Modern Steel Construction

November 2024

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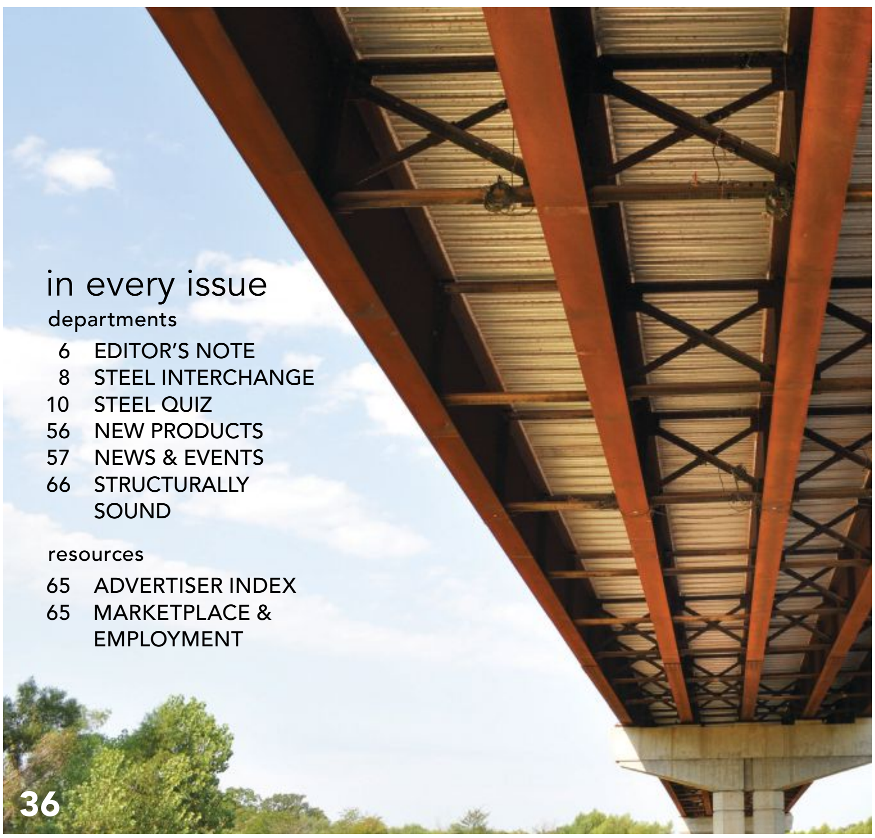

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ON THE COVER: An expansion project added nearly 9,000 tons of steel to Colorado Convention Center, p. 22. (Photo: Martin/Martin, Inc.)

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editor's note

In mid-August, we dropped our daughter off for her first semester of college. A lot of life events get described as bittersweet ad nauseam, and this one is definitely up there.

I'm sad she's no longer a permanent part of the household, but I'm *extraordinarily* happy for her and proud of her. Added bonus: My car, which became *our* car and then ostensibly *her* car for the last couple of years, is now *my* car once again—though it is now branded with a maize Michigan "M" magnet. Alas.

My daughter has always been driven and self-motivated and, frankly, has always been destined to be smarter than me (I came to this conclusion when she was about a year old). I have no doubt she will achieve great things. And trust me, you all will hear about it when she does.

Speaking of driven and motivated college students working to achieve great things, turn to page 60 in our News section, where you'll see more than 100 undergraduate and graduate students who, combined, have been awarded more than $350,000 in funding from AISC for their education this year. They're the winners of this year's various scholarships awarded by the AISC Education Foundation, whose mission is to invest in the people who will drive the future of design, fabrication, and construction of structural steel to create a future where people of all backgrounds work to build sustainable steel structures and communities. If you'd like to contribute to the success of college and university students—and, ultimately, the structural steel industry—you can learn more about the Education Foundation and how to help at **aisc.org/giving**.

Another handful of high-achieving students have crafted some jaw-dropping conceptual designs and are recognized on page 42. These are the winners of the annual Steel Design Student Competition, sponsored by AISC and administered by the Association of Collegiate Schools of Architecture (ASCA). The competition features two categories every year. The first presents a changing theme and the second is open. This year's theme challenged participants to create a steel innovation center along the Mississippi River in St. Louis near the famous Gateway Arch. Geared toward AEC professionals, its primary purpose is to provide hands-on opportunities for full-scale steel construction research and training.

Eleven winners were selected from entries submitted by more than 750 students from 47 universities. The designs are creative, beautiful, and inspiring, all of them featuring an abundance of exposed steel.

One more initiative involving college kids doing amazing things is, of course, the Student Steel Bridge Competition, an annual contest that challenges student teams to develop a scale-model steel bridge. Each team must determine how to fabricate their bridge and plan for an efficient assembly under timed construction.

While the regional competitions won't kick off for a few months and the National Finals event doesn't take place until the end of May, the rules for this year's competition are now posted at **aisc.org/ssbc**. In addition, if you're interested in supporting the competition and its students via a sponsorship, click the Sponsorships link at that page to learn about the various opportunities—or feel free to contact me directly!

Geoff Weisenberger
Editor and Publisher

Modern Steel Construction

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

Editorial Contacts
EDITOR AND PUBLISHER
Geoff Weisenberger
312.493.7694
weisenberger@aisc.org
ASSOCIATE EDITOR
Patrick Engel
312.550.9652
engel@aisc.org
SENIOR DIRECTOR OF PUBLICATIONS
Keith A. Grubb, SE, PE
312.804.0813
grubb@aisc.org
DIRECTOR OF GRAPHIC DESIGN
Kristin Hall
773.636.8543
hall@aisc.org
EDITORIAL DIRECTOR
Scott Melnick
312.804.1535
melnick@aisc.org

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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**.

Changes in Available Bolt Strength Values from 1989 to 2022

When comparing the 1989 AISC *Specification for Structural Steel Buildings* to the 2022 AISC *Specification*, there seems to be a lot more available strength in bolt shear. For a Grade A325 bolt with threads not excluded from the shear plane, Table J3.2 in the 1989 *Specification* lists an available strength based on 21 ksi. In the 2022 *Specification*, the available strength would be based on 27 ksi, per Table J3.2 (54 ksi / 2 = 27 ksi). Do you have any information that explains the difference in the available strength?

The changes in the available strength from the 1989 *Specification* to the 2022 *Specification* have to do with changes made in the *Specification* rather than changes to the bolt compositions themselves. There are two changes that were made that would explain the difference you are seeing.

First, the reduced area of the bolt due to the threaded portion was modified. This reduction was taken as 0.7 in the 1989 *Specification*. We know this because the available stress for the thread excluded condition in the 1989 *Specification* is listed at 30 ksi. 21 ksi / 30 ksi = 0.7. Second, the factor accounting for differential strain was changed from 0.8 to 0.9.

The commentary to Section J3.7 in the 2022 *Specification* states, "The factor 0.563 accounts for the effect of a shear/tension ratio of 0.625 and a 0.90 length reduction factor. The factor of 0.45 is 80% of 0.563, which accounts for the reduced area of the threaded portion of the fastener when the threads are not excluded from the shear plane. The initial reduction factor of 0.90 is imposed on connections with lengths up to and including 38 in. (950 mm). The resistance factor, ϕ, and the safety factor, Ω, for shear in bearing-type connections in combination with the initial 0.90 factor accommodate the effects of differential strain and second-order effects in connections less than or equal to 38 in. (950 mm) in length."

1989 *Specification*
0.8 [differential strain factor] × 0.7 [thread area reduction] × 0.625 [shear/tension ratio] 120 ksi [F_u for Grade A325 bolts] / 2 [safety factor] = 21 ksi

2022 *Specification*
0.9 [differential strain factor] × 0.8 [thread area reduction] × 0.625 [shear/tension ratio] 120 ksi [F_u for Grade A325 bolts] / 2 [safety factor] = 27 ksi

The change in the differential strain factor, which accounts for end-loaded effects, occurred in the 2010 *Specification*. The rationale used to support the change is described in "Bolt Shear Design Considerations" in the first quarter 2010 edition of *Engineering Journal* (read at **aisc.org/ej**). The steel quiz in the March 2014 issue (read at **modernsteel.com/archives**) provides a good refresher on end-loaded effects. A discussion on thread reduction area is provided in Section 4.3 in AISC Design Guide 17: *High Strength Bolts – A Primer for Structural Engineers* (download for free at **aisc.org/dg**).

When evaluating the strength of an existing Grade A325 bolt, you are permitted to use the 2022 AISC *Specification*. Section 5.3.2 of the *Specification* states, "The available strength of members and connections shall be determined from applicable provisions of Chapters B through K and Appendix 5 of this *Specification*."

Caitlin Colsia

Beam to HSS Column Moment Connection

I am looking at Design Example 6.3 in AISC Design Guide 24: *HSS Connections* and had a question about the weld design (see Figure 1). The strength of the weld was not explicitly checked. Doesn't Table J2.5 in the 2022 AISC *Specification* require that both the base metal and weld metal be checked?

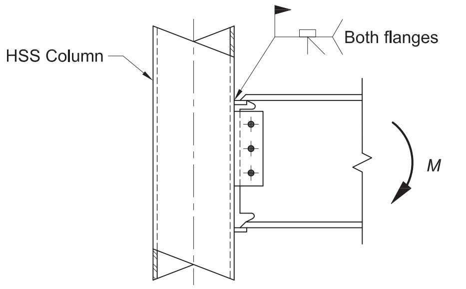


Fig. 1. Directly welded moment connection for Example 6.3

No. For the condition shown in the design example, Table J2.5 states, "Strength of the joint is controlled by the base metal." Since the strength of the joint is controlled by the base metal, the strength of the complete joint penetration (CJP) groove weld based on the weld metal does not need to be computed.

For CJP groove welds with tension normal to weld axis, "matching filler metal shall be used." For CJP groove welds with compression normal to weld axis, "filler metal with a strength level equal to or one strength level less than matching filler metal is permitted." These relationships will cause the strength of the weld to exceed the strength of the base metal.

Some additional information:

For moment connections, particularly moment connection to HSS columns, it is important to consider stiffness. Chapter 6 of Design Guide 24 (download for free at **aisc.org/dg**) states, "Moment connections are defined as connections where the transfer of moment forces is expected to occur and are classified as fully restrained (FR) and partially restrained (PR) in the AISC *Steel Construction Manual*. FR moment connections are sufficiently rigid to maintain the angle between the members at the joint when load is applied. A PR moment connection's behavior lies between the full rigidity of a FR moment connection and that of a simple shear connection.

"A PR connection can transfer moment to the supporting member, but the rotation is not negligible. The discussion in this chapter assumes the supporting HSS member is stiff enough to classify the connection as FR, as defined in AISC *Specification* Section B3.4b. Moment connections to unstiffened HSS columns with thin walls may behave in a semi-rigid manner. Design moments are limited to the yield moment produced by the plastification of the column wall, which is limited to a commonly accepted ultimate load deformation limit of 3%. Regardless of the shape of the column, developing full moment capacity of a beam often requires transverse column stiffeners to transfer axial loads in the beam flanges. For HSS column connections, these stiffeners can go through the HSS, internal to the HSS, or external to (or around) the HSS."

The Commentary to Section B3.4 provides guidance on how one can evaluate if a connection is fully restrained. This brings up a couple more points of consideration.

1. If the contract documents indicate an FR moment connection, but you have doubts that the connection detail is FR, you may want to seek clarification. Keep in mind that "developing full moment capacity of a beam [to HSS columns] often requires transverse column stiffeners."

2. Where column stiffeners are required, Section 3.2.4 of the *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-22) states, "(a) These items, if required, shall be designed by the *ODRD* and shown in the structural *design documents* so that the quantity, detailing, and fabrication requirements can be readily understood, or (b) Where *connections* and member reinforcement are specified to be designed by a licensed *engineer* working for the *fabricator*, the *ODRD* shall provide project-specific schematic details for member reinforcement with sufficient information for a *fabricator* to obtain an accurate bidding quantity and any limitations regarding the type and connection of member reinforcement. If no quantities or conceptual configurations are shown, member reinforcement at *connections* will not be included in the bid."

Larry Muir, PE

Caitlin Colsia (**colsia@aisc.org**) is a staff engineer in AISC's Steel Solutions Center. **Larry Muir** is a consultant to AISC.

steel quiz

Brace yourself for this month's quiz on vertical bracing connections! Learn more with AISC Design Guide 29: *Vertical Bracing Connections – Analysis and Design*. This guide includes an overview of common bracing systems and connection arrangements, force distribution methods, and detailed design examples. Download your copy today at **aisc.org/dg**.

1 **True or False:** Corner type brace connections are statically indeterminate.

2 **True or False:** Typical center type (or chevron) brace connections, such as that shown in Figure 1, are statically indeterminate.

3 **Fill in the Blank:** The effective width of the Whitmore section, l_w, is determined at the end of the joint by spreading the force from the start of the joint ______ degrees to each side in the connecting element along the line of force.

4 **True or False:** Figure 2 illustrates an admissible force field according to the KISS (keep it simple, stupid) method.

5 **True or False:** For high-seismic applications (R > 3), the effect of frame distortion in the brace connections cannot be ignored.

6 **True or False:** When applied to the same completely designed connection, the uniform force method (UFM) will always produce a design capacity greater than or equal to that produced by the KISS method, parallel force method, or truss analogy method.

TURN TO PAGE 12 FOR ANSWERS

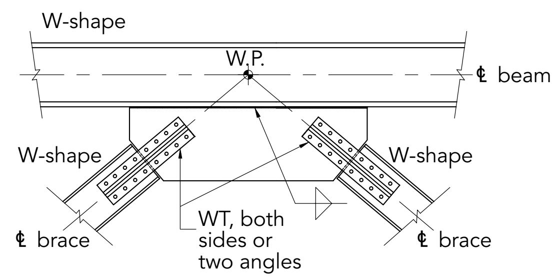


Fig. 1.

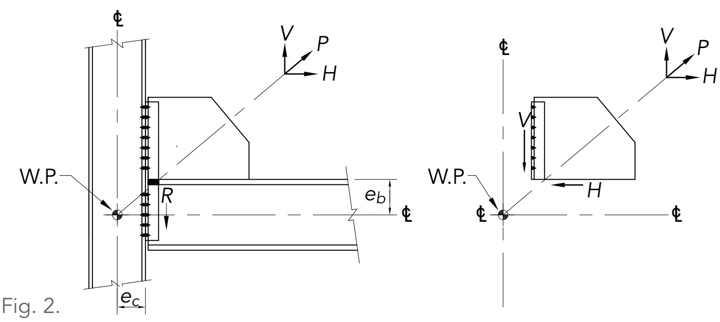


Fig. 2.


Designing for tomorrow, today

Answers reference AISC Design Guide 29: *Vertical Bracing Connections – Analysis and Design*. Download your copy today at **aisc.org/dg**.

1 **True.** Two types of bracing connections are generally considered in Design Guide 29: corner connections and central connections. Corner connections are statically indeterminate. There is no unique solution to the distribution of forces within these connections, but in accordance with the lower bound theorem, any solution that involves an admissible internal force distribution and satisfies all the limit states of the configuration (with appropriate steps taken to account for those of limited ductility) is an acceptable solution. Several acceptable methods for evaluating corner connections are presented in Chapter 4.

2 **False.** Unlike corner brace connections, typical central connections, as shown in Figure 1, are statically determinate, making the force distribution in them essentially unique. Section 4.1.2 discusses the most common approach to determine the force distribution for central or chevron type connections.

3 **30.** The 30° Whitmore section defines the maximum effective width of the load spread from the beginning to the end of the brace-to-gusset connection. When the entire Whitmore section is accommodated, the entire section is effective in resisting tensile and compressive forces in the gusset; thus, accommodating the entire Whitmore section will result in the minimum gusset thickness. If a smaller gusset is required, the spread angle can be taken as any angle between 0° and 30°. Such an assumption will result in smaller, thicker gussets (Section 6.1, page 303).

4 **False.** When using the KISS method, the horizontal component of the brace force is assumed to be carried through the gusset-to-beam connection, and the vertical component of the brace force is assumed to be carried through the gusset-to-column connection, as shown in Figure 2. However, unless couples are included at the gusset edge, neither the gusset nor the beam and column will be in equilibrium. Thus, omitting the gusset edge couples will invalidate the method. The KISS method is acceptable in its full form (with couples considered in the design) but does not provide the most economical designs. (Section 4.1, Figure 4-1).

5 **True.** Typically, distortional forces have been ignored in bracing connection design with no known negative consequences for non-seismic and low-seismic (R = 3) applications. However, because of the high drift ratios of about 2% to 2.5%, which produce very high distortional forces, these forces cannot be ignored in high-seismic design (R > 3). Section 4.2.6 discusses methods for controlling distortional forces, and Chapter 6 discusses design of bracing connections for seismic resistance.

6 **True.** The UFM is universally applicable and has been shown to produce safe and economical designs. When all four methods presented in Design Guide 29 are applied to the same completely designed connection, the UFM will always produce a design capacity greater than or equal to that produced by any of the other three. Appendix A provides a derivation and generalization of the UFM.

STEEL SOLUTIONS CENTER

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

Beyond the Base-ics

BY JOSHUA BUCKHOLT, SE, PE, AMIT KANVINDE, PHD, AND MAHMOUD MAAMOURI, SE, PE, PHD

Improve your knowledge of base connection design with the recently released third edition of AISC's Design Guide 1.

BASE CONNECTIONS ARE, quite literally, the foundation of every steel structure. They are a critical part of the load path in resisting design forces and are usually the first elements to be erected in a steel frame.

AISC Design Guide 1: *Base Connection Design for Steel Structures* has been a foundational document since the publication of its first edition in 1990. In June, AISC published the third edition of Design Guide 1 to expand and update the guidance available to designers and the steel industry for base connection design of steel structures.

Steel base connection design, at its most fundamental level, looks to transfer steel frame load reactions to the foundation by providing adequate strength and stiffness in an economical and constructible way. Base connection configurations vary depending on the intended use of the connection within the structure.

For example, details for exposed base connections (shown in Figure 1) use a base plate supported by a foundation and steel anchor rods embedded within concrete. Exposed base connections are prevalent throughout the construction industry and are supported by a long tradition of use in various configurations. An embedded base connection (shown in Figure 2) provides an alternative approach taken when force demands exceed those that can be accommodated using traditional exposed base plates.

In some common cases, base connections may also be embedded within a slab-on-grade, which conceals the base connection from view even though the slab-on-grade is not relied upon to structurally resist forces. Base connections subject to large shear demands may be configured with shear lugs to transfer shear forces from the base plate to the foundation without transferring significant shear to the anchor rods.

Base connections, whether exposed or embedded, must be proportioned to resist the force demand and provide adequate strength. Strength limit states pertaining to steel elements in exposed base connections encompass the steel strength of the anchor rods, stiffeners, shear lugs, base plate, and weld rupture. The strength of an exposed base connection and its anchor rods could also be limited by the concrete limit states of bearing, pullout, breakout, side-face blowout, or pryout.

Concrete limit state strength, such as concrete breakout strength, can be improved by using reinforcement, as shown in Figure 3. The strength of an embedded base connection is primarily developed by transferring forces through lateral bearing of the column flanges on the encompassing concrete. This is supplemented by vertical bearing stresses that resist the rotation of an embedded base plate (if provided).

Large uplift and shear force demands are expected for base connections taking part in brace frames, while large flexural demands are expected for base connections that are flexurally restrained and taking part in a moment frame system. Columns in the gravity load system may be subjected only to compression loads and see uplift or overturning demands mainly during construction. Added requirements for strength and ductility will be needed for base connections that form a part of seismic force-resisting systems in areas of elevated seismicity or are detailed according to the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341-22)

The stiffness of the base connection influences global structural response, especially under lateral loads. An evaluation of the stiffness of the base connection should be done and compared to its intended

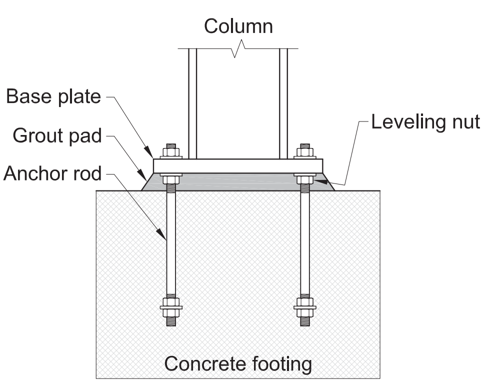


Fig. 1.

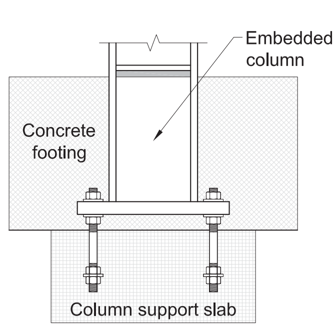


Fig. 2.

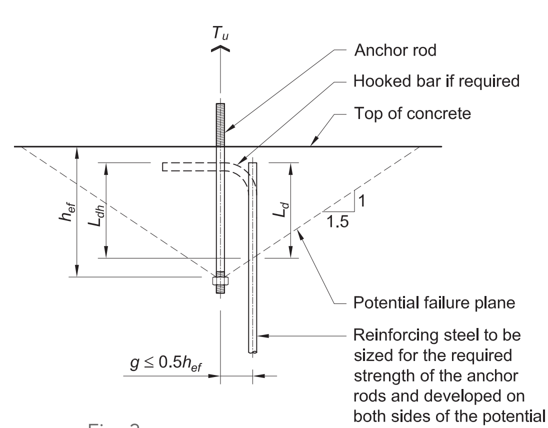


Fig. 3.

behavior. Underpredicted flexibility in a base connection may result in more story drifts and an unexpected distribution of forces within the frame. Conversely, underpredicted rigidity of a base connection may lead to unanticipated forces being drawn to that connection.

What's New in the Third Edition?

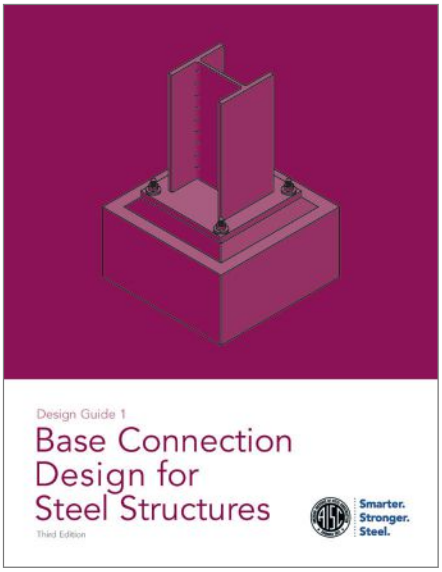
The third edition of Design Guide 1 is a significant expansion of covered topics relating to base connection design, in addition to updating previously covered material for alignment with current practice and design standards.

References to codes and standards have been updated to reflect changes since the publication of the second edition in 2006. The third edition also incorporates AISC-sponsored and independent research that has occurred in the interim. Although previously published material was maintained, it was reorganized to allow for new chapters, appendices, and practical design examples.

