# Modern Steel Construction

January 2020

# Modern Steel Construction

January 2020


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**ON THE COVER:** Twisting, turning steel trees are growing in a riverside park in Des Moines, p. 22. (Photo: Courtesy of Johnson Machine Works)


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# editor's note

My wife's best friend and I were shooting the breeze recently and we got to talking about home improvement projects. We're both in the process of replacing decks, but she went with pressure-treated wood while we chose composite decking.

Why, she wondered, did we make that choice when a wood deck is so much less expensive than composite? But is it really? If we went with wood, we'd have to stain it every couple of years and its lifespan is just 15–20 years, which meant we'd probably need to replace it again at some point. The composite deck? Just some annual scrubbing and it should easily outlast me. The initial cost shouldn't be the only factor in making a decision, I pointed out.

The same point was hammered home in a story I recently heard from Jim Fisher during a preview of his upcoming keynote address at the 2020 NASCC: The Steel Conference in Atlanta in April (**aisc.org/nascc**). If you don't know Jim, he's one of the country's leading structural engineers, a distinguished author, and a fantastic storyteller (to get a better idea of Jim's accomplishments, listen to this podcast at **aisc.org/podcasts/**). Now retired, Jim told a story about when he was first starting out and was consulting on a massive industrial building. After looking at the original design, Jim proudly told the owner he had an idea that would save around $300,000. By using an innovative horizontal truss system, they'd reduce the cost of the steel and of the foundation. The owner looked at Jim and asked how long it would take him to design. A week or two, maybe. How much time would it take to detail? Maybe another two weeks. How about fabrication and erection? Another few weeks. So, the owner said, you can save me $300,000? My construction loan on the project is $325 million. When you look at carrying costs for the loan, and the delay in realizing income from adding at least another six weeks to the project, you've cost me a lot more than you've saved. It's a lesson he never forgot.

(Of course, the same principles hold true today, and SpeedCore is today's highest-profile example. If you haven't heard about this fantastic system, check out **aisc.org/speedcore**. Using SpeedCore won't save you money in terms of material or fabrication; in fact, you may pay a small premium. But the time savings, both in terms of lower financing costs and quicker occupancy, make it a no-brainer. How much time do you save? SpeedCore shaved *eight months* off the construction schedule on its inaugural project!)

Constructability is a theme that runs through a lot of Jim's stories. I'm not sure how often I've heard him stress that least weight is *not* least cost, that collaboration between the building team is key to successfully completing projects, and that personal relationships matter most. For Jim, constructability is closely tied to engineering judgment. As prominent designer Bill LeMessurier told Jim over a bottle of scotch one night, "If you can't design a building on the back of an envelope, you shouldn't design it." Or as Jim says, "You've got to understand the structure."

Over the years, Jim has given nearly 100 lectures for AISC. I hope you'll join us in Atlanta for his capstone presentation.

Scott Melnick
Editor


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

# steel interchange

*All referenced AISC publications, unless noted otherwise, refer to the current version and are available at* ***aisc.org/specifications****.* Modern Steel Construction *articles can be found in the Archives section at* ***www.modernsteel.com****, and AISC Design Guides are available at* ***aisc.org/dg****.*

## Gusset Plate Edge Stiffeners

**What is the reason that a plate stiffener would be required, as shown in Figure 1?**

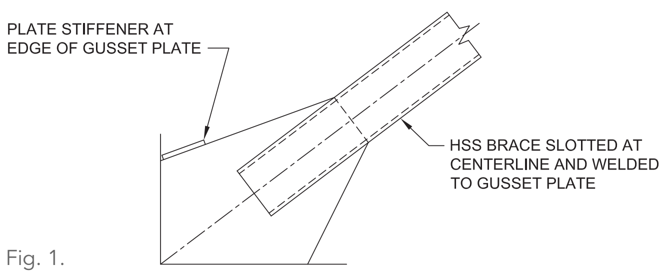


Fig. 1.

While stiffening the edge of a gusset plate is often not required, there are sometimes special conditions. If the engineer needs to determine the free-edge buckling strength of the gusset, they can consult the guidance provided in AISC Design Guide 29: *Vertical Bracing Conditions—Analysis and Design*. Note that the first edition of the AISC *Seismic Design Manual* recommended stiffening the edge of a gusset plate when the unsupported length exceeds $0.75t(E/F_y)^{1/2}$. However, recent experimental results showed that edge stiffeners do not enhance the seismic performance of gusset plates. In the current 2016 AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341) there is no limitation on the free edge length of gusset plates.

The Commentary to Section F2.6c states: "Certain references suggest limiting the free edge length of gusset plates, including SCBF brace-to-beam connection design examples in the *Seismic Design Manual*, (AISC, 2006), and other references (the IBC *Structural/Seismic Design Manual*, *Volume 3: Building Design Examples for Steel and Concrete* and *Seismic Detailing of Gusset Plates for Special Concentrically Braced Frames*, *Steel Tips* from the Structural Steel Educational Council). However, the committee has reviewed the testing cited and has concluded that such edge stiffeners do not offer any advantages in gusset plate behavior. There is, therefore, no limitation on edge dimensions in these provisions."

*Bo Dowswell, PE, PhD*

## Purchasing Agents and Tension-Control Bolts

**I am a purchasing agent for a fabricator and had a question about ordering bolts for slip-critical connections. Is the use of tension control bolts required by the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) for slip-critical connections?**

No. The *RCSC Specification for Structural Joints Using High-Strength Bolts* includes several bolt installation methods that can be used with bolts required to be installed to the slip-critical condition other than tension-control (TC) bolts. The proper designation for a TC bolt is F3125 Grade F1852 or Grade F2180. The Grade F1825 bolts are Group A bolts, which have the equivalent strength of Grade A325 bolts while Grade F2180 bolts are Group B bolts, which have the equivalent strength of Grade A490 bolts.

Even though AISC (and RCSC) does not require the use of TC bolts, there may be project-specific requirements that do. Also, erection bids may assume a particular tensioning method, and if the bolts purchased are not consistent with these assumptions, there may be cost and schedule impacts. So this may not be a decision you want to make on your own. It is always best to check with all parties involved with the project before making any decisions on the type of bolts to use.

*Larry Muir, PE*

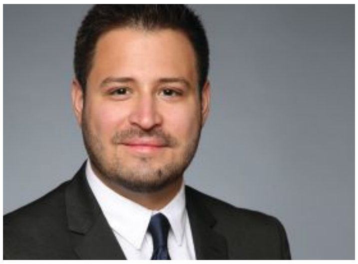
## Beam to Round HSS Clamp Connection

**Can a steel-beam-to-round-HSS shear connection be accomplished with a bolted clamp (similar to a pipe clamp)?**

While theoretically possible (as evidenced by similar connections on signage), I'm not aware of any manufacturers who have conducted the tests needed to determine the usability of their products for this application. Section A1 of the AISC *Specification* states: "Where conditions are not covered by this *Specification*, designs are permitted to be based on tests or analysis, subject to the approval of the authority having jurisdiction. Alternative methods of analysis and design are permitted, provided such alternative methods or criteria are acceptable to the authority having jurisdiction."

Having been involved in the development of pretensioning procedures for bolted joints and design provisions for slip-critical connections, I imagine that developing such design procedures would be complex and would require the inclusion of significant factors of safety. This might tend to make the connections uneconomical or impractical relative to other options.

*Larry Muir, PE*



**Jonathan Tavarez** (**tavarez@aisc.org**) is a staff engineer with AISC's Steel Solutions Center. **Bo Dowswell**, principal with ARC International, LLC, and **Larry Muir** are both consultants to AISC.

## Turn-of-Nut and Pre-Installation Verification

**The May 2015 SteelWise article "The Nuts and Bolts of Nuts and Bolts" indicates that pre-installation verification is required for all pretensioned joints, and this seems to align with RCSC *Specification* Section 8.2. However, Section 8.2.1 for turn-of-nut makes no mention of pre-installation verification, but Section 8.2.2 does for calibrated wrench pretensioning. What is the purpose of pre-installation verification when turn-of-nut is to be used?**

The discussion of the pre-installation verification in Section 8.2 applies to all four pretensioning methods in 8.2.1, through 8.2.4:

"A pretension that is equal to or greater than the value in Table 8.1 shall be provided. The pre-installation verification procedures specified in Section 7 shall be performed using fastener assemblies that are representative of the condition of those that will be pretensioned in the work.

Pre-installation testing shall be performed for each fastener assembly lot prior to the use of that assembly lot in the work. The testing shall be done at the start of the work. For calibrated wrench pretensioning, this testing shall be performed daily for the calibration of the installation wrench."

The pre-installation verification is mentioned again in Section 8.2.2 because it is required to be performed daily for calibrated wrench pretensioning specifically. Note that Section 9.2.1 states regarding turn-of-nut pretensioning: "The inspector shall observe the pre-installation verification testing required in Section 8.2." Also, note that AISC *Specification* Section N5.6(a) states that inspection of pre-installation verification (required as an observe task in Table N5.6-1) is not applicable only, to snug-tightened joints. Pre-installation verification would be required for pretensioned and slip-critical joints regardless of the method used to pretension the bolt.

The purpose of pre-installation verification is described in the Commentary for Section 7.2, which states: "Pre-installation verification testing provides a practical means for ensuring that non-conforming fastener assemblies are not incorporated into the work... Additionally, pre-installation verification testing clarifies for the bolting crew and the inspector the proper implementation of the selected pretensioning method and the adequacy of the installation equipment. It will also identify potential sources of problems, such as the need for lubrication to prevent failure of bolts by combined high torque with tension, under-strength assemblies resulting from excessive over-tapping of hot-dip galvanized nuts or other failures to meet strength or geometry requirements of applicable ASTM specifications."

*Jonathan Tavarez, PE*

## Bracing Columns with Skewed Beams

**I have a building where some of the beams attach to columns at a 45° angle. Is there any guidance available that addresses using a skewed beam to brace a column?**

If the beam is restrained axially and properly connected to the column, it will likely provide lateral bracing to the column. The column can be assumed braced about both principal axes at the location of a skewed lateral brace. However, the column can buckle about an axis parallel to the brace. For example, consider a 30-ft column with a skewed beam bracing it at the mid-height. The column strength should be analyzed about both principal axes over an unbraced length of 15 ft. Additionally, the column strength should be analyzed about the axis parallel to the brace over an unbraced length of 30 ft. The section properties for the skewed axis can be calculated using the equations in Table 17-27 on page 17-43 of the AISC *Manual*. The strength and stiffness requirements for the brace (the beam, in your case) are in Appendix 6 of the *Specification*.

*Bo Dowswell, PE, PhD*

STEEL SOLUTIONS CENTER

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# steel quiz

This month's Steel Quiz is comprised of reader submissions in response to our Halloween-themed online quiz (see the October 28 Steel in the News item at **modernsteel.com/news**). Thank you to all who sent in questions!

1 **True or False:** All threaded components of a base plate fastener assembly (anchor rod) should be galvanized by the same process.

2 If a steel member is rolled out of Grade A572 Grade 50, which steel shape series does it likely belong to?
**a.** S (American standard beams)
**b.** HP (H-Piles)
**c.** W (Wide-flanges)
**d.** HSS (Hollow structural sections)

3 **True or False:** In a building with steel moment frames, using lighter column sections is cheaper than using heavier column sections that eliminate the need for web doubler plates and stiffeners.

4 What is the maximum difference between any two stair riser heights allowed by the *International Building Code (IBC)* on a single flight for dimensional uniformity?

5 What chemical element differentiates stainless steel and structural carbon steel, and what is the minimum percentage?

6 What is the required strength of end and intermediate column point braces?
**a.** $0.02P_r$
**b.** $0.01P_r$
**c.** $0.001P_r$
**d.** $0.04P_r$

7 Do fabrication errors always need to be repaired?

8 **True or False:** The engineer of record (EOR) can override negative results of an inspection of a weld that does not meet AWS D1.1 requirements.

TURN TO PAGE 14 FOR THE ANSWERS


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# steel quiz ANSWERS

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**.

1 **True.** Design Guide 1: *Base Plate and Anchor Rod Design* states, in Section 2.5: "Mixing of rods galvanized by one process and nuts by another may result in an unworkable assembly. It is recommended that galvanized anchor rods and nuts be purchased from the same supplier and shipped preassembled. Because this is not an ASTM requirement, this should be specified on the contract documents." *Submitted by Tiffany Rowan.*

2 **b.** HP (H-Piles). Table 2.4 in the 15th Edition AISC *Steel Construction Manual* (**aisc.org/manual**) lists ASTM A572 Grade 50 as the preferred material for HP shapes, but it is also available for other shapes as well. Availability should be confirmed with fabricators and producers before specification. For more information, see the April 2018 article "Are You Properly Specifying Materials?" (**www.modernsteel.com**). *Submitted by Hector Ocon, Army Corps of Engineers.*

3 **False.** Fabrication costs for stiffeners and web doubler plates are typically greater than using a heavier column. Consider using heavier columns to eliminate any web doubler plates and stiffeners at moment connections. A good tool to help you evaluate the elimination of stiffeners and web doubler plates is Clean Columns (a free download at **steeltools.org/column.php**). *Submitted by Marshall Abrahamson, Ericksen Roed and Associates.*

4 $\frac{3}{8}$ in. Table 3-8 of Design Guide 34: *Steel-Framed Stairway Design* indicates that *IBC* 2015 Section 1011.5.4 requires a $\frac{3}{8}$ in. variation in tread depth or riser height within a stair flight. Note that requirements must be verified with the local authority having jurisdiction, and OSHA 1910.25(b)(3) requires that treads and risers shall have uniform heights between landings. *Submitted by Austin Dowell, Snyder Engineering.*

5 Stainless steel contains a minimum of 10.5% chromium, which is explained in Design Guide 27: *Structural Stainless Steel*. *Submitted by Austin Dowell, Snyder Engineering.*

6 **b.** *AISC Specification for Structural Steel Buildings* (ANSI/AISC 360, **aisc.org/specifications**) Appendix 6 provides bracing provisions and specifies a required strength of $0.01P_r$ for point bracing, where $P_r$ is the largest of the required axial strengths of the column within the unbraced lengths adjacent to the point brace using LRFD or ASD load combinations. *Submitted by Kyle Manweiler, Walter P Moore.*

7 **No.** Sometimes inaccuracies due to human error do not need to be altered. There are instances when holes punched in the wrong spot or beams cut to the wrong length can be easily repaired, but other times a "repair" may cause more harm than good. The structural EOR on the job should be consulted to determine if a repair is absolutely required and the method to complete the repair. Coordination with the fabricator is also necessary to determine feasibility. *Submitted by Lauren Fallon, EN Engineering.*

8 **True.** AWS D1.1 states the following in Section 6.8: "The fundamental premise of the code is to provide general stipulations applicable to most situations. Acceptance criteria for production welds different from those described in the code may be used for a particular application, provided they are suitably documented by the proposer and approved by the Engineer. These alternate acceptance criteria may be based upon evaluation of suitability for service using past experience, experimental evidence or engineering analysis considering material type, service load effects, and environmental factors." *Submitted by Tom Miller, Mound Technologies, Inc.*

All AISC Design Guides referenced in the answers can be found at **aisc.org/dg**.

steelwise

# EXPLORING STRENGTH

BY LOUIS F. GESCHWINDNER, PE, PHD

Thoughts on determining the strength of built-up flexural members.

**Lou Geschwindner** (**lfg@psu.edu**) is professor emeritus, Architectural Engineering, at Penn State, a senior consultant with Providence Engineering Corp., a former vice president of engineering and research with AISC, and the current Chair of the AISC Task Committee on Member Design of the Committee on Specifications.

**A FLEXURAL MEMBER'S STRENGTH** is directly related to its shape.

Built-up flexural members are made by combining shapes and plates in such a way that they work together as a single member. If these members are formed from several plates into an I-shape, either doubly or singly symmetric, they are generally referred to as plate girders. If they are formed by combining shapes, they are called built-up members.

When it comes to determining flexural strength for plate girders, the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360, **aisc.org/specifications**) addresses the strength of these flexural members in Sections F3, F4, and F5 (see the "Plate Girders in the *Spec*" sidebar for more information).

For built-up members, the applicable provisions of Chapter F of the *Specification* will need to be applied to determine the flexural strength. The limit states to be considered are the same as those considered for all flexural members, yielding, local buckling, and lateral torsional buckling. Which of these limit states must actually be calculated will depend on the elements that make up the final shape and which sections of Chapter F are applicable.

Let's consider some examples of built-up flexural members. The first is made up of two channels (channels are addressed in Section F2 of Chapter F). These channels can be combined in several ways as illustrated in Figure 1. Figure 1a shows back-to-back in direct contact, Figure 1b illustrates back-to-back with a gap, and Figure 1c shows toe-to-toe. Since all C-shapes are known to be compact, and combining them will not make them non-compact, then the local buckling limit states will not need to be addressed further. The limit state of yielding for two individual channels is also the upper limit for the built-up member, so the only limit state that could possibly be improved by combining these members is that of lateral-torsional buckling. By combining these two channels in such a way that they must work together, they may be treated as an I-shape—again, addressed in Section F2. The weak-axis stiffness will be greater than that of the single C-shape and thus, the lateral-torsional buckling strength will

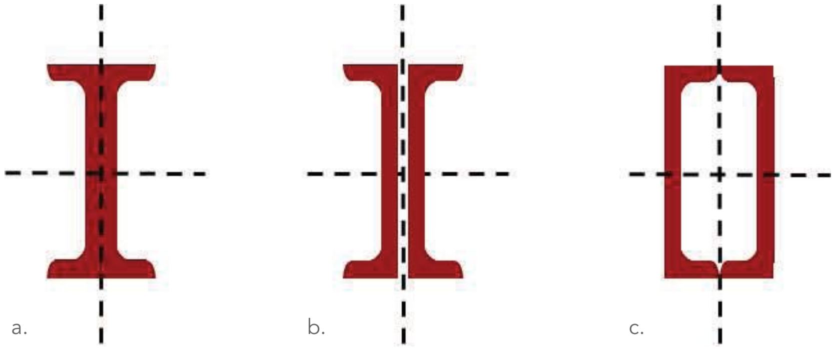



Fig. 1. A built-up flexural member using channels.

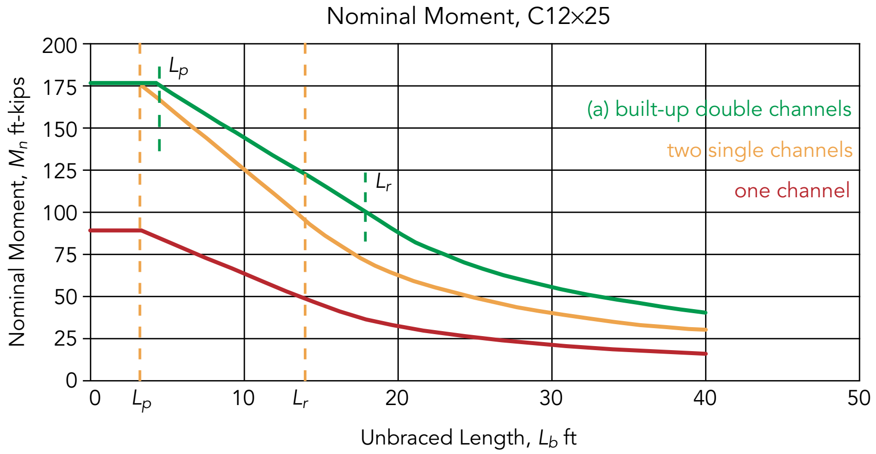



Fig. 2. Flexural strength of two channels.

increase; Figure 2 illustrates how the lateral-torsional buckling strength increases for the C12×25 channels for an unbraced length greater that 3.24 ft. If the gap between the channels is increased, the weak axis stiffness increases and the corresponding lateral-torsional buckling strength increases.

If the channels are combined toe-to-toe they form a rectangle, as illustrated in Figure 1c. Upon first glance it would appear that Section F7 would now apply to the built-up member; this section addresses square and rectangular HSS and box-sections. However, the definition of a box-section requires that it be made with four plates, quite unlike the double channel. As with the other arrangements of these channels, the only limit state that might benefit from this arrangement is lateral-torsional buckling. Although Section F2 does not specifically address this shape, there is a user note that provides the critical buckling moment strength for doubly symmetric members. Using this and other provisions in Section F2, it can be shown that the limit state of lateral-torsional buckling for this closed rectangle does not reduce the strength of the member significantly below the yield strength. Figure 3 adds the curves for the nominal moment strength of the built-up member back-to-back with a gap, the shape illustrated in Figure 1b, and toe-to-toe, the shape illustrated in Figure 1c, to that of the two channels in contact.

