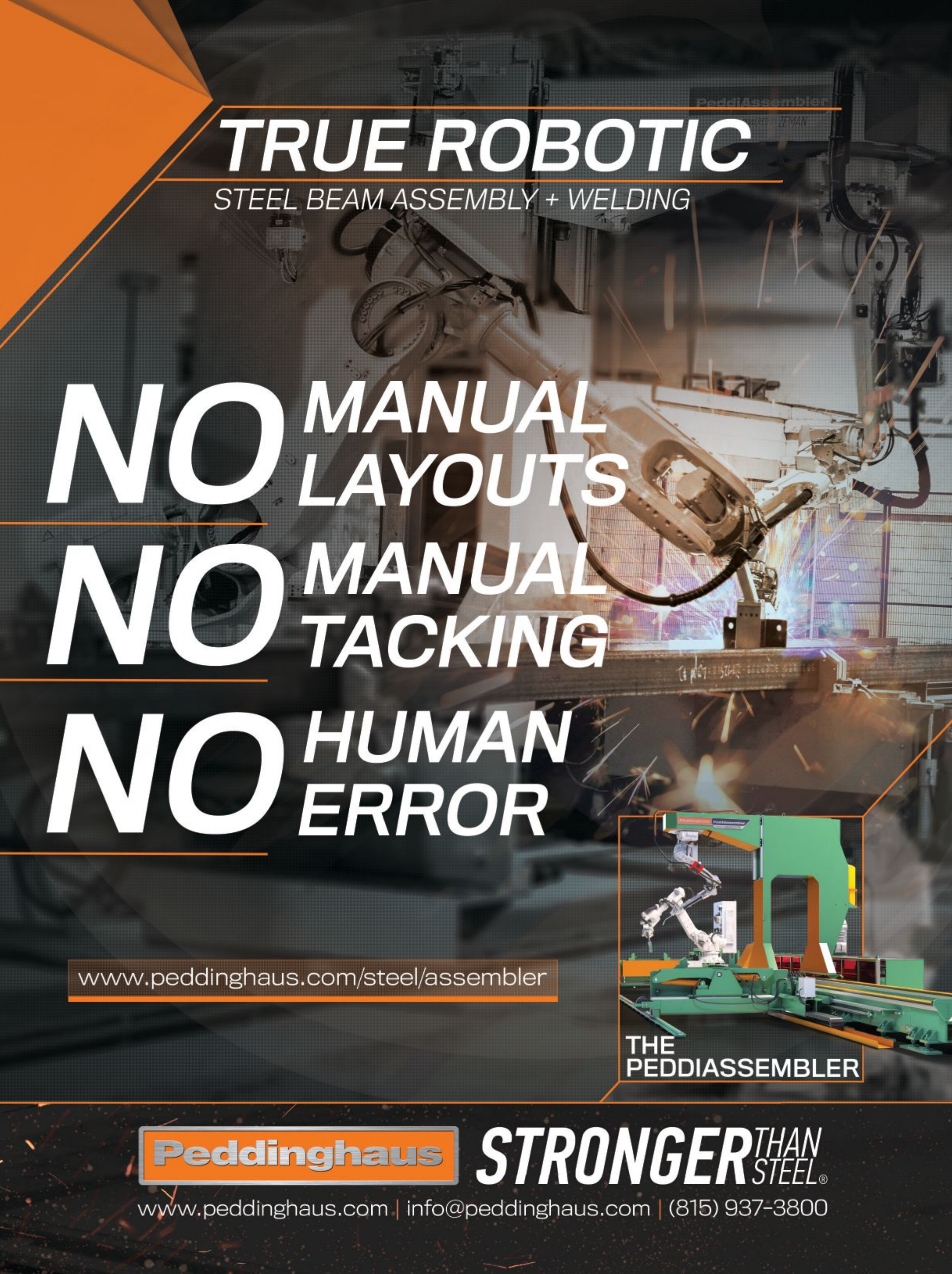
Modern Steel Construction

March 2023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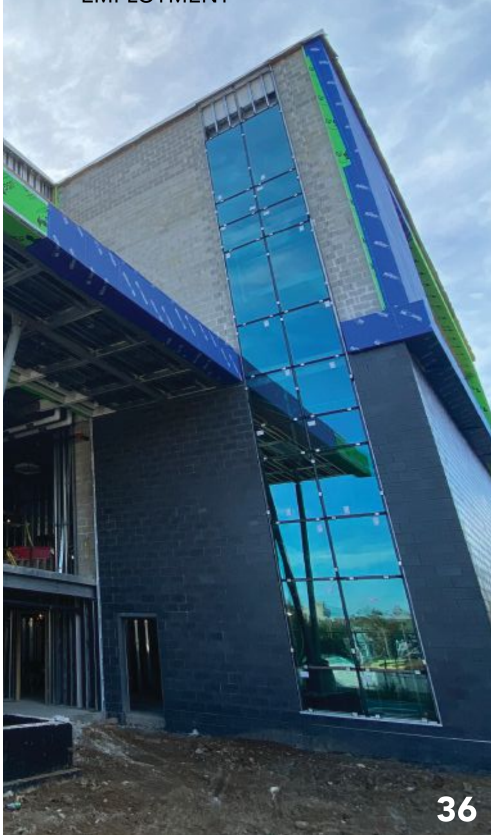
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ON THE COVER: Building as cactus? A government facility in Arizona takes a page from the saguaro playbook, p. 28. (Photo: Matt Winquist)

MODERN STEEL CONSTRUCTION (Volume 63, Number 3) ISSN (print) 0026-8445: ISSN (online) 1945-0737. Published monthly by the American Institute of Steel Construction (AISC), 130 E Randolph Street, Suite 2000, Chicago, IL 60601. Single issues $8.00; 1 year, $60. Periodicals postage paid at Chicago, IL and at additional mailing offices. Postmaster: Please send address changes to MODERN STEEL CONSTRUCTION, 130 E Randolph Street, Suite 2000, Chicago, IL 60601.

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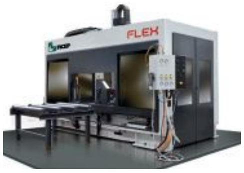

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My wife keeps a bunch of reusable bags in her car for when she goes grocery shopping. And she castigates me when I come home with a gaggle of single-use plastic bags.

But is she right?

It turns out that as with all things sustainable, the answers aren't that simple.

According to a 2018 study by the Ministry of Environment and Food of Denmark, an organic cotton tote needs to be used 20,000 times to offset its overall production impact. Surprisingly, it turns out that conventional cotton is actually better from a sustainability standpoint and only requires 7,100 uses to offset its production impact (the lower numbers are the result of higher yields). And polypropylene reusable bags only need 52 uses (and just 35 uses for polyester bags!).

Of course, you can't simply consider a product's carbon footprint. For example, cotton is biodegradable and breaks down after a few months, while single-use plastic bags may take centuries to decompose.

And if you think choosing the right grocery bag is complicated, try comparing structural materials. On the surface, it sounds like a no-brainer. Wood is an organic and renewable material that sequesters carbon. But that simplistic view neglects two obvious (and numerous less obvious) issues: how much of a tree is harvested (and conversely, how much is left behind during harvest to release carbon) and what happens at the end of a wood structure's life. The answer to the first is around 60%, and the answer to the second is even more depressing: It's typically landfilled or incinerated. And that doesn't even consider the negative environmental effects of cutting down forests—and remember, the vast majority of the wood used in construction does not come from sustainably managed forests (for a balanced look at sustainability issues, check out **aisc.org/sustainbility**).

Of course, steel production is also complicated. We've all heard that around 7.2% of the world's carbon emissions come from steel production (of course, that number includes all steel production, not just structural steel). But just like all shopping bags aren't created equal, neither are all steel products. The fact is that American structural steel used for wide-flange beams and columns produces substantially less carbon than other steel products. Why? First, rather than relying on iron ore and massive coal-fired furnaces, America's steel mills instead utilize recycled steel scrap and efficient electric furnaces. In fact, all of the wide-flange beams and columns produced in the United States during 2022 had an average recycled content of more than 92%. And as America's power grid turns more and more to renewable energy, steel just gets greener and greener. (If you want to see how modern steel is made, I encourage you to visit **aisc.org/vr** and watch our 360 video that lets you virtually walk through Nucor-Yamato's Blytheville, Ark., steel mill.)

A few months ago, I attended Greenbuild, a large conference devoted to sustainability and the built environment. I had the opportunity to speak with hundreds of sustainability professionals—almost none of whom understood how steel was made—and explain to them that American steel is a truly sustainable product (e.g., Chinese structural steel has around 2.5 times the carbon footprint as compared with domestic steel) and that steel is recycled over and over with no loss of strength or other properties.

If you want to know more about steel and sustainability, consider attending this year's NASCC: The Steel Conference (April 12–14 in Charlotte). In addition to attending specific sessions focused on sustainability, stop by AISC's booth or talk with folks from one of the steel mills exhibiting at the show and get the real scoop on the sustainability of steel and the future improvements that continue to reduce steel's environmental footprint.

Scott Melnick
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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**.

Connecting to W8 Column Webs

For W8 columns with 8-in. flanges (i.e., W8×31), is it reasonable to specify double-angle beam end connections to the column web?

Using double-angle connections to a W8 column web is typically not preferable. The AISC *Steel Construction Manual* states, on page 10-6: "Because of bolting and welding clearances, double-angle, shear end-plate, single-plate, single-angle, and tee shear connections may not be suitable for connections to the webs of W-shape and similar columns, particularly for W8 columns, unless gages are reduced. Such connections may be impossible for W6, W5, and W4 columns."

The T-dimension of W8s varies but is about 5.75 in for W8 sections typically used as columns, which limits angle legs to less than 3 in. An edge distance must be provided on the bolts, and the bolts must be accessible via tools. The erector may have to resort to hand tools and may struggle to tighten the bolts. I would recommend having a discussion with the fabricator and erector regarding which connection types would make help ease erection.

Larry Muir, PE

CJP Weld with Nonsteel Backing

A CJP welded splice was used to repair the compression flange of a beam that was cut during construction. We found out that an aluminum backer bar was used in lieu of a steel backer bar. Are there any concerns with this? Should the back side of the joint be back-gouged and rewelded?

Using a backer bar of nonsteel material is addressed in AWS D1.1/D1.1M:2020: *Structural Welding Code—Steel*. The AWS *Structural Welding Code* permits the use of backing bars other than steel if it has been qualified in accordance with the requirements in Clause 6 or in cases where the backing is removed after welding and the back side of the weld is back-gouged to sound metal and back welded.

Clause 4.18.1 in *AWS D1.1/D1.1M:2020* states:

"Groove welds, made from one side only without backing or made with backing, other than steel, that has not been qualified in conformance with Clause 6 shall be prohibited except that these prohibitions for groove welds made from one side shall not apply to the following:

(1) Secondary or nonstress carrying members.

(2) Corner joints parallel to the direction of calculated stress between components of built-up members."

Clause 5.4.1.2 addresses backing for prequalified CJP groove welds and states:

"Prequalified CJP groove welds made from one side only, except as allowed for tubular structures, shall have steel backing."

Clause 5.4.1.3 states:

"Prequalified CJP groove welds detailed without steel backing or spacers may use backing other than steel as listed in 7.9.3 when the following conditions are met:

(1) The backing is removed after welding, and,

(2) The back side of the weld is backgouged to sound metal and back welded. Welding procedures for joints welded with backing other than steel in which the weld is to be left in the as-welded condition without backgouging and welding from the other side are not prequalified."

Clause 7.9.3 states:

"Roots of groove welds may be backed by copper, flux, glass tape, ceramic, iron powder, or similar materials to prevent melt-through."

The commentary provided to Clause 7.9 states:

"All prequalified CJP groove welds made from one side only, except as allowed for tubular structures, are required to have complete fusion of the weld metal with a steel backing. Other backing, such as listed in 7.9.3, may be used, if qualified in conformance with Clause 6."