A noteworthy addition to the third edition centers around providing guidance for embedded base connections, shown schematically in Figure 2. Embedded base connections rely on intentional encasement in concrete to provide moment resistance at the base of a column when flexural demands are large, as may occur when structures increase in height or in level of seismicity.

Research and testing performed between 2010 and 2022 provided the scientific basis for a new chapter (Chapter 5) that summarizes the available research, outlines a design procedure, and walks through a design example. Another new chapter (Chapter 6) focuses on seismic design of base connections and discusses three overall philosophies for seismic design of base connections.

The first philosophy in Chapter 6 involves designing a flexurally fixed base connection for the fully yielded and strain-hardened capacity of the column, thus promoting ductility within the column and elastic behavior within the base connection. The second philosophy encourages a ductile failure mechanism within the anchor rods, resulting in a potentially lower force demand than the



first philosophy but imposing added rotational demands on the connection. The third design philosophy addresses pinned connections in which the connection must account for the rotational demand on itself without losing the ability to transfer shear forces.

New appendices address emerging and alternate topics about base connection design. An alternative way of accounting for base plate flexibility to reduce the required base plate thickness for base connections subject to compression is included, in addition to guidance on base plates subject to two-way bending. A new appendix (Appendix C) outlines guidance for simulating column base connections in a global structural analysis for exposed column base connections, base connections with incidental shallow embedment, and intentionally embedded base connections. The final appendix provides guidance on using finite element approaches in the analysis and design of exposed base connections (shown in Figure 4).

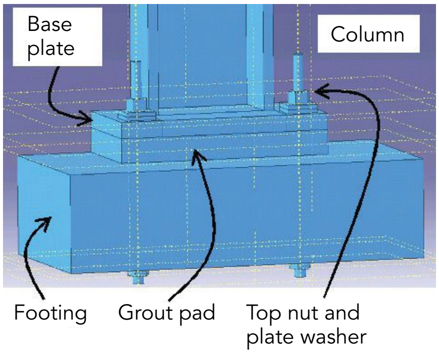


Fig. 4.

Organization

All told, the third edition consists of six chapters and four appendices. It begins with introductory content and outlines the history and research up to the current edition. A chapter addressing materials used in base connection design is followed by a chapter on the roles of base connections in overall system behavior. The next two chapters focus on conventional exposed base connections and embedded base connections, respectively. The last chapter pertains to seismic design criteria.

The guide concludes with appendices addressing special conditions such as pretensioned joints, alternative methods of design, base connection stiffness, and finite element analysis. Additionally, downloadable software that facilitates embedded column base design and calculation of base connection stiffness is included in the Design Guide 1 Bonus Materials, available at **aisc.org/dg1**.

Chapter 1 is an introductory chapter describing the scope of the third edition and how it relates to the hierarchy of building codes and standards. Commentary on relevant history and advancements then follow, in which earlier editions of the design guide are discussed and new research is introduced.

Chapter 2 summarizes material criteria pertaining to base connection design. It outlines the material standards recommended for base plate, anchor rod, weld, grout, and concrete materials.

Chapter 3 examines system issues that affect base selection, design, and simulation. A discussion of base connection configurations, direction on where within the guide to find other information, and strength and stiffness criteria are additionally outlined.

Chapter 4 makes up the bulk of design guide content and focuses on the design of conventional exposed base connections. Design procedures and examples are provided for many loading types, including compression, tension, shear, bending, and combined loadings. Sections on reinforcing concrete at anchors, base connection fabrication, base connection installation, and base connection repair are also added or expanded.

Chapter 5 is a new chapter in which the design of embedded base connections is introduced, and procedures and an example are provided. Approaches for resisting flexural demands at the base of the column using different approaches are delineated. Factors affecting fabrication and installation are discussed.

Chapter 6 is a new chapter which addresses the design of column base connections for seismic loading. It provides a research update and overview of differing expectations and approaches for the seismic design of base connections. An example stepping through the process of designing a base plate connection with ductile anchor rods is provided.

Appendix A includes special considerations for double-nut joints, pretension joints, and special structures and holds information brought forward from the second edition of the design guide with minor updates to reflect changes in reference documents.

Appendix B provides alternative methods for design, including alternative pressure distribution philosophies between the concrete or grout and the base plate. The triangular stress distribution is carried forward from the second edition, but new sections for the design of base plates considering plate flexibility and two-way bending are added.

Appendix C is a new appendix with guidance for simulating column base connections in structural analysis. The factors of base connections that contribute to their flexibility are discussed and approaches to predict their values are presented.

Appendix D is a new appendix that provides guidance for using finite element analysis in designing exposed base connections. Sections on model construction, geometry, boundary conditions, contact/interactions, element type, verification of results, and interpretation of results are included.

Web-based tools associated with Design Guide 1 are available. The third edition features bonus material—posted online at **aisc.org/dg1**—that provides web tools to facilitate base connection design and simulation. These web tools include strength calculation tools for embedded base connections, and rotational stiffness estimation tools for various types of base connection configurations.

Design Guide 1, Third Edition aims to build on basics, providing a meaningful distillation of that research into a practical form that users can readily put into application. Design examples are also provided for many common and unique design scenarios. Updates for current codes and approaches—combined with other information on seismic design and embedded base connections—increase the usefulness of the design guide for design and educational purposes. ■

Download Design Guide 1, Third Edition or purchase a copy at ***aisc.org/dg****. Downloads are free for AISC members.*

Joshua Buckholt (**jbuckholt@csd-eng.com**) is a vice president at CSD Structural Engineers, **Amit Kanvinde** (**kanvinde@ucdavis.edu**) is a professor of civil and environmental engineering at the University of California–Davis, and **Mahmoud Maamouri** (**mmaamouri@csd-eng.com**) is an executive vice president at CSD Structural Engineers.

Riveting Research

INTERVIEW BY GEOFF WEISENBERGER

University of Notre Dame professor Ashley Thrall quickly immersed herself in engineering when she discovered it after college, and she's now a respected researcher who runs a cutting-edge campus laboratory.

ENGINEERING WAS NOWHERE on Ashley Thrall's career path considerations until she read a book on structures while exploring options after graduation. Once she picked that route, though, she had a sole focus: becoming a professor.

Thrall's first teaching job—and so far, her only one—has helped her become a respected voice in steel research and instruction, particularly with bridges. She is the Myron and Rosemary Noble associate professor of structural engineering at the University of Notre Dame and also directs the school's Kinetic Structures Laboratory.

This summer, Thrall was also one of AISC's two Innovation Scholars, a new AISC program designed to boost collaboration on a steel-focused project to be performed in conjunction with the scholar's university. It involves a two-week summer residency at AISC's headquarters in Chicago.

Thrall spoke with *Modern Steel Construction* about her research, path to Notre Dame, the Innovation Scholar experience, and more.

Where are you from and where did you grow up?

I'm from a small town in Connecticut. My mom is an artist, and my dad is a scientist. He was a professor at the University of Connecticut, so I grew up in a world of art and science together.

When did structures come into the picture?

I came across them later. I didn't really know much about engineering growing up. I went to Vassar College, which is a liberal arts school in Poughkeepsie, N.Y. It didn't have an engineering track. I got a physics degree there, though my mom taught me that I should always have an art class, so I took art classes as well. I was doing printmaking, drawing, and learning art history to keep my creative side active alongside my research and studies in physics.

When I graduated, I wanted to find a career where I could integrate creativity with science. I did a little soul searching and eventually read *The Tower and the Bridge* by the late David Billington, a former engineering professor at Princeton University. It's all about structural art—structures that are economic and efficiently use materials but are also very elegant. That combination of science and art really brought me to engineering.

I emailed David when I was in grad school at Princeton and asked if he could take me on as a master's student assistant. He did, and he taught me structural analysis one-on-one in his office. He took time out of his day to teach me and help me catch up so I could succeed in a graduate program. He was amazing and is one of the greatest figures in my life.

Did you work on the design side before getting into academia?

I went straight from doing my PhD at Princeton to academia. That comes from my father's influence, where he taught me the freedom of academia. You study what you want to study and work with young people all the time. It keeps you young and in an exciting environment. Seeing that growing up, I wanted to go that route as soon as I committed to engineering. I was hired at Notre Dame in 2011, shortly after completing my PhD, and that was my first teaching position.

Can you describe the feeling of being in front of a class for the first time as a professor?

It gave me a new appreciation for all the professors who taught me. As a student, I was always in the front of the class asking tons and tons of questions. Seeing the other side of it where I'm answering all the questions was a very different feeling. Getting used to guiding people and understanding the preparation necessary to give even one lecture made me gain another level of appreciation for everyone who taught me in class.

It was a lot of work, and the first lectures were a lot. Then you get into the rhythm of it, and it feels easier and more comfortable. I teach statics for sophomores in the fall and then bridge engineering for our senior class and first-year grad students in the spring.

Can you explain the kinetic structures lab you work in at Notre Dame, which I assume focuses on structures that move?

We study the design and behavior of all kinds of moving, modular, and rapidly deployable structures. Some of my projects have been origami shelters using composite materials—deployable shelters for the U.S. Army, for example. A lot of the work I'm currently doing is in steel bridges, which is part of my interest in working with AISC. I've focused on modular steel bridges and thinking about different ways to build them faster and better.

What's the genesis of a research project? Does somebody come to you and ask you to do research on a topic, do you come up with the ideas, or is it a combination?

I've been very collaborative with industry, so I've been working a lot with different industry partners and learning what their problems are, but also coming up with my own ideas. Some things come up organically. It depends on the project.

What are some of your most memorable research projects?

One of my recent ones relates to AISC: our work on built-up press-brake-formed tub girders. It builds off the work that Karl Barth, a professor and steel bridge-focused researcher at West Virginia University, did on press-brake-formed tub girders made of one single plate of steel. We're looking at built-up sections with flat flanges bolted on the cold-bent webs to make longer spans and to harness the internal redundancy that Rob Connor at Purdue has researched.

In four years, we went from a new concept to two built bridges. One of those, the State Route 32 bridge over Stony Creek near Indianapolis, won an AISC/NSBA 2024 Prize Bridge Award (Read about that project in the July issue at **www.modernsteel.com**). Our project was funded by the Indiana Department of Transportation (INDOT), which was willing to build two demonstration bridges. INDOT was instrumental in providing research funding and the investment in the bridges themselves. It was collaborative, with HNTB serving as the design team.

Thrall (lower right) and her graduate students inside a built-up press-brake-formed tub girder.

Do you have something you want to work on in the future, like a dream research project?

In my time as an AISC Innovation Scholar, I'm trying to look at next steps. A lot of my recent work is focused on modularity and thinking about redundancy. But that leads to heavy solutions, because you're designing for the worst case of everything. But I'm thinking about sustainability now and how it fits into the mix.

Where is the sweet spot between sustainability and minimal material use with the modularity and redundancy work I'm already doing? That's why I wanted to be an Innovation Scholar, and why I want to think about new ideas and where to go next.

What's a common piece of advice you give to students starting their engineering careers?

Have open ears, because you can learn something from everybody. On my research projects when I've been out in the field, I learned a lot from ironworkers and bridge painters. Just pick people's brains to learn new things, because you're going to see different perspectives. Lose your ego and learn as much as you can from everybody.

What first attracted you to the Innovation Scholar program?

I learned about it through AISC emails, and I attended the education luncheon at NASCC: The Steel Conference in San Antonio this year. I thought it was a great opportunity to learn more from the industry, and a lot of my best projects have been collaborative with the industry. I figured the Innovation Scholar program would set up a bigger network for a project.

I'm on a teaching sabbatical for this academic year. I took this year as a launching-off point to come up with new ideas and work on them throughout the year. It was great timing and a good opportunity to get to know AISC. This year, I'm based at home, but I'm doing more research visits and attending more meetings and conferences. The time at AISC was the first of them.

Do you have any personal travel planned during sabbatical, and even if not, what location is at the top of your list?

The top of my list for personal travel is Easter Island. I want to see the Moai sculptures. That goes back to my foundation with my mom, art and creativity, and all the engineering that had to go into building those.

What have you grown to enjoy about living in South Bend since 2011, and what should visitors know?

You have to stop by the university if you're there. It's a beautiful place and it's like working in a park. There are a lot of innovative people there. ■

This interview was excerpted from my conversation with Ashley. To hear more from her, listen to the November Field Notes podcast at ***modernsteel.com/podcasts****, Apple Podcasts, or Spotify.*

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

Seeking Continuous Improvement

BY CHRISTIAN CROSBY, PE

Employing the Deming cycle can improve your fabrication business, but it must be done with intentionality.

EARLY IN MY CAREER, I had the opportunity to work with two well-respected quality systems professionals who helped me understand the premise of "you don't know what you don't know."

Under their mentorship and leadership, I acquired an immense amount of knowledge about quality management systems. They were intentional about providing a vast array of topics and authors to broaden my horizons within the field. In my studies, I noticed several reappearing authors, and one stood out: W. Edward Deming.

The first of the many texts those mentors encouraged me to read was Deming's *The New Economics*, wherein he outlines an improved management method by employing systems thinking and refers to his ideology as the system of profound knowledge. Years later, I am still compelled to offer a heartfelt thank you for those mentors' time discussing and answering countless questions on Deming's ideas with me.

Deming's 14 principles, which encompass the system of profound knowledge, resonated with me. However, it took many years before I connected a few dots as to their application to structural steel fabrication. Dr. Deming does not have all the answers to our industry's problems, but he offers many tools to aid in our endeavors in moving our organizations in a positive direction, and it's our responsibility to apply his tools with intentionality.

One tool I have found especially helpful is the Deming Cycle. Over the years, I have shouted from the hilltops and pontificated over libations about the merits of employing this idea. And like many others, I have confused the Deming Cycle with the PDCA Cycle. Not until recently, while reading Edward Martin Baker's book *The Symphony of Profound Knowledge*—did I realized the error in my ways.

Both cycles have origins dating back to Galileo, C.I. Lewis' conceptual pragmatism, and the Shewhart cycle. Sometime in the 1950s, the theories diverged: Deming evolved the Shewhart cycle, while the Japanese quality community did the same with the PDCA Cycle. Deming continued his work through the 1980s, and in the early 1990s, he named his cycle "PDSA Cycle and Model for Improvement." A model to improve the organization rooted in four questions: What are we trying to accomplish? What changes do we need to make? How will we know that a change is an improvement? What change can we make that will result in improvement?

This model uses the four familiar steps: plan, do, study, and act.

Planning involves defining the objective, purpose, and questions. Then, outline the hypothesis and predicted outcomes. Finally, planning how to do the "doing": the who, what, when, where, and how.

The "do" step is simple: execute the plan. Along the way, document problems and observations. Record notable data.

The third step is analyzing the data and observations. Study, scrutinize, investigate, contemplate, examine, and digest the outcomes. Document what was learned.

The final step explores actions that should be taken. What changes should be made? What does the next cycle look like? Do we need another cycle to understand what we discovered? What steps should be implemented to move the organization in a positive direction? An organization can employ this tool on repeat as a part of their continuous improvement process.

The PDCA cycle, though, has no emphasis on study; instead, that step is a mere "check," which is more about the successful completion of the "do" step. Did we successfully complete the planned action? Check yes or no. The Deming cycle focuses more on predicting the results of a cycle during the planning step, gathering information during the "do" step, studying the actual results, and comparing them in the "act" step for revisions to the next cycle.

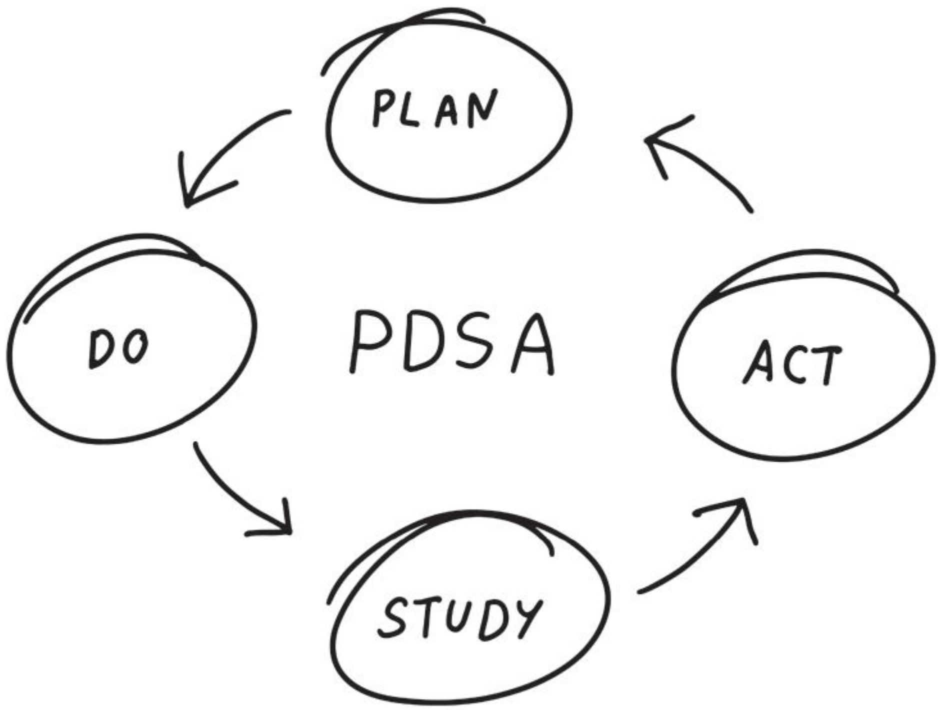
One could argue that "study" and "check" are interchangeable, however, I would submit for your consideration that they are not. The difference is studying takes the time to understand results and think about what the data says. It requires a high level of commitment, intentionality, and obligation beyond just "checking" the box pass or fail.

So, how does this apply to structural steel construction?

Plan

We talk all the time about planning, but what does that mean? Planning is the process of establishing the goals and objectives of a project and determining the resources, actions, and equipment needed to achieve those goals and objectives—and predicts the desired results. This step is universal regardless of the task: estimating a project, detailing a project, purchasing steel for a project, developing a fabrication plan, developing a site-specific erection plan, and many others.

Let's face it, there are times when our planning is no more than, "I plan to unroll the drawings the day we start the project." It happens more than any of us care to admit, but the outcomes from a lack of intentionality remind us why planning the work is crucial. I learned at an early age that if I fail to plan the work, I should not expect a positive outcome. Pre-planning is a proven method to increase the probability of a successful outcome. In my tenure in this business, I have seen too many people fail to plan their work and then spend their energy firefighting the entire project.



Do

Execution of the plan. This is our favorite part, right? We don't get paid to sit around. The planning step involves thinking, writing, discussing, and rewriting. These tasks can seem as if we are not "doing anything" and instead just sitting around and talking, but when the pressure rises, we are tempted to rush through planning or skip it altogether so that we can get on with the doing. I can hear a past supervisor yelling, "Don't just sit there, Crosby, do something."

Even poor planning can increase the probability of a successful outcome. I still clearly recall a complex box girder project that reinforced the need for planning. These boxes had stiffeners and shear tabs in a small space, which required pre-planning the proper sequence of fitting and welding to avoid building ourselves into a situation where we could not access a weld. In our rush to do something, we failed to plan the work and ended up cutting out parts to complete the inaccessible welds. We were justified in our rush: the designs were late, shop drawings pushed, approval took longer than expected, and the customer wanted the hook accelerated. Sound familiar? Lesson learned: planning before doing.

Study

Evaluate results and dive deep into the outcomes to improve future performances. One of my early career mentors was a well-seasoned journeyman named Fred Haas. He consulted with the small fabrication shop where I cut my teeth in the early 1990s. One of his many lessons was to perform a postmortem for each project, no matter the outcome.

Fred wanted an explanation of why a project performed well, poorly, or better than expected. Why did this project have a good outcome? Why did this project not meet expectations? What was learned? What went well, what could have gone better, and what are we going to do differently next time? Which processes, methods, materials, equipment, and training, performed well? Which did not? Fred required intentionality about understanding what drove our results.

Act

The "act" step is the change in the process or system. It's the payoff for the time, energy, and effort. Unfortunately, we're often too busy to study the outcomes and are bound to repeat the same missteps.

I recall one of my former employers held project close-out meetings where we discussed the results—not unlike what Fred Haas taught. Looking back, I can see that we repeated many of the same errors time and time again but never acted on our studies to make meaningful change in our processes and procedures. We planned the work, executed the plan, and studied the results, but failed to implement change. We were not intentional in our efforts to move the organization in a positive direction and thus repeated the same mistakes.

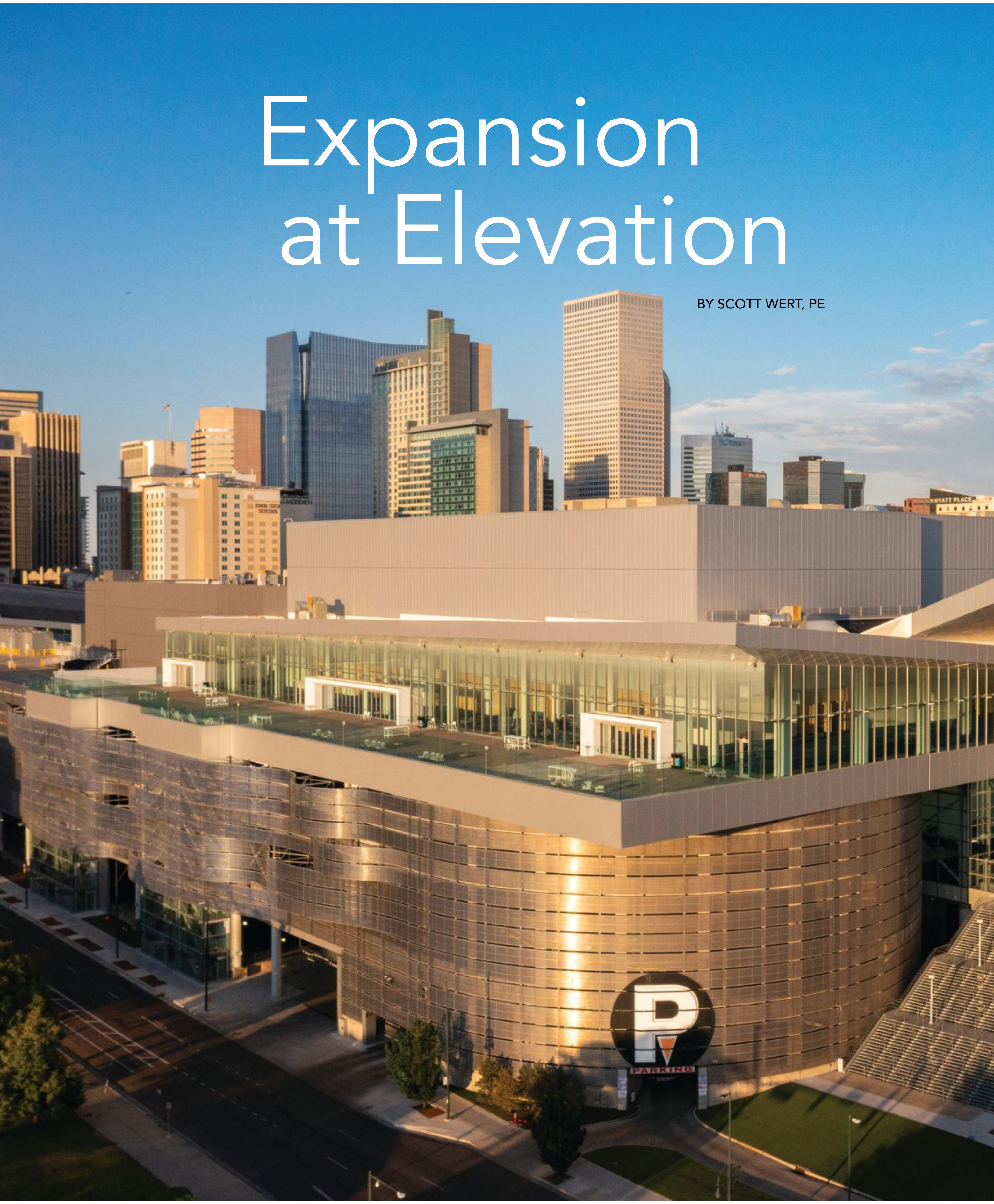
An organization can apply the Deming cycle to any project or its operational processes. The key to success with this tool is intentionality, determination, purposefulness, and awareness. If an organization sees value in the Deming cycle but is not intentional in its activities, it should not expect positive results. Planning the work, executing the work, studying the results, and making changes is an excellent method to move an organization in a positive direction, but the effort must be intentional.