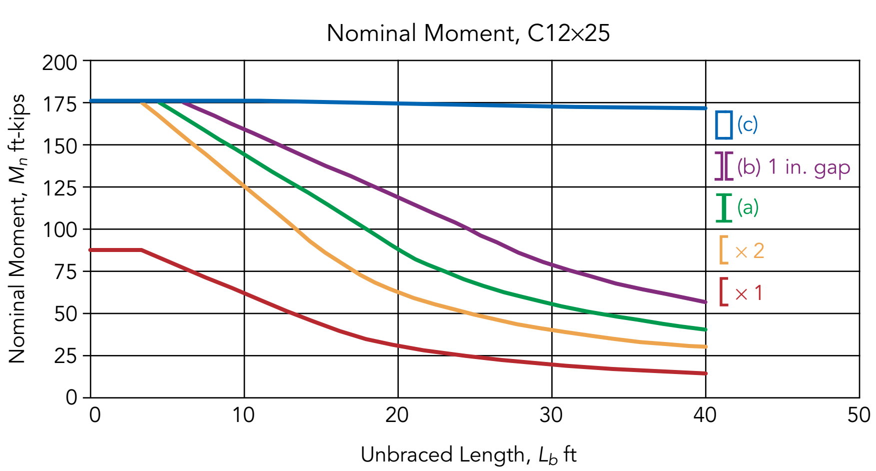



Fig. 3. Flexural strength for built-up channel members.

## Plate Girders in the *Spec*

Prior to 2005, the AISC *Specification for Structural Steel Buildings* had separate chapters with "Plate Girders" in the title, and these provisions were generally enforced for members within a specific web slenderness range. Starting with the 2005 *Specification*, the specific reference to plate girders was removed and the appropriate provisions for flexure included in Sections F3, F4, and F5, with shear provisions being included in Chapter G. Also since 2005, the provisions for built-up beams have been included in Section F13.4. In the 2016 version of the *Specification*, Section F13.4 reads:

"Where two or more beams or channels are used side-by-side to form a flexural member, they shall be connected together in compliance with Section E6.2. When concentrated loads are carried from one beam to another or distributed between the beams, diaphragms having sufficient stiffness to distribute the load shall be welded or bolted between beams."

The reference to Section E6.2 is to the chapter on compression—specifically, the subsection addressing dimensional requirements within the section on built-up members. All of these dimensional requirements are intended to force the combined elements to work together as a single member. Thus, like the requirements that apply to plate girders, there is nothing specifically included to address the strength of built-up flexural members.

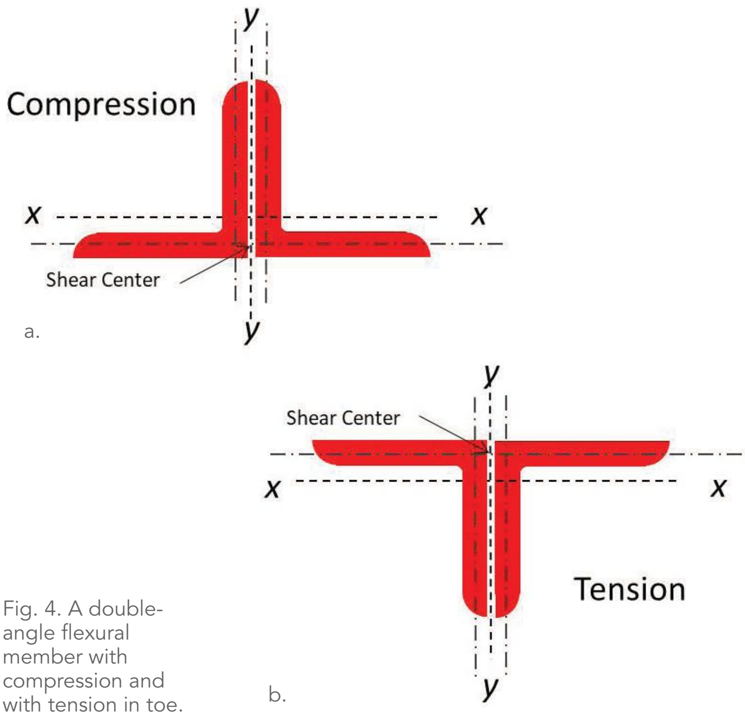



Fig. 4. A double-angle flexural member with compression and with tension in toe.

Another built-up flexural member that could be considered is the double-angle member. These built-up members are specifically addressed in Section F9, along with tees; Figure 4 illustrates the two possibilities for the double-angle flexural member addressed in the *Specification*. Figure 4a shows a double-angle member with the web legs in compression and Figure 4b shows the web legs in tension, for a simple beam with gravity load. In this example, the limit states of yielding, local buckling, and lateral-torsional buckling must be addressed, and the expectation is that the double-angle flexural member will have more strength than two single angles. But this is not always the case and is dependent on the controlling limit state.

A third form of built-up flexural member is the crane rail girder. These flexural members are built-up from a W-shape and a channel cap. Since they are not composed of two or more beams or channels used side-by-side, Section F13.4 does not apply. Another difference between the crane rail girder and the previous built-up members discussed is that this flexural member is usually loaded both vertically and horizontally;

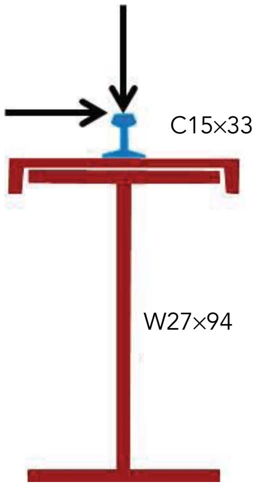



Fig. 5. A crane rail girder.

Figure 5 illustrates the shape of a crane rail girder, and AISC *Steel Construction Manual* Table 1-19 (**aisc.org/manual**) provides properties for a selection of W-shapes with cap channels. As with the other built-up members addressed, the limit states of yielding, local buckling, and lateral-torsional buckling must be addressed. The flexural strength for this type of built-up member will be determined through either Section F4 or F5, depending on the slenderness of the W-shape web.

In addition, the lateral load must be considered. The usual approach for addressing this load is by determining the flexural strength of the compression flange with cap channel bending about the y-axis for the limit state of yielding. Then, the interaction equation from Section H1.1 is used to determine if the member has sufficient strength for biaxial bending.

These are just three examples of how to investigate strength for specific types of built-up flexural members. When it comes to determining the strength of any built-up flexural member, the key is determining which provisions of Chapter F to follow. In addition to the strength calculations, for any built-up member, designers must be sure to provide for sufficient connectivity so that the members work together as one. ■

*This information will be covered in the presentation "Designing Built-Up Flexural Members" at the 2020 NASCC: The Steel Conference in Atlanta, April 22–24. For more information, visit* ***aisc.org/nascc****.*

# CLARIFY THE QUEST

BY DAN COUGHLIN

## The Actions of Leadership, Part One: Starting your organization's quest off on the right foot.

Since 1998, **Dan Coughlin** has equipped business leaders to consistently deliver excellence in management, leadership, and teamwork. Visit his Business Performance Idea Center at **www.thecoughlincompany.com**.

**LEADERS DISTINGUISH THEMSELVES** by their actions—not by their titles, income, gender, race, size, or personality type.

Leaders share certain actions in common. It is through their actions that they emerge as leaders. In the first of a three-part series called "The Actions of Leadership," we'll focus on specific actions you can take to influence a group of people to achieve something truly remarkable. Let's begin by clarifying the quest you want your group to undertake.

### Fulfilling Your Purpose

A quest is a journey to prove yourself capable of fulfilling your purpose.

If you expand that to a group of people or to an entire organization or an entire society, then a quest becomes a journey to mutually prove yourselves capable of fulfilling the group's, the organization's, or society's purpose.

Before establishing a plan or writing something or organizing a meeting, the first step is to clarify the quest. The leader might be the one who states it for the first time, or it might be someone from within the group that states it first—or it even might be someone from outside the group who states it first. It doesn't matter who establishes the quest. The key is that it is clear for everyone to understand.

Without a clear quest the words become just rhetoric. The efforts as a group become meaningless. The focus becomes diluted. And nothing really gets accomplished. The individuals don't know why they are together, and they don't how they are going to accomplish anything meaningful. It becomes a social group and then eventually disperses.

### Quest Questions to Answer

There are two essential questions to answer:

1. What meaningful purpose are we trying to fulfill?
2. What is the journey that we need to go in order to fulfill that purpose?

Whether the leader comes up with the answers or someone else does is not the important thing. The important thing is that the quest has to be clear. The answers to those two questions need to be clear.

Once these answers are clear, the leader can begin to influence the group in many important ways toward being successful on the quest. (We will focus on those actions in later articles.) However, without a clear quest, there is nothing for a leader to do.

### Not All Quests Are Created Equal

Some quests bring out remarkable efforts and passions from people, and some are meaningless duds. You need a purpose that really resonates with people. It has to hit them right between the eyes and deep into their hearts.

And then you have to describe the journey that people are going to have to go on to fulfill that purpose. Do not sugarcoat the journey. If the purpose is great enough, people will go on almost any journey. If the purpose is meaningless, people won't get off the couch.

The first action of the leader is to keep clarifying a remarkably important purpose and the journey it will take to fulfill that purpose.

**If the purpose is great enough, people will go on almost any journey.**

## What's Your Quest?

Now let's make this as real and as relevant as we can.

In your work, what quest are you on? What is the purpose you want to fulfill, and what is the journey that you and your team members need to go on to fulfill that purpose?

Is this purpose so meaningful and so relevant to your group that it is willing to go on the journey that is required to get there?

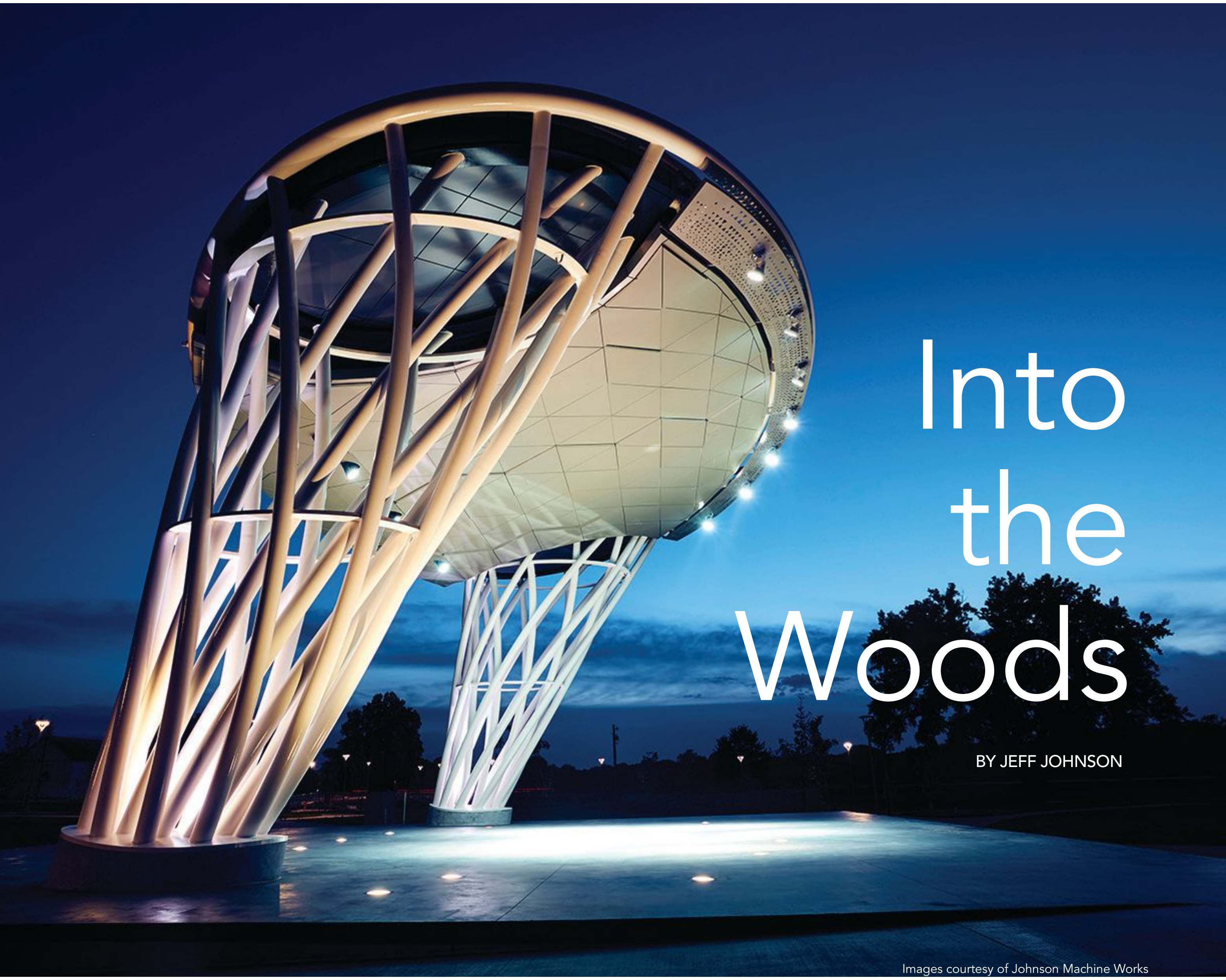
That's it. Don't overcomplicate this step. Talk with your team members, people throughout your organization, your customers, and your prospects. Find out what people are really thinking and feeling.

Take out a sheet of paper and write down the incredible purpose that you want fulfilled. Talk about it with people. See if it resonates. Keep honing it. Make it something truly noble.

And then talk about the journey—what it's going to take to fulfill that purpose.

Stay tuned for Part Two of the Actions of Leadership series, coming next month. ■

Curving steel trees frame a new outdoor performance space in Des Moines.



# Into the Woods

BY JEFF JOHNSON

Images courtesy of Johnson Machine Works

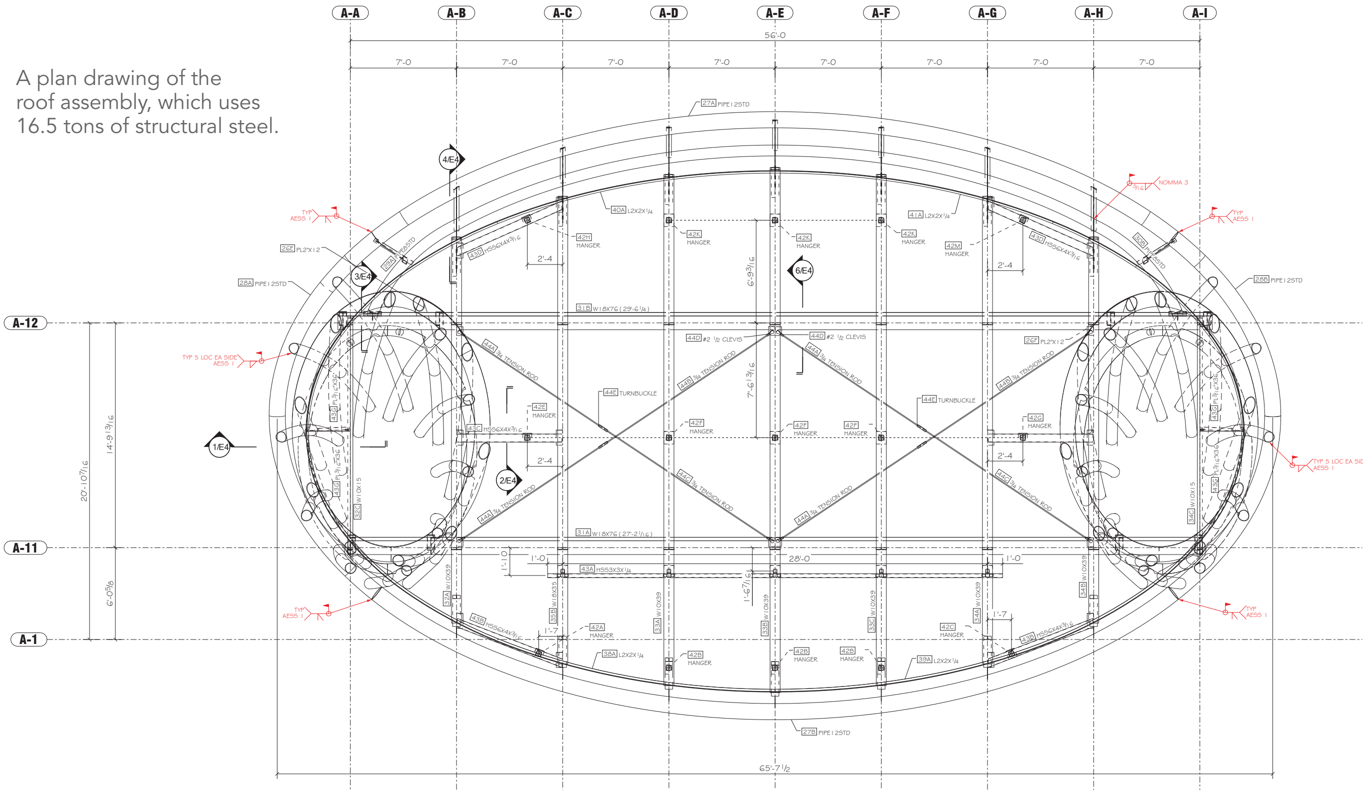
**Jeff Johnson** (jjohnson@jmworks.com) is the CEO of Johnson Machine Works, Inc.

**THERE IS MUSIC** between the trees in Water Works Park.

Hugging the bank of Raccoon River near downtown Des Moines, the 1,500-acre riverside woodland area is one of the country's largest urban parks, an outdoor oasis in the heart of the city.

In an effort to bring more residents and visitors to the park, the Water Works Park Foundation embarked on a plan to develop an underused flood-prone space alongside a mature arboretum. The focal point is the steel-framed Lauridsen Amphitheater, an outdoor stage flanked by two woven steel "trees."

Designed by architect RDG, the complex, curved steel columns are a natural response to the local environment, inspired by the form of an oak tree. "RDG was charged to provide a flood-resilient, dual-sided amphitheater structure that would primarily stand as a folly in the park for the everyday experience, but then transform as an armature to hold equipment for




A plan drawing of the roof assembly, which uses 16.5 tons of structural steel.

musical performances ranging in size—small performances facing south and medium to large performances positioned facing north," said Tyler Jessen, lead architect with RGD. "The structure needed to take on a sculptural form that was both iconic and responding to the contextual backdrop of a wooded park."

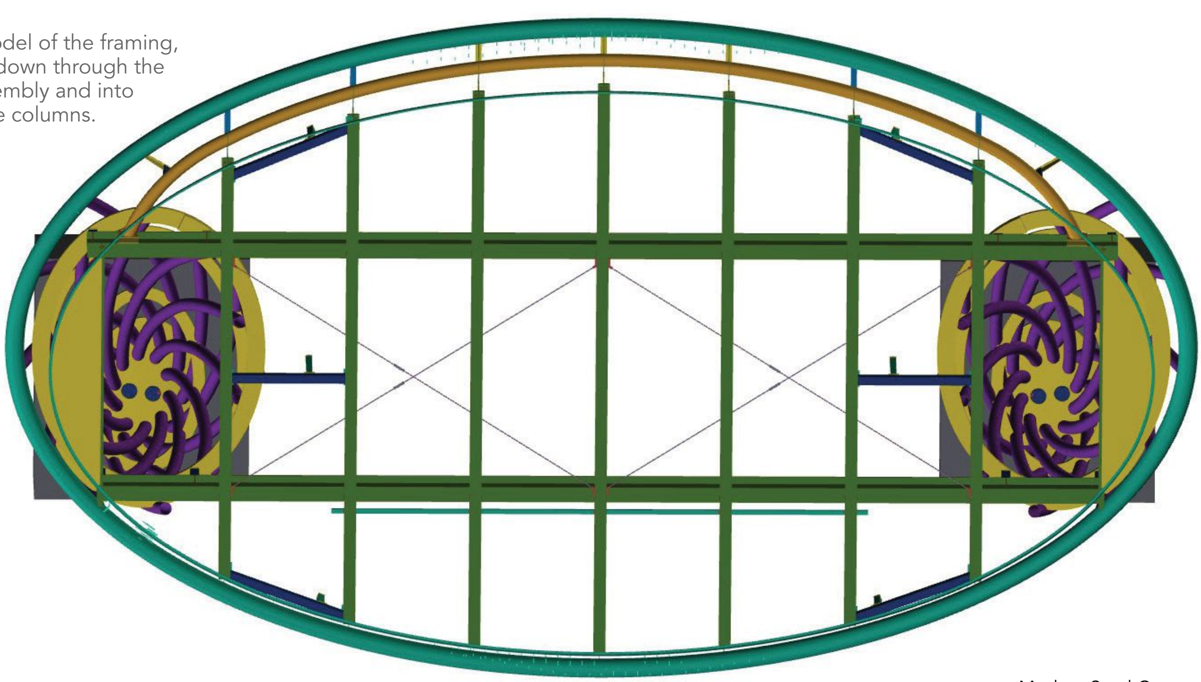
## Complex Trees

The two main column assemblies, or "tree limb cloisters," are each comprised of 20 8-in.-diameter hollow structural section (HSS) columns that twist from a concrete pier base to support a canopy clad with aluminum composite material (ACM). Each column assembly weighs approximately 13.5 tons.

The canopy, in layers.