In addition, AISC Design Guide 21: *Welded Connections—A Primer for Engineers* states:

"For CJP groove weld details welded from one side without steel backing, welding procedure qualification testing is required to prove that the full throat is developed and an acceptable back-bead is achieved. Included in this category are groove welds made with no backing (i.e., open root joints) and groove welds made with nonsteel backing, such as copper, ceramic, flux, and other nonfusible materials."

Carlo Lini, PE

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

Section J10.7 Stiffener Requirements

Section J10.7 is just a brief paragraph stating: "At unframed ends of beams and girders not otherwise restrained against rotation about their longitudinal axes, a pair of transverse stiffeners, extending the full depth of the web, shall be provided." What are the design requirements for the stiffeners?

The lateral-torsional buckling equations in Chapter F of the 2016 AISC *Specification* were derived assuming a rigid torsional restraint at each end of the unbraced length. The requirements in *Specification* Section J10.7 are intended to ensure that these idealized boundary conditions are realized in practice. If these conditions are not met, web distortion at the supports will cause the lateral-torsional buckling strength to be lower than predicted using the equations in Chapter F. The objective of the requirements is to prevent torsional rotation at the ends of the unbraced length, which can be accomplished by restraining the out-of-plane translation of the top flange relative to the bottom flange.

The design of the stiffeners is typically based on the judgment of the engineer. General information is provided in the 15th Edition AISC *Manual* (page 2-16). Although not typically done in practice, in rare cases, I have used the equations in Appendix 6 of the *Specification* to analyze unframed beam ends. The required strength and stiffness for discrete lateral bracing located at or near the compression flange can be calculated with Appendix 6 Equations A-6-7 and A-6-8. If the stability bracing is provided by web stiffeners, the cross section of the stiffeners can be modeled as a vertical cantilever, fixed at the bottom flange with a horizontal (perpendicular to the beam axis) bracing force at the top flange. The actual strength and stiffness of the cantilever can then be compared to the required values from Equations A-6-7 and A-6-8.

Bo Dowswell, PE, PhD

HSS Torsional Constant

I need to calculate the HSS torsional constant, *C*, but I can't find an equation to calculate this value. Can you provide an equation to calculate this value?

The equation for C is provided in a User Note in Section H3.1 of the 2016 AISC *Specification for Structural Steel Buildings*.

> **User Note:** The torsional constant, *C*, may be conservatively taken as:
>
> For round HSS: $C = \frac{\pi(D - t)^2 t}{2}$
>
> For rectangular HSS: $C = 2(B - t)(H - t)t - 4.5(4 - \pi)t^3$

Bo Dowswell, PE, PhD

Class A Coating applied over a Class B Coating

A slip-critical connection had surfaces where a Class A coating was applied over a Class B coating. Both coatings come from the same manufacturer. Can I treat this as a Class A surface when determining the mean slip coefficient in Section J3.8 of the AISC *Specification*?

Qualification tests in accordance with the *RCSC Specification for Structural Steel Joints Using High-Strength Bolts* will have been performed with the paint applied to some surface. The qualification is only valid relative to the conditions tested, which was likely paint over blast-cleaned steel and not paint over a Class B coating. *Specification* Section J3.8 also defines the surface classes as "coatings on blast-cleaned steel."

My interactions with paint manufacturer technical staff indicate that the system you have described will not produce a Class A faying surface. In my experience, it is common to mask the faying surfaces to avoid unqualified paint on the faying surface. This could mean eliminating all paint on the faying surface or only providing a qualified Class B coating.

Larry Muir, PE

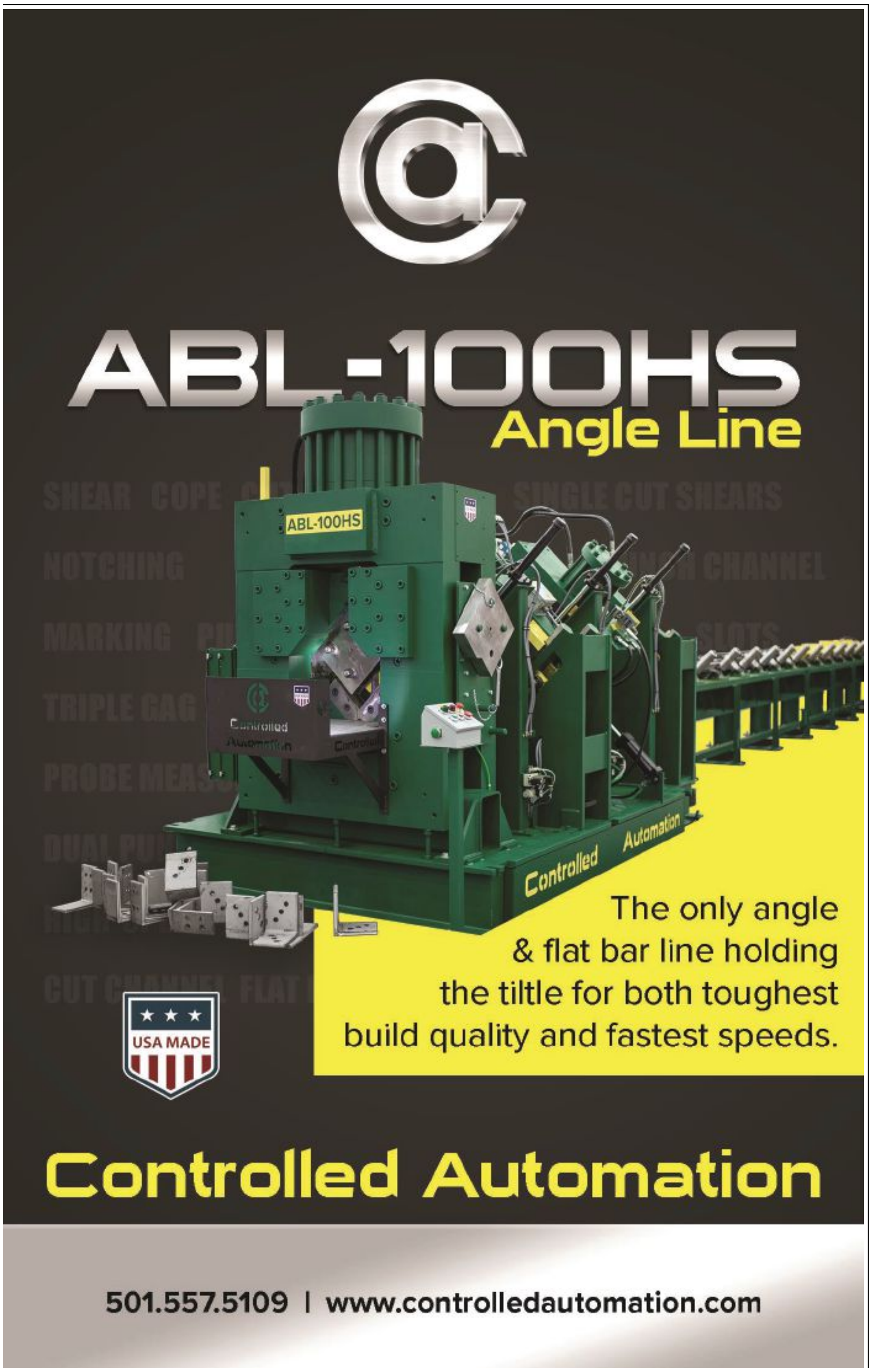
Carlo Lini (lini@aisc.org) is the director of the AISC Steel Solution Center. **Bo Dowswell**, principal with ARC International, LLC, and **Larry Muir** are consultants to AISC.

STEEL SOLUTIONS CENTER

Steel Interchange is a forum to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Contact Steel Interchange with questions or responses via AISC's Steel Solutions Center: 866.ASK.AISC | **solutions@aisc.org**

The complete collection of Steel Interchange questions and answers is available online at **www.modernsteel.com**.

If you haven't heard yet, there's a new edition of the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-22); this 2022 version supersedes the 2016 edition. This is the second part of a two-part quiz to test your knowledge of the revisions and new additions. You can find the first part in the February 2023 issue (**www.modernsteel.com**), and you can download a free copy of the new *Code* at **aisc.org/2022code**.



1 **True or False:** Shop-standard material grades have been updated for M, S, MT, ST, L, C, and MC shapes, plates, and bars to parallel updates planned for the 16th Edition AISC *Steel Construction Manual* as well as to eliminate confusion and discrepancies when ordering materials.

2 When fabrication and erection documents are not furnished by the fabricator, the 2022 *Code* now requires the __________ to review and approve these documents.
a. Authority having jurisdiction
b. Owner's designated representative for construction
c. Owner's designated representative for design
d. Structural engineer of record

3 According to the 2022 *Code*, in which of the following circumstances would the fabricator be responsible for the deterioration of the shop-applied paint?
a. The paint is exposed to atmospheric conditions that are more severe than the intended use of the paint
b. The paint is exposed to corrosive conditions that are more severe than the intended use of the paint
c. Painted members are stored for unanticipated durations due to project delays not caused by the fabricator
d. None of the above

4 **True or False:** If the selection or design of temporary erection aids is necessary, this shall be the responsibility of the owner's designated representative for construction.

5 **True or False:** According to the 2022 *Code*, architecturally exposed structural steel (AESS) Category C requires a mockup.

6 **True or False:** When a member is specified as AESS Category 4, open holes must be filled. New commentary added to the 2022 *Code* encourages that weld access holes should be filled with body filler or other mutually agreed upon non-weldable material.

7 **True or False:** Fabrication and erection tolerance requirements are located in several sections throughout the 2022 *Code*.

TURN TO PAGE 14 FOR ANSWERS

steel quiz ANSWERS

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

Need some guidance? The preface of the *Code* includes a summary list of changes and updates (and, of course, you can find hints throughout the publication itself). In addition, the January 2023 SteelWise article "Talking through the *Code*" (**www.modernsteel.com**) provides an excellent review of the updates through the lens of an engineer, a fabricator, and an erector. You can also view a four-part series of sessions devoted to the 2022 *Code* from the 2022 NASCC: The Steel Conference at **aisc.org/educationarchives**.

1 **True.** The revisions to shop-standard materials in Section 6.1.1 are coordinated with similar upcoming revisions to Table 2-4 in the 16th Edition AISC *Manual*. Updates to the shop-standard material for channels, angles, bars, plates, and the other listed shapes are based on an extensive survey of AISC of fabricators and mills of both in-production and readily available steel materials. Material availability can always be verified through the AISC website at **aisc.org/steelavailability**.

2 **c.** Owner's designated representative for design. Per Section 4.5 of the *Code*, the owner's designated representative for design must review and approve fabrication and erection documents that are not furnished by the fabricator. As a result of this required review, the fabricator is not responsible for the coordination or accuracy of fabrication and erection documents that were furnished, nor is the fabricator responsible for the general fit-up of the members that are fabricated, as long as fabrication is in accordance with the documents provided.

3 **d**. None of the above. Field touch-ups and handling damage have been areas of contention over the course of many projects and can result in extensive additional costs. Disputes may arise when responsibilities are not clearly defined in the contract documents. Section 6.4.4 specifically notes that the fabricator is not responsible for the deterioration of the shop-applied paint where the paint is exposed to atmospheric conditions or corrosive conditions that are more severe than the intended use of the paint. Further, the fabricator is not responsible for deterioration when painted members are stored for unanticipated durations due to project delays not caused by the fabricator.

4 **False.** Section 7.10.3 states: "The erector shall determine the need for, furnish, and install all temporary supports, such as temporary guys, cables, beams, falsework, cribbing, erection aids, or other elements required for the erection operation." In the 2022 *Code*, additional language was added to clarify that if the selection or design of such temporary supports is necessary, this shall be the responsibility of the erector.

5 **False.** In the 2016 *Code*, AESS Categories 3, 4, and C required a mockup—but AESS C no longer requires a mockup in the 2022 *Code*. This requirement for AESS C was removed as it may be defined to be less stringent than other AESS categories that don't require a mockup. Clarification was added to Section 10 that the requirements for AESS C must be clearly defined in the contract documents.

