Modern Steel Construction

September 2021

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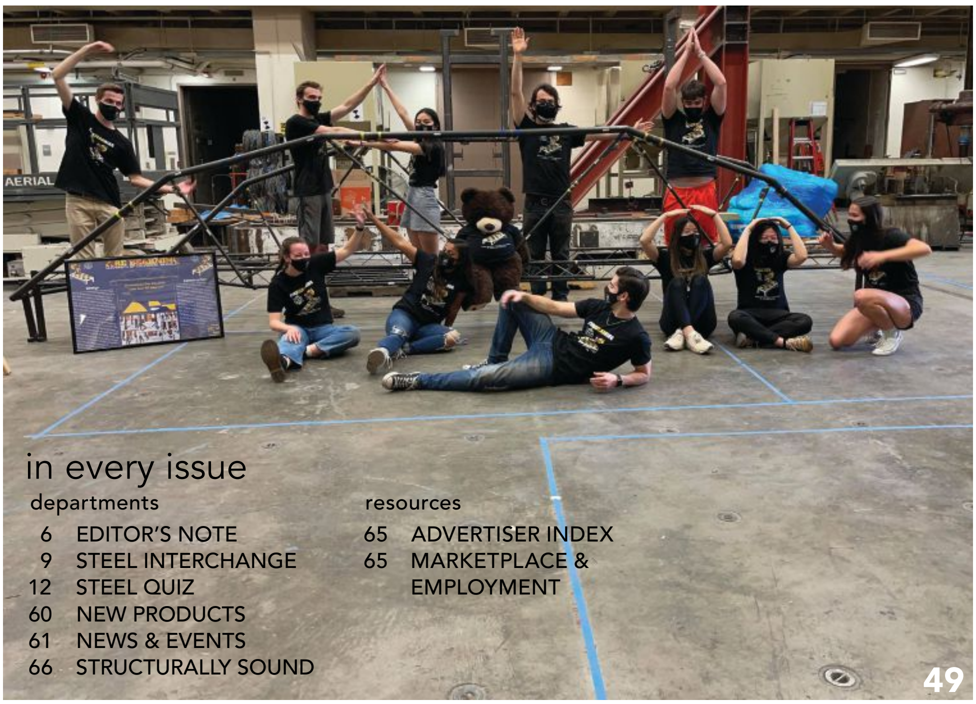
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ON THE COVER: Deerfield Academy in Massachusetts is raising its athletic profile with a new field house, p. 32. (Photo: Jeremy Bittermann/JBSA)

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editor's note

My dad was a subcontractor specializing in steel doors, frames, and hardware. As a child, my brothers and I would often spend Saturday afternoons in his shop, playing hide-and-go-seek among the partially built frames and other construction detritus. On other days, we'd accompany him to a construction site to drop off material, do a minor repair, or take measurements.

It's unlikely today that kids would be given free rein in a machine shop or even allowed on a construction site, but for me it was certainly a fantastic learning experience.

As an adult, I've been fortunate to visit numerous steel mills, steel fabricators, galvanizing plants, HSS manufacturers, service centers, machinery suppliers, joist manufacturers, and, of course, construction sites.

AISC's SteelDay was originally envisioned to create similar opportunities for professionals in the design industry. It's designed as an opportunity for engineers to see firsthand how the steel goes from their paper drawings to becoming completed steel structures. Unfortunately, this year, because of the ongoing pandemic, there are only a limited number of SteelDay events scheduled (see **aisc.org/steelday** for more information). And if you're fortunate enough to live near one, I encourage you to sign up and attend. You won't regret it!

But what do you do if there isn't a formal event nearby? You could, of course, attend one of our online presentations or take a virtual tour (**aisc.org/vr**). But somehow, while interesting and informative, online programs are no substitute for a hands-on experience. So I'd like to offer you a different opportunity.

If there isn't an in-person SteelDay event near you but you're interested in visiting and connecting with a steel fabricator, drop an email to Erika Salisbury at **salisbury@aisc.org**. Erika is our SteelDay specialist, and she'll do her best to connect you with a nearby fabricator.

I can't guarantee there's a fabricator within an hour- or two-hour drive of every reader, and I can't promise that every fabricator will welcome you into their shop, but my experience is that fabricators enjoy showing off their facilities and work. Of course, you probably won't be allowed to play hide-and-seek, but I guarantee an enlightening experience.

Scott Melnick
Editor

Modern Steel Construction

Editorial Offices
130 E Randolph St, Ste 2000
Chicago, IL 60601
312.670.2400

Editorial Contacts
EDITOR AND PUBLISHER
Scott Melnick
312.670.8314
melnick@aisc.org

SENIOR EDITOR
Geoff Weisenberger
312.670.8316
weisenberger@aisc.org

DIRECTOR OF PUBLICATIONS
Keith A. Grubb, SE, PE
312.670.8318
grubb@aisc.org

PRODUCTION SPECIALIST
Erika Salisbury
312.670.5427
salisbury@aisc.org

GRAPHIC DESIGN MANAGER
Kristin Hall
312.670.8313
hall@aisc.org

AISC Officers
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M.J. Mrvica Associates, Inc.
2 W Taunton Avenue
Berlin, NJ 08009
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Address Changes and Subscription Concerns
312.670.2401
subscriptions@aisc.org

Reprints
Erika Salisbury
312.670.5427
salisbury@aisc.org

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**.

steel interchange

All mentioned AISC codes and standards, unless noted otherwise, refer to the current version and are available at ***aisc.org/specifications****, AISC Design Guides are available at* ***aisc.org/dg****, and* Engineering Journal *articles are available at* ***aisc.org/ej****.*

Shear Buckling Coefficient

I was hoping to get some clarification regarding the shear buckling coefficient, k_v, equal to 5 under Section G4 of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360). I understand that for rolled (HSS), internal stiffeners are not possible. However, for built-up box sections, we routinely have internal transverse stiffeners. Looking at how G4 is currently written, you do not get to account for a smaller panel height in built-up box members. Is there a specific reason under box members that k_v is set to 5, or would using equation G2-5 be appropriate for built-up box members with transverse stiffeners?

While there is some logic to your desire to use a value different than 5 for k_v when stiffeners are provided, doing so is contrary to the *Specification*. It is not intended for people to use Equation G2-5 for determining k_v, as this option is not provided in Section G4.

In Section G2.1(b)(2), k_v = 5.34 for unstiffened I-shapes, not 5.0. This indicates that there are differences between unstiffened box sections and unstiffened I-shapes. So, using an equation developed for I-shapes is not appropriate based on the *Specification*. The Commentary to Section G4 for box sections states: "Post-buckling strength from Section G2.1 is not included due to lack of experimental verification." This commentary indicates that there is currently not enough information on the post-buckling strength of built-up boxed sections to use k_v greater than 5.

That said, Section A1 of the *Specification* permits the engineer of record (EOR) to use alternative analysis methods and design based on their engineering judgment, latest research, and approval from the authority having jurisdiction (AHJ). If you would like to use a k_v value greater than 5.0, you would have to do so, relying on your engineering judgment.

Lou Geschwindner, PE, PhD

Built-up Compression Member

I am checking a built-up latticed compression member per Section E6.1 of the *Specification*. I am confused about when I can use the modified slenderness ratio, $(L_c/r)_m$, for the cases shown in Figure 1. Would the modified slenderness be applicable for buckling about both the x-axis and y-axis for all three cases?

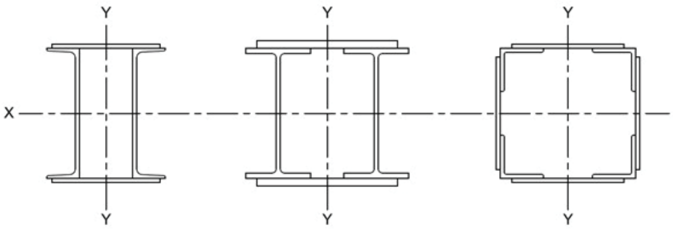

Fig. 1.

No. The second paragraph in 2016 *Specification*, Section E6.1, states that the equations are applicable "…if the buckling mode involves relative deformations that produce shear forces in the connectors between the individual shapes…" Therefore, the modified slenderness ratios are applicable only for buckling about the y-axis in Figure 1 for the double channel and double W-shape sections. For buckling of the double channel and double W-shape about the x-axis, the actual slenderness ratio can be used without modification.

Because the first paragraph in Section E6.1 states that the section "applies to built-up members composed of two shapes," the equations do not apply to the four-angle member. Therefore, you will need to use your judgment to determine an appropriate design method. For further information on the effective length of built-up columns, see *Guide to Stability Design Criteria for Metal Structures* (Sixth Edition) by R.D. Ziemian.

Bo Dowswell, PE, PhD

Web Local Yielding

I have come across what appear to be different equations for checking web local yielding. Equations J10-2 and J10-3 are taken from the 2016 *Specification*. Equations 9-46 and 9-47 are taken from Part 9 of the 15th Edition AISC *Steel Construction Manual*. Equation 2.2-11 is taken from AISC Design Guide 13: *Wide-Flange Column Stiffening at Moment Connections*, Equation 3.24 is taken from AISC Design Guide 4: *Extended End-Plate Moment Connections Seismic and Wind Applications*, and both appear to be different compared to the equations provided in the *Specification*. I would like to have a better understanding of when I should use each of these equations.

Lou Geschwindner is a former vice president of engineering and research at AISC, Professor Emeritus of Architectural Engineering at Penn State University, and senior consultant at Providence Engineering Corporation. **Bo Dowswell**, principal with ARC International, LLC, is a consultant to AISC.

2016 AISC *Specification* (page 16.1-143)

(a) When the concentrated force to be resisted is applied at a distance from the member end that is greater than the full nominal depth of the member, d,

$$R_n = F_{yw} t_w (5k + l_b) \tag{J10-2}$$

(b) When the concentrated force to be resisted is applied at a distance from the member end that is less than or equal to the full nominal depth of the member, d,

$$R_n = F_{yw} t_w (2.5k + l_b) \tag{J10-3}$$

15th Edition AISC *Steel Construction Manual* (page 9-23)

When the compressive force to be resisted is applied at a distance, x, from the member end that is less than or equal to the depth of the member ($x \le d$):

LRFD		ASD	
$\phi R_n = \phi R_1 + l_b(\phi R_2)$	(9-46a)	$R_n/\Omega = R_1/\Omega + l_b(R_2/\Omega)$	(9-46b)

When the compressive force to be resisted is applied at a distance, x, from the member end that is greater than the depth of the member ($x > d$):

LRFD		ASD	
$\phi R_n = 2(\phi R_1) + l_b(\phi R_2)$	(9-47a)	$R_n/\Omega = 2(R_1/\Omega) + l_b(R_2/\Omega)$	(9-47b)

AISC Design Guide 13 (page 9)

$$\phi R_n = 1.0 \times \left[C_t (6k + 2t_p) + N\right] F_y t_w \tag{2.2-11}$$

AISC Design Guide 4 (page 22)

$$\phi R_n = \phi \left[C_t (6k_c + 2t_p) + N\right] F_{yc} t_{wc} \tag{3.24}$$

Equations 9-46 and 9-47 in the *Manual* produce the same result as Equations J10-2 and J10-3 in the *Specification*. In the *Manual*, R_1 is equal to $2.5kF_{yw}t_w$, and R_2 is equal to $F_{yw}t_w$. The *Manual* equations are intended to simplify the calculations.

As discussed in the Commentary to *Specification* Section J10.2, the 2.5-to-1 stress trajectory through the k-distance used in the development of *Specification* Equations J10-2 and J10-3 is slightly conservative for directly welded plates. The provisions in *Specification* Section J10.2 were developed for elements (plates, flanges, etc.) that are directly connected to the flange. Because the 3-to-1 trajectory in Design Guide 4 and Design Guide 13 was recommended based on research specific to end plate moment connections, it is appropriate to use the equations in the Design Guides at end plate connections.

Because the trajectory angle increases with inelasticity, it changes throughout the load range. Therefore, different recommendations can be expected from various research projects, depending on the level of inelasticity when the specimen reached the failure point. For further information on stress trajectories and why different values are used for different situations, see "Calculation of Stress Trajectories Using Fracture Mechanics" in the First Quarter 2013 AISC *Engineering Journal*.

Bo Dowswell, PE, PhD

steel quiz

This month's Steel Quiz celebrates 100 years of AISC!
Refer to the AISC Legacy page (**aisc.org/legacy**) for the answers.

1 Which bridge won the very first NSBA Prize Bridge Award in 1928?
a. George Washington Bridge **c.** Benjamin Franklin Bridge
b. Sixth Street Bridge **d.** Fort Pitt Bridge

2 Which steel building opened in 1955 and would later house AISC's headquarters?
a. Wrigley Building **c.** Prudential Building
b. 101 Park Avenue **d.** One East Wacker Drive

3 Aymar Embury II designed this structure, which won the AISC Prize Bridge Award in 1941.
a. Golden Gate Bridge **c.** Bay Bridge
b. Triborough Bridge **d.** Rainbow Bridge

4 This building was completed in the 1930s, proceeded at four floors per week, was the tallest building in the world at the time, and is still the tallest steel-supported brick building.
a. Tribune Tower **c.** Flatiron Building
b. Empire State Building **d.** Chrysler Building

5 What year did Bethlehem Steel and United States Steel both agree to standardize wide-flange shapes?
a. 1930 **b.** 1932 **c.** 1934 **d.** 1936

6 Which steel bridge both earned an honorable mention for the Prize Bridge Awards and was the first computer-designed bowstring arch bridge? (Hint: Check the 1950s.)
a. Triborough Bridge **c.** Fort Pitt Bridge
b. Roberto Clemente Bridge **d.** Eads Bridge

7 Besides winning the NSBA Prize Bridge award in 1937, what other accolade was credited to the Golden Gate Bridge at the time?
a. Tallest and longest suspension bridge in the world
b. The highest volume of traffic in the United States
c. Brightest color ever used on a bridge
d. Safest bridge construction

8 Torre Latinoamericana in Mexico City withstood what magnitude earthquake in 1957, prompting AISC to award the building owners with a plaque?
a. 8.1 **b.** 7.6 **c.** 6.4 **d.** 7.9

9 **True or False:** The National Steel Fabricators Association, which later became incorporated as the American Institute of Steel Construction, was formed to bring standardization to the industry and advocate for the increased use of fabricated structural steel.

TURN TO PAGE 14 FOR THE ANSWERS

steel quiz ANSWERS

1 **b.** The Sixth Street Bridge (renamed the Roberto Clemente Bridge in 1998) spans the Allegheny River in downtown Pittsburgh.

2 **c.** The Prudential Building, now called Pru One or 130 East Randolph, was once the tallest skyscraper in Chicago.

3 **d.** The Niagara Falls International Rainbow Bridge spans 960 ft and connects two cities named Niagara Falls.

4 **d.** Chrysler Building

5 **a.** 1930

6 **c.** Fort Pitt Bridge

7 **a.** In 1937, the Golden Gate Bridge was the tallest and longest suspension bridge in the world and is still perhaps the most iconic bridge in the world.

8 **b.** 7.6-magnitude earthquake

9 **True.** AISC was founded in 1921 as the National Steel Fabricators Association. The name of the association was changed to the American Institute of Steel Construction in 1922.

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**.

The Prudential Building, the answer to question 2—and the current home of AISC—during its construction in the 1950s and today.

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FLEXURAL MEMBER DESIGN: A PRIMER

BY RICHARD M. DRAKE, SE, AND ERIK ESPINOZA, SE

Tips on flexural member design as it is addressed in the AISC *Specification* and *Manual.*

Richard M. Drake (**rick.drake@fluor.com**) is a senior fellow in structural engineering, and **Erik Espinoza** (**erik.espinoza@fluor.com**) is a director in structural engineering, both with Fluor Enterprises, Inc.

Rick and Erik also authored primers on compression and tension, which appeared as SteelWise articles in the May and June 2021 issues (available in the Archives section at **www.modernsteel.com**). Stay tuned for a forthcoming primer on beam-column design.

SOMETIMES, YOU JUST NEED TO FLEX.

And so do structural steel framing systems, of which flexural members are an integral component. Here, we'll discuss some key steps for designing flexural members in accordance with the provisions of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360-16, **aisc.org/specifications**). Only hot-rolled W-shape beams are considered, although much of the material is readily applicable to other rolled shapes, such as hollow structural sections (HSS), though not W-shapes built from plate steel.

Elastic Beam Behavior

First, let's take a look at elastic beam behavior. See Figure 1, which demonstrates the internal forces on a typically loaded beam. We start with a simply supported beam with any transverse loading, and we can determine the end support reactions using principles of static equilibrium. If we make a cut at any location on the beam, we see that the free body diagram of the beam must have internal shear and moment forces to keep the section in static equilibrium.

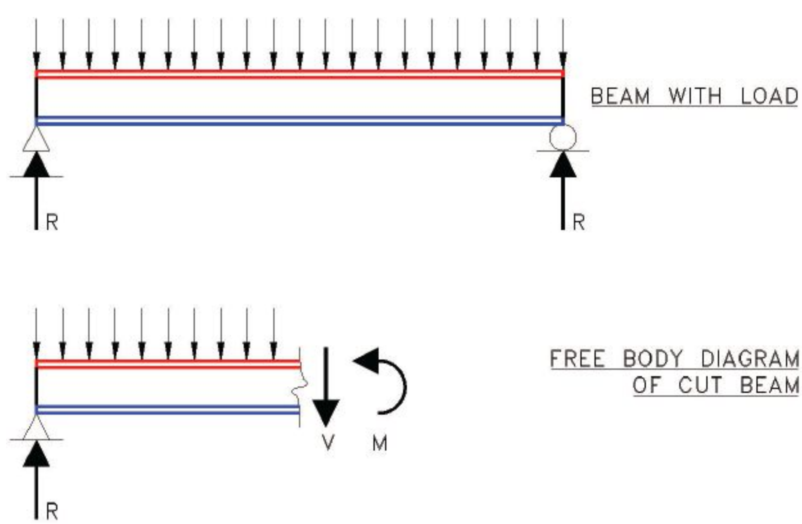


Fig. 1. Internal beam forces.

Stage A: elastic stresses. If we examine our simply supported beam with a small external load, we notice that no portion of the cross section has reached the yield stress. As shown in Figure 2, the beam acts as an ideal truss, with the top flange in compression and the bottom flange in tension. The elastic flexural stresses shown are normal to the cross section and can be determined in accordance with the usual elastic assumptions:

- A plane section before bending remains plane
- Stress is proportional to strain
- Stress is proportional to the distance y from the neutral axis
- Maximum compression and tension stresses, f_c and f_t, are less than the material yield stress

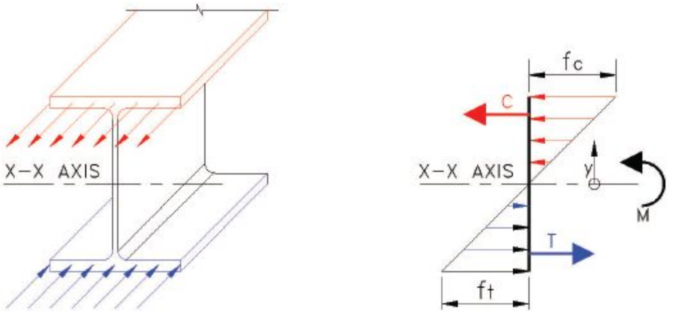


Fig. 2. Stage A: elastic stresses.

The internal moment, *M*, is equal to the integration of the flexural stress times area times the distance to the neutral axis. We can observe that the maximum compression stress is at the top fiber and most compression force is in the top flange. Similarly, the maximum tension stress is at the bottom fiber and most tension force is in the bottom flange. Therefore, the internal moment can be approximated as a force couple with one flange in compression, *C*, and the other flange in tension, *T*.

We can determine the moment of inertia, *I*, as the result of the integration of the cross-section area times the distance squared to the neutral axis. We are most interested in the maximum bending stress, which occurs at the maximum distance *y* from the neutral axis, *c*.

$$f_{b(max)} = \frac{My_{max}}{I} = \frac{Mc}{I} = \frac{M}{S}$$

$$M = f_{b(max)}S$$

$$f_{b(max)} < F_y$$

Stage B: entirely elastic stresses. Let's increase the external load on our simply supported beam until the extreme fiber reaches the yield stress, F_y, as shown in Figure 3.

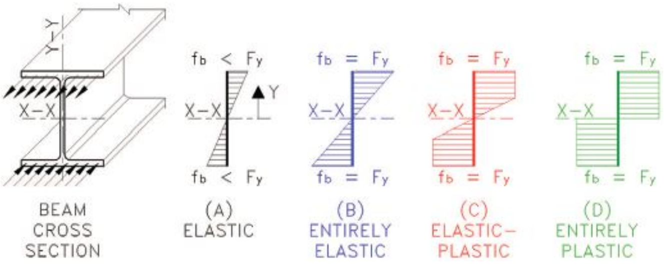


Fig. 3. Stages A, B, C, and D of internal stress as external load is created on the beam.