1 BLACK STANDING SEAM ROOF
2 PAINTED 12" DIA STEEL PIPE
3 CANOPY STEEL FRAMING
4 ALUMINUM COMPOSITE CANOPY
5 PAINTED STEEL COLUMN
6 CAST-IN-PLACE CONCRETE BASE
7 LED COLOR CHANGING LIGHTS

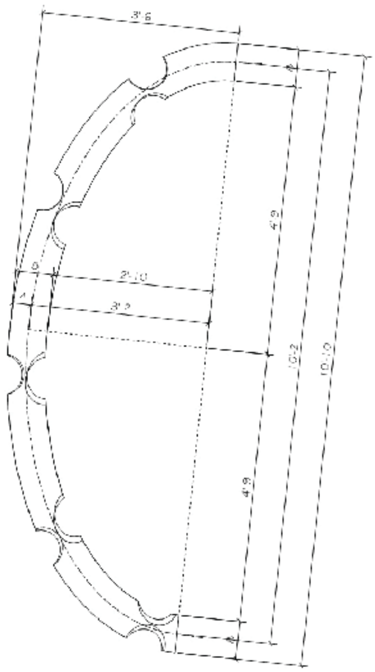
A 3D model of the framing, looking down through the roof assembly and into both tree columns.



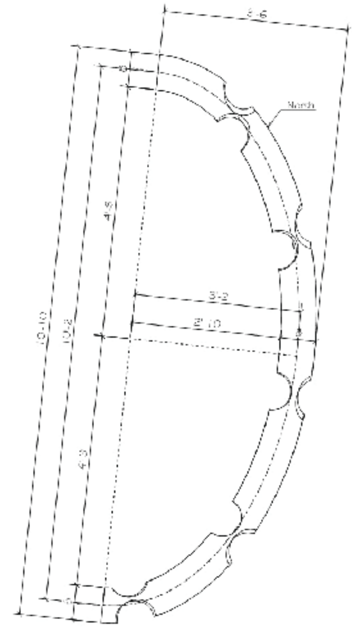
above and right: The complex, curved steel column assemblies are a natural response to the local environment, inspired by the form of an oak tree. Each weighs 13.5 tons.

"The helical, canted nature of the columns presented unique challenges for the engineering model," explained Justin Dahlberg with the project's structural engineer, Saul Engineering (now KPFF). "Base connections with overturning moments necessitated an adequate amount of steel but without compromising the design aesthetic."

As the steel fabricator, Johnson Machine Works (JMW) coordinated with general contractor Henkel Construction to fabricate and erect the large rolled shapes to achieve the tight tolerances of the round HSS, which were designated as architecturally exposed structural steel (AESS)—specifically, AESS Category 1—from the bottom of the assembly up to the bottom side of the lower ring, which is just under 13 ft above the stage floor. (Category 1 is the minimum treatment of



1 ~ PLATE RING ~ 24A



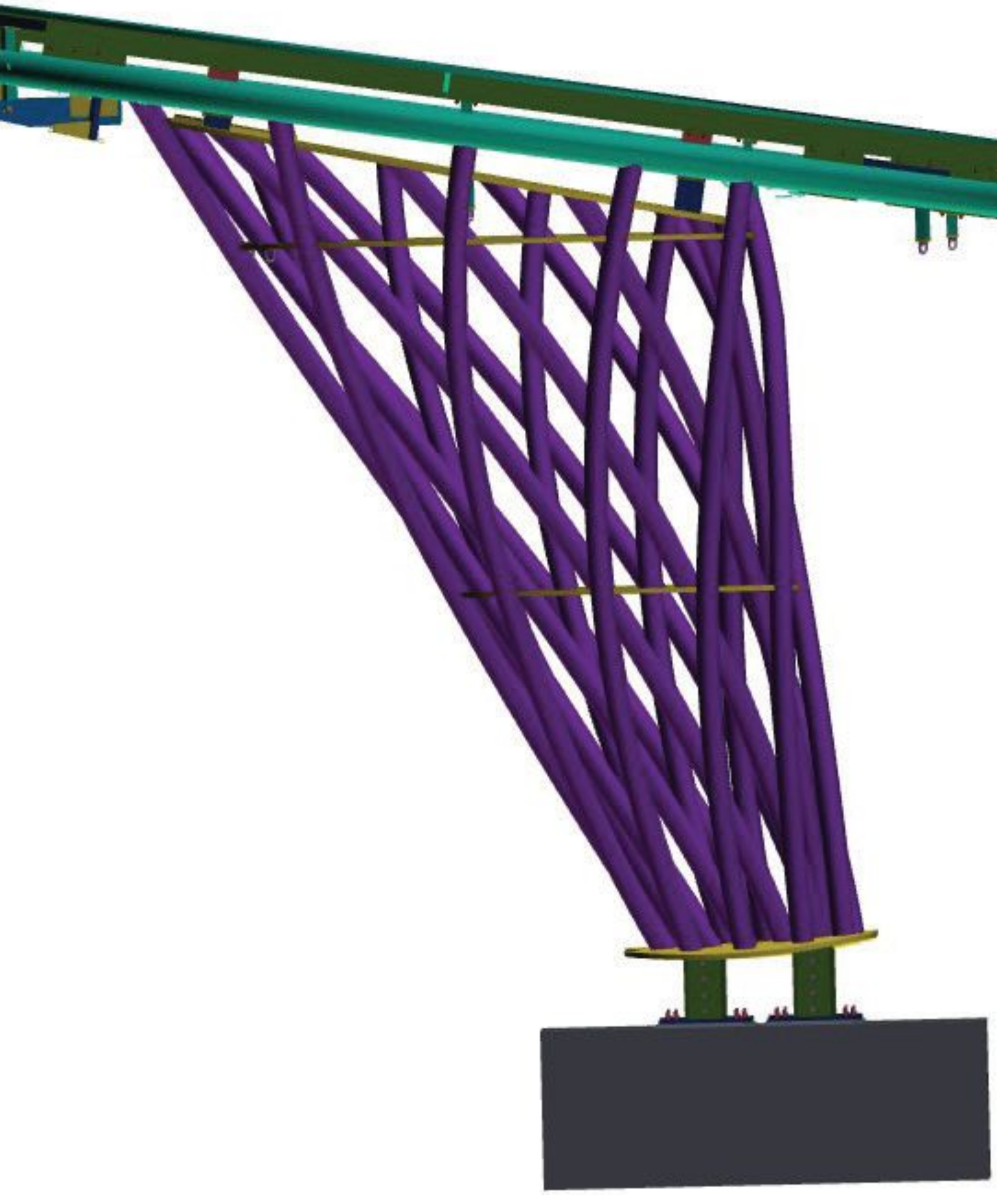
1 ~ PLATE RING ~ 24B

exposed steel beyond standard fabrication of structural steel. (For more on the various AISC AESS levels, see "Maximum Exposure" in the November 2017 issue, available at **www.modernsteel.com**.) JMW applied a PPG Coraflon ADS zinc-rich epoxy primer to the steel in the shop, and Coraflon ADS Epoxy Intermediate Primer and Coraflon ADS Intermix coats were applied in the field.

The spiral columns are held together with rings at three locations. The rings are 2-in.-thick plate, each made from two pieces.

right: The column assemblies being fit up in Johnson Machine Works' shop.

below: Each row was offset to allow the HSS—curved by bender-roller Chicago Metal Rolled Products—to spiral in opposite directions while bypassing each other without intersecting each other.



The 20 HSS columns of each tree are divided into two oval circles of ten, one inside the other, with no two columns being exactly the same. Each row was offset to allow these sections—curved by bender-roller Chicago Metal Rolled Products (CMRP)—to spiral in opposite directions while bypassing each other without intersecting each other. Each column was detailed in three sections, all with their own radius and rotation point.

The spiral columns are held together with rings at three locations. The rings are 2-in.-thick plate, each made from two pieces. JMW created these rings from flat plates that were notched in order to perfectly match the gentle transition of the inner and outer HSS as they rise and cant from their more compact base. Upon receiving the curved sections from CMRP, JMW welded them to their respective baseplate and steel rings. The 2-in. baseplates have two W-shape "stools" welded to them such that the baseplate sits on anchor bolts—1¼ in. in diameter and 1 ft, 10 in. long. The baseplates also have several anchor plates with rebar running through them, and rebar also runs through the webs of the stools. The stools and rebar were cast in concrete from the bottom of the 2-in. plate to the footing.

Topping the two woven tree column assemblies is a canopy roof structure weighing approximately 16.5 tons, comprised of W18×76, W18×35, and W10×39 beams and tension rods. In addition, 12-in. and 8-in. round HSS create another ring around the roof structure as an architectural feature.

above: Transporting the bottom half of one of the tree column assemblies to the site.

below: The bottom portions of the assemblies were fabricated to AESS Category 1 requirements.

## Growing Together

JMW and KPFF worked together on multiple design changes to facilitate smoother fabrication and installation, including altering the anchor scheme. Originally, the 2-in. baseplates were to have precast concrete section under them, with the HSS columns field-welded to the plate. But thanks to assembling the column trees and plate in the shop, field welding was avoided. The 2-in. plate rings were also a design change suggested by JMW. The rings were originally designed to be HSS with "knuckle plate" connections at each location where an HSS column penetrated a ring. The plate scheme drastically reduced the amount of fabrication and welding required for each ring and allowed for a two-component ring instead of a multiple-component HSS and bent-plate ring.

Jason Knipp, project manager with Henkel Construction, managed weather delays and job site challenges to pull the entire project together. Due it its location on a floodplain, the job site was underwater a couple times and a lot of soil was washed away at one point—though luckily the stage site itself was never underwater. Knipp also worked with JMW to modify the precast foundation to cast-in-place in order to provide a more economical and efficient foundation for the amphitheater. The coordination between the two companies also led to other enhancements regarding constructability. For example, the columns were fully erected in JMW's fabrication facility, as was the entire roof structure. Thanks to this extensive preassembly work, erection in the field was smooth and without delay. The erection team was able to unload

Due it its location on a floodplain, the job site was underwater a couple times during construction, and a lot of soil was washed away at one point—though luckily the stage site itself was never underwater.

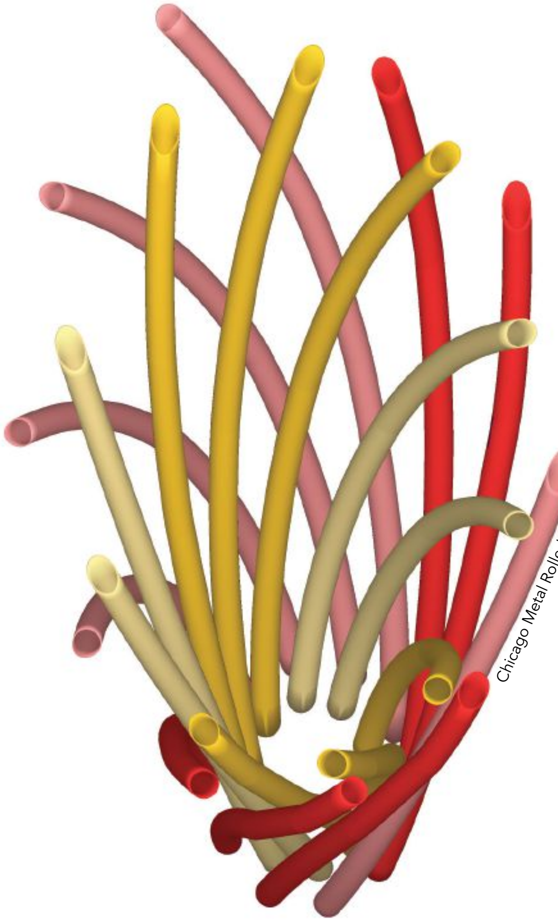
## All the Right Angles

Curving one member is difficult. Curving 20 members that rotate in proximity to one another—half of them twisting one way and the others spiraling in the opposite direction—presents a whole other level of complexity.

When presented with drawings from Johnson Machine Works, our first order of business was to obtain a full-scale model of the amphitheater to determine proper radii for twisted columns and pipe segments, then create our own in-house 3D models to generate shop instructions. Each of the 20 lengths of 8.625×0.325 HSS that form one woven column was unique; no two were of the exact same geometry. Luckily, the 20 HSS forming the second column assembly were a mirror image of the ones forming first column assembly.

Once we generated our 3D model, we were able to extract data for all 40 twisted HSS columns to draw 40 unique 2D templates used for checking each column after it was rolled. These templates allowed our experienced bending machine operator to mark a column and position it onto the template in such a way that all data points required to pass inspection were hit. We completed this complex project of rolled elliptical segments without having to turn *any* material into scrap metal.

—Laurel P. Chavez,
Project Manager and CAD Engineer,
Chicago Metal Rolled Products



Chicago Metal Rolled Products

The Water Works Park Foundation embarked on a plan to develop an underused flood-prone space alongside a mature arboretum.

the column assemblies from the truck and set them right in place—again, with no field welding required. The roof was also shop-assembled and delivered in three sections, also facilitating simpler erection.

Since opening to the public in the summer of 2019, the amphitheater has already hosted several concerts and civic events. Jessen's hope was to have visitor's initial reaction to the structure be one of awe and wonder when approached from all angles. Through the purposeful partnership between architect, engineer, contractor, and fabricator, the structure indeed inspires awe and wonder, creating a stage that is more than just a stage, that blends in beautifully and becomes one with its natural surroundings. ■

**Owner**
Water Works Park Foundation, Des Moines

**General Contractor**
Henkel Construction, Ames, Iowa

**Architect**
RDG Planning and Design, Des Moines

**Structural Engineer**
KPFF (formerly Saul Engineering), Des Moines

**Steel Team**

**Fabricator and Detailer**
Johnson Machine Works, Inc., Chariton, Iowa (AISC Certified Fabricator)

**Erector**
Northwest Steel Erection, Inc., Grimes, Iowa (AISC Associate; AISC Certified Erector)

**Bender-Roller**
Chicago Metal Rolled Products, Chicago (AISC Associate)

# Wild Blue Yonder

BY MATTHEW J. AQUINO, SE, PE, AND KEVIN HAVENS, AIA

Paul Schlismann Photography

An exposed long-span truss system illustrates and supports a Chicago area university's aviation history.

**LEWIS UNIVERSITY'S** Brother James Gaffney, FSC Student Center is designed to project an image of a contemporary, forward-thinking university—while at the same time looking back reverently at its aviation history.

Named for the university's president emeritus, the focal point of the structural steel building is an 80-ft by 70-ft clear-span exposed steel framed roof over the main dining hall. The unique structural design pays tribute to the Romeoville, Illinois-based university's rich aviation and aeronautics heritage. Evoking the spirit of a high-bay aircraft hangar, the roof framing incorporates a series of custom long-span steel trusses, which mimic the cable-and-strut construction of vintage airplanes—and actually suspends an acrobatic biplane over the dining hall.

The 25,000-sq.-ft building features a 2.5-story glass atrium, a full-service kitchen, a main dining hall, a student lounge, a 24-hour convenience store/café, student government and campus organization offices, a cultural center, a gaming/arcade area, and outdoor terraces. The structure is cut into the natural slope of the site, with the north end partially below grade while the south end is completely above. The resulting unbalanced earth pressures on the structure were transferred by rigid steel diaphragms at the first and second floors and are resolved through perimeter concrete shear


Wight & Company

above and opposite page: The focal point of the Brother James Gaffney, FSC, Student Center at Lewis University is an 80-ft by 70-ft clear span exposed steel framed roof over the main dining hall. The intent is to evoke the spirit of a high-bay aircraft hangar, and the roof framing actually suspends an acrobatic biplane.

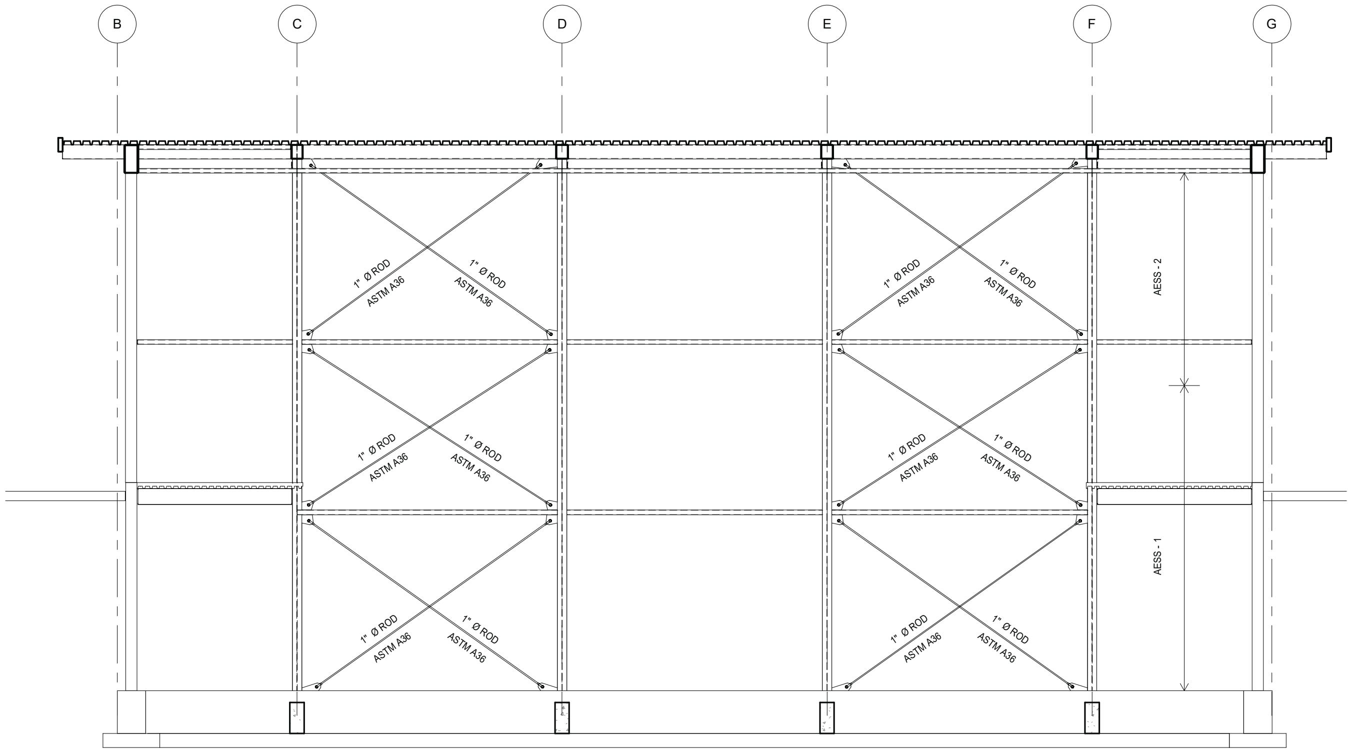
walls. The steel columns and concrete bearing walls are supported by footing foundations at frost depth and standard slab-on-grade construction, and a series of planter retaining walls flank the east and west sides of the building, bringing a beautiful landscape aesthetic to the base of the structure.

Steel framing (nearly 150 tons in all), assisted by CMU walls, supports the floor and roof structures and provide the lateral wind, seismic, and earth load resistance. The second-floor steel framing is composed of steel beams and girders supporting a composite steel deck slab, with steel moment frames providing gravity and lateral load support. The southern façade is an unobstructed glass curtain wall with structural steel-framed backup and diagonal rod bracing for lateral resistance. The curtain wall exposes a steel-framed stairwell that splits into two segments as it rises between the first and second floors.

The steel trusses supporting the roof consist of hollow structural section (HSS) top chord and vertical elements, and steel rod diagonals and bottom chord. The use of high-strength steel rods (105-ksi yield strength) resulted in smaller elements (¾-in.-diameter diagonals and 1½-in.-diameter bottom chords) and reduced the overall truss depth, giving an extremely thin profile consistent with the design aesthetic. The truss connections used curved profile gusset plates and all-welded shop connections to meet the design aesthetic.

The truss top chords extend through the building's southern curtain wall and frame a large overhang extending 26 ft. Four exposed HSS columns provide additional overhang support, are sloped 10°, and incorporate Cast Connex forged steel castings to provide a taper-and-pin connection at the top and bottom of each column.

**Matthew J. Aquino** (**maquino@wightco.com**) is vice president, director of building engineering, and **Kevin Havens** (**khavens@wightco.com**) is executive vice president, director of design, both at Wight & Company.




above and below: The southern façade is an unobstructed glass curtain wall with structural steel-framed backup and diagonal rod bracing for lateral resistance.