And to those mentors who introduced me to the good doctor so many years ago, thank you. ■

Christian Crosby (**Christian.crosby@schuff.com**) is the senior vice president of fabrication at Schuff Steel.

Expansion at Elevation

BY SCOTT WERT, PE



A massive addition to Colorado Convention Center created dynamic open spaces with long-span trusses and a creative erection plan.

All photos courtesy of Martin/Martin, Inc. unless otherwise noted

COLORADO CONVENTION CENTER'S history of evolution and continuous improvement recently added a daring and creative expansion of contemporary event space to its ledger. In early 2024, the downtown Denver venue gained more ballrooms and attractive gathering spaces—all made possible with a clever steel frame design constructed directly above existing exhibit halls and a parking garage.

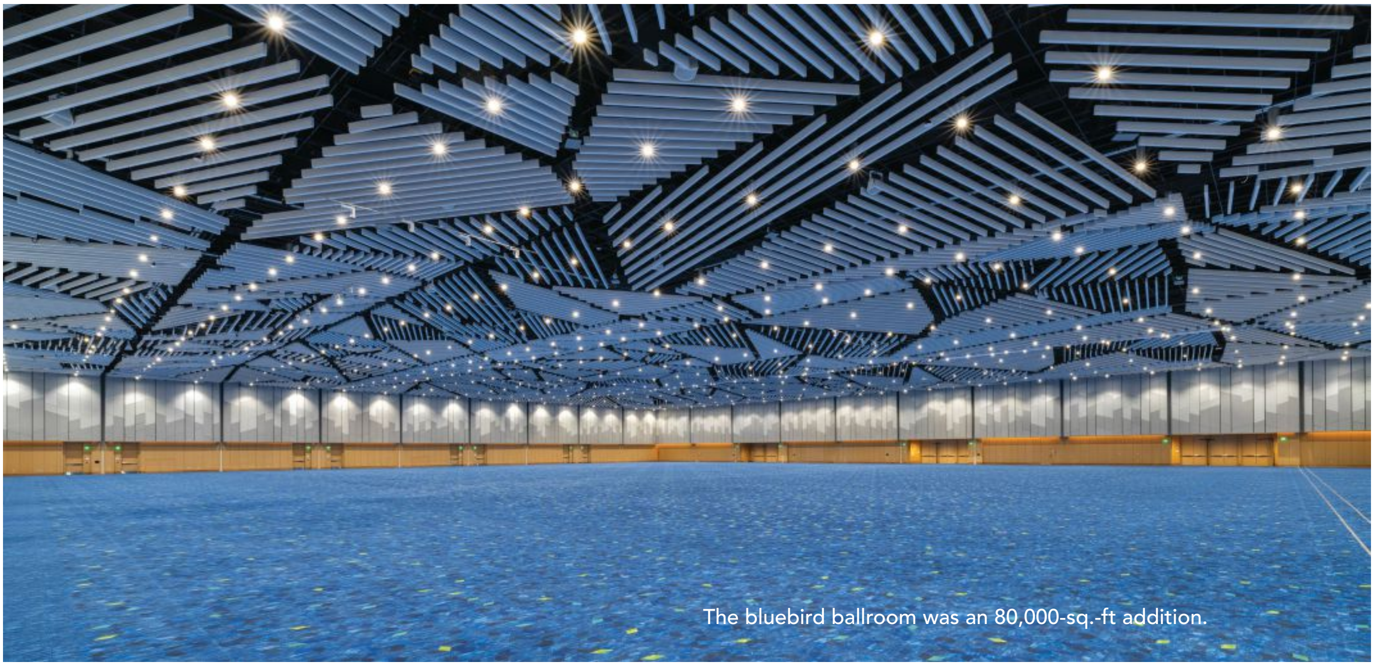
At nearly 2.5 million total sq. ft, Colorado Convention Center is among the largest convention centers in the country and now boasts significant improvements delivered by the $233 million overbuild expansion project. The project added an 80,000-sq. ft column-free ballroom, a 20,000-sq. ft outdoor terrace, and 35,000-sq. ft of pre-function lobby spaces to cater to any large event's needs. In total, 8,362 tons of steel form the new long-span floor and roof structures, which have numerous customized assemblies where framing interacts with existing structure elements.

Like any addition, the additional ballroom space needed to fit into the existing building architecturally and structurally. A new cantilevered roof over the pre-function and terrace spaces mimics the iconic cantilevered blade roof of the original architecture. Likewise, the architects designed the new ballroom and pre-function spaces to transition seamlessly from the existing lobby spaces.

Ballroom Ballet

Structurally, the existing building column grid at the expansive exhibit halls dictated the same bays and truss spans at the new ballroom floor, which is made up of 66 7.5-ft-deep trusses spanning the 90-ft distance to extensions of the existing 36-in. pipe columns. To form the high roof above, 27-ft-deep trusses span 270 ft across the three bays of the ballroom. Further, the shape of the addition's footprint avoids existing rooftop mechanical equipment and specific column locations that are transferred at a lower ballroom. All led to more efficient construction and lower costs.

The expanded Colorado Convention Center hosted the 2022 NASCC: The Steel Conference.


The bluebird ballroom was an 80,000-sq.-ft addition.

Challenging these constraints were the owner's minimum programmatic and square footage requirements. These space mandates resulted in steel truss cantilevers up to 34 ft to make up the floor area deficit. Similar cantilevers occur at the adjacent commercial kitchen and storage wing, where the roof trusses also cantilever beyond the standard column grid. A storage mezzanine level is suspended from the roof structure to help minimize overall structural depth of the wing.

The ballroom floor and roof trusses consist of W14 wide-flange chord and web elements with webs oriented horizontally and bolted flange plate connections joining each truss piece. Heavy truss sections, particularly at the roof truss chords, employed high-strength steel (ASTM A913/65-ksi) while connections used 50-ksi material to help limit connection lengths and plate thickness. Connection types were coordinated with fabricator and erector preferences, including designation of shop and field-assembled connections to provide for economical connections and maximum field tolerance, particularly between new truss elements and the existing structure.

Especially critical to ensuring a smooth erection sequence was detailing plenty of tolerance into the new floor truss to 36-in.-diameter round HSS connections. These customized connections consist of a new round HSS segment directly welded to the top of the existing round HSS columns. Collar plates connect the truss bottom chords to the round HSS. A thick cap plate at the top chord with vertical gussets connects the truss chords and webs to the column node using slip-critical bolts in oversized holes. These heavy-node connections transfer chord forces into the column and through the column where fixity is required and where truss cantilevers occur.

Columns extending up to frame the roof were then field welded to the top of the heavy cap plate at the top of the floor truss node assembly. The combination of field welding and bolts in oversized holes allowed the erector to adjust in the field based on as-built column locations and assembled truss lengths where they differed from the actual span between columns.

The bottom chords of the floor trusses were set tight to the existing roof with allowance for deflections, while truss depth was limited by setting the top chords and floor slab low enough to fit the adjacent pre-function space underneath the existing blade roof in the main lobby. Unique design criteria for the floor trusses included large crawler crane loading and vibrational performance under rhythmic activities such as concerts or dancing events.

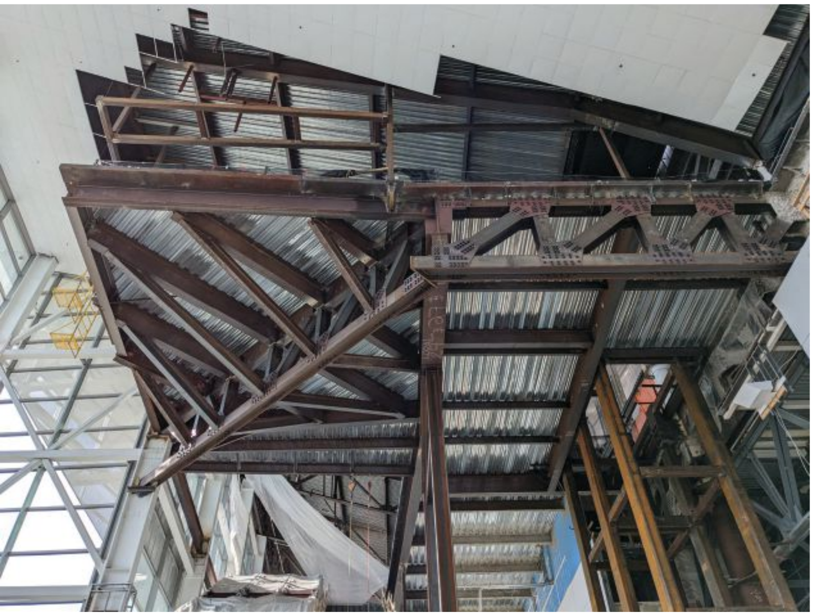
Roof truss design had to consider designated event rigging point loads and 32-ft-tall operable walls that allow the ballroom space to be divided into 19 separate spaces. Laterally, the floor and roof trusses participate in moment frames oriented in both directions by connecting both chords directly to the steel pipe columns, which deliver lateral forces to the top of existing moment frames.

Conventional composite steel framing infills the distance between floor trusses and is also present at the surrounding pre-function and terrace spaces. The outdoor terrace is framed over the existing precast parking garage and the attached cast-in-place helix access ramp. Deep plate girders were used at the terrace floor to transfer loads where new roof columns did not align with irregularly spaced existing garage columns, especially at the helix ramp.

The outdoor terrace is a highlight of the new ballroom space, delivering a unique experience and excellent views of the Rocky Mountains. The terrace includes a 40-ft cantilever placed at the corner of the building and formed by 63-in.-deep plate girders that cantilever beyond the helix ramp structure, with diagonal bracing between flanges. This bracing stiffens the framing and increases the natural frequency of the cantilever with the aim of improving vibrational behavior.

The ballroom addition capitalizes on previous phase foresight and experience designing convention spaces with future development and adaptability in mind. During a previous addition completed in 2004 (Phase 2), the primary structure was designed to accommodate future expansion, including allowances for future floor and roof gravity loads, and specific maximum lateral forces at braced frames and shear walls.

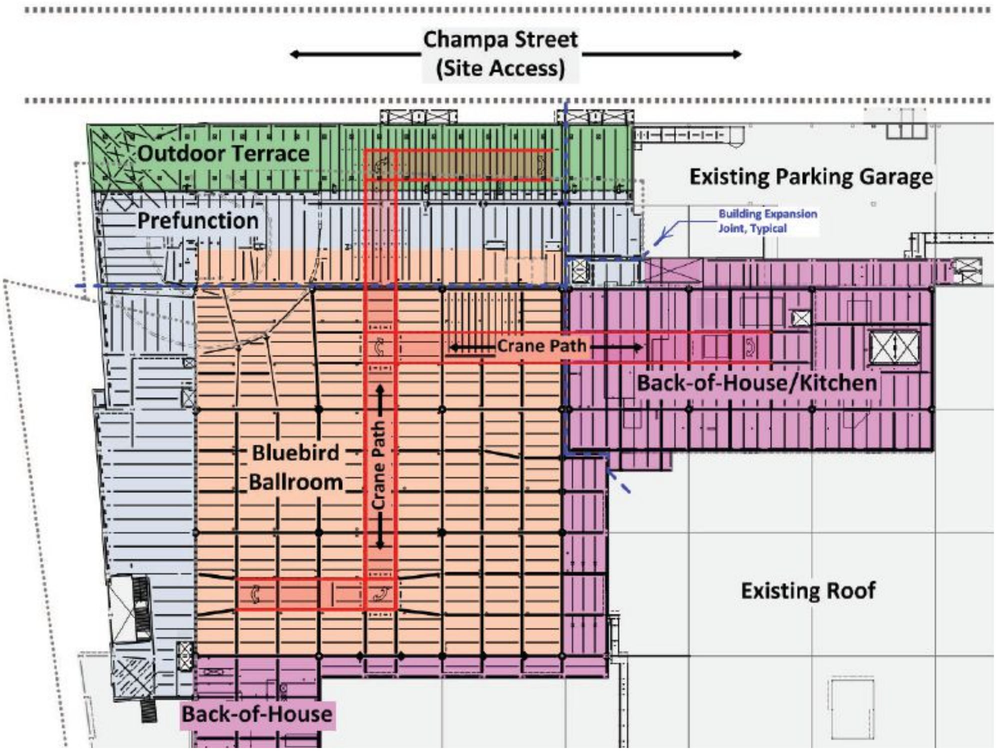
The Phase 2 planning led to the unusual circumstances under which these renovations required minimal strengthening and retrofitting at primary structural framing and foundations. Pre-planning allowed the large-diameter steel pipe columns to be filled with concrete for enhanced lateral frame stiffness and increased axial capacity for new building loads. Other retrofits within the existing building focused on supporting and making room for new escalators, elevators, and stairs to reach and egress the new ballroom space.



above: A floor truss attached to a column node.

left: The pre-function lobby framing.

below: Pre-function lobby spaces were part of the expansion.



above: A diagram of the crane path.

below: The crawler crane erecting a roof truss.

Crane Creativity

Erection of the long-span floor and roof elements required creativity and extensive coordination between the general contractor, steel erector, and structural engineers. With maximum truss pick weights of 70 tons and the maximum extent of the addition measured from the street and tower cranes of 475 ft, there were few feasible and safe methods of erecting. Instead of using a large tower crane or positioning intrusive fixed cranes within the existing building footprint, an audacious plan to operate a mobile crawler crane above the existing roof was pursued.

With all counterweights installed, the LR1300 crane weighed 500 tons, and the new ballroom floor framing was designed to carry the mobile crane and loads from maximum erection sequence picks. The crane's 470-ft reach and 330-ton pick limits were reduced to a 120-ft reach and 75-ton pick to limit forces imparted on the floor trusses it was operating over. The contractor also had to protect and accommodate an operating convention center at the level below, adding further complexity to the chosen erection method.

Floor trusses were positioned directly below a planned path of travel for the crawler tracks, and the erector's engineer coordinated extensively with the design team to ensure those floor trusses met all strength and performance targets. The erection sequence began with floor truss construction ahead of the crawler, followed by concrete slab placement and cure to create the platform needed for roof truss erection.

The crane erected the long-span trusses and roof framing before backing its way out of the ballroom footprint and being de-mobilized at the terrace side of the expansion. Truss deflections were monitored during crane operations and compared to expected deflections to ensure safety of workers and that truss elements were behaving as expected while the crane moved around the floor area.

Tower cranes and a crawler crane on the roof were part of the steel erection plan.

An overbuild expansion of this project's scale is surely rare, and its success was the result of a collaborative and innovative design-build team working towards a common goal. Constructing upward with long spans presented numerous challenges, which were creatively solved with steel solutions that made the impressive expansion fit seamlessly atop the existing building. ■

Owner
City of Denver

General Contractor
Hensel Phelps Construction Co.

Architect
TVS Architecture and Design

Structural Engineer
Martin/Martin, Inc.

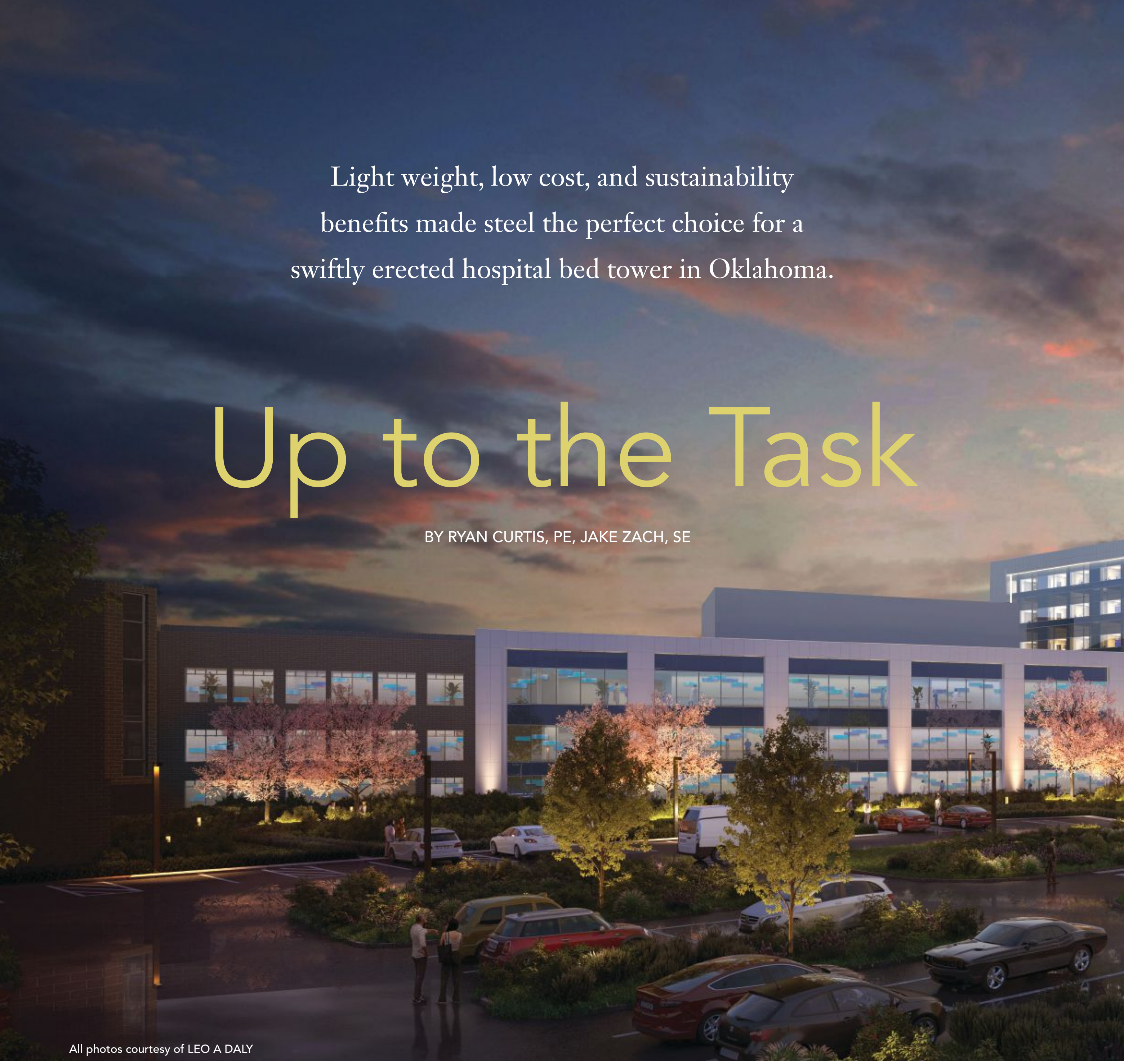
Steel Team

Fabricator and Detailer
W&W | AFCO Steel (AISC Certified Fabricator)

Erector
Derr & Gruenewald Construction (AISC Associate, AISC Certified Erector)

Erector's Engineer
Hassett Engineering

Scott Wert
(**swert@martinmartin.com**)
is a senior project engineer at Martin/Martin, Inc.



Light weight, low cost, and sustainability benefits made steel the perfect choice for a swiftly erected hospital bed tower in Oklahoma.

Up to the Task

BY RYAN CURTIS, PE, JAKE ZACH, SE

All photos courtesy of LEO A DALY

SAINT FRANCIS HEALTH SYSTEM felt the growing demand for more hospital bed space—and had the desire to meet it quickly.

It acted rapidly on its need and broke ground in 2023 on an eight-story patient bed tower addition to its existing hospital in Muskogee, Okla. The project included a 150-bed consolidation, a main entry in the new tower, and a new chapel and clinic.

The project's total estimated construction cost is $230 million, and its critical goals were to maintain focus on customer experience and modernization of the facility in keeping with the high-quality care that Saint Francis Health System delivers across northeastern Oklahoma. Saint Francis turned to LEO A DALY for architectural and structural design, and the latter's structural engineers worked with JE Dunn Construction in a construction manager at risk (CMaR) delivery method.

The project team relied heavily on a steel superstructure to keep the work on time and on budget—the result of thorough studies that revealed steel would best achieve its goals. All told, the project contained an estimated 1,700 tons of steel.

Steel Wins the Study

Upon onboarding JE Dunn Construction, LEO A DALY spent the early phases of project coordination analyzing the most efficient and value-driven superstructure to achieve the client's needs, architectural vision, and floor programming. Framing options included cast-in-place (CIP) two-way concrete floors, traditional concrete joists, and concrete on metal deck with composite steel beams and columns. Lateral systems investigated included CIP shear walls, steel moment frames, and steel concentric brace frames. The study identified several benefits to an all-steel system.

The bed tower is expected to open in 2025.

Foundation impacts. A CIP system estimate resulted in 60% to 70% more building weight, which would require much larger drilled pier sections and increase foundation concrete costs.

Seismic mass. The lighter steel building results in less seismic mass to resist: The building location and soil properties dictated a short-period spectral response acceleration parameter (S_{DS}) and a long-period acceleration parameter (S_{D1}) that resulted in the structure being designed within Seismic Design Category C. With a seismic response coefficient (C_s) of 0.076, approximately 7.6% of the additional weight of a concrete system would need to be resisted by the lateral elements. The lighter steel frame tower reduced this lateral load and subsequently allowed for efficient braced frame systems to be introduced into the lateral system.

Better carbon performance. Embodied carbon is the measure of the amount of greenhouse gas emissions associated with the production, installation, use, and disposal of a building's materials. A whole building life cycle assessment was performed using industry average data to estimate the impact of the bed tower construction.