6 **True.** Section 10.6(h) of the *Code* states: "For Category AESS 4, open holes shall be filled with weld metal or body filler and smoothed by grinding or filling to the standards applicable to the shop fabrication of the materials." New commentary to section 10.6 states: "Weld access holes, as defined by ANSI/AISC 360, should be filled with body filler or other mutually agreed upon non-weldable material. Filling weld access holes with weld metal is discouraged for reasons cited in the commentary to AWS D1.1."

7 **False.** The 2022 *Code* contains a new Section 11 to centralize all fabrication and erection tolerances in one single location from their previous locations in Sections 6.4 and 7.13. Camber tolerances are now also included in Section 11.

A Century and Counting

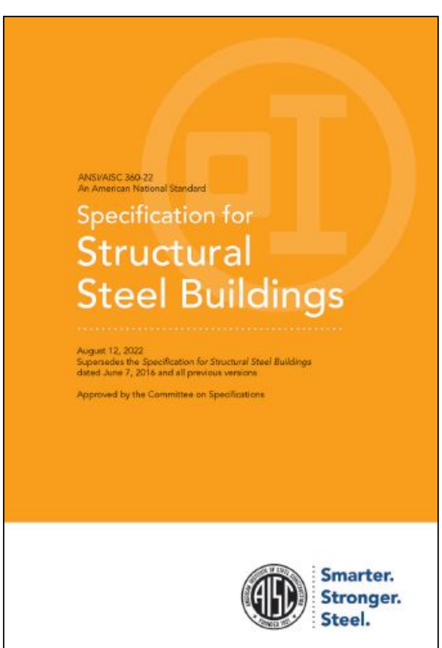
BY MICHAEL DESCH, PHD, VYSHNAVI GUDHIBANDI, AND CYNTHIA DUNCAN

Nearly 100 years old, the AISC *Specification* contains some significant changes in its latest version, all geared toward better organization and easier reference.

THE AISC SPEC is nearly 100 years old! June 1 will mark the 100th anniversary of the *Specification for Structural Steel Buildings* (ANSI/AISC 360), AISC's flagship standard for structural steel design, fabrication, and erection.

Of course, a lot has changed in the *Specification* since its introduction. For example, the latest version, the 2022 edition, is more comprehensive and, therefore, much longer, and was approved by a Committee on Specifications of 45 members—as opposed to only five back in 1923—but it continues to serve the same purpose as the first *Specification*. The committee's mission statement summarizes that purpose succinctly:

Develop the practice-oriented specification for design, fabrication, and erection of structural steel buildings that provides for life safety, economical building systems, predictable behavior and response, efficient use, and durability and facilitates speed of project delivery.



Today, the *Specification* admittedly follows a more structured development process than back in 1923. ANSI-accredited procedures guide AISC, and the *Specification* is ultimately approved by ANSI at the end of each development cycle before its release (the date displayed on the cover reflects the ANSI approval date). Some of the Committee requirements include having a balanced roster consisting of equal numbers of industry, general interest, and consulting engineer participants; requiring participation by 67% and approval by 75% of the members; and requiring all negative votes to be addressed. The procedures also require that the standard undergo public review periods, and all objections submitted by the public must also be addressed by the Committee. The public review drafts are posted on the AISC website at **aisc.org/publicreview**.

Compared to the last version of the *Specification* (2016), the 2022 version incorporates numerous changes that reflect new research and current industry practice, coordinate with other standards, and broaden the publication's scope. As in the past, many revisions are technical, but edits are also made that focus on improving usability, transparency, and editorial content. The following is an overview of some of the more significant changes.

Terminology Consistency

The term "drawings" is updated to "documents" throughout the specification. This has been done to address the use of digital models in place of paper-only drawings. This change also makes the terminology used in the AISC *Specification* consistent with the AISC *Code of Standard Practice for Structural Steel Buildings and Bridges* (ANSI/AISC 303).

The critical stress, F_{cr}, has been changed to nominal stress, F_n, throughout Chapter E. The variable, F_{cr}, is more correctly used to represent the elastic buckling stress.

In Chapter I, the term "transverse reinforcement" has been clarified as "stirrups," "ties," "hoops," and/or "spirals" to be consistent with the terminology used by the American Concrete Institute (ACI).

Code Consistency

Section 3 in the 2016 AISC *Code* specified what information needs to be provided on the structural design documents. This list of requirements has been moved to and expanded in AISC *Specification* Section A4. Additionally, the *Specification* clarifies the difference between structural design documents issued for construction and structural design documents issued for any purpose. The 2022 AISC *Specification* has a new Section A5, "Approvals," which has been added to address the review and approval of approval documents.

A new Section B8, "Dimensional Tolerances," was added to clarify that the provisions of the AISC *Specification* are based on the tolerances provided in the AISC *Code* and the ASTM standards referenced in Chapter A. These tolerances inform the design equations and assumptions throughout the AISC *Specification*, so the effects of geometric imperfections and materials that do not meet these tolerances must be addressed in the design.

Materials Specifications

Similar to past versions of the *Specification*, Section A3 lists the specific editions of all referenced standards that apply. A new Table A3.1 has been added to Section A3.1, Structural Steel Materials, that lists the allowable grades and strengths and any other specific limitations for the ASTM Standards referenced in the 2022 AISC *Specification*. As in the past, unlisted materials are permitted with the approval of the engineer of record.

Approximate Analysis Methods

The approximate method for inelastic moment distribution (often referred to as the 9/10ths rule), formerly in Section B3.3, is relocated to Appendix 8. This relocation was done to locate all the approximate analysis methods together.

Constrained-Axis Torsional Buckling

The provisions provided for the design of compression members with lateral bracing offset from the shear center (also known as constrained-axis torsional buckling) have been moved from the Commentary into Section E4 to make them more readily available to the user.

Flexural Strength

The flexural strength equations for hollow structural sections (HSS) and box sections have been reformatted to be consistent with the equations in the other sections of Chapter F. Additionally, an inconsistency was addressed by providing a restriction on box sections with slender webs and slender flanges. These box sections are not addressed in the AISC *Specification*.

For the flexural strength of members with holes in the tension flange, it has been clarified that these provisions apply only to bolt holes. This clarification reflects that the research these provisions are based on was limited to bolt holes.

Tension Field Action in End Web Panels

In past AISC *Specifications*, there were only provisions considering tension field action for interior web panels. The 2022 AISC *Specification* adds Section G2.3 to make tension field action applicable to end web panels of built-up members with transverse stiffeners.

HSS Subject to Combined Forces

Equation H3-6 has been updated to account for biaxial bending when computing the interaction of torsion, shear, flexural, and axial forces acting on HSS members.

Composite Design

In Chapter I, new provisions have been added that make this chapter the single-source standard for the design of composite members. The chapter has been expanded to include concrete-filled composite plate shear walls (SpeedCore; visit **aisc.org/speedcore** for more information), and new provisions have been added for both filled and encased members. A performance-based alternative for the design of shear connections has also been added to expand the scope of the section. This new approach allows for designs outside the dimensional and material limits currently imposed on the design equations due to a lack of test data.

A new Appendix has been added to allow the design of filled composite members with high-strength materials. Currently, the appendix is limited to concrete with $f'_c \le 15$ ksi and steel with $F_y \le 100$ ksi.

Bolted Connections

There have been many helpful updates to the connection provisions in the 2022 AISC *Specification*. For bolted connections, these updates include guidance on the AISC *Specification*'s relation to the *RCSC Specification for Structural Joints Using High-Strength Bolts*, high-strength bolt nomenclature, and the use of the entire net area for larger-diameter bolts.

Where they do not contradict the AISC *Specification*, high-strength bolts and bolting components should conform to the *RCSC Specification*. Guidance on major exceptions to the *RCSC Specification* has been added to the Commentary.

The nomenclature used for bolt grades has changed from "Group A," "Group B," and "Group C" to "Group 120," "Group 150," and "Group 200," reflecting the strength of the bolt material. Additionally, a new bolt grade, "Group 144," has been added. This group's bolt assemblies must conform to ASTM F3148

The nominal tensile stress of bolts and threaded rods based on the tensile stress area is now permitted to be used in lieu of the values presented in Table J3.2. The tabulated values are based on the simplified assumption that the net area of the threads is 0.75 times the gross area. This assumption works well for bolts smaller than 1½ in. in diameter, but for larger bolts or threaded rods, it underestimates the net area. The more precise tensile stress area may be computed in accordance with the applicable ASTM standard.

Welded Connections

For welded connections, the updates include guidance on the AISC *Specification*'s relation to the AWS *Structural Welding Code—Steel*, controls on the effective throat of partial-joint-penetration (PJP) groove welds and fillet welds, as well as the fillet weld directional strength increase factor.

Where they do not contradict the AISC *Specification*, welds should conform to AWS D1.1/D1.1M. The list of major exceptions to the AWS provisions has been moved to the Commentary.

More specific controls have been provided for PJP and fillet welds where larger effective throats are used to provide consistent penetration.

The provisions given in Section J2.4 for weld metal strength when the force is applied at an angle to the weld's longitudinal axis have been revised to clarify when the directional strength increase is permitted.

HSS Connections

In the 2022 *Specification*, Chapter K continues to address HSS connection design. It is important to remember that in addition to Chapter K, Chapter J also applies to HSS connections. Some of the new revisions directly related to HSS connection design follow:

- A more accurate effective width has been provided in Chapter K to calculate the available "punching" shear strength for rectangular HSS members
- Provisions have been added in Chapter K to address the side wall local yielding strength of rectangular HSS due to in-plane and out-of-plane moments
- Provisions have been added to Section K5 to address the design of welds for round HSS-to-round HSS connections
- The chord member stress function, Q_f, has been revised in Section K1.3. Q_f applies to many limit states for HSS connection design and has an upper limit of 1 for all members and a lower limit of 0.4 for rectangular HSS (except longitudinal plate connections). A lower limit has

been included to eliminate the possibility of calculating a negative strength and to avoid the confusion of considering the limit state as "not applicable"

- For HSS tension member connections, the shear lag factors given in Table D3.1 for slotted round and rectangular HSS members connected to gusset plates have been updated to a more accurate formulation. Also, weld pairs with lengths less than the distance between the welds may now be used

QA and QC

Section N6 has been modified to clarify that quality assurance cannot be waived, but rather the fabricator or erector may be approved to perform inspections in lieu of an independent, third-party quality assurance inspector.

A new section on quality control requirements for shop and field-applied coatings has been added to Chapter N.

Ponding

Appendix 2: Design for Ponding has been removed from the *Specification*, as the methods presented were only applicable to a limited roof configuration. Design requirements that should be considered for ponding have been added to Section B3.10.

Design for Fire Conditions

Appendix 4: Structural Design for Fire Conditions has had several significant updates, including new equations for calculating the compressive strength and the fire-resistance ratings for several types of composite elements. Additionally, a new critical temperature method has been defined. A significant amount of information on the fire resistance and design of various steel assemblies has been adopted from ASCE-29, and the *Eurocode* stress-strain-temperature equations have also been included.

The *Eurocode* stress-strain-temperature equations have been incorporated into Appendix 4 to give users more explicit guidance on what material properties they can use for steel and concrete at elevated temperatures. Other rational methods that establish elevated temperature material models based on test data are also permitted.

Appendix 4, Section 4.3: Design by Qualification Testing now includes prescriptive steel fire protection design equations and related information based on ASTM E119 fire tests. These fire-protection design equations, which are also contained in ASCE-29 and the *International Building Code*, have been included in the AISC *Specification* for user convenience and awareness.

Appendix 4 has been expanded to include the fire resistance rating and available compressive strength for SpeedCore under fire loading.

A new critical temperature method has been added to Appendix 4 that provides equations to calculate the temperature at which the demands on a member would exceed its elevated temperature capacity. Critical temperatures can be calculated for tensile yielding, flexural buckling, and flexural yielding. The provided equations can calculate the critical temperature as a function of the nominal strength at ambient temperature, the required strength at elevated temperatures, and the member slenderness.