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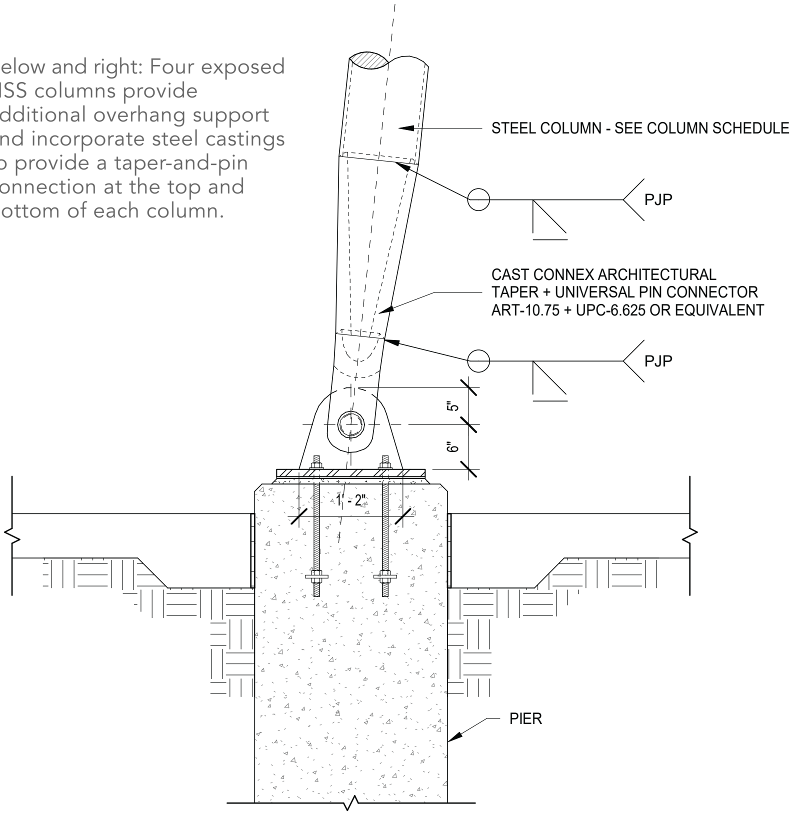
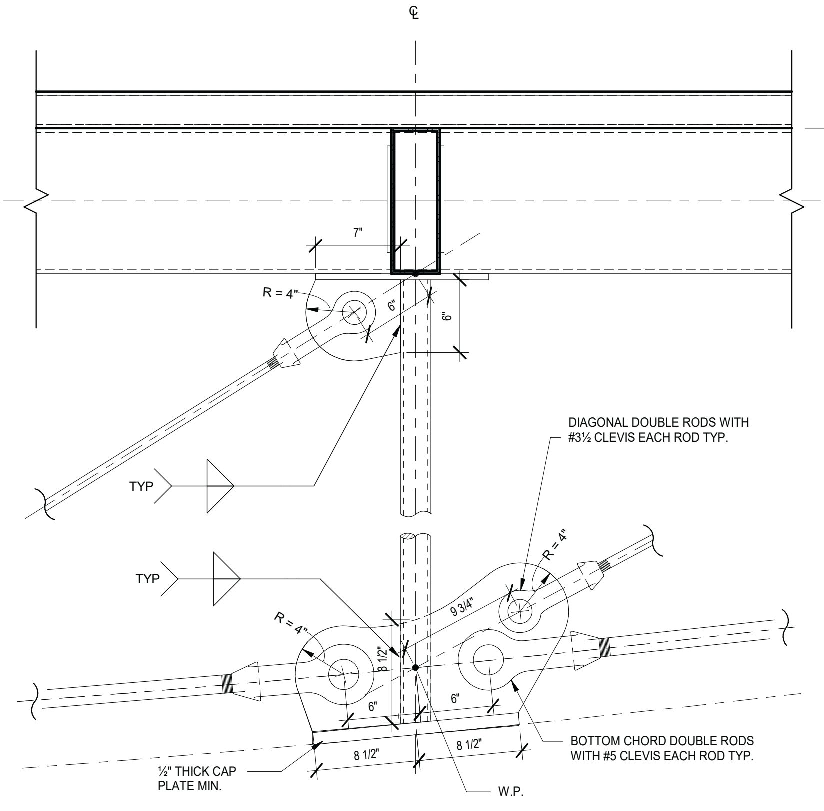
To further emphasize the inherent structural expression of the building, the design team fully exposed the entire steel structure including floor framing, roof framing, steel decking, steel columns, and the ornamental stair. Architecturally exposed structural steel (AESS) requirements were adhered to for many these elements, resulting in a smooth and continuous structure free of imperfections and visible joints—e.g., AESS Category 3 was employed for columns from the base to 20 ft above grade, Category 2 was applied for the remaining height of the columns, and Category 1 was used for the exposed roof framing. (For more on the various AISC AESS levels, see “Maximum Exposure” in the November 2017 issue, available below and right: Four exposed HSS columns provide additional overhang support and incorporate steel castings to provide a taper-and-pin connection at the top and bottom of each column.




NOTE: 1. DIAMETER OF PIN 2¾". DIAMETER OF PIN HOLE NOT MORE THAN 1/32" LARGER THAN PIN
2. INDICATED STEEL FRAMING AND CONNECTIONS SHALL MEET THE REQUIREMENTS OF AESS-1



above, right, and below: Using high-strength steel rods for the roof trusses resulted in smaller elements and reduced the overall truss depth. The truss connections also used curved profile gusset plates and all-welded shop connections to meet the design aesthetic.



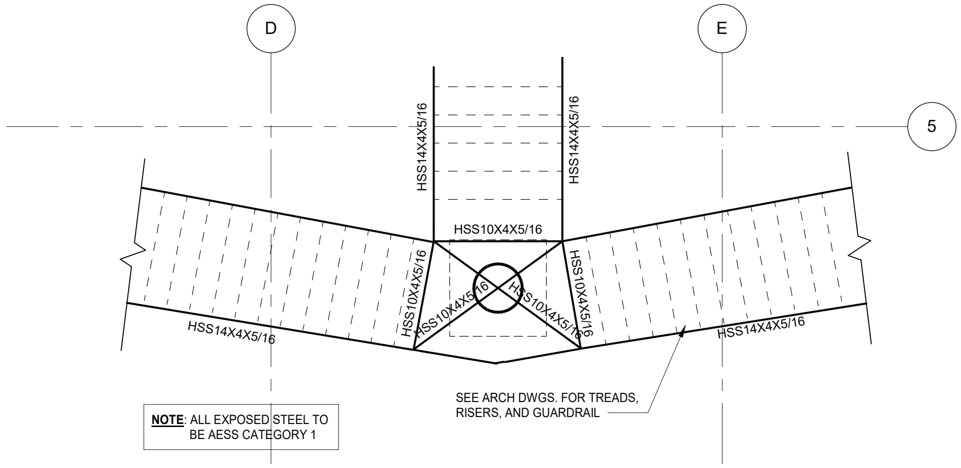

at **www.modernsteel.com**.) The holistic design approach of a fully exposed steel structure provided the engineers with a creative opportunity to incorporate a unique roof framing system while working within the overall project aesthetic and acknowledging the school's legacy.

When it came to steel erection, delivery was the biggest challenge. The four roof trusses, each 94 ft long and weighing almost 3.5 tons apiece, were all loaded on one truck. Due to the excessive length, the truck could only drive on certain routes and at certain times. As the truck was not permitted to drive through campus with an extended trailer, the construction team had to coordinate with an airport adjacent to the university to stage the trusses before they could be brought to the site, which required temporary closure of some streets and parking areas as they were delivered.

Wight & Company, implementing a design-led, design-build, integrated delivery approach, was responsible as the architect, construction manager, and structural engineer for the project. The company worked directly with steel fab-

Paul Schlismann Photography

above and below: The curtain wall exposes a steel-framed stairwell that splits into two segments as it rises between the first and second floors.




below: The 25,000-sq.-ft building features a full-service kitchen, a main dining hall, a student lounge, a 24-hour convenience store/café, student government and campus organization offices, and other student spaces.

Paul Schlismann Photography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6. **Beam The Easy Way (Y-Y Axis)** — MEAN DIA. — 44" x 335#, 36" x 925#
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13. **Tee Stem Up** — MEAN DIA. — 22" x 142 $^1/_2$# 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 $^1/_2$" Tube
18. **Rectangular Tube The Easy Way (Y-Y Axis)** — INSIDE DIA. — 20" x 12" x $^5/_8$" Tube
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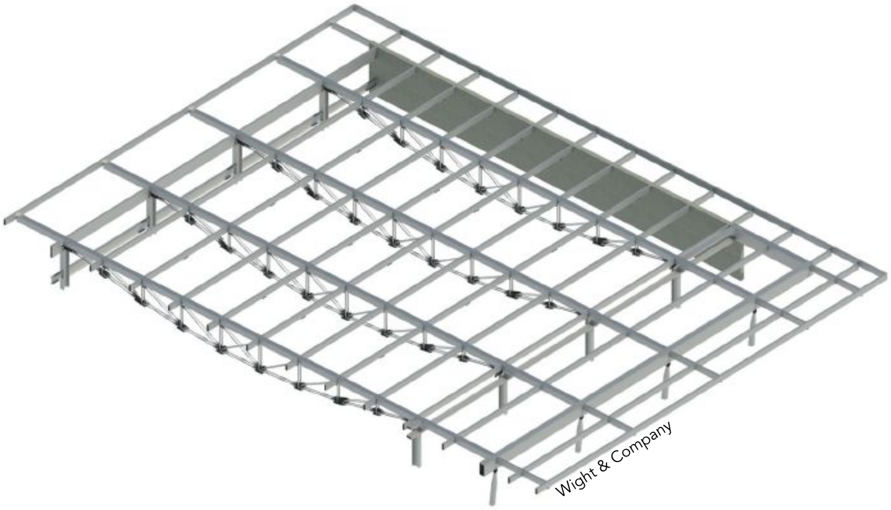
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above, left, and below: Roof framing trusses—shown in the shop, in a 3D model, and installed—were designed to invoke the cable-and-strut construction of vintage airplanes.


Wight & Company

ricator Affordable Welding to ensure that fabrication and construction were executed to a high standard of quality in keeping with the design intent. Continuous constructability reviews during the design phase promoted the project's striking aesthetics while producing a cost-efficient building. The interdisciplinary approach enabled Wight to provide a guaranteed maximum price at an early stage of design, reducing risk for the university.

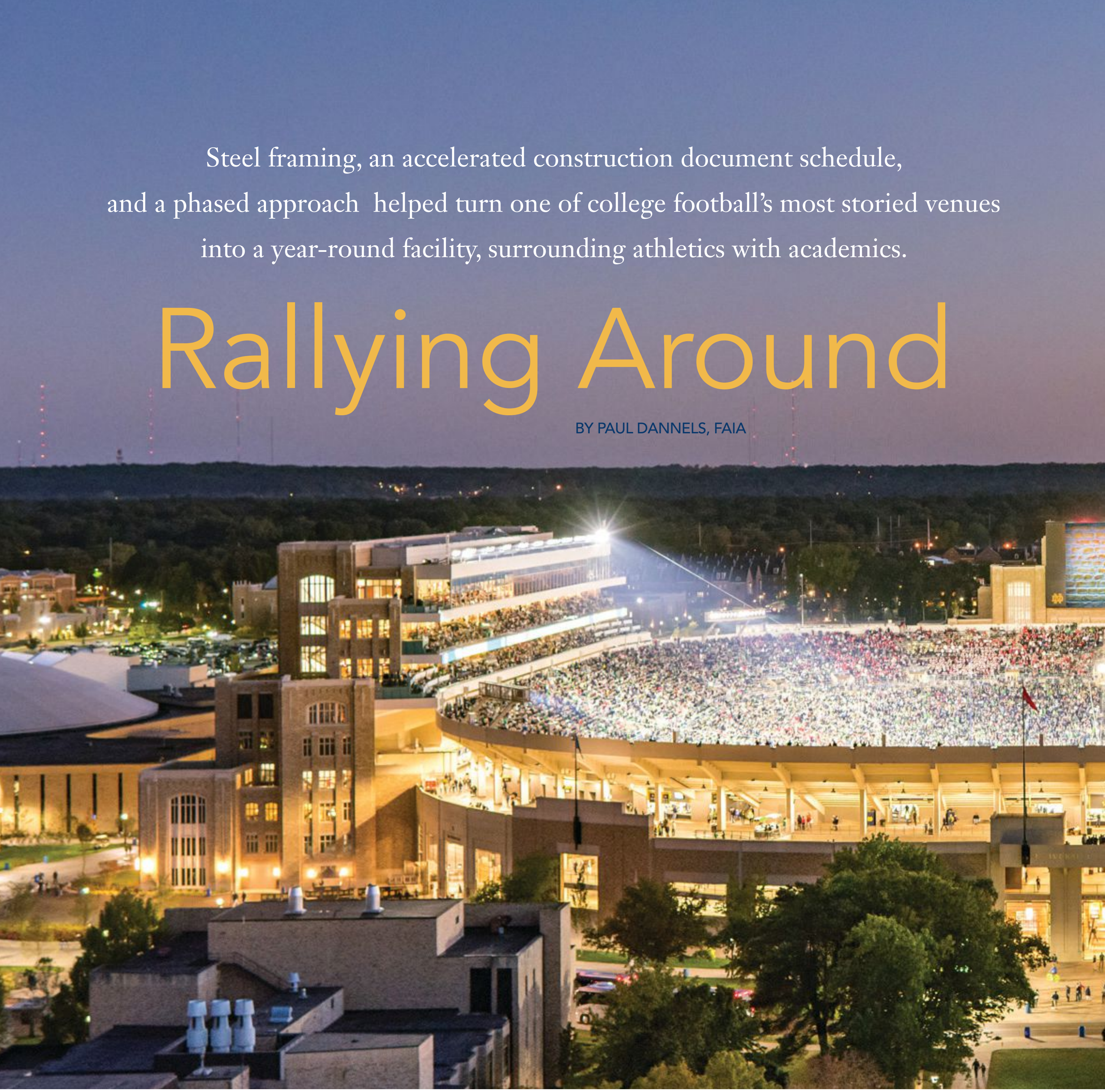
The project team's careful attention to programming, architectural design, and engineering integration became a reflection of Lewis University's flagship aviation program. As a result, the school now has a facility that brings a unique human experience that has been embraced by the administration, staff, and students. ■

**Owner**
Lewis University, Romeoville, Ill.

**Construction Manager, Architect, and Structural Engineer**
Wight & Company, Chicago

**Connection Designer (HSS)**
FORSE Consulting, Chicago

**Steel Fabricator and Detailer**
Affordable Welding US, Chicago



Steel framing, an accelerated construction document schedule, and a phased approach helped turn one of college football's most storied venues into a year-round facility, surrounding athletics with academics.

# Rallying Around

BY PAUL DANNELS, FAIA

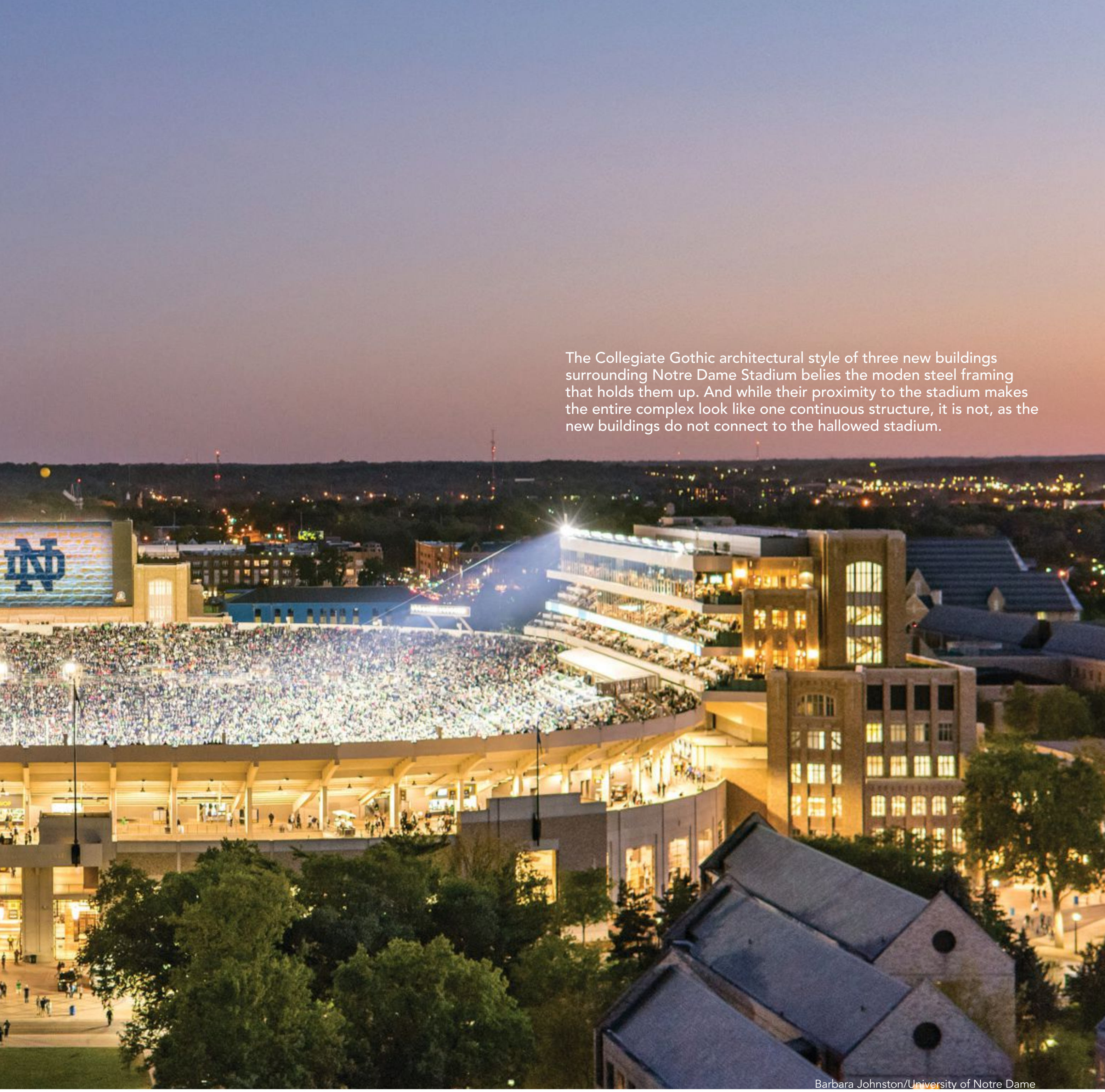
**Paul Dannels** (paul@sdistructures.com) is an architect with SDI Structures.

**FOR MANY FOOTBALL** fanatics, Notre Dame Stadium is a cathedral to the game.

The University of Notre Dame Fighting Irish football team has a long and storied past, and to many their home field holds a certain mystique.

But university leadership recognized a paradox associated with the iconic stadium. Whereas the structure was central to both the geography of the campus and the identity of the university, it was unfortunately fully used only a few days each year. So why not make it a facility that could serve the school year-round? This was the impetus of the $400 million Campus Crossroads project, the most ambitious construction program in the history of the school, which has transformed the stadium into a center for academics and student life.

The resulting facilities added 800,000 sq. ft of new classroom, research, media, performance, meeting, event, and hospitality space, as well as numerous academic, cultural, and student life functions, into a complex of spaces surrounding the storied football stadium.



The Collegiate Gothic architectural style of three new buildings surrounding Notre Dame Stadium belies the moden steel framing that holds them up. And while their proximity to the stadium makes the entire complex look like one continuous structure, it is not, as the new buildings do not connect to the hallowed stadium.

Barbara Johnston/University of Notre Dame

The new academic buildings were built along three sides of the stadium and were specifically designed not to connect to the historic structure. Along the west side, the nine-story Duncan Student Center houses student life and recreational facilities. To the south, the seven-story O'Neill Hall is home to the Music Department and the Sacred Music at Notre Dame program. And on the east side, the nine-story Corbett Family Hall contains the anthropology and psychology departments, as well as state-of-the-art media facilities.

Andy Greco, PE, with project engineer SDI Structures worked closely with architects at SLAM to use structural steel to achieve the grand Collegiate Gothic architectural style valued by the university. The layered setbacks of masonry veneer and extensive masonry openings desired by SLAM required a complex system of transfer beams and wind columns to carry gravity and lateral loads. The intricate steel substructure allowed for fast and precise placement as well as confident control of dead load deflections. Steel brick relief angles were provided throughout the project, carrying up to 40-ft-high expanses of masonry.

