolled in a university-level U.S.-based architecture program

Three finalists each win a $5,000 cash prize. All three will receive free registration and travel support to attend the 2024 Architecture in Steel specialty conference at NASCC: The Steel Conference (taking place March 20–22, 2024, in San Antonio; visit **aisc.org/nascc** for information).

Winners will also work with an AISC-member steel fabricator to refine their concept before stepping into a global spotlight to present their concepts live to the judges—and to the public—on YouTube.

The winning designers will present their visions to the industry at the conference and take home the $10,000 grand prize.

Submissions are due by November 30, 2023. Visit **forgeprize.com** for information and to register.


Adaptive Micro Cities, a 2023 Forge Prize finalist.

Letter to the Editor

Tall Tale

I really enjoyed the news item about Sears/Willis Tower turning 50 in the July 2023 issue (**www.modernsteel.com**). I was especially pleased to hear an old friend, John Zils, was doing well.

The story brought back a memory from 40-plus years ago. I was asked to be part of a panel for the Educators Session at NASCC: The Steel Conference, and I found out that I would be sharing the podium with Fazlur Kahn, who was a hero to a steel person like me. Dr. Kahn was so open and friendly, and I learned a lot about how to be a good engineer and team member. He explained to the educators the importance of being able to work as part of a team, including how to respond and be open to other ideas. He stressed how to respond in a positive way when a change was needed. He also said that "any graduate engineer can design a member, but it takes an engineer to know where to place them."

The highlight came when he talked about the design of Sears (now Willis) Tower. He explained that at that time, steel designers used a formula to estimate the weight per square foot required based on the height of a structure. He talked about going into a meeting with Morse/Diesel and the owner, who were prepared to cancel the project because of the cost. He asked if the project weight was X, could it be built? When they said yes, he unrolled the bundled tube plan with a lower weight. He had a big smile on his face like he was remembering that day.

I was so impressed by his willingness to share, and I think it taught me what it truly means to be a professional engineer.

—Larry Kloiber, Former President and CEO of LeJeune Steel

marketplace & employment

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PEDDINGHAUS PEDDIWRITER PW-1250, (2) Hypertherm ArcWriter Torches, Siemens CNC, 2013, #32397
PEDDINGHAUS ABCM-1250/3B Beam Coping Line, 50" x 24" Max Profile, Fagor 8055, Retrofit 2010, #31655
PYTHONX Robotic Plasma Cutting System, HPR260XD Plasma, Conveyor & Transfers, 2013, #32822
PYTHONX Robotic Plasma Cutting System, HPR260XD, Plasma, Conveyor & Transfers, 2007, #32626
CONTROLLED AUTOMATION DRL-348TC Drill, 3-Spindle, ATC, Hem Saw, Conveyor & Transfers, 2009, #32361
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advertiser index

Of Equity and Expression

IF YOU LOOK at the above image, you might be thinking, "Wow, that looks like City Hall in downtown Los Angeles—but what on earth is that space-age-looking structure across the street?"

As a matter of fact, it's one of last year's Steel Design Student Competition (SDSC) honorable mentions. Sponsored by AISC and administered by the Association of Collegiate Schools of Architecture (ACSA), the annual competition challenges college- and university-level architecture students to explore issues related to using steel in design and construction. All design concepts are required to incorporate steel as the primary structural material. Every year, the competition includes two categories: an open category, which offers the greatest amount of flexibility in terms of building type, and a category with a more specialized focus. For the 2022 competition, the latter included an emphasis on equitable public spaces (see "Equitable Spaces" in the November 2022 issue at **www.modernsteel.com** to see last year's winners).

And to read all about the winners of the 2023 competition, check out next month's issue. This year's specialty category challenged students to come up with a design concept resulting in "A Place for the Spirit" on a campus, where members of the campus community and visitors can learn about and express spirituality. ■