Complete Comparison

These are just some of the updates in the 2022 *Specification*. If you're interested in seeing all of them, you can find a complete comparison document for the 2022 and the 2016 editions—as well as the latest version of the *Specification* itself and all of AISC's codes and standards—at **aisc.org/specifications**. In addition, the new *Specification* will also appear in Part 16 of the 16th Edition AISC *Steel Construction Manual*, which is expected to be released this summer. An overview of these changes was also presented at the 2022 NASCC: The Steel Conference in Denver. You can view a recording of this session in the AISC Education Archive at **aisc.org/education**.

With these highlighted changes as well as the rest, the newest version of AISC's century-old go-to publication should make for a more efficient reading experience and more efficient design work.

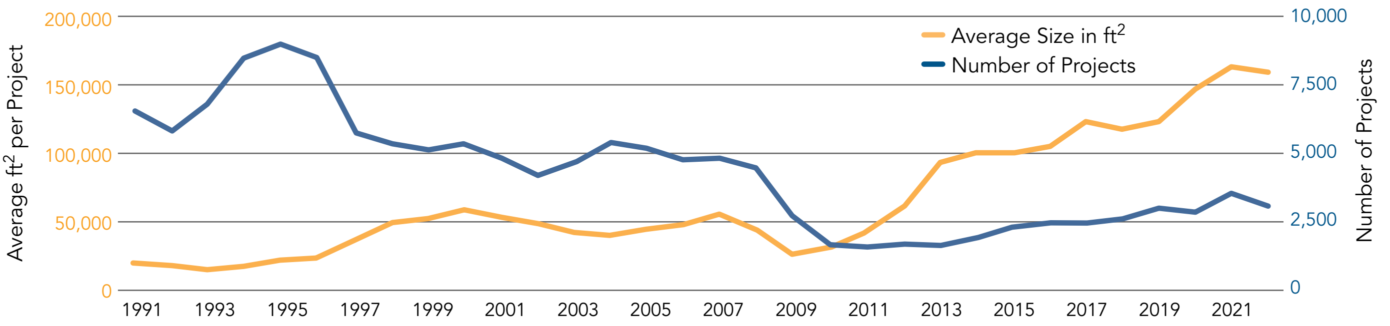
Michael Desch (desch@aisc.org) is an AISC staff engineer, **Vyshnavi Gudhibandi** is a structural designer with WT Group and a former AISC engineering and research intern, and **Cynthia Duncan** recently retired as AISC's director of engineering.

Less is More

BY BRIAN RAFF

Warehouses are typically minimalist structures, but they've maximized in size over the past few years.

Fig. 1.
Warehouses: Number of Projects and Average Square Footage



YOU MAY HAVE HEARD the saying "less is more," but you might not be aware of its origins.

For nearly a century, Mies Van Der Rohe has had a maximal impact on the built environment with an acute minimalistic sensibility. It's easy to see what that looks and feels like through Van Der Rohe's interpretation of the International Style, which the Getty Research Institute defines as "the style characterized by an emphasis on volume over mass, the use of lightweight, mass-produced, industrial materials, rejection of all ornament and color, repetitive modular forms, and the use of flat surfaces, typically alternating with areas of glass." And while the dominant warehouse sector of the U.S. construction market is certainly not in the International Style of architecture, this market truly embodies the "less is more" aphorism when we look at the data.

2022 was a strong year for nonresidential construction starts both in terms of square footage put in place and the number of projects built. Warehouses continued to dominate the building landscape, but there is one interesting takeaway from the data. Despite the massive growth in square footage in the warehouse market over the last decade, the number of warehouses represented by that area has not really kept pace. In fact, over the last 30 years, the number of warehouses built in the United States has decreased three-fold while the average size of warehouses built today has tripled in that same time period (Figure 1).

This is surely a response to the changing demands of consumers who now want their goods delivered within hours instead of days. A recent study commissioned by Attabotics found that when faced with the unrelenting success of e-commerce giants like Amazon and Walmart, industry executives now view rapid and efficient home delivery as an existential issue, as well as a major competitive opportunity. Most believe they could significantly grow company revenues by successfully meeting consumer desire for same-day delivery.

The study predicts that "at the crux of this challenge lies the need for a new generation of micro-fulfillment centers placed in closer proximity to consumers. Given the high cost of building out such a fulfillment network, many manufacturers, retailers, and e-commerce companies are now open to new shared, joint-venture models for order fulfillment and delivery." This could present some interesting future opportunities for steel warehouse construction.

Even though warehouse construction represented the lion's share of the market in 2022, we have likely reached the end of an era. Prologis, the world's largest owner, developer, and operator of logistics warehouses, predicts that "U.S. warehouse development will fall to a seven-year low in 2023 as a rapid rise in capital costs curtails borrowing and subsequent construction activity."

But, of course, warehouses aren't the only building sector out there. Look for the April Data Driven column to learn what markets are heating up and what AISC is doing to build the steel industry's future. ■

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

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INTERVIEW BY GEOFF WEISENBERGER

After three decades of building portfolios for different structural engineering companies, Helen Torres decided to start building a portfolio for a new firm—one that bears her name.

HELEN TORRES has the CTA to thank, at least in part, for her interest in buildings.

Riding Chicago's elevated train system at an early age gave her a "behind-the-scenes" look at the city's structural makeup, which eventually led to her choosing structural engineering as a career. And roughly three years ago, following 30 years with various companies, she decided to start her own design firm, Helen Torres and Associates.

Here, she discusses an early project that made a significant impact on her, starting her own company during COVID, the evolution of equity in engineering, her experience as an AISC IDEAS² Awards judge, and more.

What brought you into the world of structural engineering? Were there any particular buildings you came across in your youth that inspired you to take that path?

I don't have that storybook tale of knowing what I wanted to be when I grew up. But I grew up here in Chicago, and I can say that I've always enjoyed taking the elevated trains and being able to look into the buildings downtown from that vantage point. Also, it's revealing to ride them through the neighborhoods and get a snapshot of people's backyards. I've always been fascinated by the urban fabric, and Chicago certainly has a lot to offer. I suppose that's true wherever I travel, but especially so here. I recall visiting the John Hancock Center as a child and being intrigued by its height and simplicity—and today, it remains my favorite building. So I think those were the first clues that maybe I'd have a career in architecture or engineering.

Speaking of buildings, of all the projects you've designed over the decades, are there any that stand out in terms of how proud you are of them, how crazy they drove you, or how they were particularly significant from a learning perspective?

There is one project that stands out for all those reasons. I worked on the University of Chicago Booth School of Business in Hyde Park. It is right across the street from the Frank Lloyd Wright-designed Robie House, and it was the

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

first large-scale project I led as a project engineer. It was 400,000 sq. ft and had numerous structural challenges—not just one or two but probably 15 or 20 unique structural challenges. It also felt like we were changing things almost right up to the ribbon cutting. When the project was completed, it was about four years before I actually went and visited the facility. When I did visit, all that angst melted away because the outcome was just so incredible. All the fussing we had to do, the changes to be made, and the architectural demands all turned out fine, and you could see what your efforts had yielded in this masterpiece. I was very, very proud of our work, and what I realize now is that, over time, I have become much better at managing project stresses, especially during the construction phase.

That sounds like quite the experience, especially early in your career. Fast-forwarding a bit, can you talk a little bit about what prompted you to start your own firm?

Sure, after 30 years of working for others and spending a lot of time in the corporate world, I just decided it was time to go out on my own and control my own destiny, so to speak. There were many, many challenges and considerations, and two-and-a-half years into it, I'm still working through some of them! I was pretty quick to apply for certification as a minority and women-owned business, which I thought would be helpful in securing work, and indeed it has been.

Overall, I've really learned an incredible amount. I didn't realize how much I didn't know when I was starting out, and I'm still learning. But I feel that it has been a success. I'm very proud of the portfolio that we're building. We have been able to work on projects in the same market sectors that I've been working on for years, like healthcare, higher education, science and technology, and data centers. We've also been doing quite a few K-12 projects, which have provided some nice local work for us. It's been a crazy time with COVID, but we've learned how to be a work-from-home organization so far and are very open-minded about where that will go.

Yes, I'm sure starting a business during COVID had its challenges. Are you thinking about opening an actual office at some point?

I'm still waiting on that. If COVID didn't come our way back in 2020, I would have definitely opened an office because that would have been the expectation. Learning from our work-from-home experience, I don't see the need just yet. I believe that when we have young staff members that we have to train, it would be really important to be sitting at the same table. But right now, we're all working from home successfully.

I'm glad it's working out so far. So in your three-plus decades of experience, has the industry evolved much in terms of equity issues?

There's been progress, but I'd say it's been slow. In school and when I started working, there were always other women studying or working alongside me. But as a young engineer, when the team would meet to coordinate the project, sometimes I would be the only woman at the table. Fast-forward ten years, and there were more women at the table. Fast-forward 20 years, I was working on a project where the women working on a project were in the majority. There are women leading large-scale projects and doing a great job!

The other place I've seen progress is with professional women's organizations, and they are a great resource. I belong to an organization called WiSE—Women in Structural Engineering—which is an SEAOI (Structural Engineers Association of Illinois) group, and there's also a new organization in Chicago, Professional Women in Construction, which brings all the construction fields under one umbrella. There are a lot of women's organizations that are getting traction, and I think that's progress.

Absolutely. On that note, do you have any advice for young women considering a career in engineer or construction in general?

Yes, the construction industry offers great careers, especially if you enjoy teamwork and problem-solving. What's so great about it is that you can actually see your efforts come together in real life. I'd certainly recommend joining some of the professional organizations I mentioned so you can build your network outside of your office or your classroom. Another piece of advice, and I wish I'd had this resource earlier in my career, is to visit **www.engineersrising.com**. The founder, Stephanie Slocum, deserves the title of patron saint of structural engineers. She has very sage advice for women, and I'm sure everyone could benefit from taking a look at her website. My last piece of advice is that if you don't have a passion for what you're doing, find the courage to change your path. Your career could easily be 40 years or more. That's a long time.

It certainly is! Switching gears, you were one of this year's AISC IDEAS^2 Awards judges. What did you think of the judging process?

I really enjoyed the experience, and I thought AISC did an amazing job pulling the team together. The group covered all the disciplines of a steel building project, and it brought different viewpoints to the table. So something that I might have thought was sort of ordinary from a structural engineering perspective could have been extremely complicated or noteworthy from a fabrication or construction point of view. It was a real treat to be at that table and hear everyone's perspectives. I think we all enjoyed it and were pleased with the outcome. ■

This column was excerpted from my conversation with Helen. To hear more from her, including her thoughts on gardening, her education, and what she loves most about Chicago, check out the March 2023 Field Notes podcast at ***modernsteel.com/podcasts****. And to read about this year's AISC IDEAS^2 winners—which, again, Helen helped choose—keep an eye out for the May issue.*

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

Ethical Behavior of Ethical Engineers

BY TROY M. DYE, SE, PE

When it comes to ethics, start with the basics and strive to "be" all the right things.

WHICH BEHAVIORS in the engineering profession are considered ethical? Which are considered unethical?

Is there a master list saved somewhere on the cloud that outlines every one of these behaviors and how they apply to each ethical tenet? If so, who wrote this list?