The usual elastic assumptions still apply.

$$f_{b(max)} = F_y = \frac{My_{max}}{I} = \frac{Mc}{I} = \frac{M_y}{S}$$

$$M_y = F_y S$$

The elastic section modulus, S, is tabulated in Part 1 of the AISC *Steel Construction Manual* (**aisc.org/manual**). The yield moment, M_y, equals the bending moment about X-axis when extreme fiber has reached the yield stress. It is the maximum internal moment that the cross-section can sustain and remain elastic. Any further internal moment will result in plastic behavior and permanent deformation.

Plastic Beam Behavior

Stage C: elastic-plastic stresses. Now let's increase the external load on our simply supported beam some more so that more of the cross section reaches the yield stress, F_y , as shown in Figure 3.

The additional loading causes the extreme fiber to strain without an increase in stress and the adjacent fibers to increase their strain and stress until they reach the yield stress. The stress distribution is no longer linear, the outer fibers are in the plastic range, and the inner fibers are in the elastic range. The usual elastic assumptions no longer apply.

$$f_{b(max)} = F_y$$

$$M > M_y$$

Stage D: entirely plastic stresses. Finally, let's increase the external load on our simply supported beam until the entire cross section reaches the yield stress, F_y, as shown in Figure 3.

Now, the section is entirely plastic, the entire cross section has reached the yield stress, half of the section has reached yield in compression and the other half reaches yield in tension, and the section can resist an external load that causes the internal moment, M_p.

$$f_{b(max)} = F_y$$

$$M_p = F_y Z$$

The plastic section modulus, Z, is tabulated in Part 1 of the *Manual*. Any further external load would cause the entire cross section to progress much further on the stress-strain curve, forming a plastic hinge and an unstable structure. The plastic moment is the maximum internal moment that the cross section is permitted to sustain by the *Specification*.

Local Buckling

Now that we've tackled elastic and plastic behavior, let's move the discussion on to local buckling. Section B4 of the *Specification* includes a classification system to identify the flexural members that may experience local buckling of compression elements before yielding. Limiting width-to-thickness ratios (λ_r and λ_p) for local buckling have been developed based on elastic plate buckling theory and are listed in *Specification* Table B4.1b for members subject to flexural compression.

Flanges and webs of flexural members are classified as compact if aspect ratios (λ) are less than or equal to the limiting width-to-thickness ratios, λ_p. The entire cross section reaches the yield stress before local buckling can occur.

$$\lambda \le \lambda_p$$

Flanges and webs of flexural members are classified as noncompact if aspect ratios (λ) are greater than limiting width-to-thickness ratios (λ_p) and less than or equal to the limiting width-to-thickness ratios (λ_r). Part of the cross section reaches the yield stress before local buckling.

$$\lambda_p < \lambda \le \lambda_r$$

Flanges and webs of flexural members are classified as slender if aspect ratios (λ) are more than the limiting width-to-thickness ratios, λ_r. None of the cross section reaches the yield stress before local buckling.

$$\lambda_r < \lambda$$

Note that for flanges and webs subject to axial compression (columns), compact and noncompact elements were lumped together and called non-slender. There is no need to define λ_p for columns.

Lateral-Torsional Buckling Limit State

Next up are lateral-torsional buckling limit states. First, consider that a beam that is stable can reach its plastic moment capacity.

$$M_n = M_p$$

Beam supported laterally at its ends. Now consider the compression flange of a laterally unsupported beam as if it was a compression member. If the compression flange were a pure rectangular column, simply supported for both axes, it would buckle in its weakest direction. However, the compression flange is restrained from buckling in its weakest direction, in the vertical plane, by the continuous support of the beam web. Therefore, at higher flexural compression loads, the flange would tend to buckle in its strongest direction, in the horizontal plane, twisting the beam. It is this sudden instability in the lateral direction that is referred to as lateral-torsional buckling (see Figure 4).

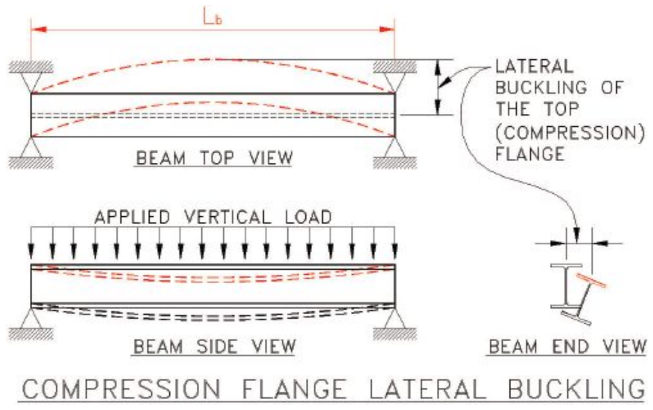


Fig. 4. Lateral-torsional buckling of the compression flange with end support only.

The internal moment, M_n, that will cause the compression flange to buckle laterally depends on the unbraced length of the compression flange, L_b. The *Specification* defines L_b as "the length between points that are either braced against lateral displacement of the compression flange or braced against twist of the cross section." To serve as a brace point, an intersection steel member must meet the strength and stiffness requirements of *Specification* Appendix 6: Member Stability Bracing.

Beam with additional lateral support at midspan. If you can add another lateral brace point at the midspan of the beam, then the unbraced length of the compression flange L_b is reduced, and the internal moment, M_n, that will cause the compression flange to buckle will increase (see Figure 5).

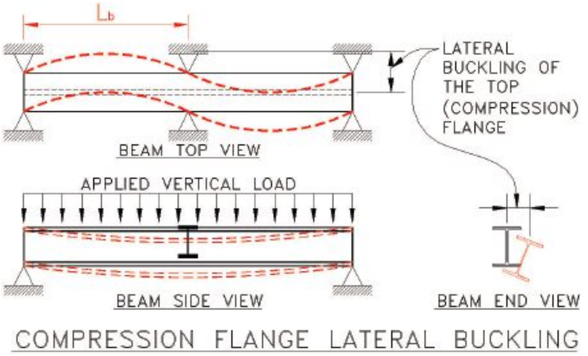


Fig. 5. Lateral torsional buckling of the compression flange with end and midspan lateral support.

Note that the lateral bracing of the compression flange has no effect on the beam's behavior in the vertical plane. The internal shears, internal moments, and vertical beam deflections are not affected.

Specification Requirements

The classification system of *Specification* Section B4 is used to identify which section of Chapter F provides the correct nominal strengths for hot-rolled W-shapes. There are several ways to classify the shape for flexural compression:

- For W-shapes of all yield stresses, perform the λ, λ_p, and λ_r calculations from *Specification* Section B4.1 and Table B4.1b.
- For W-shapes with F_y = 50 ksi, look for footnote "f" in *Manual* Part 1. AISC has provided these footnotes to identify W-Shapes that do not meet the compact flange and compact web requirements.
- For W-shapes with $F_y \leq$ 70 ksi, refer to the User Notes in *Specification* Sections F2 and F3.

Specification Section F2 covers W-shape members with both compact flanges and compact webs bent about their major (X) axis. As defined in Table B4.1b:

Case 11: $$\frac{b_f}{2t_f} \leq 0.38\sqrt{\frac{E}{F_y}}$$

Case 15: $$\frac{h}{t_w} \leq 3.76\sqrt{\frac{E}{F_y}}$$

Sections with compact flanges and compact webs can reach the plastic moment, M_p, and become fully plastic unless lateral-torsional buckling occurs first. Flange local buckling will not occur before yielding because the flange is compact. Web Local buckling will not occur before yielding because the web is compact.

Specification Section F2 includes a User Note listing all ten of the W-shapes that do not have compact flanges if $F_y \leq$ 50 ksi. The note also states that all W-shapes have compact webs if $F_y \leq$ 70 ksi.

There are two limit states to consider for compact W-shapes bent about their X-axis: yielding and lateral-torsional buckling.

Yielding limit state. The nominal moment strength, M_n, for the yielding limit state is the plastic moment, M_p, the maximum internal moment that the cross section is permitted to sustain.

$$M_n = M_p = F_y Z_x$$

Lateral-torsional buckling limit state. The *Specification* includes many equations to define the nominal moment strength, M_n, for lateral-torsional buckling. They are not included here for brevity.

The *Specification* defines two limiting unbraced lengths, L_b, for the beam's compression flange, L_r and L_p. Note that:

- If L_b is less than or equal to L_p, the yielding limit state will apply. The entire compression flange reaches the yield stress before lateral-torsional buckling occurs.
- If L_b is between L_p and L_r, the *Specification* prescribes a nominal strength, M_n, based on inelastic lateral-torsional buckling theory. Part of the compression flange reaches the yield stress before lateral-torsional buckling occurs.
- If L_b is greater than L_r, the *Specification* prescribes a nominal strength, M_n, based on elastic lateral-torsional buckling theory. None of the compression flange reaches the yield stress before lateral-torsional buckling occurs.

Figure 6 summarizes the *Specification* Section F2 requirements for the nominal moment strength, M_n, as a function of the compression flange unbraced length, L_b.

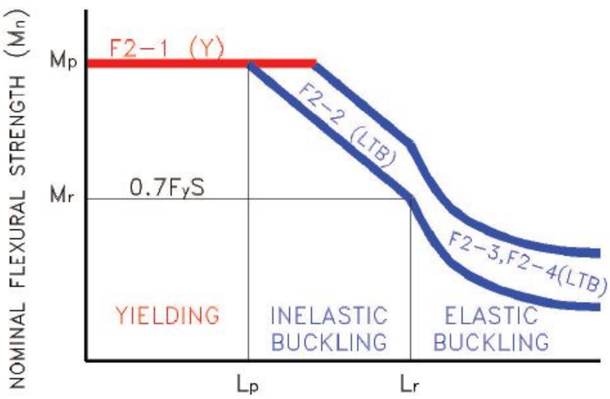


Fig. 6. Section F2 nominal moment strength vs. unbraced length of the compression flange.

Specification Section F3 covers W-shape members with noncompact or slender flanges and compact webs bent about their major X-axis. As defined in Table B4.1b:

Case 11: $\frac{b_f}{2t_f} > 0.38\sqrt{\frac{E}{F_y}}$

Case 15: $\frac{h}{t_w} \leq 3.76\sqrt{\frac{E}{F_y}}$

Sections with noncompact or slender flanges will fail in compression flange local buckling before they can reach yielding.

Section F3 also includes a User Note similar to the one in Section F2 that lists all ten of the W-shapes that do not have compact flanges if $F_y \leq 50$ ksi. The note also states that all W-shapes have compact webs if $F_y \leq 70$ ksi.

There are two limit states to consider for noncompact W-shapes bent about their X-axis: lateral-torsional buckling and compression flange local buckling. The nominal moment strength, M_n, of the member is less than the plastic moment, M_p, because compression flange local buckling will occur first.

Lateral-torsional buckling limit state. Section F3 refers to Section F2 for the lateral-torsional buckling strengths.

Compression flange local buckling limit state. The *Specification* provides separate nominal strength equations for noncompact and slender flanges (not included for brevity). It should be noted that no W-shapes with $F_y \leq 50$ ksi have slender flanges.

Figure 7 summarizes *Specification* Section F3 requirements for the nominal moment strength, M_n, as a function of the compression flange unbraced length, L_b.

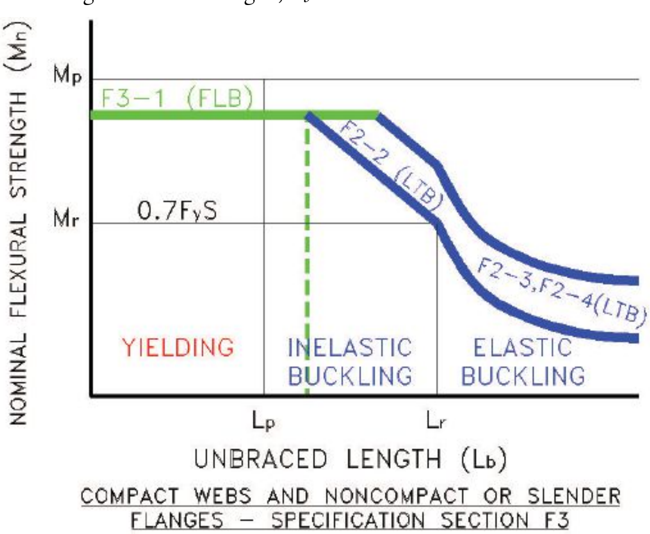
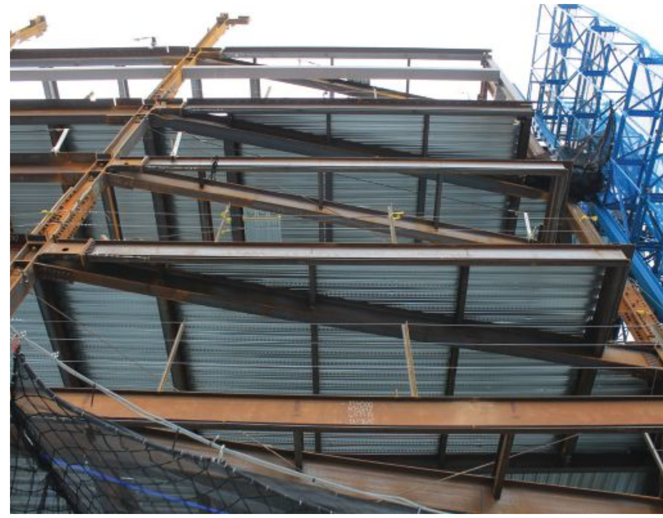


Fig. 7. Section F3 nominal moment strength vs. unbraced length of the compression flange.



Manual Design Aids

Here are some additional AISC resources to aid you in designing flexural members:

***Z_x* Tables.** Part 3 of the Manual includes nine pages of beam selection tables based on the Z_x values of W-shape beams with $F_y = 50$ ksi. These tables tabulate the moment strengths of beams in order of their Z_x values—very useful when you determine that the yielding or flange local buckling limit state will govern. An example of this would be a simply supported W-shape beam that supports a concrete slab providing continuous lateral support of the compression flange ($L_b = 0$ ft). These tables also provide the values for L_p and L_r, which are useful in identifying when the lateral-torsional buckling limit state should be considered.

Beam charts. Also located in Part 3 are 36 pages of beam charts that plot the flexural strength versus compression flange unbraced length for all W-shapes normally used as beams, for $C_b = 1$ (C_b is a term associated with the lateral-torsional buckling equations). These tables are very useful when you have determined that the lateral-torsional buckling limit state will govern. An example of this would be a simply supported W-shape beam with intermittent lateral support of the compression flange ($L_b > L_p$).

Load tables. And then there are nearly 100 pages of load tables that can be used to tabulate the calculated available strength for W-shapes ranging in size from W44 to W4 with $F_y = 50$ ksi. These tables are located in Part 6 of the *Manual*. AISC calls Table 6-2 its "Super Table" because it combines some of the best design strength features of the *Manual* beam and column design aids. Although these tables were created to facilitate designing members in combined flexure and axial compression, they are very useful for evaluating W-shape beams, combining the features of both the Z_x tables and beam charts.

This is just the tip of the iceberg when it comes to flexural member design. But by consulting these tips and resources, you'll be off to a good start.

As the majority of U.S. adults have now received the COVID vaccination, things appear to be inching back to normal. But just how hard did COVID hit and how far have we come back? This edition of Data Driven will shed some light on where we were a year and a half ago and where we are now.

data driven

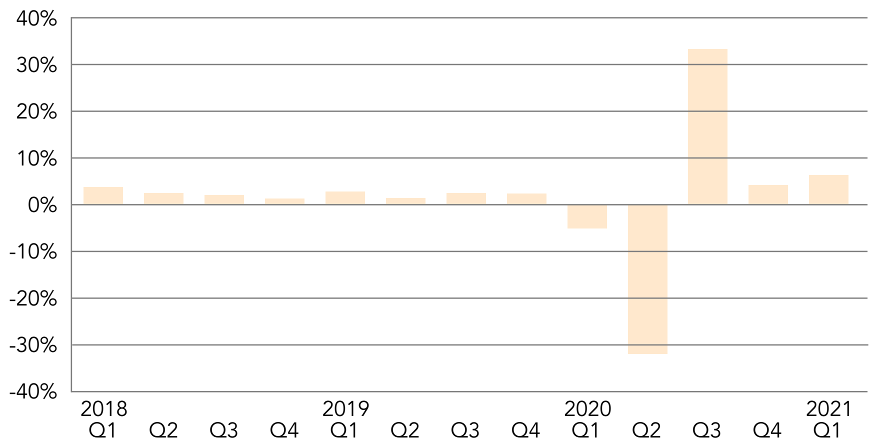
COVID COSTS

BY JOE DARDIS

TO SAY THAT COVID-19 SENT SHOCKWAVES through the domestic construction industry and the economy as a whole would be an understatement.

At the onset of COVID, just before the second quarter of 2020, U.S. GDP dropped 31.4%, the largest decline since the Great Depression. Luckily, it bounced back in the very next quarter—by an unprecedented 33.4%—and has continued to show healthy growth through the first quarter of 2021.

Percent Change in U.S. GDP

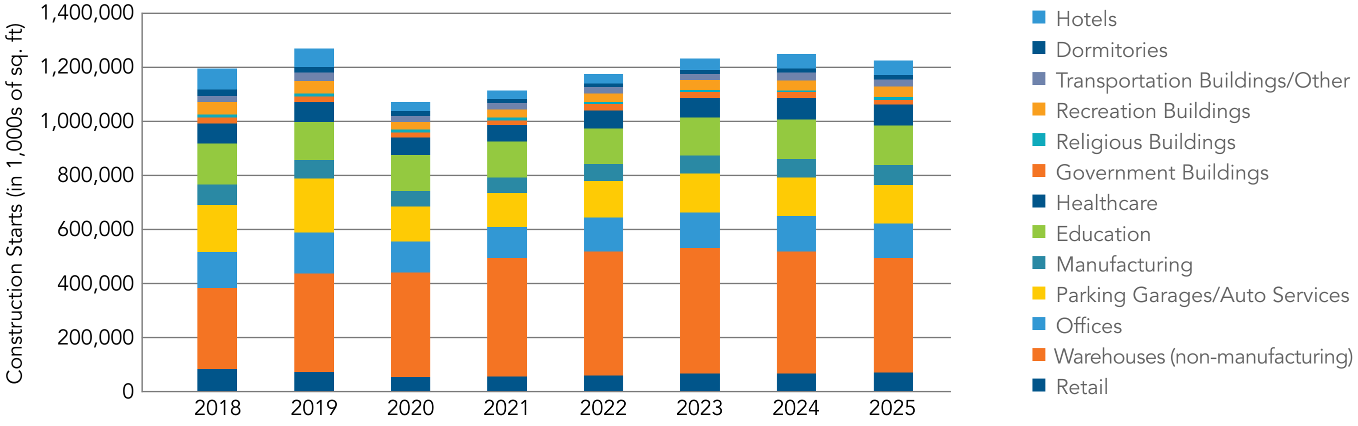


When it comes to construction, commercial construction starts (excluding single- and multi-family housing) decreased 16% from 2019 to 2020 despite the fact that pre-pandemic first-quarter 2020 construction starts were up 9% year over year from 2019. Starts appear to be on the upswing, however, as Dodge Data and Analytics predicts they will grow 10% by 2022 and hit nearly pre-pandemic levels by 2023.

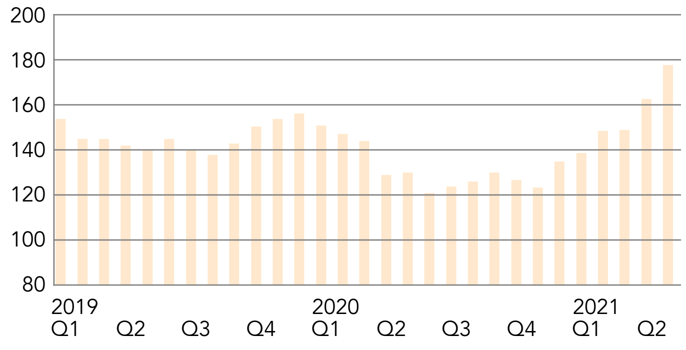
Other market indicators are also providing optimism. The Dodge Momentum Index, a monthly measure of the initial reports for nonresidential building projects in planning and a leading indicator of construction spending by up to a full year, reached its recent low in June of 2020 and remained relatively stagnant until November. But since then, it has seen a 44% increase, indicating promise for construction activity for 2021 and 2022.

Joe Dardis (dardis@aisc.org) is AISC's senior structural steel specialist for the Chicago market.