Accounting only for the structural system, the estimated embodied carbon impact of the steel bed tower is 260 kg CO_2eq/m^2. Using an early-phase embodied carbon estimating tool called EPIC, it was determined that a concrete system of the same height and area would have an impact closer to 457 kg CO_2eq/m^2. The steel frame represented a more than 40% reduction in global warming impact. In total, the design team saved approximately 5,000 metric tons of CO_2eq from entering the atmosphere, equivalent to the emissions of more than 560,000 gallons of gas consumed in vehicles.

In addition to excellent carbon performance, more than 85% of the structural steel framing came from recycled materials.

above: The two-story lobby framing under construction.

below: A rendering of the completed two-story lobby and monumental stair.

A three-story structure connects the new tower to the existing building.

Scheduling. To meet an aggressive construction schedule, the design team and construction manager worked closely to develop dedicated design packages that allowed timely construction scopes to begin while the architectural and engineering teams were still in design phases with the owner. The agile nature of steel design allowed the team to iterate quickly through schematic design, which was submitted in fall 2022, and subsequent structural packages in December 2022, allowing foundation construction to commence. Steel shop drawing packages were submitted through summer 2023 and steel erection began in December 2023.

Spans. Longer spans allowed more spacious patient room layouts and nested toilet room locations. Typical bay size was 34½ ft by 30 ft, with beams spanning the longer direction and girders spanning the shorter direction. The flexibility of a longer-spanning steel frame system outperformed a more conventional cast-in-place system, providing optimal layouts to the patient rooms through the bed tower.

Available labor market: AISC structural steel specialists and the design team identified 14 certified fabrication shops and 12 certified erectors available in the region who could bid on the project. At the time of subcontractor bidding, the local labor market for iron workers was stronger than structural concrete trades. Bennett Steel was selected as the fabricator and erector, and a sole source for both assisted in coordination. Field measurements, erection aids, site trucking logistics, sequence detailing, and coordination of fabrication to support erection were all seamless.

Additionally, industry misconceptions on steel availability and pricing were clarified with assistance from AISC based on a deeper dive into inflating material costs. For example, during early design phases, the team learned rebar costs had increased more significantly than hot-rolled W-shapes, providing additional benefit of a predominantly steel solution.

An early foundation and earthmoving package and subsequent steel order allowed for construction to start while Bennett Steel was generating shop drawings and fabricating steel in their shop. Steel was at the jobsite ready for erection as soon as foundations were complete. Due to the project's size, steel erection could occur in some parts of the site while foundation work was ongoing in others. The design and construction schedule included a well-orchestrated changeover to the steel erector once piers were set and anchor rods were ready to receive columns. Approximately 18 steel sequences allowed framing to be erected and topped out in a seven-month period.

Open Spaces and Building Skin

The new main entrance features a two-story lobby. The volume's east and north perimeters feature curtain walls spanning from Level 1 to Level 3, maximizing daylight. Designing with steel allowed for increased flexibility—columns that had to span two stories unbraced were able to remain smaller in depth and width than concrete alternatives.

The project also modernized approximately 200 ft of the existing hospital's north façade. Part of this process was the demolition of an existing steel structure along the front of the building. The existing structure was constructed on a tight field of irregularly spaced piers that could not be removed and required careful coordination for the new piers for the replacement steel structure. Since the new piers could not always align with the steel above, concrete grade beams were used to support some steel columns and transfer forces to the foundation piers.

A monumental stair in the lobby takes guests from Level 1 to Level 2. Stringers were designed by the engineer of record, while the steps and their connection to stringers were delegated to Bennett Steel.

Standard vibration considerations for stairs are heightened for monumental stairs, because people often stop on them. That makes vibration perception a possible risk. In this case, an intermediate support was added to dramatically increase system stiffness and reduce the risk of perceptible vibrations. The design team utilized Design Guide 11: *Vibrations of Steel-Frame Structural Systems Due to Human Activity* (download for free at **aisc.org/dg**) as a resource in the design procedures.

On the north side of the building, a large blade-like wall extends approximately 15 ft beyond the building perimeter and approximately 20 ft above the roof. The blade provides visual interest and a surface for brand signage—and it also creates a hotspot for wind forces, acting like a parapet or sail. An isolated steel column collects gravity on the north end of the wall.

Beams at each level connect the main building column to the isolated column and act as a cantilever of the horizontal diaphragm to resist wind load. At the roof, building columns cantilever up to form the top of the wall. These columns had to be carefully designed to resist bending from the wind forces in combination with the building dead and live loads.

A large, thin, blade-like wall extends about 15 ft beyond the building perimeter and about 20 ft above the roof.

Flattening, Bracing, and Tying

Early in the design phase, the owner expressed interest in ensuring flat floors throughout the bed tower. The client was interested in shoring the deck during wet concrete placement due to past performance concerns around floor flatness, but the proposed shoring process would be time-consuming and costly.

To avoid shoring, the structural design team used Bentley's RAM Structural System to design framing members, using a percentage of construction dead load to determine required beam camber. Any later superimposed dead and live loads were considered for strength and serviceability design of the floor framing. The beam and girder cambers, assumed concrete ponding, assumed concrete density, and construction dead loads were communicated to the construction manager and flat-work team to ensure the pathway for success was achievable.

During initial floor pours, the concrete subcontractor found it could consistently pour to constant elevation and thickness to create flat floors. The resulting floors achieved FF ratings of 35, well exceeding the specified minimum requirement of 25.

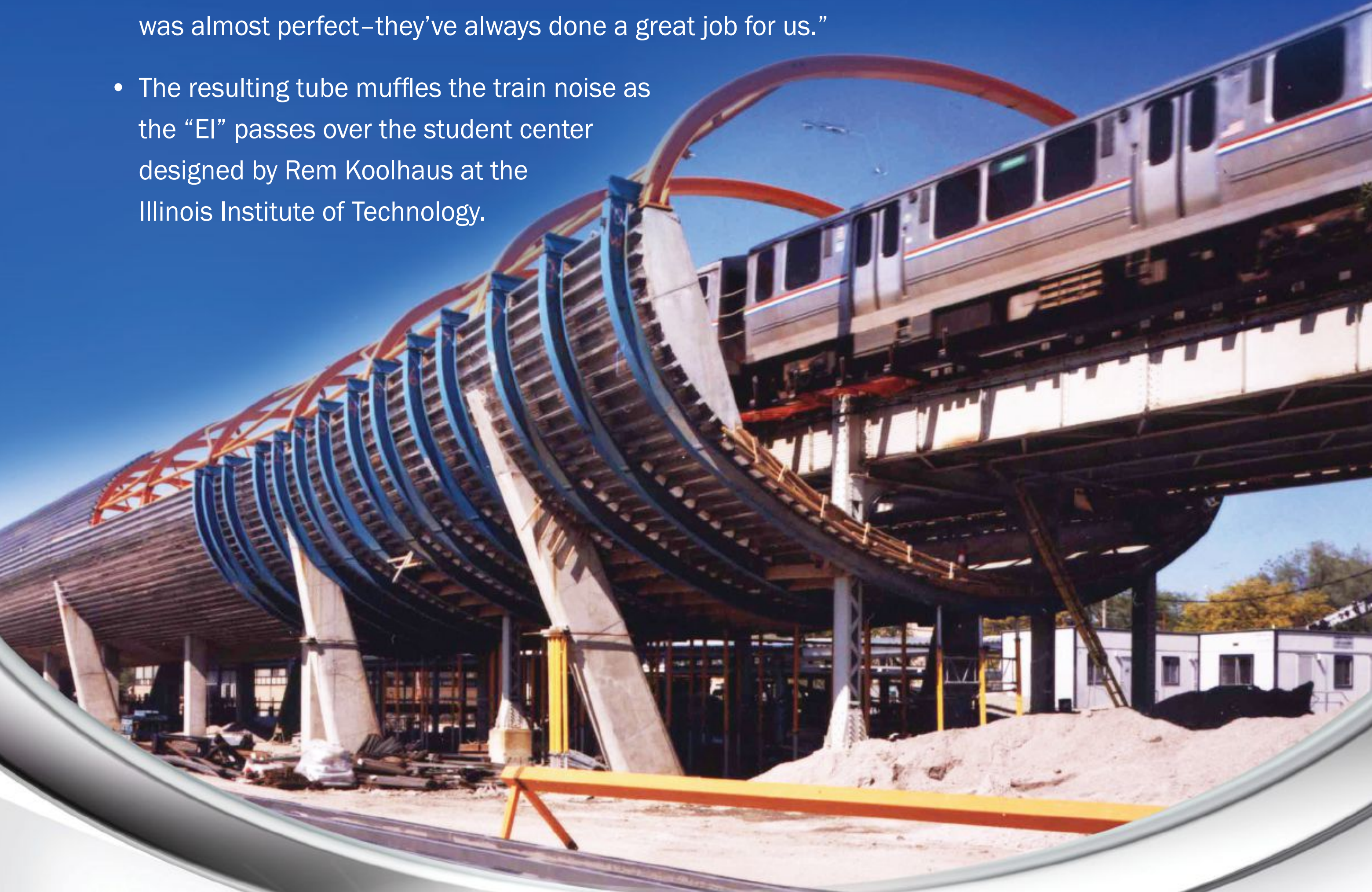
The building is approximately 350 ft by 150 ft, with the long side of the building oriented north-south. Single-bay steel braced frames oriented east-west are on the north and south perimeters. A concrete shear wall core, including two 60-ft-long east-west walls, is at the center of the building. These four elements make up the lateral system in the east-west direction. The core also contains two 30-ft-long shear walls in the north-south direction, which make up the north-south lateral system. The steel braced frames on the north and south perimeter were designed to resist any torsional behavior from the building.

Braced frames were selected for the north and south perimeter walls due to their inherent rigidity compared to moment frames, and they were easier and faster to erect than concrete shear walls. The braced frame connections were designed using Option 3 for delegated design in the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-22, **aisc.org/specifications**). Option 3, with a licensed structural engineer working for the fabricator, was Bennett Steel's preferred approach.

Braced frames on the north and south perimeter were designed to resist any torsional behavior from the building.

More than 85% of the structural steel framing came from recycled materials.

The building topped out in August 2024.



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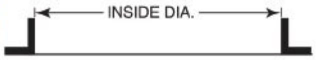

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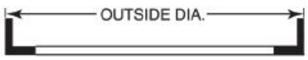
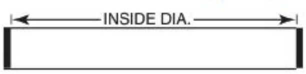


10" x 10" x 1" Angle

3 Flat Bar The Hard Way


24" x 12" Flat

4 Flat Bar The Easy Way


36" x 12" Flat

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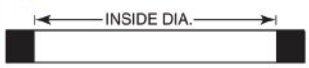

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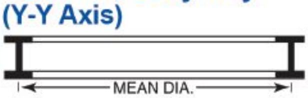

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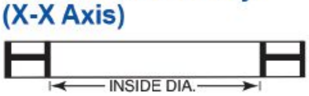
7 Beam The Hard Way (X-X Axis)


44" x 285#

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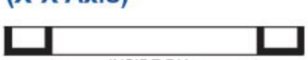
All Sizes

9 Channel Flanges Out


All Sizes

10 Channel The Hard Way (X-X Axis)


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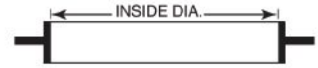
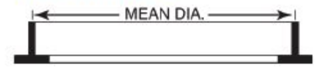
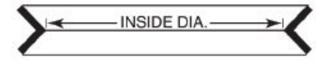


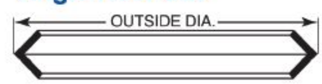
22" x 142 1/2# Tee

13 Tee Stem Up


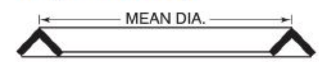
22" x 142 1/2# Tee

14 Angle Heel In


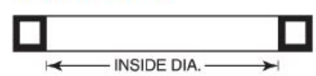
8" x 8" x 1" Angle

15 Angle Heel Out


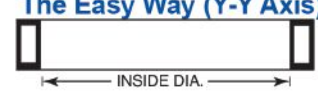
8" x 8" x 1" Angle

16 Angle Heel Up


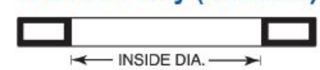
8" x 8"x1" Angle

17 Square Tube


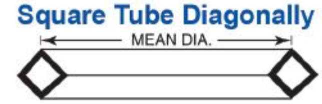
24" x 1/2" Tube

18 Rectangular Tube The Easy Way (Y-Y Axis)


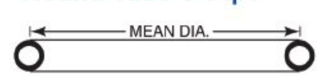
20" x 12" x 5/8" Tube

19 Rectangular Tube The Hard Way (X-X Axis)


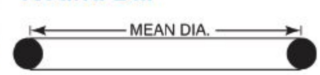
20" x 12" x 5/8" Tube

20 Square Tube Diagonally


12" x 5/8" Square Tube

21 Round Tube & Pipe


24" Sched. 80 Pipe

22 Round Bar


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The new tower's west façade.

Corner Challenges

The existing building featured many re-entrant corners along its perimeter, creating challenging geometrical conditions at the intersection of new and old construction. Structural steel could easily accommodate the geometry while maintaining expansion joints between new and existing construction. Additionally, the new tower is built at a plan angle to the existing hospital. Working with steel allowed for flexibility during construction, as it was easy and efficient to modify pieces when field conditions varied from what was expected.

All told, the project succeeded because it set and met an aggressive fast-track design and construction schedule covering everything from construction to design to submittal requirements. The schedule, which included early owner and construction manager input, was feasible largely because of the steel erection's speed and flexibility. The project is set for completion in the winter of 2025 and will serve its patients, staff, and community for many years.

Owner
Saint Francis Health System

Construction Manager
JE Dunn Construction

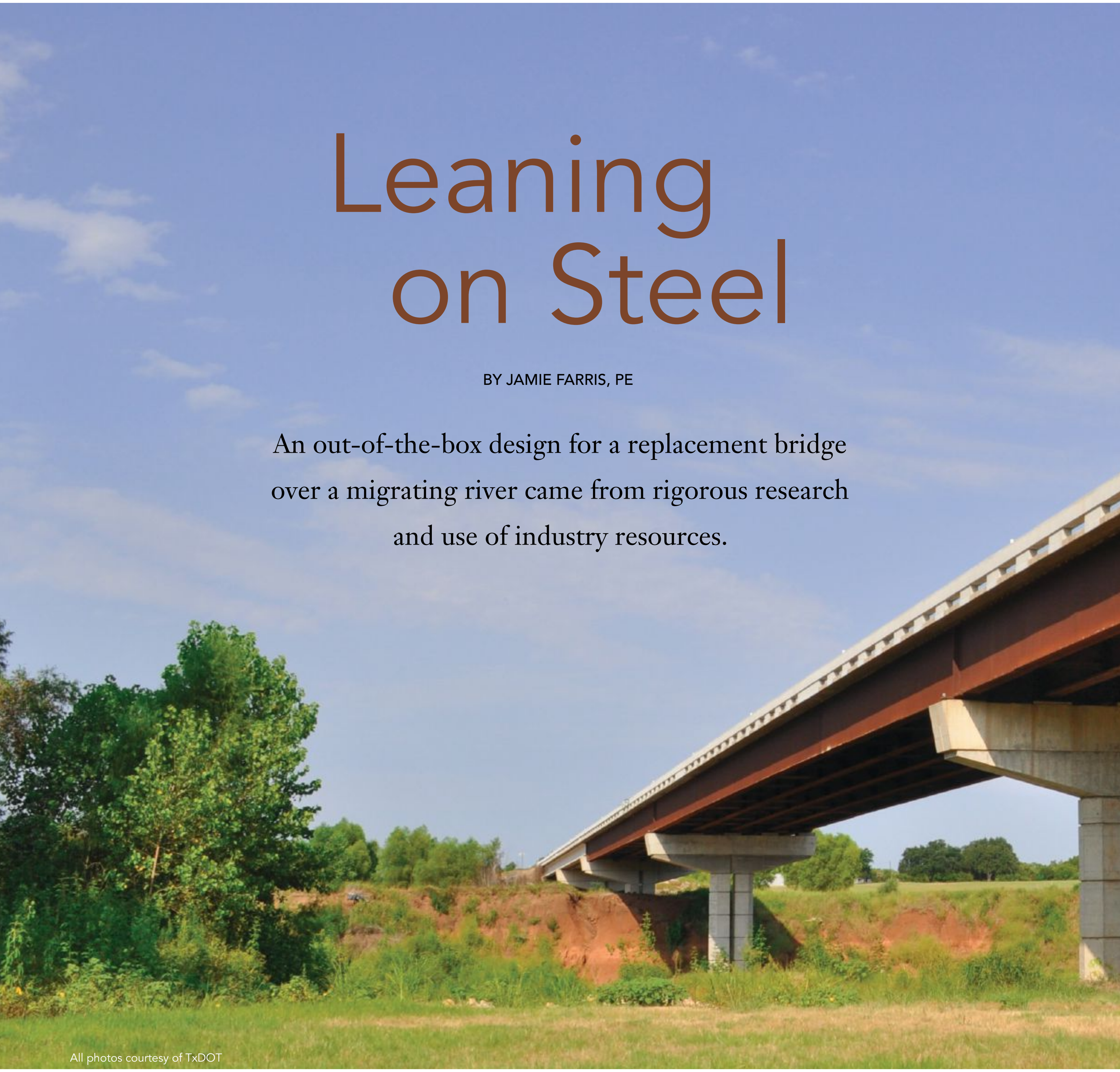
Architect and Structural Engineer
LEO A DALY

Steel Team

Fabricator and Erector
Bennett Steel (AISC Certified Fabricator)

Detailer
Axis Virtual Construction (AISC Associate)

Ryan Curtis is a former project manager and senior structural engineer and **Jake Zach** (jkzach@leoadaly.com) is a senior structural engineer, both with LEO A DALY.



Leaning on Steel

BY JAMIE FARRIS, PE

An out-of-the-box design for a replacement bridge over a migrating river came from rigorous research and use of industry resources.

THE BRAZOS RIVER discovered by Spanish explorers centuries ago is not quite the Brazos River that exists today—at least not in a rural area near Navasota, Texas.

The river is migrating south and has an active slope failure on the west bank where a bridge carried State Highway 105 over it. The Texas Department of Transportation (TxDOT) noticed those two natural circumstances and moved to replace the bridge before they could threaten the bridge's viability.

That replacement project became a venture into new steel bridge design territory, backed by thorough research.

A new long-span bridge with few environmental disturbances and all or most foundations out of the river was the ideal design for the site conditions. TxDOT proposed supporting the bridge, whose main span was designed to be 300 ft long, with single column bents founded on multi-shaft footings. The project was let for construction with two design options for the river crossing: steel I-girders or concrete spliced girders. The winning contractor, James Construction, LLC, chose steel for the long-span unit due to its economy, constructability at the site (it made using cranes possible), light weight, and the contractor's familiarity with steel bridges.

The replacement bridge was placed about 820 ft south of the original because of river migration predictions.

Before design started, the bridge's exact location had to be decided. Due to the slope failure region, the new bridge could not be placed adjacent to the existing structure. TxDOT also ruled out an upstream (north) placement due to the channel migration to the south and the flow being severely skewed to the proposed bridge. The only rational location for the replacement would be downstream (south) of the existing bridge, because the river's westward migration is likely to continue, and the team eventually chose a location about 820 ft south of the original bridge.

The first step in the steel girder option design process was determining the ideal type of girder—either an I-girder or trapezoidal box girder–and the number of girders for the transverse cross-section. The fact-finding process focused on the most economical means of fabrication, shipping costs, erection, maintenance, future inspection, and deck construction.

The AASHTO *LRFD Bridge Design Specifications* was crucial in the investigation to begin preliminary sizing of the steel members, along with a 2005 National Steel Bridge Alliance (NSBA) publication titled *Practical Steel Tub Girder Design* and a 2007 TxDOT


The five-line I-girder design allowed for partial depth precast concrete deck panels.

research report, *Design Guidelines For Steel Trapezoidal Box Girder Systems*. The TxDOT *Preferred Practices for Steel Bridge Design, Fabrication, and Erection* also helped establish criteria and guidelines to size the girders. Common practices, such as when to change flange widths, maximum field segment lengths, flange width to web depth ratios, minimum flange and web thickness, flange splice locations, and web depth are included in the *Preferred Practices.*

Three preliminary steel superstructure cross-section types were considered: four I-girders spaced at 13 ft, five I-girders spaced at 10 ft, or three trapezoidal tub girders spaced at 14 ft, 11 in. AISC's LRFD Simon (**aisc.org/simon**) was an important design tool in obtaining preliminary size ranges for each cross-section.

TxDOT also contacted a steel fabricator for an expert view on which girders were most cost-effective from a material standpoint. The fabricator's input on flange transitions, plate thickness, and plate length provided valuable information for the preliminary design process.

The girder options evaluation favored the five-line I-girder option. That system allows for using partial depth precast concrete deck panels (PCP), which would be a benefit to the contractor and add an extra element of safety to the deck construction. It would also be better for future maintenance and phasing of the deck for replacement.

The five I-girder cross-section system has a constant web depth of 92 in. and a constant flange width of 24 in. The bridge has a straight alignment and was fabricated with Grade 50W. Standard TxDOT bearing designs were modified to meet the structural needs of the steel unit.

Because cross frames represent a costly structural component in the overall steel bridge unit, a lean-on bracing concept was chosen because it saved fabrication and erection costs by reducing the number of cross frames needed. TxDOT had used the lean-on bracing concept only on bridges with skewed supports. In that regard, the SH105 bridge—which does not have bents oriented on a skew angle—was a first for the department.

TxDOT felt confident in its venture after consulting several bridge design resources. According to the NSBA *Steel Bridge Design Handbook* (**aisc.org/bridgehandbook**), minimizing the number of cross frames on the bridge can lead to better overall bridge behavior and reduced maintenance costs. Lean-on bracing provides multiple benefits to bridge owners, fabricators, and erectors, including improved structural performance and long-term durability, simplified inspections, lower cost, and easier fabrication and erection, per the NSBA *Lean-On Bracing Reference Guide* (**aisc.org/leanonbracing**).

Furthermore, the TxDOT *Bridge Design Manual – LRFD* supported the lean-on concept plan. The *Manual* was revised to allow

The five I-girders are placed 10 ft apart.

the use of lean-on bracing design after the department completed a research project on cross frame and diaphragm behavior for steel bridges with skewed supports. The bridge's straight-line geometry also contributed to choosing the lean-on bracing concept.

The typical design method used for a bridge's I-girder framing system is to place cross frames between each girder at a uniform spacing along the length of the girders. In contrast, using lean-on bracing allows several girders to be braced across the width of the bridge by a minimal number of cross frames. Girders that lean on the cross frame brace require top and bottom struts to control girder twist, per the *Steel Bridge Design Handbook*. All told, this method reduced the number of cross frames from 148 to 80, saving significant fabrication time and creating an easier erecting process.

The bridge substructure consists of single column bents supported by footings and drilled shafts. A single column support was chosen to minimize disturbances to the surrounding environment. Due to the area's clay soil and concerns with scour, the columns could not be rectangular and therefore have large, chamfered edges.