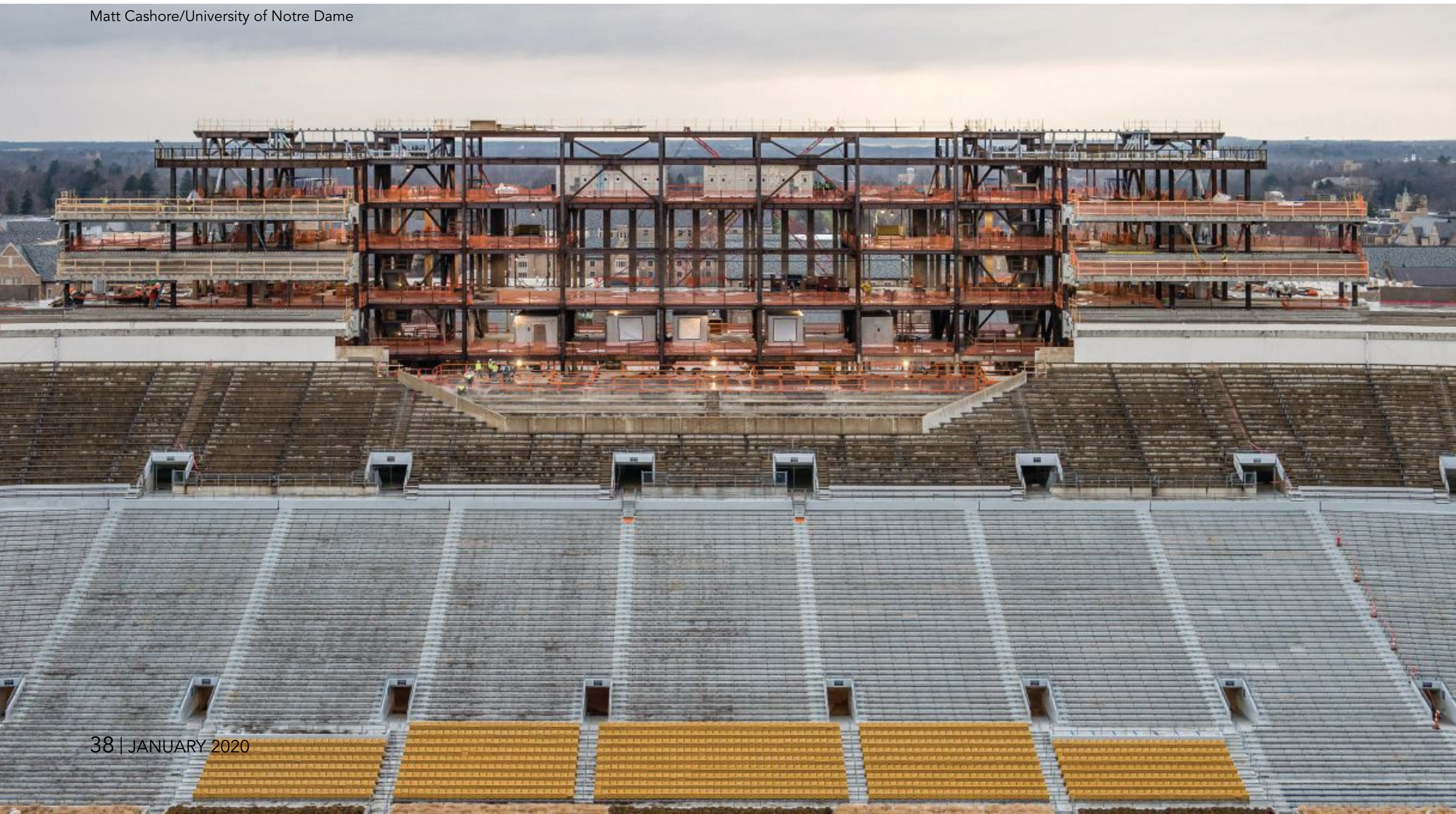
In order to minimize disruption brought to the campus by this massive project, and to keep the construction schedule within the constraints imposed by football schedules, structural steel was used to advance a very complicated structure at a rapid pace. Construction started following the 2014 season and continued in limited areas through the 2015 and 2016 football seasons. Most of the steel erection occurred primarily during the off-season, and the original

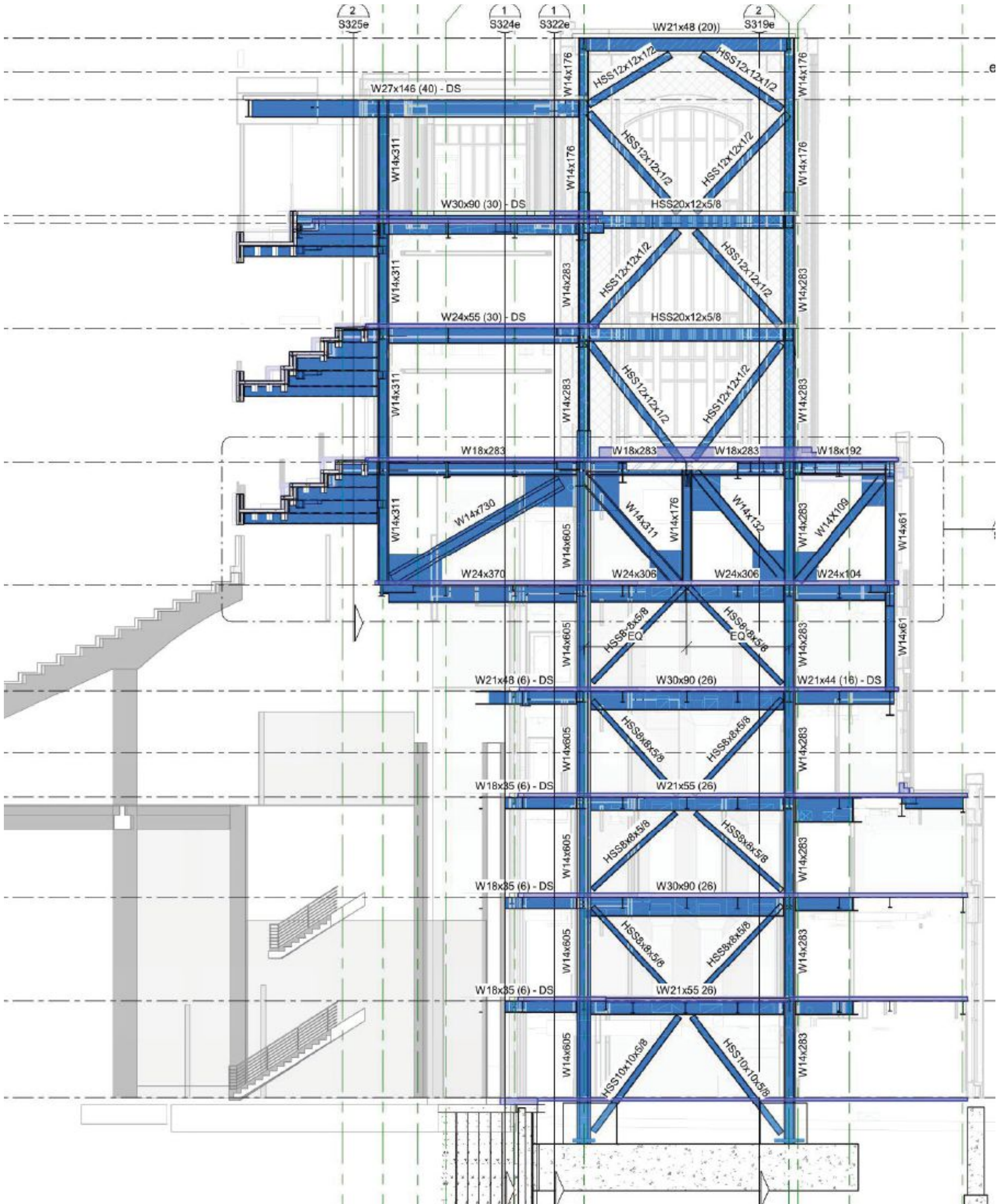

Andy Greco/SDI

below: The original press box was demolished following Notre Dame's final game of the 2016 seaon to allow the new cantilever trusses to take their place.

above and opposite page: Framing for the west building, which uses 6,100 tons of structural steel.

Matt Cashore/University of Notre Dame





SDI

press box stayed in place until completion of the 2016 season when it was immediately demolished to allow the new steel cantilever trusses to take their place.

The project had to be phased due to site access restrictions. The steel for the east and west buildings was fabricated and erected simultaneously, with a slight lag in the start of the west building. Steel for the south building began fabrication while the east and west buildings were under construction, and was erected after these two buildings were substantially complete. Both the east and west buildings feature 14 unique trusses that cantilever 35 ft to 45 ft. As laydown area was limited, the 18-ft-deep trusses were each assembled in fabricator Sippel Steel's shop, shipped in one piece, and delivered direct to hook. Due to crane capacity limitations, the back-span and cantilever sections were delivered split, then joined once they were in place. There were four Manitowoc 2250 cranes on-site with four gangs of ironworkers working ten hours a day, seven days a week to meet the schedule. Even with significant design changes during construction, the team completed the project without interruption of the 2015 season.

The east and west structures, which include skybox suites at the upper levels, incorporate diagonally braced steel frames with full-story-height cantilevers. The steel framing schemes vary significantly from building to building to accommodate the interior programmatic requirements as well as the architectural enclosure, but consist largely of braced frames using hollow structural steel (HSS) diagonal members and trusses built from wide-flange members ranging from W14×109 to W14×730. Structural engineer SDI Structures worked closely with Sippel Steel and detailer BDS to develop connections that met the project budget as well as the fabrication and erection schedule. Collaboration included weekly meetings during the shop drawing preparation phase (many were face-to-face) to overcome

The project had to be fabricated and erected in phases to accommodate the limited laydown area near the stadium.

Andy Greco/SDI

the constructability challenges. Without collaboration between the design team and fabricator on connection typology and consideration of erection constraints, the trusses could not have been installed within the project schedule.

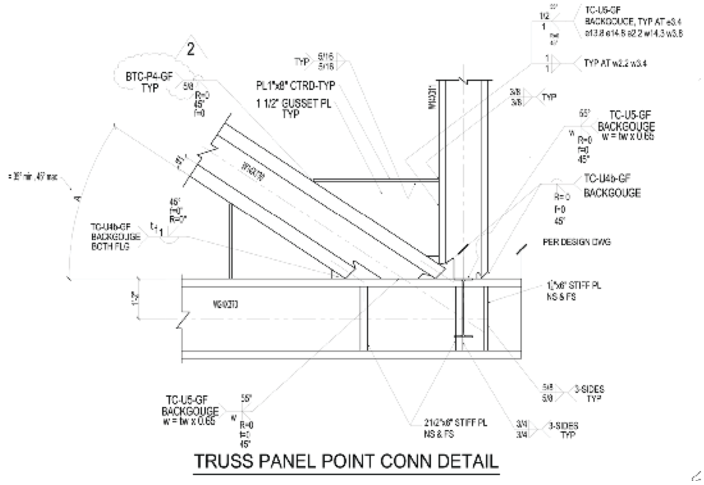
Unbalanced loading created by the cantilevered seating created both member strength design and building serviceability challenges. For this project, the unique nature of sporting events created a situation where the full live load could be expected on the cantilevered structure while fans are watching an event, while little live load would exist on the cantilever back spans. Additionally, to account for further uncertainty in actual loading on the cantilever back spans, superimposed loads were reduced beyond the code-specified load combination values to ensure that realistic uplift and drift values were predicted. The composite floor diaphragms at each level contributed to the overall building drift performance by restraining floor trusses to the braced towers on the north and south ends of the building. To account for variable stiffnesses possible in the floor diaphragms, the analysis models were run using a range of in-plane diaphragm stiffnesses to account for stiffness reductions due to cracking. By enveloping the diaphragm stiffnesses, SDI made certain that the analysis models captured the actual stiffness of the floor diaphragms in the field. Serviceability was also prioritized in the connection styles chosen for the building trusses and frames. Connections were selected to minimize slip and rotation, which might increase building movement beyond the predicted values.

Critical to maintaining the schedule was ensuring that shop drawings were completed during the construction document process. To make this happen, SDI had the nine-story frames of the east and west buildings fully modeled during design development, allowing BDS to work in a Tekla model during the construction document phase while SDI performed connection design concurrently. Steel mill orders were also generated and executed during the construction document portion. As steel shop drawings were sequentially completed, they were sent directly back to SDI—and because SDI was also responsi-

Andy Greco/SDI

Framing for the east building, which incorporates 3,900 tons of structural steel.

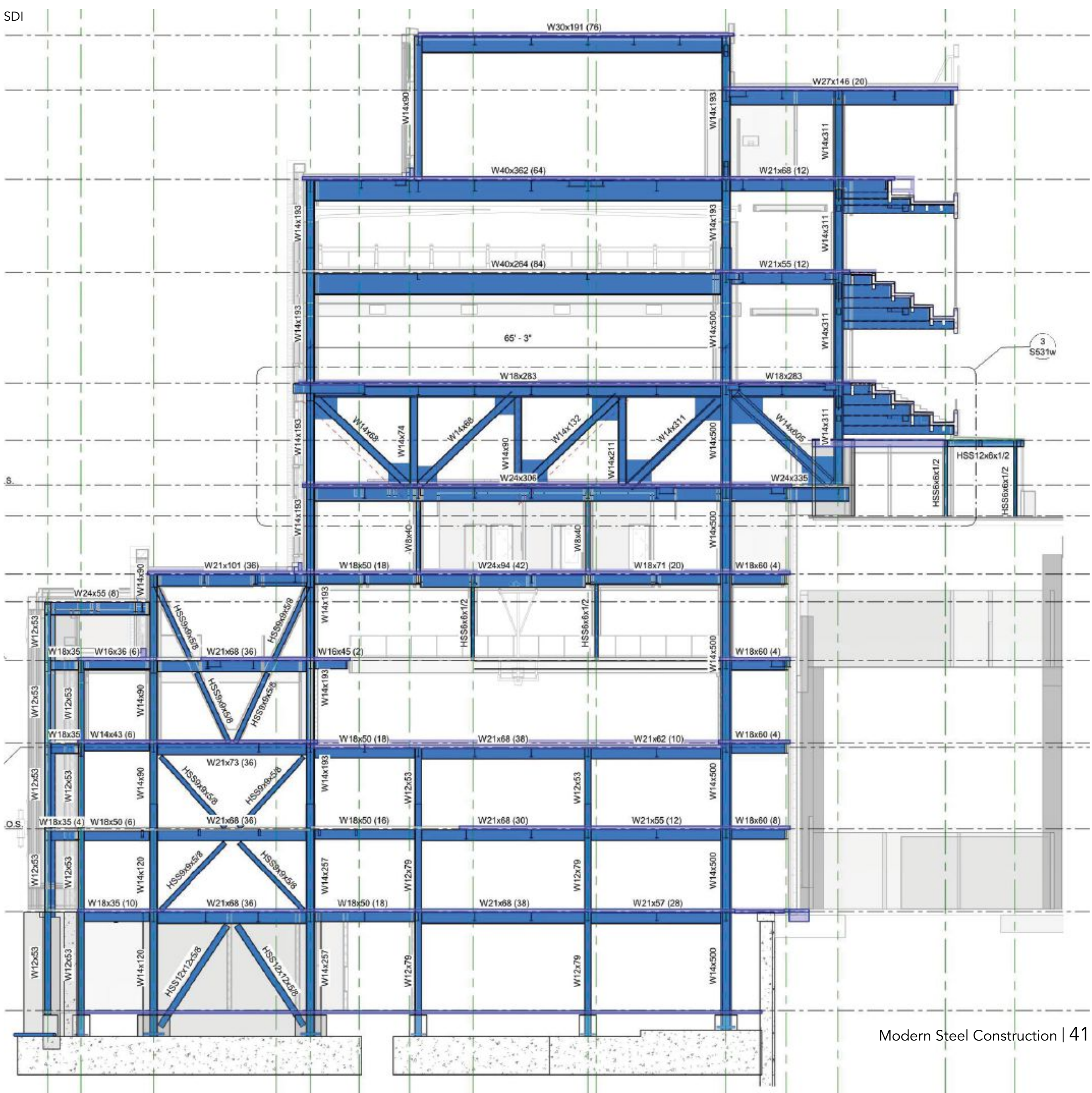

Sippel Steel




left and above: A truss in Sippel Steel's shop and a truss connection detail.

below: Both the east (below) and west buildings feature 14 unique trusses that cantilever 35 ft to 45 ft.

SDI




Robert Benson Photography

Barbara Johnston/University of Notre Dame


Matt Cashore/University of Notre Dame

opposite page and above: The 12,000 tons of steel used for the three buildings was erected over portions of two Notre Dame Fighting Irish football seasons.

ble for connection design, the shop drawings could be reviewed electronically at a rapid pace. For the 12,000 tons of structural steel used on the job (3,900 for the east building, 6,100 for the west building, and 2,000 for the south building) shop drawings were regularly prepared and approved at a rate of 400 to 500 sheets per week. By reassigning traditional responsibilities during the construction document phase, shop drawings were complete, steel was available when it was needed, and fabrication could begin immediately upon completion of the construction documents.

Overall, a team fully committed to the potential benefits of steel framing devised a delivery method that worked within the university's schedule and transformed the way the campus is experienced, not just on game day but throughout the year. ■

**Owner**
University of Notre Dame,
Notre Dame, Ind.

**General Contractor**
Barton Malow, Southfield, Mich.

**Architect**
SLAM Collaborative, Glastonbury, Conn.

**Structural Engineer and Connection Designer**
SDI Structures, Ann Arbor, Mich.

**Steel Team**

**Fabricator**
Sippel Steel Fab, AISC CERTIFIED FABRICATOR
Ambridge, Pa.

**Detailer**
BDS Steel Detailers USA, Inc., AISC DETAILER
Tempe, Ariz.

opposite page: While not technically part of Notre Dame Stadium, the new buildings provide the historic venue with an entirely new look.

# KC Kicks

BY BRIAN LEWIS, PE

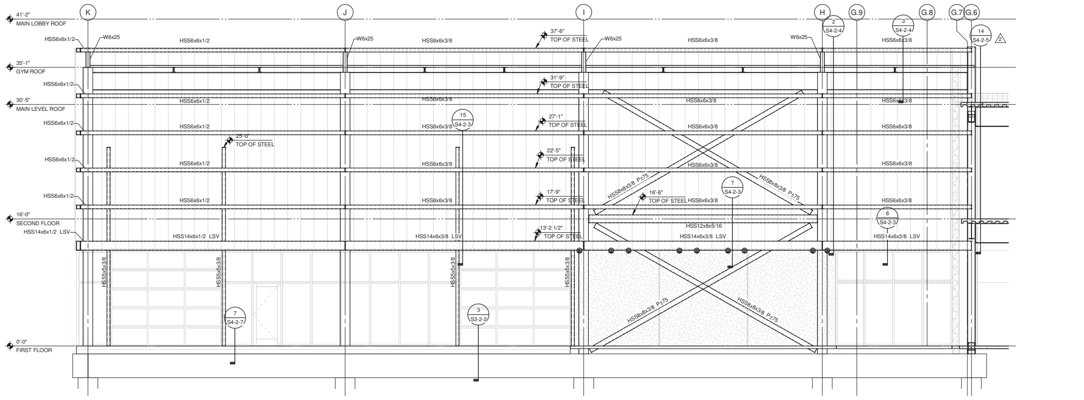
Steel raises the profile of soccer in Kansas City via a new state-of-the-art soccer facility.


Alistair Tutton Photography

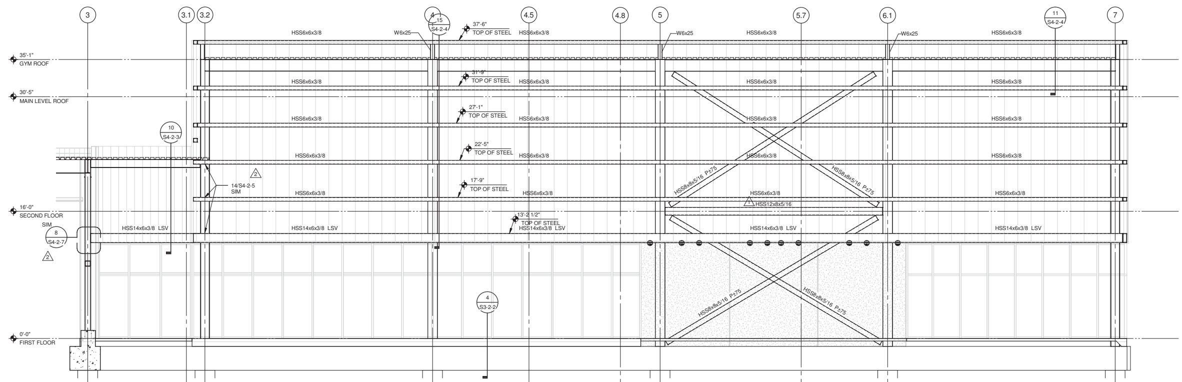
**KANSAS CITY** has historically been known for its barbeque, beautiful fountains, and rich history of jazz music. And you can add soccer to that list.

Now considered one of the country's top soccer cities, Kansas City is home to one of the largest youth soccer leagues in the U.S., with more than 35,000 kids playing soccer across the metro area of more than 2,000,000. Sporting Kansas City, the city's Major League Soccer (MLS) club, formerly the Kansas City Wizards, has enjoyed frequent success as winners of two MLS Cup titles and four U.S. Open Cup titles since its founding in the mid-1990s. Since opening in 2011, the team's home, Children's Mercy Park, has seen a 125-game MLS sellout streak, setting a high bar for the wave of soccer-specific stadiums that have been built in the U.S. To top it off, Kansas City is a finalist city to host matches for the 2026 FIFA World Cup.