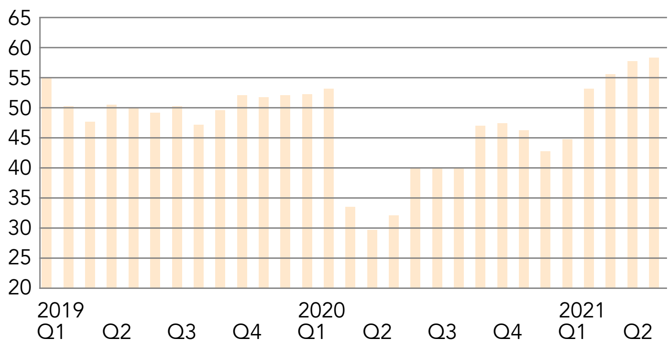
Historical and Projected Construction Starts



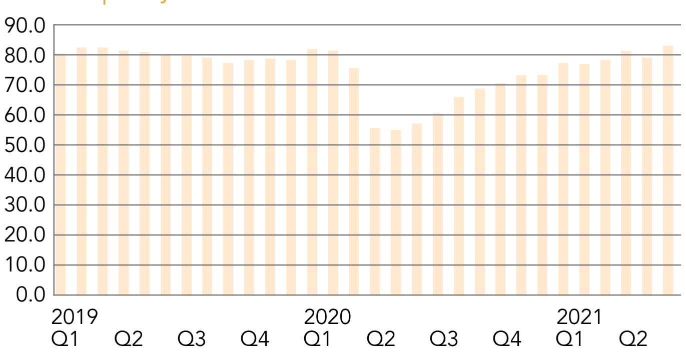
Dodge Momentum Index



Architectural Billing Index



Steel Capacity Utilization in U.S.



The Architectural Billing Index (ABI), which is derived from shifts in billings from architectural firms, is another useful economic indicator for tracking nonresidential construction activity. While the ABI fell to an all-time low in April 2020, it has been steadily climbing ever since, reaching one of the highest-ever reported index scores (58.5) in May. This indicates that more architecture firms are seeing an increase in their billings, and more projects are entering the planning and design phases. Like the Dodge Momentum Index, this is a very positive indicator for the rest of 2021 and moving into 2022.

COVID created another shockwave in the form of significant supply chain issues for a variety of industries, including construction. As demand for some goods and services dropped sharply at the onset of COVID, so did manufacturing and output. However, demand picked up again relatively quickly and outpaced the reduced output. The steel industry was no exception, with capacity utilization for all steel products (not just construction) hovering around 80% for all of 2019 and the first quarter of 2020 before taking a sharp drop to around 55% in April 2020. While this caused an increase in steel prices and much higher-than-normal lead times for products, production has caught back up and the steel industry is now producing slightly more than it was right before COVID struck. It will take time for supply and demand to reach equilibrium, but this increase in production points to a much less strained supply chain in the near future.

Of course, construction recovery typically lags behind overall economic recovery. So while we've seen recent GDP growth and other optimistic indicators, the construction industry will still need time to catch up, especially with respect to employment numbers. Luckily, the extreme data points created by COVID appear to be leveling out, and the construction industry's recovery is beginning to take shape.

field notes

ENGAGING EFFORT

INTERVIEW BY
GEOFF WEISENBERGER

University of Missouri steel bridge team captain Corey Valleroy has turned COVID-related instability into an opportunity to build a diverse new steel bridge team for his school.

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**.

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

BEFORE THE COVID-19 PANDEMIC, the University of Missouri team's lack of diversity was an area of concern because it did not accurately represent the demographics of the Mizzou university community.

Incoming team captain **Corey Valleroy**, along with Kenyon Shutt, a former bridge team captain and active advisor to the team, sought to change the situation.

Over the 2020–2021 school year, Valleroy attended more than a dozen diversity- and inclusivity-themed recruitment events hosted by the university and its College of Engineering. He also made a specific effort to involve new team recruits in more than standard entry-level tasks, encouraging everyone to participate in large group discussions about design, engineering, planning, and logistics, as well as implemented a new training program to provide all team members with hands-on metalworking equipment as early as possible.

These efforts enabled the team to return to its pre-pandemic size by recruiting six new members, as well as meet the goal of increasing diversity. The current eight-member team now includes four women, two members from the LGBTQ community, and a member from Uganda.

Here, Valleroy provides some insight into this initiative, which earned the Mizzou team this year's SSBC Team Engagement Award.

What prompted your push for diversity on the team?

It's vital that people of all backgrounds, origins, genders, and races should have an equal opportunity to expand their knowledge and love of engineering while at the same time feel comfortable and accepted by their community. As the team and its management looked to revive our decreased enrollment, we realized we had a blank slate and completely committed our recruiting focus to reflect our values of inclusivity and diversity in engineering.

Can you talk a bit about your recruitment efforts?

With the pandemic, recruiting got flipped on its head from the very start. I knew it would be a tough year, so I attended every event the team was invited to throughout the year. Beginning in the summer, the team took part in Zoom recruitment fairs and addressed all incoming civil engineers. The biggest way we were able to reach a diverse group was by continuing to recruit throughout the whole year. I could have stopped after talking with the incoming students online, but several potential members may not have had the resources or time during summer to attend those events. This is one of the big reasons we leave the team open to join all year and have a policy of coming when you can make it. We want Mizzou Steel Bridge to be a place for students who work jobs during the year because all students still deserve to develop their skills in engineering through a competitive team.

I market the team as a fun competition and a place for students to learn real-life problem-solving and teamwork skills. I tend to share a lot of my experiences about how the team has helped me when talking with job recruiters and the friends I made on the team. Last year I also made a big effort to emphasize COVID safety while giving freshmen a place to get out of their dorms and meet people who share career interests with them.

What new ideas did your team generate this year that it may not have generated or considered in previous years?

I think one of the best design choices came from the fact that we added so many new faces to the field of metalworking. To experienced members, the idea of dropping bolts and tools and receiving a penalty was not too big of a concern. For new members, it was a much larger concern, and they led us to design a bridge that could stand with zero bolts. This allowed members to use both hands in the construction process and led to fewer material and equipment drops during the competition and even a much faster time for experienced members. Having both hands free was a major benefit for everyone and really showed the benefit of getting input from our entire group.

Older members can get stuck in the train of thought that a hammer is a hammer when sometimes, the team needs it to be more. This came into play at the national competition. We ended up getting stuck badly with a bent piece we had not noticed from the vertical load test at the Regional Event. The piece ended up being off by a tiny bit but just enough for the bolt to not drop in (the bridge could still stand because of our no-bolts design but would have been disqualified for lacking the bolt). A new member quickly figured out that by using a hammer as a level, we could move the bridge that tiny bit to keep the competition alive for us. This is the strength of having many different backgrounds on your team.

What advice would you give to teams having trouble with recruitment?

The best advice I can give is to recruit all year long. We had new members joining us a week before the national competition. They didn't help out much this year, but they already started to understand the makeup of the team and the yearly schedule and have reached out about how excited they are to get started next year.

What processes and policies from this year do you expect will carry on to next year to keep your culture of inclusion and team engagement alive?

The practice that is most important to building a strong culture is communication. One of the reasons our team succeeded in building a welcoming and competitive atmosphere is that we understood how to talk through everything. No one had a problem letting me, as the captain, know if they disagreed with my ideas. Sometimes we would have intense arguments about what the bridge was going to look like or a better way to assemble it. But after any discussion, we all understood we just wanted the best for the bridge and for the team. I think this openness really pushed everyone to give their best ideas and helped everyone share any concerns. I really think it is important to make sure no one is being talked down to. Otherwise, it's easy for one person to take over and force good ideas to be tossed out. I think the team should strive for open communication from all members every year, regardless of position or experience.

Another important policy we have is allowing members the freedom to step away and come back at any time. There are no sign-ups and no attendance taken at meetings, and this allows anyone to come and try out the team for a few weeks. This approach has ensured that all backgrounds feel less pressure, especially if they might suddenly have to work more hours at a job. It also allows students to join other clubs or stay actively engaged in their religious communities or other endeavors without the pressure to attend every single team meeting.

What was the most surprising thing that you learned from the competition this year, especially in the face of COVID?

The most surprising thing I learned was not to judge a year until the very end. The team had a really tough start. The co-captain and several supporting officers could not return to college due to the pandemic. After returning from winter break, we lost even more members for co-ops and family reasons. It would have been really easy for the team to give up after losing as many people as we did this year—but instead, the people who were able to stay really stepped up. I really think our deep background of experiences kept us going strong. The result was one of the best communities and cultures I have seen on a team, as well as the team's first visit to the National Final in a number of years! ■

This article was excerpted from my conversation with Corey. To hear more, check out the September Field Notes podcast at ***modernsteel.com/podcasts****. And to read about this year's AISC Student Steel Bridge Competition, see* *"Embracing the Moment" on page 49.*

business issues

MORE ESSENTIALS OF TEAMWORK

BY DAN COUGHLIN

A team is a group of individuals who support one another toward achieving important goals and fulfilling a meaningful purpose. But effective teamwork doesn't just happen. Like any type of relationship, you have to work at it.

Since 1998, **Dan Coughlin** has provided individual and group coaching to improve leadership and management performance. His topics are personal effectiveness, interpersonal effectiveness, leadership, teamwork, and management. Visit his free Business Performance Idea Center at **www.thecoughlincompany.com**.

Dan has also presented several presentations over the past few years at NASCC: The Steel Conference. To hear recordings of them, visit **aisc.org/education-archives** and search for "Coughlin."

LAST MONTH'S BUSINESS ISSUES focused on three essentials of teamwork: goals, roles, and trust. This month's column continues the conversation, delving into three more essentials: preserving emotional safety, caring about your fellow team members, and actively supporting them.

Emotional Safety

Let's start with preserving emotional safety. If you want to be effective in any team environment, it is crucial that you establish your priorities before entering any meeting or group discussion. Here are five priorities. Pick the one you think is most important:

1. Articulate your perspective clearly to move the group in the direction you want it to go
2. Be prepared to support your perspective with data
3. Be willing to support another person's presentation who is in alignment with your perspective
4. Always be very honest with the group about how you feel about a topic
5. Preserve the emotional safety of the other people in the room

If you selected 5, then you are the big winner. If you want to be effective as a team member and as a leader within the team, then the top priority at all times needs to be the preservation of the emotional safety of everyone in the conversation.

Do you think this is a bunch of fluff? Let me explain why it isn't.

When people feel they are emotionally under attack, they will react quickly in an emotional way. They might become scared, worried, angry, or protective. If you are the person creating that feeling within them, they will work to ignore you, disempower you, stay away from you, or protect other members of the group. They may even work to ridicule you. The trust between the two of you will be greatly reduced.

When that happens, you will not be in a position to be an effective team member or leader.

If people feel that you are threatening their emotional safety, you will not be able to support them or influence them. If your top goal is to get your perspective supported and the group moving in a certain direction, you will fail every time by making that your top priority. In every moment of your interaction with the group, you need to always make their emotional safety the top priority.

In order to gain an in-depth understanding of this concept, I recommend that you read *Social Thinking at Work* by Michelle Garcia Winner and Pamela Crooke. This magnificent book focuses on how to maintain strong relationships with the people in your group meetings—and also how to destroy those relationships. This all revolves around the many nuances of communication, which include:

1. Your objective for the discussion
2. Your understanding of the culture of the group and what is expected
3. Your thoughts about the other people in the group
4. Your body positioning during the interaction
5. Your facial expressions
6. Your eye movements
7. The topics you comment on
8. The timing in that given situation
9. The words you use
10. The tone and volume of your voice
11. Your engagement during the conversation

I really wish I had read this book on day one of my career. As I read it, I thought about the times when I was a peer on a volunteer committee or board. Whenever I was in those situations, my primary objective was always to add value to the group by offering my honest perspective on whatever topic we were discussing. I thought that was the best way for me to make a valuable contribution to the group. I was wrong to make that my top priority. I should have made preserving emotional safety my number one priority.

At times, I came on so strong in trying to support my perspective or point of view that I made other people feel emotionally uncomfortable and possibly emotionally unsafe. I didn't use foul language or belittle people. However, I became very intense as I persevered in arguing a point. And then I was bewildered at how I was so often ineffective at getting support for my point of view. In my brain, I thought I was doing a good thing for the group by being honest about my perspective, but now I realize that I was being ineffective. If I had spent more of my career putting the preservation of emotional safety at the top of the list, I think I would have been able to build much better, trusting relationships with the people on those boards and committees, and I could have had a much more positive influence at certain moments and on certain topics. More importantly, I could have been much more effective at supporting the efforts of the team toward achieving the desired outcomes.

For me, the big lesson was that the tradeoff is not worth it. Working to make or win a point is not worth hurting a relationship with another group member if you really want to help the team succeed. You might win in the moment, but it will reduce your effectiveness in the long term. You will not be able to influence others once the emotional safety has been broken. People will avoid you if they feel emotionally threatened.

I advise you to take your own trip down the memory lane of your team interactions. Think about your priorities going into various meetings.

1. Were you focused more on your personal agenda and arguing for your ideas, or were you focused more on preserving the emotional safety of the other people in the room?
2. How effective was your approach?
3. If you could do anything differently in group settings, what would you do to improve the next ten years in terms of your effectiveness as a team member and as a leader?

Caring About Your Team

This leads to the second topic: caring about your fellow team members—which is much easier said than done.

Caring doesn't mean you have to be best friends or hang out on the weekends. It doesn't mean you have to do what every person wants you to do. And it certainly doesn't mean you have to agree with everyone all the time.

It means you know something about the person and what is important to them. It means you listen with empathy. And it means that, in your thoughts and actions, you are focused on that person's goals, concerns, and feelings.

Again, much easier said than done. You are extremely busy. You have your own family, your own goals, your own desires, your own thoughts, and your own emotions to be concerned with. However, if you want to help build a truly great team, then you have to care about the other people on your team.

Most workgroups are not teams. They are a collection of individual performers, cliques, subgroups, departments, special interest groups, or committees. If you truly want to build a *team*, here are three suggestions.

Learn everyone's name. Whenever I come into an organization and speak to a group of 80 or fewer people, I ask for a list of the names of the people who will be in the room. I also ask for a pictorial directory in case they have one available for me to study. Before I start speaking, I get to know each person's name, and then I start my presentation by going up to each person and saying their name without looking at any notes or lists. Almost every time at the end of the presentation, some people say to me, "How did *you* know all of the names? *I* don't even know all of their names."

Are you kidding? How can you possibly be a good team member if you don't know the names of the people on your team? If you genuinely care about the people on your team, then you have to *at least* know their first name—*every* first name, not just five people who are close to you on the org chart. Knowing each person's first name is the minimum standard for teamwork. Invest the time to get to know the name and face of every person on your team, or stop calling it a team.

Know some of every team member's aspirations, values, strengths, passions, and morals. Of course, it's not enough to just know someone's name. You need to really get to *know* your team members. You need to know what's important to them. That includes their aspirations, values, strengths, passions, and morals. Here are five questions you should ask them:

- What do you aspire to achieve or become?
- What do you believe is so important that it drives your behaviors on a consistent basis?
- What are you better at doing than anything else that you do?
- What energizes you?
- What do you believe is right and wrong in a given situation?

Now see if you can answer each of those questions about the members of your team. Not in the aggregate but on an individual basis. Do you know these folks? How can you support individuals toward fulfilling a meaningful purpose and achieving important outcomes if you don't really know the people on the team?

Listen with empathy. One of the most effective ways to demonstrate that you genuinely care about another person is to listen with empathy. Empathy means working to understand what another person is thinking and feeling and then respond in an effective way. It doesn't mean you have to agree or that you have to do what the other person wants. It just means putting in the effort to really try to understand what the other person is thinking and feeling. And then after you understand that, try to say or do something that is effective for the other person.

This can be difficult, but even by trying to do it, you are demonstrating that you care about the other human being. The effort to care is the key.

Please remember this famous and useful advice: People don't care how much you know until they know how much you care.

Active Support

The final topic is actively supporting your fellow teammates. Here are four ways you can do so.

Provide emotional support. Many times, what a teammate needs is not a solution, but rather someone to truly listen and be emotionally supportive. People can have rough days, weeks, or months. Painful conflicts at home, disappointments in results at work, a health flareup, and a host of other realities can wear a person down. The person can't always turn to a spouse or family member over and over for support. Those people may be stressed out as well.

What can you do to be a supportive teammate? Sometimes just stopping what you are doing, facing the person, and listening non-stop without inserting any advice at all can be tremendously supportive of the other person. You don't have to feel it's necessary to comment on the person's situation or judge it or tell the person what to do. Just look the person in the eye and let the person vent. Let the person pour out their emotions, and don't walk away from them while they're doing it.

Share knowledge. If you have information that would help a teammate, offer that information. Let's say you worked with a difficult customer on a past project, and you know this person is a quick decision-maker who wants no small talk, three options, a recommendation, and the opportunity to make the final decision. You have a colleague that tends to be friendly and relaxed with customers and warm them up by asking about their family and their vacations. Your colleague is now going to be working with this customer. If you are a team player, you should give your colleague a heads-up about this customer before they walk into the first meeting.

Offer honest suggestions. Teammates are not bosses of each other. It is not always your role or responsibility to tell other members of your team what to do. However, you can support a teammate by offering an honest suggestion in a one-on-one conversation.

For example, if you believe a teammate is sabotaging their success by making judgmental comments about other team members, then I'd encourage you to set up a time to talk with this teammate in private. You might say something like: "I don't know if you realize it, but in our group meetings, you often make disparaging comments about people who are not in the room and who are working on projects for some of our other team members. I'm just letting you know this because I think it might hurt your credibility with people in the room. What do you think?"

They might get upset with you. Or they might be grateful for the advice. They may or may not do what you are suggesting. That's up to them. But you offered your honest suggestion in a private conversation. You made an effort to support them. The next step? Let it go. Don't keep harping on their behavior. If you do, then you are not being a supportive teammate. You are becoming a person who thinks he or she is the boss of the other person. That would likely weaken the feeling of teamwork.

Do what is asked. Sometimes being a supportive teammate is doing what is asked of you. Don't debate it or fight it or ignore it. Just do what another teammate is asking you. Consider this exchange:

"Would you be willing to call this list of ten prospects to see if we can generate any interest in this new product launch?"

"Yes, thanks for thinking of me and asking me to do that. I'm on it and will let you know how it goes."

Did you notice how simple that exchange was to complete? No drama, no intense scrutinizing, just one teammate asking another to do something, and the second teammate saying yes.

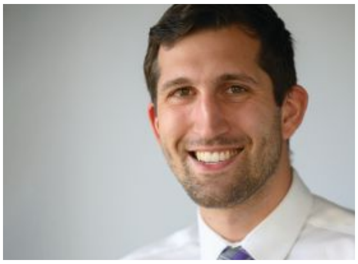
As I stated in my previous article, a team is a group of individuals who support one another toward achieving important goals and fulfilling a meaningful purpose. And for a team to be effective and "gel," it takes a conscious effort from all members. The steps mentioned here can go a long way in creating a true team that can work together to yield great results. ■

The first part of this series, "The Essentials of Teamwork," was the Business Issues article in the August 2021 issue and is available in the Archives section at ***www.modernsteel.com****.*

A Field House on Ice

BY NATHAN C. ROY, PE, MATHEW E. SMITH, AND DOUG E. FISCHER, PE

A stacked steel solution enables efficient expansion of a college prep campus' athletic complex, positioning a new field house above an existing ice rink.



Nathan C. Roy is a principal, **Mathew E. Smith** is a BIM modeler, and **Doug E. Fischer** is an engineer, all with LeMessurier.

TUCKED AWAY IN PICTURESQUE WESTERN MASSACHUSETTS adjacent to the historic village of Old Deerfield is one of the oldest secondary schools in the United States.

Since its founding in 1797, Deerfield Academy has provided students exceptional scholastic and athletic programs complemented with scenic landscapes. In order to maintain its high level of athletic achievement, the four-year college-preparatory school recently turned to global design firm Sasaki and structural engineering firm LeMessurier to replace its existing hockey rink and expand the overall athletic complex. The project includes the addition of a field house containing an indoor turf field with an elevated jogging track, an indoor volleyball court, multipurpose rooms, an indoor crew tank, and associated support spaces.

Geometric Constraints

The building's design was challenged with geometric constraints in both plan and elevation. The new field house and hockey rink were initially planned to be located adjacent to the existing athletic complex, consisting of a gymnasium (circa 1930), an addition to the West Gym (circa 1962), a hockey rink (circa 1957), a natatorium (circa 1993), and squash courts (circa 2007). However, the existing athletic facility (located to the east), dormitories to the north, a historic cemetery to the west, and wetlands to the south of the proposed building site limited the available space to expand the athletic facilities. Stacking the field house above the hockey rink became a creative approach for overcoming these obstacles while also interlocking the expansion to the existing athletic facilities.

The upper level of the new building, set into a sloping site, includes the field house, group exercise areas, and a tennis court. Matching the geometry of the existing athletic facilities, the upper level's floor elevation was set to match the adjacent West Gym and is approximately at grade to the north. Below this level is the partial mid-level consisting of exercise areas, meeting rooms, and spectator access to the rink. The mid-level was designed to align with the basement level of the West Gym. The lower level of the new facility houses the ice rink and a suite of locker rooms for multiple sports.