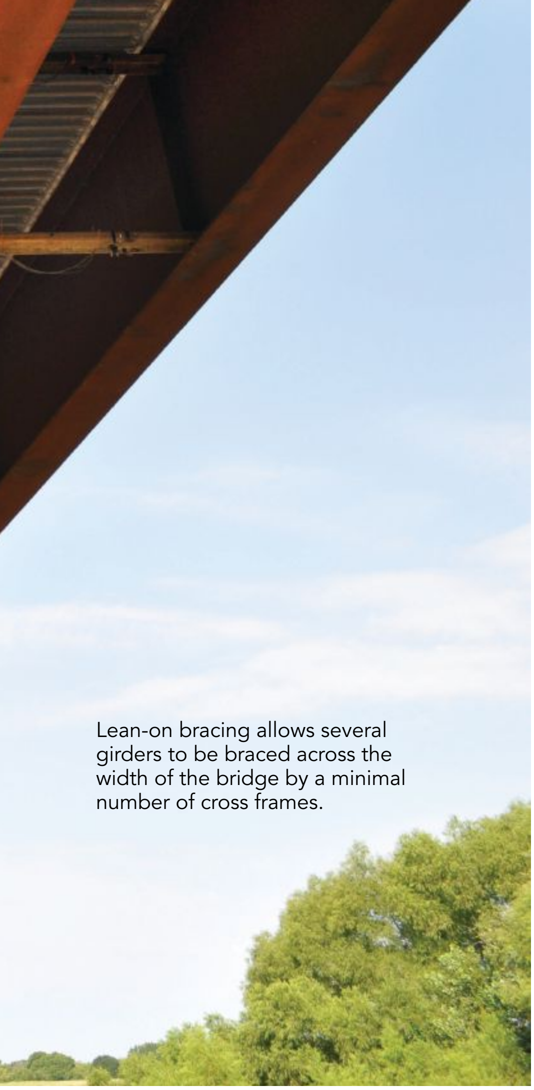
An important piece of developing the lean-on bracing system configuration was the erection sequence of the steel girders, and that had to be considered during the bridge design phase. TxDOT consulted with a local steel erector to help form a plan for erecting the steel. The lean-on bracing configuration assumed steel erection would start at the first and last bent of the steel unit, with a drop-in section at mid span of the middle span of the steel unit.

The framing plan was crafted assuming the leftmost girder is placed first, with the other four girders placed in succession next to it. The bridge was designed using software from MDX and modeled for the construction phases in UT Bridge, a software first released in 2010 and developed through a TxDOT research project. The program allows an engineer to create a three-dimensional model of straight and curved bridge systems so that the behavior during erection and construction can be evaluated while considering a wide variety of erection or deck placement scenarios. TxDOT also developed spreadsheets to check the stiffness at each line of bracing across the width of the bridge.

The aesthetic concept mirrors the original name Spanish settlers gave the Brazos River: The River of the Arms of God. The two columns represent two arms reaching up and supporting the bridge over the river. The single column splits into two columns near the top with a recessed concrete area between them to appear as a void or window.

The aesthetic interior bents provide the support for most of the bridge. The abutments, which support the beginning and end of the bridge, are also unique and were designed as bent caps that will allow for bridge lengthening if the Brazos River's projected future migration renders it necessary.

The SH105 Brazos River Bridge replacement prompted TxDOT to initiate another research project, 0-7093 *Refined Design Methods for Lean-on Bracing*, whose scope included monitoring and field-testing bridges using lean-on bracing, finite element modeling, parametric studies, and refinement of existing design expressions. The project—completed in spring 2024—resulted in more efficient lean-on bracing concepts and optimal cross frame system layouts and provided recommendations for improvements to design parameters, such as in-plane girder stiffness, effects of



Lean-on bracing allows several girders to be braced across the width of the bridge by a minimal number of cross frames.

eccentric connections, and cross frame type. With this additional research, bridge designers will have more tools and knowledge to design steel bridges with a lean-on bracing system. ■

Owner
Texas Department of Transportation (TxDOT)

General Contractor
James Construction, LLC

Structural Engineer
TxDOT, Bridge Division

Steel Fabricator and Detailer
W&W | AFCO Steel (AISC Certified Fabricator)

Jamie Farris (Jamie.farris@txdot.gov) is the bridge division deputy director at the Texas Department of Transportation.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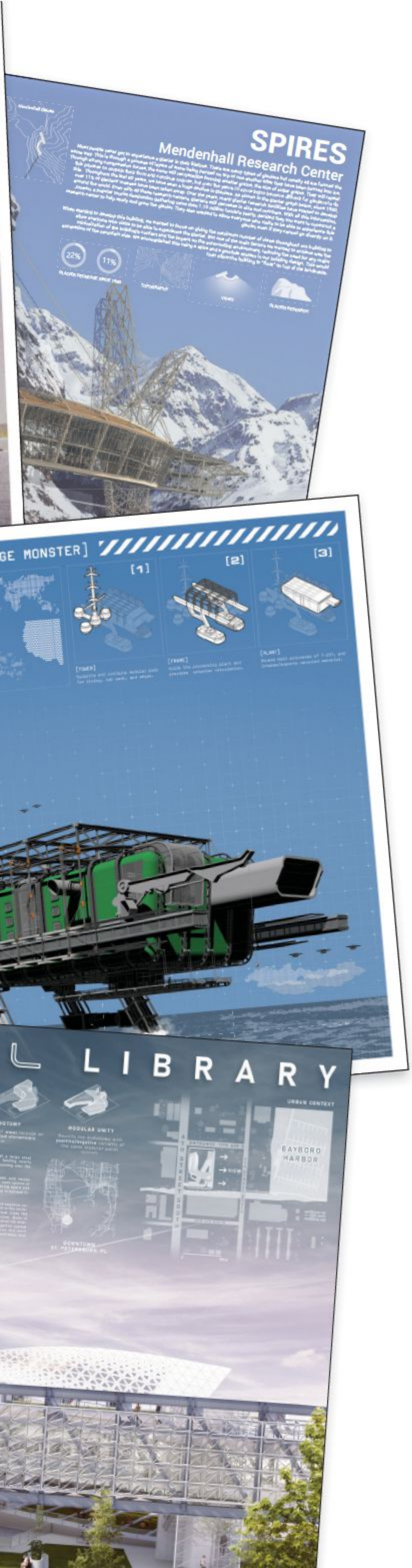


Steel Innovators

The 2024 Steel Design Student Competition challenged students to craft a building that will be a centerpiece of steel innovation, research, and training for years to come.

THE DESIGN TASK for the 2024 Steel Design Student Competition was not to create just any steel building, but one that will aid the steel industry itself for decades.

The challenge for this year's participants was to design a steel innovation center on an undeveloped plot of land along the Mississippi River in St. Louis, less than a mile south of the Gateway Arch. The center is geared toward AEC professionals, and its primary purpose is providing hands-on opportunities for full-scale steel construction research and training. The contest also featured an open category for students who had other design ideas.

Eleven winners were chosen, five from the main category and six from the open category. More than 750 students from 47 universities submitted concepts in this year's contest. Now in its 24th iteration, the SDSC is sponsored by AISC and administered by the Association of Collegiate Schools of Architecture (ASCA).

Students and faculty sponsors who worked on the winning projects earned cash prizes that ranged from $500 to $4,000. The winners were chosen by panel of distinguished jurors:

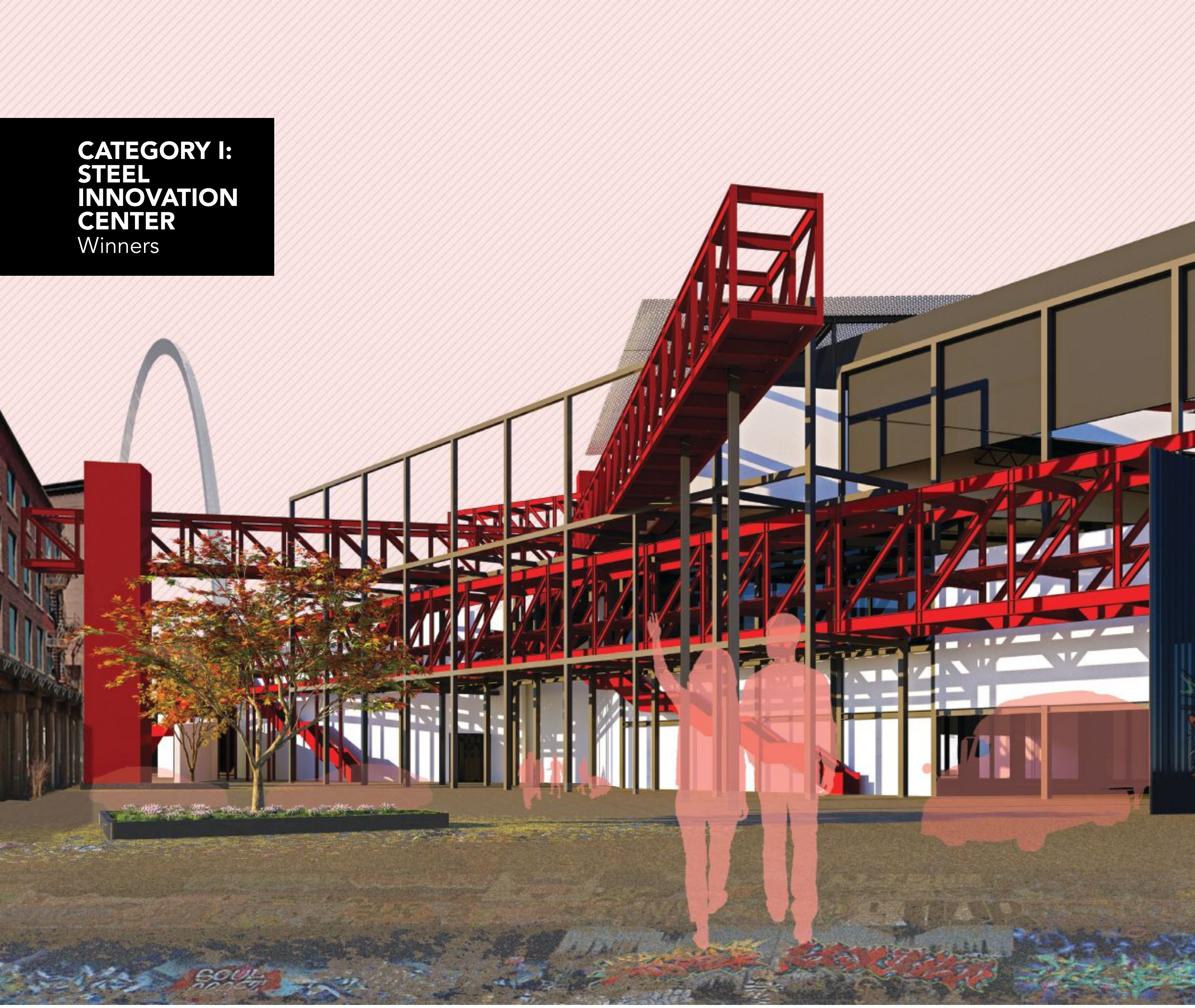
CATEGORY I: STEEL INNOVATION CENTER

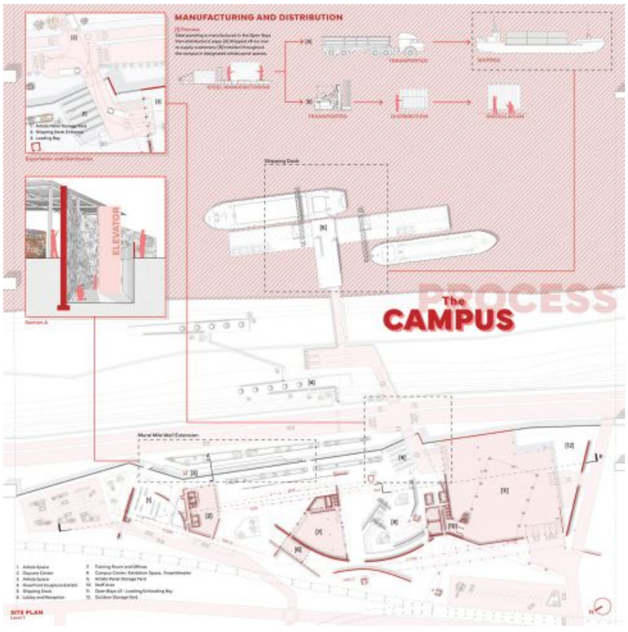
- Dana Gulling, North Carolina State University
- Maria Mohammed, Structural Focus
- Paolo Sanza, University of Oklahoma

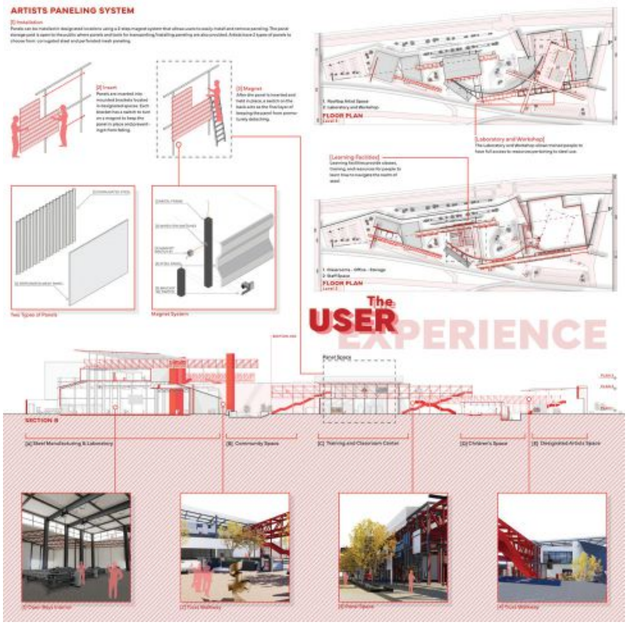
CATEGORY II: OPEN

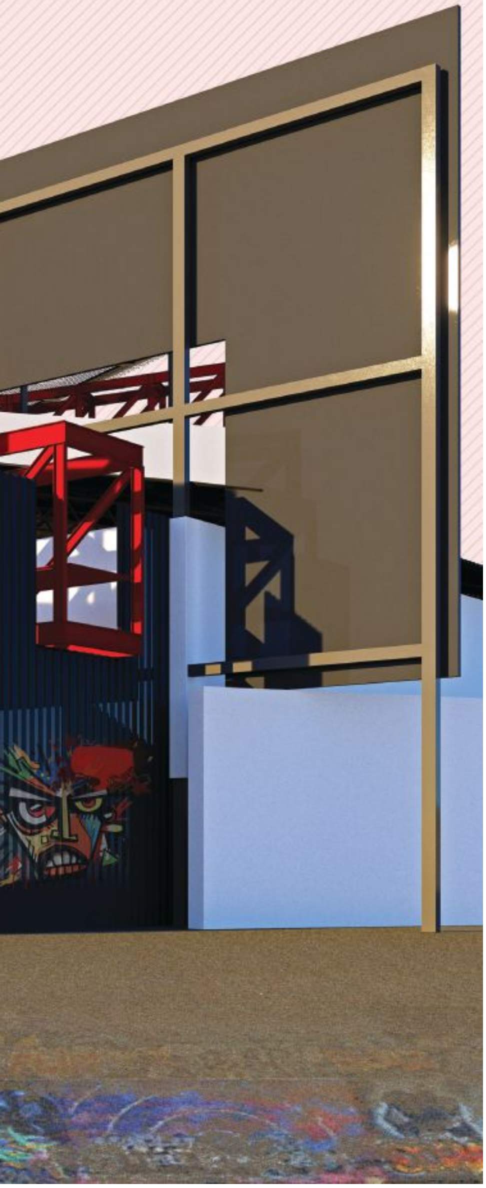
- Genevieve Baudoin, Kansas State University
- Bruce Danziger, Danziger Engineering Collaborative, Inc.
- Jodi La Coe, Marywood University

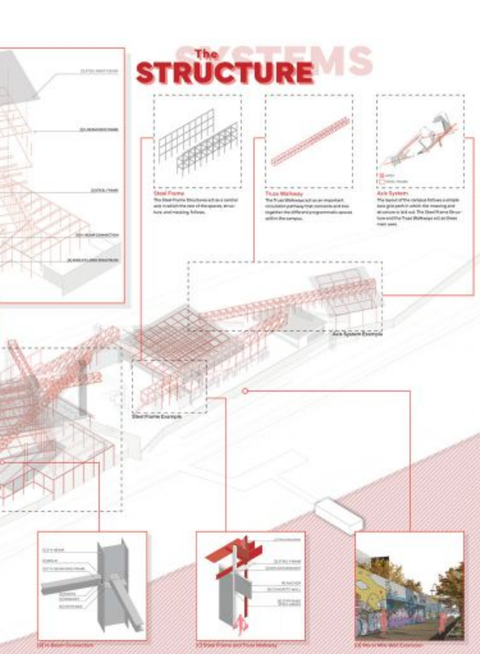
CATEGORY I: STEEL INNOVATION CENTER
Winners











CATEGORY I: STEEL INNOVATION CENTER

This category asks students to design a Steel Innovation Construction Center in downtown St. Louis. The site is part of the Construction Innovation District and Master Development just south of the Gateway Arch. Program spaces must include areas for exhibition, fabrication, training, and community outreach. Steel is the primary material.

1st

The Exploration of Expression

Students: Russell Tong and Porter Watson
Faculty Sponsor: Carlo Sturken
Institution: Woodbury University

The Exploration of Expression Steel Center is an extension and continuation of St. Louis' Mural Mile Wall, a Mississippi River flood wall section about a mile south of the Gateway Arch. Each year, the city holds an event that brings people together to paint, tag, and decorate a portion of the flood wall. The steel center alludes to the practices of street art used on the Mural Mile Wall, acting as a metaphorical extension of the wall in addition to a literal one.

The center provides additional square footage and resources that house designated artist spaces, exhibition spaces, and steel panel manufacturing. The steel panels can be shipped via the Mississippi River or distributed and installed throughout the campus as open canvases for expression.

Laboratories, workshops, and classes within the campus train staff for steel production and are open to the public so people can learn and experiment with steel. There is no correct or preferred form of artistic expression. The center's atmosphere and open nature is designed to encourage and foster the exploration of one's creative expression. Overall, it aims to add life and vibrancy into an aging industrial area.

The metal panels are instrumental to the center's purpose. They're manufactured in-house and used throughout the campus as canvases for the artists to express creativity in any way they see fit. The panels kept on site instead of shipped away are not a permanent fixture, though. They're a public gallery that is changed and added to over time. The panel filtration and changeover process relies on public interest and a steady flow of artists. People can leave their work on display for all, where other artists will eventually replace, change, or move it.

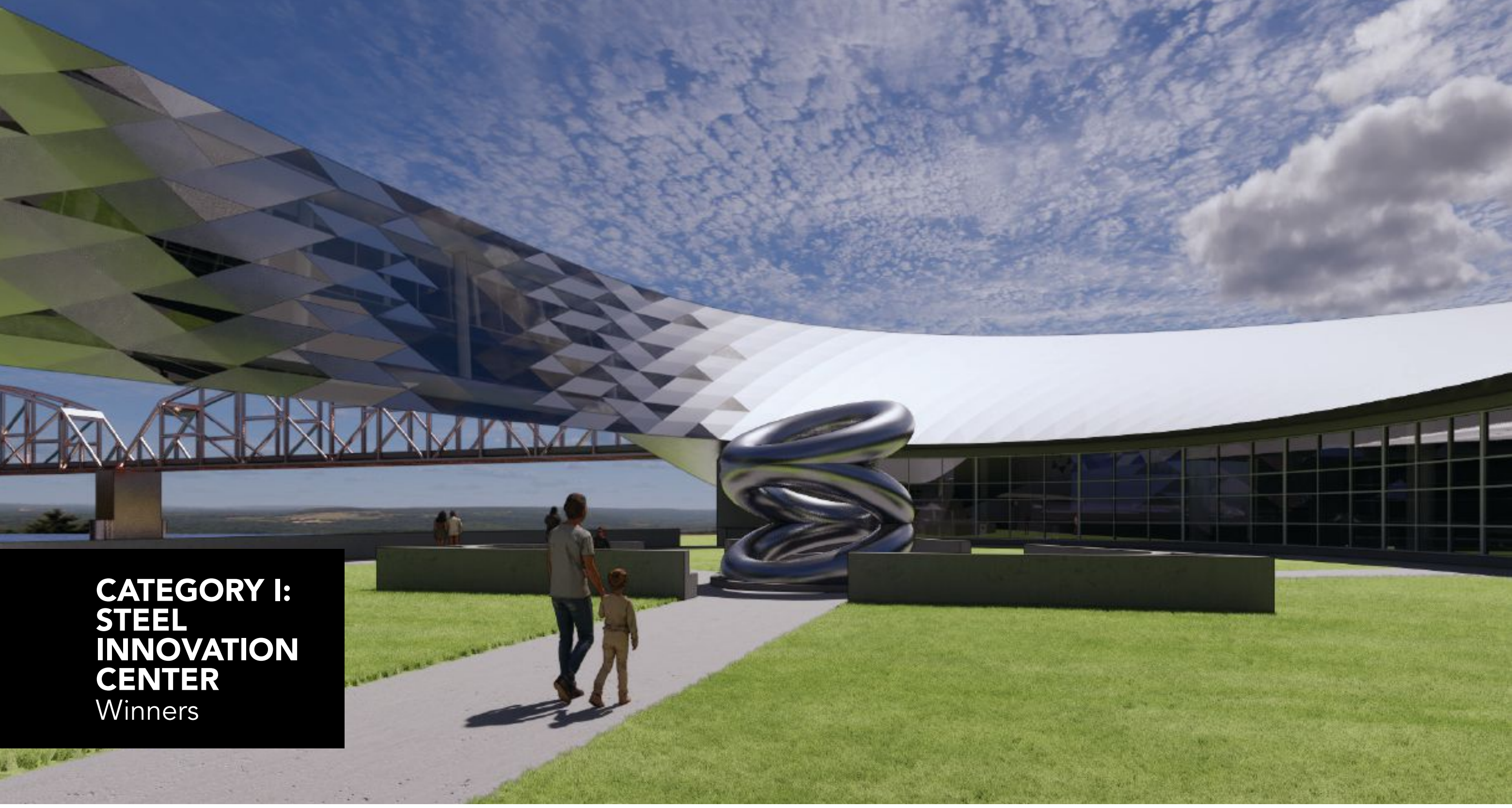
Red trusses seen throughout the campus grab attention, serving as guides of exploration that offer a suggested path of journey. There is no designated path through the campus. Instead, it's designed to invite visitors to create their own, showing that not all people think and move the same.

The open bays house the manufacturing of steel panels. Designated artistic spaces are located throughout the campus and include the flood wall, panel spaces, exhibition spaces, and resources for steel artwork. The campus has a unique circulation strategy, giving the public a view of the artist spaces, steel production facilities, and steel experimentation spaces. The nature of the circulation creates and emphasizes an atmosphere of exploration and a non-traditional creative space.