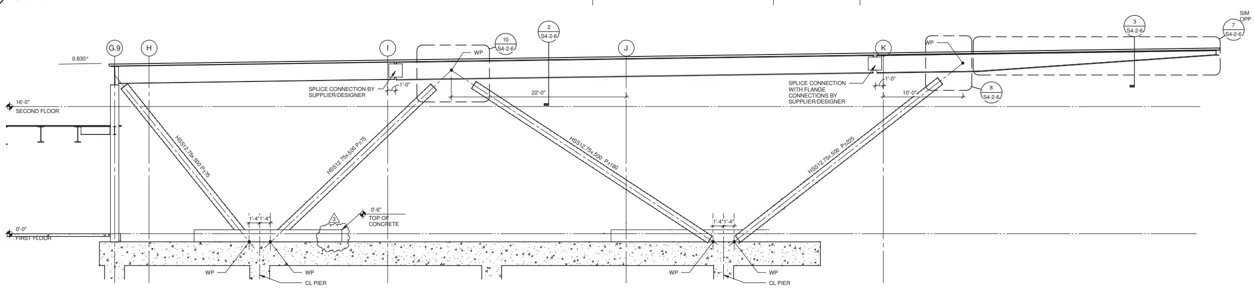
Opened in 2018, the state-of-the-art Pinnacle National Development Center is the latest asset contributing to Kansas City's soccer prowess. A collaboration between Sporting Kansas City, U.S. Soccer, and Children's Mercy Medical Center, the $75 million campus covers 50 acres in Kansas City, Kan. (on the other side of the river from Kansas City, Mo.) just one mile from Children's Mercy Park. Its five outdoor pitches located around the main structure are used by Sporting Kansas City and visiting U.S. men's, women's, and youth national teams. Pinnacle also serves as the official home for U.S. Soccer's coaching and referee training and development, and a two-story, 2,800-sq.-ft coaching pavilion located between two pitches uses audio and video technology to enhance the training experience.



5 BUILDING ELEVATION - GRID 7
3/16" = 1'-0"



10 BUILDING ELEVATION - GRID K
3/16" = 1'-0"



15 CANOPY SUPPORT FRAME
3/16" = 1'-0"

opposite page: The Pinnacle campus' centerpiece is its two-story, 81,100-sq.-ft main building.

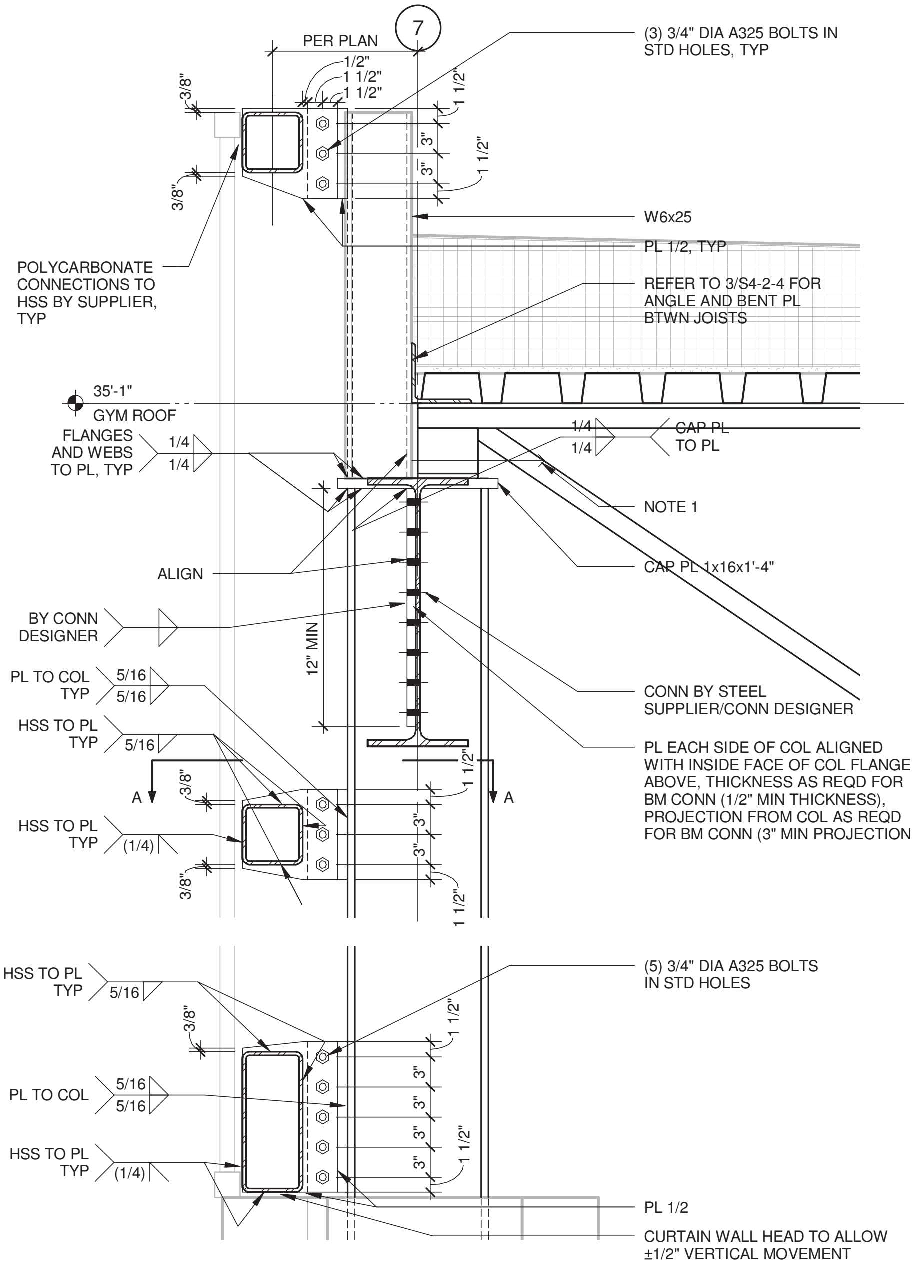
below: The design team reserved space for braced frames early in the design process and completed the design around these locations. Some were enclosed in interior walls, others were placed in exterior bays without windows, and yet others were left exposed in the gym.

above: Framing drawings for two sections and the entrance canopy.

Courtesy of Walter P Moore

**Brian Lewis** (**blewis@walterpmoore.com**) is a principal at Walter P Moore's Washington, D.C., office.


Alistair Tutton Photography



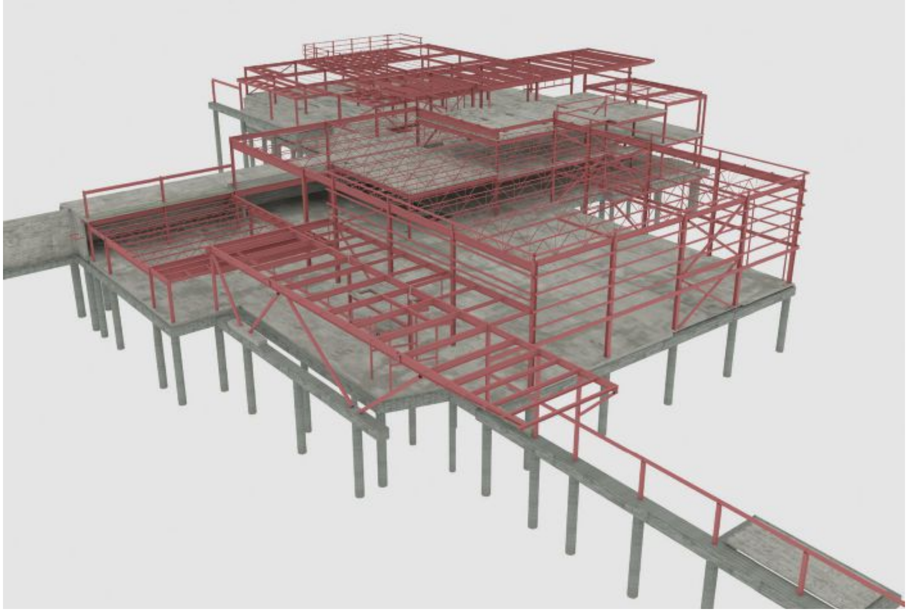

above: Polycarbonate cladding around the gym diffuses natural light.

left: A grillage of continuous square HSS for support of the polycarbonate runs proud of the exterior gymnasium columns.

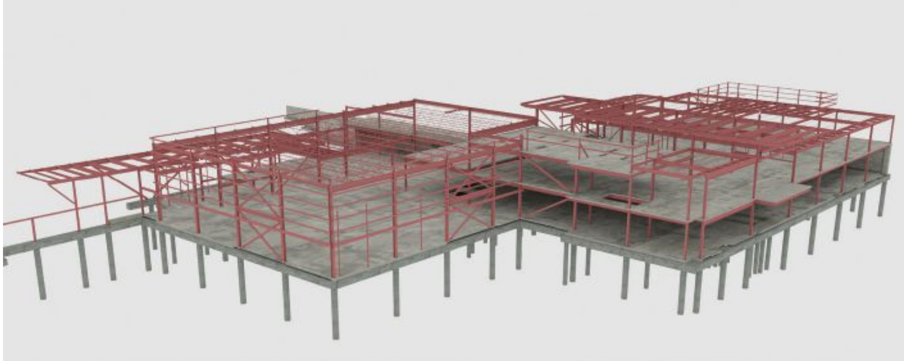
The steel-framed centerpiece for the campus is the two-story, 81,100-sq.-ft main building serving all three of its tenants with world-class facilities and top-notch equipment. In addition to housing Sporting KC's lounge, media studio, locker rooms, training rooms, and coaches' offices, it also includes a sports performance lab loaded with state-of-the-art equipment including hyperbaric chambers, cryotherapy, an Accupower force plate, and an environmental/atmospheric chamber. U.S. Soccer has access to many of Sporting KC's premium facilities in addition to its own offices, locker rooms, and classrooms. Pinnacle is also home to Children's Mercy Sports Medicine Center, which houses exam rooms and a radiology center. Shared resources include the 12,870-sq.-ft sports medicine gym, four hydrotherapy pools, a human analysis/gait lab, and a kitchen. While the gait lab was built on grade, AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity* (**aisc.org/dg**) assisted in designing for walking vibrations on the elevated floors.

Knowing that an economical superstructure design was critical for the project budget, the design team of Walter P Moore (WPM) and Leigh and O'Kane decided on a structural steel system. The typical bay spacing is 30 ft × 30 ft with W14 columns, and the building uses 436 tons of structural steel in all. The elevated floors are concrete slabs on composite metal deck supported by wide-flange steel beams and girders. The roof structure is a metal deck supported by open-web steel joists as well as W27 beams in the gym and W21 girders in other areas. The vertical lateral force-resisting is a seismic $R$=3 system with concentrically braced frames made from square hollow structural section (HSS) members (HSS6×6, HSS8×8, and HSS10×10). This lateral system was determined to be the most efficient for the building and required careful integration of braced frames into the architectural design. WPM and architect Populous reserved space for braced frames early in the design process and completed the design around these locations. Some were enclosed in interior walls, others were placed in exterior bays without windows, and yet others were left exposed in the gym.

WPM also collaborated with Populous to design the entry lobby, which features canted steel columns (ranging 30° to 50° from horizontal) and a soaring canopy that cantilevers 60 ft from the outer column base. The signature canted columns are made of 12.75-in.-diameter HSS of varying slopes. They are exposed to view and located outside the building enclosure,

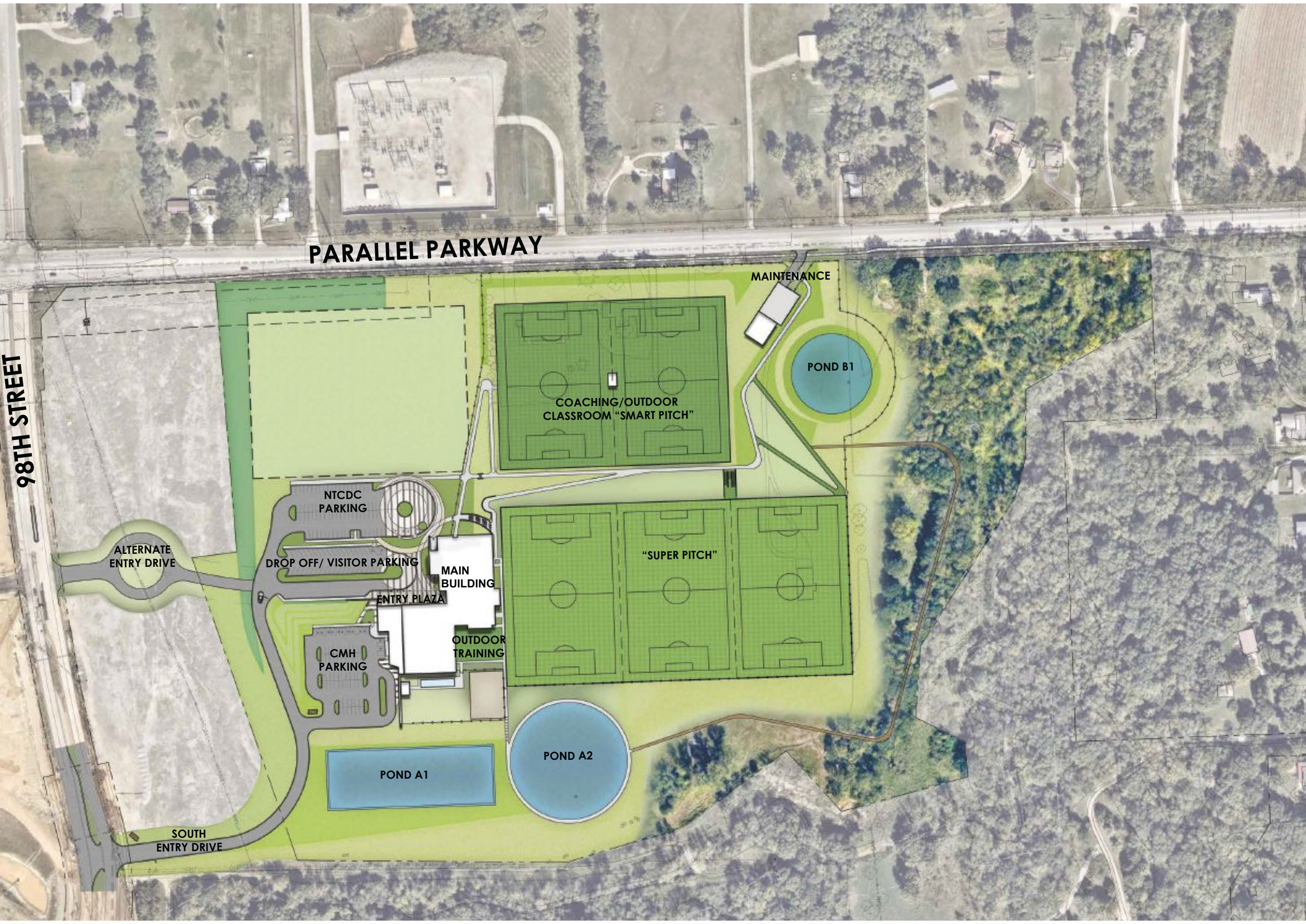


above and below: Two different 3D model views of the steel framing, which comprises 436 tons in all.



below: In addition to Sporting Kansas City and visiting U.S. men's, women's, and youth national teams, the building also serves U.S. Soccer coaching and referee training and development and Children's Mercy Sports Medicine Center.

Alistair Tutton Photography





above: The Pinnacle National Development Center encompasses more than 50 acres.

left: Typical bay spacing for the main building spaces is 30 ft × 30 ft with W14 columns.

making them an important component of the exterior building aesthetic (all exposed elements were coated with intumescent paint). The primary member in the canopy structure is a W27×129 girder that is tapered down to a depth of 8 in. at the canopy tip, with the canopy extending 30 ft beyond the support at the canted column.

Structural steel was key in achieving two important design components for the sports performance gymnasium: openness and abundant natural light. Deep long-span (DLH) joists (68 in.) supplied by Vulcraft span 115 ft over the gymnasium without interior columns, providing an open space with flexibility for future equipment arrangements. Polycarbonate cladding around the gym is used to create an environment with diffused natural light. A grillage of continuous square HSS for support of the polycarbonate runs proud of the exterior gymnasium columns. The HSS are spaced vertically at approximately 5 ft to limit the span of the 40-mm-thick polycarbonate. Braced frames around the perimeter are integrated into the building aesthetic and are visible from inside and outside the gymnasium.

WPM and Leigh and O'Kane considered shallow and deep foundations for the main building. A cost comparison by Turner Construction Company found drilled piers to be the most economical option for the project due to the 150-KSF allowable end bearing capacity of the limestone bedrock and its proximity to finished grade. The drilled piers also provide high capacity for resisting lateral loading from wind, seismic, and unbalanced loading resulting from a 16-ft grade change across the main building.

right: The gym's roof is supported by open-web steel joists and W27 beams.

below: The building's entry canopy cantilevers 60 ft from the outer column base.

Alistair Tutton Photography

Courtesy of Walter P Moore


Wood and metal paneling, a glass curtain wall, polycarbonate cladding, and architectural precast concrete encase the building.

The exterior cladding includes wood and metal panels, a glass curtain wall, polycarbonate, and architectural precast concrete. The latter creates a unique aesthetic, with patterns that have a connection to Sporting KC's branding, and is supported by the primary steel structure.

Kansas City and Sporting KC have been progressive leaders in soccer programs and the development of soccer-specific facilities, including the steel-framed Pinnacle National Development Center—again, helping to add soccer to the list of cultural amenities and contributions that the city is known for.

**Owner**
Sporting Kansas City

**General Contractor**
Turner Construction Company

**Architect**
Populous, Kansas City

**Structural Engineers**
Walter P Moore, Kansas City and Washington, D.C.
Leigh and O'Kane, Kansas City

**Steel Fabricator, Erector, and Detailer**
Doherty Steel, Inc., Paola, Kan. AISC CERTIFIED FABRICATOR

NILES NORTH HS AQUATIC CENTER
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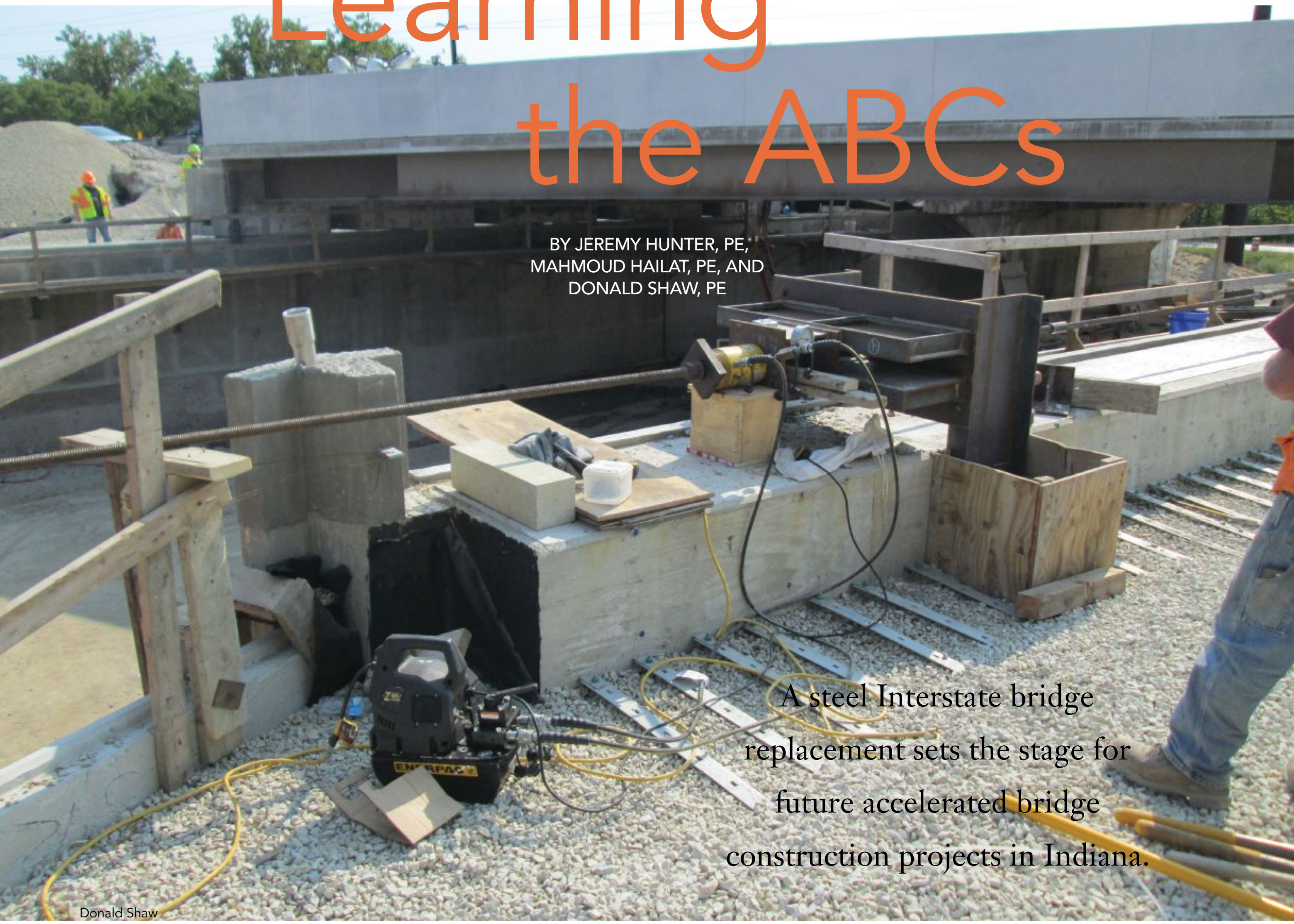
# Learning the ABCs

BY JEREMY HUNTER, PE, MAHMOUD HAILAT, PE, AND DONALD SHAW, PE

A steel Interstate bridge replacement sets the stage for future accelerated bridge construction projects in Indiana.