Controlled by Vibration

A clear 126-ft span of the field house floor was required to allow for the hockey rink below, so minimizing structural depth to maximize space in the hockey rink was a priority. Careful study and analysis determined that the floor framing was controlled by vibration, and the team consulted AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity* (**aisc.org/dg**) to limit acceleration due to rhythmic aerobic activity to 7% of gravity.

Jeremy Bittermann/JBSA

above and right: The project includes the addition of a field house containing an indoor turf field with an elevated jogging track, an indoor volleyball court, multipurpose rooms, an indoor crew tank, and associated support spaces.

below: A plan diagram of the Deerfield Athletic Complex showing new construction in relation to existing buildings.

Jeremy Bittermann/JBSA

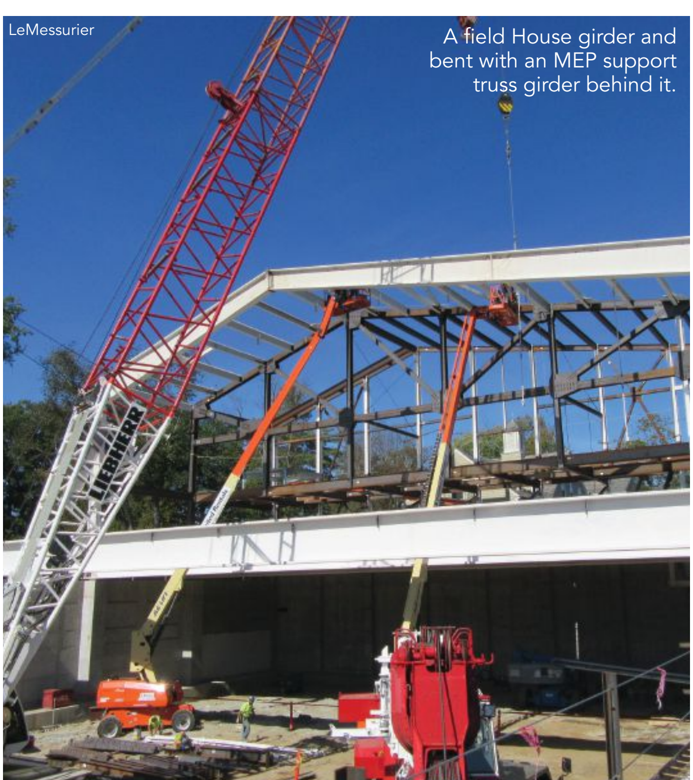
Sasaki

Sasaki

left: A cross section showing the stacking of the track and field above the ice rink.

below: Erecting a field house plate girder.

Sasaki



LeMessurier

A field House girder and bent with an MEP support truss girder behind it.

Initial analysis indicated that it was impractical to design the field house floor for dynamic loading per Design Guide 11 over the entire field house floor at one time. Working with Sasaki and Deerfield, the team determined that the floor structure would be tuned for rhythmic aerobic activity from 30 people (at 35 sq. ft per person) while maintaining acceptable vibration levels. Multiple arrangements and locations of the dynamic loading within the field house were analyzed. Options for both steel framing alone and steel framing supplemented with tuned mass dampers were studied and priced, with the team finally determining that 126-ft-long, 60-in.-deep built-up composite steel plate girders, weighing 845 lb per linear ft and spaced at 27 ft on center, provided the right balance between optimal structural performance, cost, and the acceptable vertical clearance in the ice rink below—and without the need for dampers. The plate girders (seven in all) were cambered for the self-weight of the floor slab and framing and provide 20 ft, 3 in. of clear height between the bottoms of the girders and the surface of the ice. The west ends of the plate girders bear on 3-ft by 6-ft concrete piers integral with the foundation wall, with the east end of plate girders supported by W14 columns on isolated spread footings. The project incorporates roughly 1,600 tons of structural steel in all.

Syncing Up

Roof framing above the field house consists of architectural asymmetric steel bents with roof ridges at approximately

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22" x $142\frac{1}{2}$# Tee

13 **Tee Stem Up**
MEAN DIA.
22" x $142\frac{1}{2}$# Tee

14 **Angle Heel In**
INSIDE DIA.
8" x 8" x 1" Angle

15 **Angle Heel Out**
OUTSIDE DIA.
8" x 8" x 1" Angle

16 **Angle Heel Up**
MEAN DIA.
8" x 8"x1" Angle

17 **Square Tube**
INSIDE DIA.
24" x $\frac{1}{2}$" Tube

18 **Rectangular Tube The Easy Way (Y-Y Axis)**
INSIDE DIA.
20" x 12" x $\frac{5}{8}$" Tube

19 **Rectangular Tube The Hard Way (X-X Axis)**
INSIDE DIA.
20" x 12" x $\frac{5}{8}$" Tube

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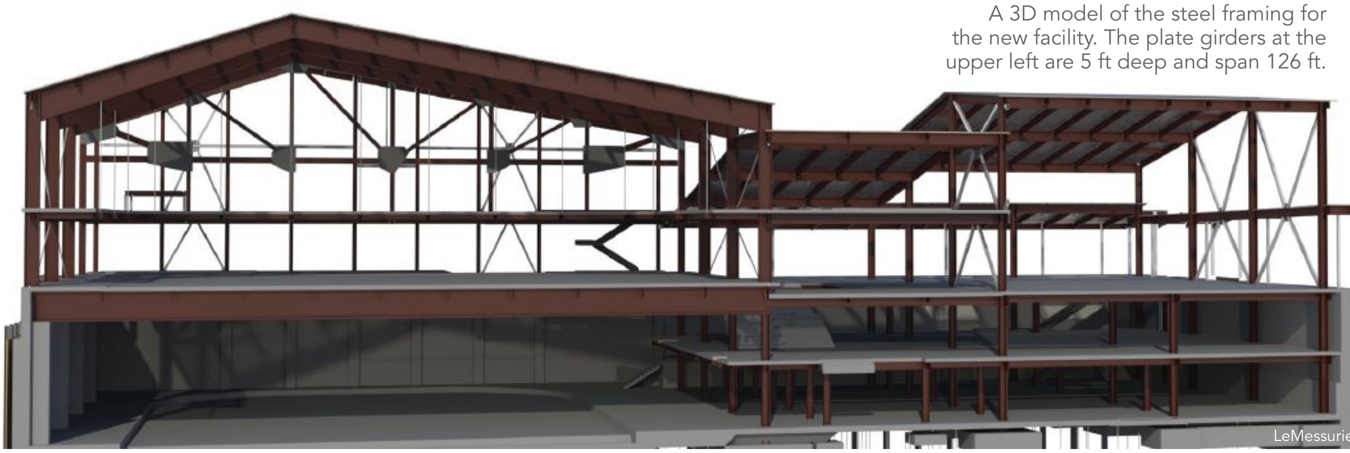


A 3D model of the steel framing for the new facility. The plate girders at the upper left are 5 ft deep and span 126 ft.

LeMessurier

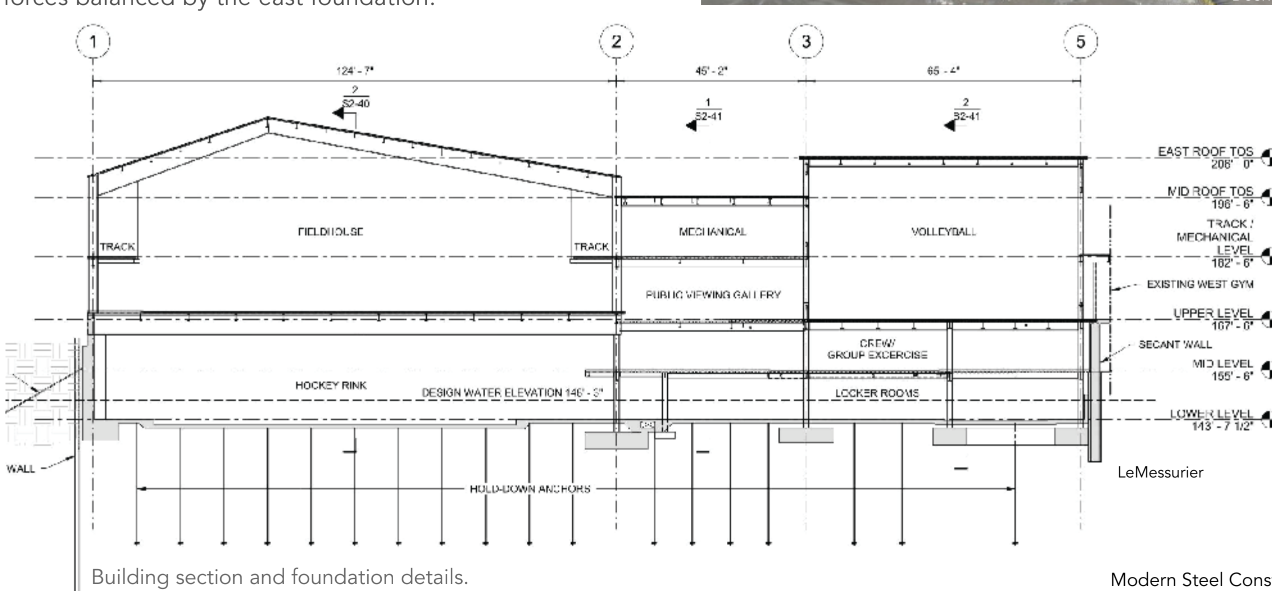
Flood Considerations

In addition to challenging geometric constraints, the design of the new building also had to factor in potential floods. An August 2011 flood of the nearby Deerfield River during Tropical Storm Irene, where river discharge increased from 2,000 cubic ft per second to over 100,000 cubic ft per second, resulted in the river rising over 20 ft in less than a six-hour span and flooding a portion of the campus. As such, the team designed for a flood event that would potentially reach 5 ft above the lower level.

The building is set into a hill with a differential of over 20 ft between the highest grade to the north and the lowest grade to the south. LeMessurier worked with the geotechnical engineering firm McPhail Associates to select and design the foundation system, which uses steel soldier piles and timber lagging with Dywidag strand anchor tie-backs on the north and west sides for support of excavation (SOE); the soldier pile wall is the permanent system employed to retain soil along the north wall and uses 60-ft-long anchors at 15°. A cast-in-place concrete foundation wall spans horizontally between soldier piles and is connected with shear studs to the soldier piles. Tie-back lengths were limited to 40 ft long at 30° at the west SOE due to the adjacent cemetery, which prevented the SOE system from being part of the permanent system. The concrete foundation wall on the west spans between the lower level (hockey rink) and upper level (field house) with forces balanced by the east foundation.

The east SOE extends 18 ft below the mid-level (West Gym lowest floor) and supports both the soil and surcharge from the West Gym foundations. The West Gym, which has a brick masonry façade, required a stiff SOE wall, which was achieved with a secant pile foundation wall with four major components: 39-in.-diameter concrete piles at 5 ft on center, 45-ft-long temporary Dywidag strand tie-back anchors, temporary channel walers, and embedded cantilever steel W24s in alternate shafts. The W24 members were extended from the top of the secant piles to the upper level and cast within a reinforced concrete wall. In the final condition, the W24 members span between the lower and upper levels to resist both soil and surcharge loads from the West Gym foundations and balance lateral soil loads from the west foundation wall. In addition, flood doors were provided at the lower level along the south façade to ensure the building is watertight in the event of future flooding.

Deerfield Academy



LeMessurier

Building section and foundation details.

Jeremy Bittermann/JBSA

Jeremy Bittermann/JBSA

above: The field house is ringed by an elevated running track.

left: The ice rink is directly below the field house.

below: The expansion totals 132,000 sq. ft.

Jeremy Bittermann/JBSA

one-third of the bent span and centered on the same 21-ft spacing as the floor girders. The bent columns are made from straight W24 members, differing from more typical tapered columns used in similar field house-type facilities so as to not encroach on the perimeter running track above the field house floor. Columns were moment connected to the floor plate girders after placement of the floor slab to take advantage of the girder stiffness and minimize their size. Tapered plate girders, transitioning from 5 ft at the columns to 3 ft, 6 in. at the ridge and moment connected at each end, complete the bent frames.

The perimeter running track is 10 ft wide and located 13 ft above the field house floor, and the steel framing is designed to cantilever off the W24 perimeter columns for strength. In addition, 2-in. threaded rod hangers extend to the bent frames to limit framing vibration.

The building required a 30-ft by 126-ft mechanical room to the north at the track level—and like the floor framing for the field house, this area's floor framing was also required to span 126 ft to allow for the hockey rink below. The mechanical room framing is hung from the field house roof framing, and due to its heavy floor load, a story-deep steel truss (instead of the typical steel bent) is provided at the northernmost interior column line. The truss is comprised of bolted W14 members and is 7 ft, 9 in. deep at the ends and 21 ft, 6 in. deep at the roof ridge.

The 132,000-sq.-ft expansion to the Deerfield Athletic Complex, set into the sloping site, provides a "missing link" between the campus and athletic fields. The new field house complements the academy's existing athletic facilities, and its location above the hockey rink allows the building to make the most of its space and fit in perfectly within the campus. ■

Owner
Deerfield Academy

General Contractor
Skanska

Architect
Sasaki

Structural Engineer
LeMessurier

Geotechnical Engineer
McPhail Associates

Steel Team

Fabricator and Erector
United Steel, Inc., AISC Certified Fabricator,
East Hartford, Conn.

Detailer
Arcan Detailing, Inc., AISC Detailer,
Windsor, Ont.

Wedged In

BY THOMAS DENSFORD, PE, AND PETER MOSER, SE, PE

A look at the benefits of a wedged girder arrangement for curved steel girder bridges.

SOMETIMES BRIDGE LAYOUT CONSTRAINTS mean rethinking conventional bridge design.

Such was the case of two recent replacement bridges on U.S. Route 2 in Milford, Maine. The bridges crossed two sensitive streams—Sunkhaze Stream and Lower Trestle overflow at the Penobscott River—with very limited headroom and right of way, requiring shallow superstructure depths on curved horizontal alignments.

After winning the bid for reconstructing the two spans, Reed and Reed, Inc., decided to change the initial multi-span concrete slab design to a single-span steel plate girder approach for both, thus realizing significant cost savings by removing the piers in the original design. The new Sunkhaze Stream bridge spans 96 ft (significantly longer than the existing bridge's length of 47 ft) and uses 92 tons of steel, and the Lower Trestle bridge is 126 ft long (the existing bridge was 198 ft long) and incorporates and 174 tons. Increasing the span lengths of the as-bid concrete spans (48 ft and 43 ft) would normally require increasing superstructure depth, but the vertical clearance over the waterway was limited and raising the highway's vertical profile was forbidden in order to prevent the spread of the approach roadway embankment toes into the sensitive streams—and also because adjacent driveways needed access at existing roadway elevations. The solution was to design a "wedged" steel superstructure cross section, with girders decreasing in depth toward the center of the curved roadway horizontal alignment.

Wedge Design

Traditional horizontally curved steel plate girder bridges use constant web depths at a given transverse section (see Figure 1, left side). Horizontal curvature in roadway alignment requires superelevation to equilibrate centrifugal forces on a vehicle traversing the curve, and typical roadway superelevation rates of 4% to 6% demand a larger girder space envelope, compared to a typical bridge section on tangent alignment with a normal crown of 2% cross slope. Vertical under-clearance is most often controlled by the girder depth toward the inside of the horizontal curve on the low side of the superelevated road surface. However, due to torsional forces, girder structural demands decrease toward the inside of the horizontal curve, which suggests that girder depths may also decrease as they progress toward the girders on the inside of the curve (and indeed, this is true). The right side of Figure 1 shows the combined effects of reducing girder depth with decreasing structural demand toward the inside of the horizontal roadway curve while offsetting the depth effects of superelevation, creating the wedged superstructure cross section.

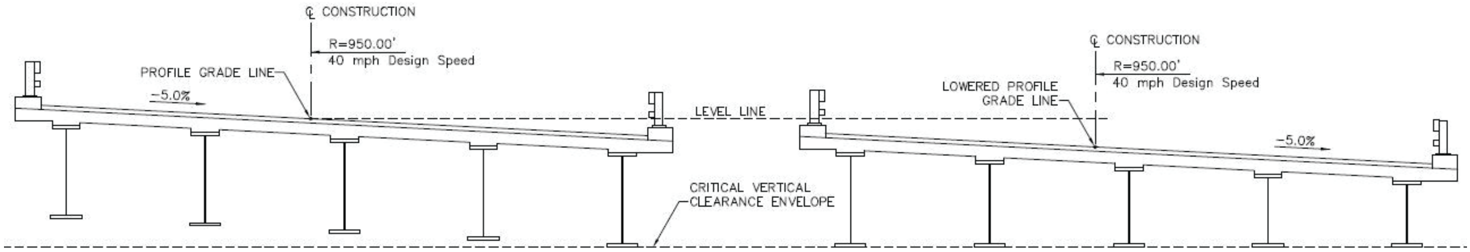


Fig. 1. A traditional curved deck section versus a "wedged" curved deck section.

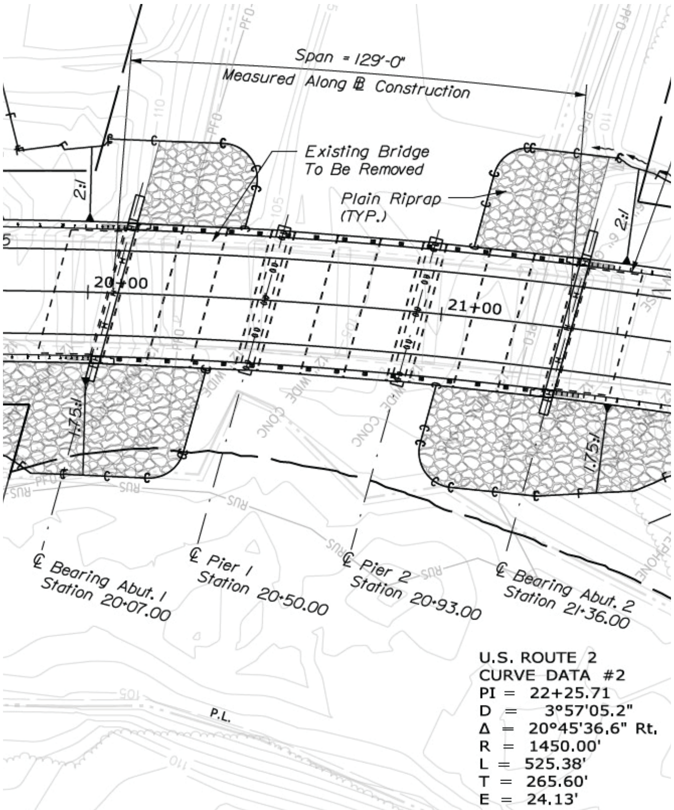


Fig. 2.

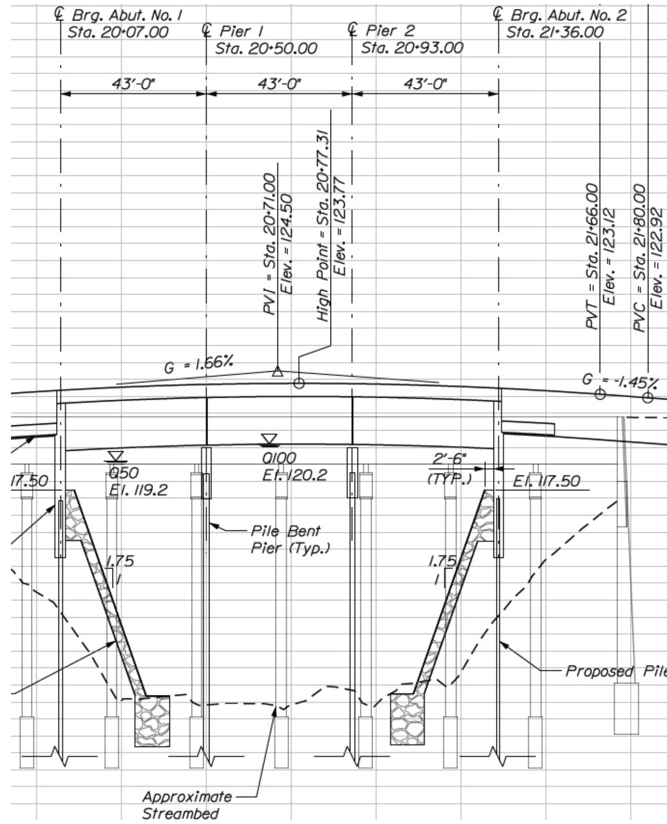


Fig. 3.

Design Evolution

Using the Lower Trestle as an example, Figures 2, 3, and 4 show the plan, profile, and typical section, respectively, of the initial three-span concrete slab bridge arrangement. The initial design called for a bridge length of 129 ft (with three spans of 43 ft) and a width of about 40 ft. The superstructure is superelevated at 4.7%, and the minimum vertical clearance toward the inside of the curve controlled the profile and waterway area to be provided. The piers included piles set in drilled rock sockets and clad with fiber-reinforced polymer (FRP) shells.