Steel panels for artistic use can be installed in designated locations using a two-step magnet system that allows users to change out paneling easily. The panel storage yard is open to the public, where panels and tools for transportation and installation are provided. Artists can choose corrugated steel and perforated mesh paneling.

Panels are inserted into mounted brackets located in designated spaces. Each bracket has a switch to turn on a magnet to keep the panel in place and prevent it from falling. After the panel is inserted and held in place, a switch on the back acts as the final layer of panel support.

The overall layout follows a simple axis grid path in which the massing and structure is laid out, and the steel frame and the truss walkway serve as the main axes. The center's steel frame acts as a central axis in which the rest of the spaces, structure, and massing follow. The walkways act as an important circulation pathway that connects and ties together the programmatic spaces within the campus. ■



CATEGORY I: STEEL INNOVATION CENTER
Winners

Infinite Innovation

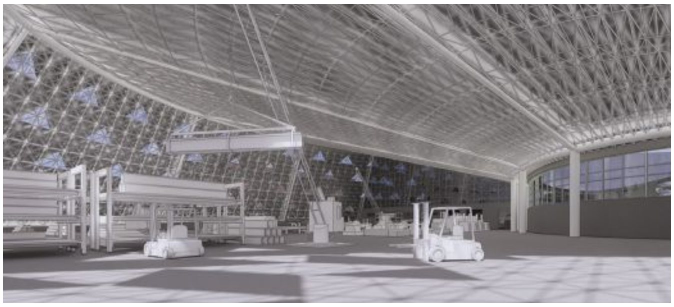
2nd

Student: Eric Duenser
Faculty Sponsor: Randall Deutsch
Institution: University of Illinois, Urbana-Champaign

The Gateway Arch's sleek stainless steel and striking weighted catenary form made it the signature structure along the Mississippi River when it opened in 1967. Infinite Innovation would make a similar impact—right in the arch's shadow.

Infinite Innovation draws inspiration from the arch's extruded triangular form and aims to create a new, unique geometrical shape on the riverbank near the arch. The project's toroidal, twisting shape is reminiscent of a three-sided Möbius strip, nesting a center courtyard that looks over the site's levee wall and the river. Its unique shape means that it only has one side, because the walls rotate with the twist and continue to form the roof and floor.

The seamless steel and glass panels account for the twist, fading in and out with the angled walls to use daylight effectively. The glass paneling also reveals the unique structural supports required to hold up a long-span cantilever while retaining the building's sculptural form. The building has more than 100,000 sq. ft of space, primarily dedicated to developing new steel and structural technologies. The structure, a marvel of steel innovation itself, seeks to inspire researchers in their own innovation efforts.



The building's main structure has large hollow structural sections (HSS) supports and a space frame celebrated with patterned glazing that uncovers it from an otherwise solid form. There are three distinct sections of supports. The first connects the structure to the caissons in the ground, the second segments the building into triangles, and the third is a wire that loops around the building, connecting the vertices of those triangular sections. In between each section is the space frame, which holds up the paneling system. The building is designed with a large, double-sided cantilever over the levee wall and long spans over the steel fabrication bays.

The structure's inherent parametric shape posed a unique façade challenge like the Gateway Arch once faced. The need for a seamless paneling system that worked for steel and glass panels led to choosing a spider glazing system. Instead of using traditional mullions to hold panes in place, this system uses aluminum "spiders" that attach the glass to the space frame. The system preserves the flush organic forms without the need to curve any glass or steel and provides easy installation and replacement. The geometric pattern allows for the glass to fade in and out with the changing slope of the walls.

The levee wall to the east of the site was a significant consideration during design. Rather than obstruct views of the Mississippi River, the courtyard acts as a large ramp and park that looks outward over the river and inward toward the steel fabrication space. The community hub and steel history museum on the second floor look north towards the Gateway Arch, providing information about various steel projects in St. Louis and giving direct context to them.

The third floor houses administrative offices, a staff lounge, and classrooms with nearly 360° views around the building and easy access to the front- and back-of-house areas. The main entrance and daycare are positioned on the north side, accommodating pedestrian and vehicular traffic from Gateway Arch National Park, whereas the employee entrance and loading dock are positioned on the south to separate trucks and heavy machinery from the public entrance.

3rd

Gateway South Innovation Center

Students: Sulaima Salim
Faculty Sponsors: Osman Attmann
University of Colorado Denver

A building's design at its opening doesn't have to be its only design.

Transformative architecture is useful when designing a building that could undergo a change in use, appearance, or sustainability during its lifespan. It involves making changes and improvements to the building's context through materials, a sustainable structure, or an adaptable program, among other methods. Transformation of buildings happens in response to varying conditions, such as promoting well-being, contributing positively to the environment and context as it evolves, and transforming to sustain elements that consider the longevity of the building and structure.

The disassembly-oriented design philosophy behind Gateway South Innovation Center is rooted in a transformative approach. The project is a prefabricated unit that arrives at the site with instructions, and pieces of it can be taken apart if the building later needs additions or subtractions.

The building features a pier foundation system for stability in a flood zone and a temporary over-grade grid system for flexibility, offering adaptability to meet the evolving needs of the researchers, trainees, students, and clients. The grid pier system will provide a dynamic solution capable of growing quickly alongside development from St. Louis' master-planned Gateway South project.

An exposed steel structure runs throughout the building design, creating a visually engaging experience as occupants move through its spaces. The interior program functions as a building machine that features varying levels connected by ramps, while a prominent skylight runs along the building's major datum acting as a buffer zone through a green biophilic wall. The datum became the building's main exhibit, engaging the public by showcasing steel production and new technologies. ■

Overlapping Illumination
Students: Cristian Gomez and Mo Zaina
Faculty Sponsor: Osman Attmann
Institution: University of Colorado Denver

The design philosophy behind Overlapping Illumination is in its name.

The project, which aims to integrate concept and functionality seamlessly, is programmatically driven by a commitment to illumination and overlap. It's functionally driven through the method of the building as a machine. Illumination symbolizes the enlightenment of understanding steel production, while operational functionality ensures every aspect serves a purpose. Overlapping functionalities create a dynamic environment where steel innovation and education harmonize.

All told, the building's primary purpose is to be a hub for steel innovation and create a safe space to care for and educate children while contributing to the visual and cultural landscape. The architectural expression, embodied in a translucent façade, transforms functionality into artistry, captivating visitors visually and intellectually.

Overlapping Illumination epitomizes the fusion of form and function, embodying the essence of a living machine. It's crafted with precision-cut nuts, bolts, and steel cables. Every element showcases steel's adaptability, speed, and resilience. Its expandable framework anticipates growth, and its transparent design fosters collaboration. Light dances through steel-framed windows, highlighting its industrial beauty. The building is temporary but sustainable and displays a new era of architectural ingenuity, showcasing steel's limitless possibilities in every detail.

By embracing steel's inherent sustainability and efficiency, the project meets today's needs and anticipates tomorrow's challenges. From the seamless integration of educational spaces to incorporating innovative design elements, every aspect is meticulously crafted to present steel's potential in a practical and inspiring way.

CATEGORY I: STEEL INNOVATION CENTER
Honorable Mentions

Skyforge/Steel Horizon
Students: Kevin Bui and Garrett Gudmundson
Faculty Sponsor: Gerard Smulevich
Institution: Woodbury University

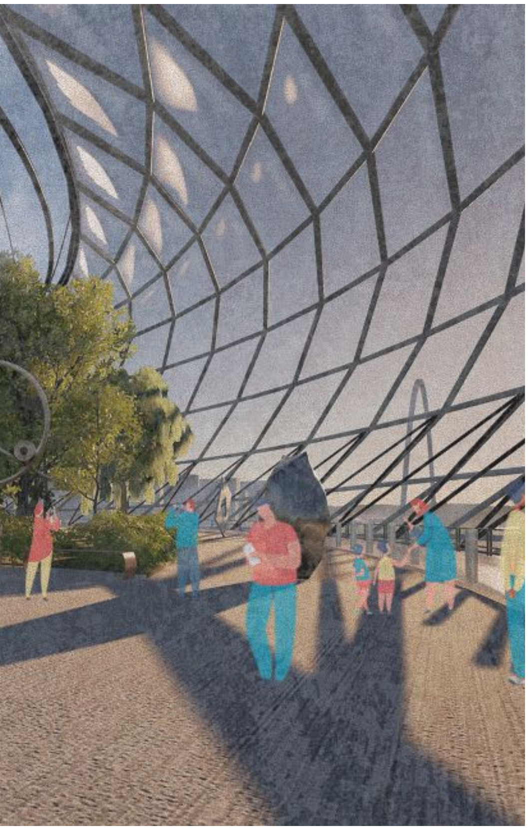
Skyforge/Steel Horizon is dedicated to the design, education, and exploration of steel and its possibilities. The project delves into the intersection of the vertical sky and horizontal land, symbolizing the genesis and realization of ideas—where the sky signifies the formation of ideas, and the land embodies their implementation. It seeks to push the boundaries of steel and explores various aspects of design, such as space, orientation, and climate control, that are central to the design philosophy.

The concept aims to reverse population fragmentation and draw people in with its transparent design. Like the Gateway Arch, the tower's transparency and height are visible from far away, sparking interest and desire to visit from all around the city.

The design features three linear, interconnected open bays that cantilever over the river's flood wall. The cantilevering open bays—designed for efficiency and river access—allow for efficient barge loading and unloading from the bay's underside and over the river, facilitating access to river shipments. This streamlined approach optimizes material movement within the open bays. The cantilevering bays over the river are also a symbolic gesture of sky and land.

All other facility functions are centralized within the high-rise tower, which is designed to resemble a fish tank and integrates with the cityscape. This transparent design allows the community to engage with and feel connected to the project. The exhibition center, located at the top of the tower, is the project's focal point. Its elevated position offers panoramic city views and provides insight into the building's structural design and support system.

The structure has many connection types. A five-joint connection links the space frame to a steel plate façade. The space frame uses a four-way glass spider fitting to hold up high-performance glazing glasses. Space



A design philosophy centerpiece is the building's pulsating overlap, where the clinks and clangs of steel creation resonate with children's laughter. The childcare facility, infused with factory transparencies, becomes an interactive classroom, educating young minds in a way that mirrors the energy of the steelmaking process. Meanwhile, spaces tailored to adult learning foster a community that embraces a culture of continuous steel innovation education.

Illumination as a guiding principle goes beyond the literal sense of lighting up a space. It embodies the metaphorical light shed by knowledge and discovery. The concept, conceived as a lantern, symbolizes enlightenment that stems from understanding the intricacies of steel production.

Befitting its proximity to the Gateway Arch, it's a gateway to a world where steel innovation and education mesh and illuminate minds of all ages. It's more than a factory facility. It's a space where functionality, overlap, and operational efficiency create a space that stands as a beacon of progress promoting knowledge and curiosity. ■

frames are connected to the open bay truss through a steel plate, allowing for a four-pipe connection. The plate is then mounted onto the truss.

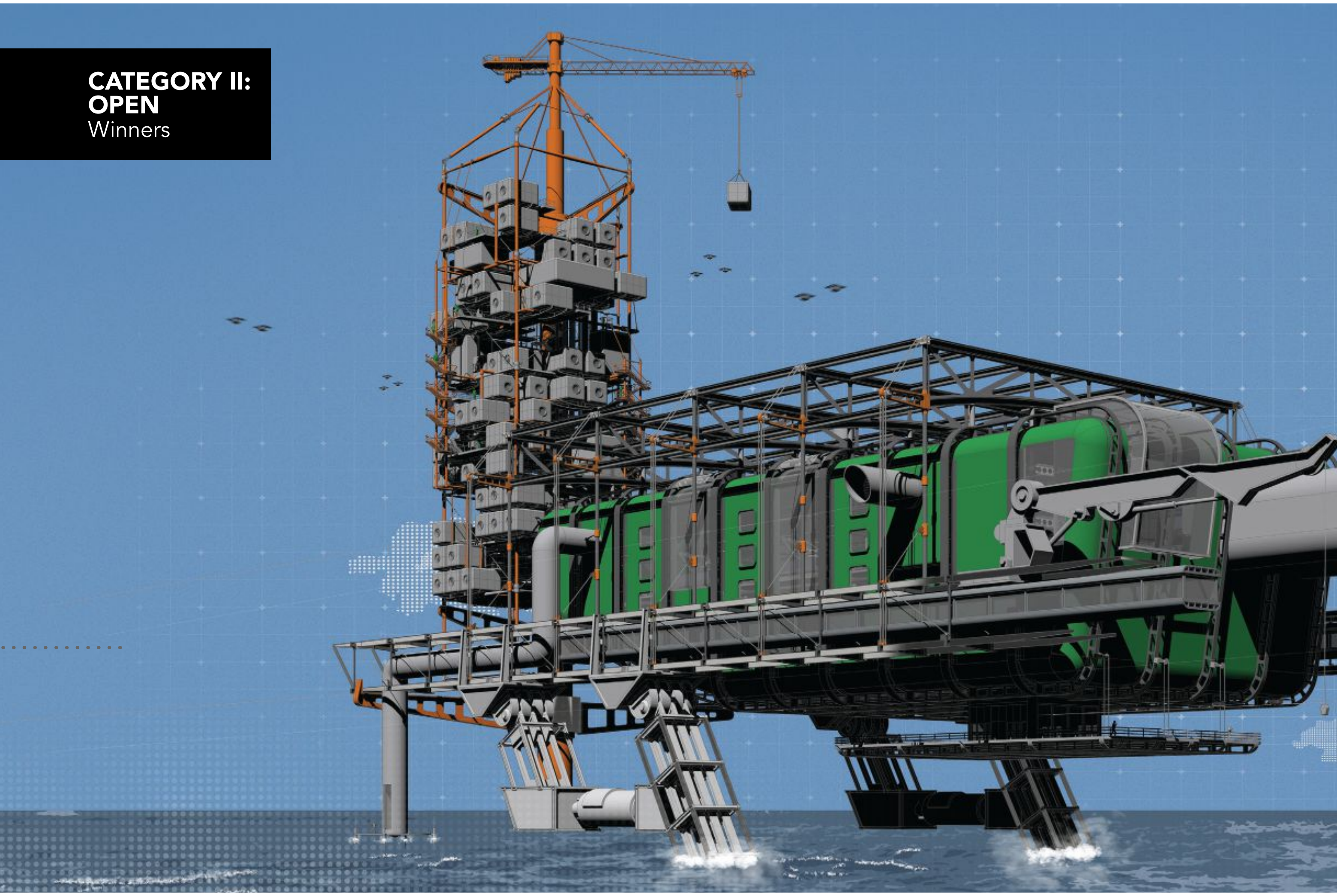
Elsewhere, combining an inverted pyramid truss with vertical trusses formed a primary internal structure that supports the building. A three-point vertical truss is used in conjunction with the primary tower structure to counter lateral loads. This connection to the tower frame results in a stiffer, more resilient structure.

The three-point vertical truss stabilizes itself through its attachment to the main tower structure. It is mounted on a C-beam that connects to the primary tower support. Using "bamboo" columns to support the initial floor plates creates redundancy and reduces the load on the main tower structure.

Skyforge/Steel Horizon's cooling system is inspired by GSW Headquarters, an office building in Berlin. Studying the structure of aircraft wings provided a better understanding of Bernouilli's principle, the pressure phenomenon that creates lift. The building incorporates the wing concept in the form of an inverted airfoil at the top that will function as a passive cooling system. The low pressure created between the airfoil and the building's roof will draw up warm air, effectively cooling the structure. ■

CATEGORY II: OPEN

Architecture students could select a site and building program using steel as the primary material. This competition category permits the greatest amount of flexibility for any building type.



1st

OPCS T-157 (Garbage Monster)

Students: Logan Jacobs, Jude Bell, and Christian Salazar
Faculty Sponsors: Pasquale De Paola and Kevin Singh
Institution: Louisiana Tech University

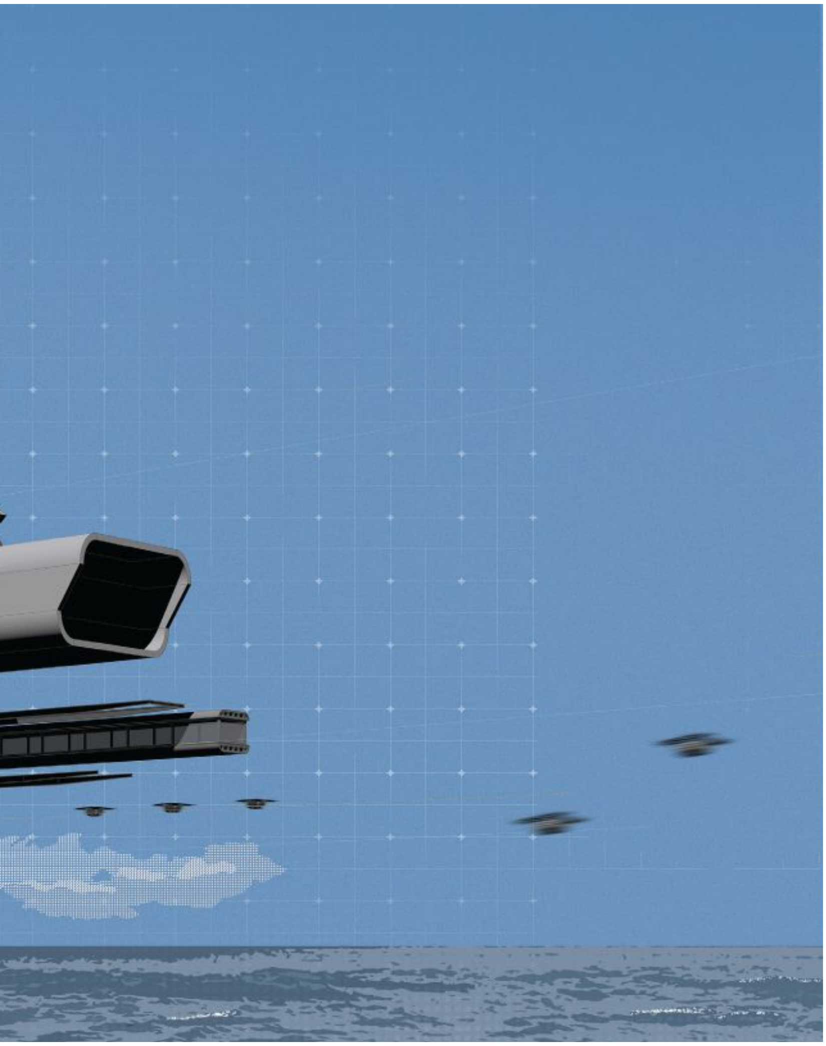
Rivers across the world dump more than 1 million tons of plastic into the ocean most years, according to a 2021 study. Plastic gathers in the ocean's gyres, and the largest and densest collection is the Great Pacific Garbage Patch, which covers 618,000 sq. mi between Hawaii and California. An issue of these proportions requires a solution of equal magnitude: The T-157 Garbage Monster, a key component of the Ocean Plastic Collection System (OPCS).

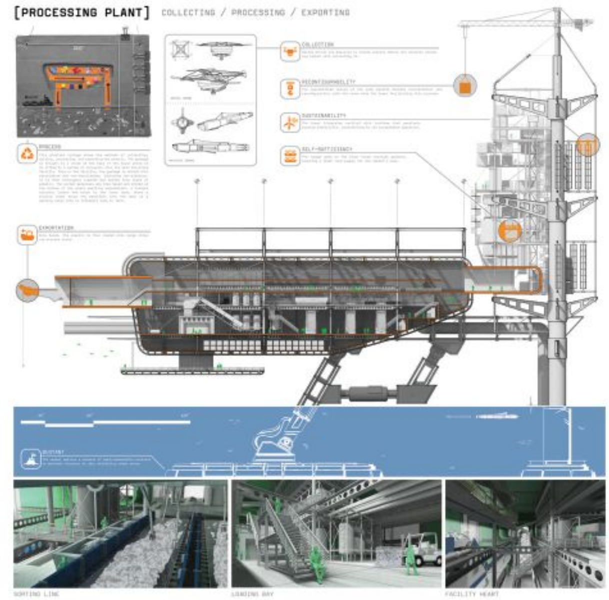
The OPCS includes an on-board recycling center, a tower of pods for worker accommodations, and a fleet of aerial and nautical drones. The aerial drones identify hotspots of garbage, while the nautical drones work in pairs to collect the plastic using a dragnet system. After gathering sufficient plastic, the drones deposit their collections on the main vessel. The crew then cleans, sorts, bales, and stores the plastic until exportation back to land. Once plastic is baled, a knuckle crane loads it onto cargo ships.

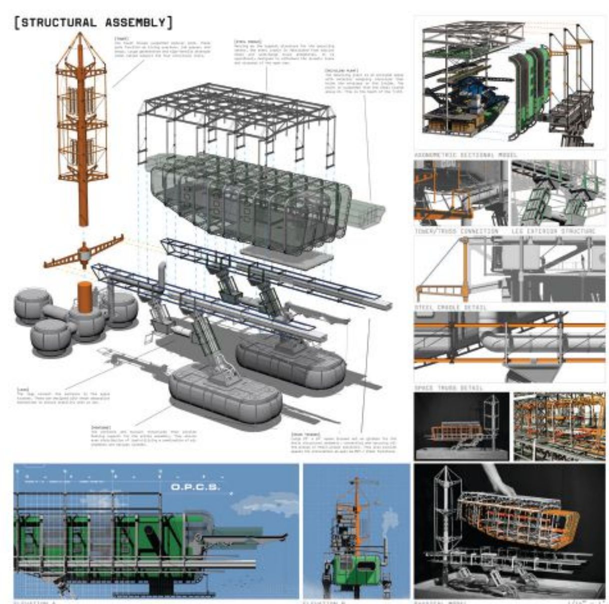
Drones bring the garbage to a chute at the base of the tower, where it is lifted by a series of conveyors into the main recycling facility. Once in the facility, the garbage is sorted into recyclables and non-recyclables, including non-plastics. It is then thoroughly cleaned and sorted into types of plastic. The sorted materials are baled and stored at the bottom of the plant, awaiting exportation. A freight elevator lowers the bales to the lower deck, where a knuckle crane moves the materials onto the deck of a waiting cargo ship to transport back to land.

A steel cradle is the support structure for the recycling center and is fabricated from tubular steel and wide-flange truss assemblies. It is specifically designed to withstand the dynamic loads and stresses of the open sea.