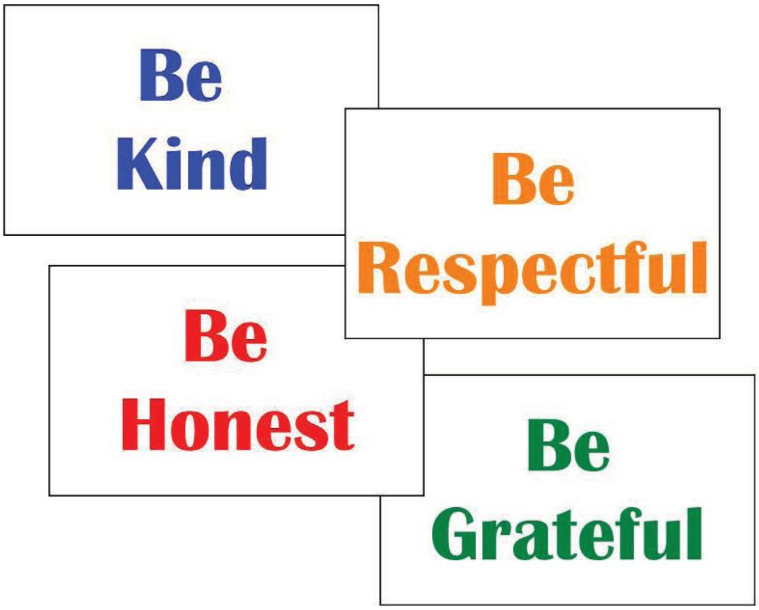
Let me suggest another approach that will help us behave ethically without the need for a list.

Imagine for a moment a fifth-grade classroom with white poster boards on all four walls. Each poster board is filled with a list of dos and don'ts, neatly typed in 48-pt Arial font, that the students must follow to create an environment of learning and respect. Every day they recite these lists so that the messages become engrained in their pliable minds. The teacher's goal is to create the most well-behaved class that other teachers admire and aspire to in their own classrooms. The students' goal is to recite the lists from memory to impress their parents or classmates. Meanwhile, the eyes of a young girl sitting in the front row are tear-stained and red because a girl in her class made fun of her clothing while standing at the bus stop.

In the adjacent classroom are the same white posterboards on all four walls. Each one, however, has one simple phrase in 120-pt Britannic Bold font that reads, "Be Kind, Be Respectful, Be Grateful, Be Honest." There is a young girl in the front row diligently writing a note of comfort because of what she saw that morning while sitting on the bus. Her teacher notices she's not on task but doesn't stop her because she glances down and reads the phrase: "You are nice and smart."

The list of ethical behaviors in the second classroom is not recorded on paper for others to follow, but it is recorded in the very nature of the students wanting to "be" ethical by everyday actions.

Guiding principles, or ethical tenets, are created by organizations to help their members provide a service to humankind. For structural engineers, one of our guiding principles is to "use our knowledge and skill in the performance of our professional duties to make decisions in the interest of safety, health, and welfare of the public" (per the NCSEA Code of Ethics). In the public's eye, this may look like an engineer posting a green, yellow, or red placard on a building during a post-disaster assessment. In a structural engineer's world, it may look like a colleague sitting at a cubicle (or home) desk with a calculator in hand, determining the load path and code prescribed forces to design a steel connection of a transfer girder supporting multiple floors. This engineer's efforts, which are out of the public eye, can have lasting impacts on individuals, families, and property if the engineer becomes distracted or careless in their duty.



As engineers, we are faced with hundreds of decisions each day that can affect the well-being of others. These include technical aspects of design but also extend to interactions and relationships with our fellow human beings. With the trust of the public's safety and well-being in our charge, we owe it to all to be ethical, fair, honest, kind, and respectful. By acting on principles instead of tasks, we help create a better world around us and build lasting relationships. ■

*For more on engineering and ethics, check out the session "Ethical Behavior of Ethical Engineers" at NASCC: The Steel Conference, taking place April 12–14 in Charlotte. You can learn more about the conference and register at **aisc.org/nascc**.*

Troy Dye (**troyd@arwengineers.com**) is a principal with ARW Engineers.

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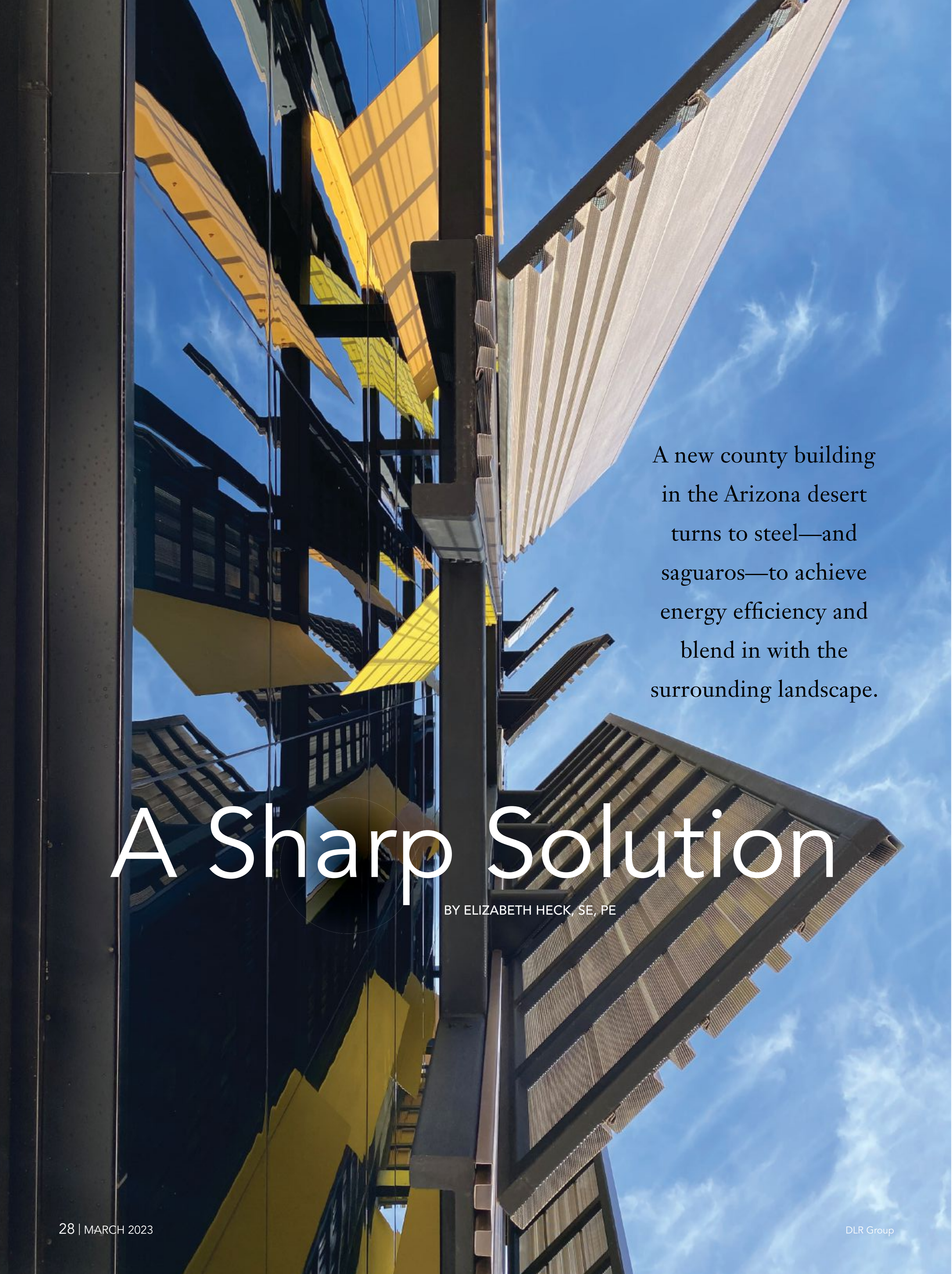


A Sharp Solution

A new county building in the Arizona desert turns to steel—and saguaros—to achieve energy efficiency and blend in with the surrounding landscape.

BY ELIZABETH HECK, SE, PE

DLR Group

opposite page: The shading fins of the Pinal County Attorney's Office are supported by exterior cantilevered framing.

The new building in Florence, Ariz., addressed Pinal County's constrained budget by condensing the building footprint and maximizing energy efficiency through biomimicry, specifically of the area's famed saguaro cactus.

Matt Winquist

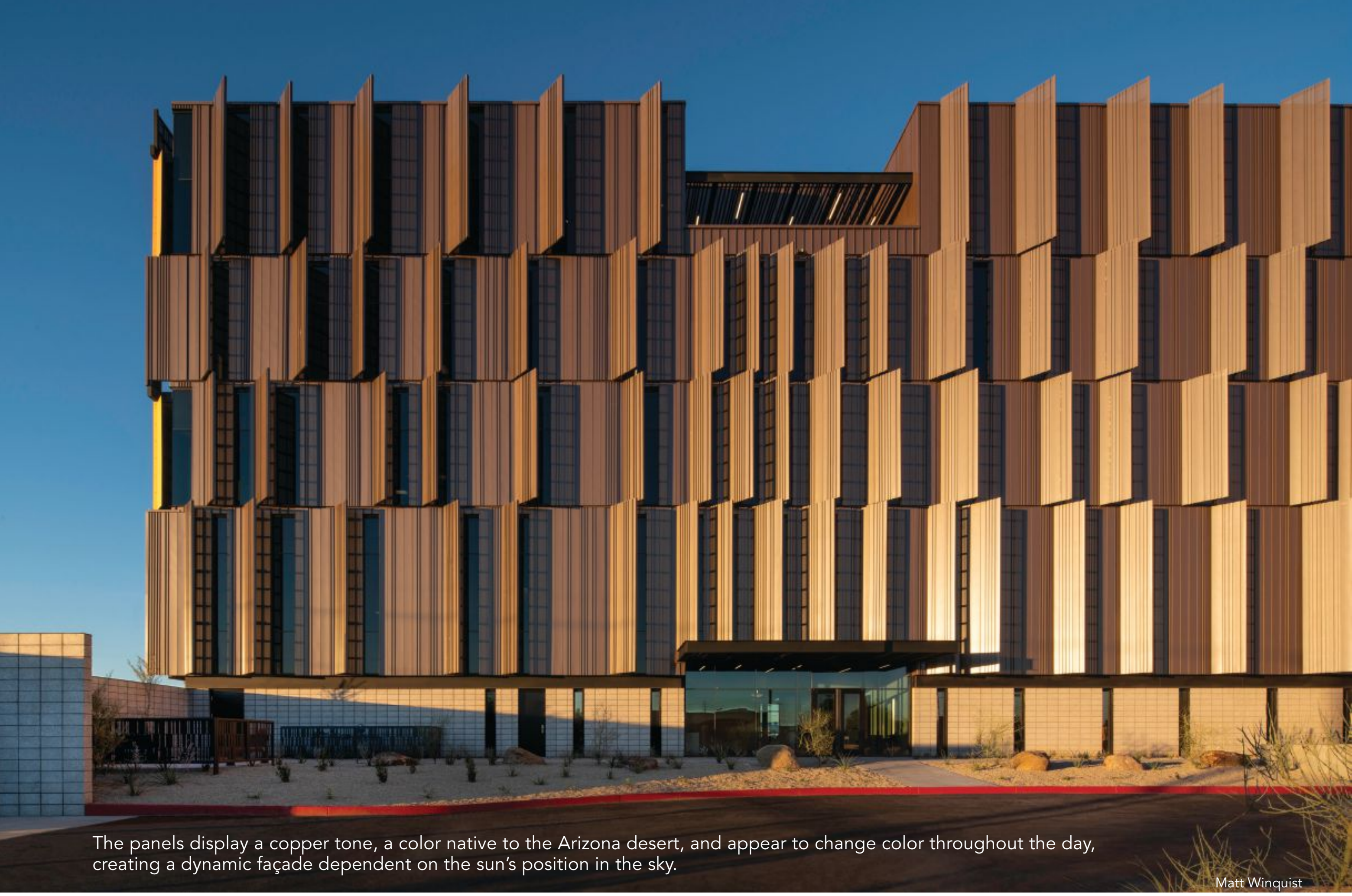
WHILE GOVERNMENT BUILDINGS are typically built to be efficient and functional, rarely do they incorporate biomimicry in their design elements.

But one government structure in the middle of the Arizona desert uses the former to achieve the latter.

The new Pinal County Attorney's Office in Florence, Ariz., addressed the county's constrained budget by condensing the building footprint and maximizing energy efficiency through biomimicry, specifically of the area's famed saguaro cactus. The design translates the shifting shadows across the cactus into rigid self-shading fins on the building, which also includes a pop of desert color when the fins are extended for viewers to enjoy as they pass by.