Donald Shaw

**JUST WEST OF** the Ohio state line near Richmond, Ind., twin three-span bridges carried the east- and westbound lanes of Interstate 70 over Indiana 121

At 58-years-old, the steel main span and concrete tail spans were in need of replacement. But what would be the best method for installing new bridges along a busy section of cross-country Interstate? Structural engineer Beam, Longest, and Neff (BLN) was selected to prepare contract documents for the bridges using conventional construction methods. However, during the initial scoping and engineering assessment, BLN and the Indiana Department of Transportation (INDOT) determined that accelerated bridge construction (ABC) methods would be ideal for the project, especially when it came to minimizing the burden on drivers during construction, maximizing construction zone safety, and providing the state with a high-quality product.

This section of I-70 carries approximately 35,000 vehicles per day. Based on INDOT's Interstate and highway congestion policy, the construction team would be required to maintain two lanes of traffic in each direction for the vast majority of the construction time. It would also need to maintain one lane of traffic in each direction while the existing bridges were demolished and the new bridges were moved into their permanent locations.

Of course, one of INDOT's primary goals was to complete the project as quickly as possible. BLN investigated several options to meet this goal, eventually deciding to build the new bridge in the median between the I-70 eastbound and westbound lanes and proposed two common ABC methods in the contract documents: slide the new superstructures across new abutments or move them to their final locations via self-propelled modular transporter (SPMT).


Donald Shaw

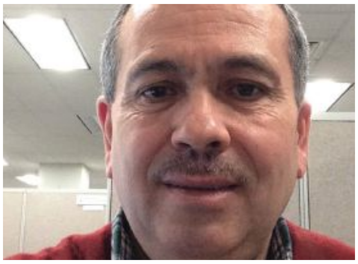
above: The new bridges replace an Interstate span that was nearly 60 years old.

opposite page: Hydraulic jacks pulled the superstructure into place with high-strength 1½-in. threaded rods. The jacks were placed behind stressing frames built from structural members that were bolted/welded together and connected to the abutment using high-strength bolts.

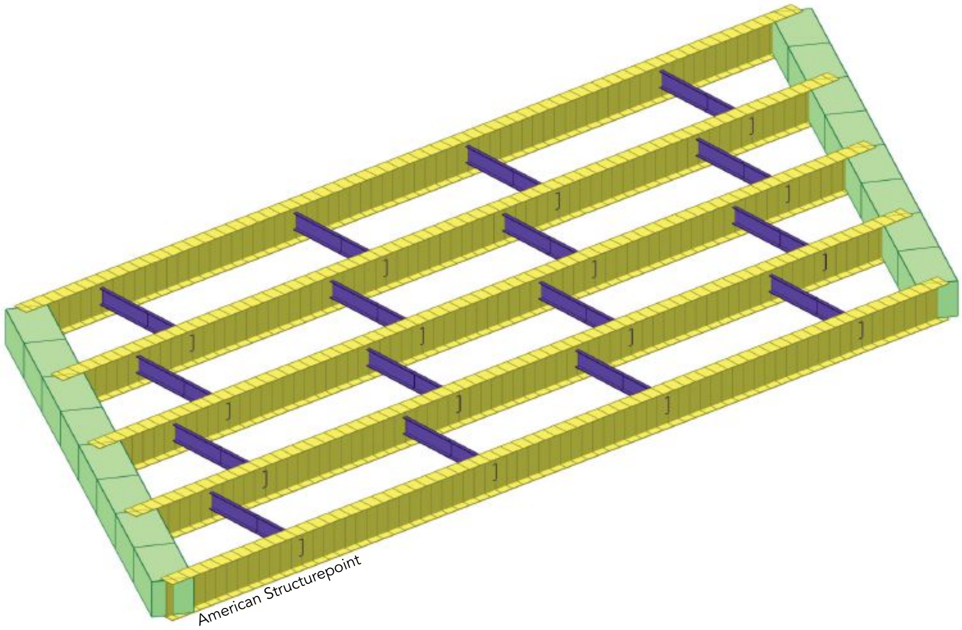
Two options were also considered when it came to the construction delivery method: design-build (DB) and design-bid-build (DBB). The DBB method was eventually chosen as it provided several opportunities for INDOT personnel to learn throughout the project, allowed the design team more oversight of both design and construction, and also enabled INDOT to build the necessary tools and experience for future ABC projects. In addition, it would allow the contractor to minimize construction time and project cost by bidding on the ABC method it could most quickly and economically complete. This provided INDOT with the highest bid value and a cost-effective ABC alternative because the greatest number of contractors could bid on the project. In addition, with the information collected from multiple bids on the two ABC methods, INDOT maximized the possibilities for future ABC project planning, standards development, and policy improvement.

Ultimately, the winning contractor, Walsh Construction, elected to use the slide construction alternative. The bridge superstructure was built temporarily in the median on permanent concrete straddle-bent abutments. The abutments were constructed in front of the existing abutments and extended underneath the existing superstructures. Four drilled shafts were built outside the coping of the existing twin bridges to support the new abutments, and both the shafts and abutments were built while the existing bridges remained open to traffic. This construction strategy significantly reduced construction time, and this stretch of I-70 traffic experienced no interruptions during this phase.

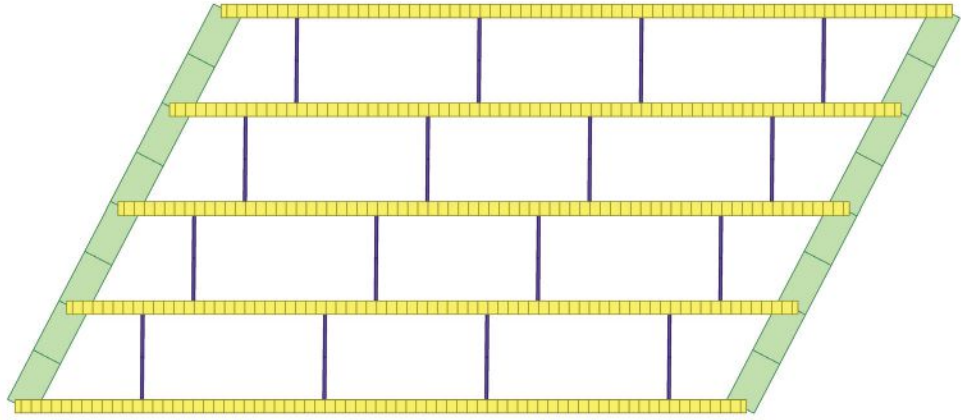
Structural steel aligned perfectly with the adopted ABC methodology, as lightness and flexibility were both crucial to the project. A steel superstructure weighs less than a comparable pre-stressed concrete superstructure, and the jacking forces required to both slide the superstructure to the final bridge seat location and raise the bridge to accommodate permanent bearings installation would have been much higher if prestressed concrete beams were selected. In addition, steel beams are more resilient to differential sliding forces. Both bridges comprised steel beams, steel diaphragms, concrete deck, bridge rails, and integral concrete end caps. Each steel bridge superstructure, made from W33×201 and concrete deck, includes five skewed 71-ft-long girders spaced at 9 ft, 9 in. apart with four steel bracing elements per gap (16 in all at 9 ft, $4\frac{5}{16}$ in. wide). The crossing uses 800 tons of steel in all, with 415 tons for the eastbound side and 385 for the westbound side.



**Jeremy Hunter** (**jhunter@indot.in.gov**) is chief engineer of design, **Mahmoud Hailat** (**mhailat@indot.in.gov**) is lead bridge design engineer, and **Donald Shaw** (**doshaw@indot.in.gov**) is a bridge design engineer, all with the Indiana Department of Transportation (INDOT).




Isometric (top) and plan (below) views of the steel superstructure framing, which was the same for both bridges. Together, they used 800 tons of steel.





The steel bridge superstructure, made from W33×201 and concrete deck, includes five skewed 71-ft-long girders spaced at 9 ft, 9 in. apart, with four steel bracing elements per gap (16 in all).

The estimated closure time for demolition and bridge slide was 14 days per bridge. The bid process used a common ABC contracting method: "A + B." The "A" component represents the cost of construction and the "B" component represents the incentive or disincentive component. The "B" component built into the contract was based on the amount of time one lane of I-70 or Indiana 121 was closed to through traffic. Walsh completed the slide process in 11.5 days per bridge. The savings of five total days resulted in Walsh being awarded $170,000 (the maximum incentive amount stipulated by the contract). The maximum traffic queue for the project was six miles, and the Ohio Department of Transportation assisted with managing traffic by establishing a radio broadcaster at the Indiana-Ohio state line (just a mile east of the project along the Interstate) and at the 5-mile marker (on the Ohio side) in addition to providing three traffic cameras.

## Lessons Learned

After construction was complete, INDOT held a meeting with all project partners to evaluate the ABC project and discuss the lessons learned in the design and construction. This meeting enabled INDOT to improve the ABC project process within Indiana and retain tools for future ABC projects. (Note that this was the first conventional ABC project at this scale in Indiana. One larger-scale Indiana steel bridge project—the Milton-Madison Bridge, which is the longest bridge slide in North America to date at a half-mile—was also built via ABC. Read about it in the February 2012 article "Move that Bridge" as well as in our June 2016 Prize Bridge Awards coverage, both via the Archives section at **www.modernsteel.com**.)

One finding was that the cost to slide the new bridges did not add much additional cost to the contract; most of the contract cost incurred was in the substructure construction. All of the structural steel was specifically designed by BLN and fabricated by Kard Welding to minimize the overall weight of the superstructure, which, along with the application of soap on the sliding surface, allowed the construction team to efficiently overcome the normal resisting forces and slide the bridge into place.

Of course, safety is the primary concern for all INDOT projects, and the decision to close I-70 during the bridge slides proved to be much safer for construction workers and the driving public than using traditional bridge construction methods. While the bridge was temporarily constructed in the median, two lanes of I-70 traffic were open, and the substructure was built below the existing bridge superstructures while the existing I-70 bridges remained open to traffic. Maintaining Interstate traffic safely through a steel-framed ABC project site went smoothly and more quickly than anticipated, presenting Indiana with an excellent option for future roadway bridge projects of comparable scale. ■

*For a video of the bridge slide, see the Project Extras section at* ***www.modernsteel.com****.*

**Owner**
Indiana Department of Transportation

**General Contractor**
Walsh Construction

**Structural Engineer**
Beam, Longest, and Neff, Indianapolis

**Steel Fabricator and Detailer**
Kard Welding, Inc., Minster, Ohio AISC CERTIFIED FABRICATOR

Donald Shaw

The slide process for the east- and westbound bridges took 11.5 days apiece.

# Robot Ready

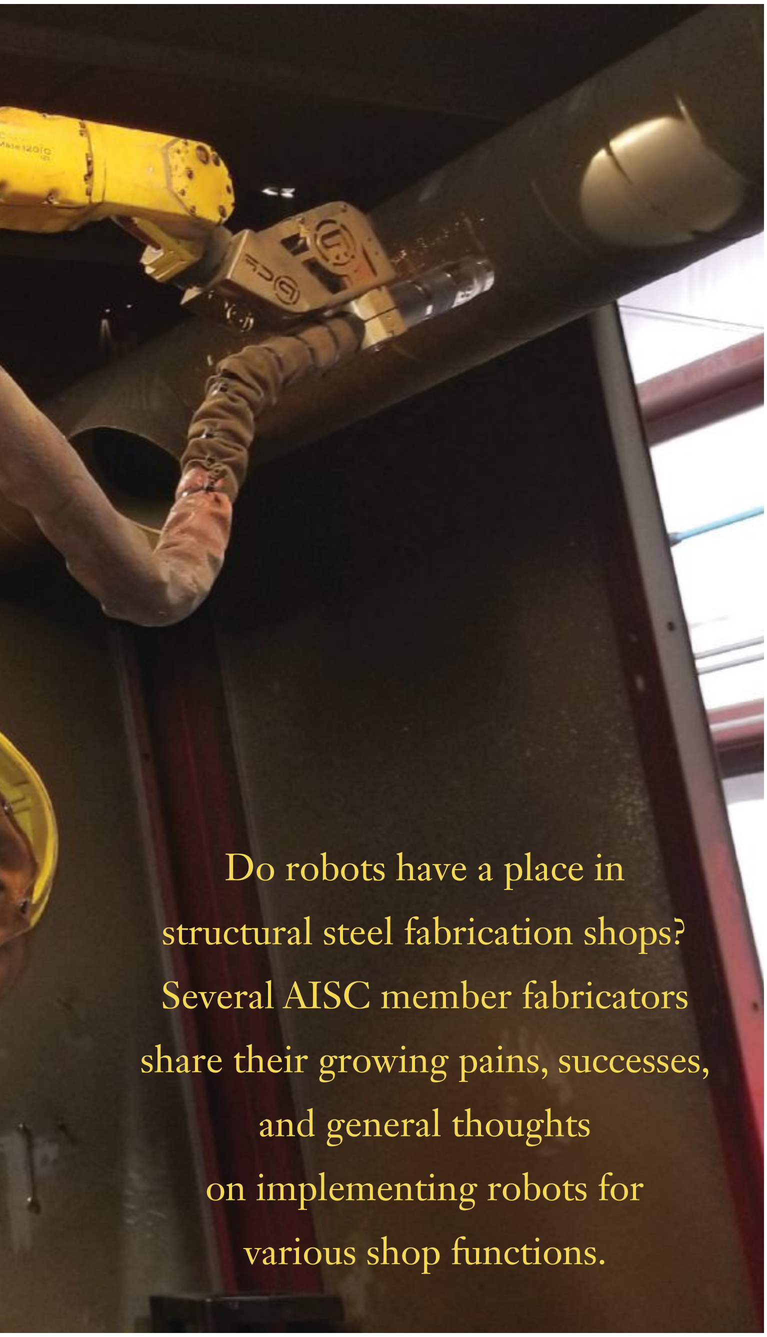
BY GEOFF WEISENBERGER


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


**FOR A WHILE,** the discussion on robotics in structural steel fabrication shops started and ended with, "There's not enough repeatable work to justify buying a robot."

More and more, though, labor availability—or rather a lack thereof—has been driving some structural fabricators to modify this statement to, "There's not enough labor to justify *not* buying a robot."

We recently performed a survey of AISC member fabricators to get their take, asking whether they've implemented robotic equipment in their shops or are planning to in the near future, and what the challenges have been. Of course, everyone has a different opinion of what a "robot" is. To some, an electric can opener qualifies. For purposes of this survey, we were thinking beyond CNC machinery and focusing on the next level of automation, reserving the robot moniker for fabrication equipment such as multiple-axis robotic arms that can plasma cut, weld, or cope, or machines that can automatically place or assemble steel components.



Do robots have a place in structural steel fabrication shops? Several AISC member fabricators share their growing pains, successes, and general thoughts on implementing robots for various shop functions.


## Early Adopters

Everything happens on a bell curve, and robots as we defined them have by no means taken over structural steel fabrication. Several respondents revealed why they weren't quite ready for robots, citing reasons such as cost, not having enough fabrication to justify the investment, and programming and training time.

But for those that have taken the plunge, the results have been largely beneficial. And the reasons for implementing robots range from having trouble finding workers to improving quality and minimizing errors to faster fabrication to creating a safer working environment via less human interaction with steel moving through the shop.

When it comes to labor, it's not just a matter of addressing the current shortage but also getting a head start on anticipated challenges.

"We were prompted into looking at robotics due to future labor shortages, increased quality, and our desire to drive innovation in the fabrication community," says Patrick Schueck, president and CEO of Lexicon, Inc.

The company has installed a robotic fitting machine and a robotic welding machine, both from Zeman, which it uses for all project types going through the shop.

"We have two robotic lines, both robotic fit and weld lines located within the same machine," he explains. "The difference is the SBA 2 Conti has one fitting robot that works with two welding lines, and the Compact + has one fitting robot that works with one welding line. Both are extremely efficient, with limited handling."

There is a learning curve with implementing any new technology or equipment, and robots are no exception. While programming has long been seen as the primary challenge, altering detailing processes, fitting robots into an existing workflow, training, and other adjustments all need to be considered as well.

"We continue to try to maximize the robots' output, which can be a challenge," notes Schueck. "We have had to relook at how we detail and model our projects to use the robots' strengths to the fullest. But in general, the experience has been positive so far."

Banker Steel has also implemented robotic equipment—a Voortman machine using Fanuc robotics—for welding, cutting, and coping.

"The coping robot was a struggle in the beginning, because it required a little more from both the detailers and the production control department with the files before anything got to the machine," explains Heath Maxey, who specializes in research and development with Banker. "The welding robots required us to change around some of the planning we were doing in the shop, and we found that we needed to plan ahead more for the robotic welding than for some of the other processes through the shop."

Now things are not only up to speed, but faster than ever.

"Using the welding robots, we have more than doubled the arc time that we would normally get from a person welding by hand," continues Maxey. "And with the coping robot, we have considerably increased the throughput of work to the shops."

He stresses that there is a learning curve in bringing robots into practice, both from a management side and an operator side.

"I know everyone thinks, 'It's a robot, bring it in, plug it up, and it works.' But we are finding out that each one is changing the way we think and operate so we can squeeze more production through the same floor space."

"Improved communication between the models and the robots is key," adds Chet McPhatter, Banker's president. "Once the equipment is set up and running properly, it can be very productive."

Preparing for training and making the robot work for your specific workflow—or vice versa—are both keys to success. Bryan Frazier, vice president with Zalk Josephs, explains that technology and robotic equipment come with their fair share of management issues.

"Having our maintenance department and operators trained on this equipment was our first hurdle," he explains. "The second was finding the sweet spot of fabrication flow through our shop."

But once those areas were addressed, the company's Ficep machine—a six-axis robotic arm in tandem with a three-spindle drill line—became an asset, reducing layout time for copes, increasing productivity, and reducing shop errors.

"The output of beams from the robotic coper was much more than the output of our fabricators welding parts onto these beams," Frazier says. "In lieu of having unsafe stacks of beams at the outfeed of our production lines, we addressed material management to align with our fabricator production. More recently, this has led to an increase in shop labor, which allows us to increase the outflow of the Ficep equipment." In fact, he estimates that the machine has provided a labor hour savings of roughly 30%.

Mike Marian, a project engineer at Paxton and Vierling Steel—which uses a Peddinghaus Beam Assembler and Voortman robotic coping machine—notes that programming, long considered a barrier to robotics implementation, has become less of an issue.

"Robotic equipment is finally advanced enough that programming and operating is not the concern that it once was when it first came out," he says. "The challenges are more in understanding the limitations of the equipment and finding the best way to use it. Another challenge is with troubleshooting. When a human makes a bad cut or weld, it is typically easy to determine what happened. When robotic equipment is not performing as it should, it is more of a challenge to determine the root cause of the issue and will often require manufacturer support. As for the learning curve, it is less with actually operating and using robotic equipment and more about how to best modify the other processes in our shop to make best use of the equipment."

"At the end of the day, it is all about our customers' experiences," notes Paxton and Vierling general manager, Brent Pfeiffer. "As we become more intentional in pre-sale project design, robotic automation has the potential to lower production costs and increase operational efficiencies to deliver an improved customer experience."

"We have changed the way we think about fabrication since we purchased our robotic machinery," notes Bill McCombs, vice president of McCombs Steel Co., which has implemented AGT and Ficep equipment for welding, coping, and cutting. "Our detailing now is per the machinery requirements. Any new machine requires change, and learning these machines was no more difficult than with any other new machine. Our office now must ensure that anything sent to these machines is prepared for the way they fabricate."

## Coping with Coping

While some companies have embraced robotics for multiple tasks, others have used the coping operation as a gateway. David Lewis, president of American Steel, Inc., notes that his company's Prodevco plasma coper (using a Fanuc robot) has reduced coping time by more than 50%.

"The learning curve has been steep and expensive, but the payoff has been worth it," he says. Part of the issue is calibration. "Any change in material size requires recalibration, and occasional and random calibrations are also needed to maintain quality. Sometimes it is difficult to know when the machine will lose its calibration. When the machine is in calibration, the coping is quite good and the range of motion and access to the material to be cut is exceptional."

"Random length errors have also been an issue," he continues. "The laser that determines the length moved is not engineered to handle the tolerance required for this process, so we learned to maintain temperature control of this device to eliminate dramatic length errors."

Lewis also expects to add robotic welding equipment in the coming years, thanks to what he sees as a continuing ease of programming.

"As the years have progressed, the cost of the equipment has come down and the sophistication of ability to perform tasks has increased," he says. "Control technology and specialty control or pre-control software has made these devices more applicable to production operations without highly trained or expensive operating staff."

Geiger and Peters is another shop that has entered robotics via coping, notes the company's president, Steve Knitter. The company had experienced an increase in hollow structural section (HSS) usage for building projects over the past decade and was in search of a solution to assist with that type of work. The company installed an Inovatech plasma robot in 2017 and has seen labor hour savings north of 20% for some projects.

"The plasma robot has been great," he says. "It has an articulating arm that can cut on all four sides of a tube. The copes, piece bevels, and weld prep bevels are a huge time savings for our fitters."