The recycling plant is an enclosed space with an exterior wrapping structure that holds the envelope on the inside and is suspended by the steel cradle above it. The legs connect the pontoons to the space trusses and are designed with shock absorption





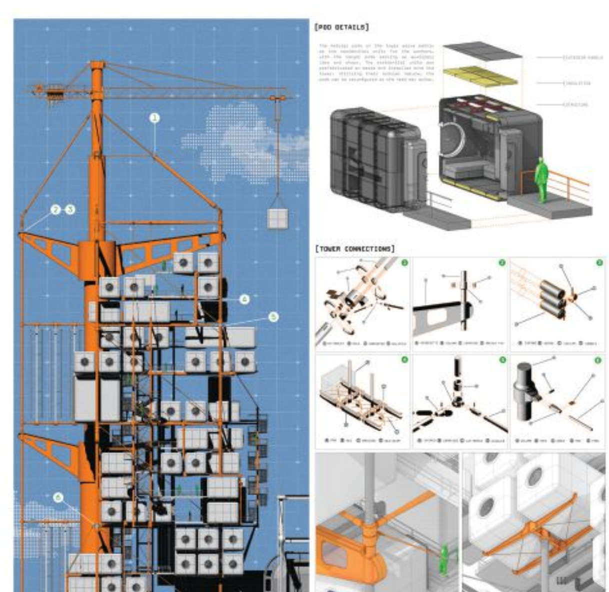


mechanisms to ensure stability when at sea. The pontoons are buoyant structures that provide floating support for the entire assembly. They ensure an even distribution of load by using a combination of air chambers and ballast systems.

The 20-ft by 24-ft space trusses act as girders for the whole structural assembly, connecting and securing all the pieces in their proper positions. They also provide spaces for circulation, MEP, and other functions.

The modular pods on the tower are mainly residential units for the workers, with the larger pods serving as auxiliary labs and shops. The larger pods on the tower house vertical gardens, ensuring a fresh food supply for the vessel's crew. The residential units are prefabricated and installed onto the tower. Large gerberettes and high-tensile strength steel cables support the four structural tiers.

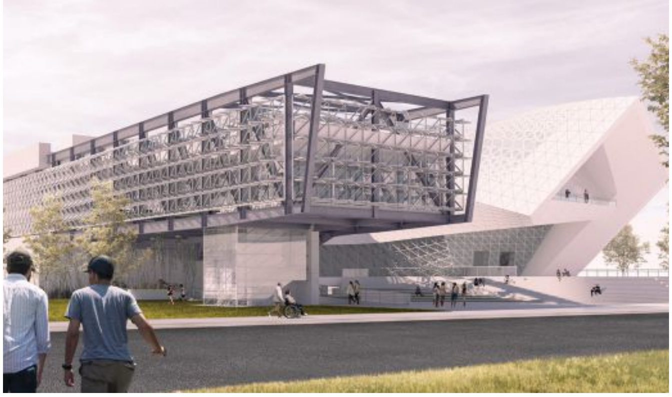
The pods' standardized nature and modularity permits flexible reorientation and reconfiguration, with the crane atop the tower facilitating that process. The tower integrates vertical wind turbines that passively produce electricity, contributing to its sustainable operation. The vessel employs a network of semi-submersible pontoons that maintain buoyancy at sea, minimizing ocean waves. ■



CATEGORY II: OPEN
Winners

2nd

Liminal Library
Student: Collin Rohr
Faculty Sponsors:
Lee Su Huang and Sarah Gamble
Institution: University of Florida



Liminal Library challenges traditional concepts of accessibility, conceptualizing a library and an enabling center with the idea of creating a unified experience. Situated in a flood zone in St. Petersburg, Fla., the site has a base elevation of 9 ft to prevent flooding and resist shearing forces during hurricanes and intense storms.

The height creates accessibility challenges, though. In response, the site is organized around an ADA-compliant ramp that progressively moves people from the site entrance to a rooftop green space that overlooks the St. Petersburg harbor. The vertical rise generated by the ramp not only addresses the flooding issues but also reclaims the ground and rooftop space of the site, giving it back to the community of St. Petersburg.

Structural steel was the only material option for the concept. Liminal Library expresses steel's versatility through the use of tectonic and stereotomic systems that align programmatically.

The expressed tectonic system, composed of a large steel truss, houses the library within its depth. The library holds nearly 30,000 volumes and ample reading and lounge space. It spans over the site and shades the space beneath.

The concealed stereotomic space truss bends and twists around the tectonic system, housing the larger, open spaces of the enabling center, including the community meeting space and main lobby. It projects north to open the building to optimal lighting.

To blend the two design approaches, positive and negative variants of a triangular panel system were applied to the tectonic and stereotomic systems. The positive system clads the tectonic library as a solar-responsive panel system. The perforated steel panels open and close to control the interior lighting, creating a comfortable, atmospheric experience. The depth of the space truss and the positive panel system passively cool the building by preventing undesirable amounts of heat from entering the interior.

During intense storms and hurricanes, the positive panel system will rotate closed and lock into place, protecting the cantilevered library like a steel shield. Galvanized steel with a protective zinc layer prevents the salty coastal winds from corroding the steel. Concrete cores anchor the building's structure at primary points of contact, helping to resist shearing caused by hurricane-force winds.

The negative system subtracts triangular voids from the enabling center that work within the space truss, giving the illusion of a solid mass that has been carved away. The unique structure of the truss system enables the building to loop back onto itself, creating an uninterrupted experience that doesn't require stairs or elevators to reach the rooftop green space.

3rd

Almaraz Cross-Creation Hub
Student: Benjamin Shapiro
Faculty Sponsor: Ines Martin-Robles
Institution: University of Virginia

The Cross-Creation Arts Center is a meeting place for Los Angeles' Latino and Chicano community that gives a new home to art practices and groups previously forced into secondary and temporary spaces. It's centrally located between two commercial corridors in the primarily Chicano Boyle Heights neighborhood near downtown and is near a Metro stop, allowing for easy non-car access from all over the city. It also links two areas with plentiful public art and a prominent pre-existing arts scene.

The building's porous diagrid structure contains a series of workshops and display spaces levitating within, and it supports art creation and gathering at many scales. The spaces include a textile weaving workshop, a textile dying workshop, a textile loom workshop, an artist lounge, a mural gallery, three pottery studios, a pottery firing and drying workshop, and a visiting artist workshop.

The structure's first floor is lifted above the ground, extending the public plaza on the site into a covered space to create a 24-hour accessible public space. Inside, the primary exhibition space moves beyond the confines of the frame and invites the community to interact with the art. As visitors move up the building, various scales of workspaces sit in the frame and create a public commons between them for display, collaboration, and cross-pollination of ideas.

The structural stability of the diagrid allows the workshops and display spaces to function as adaptable shells, which will continue to support the community as its needs develop over time. These shells can be quickly assembled or expanded along the grid with simple, inexpensive materials that support the community-driven capacity for self-determined use. ■

CATEGORY II: OPEN
Honorable Mention

Performing on the Cliff

Students: Lucas Peiyu Luo, Adrian Suciu
Faculty Sponsor: Fei Wang
Institution: Syracuse University

Performing on the Cliff is embedded into an exposed cliffside overlooking the East China Sea—and aims to blend into those surroundings as much as a modern building can.

It integrates diverse immersive performance spaces within a larger community cultural center in Wenling, China, targeted toward visitors and locals. The design draws inspiration from the Taizhou region's unique traditions and crafts, which are heavily influenced by its coastal setting. Wenling is renowned for its crab shell paintings and marine paper-cut artwork, reflecting the dominant fishing industry that drives the town's identity. Festive processions and drumming events also celebrate tradition while fostering diverse interactions between performers and audiences.

With younger populations gravitating towards larger cities, the project aims to create an institution that safeguards and preserves local cultures while offering visitors the opportunity to engage with and familiarize themselves with these traditions. The design prioritizes versatile performance spaces to accommodate a range of activities and experiences. The ground floor houses a traditional indoor performance space, while a prominent exterior platform divides the building vertically into two sections. The platform is the main gathering spot, providing stunning ocean views and an informal outdoor performance area that grants easy access to spaces above and below.

The concept's upper volume introduces galleries, workshops, and studios, promoting interaction and flexibility. An atrium cuts through the floors, extending to the primary platform level to enhance engagement between spaces. The project meticulously crafts dynamic vertical spaces that respond to the site, ensuring accessibility and horizontal scaling to prevent a monotonous progression throughout the building.

Given the prominence of the uninterrupted outdoor platform level, significant structural considerations were dedicated to creating a cantilevered system for the upper volume. Continuous large truss systems are embedded and cast within the cliff to support these upper floors. The fifth and seventh floors are strategically utilized to integrate most of the structure, freeing up vital public space on the sixth floor.

The concept seeks to harmonize the massing with the stepped topography, merging with the mountain to appear as an organic extension rather than an imposition. The primary east façade is characterized by undulating setbacks that mimic the mountain's natural contours. Texture and seams incorporated into each exterior panel further enhance the integration. Semi-transparent FRP panels act as the outermost decorative skin of the building, with a double-glazed window system behind them defining the protected interior spaces.

Additionally, the atrium space within the top floors is crowned by a lightbox that extends towards the south façade, cascading light onto the platform level and providing ample natural illumination for the floor above. The thoughtful natural light integration boosts the aesthetic appeal and contributes to the building's energy efficiency.

Performing on the Cliff is a positive anchor point for preserving and promoting the local culture while exemplifying the regeneration of the entire neighborhood. The project successfully addresses the architectural challenges posed by its unique location and is also a catalyst for cultural preservation and community revitalization, seamlessly blending tradition with innovation in design and function. ■

PRSM

Students: Nathan Bucy and Alfredo Avendano Salcedo
Faculty Sponsors: Pasquale De Paola and Kevin Singh
Institution:
Louisiana Tech University

PRSM (Predictive Research Station for Meteorology) is Southcentral Alaska's state-of-the-art weather research hub, and its location maximizes its research potential. It's perched just a few miles away from Anchorage on the cliff edge of Goose Bay, bordered by the Chugach Mountains to the east and the Pacific Ocean to the west. The site experiences a wide range of weather phenomena that will encourage study, discovery, and advancements in meteorology.

PRSM has prime space for in-house laboratory research and research through its aviation operations division, which helped decide its placement at Goose Bay-Point Mackenzie Airport. It aspires to help grow the single-runway airport into the headquarters for meteorology aviation operations as an extension of the center's research capabilities.

The building's structural design is, appropriately, derived from the weather. Most notably, the structural elements express a snowflake's prisms. To ensure PRSM services the surrounding community, the building has lighting integrated with the

steel structure that changes color based on weather conditions, acting as a lighthouse for the region. PRSM's raised, cantilevered position near the cliff edge ensures its lights are visible from miles away.

The columns—driven by a snowflake's six-sided shape as the ice crystal forms—are a central piece of the design, and their structure is comprised of multiple elements. At the center is the main interior steel beam reinforced with strength plates on each side and then clad with the exterior plates. The edge caps and cladding panels are secured, snapping into place.

A snowflake's vertical elements are concentrated horizontally along the building's central spine. Each spine connection within the truss is a system of overlapping plates secured in place with pins. The snowflake columns connect to the central spine with tension cables set in place using a three-way hinge and pin. Tension cables also secure the glazing wall and are fastened into place in the center of the column. Each column is bolted to the base girder using custom brackets that secure and fasten the receiving ends of the threaded columns.

PRSM's base is a V-column-structure consisting of four steel plates that encase the reinforced concrete pedestals. Overlapping steel plates secure the arms of the columns, which are slid into place. The stairs are suspended under the building using a bracket that slides into place. The bracket is then bolted to the tension cable.

Spires Mendenhall Research Center

Students: Noah Berryhill and Alex Klocek
Faculty Sponsor: Pasquale De Paola and Kevin Singh
Institution: Louisiana Tech University

The 1,500-sq.-mi Juneau Icefield originated from the Little Ice Age more than 3,000 years ago. It's located in the southern Alaska panhandle, with the Gulf of Alaska to the west and British Columbia to the east. The Mendenhall Glacier, one of the area's signature landmarks, extends approximately 13 miles south of the icefield to Mendenhall Lake.

The glacier is a popular port destination for cruise ships. It draws more than 1.15 million tourists annually, making it an ideal location for a research facility and observatory dedicated to educating the public about glaciers and glacier studies. A warming in the climate has increased glaciers' rate of retreat, highlighting the need for resilient and sustainable steel structures that can help observe and research glacier decrease. The nearly 71,000-sq.-ft Spires Mendenall Research Center aims to serve that purpose.

The center's two-level, curved steel structure mimics the topography of the steep eastern slope directly adjacent to and overlooking the Mendenhall Glacier. A major design factor was minimizing the building's contact with and impact on the surrounding environment to reduce the need for any major mountainside excavation or potential glacier destruction. Preservation and conservation were of utmost importance.

A spire and gondola system incorporated into the building design achieves minimal environmental contact and creates the appearance of a building that floats on top of the landscape. The building's entire outward-facing curved surface is made of steel-supported windows, allowing maximum glacier-viewing vantage points.

Cable anchorage systems connected to the spires and the mountainside reduce the wind-induced sway the spires experience. Two expansion joints located on the west and east corners of the curve hold the modular bridge curve together and safely absorb temperature-induced expansion and contraction of building materials.

The concept represents a union between steel and the rugged Alaskan frontier, highlighting the potential for innovation in design that can also support environmental conservation. Its architecturally expressive design adds to an already awe-inspiring natural phenomenon that few people experience up close. The engaging design elements provide an inspirational foundation for research and education that will impact many generations.

Among the spaces inside are a research workspace, a research library and co-working space, a food and relaxation area, a restaurant, a lobby, a glacier display area, and laboratories.

This month's New Products section features a telehandler, a telescopic boom lift, a cutting bandsaw, and a beam rotator.

Magni Rotating Telehandler

The Magni RTH 10.37 rotating telehandler sets a new standard in construction equipment. Its 22,700-lb lift capacity and 120-ft reach excel in steelwork and other challenging applications. Its patented outrigger system adapts to uneven terrain, while automatic leveling boosts safety and efficiency by reducing setup time.

The telehandler is equipped with Magni's exclusive Load Moment Indicator system, and its real-time load chart adjustments enhance precision and security. The RTH 10.37 serves as a versatile 3-in-1 solution, operating as a telehandler, RT crane, and aerial work platform. A touchscreen display, ergonomic cab with HVAC, and multiple safety features make it a top choice for demanding job sites.

The RTH 10.37 delivers unmatched versatility, innovation, and safety, empowering steel erectors to complete projects with confidence. For more information, visit **www.magnith.com**.

Steelmax MBS4 Cutting Bandsaw

The Steelmax MBS4 is the ideal metal cutting solution for small shops, do-it-yourself projects, and on-site projects. Lightweight and easy to transport, this portable bandsaw delivers clean, precise cuts in a variety of metals. With an adjustable feed speed and auto stop functionality, the MBS4 ensures smooth operation and long-lasting performance. Its integrated vise provides a secure material hold for enhanced stability and safety during use.

Any project you tackle deserves a reliable tool, and the MBS4 is designed to handle your needs efficiently and effectively. It's compact, durable, and easy to operate, making it the perfect fit for those who need performance without the bulk. It has 18 TPI and 14 TPI blades available. Visit **www.steelmax.com/metal-cutting** to learn more.

JLG Hi-Capacity HC3 Telescopic Boom Lifts

JLG HC3 boom lifts can hoist up to 1,000 lb, reducing the need for multiple trips and additional equipment. The HC3 boom lifts feature three distinct working zones to enhance safety and operational efficiency: An unrestricted 660-lb zone and two restricted zones of 750 lb and 1,000 lb.

As the machine moves between these zones, the system automatically adjusts the lifting capacity to match operational demands and ensure safety. This feature prevents overloading and maintains stability, giving operators the confidence to work at height with heavy loads. JLG also incorporated a zero-calibration, automatic load sensing system into its HC3 boom lifts. If an overload situation occurs, operators can quickly respond by removing or unloading items, and the machine will recognize when it is back within its rated capacity.

The HC3 line includes six telescopic boom lift models and three articulated boom lift models. Visit **www.jlg.com** to learn more.

BZI Beam Champ Beam Rotator

BZI's proprietary Beam Champ optimizes weld positioning while working on specialty trusses, offering a new and improved way for welding teams to safely access all sides of a beam. While various rotator solutions have been tested, they don't address practical needs such as beam placement, removal, and secure positioning.

The patent-pending Beam Champ System addresses these challenges with its unique design. It cradles the beam on a chain and rotates it within two or more units. Key features include a vertical jaw arm for effortless beam insertion or removal and a support arm that holds the beam securely in place. By significantly improving efficiency and safety, the Beam Champ sets a new standard in the steel industry. To learn more, visit **www.bzi.com**.

FORGE PRIZE

AISC Accepting Entries for 2025 Forge Prize

Do you have a visionary idea that pushes the boundary of what's possible? AISC's Forge Prize challenges emerging architects, architecture educators, and architecture students to create design concepts that embrace innovations using steel as a primary structural material—with up to $15,000 on the line. It is co-administered by AISC's brand-new Architecture Center and AISC University Relations.

"The Forge Prize is the Architecture Center's flagship design competition—and it's just one way that the center sparks creativity to inspire great designers," said AISC director of architecture Nima Balasubramanian, AIA, NOMA. "The basic questions are simple: What will the future look like? What will people build with? Where will they live, work, and play? And how could steel make it happen?"

Three finalists will each win $5,000 (plus free registration and travel support to attend the Architecture in Steel Conference) and work with a steel fabricator to refine their design before presenting it to the judges and the world in a live YouTube stream on March 18, 2025. The winner will receive a $10,000 grand prize and a showcase at the 2025 Architecture in Steel Conference (part of NASCC: The Steel Conference, April 2–4, 2025, in Louisville, Ky.).

Some previous concepts have gone even further. The Spin-Valence concept created by the University of Arkansas' Emily Baker was featured at the national AIA convention, and her work will be exhibited at the National Museum of Industrial History in September.

The competition is open to designers, teams of designers, or interdisciplinary teams led by an architect based in the U.S. who are:

- Emerging practicing architects (those licensed for less than 10 years or on the path to licensure)
- Tenured or tenure-track educators who have taught for less than 10 years in a university-level architecture program in the U.S.
- Adjunct architecture educators who have taught for less than 10 years, have been licensed for less than 10 years, or are on the path to licensure
- Graduate-level architecture students enrolled in a university-level, U.S.-based architecture program

The design community has embraced the challenge since the competition's inception, creating concepts for jaw-dropping pedestrian bridges in San Diego and New York, a revitalized public housing community in Harlem, and a revolutionary space-frame system as beautiful as it is functional.

Submissions are due by 11:59 p.m. Central on November 22, 2024.

AWARDS

Council on Tall Buildings and Urban Habitat Announces 2024 Individual Award Winners

The Council on Tall Buildings and Urban Habitat honored two prominent structural steel designers with one of its annual awards.

Santiago Calatrava, a renowned architect, structural engineer, sculptor, and painter, earned the 2024 Lynn S. Beedle Lifetime Achievement Award. John Zils, a retired engineer who spent more than 40 years at Skidmore, Owings & Merrill (SOM), earned the 2024 Fazlur R. Khan Lifetime Achievement Award.

"Santiago Calatrava has seamlessly blended art and engineering to create iconic structures that redefine skylines and urban spaces across the globe," Council CEO Javier Quintana de Una said. "John Zils has significantly advanced the structural design of skyscrapers and helped make them more efficient and enduring. We are thrilled to honor these individuals' exceptional contributions to livable vertical urbanism."

Calatrava is celebrated for his visionary designs harmonizing architecture, engineering, art, and nature that appear all over the world. He has received a multitude of awards and accolades for his innovative approaches and aesthetic brilliance. He was the architect of the Margaret Hunt Hill Bridge in Dallas and the World Trade Center Transportation Hub in New York. The latter won a 2018 AISC IDEAS² Award.

Zils worked closely with the namesake of the award he earned. He and Khan helped pioneer the bundled-tube design and the other structural engineering pieces of the Willis Tower in Chicago. He also designed Pritzker Pavilion in Chicago's Millennium Park. He has led numerous projects worldwide that range widely in scope and scale. He has earned multiple individual honors from the American Society of Civil Engineers (including its 2001 Lifetime Achievement Award) and the Structural Engineers Association of Illinois.

The Lynn S. Beedle Lifetime Achievement Award recognizes an individual who has made extraordinary contributions to advancing tall buildings and the urban environment. These contributions significantly enhance cities and the lives of their inhabitants and may take any form, including completed buildings, research, technology, methods, ideas, or industry leadership.

The Fazlur R. Khan Lifetime Achievement Award recognizes an individual for proven excellence in technical design and/or research that significantly contributes to the design of tall buildings and the built urban environment. These contributions may be demonstrated as specific technical advances, innovations, design breakthroughs, building systems integration, or innovative engineering systems.

ENGINEERING JOURNAL

Fourth Quarter 2024 *Engineering Journal* Now Available

The fourth-quarter issue of AISC's *Engineering Journal* is now available at **aisc.org/ej**. It includes papers on design processes for corrosion resistance, behavior of extended single-shear plate connections subjected to combined shear and compression forces, and seismic local buckling limits for HSS and built-up box columns. Here are some highlights.

Steel Structures to Withstand the Elements: What Structural Engineers Need to Know About Corrosion
Jennifer McConnell

While regimented design processes for load-induced effects in structures are ubiquitous, similar design processes for considering corrosion resistance are lacking and create a significant gap. This paper reviews basic principles governing corrosion, how these corrosion principles translate to real-world environments, commonly available corrosion protection systems, long-term field data assessing corrosion in varied quantified environments and associated conclusions, and practical design and maintenance strategies for improving corrosion resistance.

These concepts are connected through a proposed framework for considering corrosion as a limit state that can be applied to all structures. Detailed consideration of uncoated weathering steel (UWS) bridges is provided as a pilot material and structure type for considering corrosion as a limit state. Thoughtful application of these concepts can be used to optimize corrosion resistance, improving life-cycle costs and service lives of civil engineering structures.

Behavior of Extended Single-Plate Shear Connections Subjected to Combined Shear and Compression Forces Using Finite Element Analysis
Sunil Sapkota, Gian Andrea Rassati, James A. Swanson, and Bo Dowswell

Extended single-plate shear connections can be subjected to compression loads—in addition to shear loads—during extreme events like wind and earthquakes. However, the existing interaction equations found in the 16th Edition *Steel Construction Manual*, literature, and design examples—which are being used in design for combined loading cases—have not been formally validated for use by experimental testing or finite element analysis.

This research aims to study the behavior of these connections when subjected to combined loading of shear and compression force by performing a nonlinear finite element analysis in ABAQUS. The variables considered in the study are column web stiffness, connection configurations, and different bracing conditions of the beam. The results from these analyses were compared to the available interaction equations in the *Manual* and in literature to assess their applicability under different conditions.

Steel Structures Research Update
Seismic Local Buckling Limits for Hollow Structural Section and Built-Up Box Columns
Judy Liu

Recently completed research on seismic local buckling limits for steel hollow structural section (HSS) and built-up box columns is featured. These National Center for Research on Earthquake Engineering (NCREE) studies are led by Dr. Chung-Che Chou and Dr. Tung-Yu Wu in the Department of Civil Engineering at National Taiwan University (NTU).

Dr. Chou's research has focused on seismic testing, analysis, and design for steel and post-tensioned self-centering structures. Some recent work includes studies on hybrid simulation of a full-scale steel moment frame, a post-tensioned self-centering brace, novel prediction models for early earthquake warnings, and earthquake reconnaissance work in eastern Taiwan.