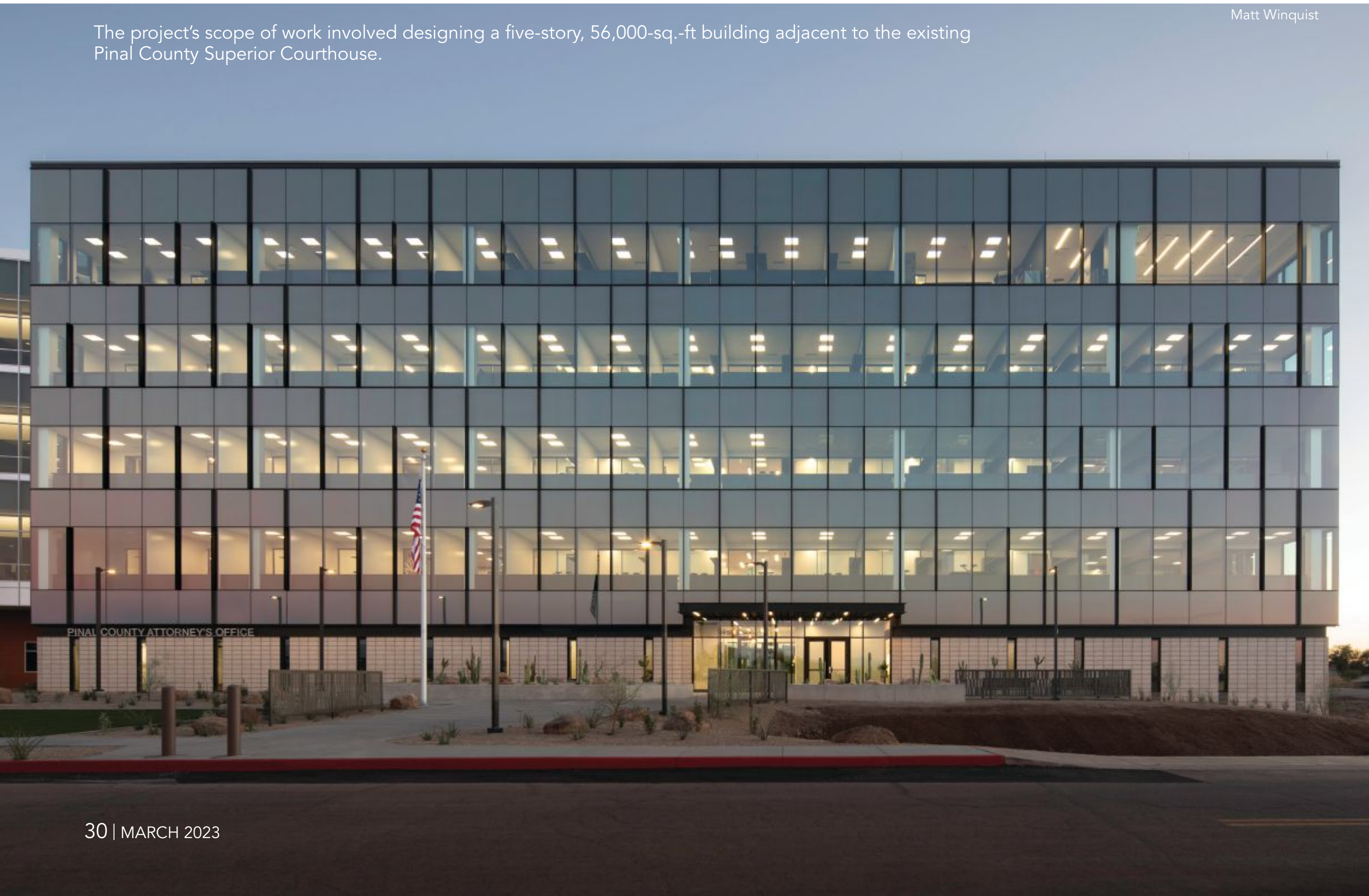
The design process began with the design team meeting with the county attorney staff to develop a vision for the project as a "lighthouse of justice." The scope of work involved designing a five-story, 56,000-sq.-ft building adjacent to the existing Pinal County Superior Courthouse. The main structural system is comprised of wide-flange steel beams and columns and interior concrete shear walls supporting metal roof deck and composite floor deck. Steel gravity framing was selected for its repetitive framing layout, quick installation, durability, and low maintenance—and steel's aesthetic qualities made it the obvious choice for other key design features. In all, the project incorporates 266 tons of structural steel.

The north and south entrances and the fifth-level patio feature decorative steel canopies cantilevering from the exterior wall, visually indicating the location of the lobby. Steel was the obvious aesthetic choice for the materiality of the canopy as it was able to mimic the vertical steel on the façade of the building and bring the duality of form and function. The canopy consists of hollow structural sections (HSS) hung from the interior floor framing and then extending out to provide dappled shading at the entrances with no exterior columns. The fascia is detailed with exposed steel channels with the flange facing out, creating texture at the edges. In between the HSS8×8×¼ beams, smaller HSS purlins (HSS4×2×$^{3}/_{16}$) were used as infill to create shade below. The canopy not only acts as a visual cue but also solves the challenge of the programmatically



The panels display a copper tone, a color native to the Arizona desert, and appear to change color throughout the day, creating a dynamic façade dependent on the sun's position in the sky.

Matt Winquist



Matt Winquist

The project's scope of work involved designing a five-story, 56,000-sq.-ft building adjacent to the existing Pinal County Superior Courthouse.

small lobby spaces by visually extending the lobby space from inside to the outdoors.

Metal Flower

The building's ribbed metal panel façade, designed to mimic a saguaro, is its feature design element, combining a modern, eye-catching design with a structure that reduces energy consumption. The galvanized steel panels are supported by square HSS framing and break the sunlight over shifting areas, allowing heat loads to redistribute until natural air convection can cool the exterior. Where windows were desired on the south façade, the wall system angles out from the building and becomes a self-shading device while maintaining the look of a continuous protective skin. The panels display a copper tone, a color native to the Arizona desert, and appear to change color throughout the day, creating a dynamic façade dependent on the sun's position in the sky. Additionally, on the west side, ¼-in.-thick steel plates extend from the HSS framing and are painted yellow and orange to provide pops of color, similar to the colors of the blooming saguaro flower.

Designing the steel support for the building's ribbed metal panel was a unique challenge for DLR Group, the project's structural engineer. On the west side, the metal fins are attached to a frame that floats in front of the exterior glazing. On the south side, the metal fins are integral to the exterior wall. The design goal was to have the metal panels extend from the exterior wall adjacent to window openings, creating shade during the hottest portion of the day. Locating the shade fins adjacent to the windows meant reducing the potential location for structural support; creating a strut at the protruded end of the shade fin would obstruct the view from inside.

The solution was to cantilever the shade fins from two HSS jamb posts in-plane with the exterior wall's metal framing. Several materials and configurations were analyzed via RAM Elements finite-element analysis (FEA) software to pick the design solution, comparing many different design parameters such as material compatibility, redundancy in support, and torsional resistance. In addition, the panels were designed to stringent performance criteria. The panels range from 14 ft to 19 ft tall and protrude 3 ft to 4 ft from the building, and the engineers aimed to keep deflections low and used higher gust wind loads during design.

In addition to the performance of the cantilevered fins, the structural steel jambs allowed for a consistent design and detailing for all the fins. Most of the assembly was fabricated in the shop, resulting in a modular design that the ironworkers were able to erect in the field quickly. The fins and jambs were fabricated separately, allowing for the jambs to be constructed on the south side at the same time that the surrounding cold-formed metal studs were being installed, which allowed for the exterior fins to be attached after the remaining façade materials were in place. This streamlined erection process allowed for better efficiency and quality control of the wall components, as the cantilever fins were not in the way. Once the entire wall was constructed, the erector was able to bolt on the cantilevered fin to the in-place steel jambs.

Learning from Nature

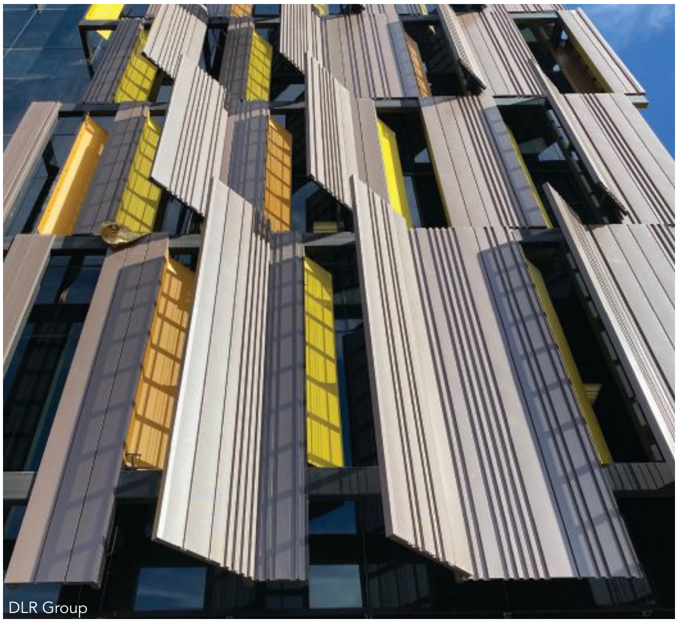
The design team for the new Pinal County Attorney's Office was able to provide a project with 52% external glazing while reducing energy usage and solar glare. This is a high percentage considering the harsh climate of the surrounding desert. How did they successfully achieve it? Biomimicry.

Biomimicry is not the same as bio-inspired design, which makes a building look like an element of nature, and it is not simply adding a green roof or a plant wall—rather, it studies and then replicates nature's forms, processes, and ecosystems to create designs that affect the way a building functions. In other words, the design mimics nature to create conditions conducive to the resilience of a building.

The vertical fins of a saguaro cactus provide continuous self-shading and redistribution of heat. This ability to self-shade breaks sunlight up into smaller areas that shift continually, preventing any one area of the cactus skin from overheating. This makes the saguaro viable while giving it a beautiful and distinct character. By creating a 3D SketchUp model of a saguaro cactus and using a daylighting simulation model, the design team confirmed that no part of the plant received more than 15-to-20 minutes of direct sun at any one time, avoiding sunburn.

Using the lessons learned from the saguaro, the exterior façade of the building is built with rigid self-shading fins. Additionally, the ribbed metal panel skin allows the head load to shift until natural air convection cools the fins. On the south façade, which is the exterior face with the most sun exposure throughout the day, the fins are carefully placed to shade the windows while also maintaining the look of the continuous skin.