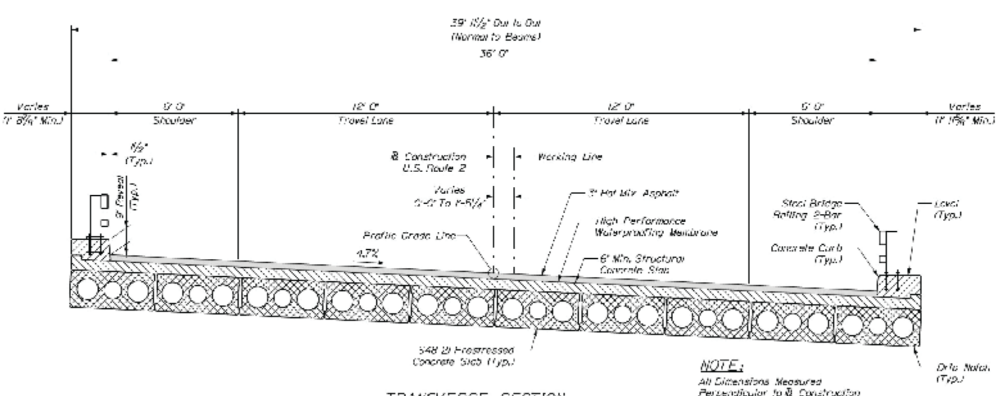


Fig. 4.

Thomas Densford (**tomdensford@gmail.com**) is a bridge engineer with Biggs Cardosa Associates, Inc., Orange Calif., and **Peter Moser** (**peter.moser@stantec.com**) is a bridge engineer with Stantec Consulting Services, Inc., in Burlington, Mass.

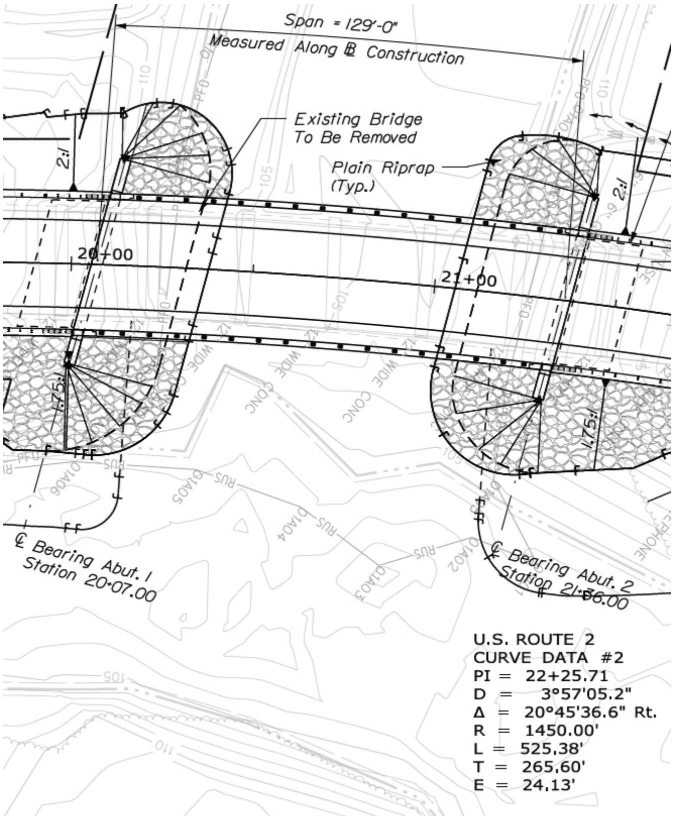


Fig. 5.

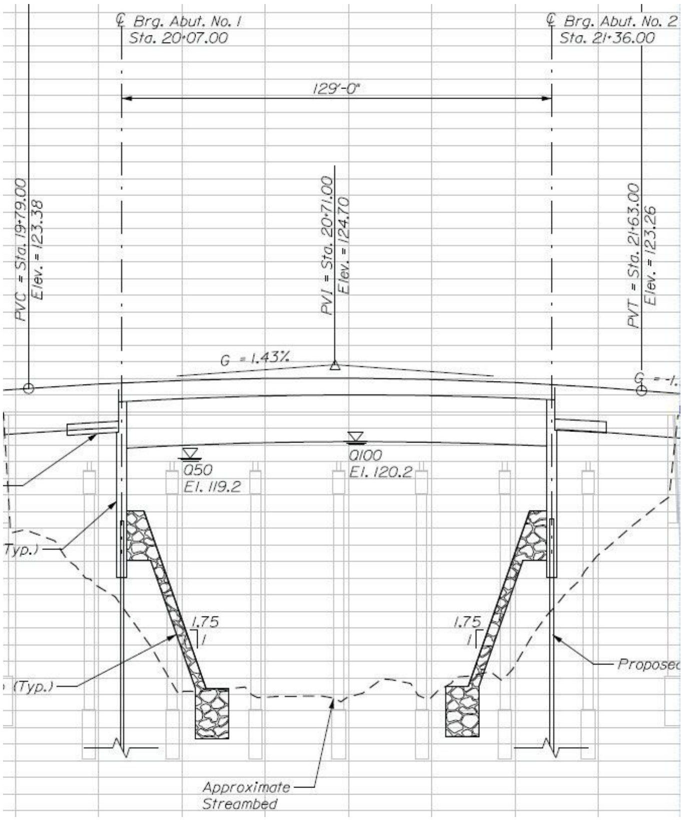


Fig. 6.

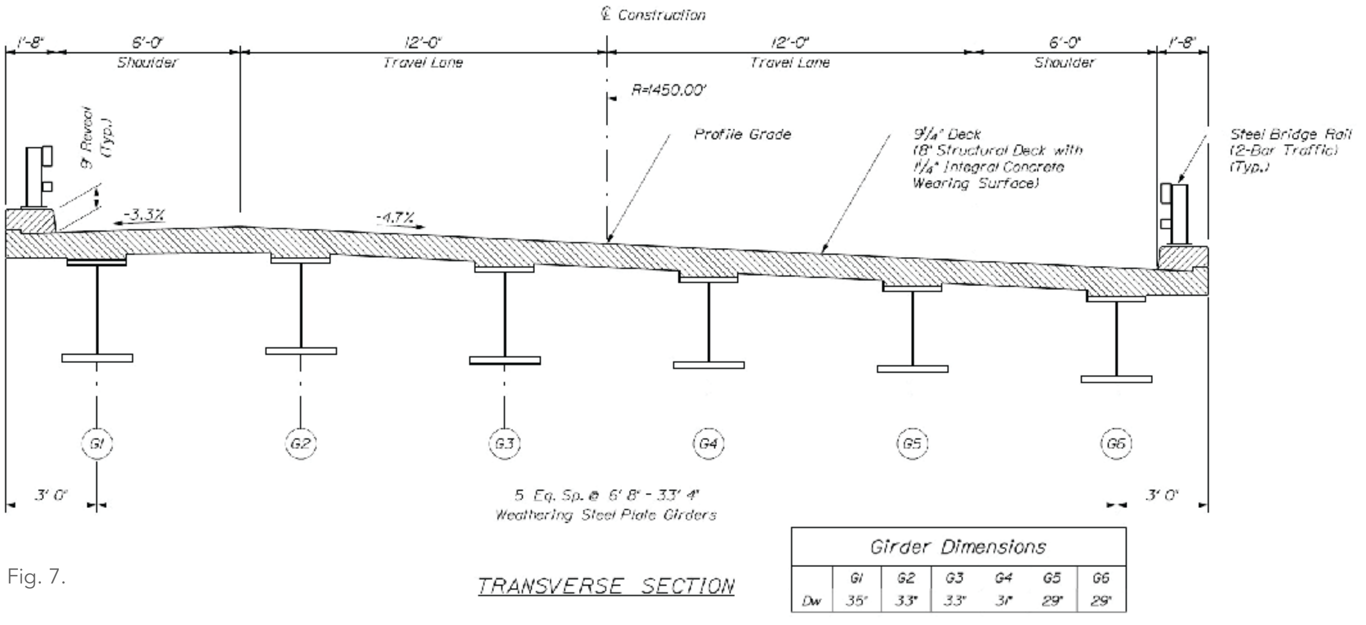


Fig. 7.

Figures 5, 6, and 7 show the plan, profile, and typical section, respectively, of the single-span steel design that was actually built. The profile shows the deletion of two piers from the original design while providing the required waterway opening and clearance to water surfaces. The elimination of pier construction resulted in a 10% overall net cost savings, including the cost for redesigning the bridges in steel.

The design team used NSBA's Simon software (**aisc.org/nsba/design-resources**) for the basic design and to determine steel plate sizes, then checked and modified the design via MDX 3D finite-element bridge design software, with plate elements for the girders and frame elements for the diaphragms, and confirmed the strength and service design with a second finite-element bridge software package (CSiBridge). For the Sunkhaze bridge, the top flanges are 1.5 in. by 18 in., the bottom flanges are 1.75 in. to 2.5 in. thick by 24 in. to 26 in. wide, and the webs are 0.5 in. thick by 24 in. to 28 in. deep. For the Lower Trestle bridge, the top flanges are 1.25 in. to 2 in. thick by 23 in. to 26 in. wide, the bottom flanges are 1.75 in. to 2.75 in. thick by 28 in. to 30 in. wide, and the webs are 0.75 in. thick by 29 in. to 35 in. deep.

Why Wedged?

Why consider this method for future projects? From a roadway design perspective, lowering the bridge profile also results in narrower slope limits, with less encroachment into wetlands and private property and less earthwork volume and surcharge of subsoils. Consider that a profile that is lower by 1 ft, with a roadway approach embankment at 2:1 slope, results in a 4-ft narrower embankment footprint (2 ft on each side). Lowering the profile also allows shorter approach roadway reconstruction limits, provides simpler ties to existing driveways and intersections, facilitates better access during construction traffic staging, and results in fewer impacts to utilities. And it simply looks good.

In addition, horizontally curved girders in positive primary bending torsionally shift load toward the outside of the horizontal curve, with the outer girders supporting increased load demand and the inner girders supporting a decreased load demand. Matching the increased load demand on the girders to the outside of the curve, where the roadway superelevation has raised the grade of the roadway, is a deeper available girder space. Conversely, the girders toward the inside of the curve have reduced load demand and may be made shallower to match the lesser space provided on the low side of the roadway superelevation.

Thus, the wedged deck section provides a better fit for the combined spatial constraints and structural demands peculiar to curved bridges. This allows a lowering of the roadway profile while also providing the needed vertical clearance. Since the structure depth is decreased at the girders toward the inside of the horizontal curve and deeper girders are provided at the outer (high side) of the curve, the deeper girders may allow the elimination of pier substructures, as demonstrated in this project.

And the resources are there to make it happen. The current AASHTO *LRFD Bridge Design Specification* provides refined analysis methods, and the excellent document G13.1: *Guidelines for Steel Girder Bridge Analysis* (**aisc.org/gdocs**) and associated research have pushed bridge design specifications forward and encouraged new design methodologies. It's also important to note that fabricator and detailer buy-in is necessary when implementing

above: The completed Lower Trestle bridge.

below: Steel plate girder framing for the Lower Trestle bridge.

The Lower Trestle bridge deck.

Troy Devoe

The bridge appears to employ unusually large intermediate diaphragm connections. Since diaphragms are considered to be primary members, diaphragm design forces were determined during finite-element analysis, with the connections designed according to computed forces and minimum required connection strength. (Determining the geometry needs for large diaphragm connections should be considered early in the design process.)

a new design technique like the wedged girder approach, and Casco Bay Steel Structures and Tensor Engineering—the fabricator and detailer, respectively, for the Milford bridges—had no issues with the different dimensions of every girder and diaphragm.

A Bigger Wedge

In considering whether to propose the wedged deck section for more widespread use, we evaluated a larger multi-span bridge arrangement. The results showed that the wedged section works well for the larger bridge, with considerable savings in structure depth at the girder on the inside of the horizontal curve, which usually controls vertical under-clearance. This allows the profile grade line to be lowered by about 1.67 ft, with about 30% reduced superstructure depth on the low side for the chosen geometry. The superstructure modeled has two spans at 152 ft each, using a typical urban two-lane roadway with a deck section (see Figure a).

Figure b shows the conceptual framing plan, with radial substructures and cross frames, and Figure c shows the finite element model sectional rendering, with the girders in a wedged arrangement.

At the inside of the curve (at right in Figure c), the girders decrease in depth following the roadway superelevation, and the bottom flanges are all at the same elevation. The analysis proceeded sequentially from the non-composite construction stages of girder erection and placement of concrete to the stages of composite live and dead loads for the respective short-term and long-term concrete modular ratios. Design checks for strength, serviceability, stability, and fatigue all met load and resistance factor design (LRFD) requirements and optional live load deflection limits, and girder stresses and cross frame forces were manageable in terms of welding and connection sizes.

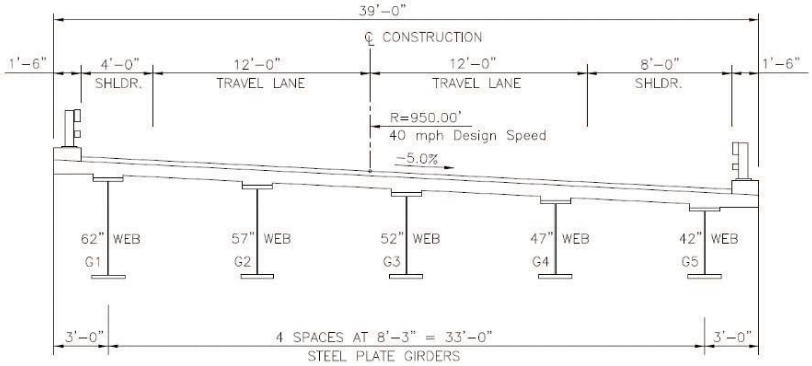


Fig. a.

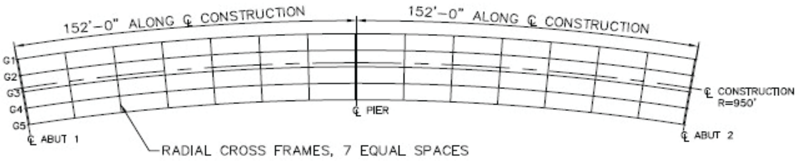


Fig. b.

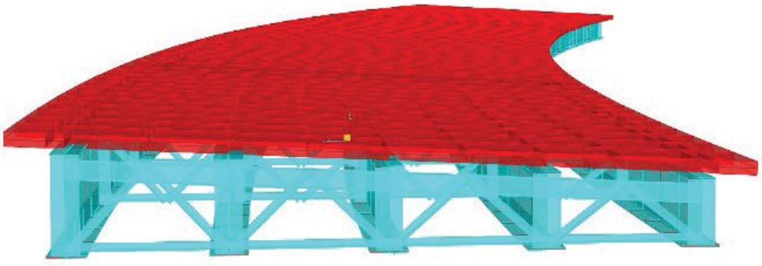


Fig. c.

Design Thoughts

Following the Milford project, we developed a few recommendations when considering the wedged girder section design:

- Set the starting depth of the deepest girder based on the arc span discussion in Section 2.5.2.6.3 of the *LRFD Bridge Design Specification*, and then decrease the girder depths toward the inside of the curve.
- Select common plate thicknesses and vary flange widths of adjacent girders to meet demands. This allows the fabricator to procure wide slabs of plate for a given flange thickness to be nested for several girders.
- Use finite elements to model the girder plates and concrete slab by stage.
- Decrease the spacing of the cross frames or diaphragms because this provides a large (i.e., spacing squared) reduction in girder lateral stresses and cross-frame/diaphragm forces. (See *LRFD Bridge Design Specification*, Section 4.6.1.2.4b, the lateral bending notes.)
- Early in the analysis, analyze the forces in the cross frames and diaphragms and their connections to the girders. The forces and connection sizes are large and significant, and bulky connections should be avoided.
- Use single-angle cross frames where possible to simplify connections and painting.
- Consider the stability of the piecewise erected structure as described in the NSBA G13.1 document mentioned above and FHWA's *Steel Bridge Design Handbook* (**highways.dot.gov**). Temporary bracing may be needed in interim erected conditions.
- Apply the concepts of AISC's direct analysis method (in the *Specification for Structural Steel Buildings*, ANSI/AISC 360, **aisc.org/specifications**) for second-order evaluation of stability and member forces, including the 20% reduction in steel modulus, and the use of destabilizing notional loads, and extend these ideas to horizontal structures to provide a refined analysis.
- Consider using bolted attachments of connection plates to girder tension flanges and associated increases in fatigue stress range resistance.
- Always check the camber using a second (or third) analysis because properly setting the camber is crucial to bridge acceptance.

For both bridges, the substituted single-span curved steel girder bridges were constructed successfully and are currently in operation. After being fabricated to a predicted cambered shape to conform to design grades after concrete placement, the girders deflected into their final position within tolerance without needing stability bracing or shoring during erection. With this proof-of-concept project, the wedged concept is definitely worth considering for future bridge projects. ■

Owner
Maine Department of Transportation

General Contractor
Reed and Reed, Inc.

Structural Engineer
Stantec Consulting Services, Inc., Burlington, Mass.

Steel Team

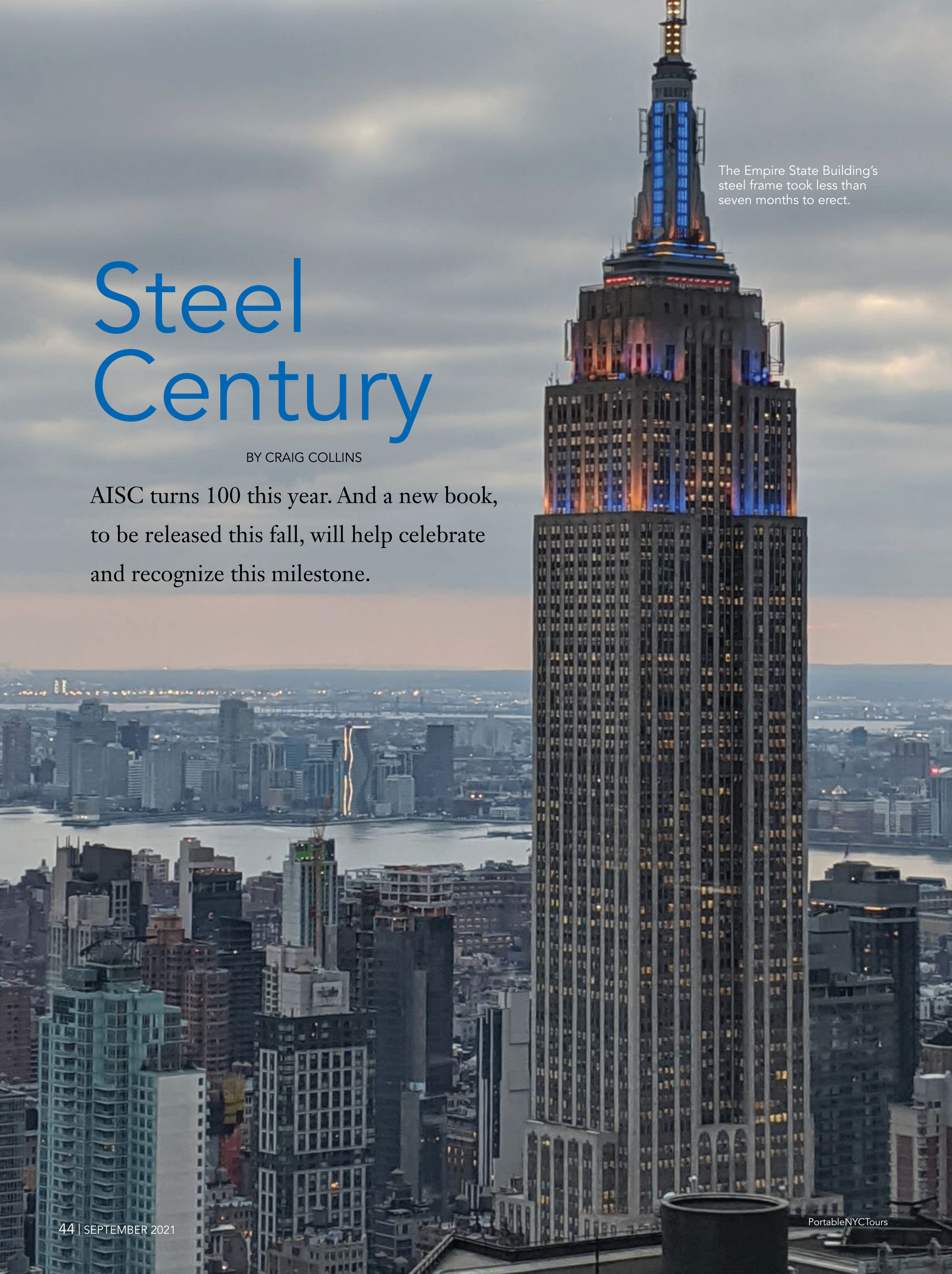
Fabricator
Casco Bay Steel Structures, Inc. (AISC Certified Fabricator), South Portland, Maine.