"The install went extremely well, with very limited downtime for that machine area," he continues. "Once the last shift of the automated punch/saw combo was done, the robot and new conveyors were installed within a week, and it was producing full production material within a few days."

Mark Selvaggio, president of Selvaggio Steel, was also drawn to robotic equipment for its coping capabilities. While there was some initial trial and error, the decision eventually proved beneficial.


"When we ran the first beam through the Daito machine, we discovered a problem that plagues 100% of copers in the world," he explains. "When you burn the web to create a rat hole for the moment flange prep, the coper burned through the web into material that is not being cut out, thus damaging the flange below the web. This is a huge problem for moment connections, especially in protected zones in seismic connections. Daito was notified during the install process and they developed a procedure to do a 'rat hole layout,' marking the beam web and cutting the rat hole out later, using the normal manual torch method and eliminating all damage to the flange below the web from moment connections."

"While I don't feel that current robotic options are an effective solution for fitting and welding on heavy structural steel, we are happy with our Ficep coper, which uses a robot to perform all types of plasma arc and oxy-fuel cutting and beveling on the full range of structural sections," says David DeBlasio, vice president of Gayle Manufacturing. "Development of the software suitable for our type of work with the Ficep cutting system was challenging, but we progressed through that phase of development within four to six months."

## Almost (or not quite) there

For those fabricators that haven't yet implemented robotic shop machinery, one of the main reasons for holding off is a lack of repetitive work.

"Robots have come a long way but still require a higher quantity of repetitious work to make them worthwhile," says Russell Barngrover, executive vice president and plant manager with SteelFab. "The automated systems currently out there still have a long way to go before they become viable to us. The issue is volume."

Still, the company is planning to add some equipment next year, primarily for stud welding and general welding of repetitive units. The plan is to start with one shop, get the bugs worked out, then roll it out at other SteelFab locations.

Todd Weaver, president of Metals Fabrication Company, says that his company is also planning to implement robotic fitting and welding equipment at his company's shop next year and has already purchased a machine.

"We need to improve our capacity and efficiency," he says. "We spend a lot of resources on training. However, it's difficult to find capable fitters and welders to support our growth. We've had a lot of success training machine operators from within the company."

Ben Humrichouser, division president of Firelands Fabrication, is also looking to push further into the robot realm and is considering implementing a beam-welding robot, with a primary goal of automating welds after fitting.

"We're a small shop but we aren't afraid of technology and improvement, and we see the welding as a logical next step in our process," he says. "Robotic welding technology is very stable but difficult for high-customization or non-repetitive applications. If we can prove stability in generating the NC program from SDS/2 to the robot, then this would be an easy justification. That said, we're are not sure the software is there yet. I think there needs to be continued development with the structural detailing/modeling software developers to allow better translation to the structural welding equipment. We have seen similar issues worked out in the past, but the developers need to see a mutual benefit and work together."

Ted Peshia, president of fabrication with Garbe Iron Works, says his company is waiting for the next "round" of robots before considering implementing them.

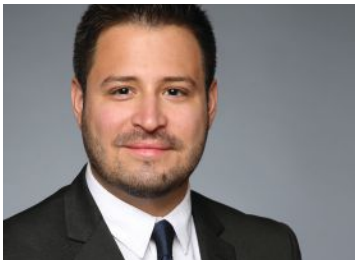
"I don't want to work the bugs out," he notes. "I'd wait to buy a second-generation robotic assembler. If work is consistent and the machines are reliable, we would consider them for the shop. Manpower to monitor, inspect, and maintain them is the key to how widespread the use of robotic equipment will be in structural shops in the future."

*Want to see some structural steel fabrication robots in action? Come to NASCC: The Steel Conference in Atlanta, April 22–24, where several heavy equipment manufacturers will display their offerings. Visit* ***aisc.org/nascc*** *for more information and to register.*

# Raising the Standard

BY JONATHAN TAVAREZ, PE

## An inside look at how AISC's standards are developed.



**Jonathan Tavarez** (**tavarez@aisc.org**) is a staff engineer in AISC's Steel Solutions Center and serves as secretary of the Nuclear Facilities Task Committee 11 and assistant secretary of the Committee on the Code of Standard Practice.

**AISC IS KNOWN** for many things, and the *Steel Construction Manual* is certainly toward the top of the list.

Engineers are all well acquainted with lugging their copy of the "Steel Bible" around campus during college and rely on the wealth of information contained within the multi-colored tabbed pages throughout their design careers.

What many may not be aware of, however, is how the *Specification for Structural Steel Buildings* contained within the *Manual*, as well as AISC's myriad other standards, are developed. For example, we all rely on the bolted connection design equations in Chapter J and everyone follows the buckling limit curves provided in Chapter E—but how did they come to be?

Here, we'll take a behind-the-scenes look at the process of developing all the standards managed by AISC.

### Standard Overview

AISC currently maintains six standards, five of which are ANSI-approved:

- *Specification for Structural Steel Buildings* (ANSI/AISC 360-16)
- *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341-16)
- *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-16)
- *Specification for Safety-Related Steel Structures for Nuclear Facilities* (ANSI/AISC N690-18)
- *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* (ANSI/AISC 358-16)
- *Certification Standard for Steel Fabrication and Erection, and Manufacturing of Metal Components* (AISC 207-16)

The numbers appearing after each name are the designations used when referencing each standard, and the number after the hyphen designates the year it was released. There are also two new standards on the horizon: *Seismic Provisions for Evaluation and Retrofit of Existing Structural Steel Buildings* (AISC 342), expected to be released this coming fall, and the *Specification for Structural Stainless Steel Buildings* (AISC 370), expected to be released fall of 2021.

Many questions submitted to the Steel Solutions Center revolve around confusion on the role of the above-mentioned standards and the many other documents produced by AISC, such as our series of 35 (and counting) Design Guides, white papers, and other publications. It is important to note that the standards mentioned above are adopted into law through reference by the authority having jurisdiction and provide design requirements that must be met. (For more insight, see the article "Says Who?" in the August 2013 issue, available at **www.modernsteel.com**).

**Committee Assignments**

| Consensus Body Approving a Standard | Task Committee | Assigned Standard or Section |
|---|---|---|
| Committee on Specifications | TC 1 – Coordination | AISC 360: A1, A4, General Coordination |
| | TC 2 – Editorial, Economy, and Practical Use | AISC 360, 341, & N690 |
| | TC 3 – Loads, Analysis, and Stability | AISC 360: B1, B2, B3, C, L, App. 1, 2, 6, 7, & 8 |
| | | AISC 341: B1, B2, B3, B4, C |
| | TC 4 – Member Design | AISC 360: B4.1, B4.2 (local buckling), D1, D2, D4, D5, D6, E, F, G, H |
| | | AISC 341: D1, D3, D4 (excluding composite) |
| | TC 5 – Composite Design | AISC 360: I |
| | | AISC 341: G, H, composite portions of A & D |
| | TC 6 – Connections | AISC 360: B4.3, D3, J, K, App. 3 |
| | | AISC 341: D2 (excluding D2.7 & D2.8) |
| | TC 7 – Evaluation and Repair | AISC 360: B7, App. 5 |
| | | AISC 342 |
| | TC 8 – AISI/AISC Fire Committee | AISC 360: App. 4 |
| | TC 9 – Seismic Systems | AISC 341: B5, E, F, K1, K2, K3 |
| | TC 10 – Materials, Fabrication, and Erection | AISC 360: A2, A3, B5, M |
| | | AISC 341: A2, A3, I |
| | TC 11 – Nuclear Facilities Design | AISC N690 |
| | TC 12 – Quality Control and Assurance | AISC 360: B6, N |
| | | AISC 341: J |
| Committee on Structural Stainless Steel | – | AISC 370 |
| Connection Prequalification Review Panel | – | AISC 358 |
| Committee on Code of Standard Practice | – | AISC 303 |
| Certification Standards Committee | – | AISC 207 |

## Committee Overview

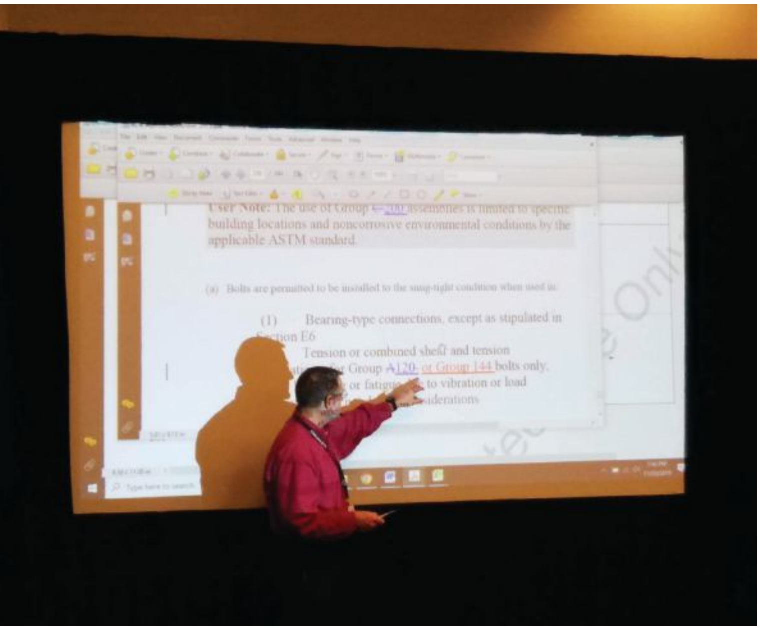
The Committee on Specifications (COS) is one of the AISC consensus bodies whose mission is to maintain a practice-oriented specification that provides for life safety, economy, predictable behavior and response, and ease of use while incorporating important updates in response to academic research and industry practice. The COS oversees and approves the AISC 360, 341, N690, and 342 standards. Underneath the COS are a total of 12 task committees (TCs) that work to develop these standards; see the table on Committee Assignments for their specific assignments.

Each consensus body has a target size of 21 members, except the COS, which has a target size of 45. All committees must also be balanced by the following member interest groups: industry (steel producers or fabricators), consultants (structural engineers, detailers, architects), and general interest (those not falling under the above two categories such as academic researchers). AISC staff comprises the Secretariat of all committees and oversees the compliance with procedures, manages consensus body appointments, and oversees the publication of standards.

There's also the Connection Prequalification Review Panel (CPRP), which reviews and approves moment connections for use in intermediate and special moment frames and develops the *Prequalified Connections* standard. The Committee on Code of Standard Practice develops, you guessed it, the AISC 303 standard, the Certification Standards Committee develops the *Certification Standard*, and the Committee on Structural Stainless Steel develops the soon-to-be-released AISC 370. A list of the voting members of each consensus body approving a standard can be found in the Preface of each standard.

## Six Years

Where the various AISC standards used to be updated on varying schedules, they are now updated on a regular six-year cycle. Committees have already started work on the 2022 revision of ANSI/AISC 360-16, ANSI/AISC 341-16, ANSI/AISC 303-16, and ANSI/AISC 358-16. Guests are welcome to attend many of our committee meetings. Anyone interested in joining an AISC technical committee may apply for membership by emailing Cynthia Duncan, AISC's director of engineering, at **duncan@aisc.org**. Committee appointments occur on a biennial schedule, with the next roster cycle beginning in 2022.




## Development Process

AISC's consensus bodies follow ANSI-accredited procedures, which you can review at **aisc.org/standards**. Meetings are held biannually to conduct official committee business, although typically many conference calls and smaller meetings are held externally throughout the year. Guests are free to attend meetings held by consensus bodies approving a standard, as well as any other committee meetings when the chair has agreed for the meeting to be open. Attendees from around the U.S. converge, making for a very constructive and insightful discussion. These meetings consist of discussions on testing and research that is applicable to each individual committee's goals for that development cycle and any work items by task groups within the particular committee. Any additions, removals, or revisions to the standard or text in question are proposed to the committee and discussed.

At the TC level, if the proposal is found to be beneficial, a vote is held to move the item to ballot by the COS. Depending on the scale of revisions, several ballots will be conducted for committee members to vote using the approve, negative (with reasons), or abstain methodology. Consensus body voting must have 67% participation of entire voting membership and a 75% majority approval (of the total voting minus abstentions). Negative comments must be addressed and resolved before moving the standard to a round of public review, which is to last 45 days. (Public review periods and documents are announced by email by AISC and posted at **aisc.org/publicreview**.) Once again, any negative comments should be addressed and resolved as persuasive or non-persuasive (with reasons) after exhaustive consideration of the committee. The standard is then submitted to the AISC Board of Directors and requires a majority vote for approval before being submitted to ANSI for approval.

## Moving Forward

All of the AISC current standards are available for free download at **aisc.org/specifications**. Historic specifications are available online as well, including a useful comparison document that lists changes between the last edition of the Specification and the most current. A tremendous amount of work and countless hours are invested in the development of these documents to ensure the most up to date in technical understanding. AISC is extremely grateful to the many volunteers sitting on these committees and is poised to continue working to make structural steel economical and safe for the world's challenges ahead. ■

## Solid Solutions

The Steel Solutions Center aids the various standards committees by acting as a thermometer for the industry, constantly monitoring the state of structural steel design, fabrication, and erection and forwarding any issues that may potentially result in standard revisions to the appropriate committee. This process sets AISC apart by maintaining a close tie with the users of the documents it publishes, while also constantly striving to resolve logistical and scientific deficiencies. The Steel Solutions Center is a one-stop for any questions related to structural steel, and responds to upwards of 150 questions per week, free of charge. Feel free to reach out to us at **solutions@aisc.org** or 866.ASK.AISC.

**AWARDS**

## AISC's Forge Prize Program Now Accepting Entries


AISC's Forge Prize recognizes innovation in the use of steel and how it can be used to reduce design and construction time. AISC is inviting emerging architects to submit proposals for visionary designs that embrace steel as the primary structural component to increase project speed. The Forge Prize is intended to engage emerging architects in developing imaginative solutions through a two-stage design challenge.

Whether solving a logistical constraint or social issue through your proposed vision, channel your inner Mies Van Der Rohe or Philip Johnson by leveraging the inherent characteristics of designing with structural steel. The Forge Prize provides a wonderful platform for conceptual design in which designers are not limited to the scope or complexity of their submissions.

The competition is open to designers based in the United States. There is no entry fee, but you must enter by January 15 at **www.forgeprize.com**. Winners will be announced in the spring.

**NASCC**

## NASCC 2020 Registration Opens January 2

Planning to attend the 2020 NASCC: The Steel Conference? You should be! It's your once-a-year opportunity to meet 5,000 other industry practitioners, talk with the leading experts in the steel community and catch up with your peers. The 2020 Steel Conference takes place April 22-24 in Atlanta and will offer nearly 200 technical sessions on the latest design concepts, construction techniques and cutting-edge research. The conference will also feature around 275 exhibitors showcasing everything from fabrication equipment to structural engineering software. Also included are several conferences within the conference: the World Steel Bridge Symposium, QualityCon, the NISD Conference in Steel Detailing, and Architecture in Steel.

You can earn up to 17.5 PDHs by attending the conference's dynamic, expert-led sessions (plus an additional 4 PDHs if you attend the optional pre-conference short course). One low registration fee gains you access to all of the technical sessions, the keynote sessions, the T.R. Higgins Lecture, and the exhibition hall. Registration opens January 20. For more information, visit **aisc.org/nascc**.

**SAFETY**

## AISC Now Accepting Annual Safety Awards Submissions

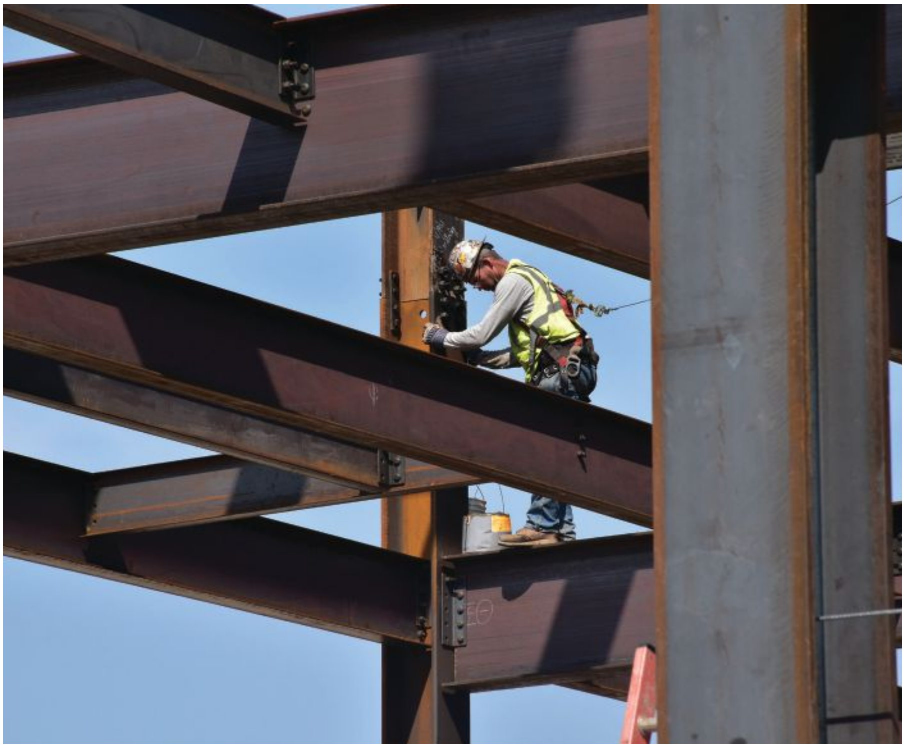
To a customer, visiting an unsafe shop or job site is like visiting a messy house. Even if safety is not an explicit requirement, its absence leaves a bad impression. On the other hand, seeing a shop or job site where the organization achieves a commendable level of safety gives a good impression. It is reasonable to think that a company managing safety is also successfully managing production and quality. AISC encourages you to manage safety to achieve that commendable record, and we want to help you display your success with an AISC Safety Award.

AISC member steel fabricators and erectors are eligible and encouraged to submit their company's safety record for AISC's annual Safety Awards. The awards, given in the Fabricator and Erector Categories, include the Honor Award (DART=0), the top safety award, presented for a perfect safety record of no disabling injuries; the Merit Award (0<DART≤1); and Commendation Awards (1<DART≤2).

"AISC's annual Safety Awards program recognizes excellent records of safety performance, and we commend these facilities for their effective accident prevention programs," said Thomas Schlafly, AISC's director of safety. "Periodic recognition of safety in the workplace has been demonstrated to provide worker incentive and a reminder of the importance of safe practices."

"Owners and clients pay attention to these awards," noted Kathleen Dobson, AISC Safety Committee member and safety director for Hillsdale Fabricators/J.S. Alberici Construction (an AISC member fabricator and erector). "They want to know that a fabricator or erector is proud of their safety records—and just as important, it means a lot to the workforce to see that their efforts are recognized by an industry leader like AISC."

The AISC Safety Awards program is open to all full fabricator members and erector associate members of AISC. Entries must be submitted by February 3. For more information about the program and how to enter, as well as safety resources available for the domestically fabricated and erected structural steel industry, please visit **aisc.org/safety**.



## People and Schools

- International design firm **Ware Malcomb** has expanded and relocated to Newark, N.J., specifically to the iconic Ironside Newark building. Ware Malcomb also maintains offices in the region in Princeton, N.J., and New York City. The firm's move to Newark was driven by the growth of its local employee and client base, as well as the opportunity to be closer to clients in a vibrant growth market.

- **DeSimone** announced **Eric Fenske** as associate principal of the firm's expanding structural engineering practice in Chicago. With over 17 years of experience in the design of high-rise buildings, mixed-use developments, exhibition halls, and specialty structures, Fenske will serve as a leader of the company's structural practice in the Midwest region.

- Knoxville-based structural engineering firm **CSA Knoxville** has recently changed its name to **Haines Structural Group** as it celebrates ten years of community partnership and service.

- **The National Academy of Construction (NAC)** has elected **Malcolm G. McLaren**, CEO of **McLaren Engineering Group**, to its 2019 class. Since founding the McLaren Engineering Group in his basement in 1977, McLaren has designed and engineered some of the country's most important bridges, structures, waterfront destinations, and entertainment venues. Today, McLaren Engineering Group employs more than 250 people in 11 offices.

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John Carino

# IN THE CLOUDS

**IF YOU WANT** to see the trees, you need to look up.

But in one outdoor plaza in Syracuse, N.Y., it depends on your height. Here, the trees are reflected in dozens of polished stainless steel disks mounted on a forest of galvanized steel columns fabricated by AISC member JPW Structural Contracting. The lowest can be used as benches while the tallest tower over visitors.

Called *Immersive Cloud*, the array is approximately 56 ft in diameter. Designed by MATR Studio and Palucci Engineering, it is the first in a series of projects that aims to improve underused community spaces within the city's urban core. When immersed amongst the undulating ribbon of disks, which vary in diameter, the surrounding environment—the trees, people, sky, and cityscape—are simultaneously reflected, distorted, and multiplied.

The experience and natural lighting change along with the seasons, and the disks amplify the beauty of each one—vibrant colors in fall, bare, skeletal branches in winter, and a lush green canopy emerging in spring and peaking in summer.


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