Although the metal panel skin absorbs heat, the "breathable" facade system is mounted a few feet off the building to allow air to circulate and dissipate heat. In addition, the heat-reflecting, high-performance glazing aids solar control, and the low-E coating manages the light spectrum, balancing visible light transmittance and reducing glare. This high performance created opportunities for downsized mechanical equipment, leading to reduced long-term energy costs.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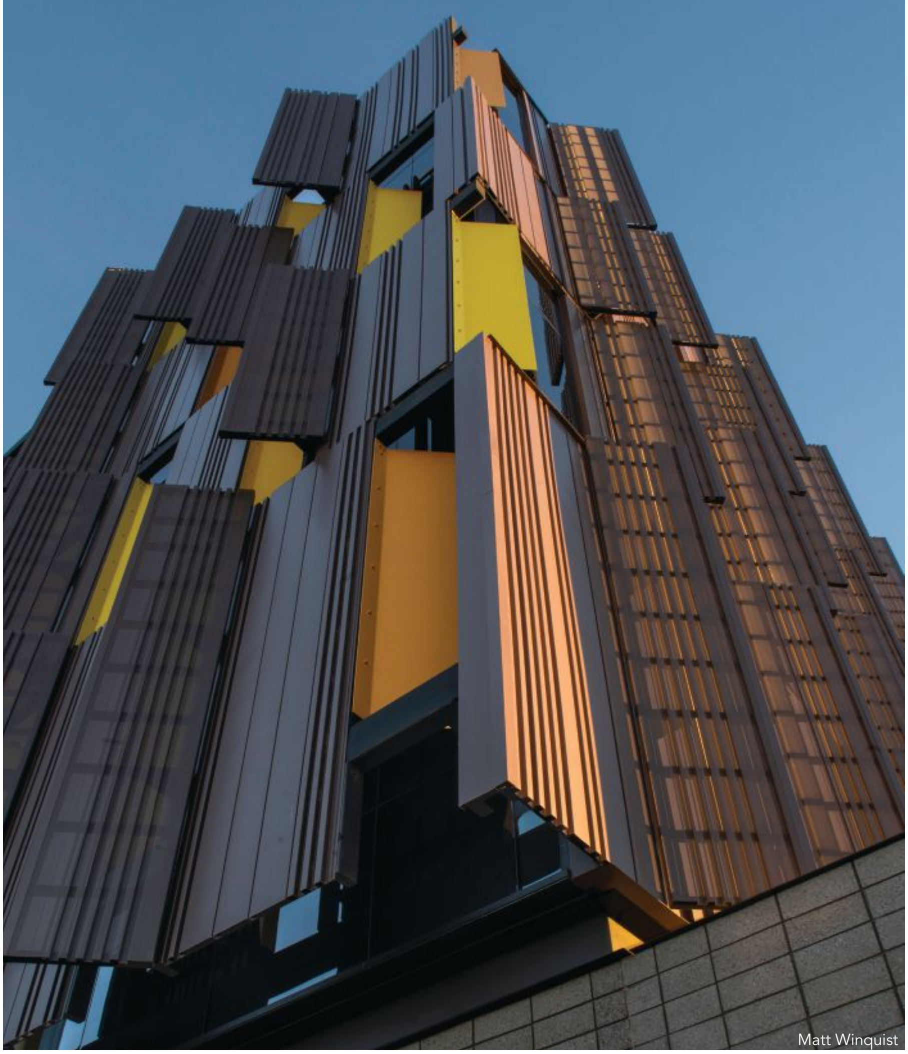
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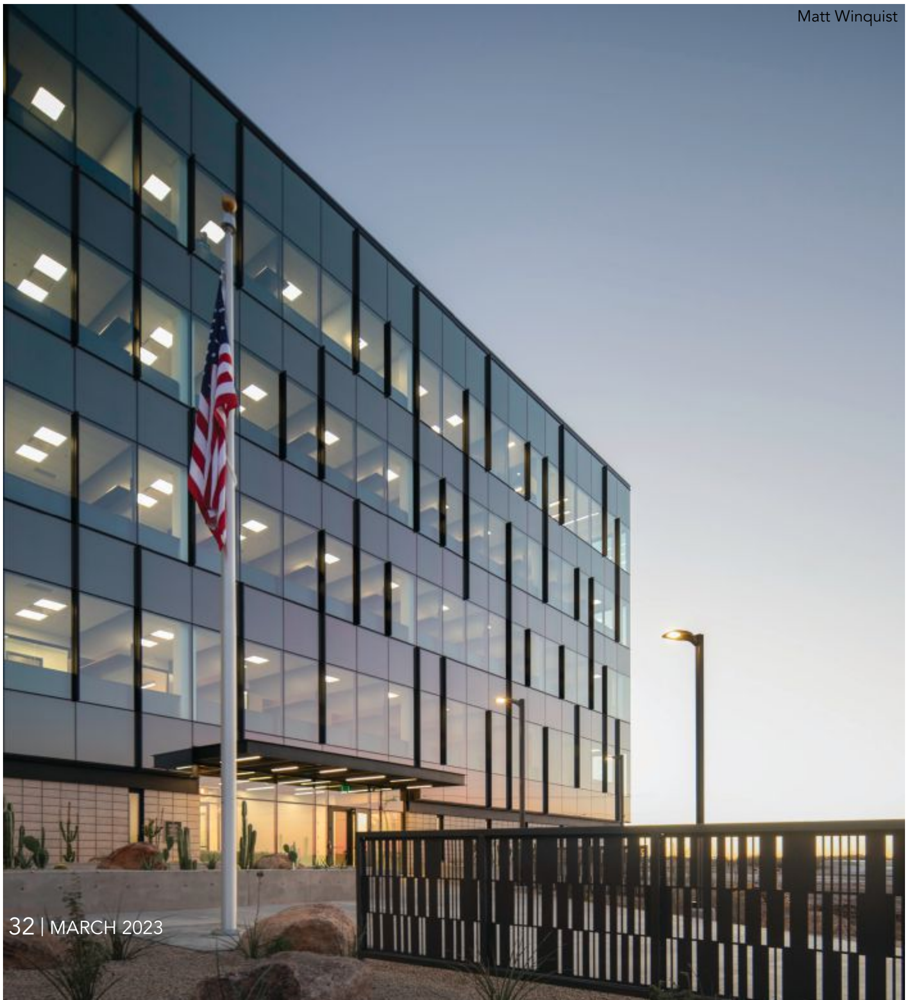

Matt Winquist

The panels range from 14 ft to 19 ft tall and protrude 3 ft to 4 ft from the building.

The bolted connection between the jambs and cantilever fin was a custom configuration. The connection consists of an HSS rectangular member cut at the angle required for the fin. The HSS assembly has a fixed-end plate with a pair of welded threaded studs to allow for the fin assembly to bolt directly to the HSS support. This connection helps distribute the force couple and torsion from the cantilevered fin to the HSS jamb supports while preventing thin-wall buckling of the jamb members.

Additionally, having the entire fin assembly consist of structural steel meant that the fin subcontractor only had to manage one source for material and also facilitated a close working relationship between the subcontractor and the fabricator to ensure the design intent was properly implemented.

Right-Sizing

Although Pinal County had a specific site in mind for the project, the proposed location provided many design challenges. Therefore, DLR Group's High-Performance Design Team researched four options to find the most efficient building and site solutions while delivering a positive design impact on the community. The predesign process ensured that the location, shape, and size met functional planning requirements and used life-cycle analysis to determine the full cost savings in utilities.

Using annual daylighting and energy analysis for different building iterations, the design team calculated the impact of building location and size on energy use. The results were used to find opportunities to bring more daylight inside the building and with improved views for the occupants. Four options were studied, two each on the east and west sides of the existing building. Massing models were developed with building areas varying from 60,000 sq. ft to 70,000 sq. ft over five floors with 15-ft floor-to-floor heights and a 40% wall-to-window ratio.

The different iterations were modeled with light-reflective colored surfaces, and

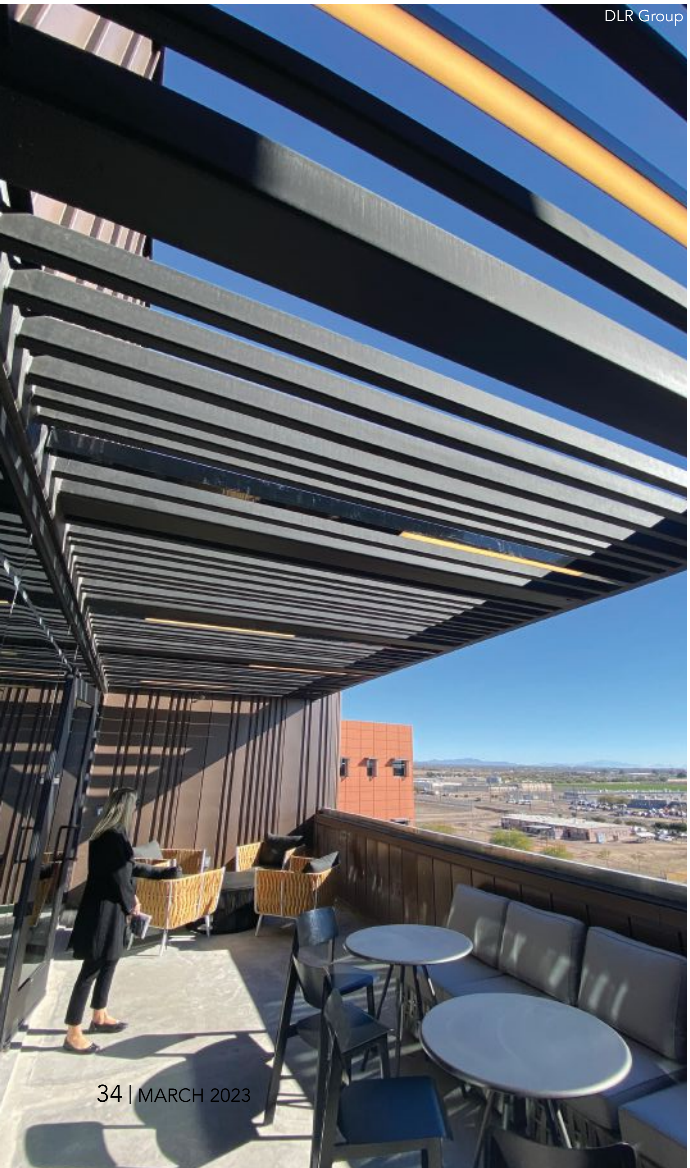
An iterative design process resulted in a reduced footprint and floor-to-floor height, as well as helped maximize natural daylighting.

Matt Winquist

The building's ribbed metal panel façade, designed to mimic a saguaro, is its feature design element, combining a modern eye-catching design with a structure that reduces energy consumption.

Matt Winquist

The north and south entrances (north is pictured here) and the fifth-level patio feature a decorative steel canopy cantilevering from the exterior wall, visually indicating the location of the lobby.

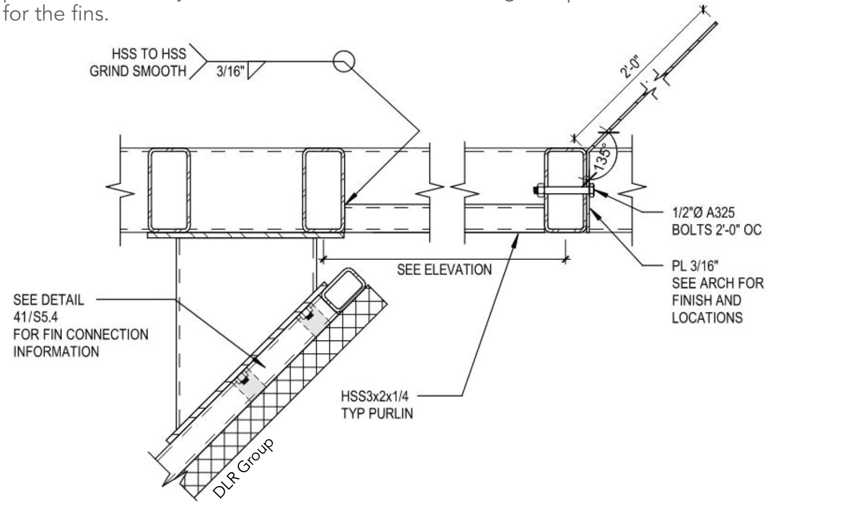


DLR Group

DLR Group

left: The cantilevered steel canopy on the fifth level.

above and below: Triangular HSS assemblies (three per panel) connect the panels to the HSS jambs and are fabricated at the angle required for the fins.