Detailer
Tensor Engineering Co. (AISC Detailer), Indian Harbour Beach, Fla.

Steel Century

BY CRAIG COLLINS

AISC turns 100 this year. And a new book, to be released this fall, will help celebrate and recognize this milestone.



The Empire State Building's steel frame took less than seven months to erect.

PortableNYCTours


When it opened in 1883, the Brooklyn Bridge was the longest suspension bridge in the world.

Jesse Lee Tucker

IT HAPPENED IN NEW YORK CITY, nearly a half-century after the word "skyscraper" was first used in print.

From May 1930 to May 1931, three mammoth steel-framed structures sprang up to dominate the Manhattan skyline. Each was, upon its completion, the world's tallest building: The Bank of Manhattan Trust Building (71 stories); the Chrysler Building (77 stories); and finally the colossus that remained the world's tallest for nearly four decades, the 102-story Empire State Building, an Art Deco masterpiece designed by Homer Gage Balcom and built around a 60,000-ton steel skeleton so strong it would withstand the impact of a B-25 bomber, lost in the fog, that smashed into the building's 79th floor in July of 1945.

The Chrysler and Empire State Buildings were at the time equally remarkable for the speed and ease with which they were built. The steelwork for the Empire State Building was completed before seven months had passed; the building itself was finished in a little more than 13 months—and came in about $19 million under budget.

The steel holding up the Empire State Building isn't much different from the material American mills had been churning out at the turn of the 20th century. In 1900, American steel was the best, least expensive, and most abundant in the world, but most of the buildings Americans called skyscrapers topped out at about 15 stories: one-seventh the height of the Empire State Building. It's unlikely Homer Balcom and his team would have dared such a design even a decade earlier than they did because fabricated structural steel—the only material that could conceivably support a building of such dimensions—was, for a number of reasons, fraught with expense and uncertainty.

Why did it take more than a half-century from the onset of modern steelmaking to the birth of the Manhattan skyline? The short answer is: Steel was ready; we weren't. The longer answer is complicated. It involves money, of course, but also human nature, technology, demography, and bureaucracy. For many years, each of these was a stumbling block for anyone considering steel as a construction material.

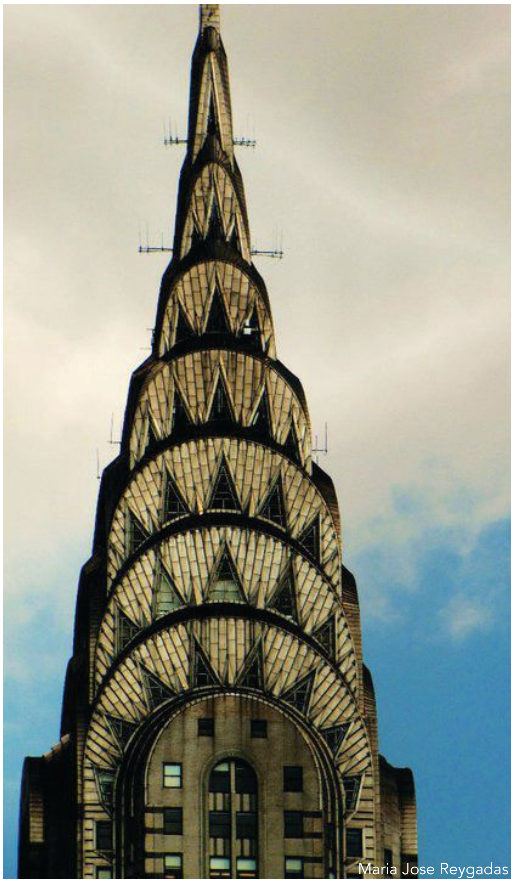
It's no exaggeration to say the event that did the most to clear the way was the 1921 founding of the organization that would become known as the American Institute of Steel Construction (AISC). It's rare for a historical marker to be as clear-cut as the geological stratum that separates the world of dinosaurs from the one without them, but in creating a common operating environment and vocabulary for the structural steel community—producers, fabricators, engineers, architects, code officials, and others—AISC laid down such a marker.

Craig Collins is a California-based freelancer who writes about science, technology, and government.

CELEBRATING 100 YEARS 1921–2021

left: The Bank of Manhattan Trust Building (now known as 40 Wall Street).

below: The Chrysler Building was the world's tallest building before it was surpassed by the Empire State Building.



In the world before the Institute, steel bridges and buildings were limited by stubborn conventions and codes, and many designers were content to choose more familiar materials. In the world launched when AISC began to get rid of these constraints—a Golden Age of steel construction, a hundred years and counting—those who create with steel are limited only by the material itself and their own imaginations. Every steel masterwork of the past century, and each of those to come, can trace its lineage to the year 1921.

Iron Bridges

Iron bridges, the Western world's first metal structures, appeared much earlier than most people realize: a 73-ft wrought-iron footbridge was completed over a waterway in Yorkshire, England, in 1769. The more famous Iron Bridge, a 100-ft cast-iron arch over England's Severn River, was opened to traffic in 1781. After a massive flood swept through in 1795, the span's open architecture left it the only bridge in the area still standing. Its success was inspirational; around the developed world, more builders began to use cast iron as a structural material. The Iron Bridge, closed to vehicle traffic in 1934, still stands in County Shropshire as a pedestrian crossing; it was named a UNESCO World Heritage site in 1986, commemorated as "a symbol of the Industrial Revolution."

The first all-metal bridge in America was the Dunlap's Creek Bridge, an 80-ft arch supported by five tubular ribs of cast iron and completed in 1839 to carry the first federal highway, the National Road, through Brownsville, Pa. The bridge, a designated National Historic Civil Engineering Landmark, still stands today and is listed on the National Register of Historic Places.

The advent of the railroads made longer spans, over major rivers, necessary. Henry Bessemer's 1856 patent of the first inexpensive process for mass-producing steel—an alloy of iron with better strength, tension, and compression properties—made them possible.

The nation's first all-steel bridge was the Eads Bridge, a marvel of 19th-century American engineering, commissioned by steel magnate Andrew Carnegie to join the cities of St. Louis, Mo. and East St. Louis, Ill. at a wide and fast-moving section of the Mississippi River. Designed and built by its namesake, James Buchanan Eads, the bridge is a triple-span of steel arches, high

When the Eads Bridge opened in 1874, its 520-ft-long center arch was the longest rigid span ever built.

enough to accommodate regular steamboat traffic, and linking two shore abutments and two mid-river piers. It was the first bridge attempted downstream from the Missouri/Mississippi River confluence. Its center arch, at 520 ft, was the longest rigid span ever built at that time. The total bridge length, including its approaches, was 6,442 ft.

The Eads Bridge's grand opening, on July 4, 1874, was an event witnessed by President U.S. Grant, a host of politicians and luminaries, and more than 150,000 onlookers; ceremonies included a 14-mile parade, saluting guns, and fireworks. For the next century, the double-decker bridge carried vehicle and rail traffic. Today the refurbished 147-year-old Eads Bridge, a National Historic Landmark, continues to serve automobiles, pedestrians, cyclists, and trains for MetroLink, St. Louis's light-rail system.

Another modern engineering marvel and National Historic Landmark, the Brooklyn Bridge, was completed less than a decade later over the East River at New York City, connecting the boroughs of Manhattan and Brooklyn. At the time, it was the longest suspension bridge in the world, with a hybrid steel cable/suspension design. Originally built for elevated rail traffic and horse-drawn carriages, the 6,016-ft span has undergone several reconfigurations over its 138 years of existence.

Iron in Buildings

As a building material, cast iron was used as early as the 9th century to form Buddhist pagodas in China's Tang Dynasty. It would take nearly another millennium for the Western world to begin using human-made structural materials—cast-iron columns—in buildings. It was an invention born of necessity.

The textile mills that sprang up in northwest England during the Industrial Revolution had a nagging tendency to burn down. Their interior spaces, lit by candles and oil lamps, were also packed with flammable airborne dust and fibers. Too often, this proved a fatal combination, and the need to use something other than wood as a structural material was urgent. As early as 1780, cast-iron columns replaced wooden posts as roof supports in cotton mills. The first iron-framed building in the world, a five-story flax mill in Ditherington, Shrewsbury, was completed in 1797.

Probably the most famous iron-framed building of the era was the North Mill in Belper, Derbyshire, designed by William Strutt as a replacement after his father's original North Mill burned down in 1803. Born a cotton-spinner, Strutt became better known as the civil engineer and architect who helped to create the fireproof textile mill: an iron-framed structure supporting floors of tile, brick, or gypsum plaster and roofed in slate. Completed in 1804, Strutt's North Mill is open today as a museum.

American industrialist Peter Cooper, at his Trenton Iron Works, began producing structural iron in 1847, and the factory rolled its first I-beam in 1854. These beams were used to construct the Cooper Union Building in downtown Manhattan – the first building to use rolled beams in any form, which has led some architectural historians to consider it a forerunner to the modern skyscraper. The building was declared a National Historic Landmark in 1961.

Cooper was confident a reliable passenger elevator would be invented soon, and the Cooper Union was the first in the world to be built with an elevator shaft. This had been one of the main obstacles to designing tall buildings: elevators had been around for years, used to hoist freight, but the hydraulic ones didn't lift very high, and other types weren't yet safe for people: cables snapped, or winches failed, and loads plunged to the earth. In mid-19th century American cities, the highest floors usually had the lowest rents because people were reluctant to take on the trouble—or the danger—of reaching them.

A year after Cooper made his bet on the passenger elevator, Elisha Graves Otis, of Otis Elevator renown, delivered in spectacular fashion at the World's Fair in New York. Beneath the glittering vault of the New York Crystal Palace, Otis had himself hoisted above the crowd on a platform elevator and, once it reached maximum height, ordered an assistant to sever the suspension cable. The platform lurched but remained in place. The crowd gasped. With the flair of P.T. Barnum, Otis explained how his new emergency brakes worked. ■

This article was excerpted from the prologue and first chapter of a forthcoming book documenting the first 100 years of AISC's existence. The book will be available at ***aisc.org/legacy*** *later this fall. Next month, we'll include an excerpt from the second chapter.*

Embracing the Moment

BY KRISTI SATTLER, SE, PE, PhD

More than 100 university teams worked through the obstacles of COVID to build bridges and make the most of this year's AISC Student Steel Bridge Competition.

COLLEGE CAMPUSES ACROSS THE COUNTRY certainly looked different over the past year due to the COVID-19 virus.

And with a focus on remote learning and limited in-person student activities, designing a 20-ft long steel bridge for AISC's annual Student Steel Bridge Competition (SSBC) may have seemed like an impossible task. It would have been easy for SSBC teams to hang up their hard hats and just try again next year. However, navigating the unknown was not a big enough deterrent for the 102 tenacious teams who opted to participate in one form or another in this year's competition.

In a typical year, SSBC teams travel to one of several Regional Events to compete against teams from neighboring schools. They race to assemble their bridges within a specified construction site. The constructed bridges are weighed, subjected to lateral and vertical load testing, and put on display to be judged on aesthetics, and then the top finishers in each region earn a spot in the National Finals.

For the 2021 competition season, it became clear (for the second year in a row) that many teams might still be hesitant to attend in-person Regional Events. As such, AISC created two options: a design-only Supplemental Competition and a Compete from Campus option. The latter allowed teams to still compete remotely from their own campuses, provided that it was safe to do so.

Because campus conditions varied, AISC also provided the option for student teams to participate in either or both SSBC formats, allowing students with the best opportunity to compete as they were able. In the end, 64 schools chose the Compete from Campus route, 38 schools participated in the Supplemental Competition, and 16 opted to do both.

Kristi Sattler (sattler@aisc.org) is a senior engineer with AISC's university relations department.

The UT Tyler team was the top performer in the Texas Region and earned its first-ever spot in the SSBC National Finals.

Compete from Campus

Teams that chose the Compete from Campus option were required to recruit at least one volunteer judge to oversee the competition, then submitted videos of their construction and load-testing events. They also submitted photos of their completed bridges for the aesthetics portion so that teams in the same region could be judged in reference to one another.

As one of the 80 teams that chose the Compete from Campus option, the University of Texas at Tyler (UT Tyler) team was determined to actually build their bridge and get the most out of the competition.

"By seeing [the bridge] in person, things from the classroom start to make sense," said Taylor Knight, one of the captains for the UT Tyler team.

Given the abrupt end to the 2020 competition season, the official rules for that year were transferred to the 2021 season. The mock scenario remained the same: a skewed bridge with the waterway running parallel to the skew, though teams had to consider a different construction site layout this year when determining how to assemble the bridge.

When it came to the actual bridges, teams could use or modify their 2020 bridges or develop a completely new design as they saw fit—and the UT Tyler team took full advantage of these options.

"We knew our 2020 bridge actually worked, so we decided to build on our success from last year," said Knight. "We reused some pieces from last year's bridge, but we changed the angles at the upper connections so the overall geometry was totally different. It required about 30% brand new parts that had to integrate with the old parts."

The number of participants on any given SSBC team tends to vary. However, one thing that is consistent across the board is the drive to work together. Like many teams, Knight and his fellow teammates were accustomed to regularly meeting on campus to discuss and finalize their bridge design. But with campus restrictions, they had to get creative and find other ways to communicate and collaborate remotely on the design of their bridge—and what may have initially seemed a hindrance ended up being a benefit. Rather than trying to coordinate more than a dozen team members' schedules for weekly on-campus meetings, the team was able to meet on a more regular basis in a remote format.

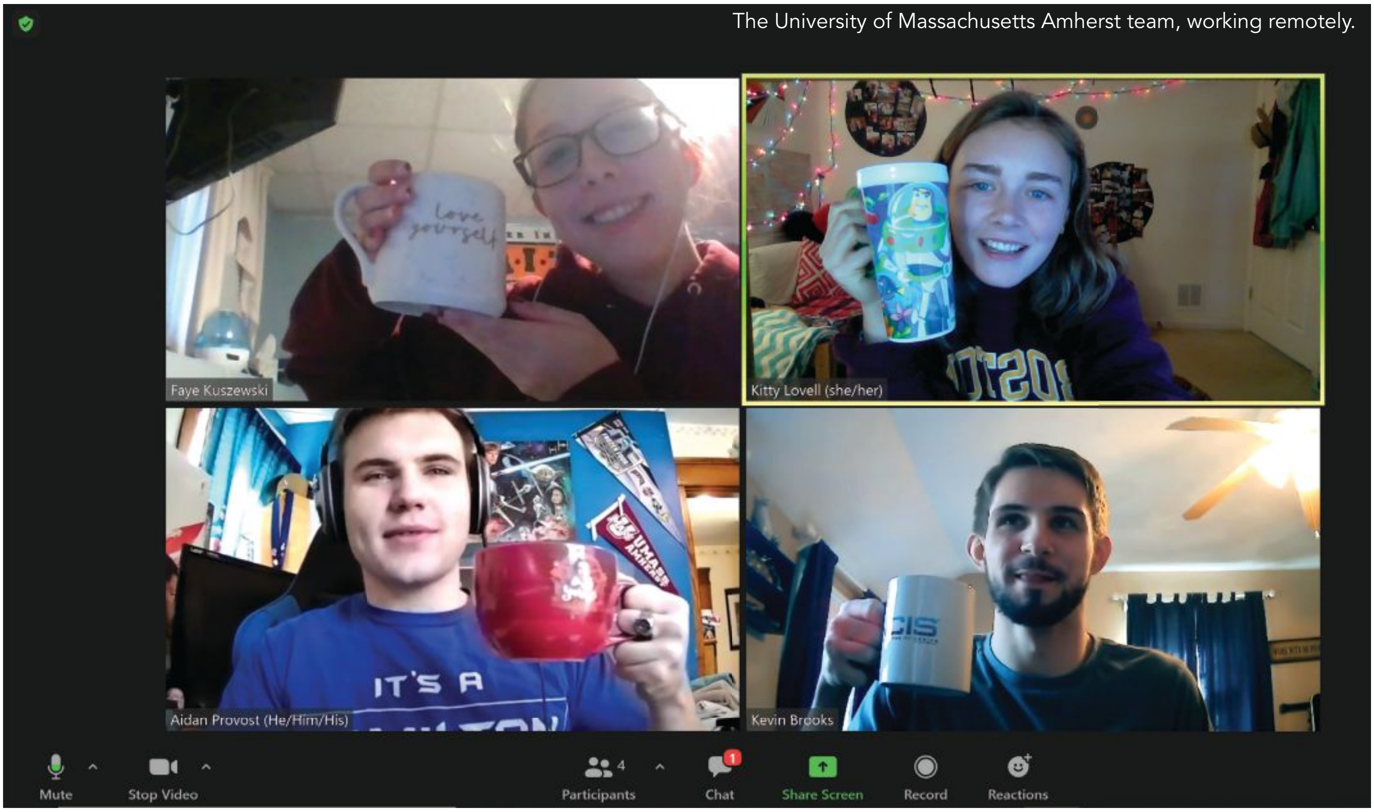
"In some ways, we actually had more consistent communication than previous years because we could just get on Zoom and talk for 15 to 20 minutes every day," said Knight.

The UT Tyler team also learned the importance of practicing for the timed construction portion of the competition. Because they opted to significantly modify their 2020 bridge, the team was able to use their old bridge for practice while fabricating the new sections. One of their sponsors graciously opened the doors to their shop so that the team could fabricate those new bridge parts while access to their own campus was limited.

"This is the first year that we had a bridge ready for build team practice months before the competition," said Knight.

All that practice paid off for the UT Tyler team, as they were the top performer in the Texas Region and earned their first-ever spot in the SSBC National Finals.

"I am extremely proud of the team," said Knight. "They took us to our highest level and did it during a pandemic."



The University of Massachusetts Amherst team, working remotely.

Supplemental Competition

Not all SSBC teams had the ability, resources, or desire to compete in the more traditional format this year, and the Supplemental Competition allowed teams to participate in the design and analysis process without the requirement to fabricate and construct a physical bridge. It was an option that the University of Massachusetts Amherst (UMass Amherst) team embraced.

"During the 2019–2020 school year, we worked really hard on creating a design that we were proud of for the 2020 competition requirements," said Kevin Brooks, one of the UMass Amherst team captains. "We were crushed when COVID hit and we didn't get to finish the fabrication of our design. The Supplemental Competition allowed us to make sure we could finish what we started and not let our design go to waste."

The Supplemental Competition took a different spin on the SSBC experience. Teams were required to summarize the design, analysis, and construction sequencing for their bridge through an engineering report with strict page limitations. This challenged the teams to be concise with their technical writing and to clearly describe their approach. Teams were also required to submit a 10-minute video presentation that summarized their design.

"The Supplemental Competition put much more weight on understanding our design," explained Brooks. "This year, instead of physically building it, we had to develop a conceptual understanding of what was happening in the bridge and how we could analyze it on paper."

The UMass team's experience this year inspired them to modify their approach for next year.

"We learned that simpler is often better. Our design was very complex and hard to wrap our heads around," noted Brooks. "Next year we're going to aim for something simpler, easier to understand, and quicker to build. We're also going to make sure we understand what we design as we design it, rather than designing it then trying to comprehend it."

With their campus closed, all of the analysis and report writing had to be completed in a virtual format. It was not quite the same as meeting in their favorite study spot on campus, but their tight-knit group bonded well and, like the UT Tyler team, met regularly over Zoom.

"Throughout a difficult online year, we were able to keep our heads up and have fun on Zoom," explained Brooks. "Everyone on the team took the work very seriously and finished on time with no all-nighters needed."

Similar to the traditional format, the Supplemental Competition teams competed at a regional level where their reports and video submissions were scored, and the top-performing teams advanced to the National Finals level of competition.

The UMass Amherst team was the top team in the New England Region, earning the school's first-ever berth in the National Finals. Winning their regional event was well beyond their expectations. Brooks noted that their team was noticeably smaller this year, with only four people consistently participating. That small but mighty group took a lot of pride in simply showing up to participate.

"We had to remind ourselves throughout the process that the real reward from the steel bridge competition was all of the knowledge that we gained," said Brooks. "We took on a very daunting bridge design and presented it well despite the constraints of online school and COVID-19, and the feeling of being able to overcome that challenge is something we'll carry with us for a long time to come."

National Finals

The SSBC typically culminates over Memorial Day weekend with more than 40 teams vying for their chance to be National Finals champions. All of the bridges are first put on a display for aesthetics judging, and then over the course of the weekend, the teams construct, weigh, and load test their bridges.

The University of Florida team was the overall winner in the Compete from Campus Competition

Lafayette College came in second place in the Compete from Campus Competition.

Youngstown University took third place in the Compete from Campus Competition.

In all, 25 teams representing 12 regions participated in the SSBC: Compete from Campus National Finals. Like the Regional Events, this year's National Finals were transitioned to a virtual format. All entries for both the Compete from Campus and the Supplemental Competition were judged remotely, with the awards ceremony conducted via webinar.