Dr. Wu's research interests include collapse behavior of cold-formed HSS columns under seismic loading, subwavelength seismic metamaterial structures, crack growth in railway crossings under high wheel-rail impacts, and seismic resilience of steel buildings.

The National Science and Technology Council is supporting this research on seismic local buckling limits for HSS and built-up box columns. Selected highlights from both projects are presented, along with a preview of future research tasks.

People & Companies

JLG Industries, Inc., an Oshkosh Corporation business and a leading global manufacturer of mobile elevating work platforms and telehandlers, acquired **AUSACORP S.L.** (AUSA). The acquisition adds the market-leading brand's compact all-terrain machines for transportation and material handling to the Oshkosh Access segment. Following the 2023 acquisition of Hinowa, adding AUSA further supports the Oshkosh accelerated growth strategy and strengthens the JLG equipment portfolio.

Established in 1956, AUSA specializes in designing, manufacturing, and selling wheeled dumpers, rough-terrain forklifts, and compact telehandlers. The equipment is targeted toward the residential, civil, and road construction industry and the transportation and handling of industrial and agricultural materials.

Acrow is supplying 186 modular steel bridges to the Republic of Angola that will help modernize the country's road and transportation infrastructure. The bridges will be installed throughout the country by Angolan engineers, technicians and contractors trained by Acrow in the assembly, installation, and maintenance of the bridges.

Acrow has provided sustainable infrastructure solutions to more than 150 countries since its founding in 1951. Since the 1990s, the firm has supplied more than 2,000 bridges to more than 40 African nations. These durable and permanent infrastructure assets can withstand the most rugged conditions and are well-suited for secondary and rural road networks. Acrow modular bridges are manufactured to the finest international quality standards and customized to meet site requirements. They can be quickly transported to remote sites and assembled in a matter of days or weeks with local labor and minimal heavy equipment.

IN MEMORIAM

Industry Remembers Vibration Design Trailblazer Thomas M. Murray

Thomas M. Murray, PhD, the nation's leading expert on the vibration design of buildings, died August 29 at the age of 84.

Murray, an emeritus professor at Virginia Polytechnic Institute and State University, was well known for his expertise on steel connections, floor system serviceability, pre-engineered building design, and light-gauge design. His place among the highest pantheon of steel researchers, though, was secured by his foundational work on vibration design, including his plainly titled paper "Building Floor Vibrations," for which he won AISC's 1991 T.R. Higgins Lectureship Award.

Murray was also one of the authors of AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity*, which is one of AISC's most widely accessed technical resources, and a perennially popular lecturer on the subject.

"Tom's involvement, contribution, and legacy are extremely broad and significant in AISC's technical resources over the last four decades," said AISC President Charles J. Carter, SE, PE, PhD. "He was always thinking, and he always contributed a practical solution to our discussions. We will all miss his wisdom and talent—and the quick wit he'd use to help us get past an impasse."

Murray joined Virginia Tech's faculty in 1987 after 17 years at the University of Oklahoma. At Virginia Tech, he was named the Montague-Betts Professor of Structural Steel Design, and in 2006, he received the Outstanding Faculty Award from the State Council of Higher Education in Virginia. He also served on the AISC Specification and Manual committees and the Connection Prequalification Review Committee. In 2007, he received the AISC Lifetime Achievement Award, and in 2010 he was presented the prestigious AISC Geerhard Haaijer Award for Excellence in Education, which at the time had only been given to five other recipients.

In 2002, Murray was elected to the National Academy of Engineering, and in 2012, he became a Distinguished Member of ASCE.

"Tom Murray was an icon in the steel community," said W. Samuel Easterling, PhD, a longtime Virginia Tech colleague who is now the dean of engineering at Iowa State University. "His passing is a great loss to the profession, but an even greater loss to those of us who knew him as a colleague, mentor, or friend. It is difficult for me to process that someone who has meant so much to me personally for nearly 40 years is no longer here to talk, provide advice, or just enjoy each other's company. I will miss him dearly."

Murray started his engineering career in 1962 after graduating from Iowa State. He later earned a master's in civil engineering at Lehigh University and a PhD in engineering mechanics at the University of Kansas. Early in his career at Virginia Tech, he led the development of an experimental research laboratory and within two years, it became the fifth-largest structural engineering research lab in the nation. In 2002, the lab was renamed the Thomas M. Murray Structural Engineering Laboratory in his honor.

"I couldn't have asked for a better teacher, mentor, and friend than Dr. Murray," said Brad Davis, SE, PhD, an associate professor of civil engineering at the University of Kentucky and a former student and collaborator of Murray's. "When I first had him as a professor in 1992, his class was on a completely different level, and that hooked me on structural engineering. In his research, he poured countless hours into developing graduate students to get their careers off to a good start. His research was unique because it provided direct guidance for real-life problems. Dr. Murray's knack for explaining technical material was simply the best."

During his career, Murray was involved in more than 130 research projects, many with an emphasis on floor serviceability. He authored or co-authored more than 200 books, design guides, and papers and supervised around 150 grad student theses and dissertations. Many of his papers can be found in AISC's *Engineering Journal* and *Modern Steel Construction* archives, and nearly a dozen of his lectures are available at **aisc.org/learning**.

Murray retired from his full-time teaching job at Virginia Tech in 2008. In 2021, Virginia Tech established the Thomas M. Murray Family Junior Faculty Fellowship through a gift from Murray.

"Tom was more than a mentor to me," said Mark Holland, PE, chief engineer at AISC full-member fabricator Paxton & Vierling Steel in Omaha, Neb. "I owe my career to Tom. He got me my first job, trained me to think like an engineer, and was everything a mentor needed to be. His ability to explain complex problems in ways people of different levels of technology knowledge could understand set him apart from most other academics. Tom was also my friend. I will miss him personally and, along with the rest of the steel industry, professionally."

SCHOLARSHIPS

AISC Education Foundation Awards More Than $350,000 in Scholarships

The AISC Education Foundation has awarded 107 undergraduate and master's students with $357,250 in scholarships for the 2024–2025 academic year. The AISC Education Foundation is a registered 501(c)(3) nonprofit organization, and every penny donated to the AISC Education Foundation is 100% tax-deductible and goes to students, educators, and education programs. Visit **aisc.org/giving** for more information.

The AISC David B. Ratterman Fast Start Scholarships program awarded 19 scholarships totaling $86,000. The program supports the immediate family members of AISC full-member company employees who will be freshmen and sophomores during the 2024–25 academic year—or the employees themselves, in some cases. The students may attend two- or four-year programs and may choose any area of study.

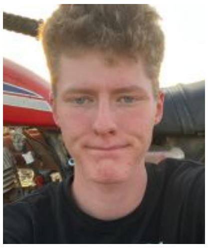
Six students in Wyoming are turning up the heat with Rex I. Lewis Fast Start Scholarships they won at the 2023 Puma Steel welding competition in Cheyenne, Wyo. They competed against other high schoolers to win scholarships to local welding programs. The AISC Education Foundation administered $4,500 to these six recipients.

AISC also awarded a total of $15,000 in funds to the top-scoring teams in the Student Steel Bridge Competition, plus three team awards for spirit, ingenuity, and engagement.

The AISC Education Foundation, in partnership with several other structural steel industry associations, awarded the remaining $251,750 to 72 additional students. The Foundation is deeply thankful for the growing support of industry partners and all the individual contributors who help support the next generation of great thinkers. The following students received AISC scholarships for the 2024–2025 academic year:

David B. Ratterman Fast Start Scholarships

- Elijah Beebout, Faith Baptist Bible College and Theological Seminary
- Lydia Burrows, University of Wisconsin – Stevens Point
- Clara Cobb, Louisiana Tech University
- Elijah DeBruler, Indiana Wesleyan University
- Caleb Dodd, Mississippi Delta Community College
- Gianna Frasher, University of Mary
- Julia Huls, Montana State University
- Molly Lusk, North Carolina State University
- Marissa McLaughlin, University of Maine Farmington
- Josie Miller, SUNY Plattsburgh
- Michael Moyano, Thaddeus Stevens College of Technology
- Payton Rude, North Dakota State University
- Ayden Sandefur, Western Kentucky University
- Mallie Zielinski, University of Mississippi













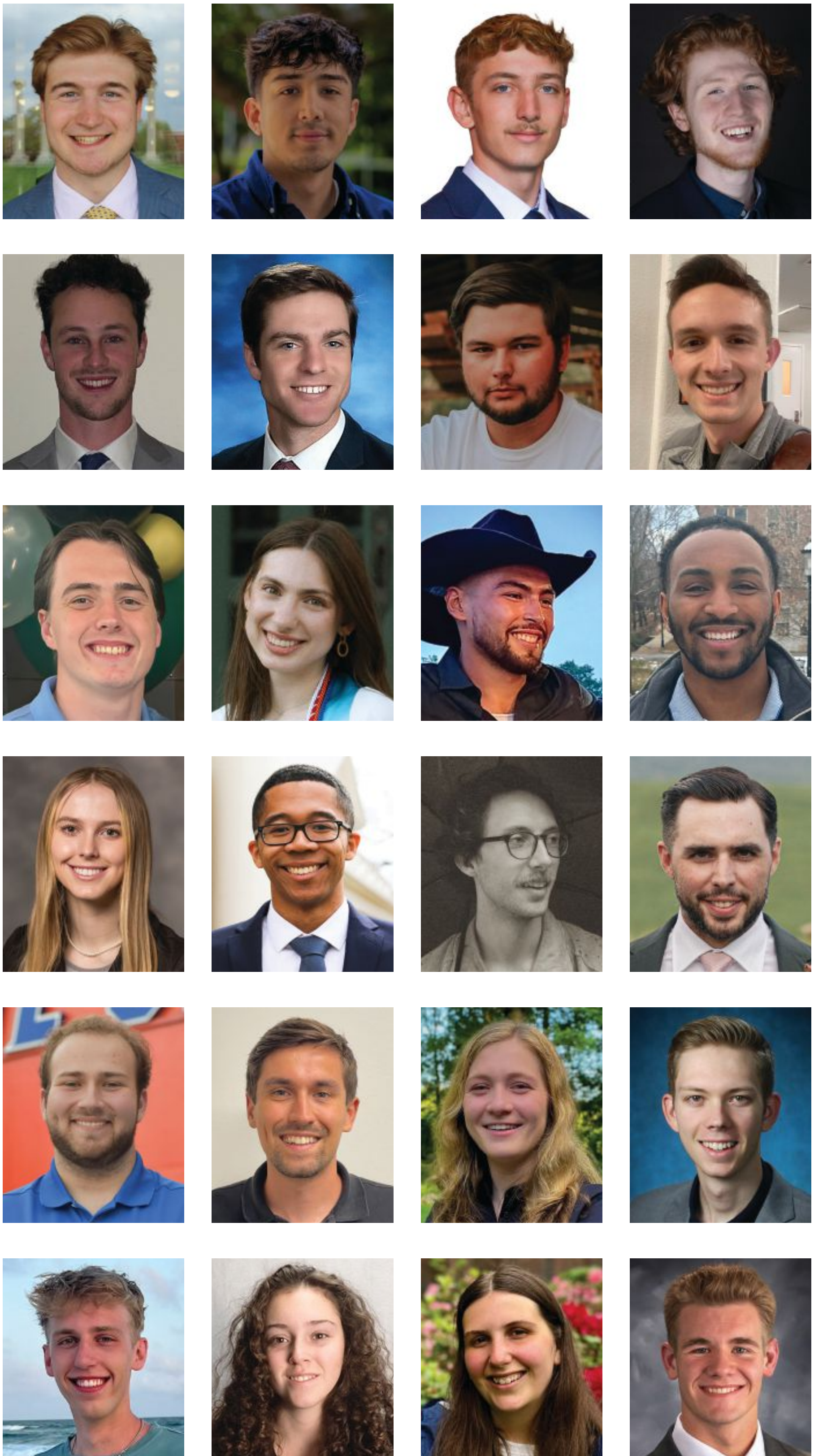

AISC thanks this year's David B. Ratterman Scholarship jury for their time and dedication:

- Greg Borchardt, Infra-Metals Co.
- Kelsey DeLong, DeLong's, Inc.
- Babette Freund, Dave Steel Co., Inc.
- Steve Knitter, Geiger & Peters, Inc.
- John O'Quinn, High Steel Structures, LLC
- Duff Zimmerman, Cooper Steel

not pictured:

- Amber Winzenburg, Ridgewater College
- Olivia Ehlers, University of Nebraska – Lincoln
- Osihel Leos, University of Texas at Arlington
- Konner Parsley, Purdue University – Indianapolis
- Ella Rogowski, University of Wisconsin – Green Bay

AISC Education Foundation Scholarships for Juniors, Seniors, and Master's Students



- Jonathan Adkins, University of Missouri
- William Almaraz Vargas, Michigan State University
- Ethan Baum, Arizona State University
- Sean Bernhard, CUNY New York City College of Technology
- Ryan Bigler, Ferris State University
- Miles Book, Virginia Tech
- Jacob Bowers, Clemson University
- Christian Brack, Oklahoma State University
- Tyler Burns (W&W | AFCO Steel Scholarship), University of Arkansas at Little Rock
- Sabina Busch (Cohen Seglias Scholarship), Columbia University
- Alonzo Calvillo, University of South Alabama
- Wayne Carter (Cohen Seglias Scholarship), University of California, Berkeley
- Sarah Cole, Boise State University
- Leon Crawford, Columbia University
- Samuel Curry, Belmont University
- Christopher Dent, CUNY New York City College of Technology
- Maxwell Fletcher, University of Florida
- Josh Gargan, Georgia Tech
- Julie Garry, Stevens Institute of Technology
- Ryan Hamman, University of Arizona
- Grant Harrington, Oklahoma State University
- Tori Hay, Ferris State University
- Amelia Hilterbrand, Brigham Young University
- Jonathon Keller, University of Nebraska Omaha

AISC Scholarships continued on page 62 >>

Thank you to this year's AISC Scholarship jury for Juniors, Seniors, and Master's-level scholarships:

- Ezra Arif Edwin, SE, Simpson Gumpertz & Heger
- Benjamin Baer, SE, PE, Sheffee Lulkin & Associates, Inc.
- Jeanne Homer, AIA, AISC
- Luke Johnson, SE, PE, Nucor
- Matt Streid, SE, PE, Magnusson Klemencic Associates
- Jacquelyn Wong, PE, California Department of Transportation

AISC Education Foundation Scholarships (cont.)

- Tracy Kinzer, Penn State Harrisburg
- Berit Klein, University of Minnesota – Twin Cities
- Jack Laws, Auburn University
- Austin Leland, California Polytechnic State University
- Abigail Markel, Ferris State University
- Connor May, Auburn University
- Joseph Mirza, Stanford University
- William Newhoff (Steven J. Fenves Scholarship), Stanford University
- Kaitlin Pickart, Lawrence Technological University
- Megan Quinn, University of Colorado Boulder
- Rebecca Rasmussen, Brigham Young University
- Justin Reed, University of Arizona
- Lennart-Fredrik Schmitz (Fred R. Havens Scholarship), University of Wisconsin – Madison
- Lelyan Shaded, Texas A&M University
- Anne Townsend, University of Virginia School of Architecture
- Anna Turco, Clemson University
- Shaun Varghese, Temple University
- Kelsi Weilage, University of Nebraska Omaha
- Donald White, University of Missouri
- Jacob Wills, Stevens Institute of Technology

not pictured:

- Calvin Reeves, University of Virginia
- Joshua Trimm, University of Texas at Austin









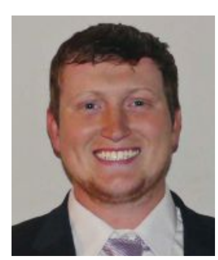













AISC/Associated Steel Erectors of Chicago Scholarships




- Stephanie Bonilla, University of Illinois Chicago
- Elizabeth Capretta, University of Illinois Urbana-Champaign
- Alec Spano, University of Illinois Urbana-Champaign
- Zoe Sterr, Rose-Hulman Institute of Technology

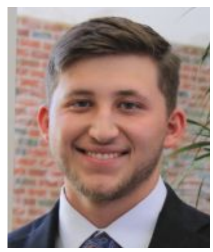
not pictured:

- Prasant Kafle, Illinois Institute of Technology

AISC/W&W | AFCO Steel/ Oklahoma State University Scholarships






Seniors
- Georgia Giddens, Civil Engineering
- Elyssa Gowriluk, Architectural Engineering
- Weston Light, Construction Engineering Technology

Juniors
- Joseph Black, Construction Engineering Technology
- Caitlyn Lutrell, Architectural Engineering
- Griffin Moore, Civil Engineering

Sophomores
- Cadence Cross, Civil Engineering

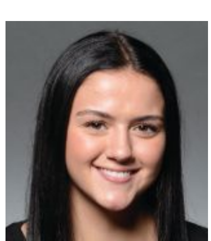
not pictured:
- Alyssa Durham, Architectural Engineering
- Cade Scarbrough, Construction Engineering Technology




AISC/Indiana Fabricators Association Scholarships

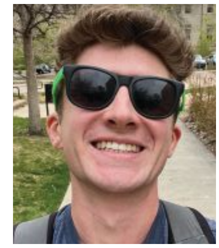
- Karsten Arnold, Purdue University Fort Wayne
- Bradley Richman, University of Notre Dame
- Mady Seif, Purdue University
- Kate Wood, Rose-Hulman Institute of Technology

not pictured:
- Mateo Duran, Valparaiso University
- Connor Thiel, Trine University
- Zachary Worley, University of Evansville

Virginia Carolinas Structural Steel Fabricators Association Family Scholarships

- Anna Beddingfield, University of North Carolina at Chapel Hill
- Molly Lusk, North Carolina State University

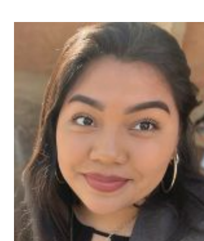



AISC/Rocky Mountain Steel Construction Association Scholarships

- Jonathan Fezell, Colorado School of Mines
- Megan Quinn, University of Colorado Boulder


AISC/ Southern Association of Steel Fabricators Scholarships

- Jack Laws, Auburn University
- Connor May, Auburn University

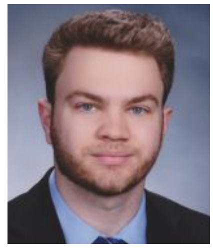



AISC/Virginia Carolinas Structural Steel Fabricators Association Scholarships

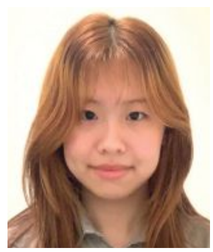
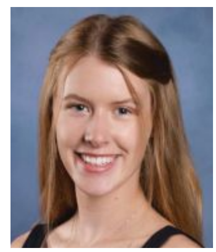
- Shannon Hodul, Virginia Tech
- Samantha Villeda Salinas, University of North Carolina at Charlotte

Student Steel Bridge Competition Scholarships







- Kevin Chen, University at Buffalo
- Maple Crow, University of Nevada, Las Vegas
- Christopher Good, Virginia Tech*
- Kaeden He, University at Buffalo
- Angelina Paoni, University of Nevada, Las Vegas
- Anthony Perez Ortegon, University of Florida
- Emily Tan, University at Buffalo
- Kathryn Wright, Lafayette College

not pictured:

- Gabriel Papiernik, South Dakota School of Mines and Technology
- Donald Stowell-Moore, University of Florida

**Recipient chose to begin their postgraduate studies at a new school. The school listed does not indicate the winning SSBC team.*

AISC/Ohio Steel Association Scholarship

- Nate Salata, The Ohio State University

Rex I. Lewis Scholarships

not pictured:

- Spencer Browning Jr., Laramie County Community College
- Nicolas Cantu, Laramie County Community College
- Dalton Erickson, Laramie County Community College
- Jedidiah Hoyt, Western Wyoming College
- Chloe Pruitt, Laramie County Community College
- Tyshon Swalstad, Casper College

SSRC

Todd Helwig Named 2025 Lynn S. Beedle Award Recipient

The Structural Stability Research Council (SSRC) has selected Todd Helwig, PE, PhD as the 2025 recipient of the Lynn S. Beedle Award, SSRC's highest honor. It recognizes longtime SSRC members who have carried out world-class research or structural design in the field of structural stability, been a leader in fostering cooperation between professionals worldwide, and made significant contributions to code development. It was established in honor of the late Lynn S. Beedle, who was an international authority on stability and the development of code criteria for steel and composite structures.

Helwig, who holds the Jewel McAlister Smith Professorship in Engineering at the University of Texas at Austin, will receive his award and give a presentation titled "A 30-Year Career Led by Buckling and Bracing Problems" on April 1 at the 2025 Annual Stability Conference, held in conjunction with NASCC: The Steel Conference in Louisville, Ky.

Helwig's primary area of interest is the design and behavior of steel structures with an emphasis in full-scale testing, field monitoring, structural stability, fatigue, and stability bracing requirements. He is a member of several technical committees within AISC, the AASHTO/National Steel Bridge Alliance Collaboration, the Design Advisory Group and Steel Bridge Task Force for AASHTO, and SSRC. He is also a member of the AISC Committee on Specifications. He served on the Executive Committee for SSRC from 2002–19 and was its chair from 2016–19.

Helwig's research has been recognized with several awards, including the 2023 George Richardson Medal presented at the International Bridge Conference, 2022 Richard S. Fountain Award given by AASHTO/ AISI/NSBA, a 2022 AISC Lifetime Achievement Award, the 2017 AISC T. R. Higgins Lectureship Award, an AISC Special Achievement Award, the ASCE Collingwood Research Prize, the ASCE Moisseiff Award, and the ASCE Shortridge Hardesty Award.

advertiser index

Raise the Roof

AN UNUSED, EMPTY COURTYARD became a school's centerpiece, and a steel roof that created an inviting atmosphere was the driving force behind the transformation.

Downers Grove North High School in Downers Grove, Ill., wanted to turn a landlocked courtyard into a student commons with communal spaces and ample natural light. To achieve the latter, the space needed to be enclosed with a roof that permitted a steady flow of sunlight. A steel structure provided the ideal solution and did not disrupt the pre-existing buildings that support it.

The roof is made of eight identical custom-framed king post trusses, which rest on a perimeter frame that helps transfer the roof loads directly to existing columns and foundations. The undersides of the trusses are exposed to view and were specified to AESS Category 2 requirements. Three years after its completion, the commons has become the school's student life hub.

The commons roof is one of several projects in the annual *Modern Steel Construction* What's Cool In Steel feature. Check out the December issue to learn more about the roof design and how it fit onto decades-old buildings without issue.

What's Cool in Steel showcases recent projects, initiatives, and happenings from around the country. It primarily focuses on smaller projects and temporary structures that creatively use steel. The 2024 iteration will also highlight a new rest stop in Indiana designed to honor its surroundings, a fishing platform and city overlook on the Schuylkill River in Philadelphia, a reconfiguration project that led to a Manhattan building changing its address, a photo book that highlights a historically significant adaptive reuse project in Chicago, and more.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