As with the Regional Events, Compete from Campus teams competed via video submission, where they constructed and load tested their bridge again from the safety of their own campus. As part of the vertical load test, the required location of the 2,500 lb load was changed to subject the bridge to a different loading scenario from the Regional Event.

The University of Florida took first place overall and had an impressive construction time of 1 minute and 49 seconds. They were closely followed by Lafayette College and Youngstown State University, which took second and third place overall, respectively.

University of Puerto Rico – Mayaguez took first Place in the Aesthetics category.

University of California, Berkeley, recipient of the Robert E. Shaw Spirit of the Competition Award.

The University of Alaska Fairbanks team won the Frank J. Hatfield Ingenuity Award.

The University of Missouri-Columbia team won the Team Engagement Award.

In addition to the overall and individual category awards, several other awards were also given. The University of Alaska Fairbanks (UAF) team earned the Frank J. Hatfield Ingenuity Award, which is presented to a team that shows the most engineering ingenuity in the design or construction of their bridge based on the requirements of the competition rules. The Rules Committee noted that UAF received this award "for their unique truss with splayed ends, featuring offset top chord and web members and connection to the bridge piers as well as an innovative twist-lock connection."

The University of California, Berkeley (UC Berkeley) earned the Robert E. Shaw Spirit of the Competition Award for their enthusiasm. In a typical year, a large group of UC Berkeley students can be heard cheering for the build team while they race to construct their bridge. Even given the remote format this year, the cheering squad still "showed up" and could be seen and heard in the team's video submission, bringing some sense of normalcy to this unique format.

The University of Missouri-Columbia received the Team Engagement Award for demonstrating its commitment to building a diverse team and creating an inclusive environment. (See this month's Field Notes column, "Engaging Effort," on page 24 to hear more about the team.)

Oregon Institute of Technology took first place overall in the Supplemental Competition.

The University of Hawaii at Manoa team.

The University of Illinois at Urbana-Champaign team.

On the Supplemental Competition side, nine teams qualified for the National Finals. The submitted reports and videos from the qualifying teams were reviewed again by a different panel of judges, then ranked with respect to one another. The video submissions were also posted for a public vote, which factored into the overall score for the National Finals.

Oregon Institute of Technology took first place overall in the Supplemental Competition, which also secured them a spot in next year's 2022 SSBC National Finals. University of California, Berkeley took second place overall, and Michigan Technological University took third place.

The SSBC National Finals awards ceremony was hosted virtually by Christina Harber, AISC's director of education.

"I miss seeing all of you," she said at the ceremony. "This is a little bit strange for me, this one-way conversation. The one thing that I really want to communicate to you is that I am so impressed by your participation this year."


The University of Wisconsin-Madison team.

The University of Texas at San Antonio team.

"I know you had to overcome some obstacles this year, in addition to your classwork and your normal levels of busyness that you experience as a student. I know you had to do a lot more this year to participate, and you didn't just participate, but you excelled!"

After a couple of very unusual SSBC seasons, one thing is for certain: We are all looking forward to seeing what's in store for these teams next year—and hopefully all live and in person!

Visit **aisc.org/ssbc** to view the full results of the 2021 Student Steel Bridge Competition, as well as the recordings of the National Finals awards presentation and the Supplemental Competition videos. ■

An Outpouring of Support

When the 2021 SSBC events were officially transitioned to remote format, AISC reached out to its member network to recruit volunteers to help locally and remotely.

Several opportunities were available, including serving as in-person judges for the Compete from Campus events, virtual judges for the aesthetics portion, and reviewing engineering reports as part of the Supplemental Competition.

The outpouring of support came so quickly that the online response form had to be closed after a couple of days. Hundreds of willing volunteers reached out to offer their help, many of whom were previous competitors. (And AISC is grateful for the service, enthusiasm, and commitment from such willing volunteers who helped make this year's competition a success!)

A prime example of such enthusiasm was displayed by Tim Davis, PE, senior bridge engineer at McNary Bergeron and Associates, and Trent Liguori, PE, project engineer at Southland Holdings, LLC.

The two embarked on a tour of the Southeast Region, offering to be in-person judges for any team in the region that needed one. They visited eight schools over the course of five days, starting with the University of Central Florida and ending at the Polytechnic University of Puerto Rico. Davis even brought his two children along for the tour.

"It was a great surprise to have Tim and Trent come to our campus to judge our steel bridge team," said Mark Denavit, PE, PhD, assistant professor in the Department of Civil and Environmental Engineering at the University of Tennessee, Knoxville, and faculty advisor for the SSBC team. "We got the same high-quality level of judging as any other year—plus afterward, Tim spoke with the students about his experience with the steel bridge competition and how it relates to his current engineering work. We very much appreciate their generosity."

"It was really good to be able to spend one-on-one time with each of the teams, without their competitors present," noted Davis. "It gave them a chance to ask important questions and showed them that we, the judges, are advocates for all of them doing well."

Starting this fall, Davis and Ligouri intend to do a mini-tour like this every fall, visiting schools individually and serving as a mentor for the teams. And Davis has high hopes for the teams in his area.

"It's no surprise that the top schools from the Southeast Region consistently perform well, and win, at the national competition," he said. "They'd better be watching their tails, though. There are some teams that have big plans for 2022."


Mark Denavit

Superstar SSBC volunteer judges, Trent Ligouri (left) and Tim Davis (right), with their traveling sidekicks, Alex Davis and Haley Davis (center).

Making Connections

BY ERIKA SALISBURY AND GEOFF WEISENBERGER

Get ready:
SteelDay is September 24.
And as the world continues to return to normal, so does this annual celebration of steel, which will include in-person events for the first time since 2019.

Erika Salisbury (salisbury@aisc.org) is a production specialist in AISC's publications department, and **Geoff Weisenberger** (weisenberger@aisc.org) is senior editor of *Modern Steel Construction*.

STEELDAY IS ALL ABOUT CONNECTIONS—structural, yes, but also, and more importantly, personal ones.

Every year, SteelDay connects AISC members with the larger AEC community to celebrate the tremendous positive impact of America's fabricated structural steel industry. For AISC members and other hosts, it's a chance to rekindle relationships with existing clients, meet potential new customers, and teach the world about how steel buildings and bridges come together. For attendees, it's a fantastic learning opportunity—sometimes hands-on—providing a behind-the-scenes look at the steel design and construction process in the form of facility visits, job-site tours, seminars, and more, complete with conversations with the folks who make it all possible, continuing education credits, and fun.

"I really enjoyed hearing all the unique structural aspects of a building I walk by every day," said Lauren Rush, a project designer with C.E. Anderson and Associates in Chicago, of a 2019 event. "It was cool to hear the whole story, firsthand, from the actual people who planned, designed, and built the structure. I'm always amazed by the continued excitement and enthusiasm oozing from the presenters and attendees."

While presenters and attendees were forced to take a year off from in-person events last year, thousands tuned into dozens of virtual events. And while the virtual option is still a part of this year's SteelDay, plenty of in-person events are also scheduled for the first time in two years.

For example, if you're in Southern California, you can join AISC for a hands-on welding demonstration and a guided tour of IMPACT's (Ironworker Management Progressive Action Cooperative Trust) California Welding Training Center in La Palma, followed by a reception.

A hop, skip and jump away in Riverside, Calif., you can visit Simpson Strong-Tie's facility and learn about the Yield-Link moment connection.

"Simpson Strong-Tie is excited to provide SteelDay attendees with the opportunity to tour our state-of-the-art facility where Yield-Link moment connections are fabricated," said Tim Ellis, market segment manager for structural steel at Simpson Strong-Tie. "After the facility tour, attendees will have the opportunity to ask questions of our development, engineering, and fabrication teams, and we will also demo our software plug-ins."

If you're a couple of states north, you can behind-the-scenes look at the steel fabrication process at AISC member fabricator Precision Iron Works' shop in Pacific, Wash.

"We're thrilled to be a part of SteelDay!" exclaimed Cade Marchall, COO of Precision. "We take great pride in our craft and appreciate the opportunity to share that with individuals who may not have experienced steel fabrication on a firsthand basis. We will demonstrate welding, cutting, punching, and forming in a safe and friendly environment with the hopes of enlightening local building professionals. We feel that the more direct interaction building designers can get with specialized trades, the more cohesive the building designs of tomorrow will be."

Further east, in Littleton, Colo., AISC member fabricator Zimkor, AZZ Galvanizing, and the American Galvanizers Association (AGA) are hosting a multi-stage event showcasing a day in the life of steel. From a fabrication shop to a galvanizing facility, attendees will be able to follow along for several steps in the steel supply chain.

"The AGA has been a supporter of SteelDay since its inception," said Melissa Lindsley, AGA's executive director. "It's a unique opportunity to learn about designing with structural steel and to getting to know your local fabricators and galvanizers. Attendees this year will have a fantastic learning experience through the tours and continuing education presentation."

Moving on to the Midwest, if you've ever wondered how hollow structural sections (HSS) are made, you can visit Atlas Tube's Chicago facility to see learn all about HSS via a tour.

"We are excited to open up the Atlas Tube Chicago facility for our SteelDay event," expressed Brad Fletcher, SE, senior sales engineer with Atlas Tube. "It will give us the chance to continue to educate about how HSS is produced and how it can efficiently be used in design. The event will also let us showcase our brand-new mill at our expanded facility in Blytheville, Ark., where we're opening the world's largest single seam ERW mill this fall and where we'll produce the largest HSS sections available anywhere in the world. This is a big investment in the domestic steel market and we are excited to show it off."

Also in the Midwest—in Eau Claire, Wis.—AISC member Veritas Steel will host shop tours, lunch, presentations, and more at its SteelDay event.

Down in Lakeland, Fla., you can join AISC member GMF Steel Group for a presentation exploring the factors that drive steel pricing, including scrap pricing and increasing demand—and also a shop tour.

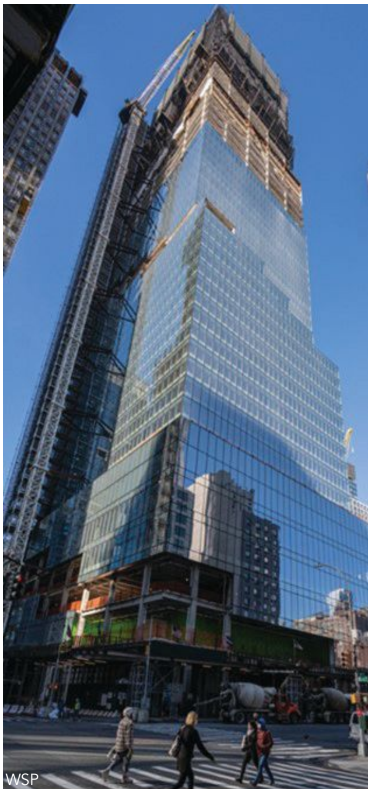
Up the East Coast from Florida, you can reach new heights at another SteelDay event near D.C. The vertically oriented Heights school in Arlington, Va., houses two educational programs that are just as innovative as the extraordinary building they call

above: SteelDay is a great opportunity for people to visit construction project sites and get an up-close look at how steel framing comes together in the field.

right: Simpson Stong-Tie's event in Riverside, Calif., will provide insight on the company's Yield-Link moment connection.

below: The Heights school in Arlington, Va., an AISC IDEAS^2 Award winner, is the focus of a SteelDay event involving members of the project team.

Silman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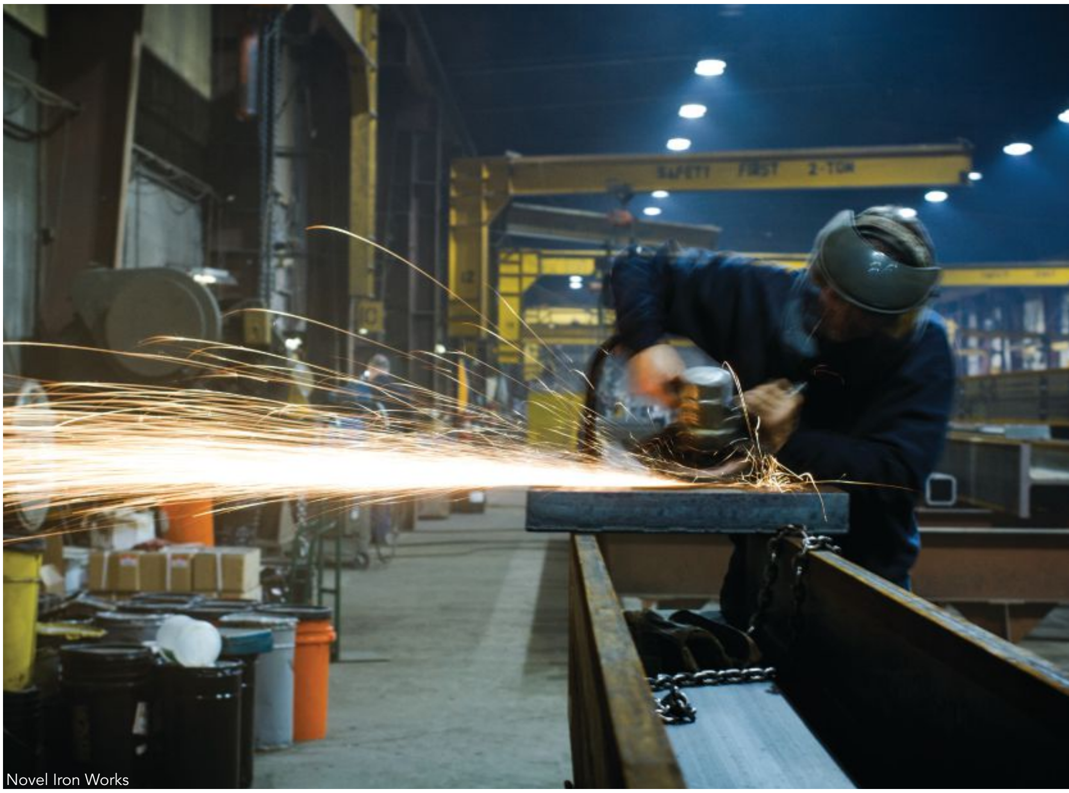

Novel Iron Works

above: 66 Hudson in Manhattan will be discussed in a virtual event.

below: The National Museum of Industrial History in Bethlehem, Pa., will host a weekend's worth of SteeDay activities.

above: Novel Iron Works in Greenland, N.H., is hosting a SteelDay event focusing on the fabrication process.

home. Go back to school with the project team to learn more about this 2021 IDEAS^2 Award-winning project during a reception. You can also read about it in "Pivot Point" in the December 2019 issue (**modernsteel.com/archives**).

Further north (well, virtually) an online event will highlight one of the latest additions to Manhattan's celebrated skyline: 66 Hudson, also known as "The Spiral," in the city's Hudson Yards neighborhood. One of the presenters is Jeff Smilow with the project's structural engineer, WSP (and be sure to keep an eye out for Smilow's article on the project in the October issue).

If bridges are within your purview, AISC member fabricator High Steel will provide the latest technical updates from the steel bridge industry at its Lancaster, Pa., shop, as well as a BBQ picnic and guided facility tours.

"2021 marks the 15th anniversary of High Steel Structures' own first 'Steel Day,' held each year in conjunction with the AISC's national SteelDay celebration," noted Don W. Lee, sales manager with High Steel. "The inaugural event included 70 attendees and has grown to around 225 guests over the last 15 years! Project owners, design consultants, contractors, and other industry professionals join us each year for an informative day showcasing how High Steel and the steel industry contribute to building America."

Another bridge-related event, at AISC member fabricator Canam-Bridges' shop in Claremont, N.H., will demonstrate how bridge designs become realities.

"Our open house will showcase the capabilities of our operation and our people, showing those who design structures and connections the actual processes that transform their designs into reality in a modern major bridge fabrication facility," explained Tony Matutis, Canam-Bridges' national sales manager.

Another AISC member is holding a fabrication shop tour and networking event in the Granite State: Novel Iron Works in Greenland, N.H.

Hands-on activities like this welding competition at Patriot Erectors' 2019 event allow amateurs and professionals to show off their skills.

"We see SteelDay as an opportunity to showcase the breadth of capabilities of the men and women of structural steel fabrication," said Hollie Noveletsky, the company's CEO. "It is these talented, hard-working people who bring the architects' and engineers' visions to fruition. They make the vision a reality every day. (If you want to learn more about Hollie, you can listen to her Field Notes podcast at **modernsteel.com/podcasts** or read "Lifetime Advocate" in the August 2020 issue at **modernsteel.com/archives**.)

If SteelDay isn't enough, you can opt for a steel weekend at the National Museum of Industrial History in Bethlehem, Pa. Housed in the former Electric Repair Shop of the Bethlehem Steel plant site on the vibrant SteelStacks arts & culture campus, the museum interprets industry's past, present, and future through dynamic exhibits and engaging, interactive programs. Visitors of all ages can enjoy the stories of the people, machines, and ideas that transformed our nation through a rich collection of rare artifacts, including the esteemed 1876 Smithsonian Industrial collection. Come steel industry past, present, and future through tours, lectures, and demonstrations throughout the weekend.

Of course, you can join SteelDay virtually for Steel Quiz Live!, an online adaptation of the popular feature monthly feature (on page 12 in this issue).

"Want to put your structural steel knowledge to the test?" asked quiz master Carlo Lini, AISC's director of technical assistance. "Sign up! It's going to be fun!"

Lini will present a series of steel-related quiz questions based on the latest topics coming into the Steel Solutions Center, and participants will be able to vote and then share the correct answers and supporting information—and earn one PDH!

Visit **aisc.org/steelday** to find an event near you! ■

SteelDay Origins

It was an offhand comment John Cross made at a 2007 meeting in Seattle, where AISC's marketing committee had gathered to talk about how to increase the visibility of structural steel beyond the design and construction industry: steel should have its own day of celebration, like National Donut Day or National Popcorn Day.

"At that point it wasn't really a serious comment," said Cross, who was then AISC's vice president of marketing. "It was more of an, 'Oh, yeah, that would be interesting' kind of thought." But it stuck with everyone at the meeting, and by the end of the session plans were underway.

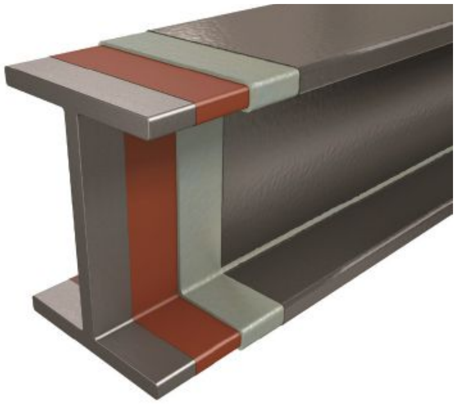
They were still underway when the 2008 financial crisis hit—but if anything, said Cross, the ensuing recession added impetus to the idea of a day for steel. "Everybody was depressed," he said. "So we created an event that has happened every September since, called SteelDay. Historically, it's been the last Friday in September, although it moves a little bit. The idea wasn't that it would be one big event, but that we would blanket the country with a discussion of steel."

Since the first SteelDay in 2009, the celebration has consisted of dozens of events hosted by fabricators, producers, service centers, bender-rollers, erectors, detailers, galvanizers, hollow structural section producers, and others around the country—ranging from tours of plants and job sites to special events and seminars in major cities. One of Cross's favorite SteelDay memories is of the time a West Virginia fabricator hosted an open house attended by then-governor Joe Manchin, who was trailed by a group of journalists, one of whom interviewed a structural engineer for a local news broadcast. "He said, 'I've been designing buildings and bridges in West Virginia for 30 years, and I've never been inside a steel fabricator. And what I've learned today will make every design I make in the future better and more efficient.'"

SteelDay is designed to be an interactive day, and not just for industry insiders: Dave Steel Company of Asheville, North Carolina, a regular participant, focuses its SteelDay attention on elementary school students. "What we've started doing," said Jeffrey Dave (PE), the company's president and CEO (and a current AISC board member), "is to go into the elementary schools. We'll have a couple of engineers go in and speak on steel and engineering in a very elementary way, to try to get people turned on to the industry very early." *—Craig Collins*

new products

This month's New Products section features a cellulosic fireproofing coating, a single-seal expansion joint for road bridges, and a portable TIG welder.



Sherwin-Williams FIRETEX FX9502

The FIRETEX FX9502 cellulosic fireproofing coating from Sherwin-Williams Protective and Marine offers applicators an array of efficiencies when applying long-term corrosion and fire protection to structural steel for buildings. A typical applied system includes a base primer coat (orange layer) followed by the FIRETEX FX9502 coat (green layer), with a topcoat (dark gray layer) being optional for most applications. The coating offers an attractive, architecturally pleasing finish compared to bulky cementitious spray-applied fire-resistant materials (SFRMs), enabling the use of exposed steel throughout buildings. It offers some of the lowest competitive thicknesses in the ASTM E119 designs for fire ratings up to three hours and features a reduced total number of coats compared to acrylic intumescents.

For more information, visit **www.sherwin-williams.com**.

Maurer XC1

The XC1, a new single-seal expansion joint for road bridges, is capable of compensating bridge movements of up to 100 mm (approximately 4 in.) and features low noise emission. In comparison to its proven predecessor XL1, it offers a longer service life of 50 years and at higher possible load impacts. It is half the weight of the XL1, which increases economic efficiency by 20% and enables faster installation. In addition, the edge profiles were optimized in shape to make them more durable and more robust. The low-noise overhead M-Plates are bolted with pretension onto the edge profile in such a manner that a clearly defined and thus improved force application is achieved.

For more information, visit **maurer.eu**.

Miller Electric Mfg. CST 282

The new CST 282 stick/TIG welder, designed for construction, shipbuilding, pipe welding, and maintenance and repair applications, delivers lightweight portability and the flexibility to be plugged into nearly any source of primary power on the job site—so operators can get the work done in any location. Designed for stick and TIG welding, the power source provides 280 amps of welding performance. The machine includes a digital meter that provides precise control when presetting or monitoring welding amperage, so operators can be assured of their proper settings to produce quality welds. In addition, voltage-reducing device (VRD) technology reduces output when the operator isn't welding, improving safety by reducing the potential harm from inadvertent contact with the electrode during non-welding pauses.

For more information, visit **www.millerwelds.com**.

ERECTORS

SEAA Announces Winners of Project of the Year, Safety Excellence Awards

The Steel Erectors Association of America (SEAA) recently announced the winners of two of its annual awards programs: Project of the Year and Safety Excellence Awards.

Seven steel erection companies won Project of the Year awards this year, with one winner being selected in each of four categories based on the dollar amount of the erection contract and three winning Honorable Mentions.

Three of the projects were part of broader redevelopment plans in the local communities where they were built, and five of them house centers for cultural expression—including performing arts, sports, and a museum.

Chosen by an independent panel of judges, the companies received notice of their awards in April 2021 for projects that winning projects all topped out in 2019 or 2020. Here are this year's winners:

- Hodges Erectors, Inc., an AISC member, for Turnberry Ocean Club condo entrance, Sunny Isles, Fla. (Class I for erection contracts up to $500,000)
- FM Steel LLC, for Talking Stick Resort arena renovations, Phoenix, Ariz. (Class II for $500,000 to $1 million)
- United Steel Inc., an AISC member, for Hartford Healthcare Amphitheater, Bridgeport, Conn. (Class III for $1 million to $2.5 million)
- Deem Structural Services, LLC, an AISC member, for Buddy Holly Hall performing arts center, Lubbock, Texas (Class IV for over $2.5 million)
- High Plains Steel Services, LLC, an AISC member, for Hunters Overlook Bridge, Windsor, Colo. (Honorable Mention)
- CAS Steel Erectors, Inc., an AISC member, for International African American Museum, Charleston, S.C. (Honorable Mention)
- Cooper Steel, an AISC member, for Belmont University Performing Arts Center, Nashville, Tenn. (Honorable Mention)

Nine SEAA members received Safety Excellence Awards in three categories thanks to their excellent 2020 safety records. Recipients were selected based on evaluations of their experience modifier rate (EMR), OSHA 300A statistics, and safety program processes over the last three years. Scoring was based on points assigned to a multi-criteria analysis, conducted in a blind review by members of SEAA's Safety and Education Committee. Here are the winners:

World Class

- Cooper Steel, an AISC member
- Derr & Gruenewald Construction, LLC, an AISC member
- FM Steel, LLC
- High Plains Steel Services, an AISC member

Premier

- Black Cat, LLC, an AISC member
- Gardner-Watson Decking
- Quality Steel Services, an AISC member

Gold

- Pro Steel Erectors
- Shelby Erectors

In addition, five companies were recognized for their craft training programs. Applicants were evaluated on the portability of credentials, availability of apprenticeship programs, training, and recruitment efforts. Evaluations are made in comparison to other companies of similar size, based on the number of ironworkers employed.

World Class

- Derr & Gruenewald Construction, LLC, an AISC member
- High Plains Steel Services, LLC, an AISC member

Premier

- Shelby Erectors
- Ironworker Skills Institute

Gold

- Gardner-Watson Decking

For more details on both awards programs and this year's winners, as well as information on SEAA's 48th Convention and Trade Show (taking place in Orlando October 12-14), visit **www.seaa.net**.

People & Companies

Steel Dynamics, Inc., an AISC member producer, recently announced a goal to be carbon neutral by 2050 for its electric arc furnace (EAF) steel mill operations. To achieve this target, the company also set interim emissions reduction and renewable energy milestones to be achieved by 2025 and 2030.

On the path to carbon neutrality, Steel Dynamics is targeting a 20% Scope 1 and Scope 2 combined greenhouse gas (GHG) emissions intensity reduction across its EAF steel mills by 2025 and a 50% reduction by 2030, compared to a 2018 baseline. Additionally, the company plans to increase the use of renewable energy for its EAF steel mills to 10% by 2025 and 30% by 2030.

These goals expand on Steel Dynamics' existing sustainability focus, which includes exclusive use of EAF technology, circular manufacturing model, and innovative teams creating solutions to increase efficiencies, reduce raw material usage, reuse secondary materials, and promote material conservation and recycling. Its ongoing efforts will focus on identifying and implementing emission-reduction projects, improving energy management to reduce emissions and enhance operational efficiency, increasing the use of renewable energy (including partnering with local utilities), and researching and developing innovative technologies.

Based on International Energy Agency recommendations for the steel sector, Steel Dynamics' current steelmaking operations already fall within the 2050 intensity targets designed to meet the Paris Agreement and its 2 °C scenario. Further, the company is aligned with the Science Based Targets Initiative (SBTi) as its EAF steel mills plan to meet the SBTi "well below 2 °C" scenario target for Scope 1 and 2 combined emissions intensity by at least 2030, based on the Iron and Steel Sectoral Decarbonization Approach.

CONNECTIONS

AISC Offering $5,000 Prize for Next Great Idea in Connections

The Steel SpeedConnection Challenge is looking for the next great idea in connections, and there is $5,000 on the line for the best concept! The challenge is part of ISC's "Need for Speed" initiative, which is aimed at increasing the speed of steel construction by 50% by 2025 (**aisc.org/needforspeed**).

Standard shear connections have long been used for the majority of steel beam and column connections, as they are viewed as easy and economical. But what if we can do it better?

We welcome all participants with a spark of inspiration. Your outside-the-box idea could revolutionize the industry!

To register for the challenge, visit **herox.com/speedconnectionsteel** and click the "ACCEPT CHALLENGE" button. Be sure to submit your entry by October 8, 2021.

MEMBERSHIP

AISC Board Announces New Members

Full

Anco Iron and Construction, Inc., San Francisco
Commercial Metal Products, Inc., Springfield, Ore.
Lawton Welding Co., Topsfield, Mass.
Marvin Metals, Inc., Waupaca, Wis.
P & A Welding and Machine, Inc., Mulberry, Fla.
Troy Industrial Solutions, Brewer, Maine
Yankee Metals, LLC, Bridgeport, Conn.

AISC ASSOCIATE AISC DETAILER **Associate**

Agile Steel Detailing, Inc., Medford, Ore., *Detailer*
Digital Structure Design, Albany, N.Y., *Detailer*
Fabertek S.A.C., Lima, Peru, *Erector*
Guytec Steel, Inc., Ridgewood, N.Y., *Erector*
Hochtief (India) Private Limited, Chennai, India, *Detailer*
Intelligent Solutions in CADD, Elmendorf, Texas, *Detailer*
Interglobal Technologies, Inc., Port Hope, Ontario, Canada, *Detailer*
Lapeyre Stair, Harahan, La., *Non-Structural Fabricator*
LeJeune Bolt Company, Burnsville, Minn., *Bolt Manufacturer*
Nexus Steel Detailing, Inc., Bellwood, Ill., *Detailer*
Rydberg Engineering Private Limited, Kolkata, India, *Detailer*
Structural Engineering Partnership, LLC, Orlando, Fla., *Detailer*
Trinity Steel Erection, Inc., Powhatan, Va., *Erector*

FORGE PRIZE

Emerging Architects: Get the Industry Recognition You Deserve—and Win $15,000!

Are you an up-and-coming architect? Then we want to hear about your creative vision of the future. The fourth annual Forge Prize competition is now accepting entries!

The competition, established by AISC in 2018, recognizes visionary emerging architects for designs that embrace steel as a primary structural component and capitalize on steel's ability to increase a project's speed.

U.S.-based architects who are either currently seeking licensure or have been licensed for fewer than ten years may enter online at **www.forgeprize.com**.

Three finalists will each win $5,000. They'll work with a steel fabricator to refine their concept before stepping into the industry spotlight to present their concepts live to the judges—and the world—on YouTube.

The winner will take home an additional $10,000 and be invited to present their design to the industry at the Architecture in Steel conference, which is incorporated in NASCC: The Steel Conference, in Denver next March. Entries are due by October 31, 2021.

Hunter Ruthrauff of T.Y. Lin International Group in San Diego took top honors in the 2021 competition with a stunning 3D-printed steel pedestrian bridge. Visit **forgeprize.com/2021-winner** to learn more about Ruthrauff's design.

BRIDGES

New Pedestrian Bridge Connects Cleveland Residents to Lake Erie Waterfront

On June 24, just in time for Fourth of July festivities, Cleveland Metroparks opened the Wendy Park Bridge, a 500-ft-long pedestrian bridge that provides a new link between downtown Cleveland and waterfront parks alongside Lake Erie.

The bridge is one of the final elements in the $16.45 million "Re-Connecting Cleveland" federal Transportation Investment Generating Economic Recovery (TIGER) trails project. The goal of the TIGER project is to provide safe, seamless, car-free connectivity to parks and waterfronts on Cleveland's west side. Creating a path over the Norfolk-Southern railroad tracks, the Wendy Park Bridge aligns closely with this goal in eliminating a 3.6-mile detour that had been required to reach the park from the south.

With its distinctive arch, the bridge stands out as a new city landmark. Its two approach spans, 125 ft each, are Pratt trusses, and the main span is 250-ft tied-arch structure. Pedestrians and bikers can traverse a 12-ft-wide clear deck that not only leads to Wendy Park but also Whiskey Island, the former historic coast guard station, and Edgewater Park.

AISC member and certified fabricator Contech Engineered Solutions, LLC, provided the steel for the $6 million project, which was designed by KS Associates, Inc., and constructed by Great Lakes Construction Co.

Find out more about the Wendy Park Bridge and Re-Connecting Cleveland TIGER Trails Project at **www.clevelandmetroparks.com**.

Letters to the Editor

Don't Yell "Fire"

The July 2021 article "Back to Building" (**www.modernsteel.com**), suggested that substituting steel wide-flange beams in place of open-web joists due to long lead times and rising costs can "keep projects on track with a more palatable timeline." As a teammate of a company that produces both wide-flange beams and open-web steel joists and a long-time advocate of the domestic steel industry, these statements are contradictory to what makes steel the most efficient material to build with.

Everyone can agree that we are experiencing an extremely unique market. When it comes to construction materials, demand is high and lead times are extended. This impacts all materials and not just steel. Whether it's erectors or installers, roofing insulation, trucking, or even electric or mechanical systems products, many construction delay considerations are at play that are directly unrelated to joists and deck—but are impacting their unique availability. Simply swapping out one material versus another may not guarantee schedule improvement. While the cost per ton of open-web steel joists has risen, a joist is still significantly lighter than a wide-flange beam of comparable load capacity and serviceability requirements. The result of replacing open-web steel joists with wide-flange beams will be a heavier building that may impact column and foundation sizes—all at a higher cost. Additionally, the redesign of the columns and foundations adds time, money, and material.

In every market, lead times will vary between jobs and geographic location. In response to the current demand, the joist industry has added capacity as rapidly as possible. Due to the robustness of our economy, the joist production backlogs in the first half of 2021 have grown longer than a standard lead time, and increased demand was realized faster than the additional capacity could be brought online. The industry has some catching up to do. It is already happening and will continue as this market normalizes.

Rather than swapping out framing systems, a more productive plan of attack for designers is early involvement. Contacting a fabricator or the local office of a joist supplier to help you manage the schedule and cost risks early in the design phase will always keep your project on track. These entities can give you lead time estimates based on actual work in their shops and not a rumor from the water cooler.

Lastly, it's important that we take a deep breath and not yell "fire" when the market experiences unique or challenging times. As AISC has touted for years, least weight is not least cost. The true drivers for project costs are labor and erection, not solely materials. The escalations in these factors can translate to a possible 1% to 2% increase of the total project costs. Steel's value over concrete and mass timber is seen in its speed of construction, adaptability, and sustainability. Focus should remain there and not on pitting steel against steel.

—Tabitha S. Stine SE, PE
Director of Construction Solutions
Nucor Corporation

Avoiding Reinforcement

Regarding the July letter to the editor and response about the March 2021 article "Thinking Inside the (Big) Box" (**www.modernsteel.com**), I found it interesting that the only issue that Mr. Fisher and the article's authors appeared to agree on was item 4, "Reinforcing existing joists is doable."

That said, based on my experience investigating existing joists that have already been reinforced (and exhibiting structural duress or, in some cases, failure), I avoid reinforcing joists at all costs. In fact, the only joist reinforcing that I do specify is web reinforcing at concentrated loads that are either not at the top or bottom chord panel point or of a magnitude, and not at the chord panel points, that exceeds that recommended by the SJI. However, the reinforcing that I do call for is not welded and instead employs Lindapter bolts. This approach avoids not only the potential for damage to the existing joist from poorly executed field welding but also the need to take extraordinary safety precautions associated with welding inside an operating facility.

The are several reasons I avoid reinforcing existing joists to provide additional flexural or shear strength, which typically involves field welding:

1. Open-web joists are pre-engineered, manufactured members. However, when an engineer (other than the manufacturer) designs joist reinforcing, concealed, deficient pre-existing conditions that may manifest themselves after the reinforcing is installed become the responsibility of the reinforcing design engineer. Such deficiencies can include concealed top chord panel point factory welds or other similar issues that do not become apparent until the revised loading and related reinforcing exacerbate the pre-existing condition.
2. Reinforcing joists, unfortunately, are typically not installed by certified welders or experienced steel erectors. Instead, more often than not, the contractor involved with the installation of the new equipment or work that necessitated the reinforcing also installs the reinforcing. This almost always results in poor welds and/or damage to the existing joists.
3. Although the quantity of materials associated with joist reinforcing is typically nominal, the labor associated with the installation, including welding, is very costly. As a result, alternate approaches to addressing the adaptive reuse of the joists are often less or no more costly than reinforcing the joists in situ.
4. Alternate approaches to reinforcing joists can include load redistribution via the introduction of transverse "trussed" framing perpendicular to the joist span (see load distribution methods of analysis in the referenced book by Fisher) using Lindapter bolts rather than field welding, adding new joists, adding new beam and column framing, or adding independent dunnage framing spanning between existing columns.

—D. Matthew Stuart, SE, PE, PEng
Senior Structural Engineer
Pennoni Associates, Inc., Philadelphia

QMC **Contract Auditor**

Quality Management Company, LLC (QMC) is seeking qualified independent contract auditors to conduct site audits for the American Institute of Steel Construction (AISC) Certified Fabricators and Certified Erector Programs.

This contract requires travel throughout North America and limited International travel. This is not a regionally based contract and a minimum travel of 75% should be expected.

Contract auditors must have knowledge of quality management systems, audit principles and techniques. Knowledge of the structural steel construction industry quality management systems is preferred but not required as is certifications for CWI, CQA or NDT. Prior or current auditing experience or auditing certifications are preferred but not required. Interested contractors should submit a statement of interest and resume to **contractor@qmconline.org**.

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TIME CAPSULE

A FEW YEARS BACK, AISC opened its proverbial vault and allowed staff to peruse and keep photos from its vast archives. Boxes and boxes (and boxes) of old pictures, many of them black and white, were put out in the common areas of the office, and interested parties rummaged through them and pulled out whatever gems they liked. (While the hard copies were discarded, fear not: Historically valuable photos were scanned and live on in perpetuity in the digital realm.)

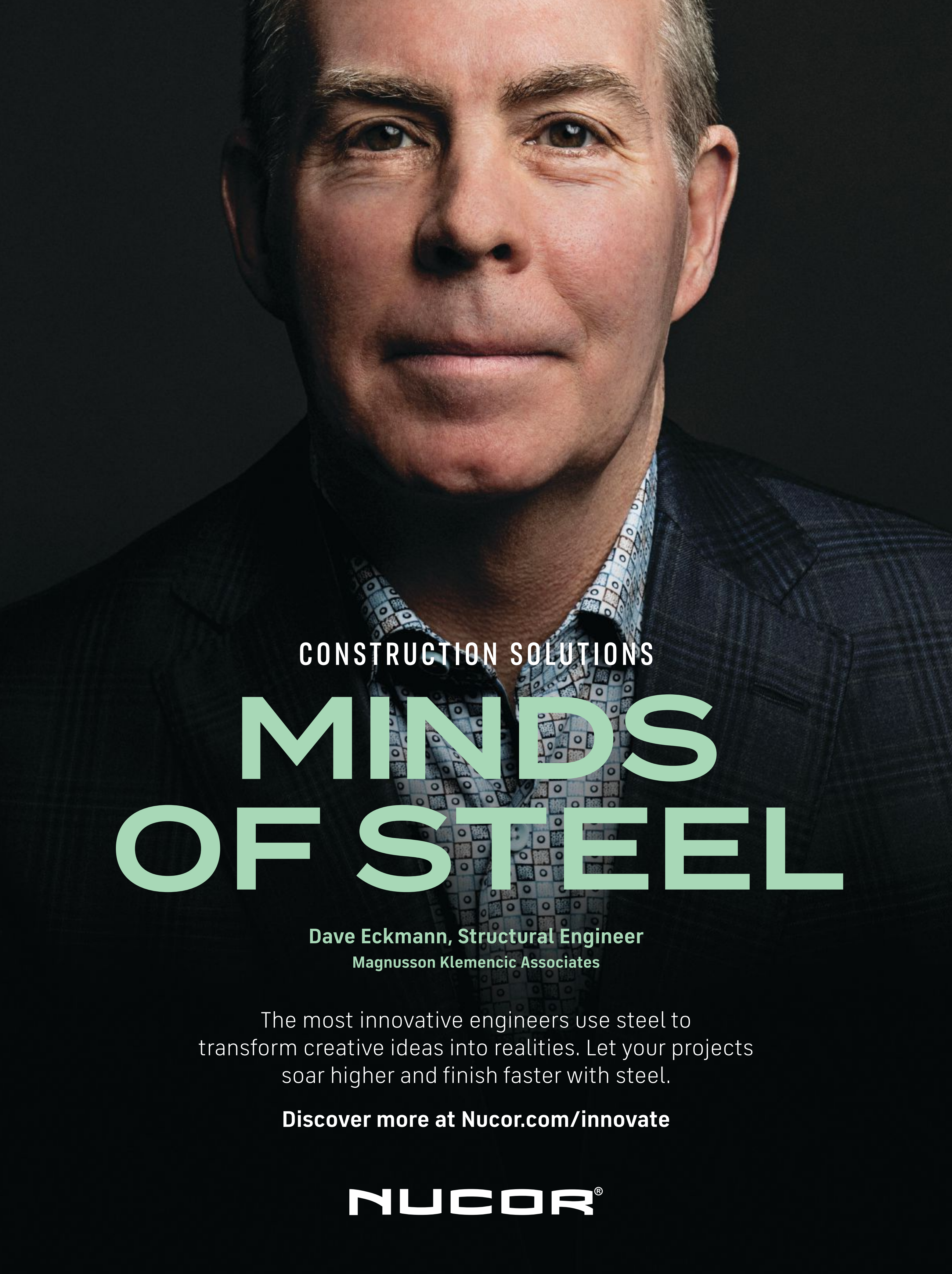
I nabbed a handful, including a couple of the Empire State Building that were taken right after it was built and also some great historical steel bridge shots. The above shot also caught my eye. When I first came upon it, a few things were immediately clear.

One, it was taken several decades ago, likely in the first half of the 20th Century. Two, it was taken in Manhattan, as Central Park is evident in the upper-right of the photo. Three, safety standards have come a long way since it was taken.

This photo wasn't labeled, so the exact building is somewhat of a mystery, though the prime suspects are the Empire State Building, Rockefeller Plaza, and the Lincoln Building (now known as One Grand Central Place). It struck me as a lonesome version of the famous "lunch atop a skyscraper" shot.

While the precise time and location remain a mystery, it represents one of countless moments from steel construction's—and AISC's—history. Of course, it's impossible to capture every moment in an industry's or organization's history, but we've done our best to include the significant ones in a soon-to-be-released book celebrating the first 100 years of AISC. You can see a preview of the book, including the introduction and a portion of the first chapter, in "Steel Century" on page 44. We'll also feature excerpts from subsequent chapters in the remaining 2021 issues of *Modern Steel*. And to learn more about AISC turning 100, **aisc.org/legacy**.

—Geoff Weisenberger, Senior Editor



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