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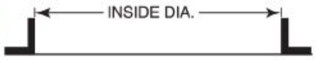
1 Angle Leg Out



10" x 10" x 1" Angle

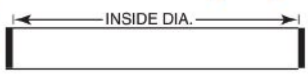
2 Angle Leg In

10" x 10" x 1" Angle

3 Flat Bar The Hard Way

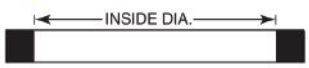
24" x 12" Flat

4 Flat Bar The Easy Way



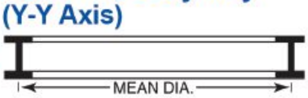
36" x 12" Flat

5 Square Bar



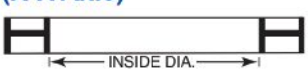
18" Square

6 Beam The Easy Way (Y-Y Axis)



44" x 335#, 36" x 925#

7 Beam The Hard Way (X-X Axis)



44" x 285#

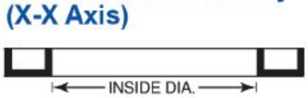
8 Channel Flanges In

All Sizes

9 Channel Flanges Out

All Sizes

10 Channel The Hard Way (X-X Axis)



All Sizes

11 Tee Stem In

22" x 142 1/2# Tee

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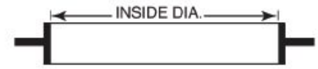
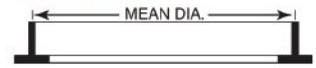
12 Tee Stem Out



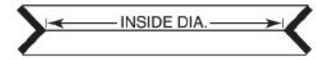
22" x 142 1/2# Tee

13 Tee Stem Up



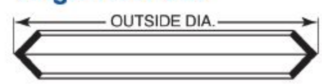
22" x 142 1/2# Tee

14 Angle Heel In



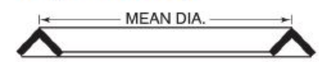
8" x 8" x 1" Angle

15 Angle Heel Out



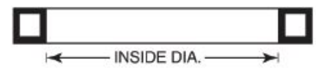
8" x 8" x 1" Angle

16 Angle Heel Up



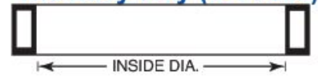
8" x 8"x1" Angle

17 Square Tube



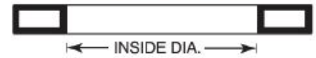
24" x 1/2" Tube

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



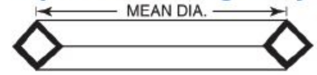
20" x 12" x 5/8" Tube

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



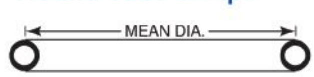
20" x 12" x 5/8" Tube

20 Square Tube Diagonally



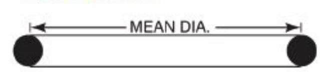
12" x 5/8" Square Tube

21 Round Tube & Pipe



24" Sched. 80 Pipe

22 Round Bar



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the interior offices brought in daylight by eliminating high-partition cubicles. Sliding glass barn doors not only created a transparent connection to the outdoors but also eliminated door swings, which allowed for a narrower building. The final data-driven solution reduced the footprint to 56,000 sq. ft reducing energy use while maximizing natural daylighting.

In addition to the data-driven design processes used in predesign, this project was analyzed using Tally, a Revit plug-in that completes a life cycle used and provides comprehensive embodied carbon reporting. Pinal County Attorney's Office was one of the founding projects reported as part of DLR Group's pledge to the SE 2050 Commitment, which states: "All structural engineers shall understand, reduce, and ultimately eliminate embodied carbon in their projects by 2050." Analyzing the embodied carbon of the building allowed the design team to establish a baseline and use this data to design lower embodied carbon-intensive projects in the future. ■

Owner
Pinal County, Arizona

General Contractor
FCI Constructors, Inc., Glendale, Ariz.

Architect and Structural Engineer
DLR Group, Phoenix

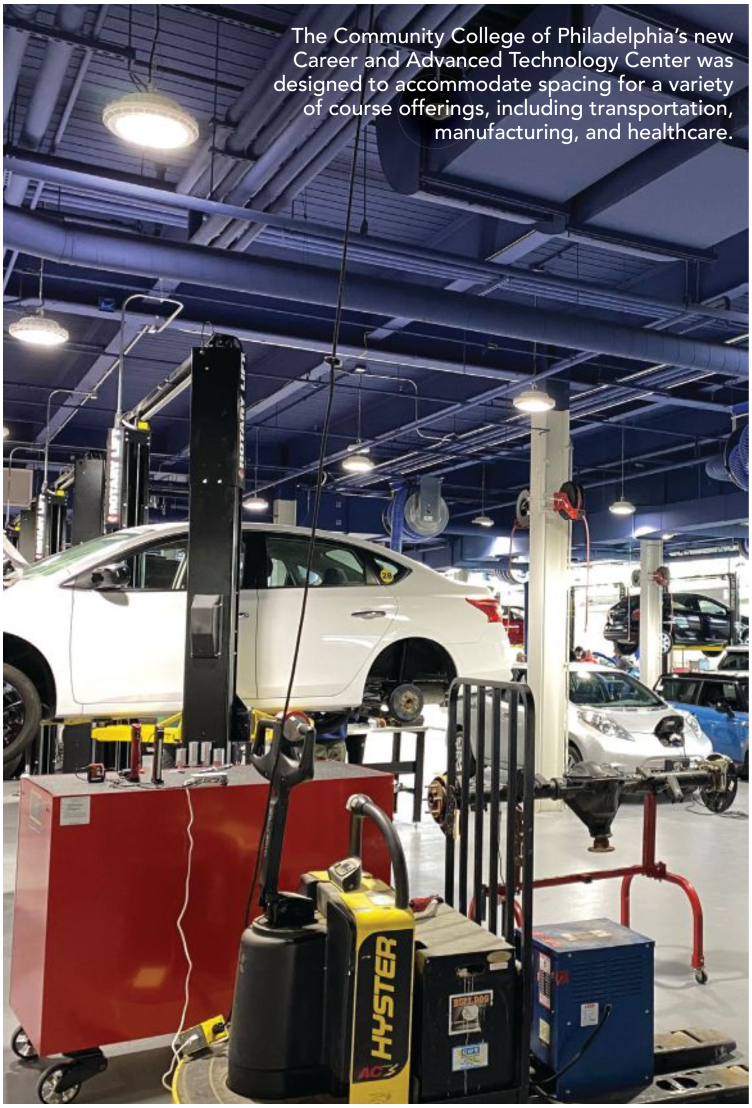
Steel Fabricator
Alstate Steel, Inc.
Albuquerque

Elizabeth Heck (eheck@dlrgroup.com) is a senior associate and structural engineer with DLR Group in Phoenix and was the lead designer for the Pinal County Attorney's Office project.

A Sense of Community

BY TOM FORSBERG, PE, AND MELISSA BOULDEN, PE

A Philadelphia community college puts its steel frame on full display in a new career center.



The Community College of Philadelphia's new Career and Advanced Technology Center was designed to accommodate spacing for a variety of course offerings, including transportation, manufacturing, and healthcare.

BUILDING A BETTER PHILADELPHIA is what the Community College of Philadelphia (CCP) is all about—and its latest addition prominently shows how steel can make a better building.

The school's stated goal for its new steel-framed Career and Advanced Technology Center (CATC) is to bring career training and community building to the forefront of the city's neighborhoods through state-of-the-art facilities, support for local entrepreneurship, and hands-on learning experiences for in-demand careers. Specifically, the four-story, 74,000-sq.-ft building's course offerings focus on career readiness and creating a thriving workforce in the city's transportation, manufacturing, and healthcare fields.

Structural Visibility

With structural visibility as an integral component of the design, steel was the logical choice to frame the new facility, and the design team participated in myriad conversations about exposed connections, round hollow structural sections (HSS) for bracing, slab edge framing for atria and mezzanines, and architecturally exposed structural steel (AESS) considerations in general early in the process.

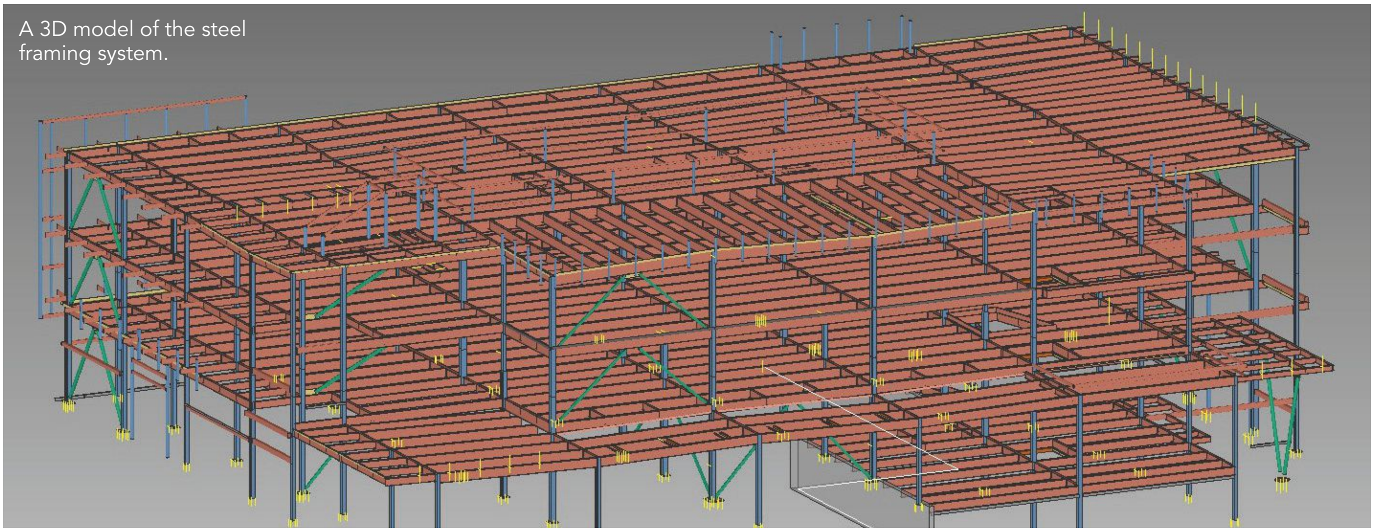
Steel also made sense for the project thanks to its flexibility in terms of geometry and framing bay dimensions. The new facility houses a wide array of equipment supporting its various educational programs—automotive and diesel technology, manufacturing, welding, and healthcare—with each program space designed around the task-specific equipment, requiring considerable push and pull in terms of building and grid dimensions.

Maximizing interior daylighting was another of the design team's goals, as was facilitating views for the building's occupants—especially on the east side of the building, which provides a spectacular view of the Philadelphia skyline. This scenario called for a significant amount of perimeter glass, allowing the steel lateral load-resisting system, which is often

above: Each program space was designed around task-specific equipment, requiring considerable push and pull in terms of building and grid dimensions.

below: Structural visibility was an integral component of the building's design, and the framing system incorporates exposed connections, round HSS for bracing, and abundant AESS.

In visible areas, braces are typically composed of round HSS8.625, and hidden brace members are mostly HSS5×5 and 6×6.



A 3D model of the steel framing system.

hidden, to be put on display as a design element. In visible areas, the braces are typically composed of round HSS8.625, and hidden brace members are mostly HSS5×5 and 6×6.

Site Logistics

The building's site is bordered on the north, west, and south by heavily used Center City roadways and an elevated commuter train line, and on the east by a neighboring property, allowing almost no space for material laydown. Moreover, numerous overhead power lines had to be moved and/or protected in place to have crane movement and steel erection comply with OSHA regulations and ensure safe on-site working conditions.

For the steel fabricator and erector, Mid-Atlantic Steel/East Coast Erectors, the site logistics required well-planned trucking and crane placement analyses, and 3D crane lift plans aided this planning process to ensure smooth erection and crane reach. With little reasonable material storage or on-site laydown areas, steel delivery sequencing and timing were critical. In many instances, pieces were picked directly from delivery trucks and swung into place. Given that Mid-Atlantic Steel offered a turn-key experience with both fabrication and erection services under one umbrella, the team was able to maximize coordination between shop and field, resulting in increased productivity. The project incorporated approximately 600 tons of structural steel, metal deck, and miscellaneous metals in all (structural framing consisted primarily of W21×57 for floor filler beams W18×35 for roof filler beams, W10×33, W10×39, and W12×72 for columns).

Site constraints dictated that the building had to be erected with the crane inside the foundation footprint and backing its way out as erection proceeded. A key coordination component of this sequence was the stairs. Housed in masonry enclosures, stairs that would typically bear on these walls had to be put in place first and were hung from the primary structural framework. Once the crane moved to its next sequence, it would be unable to reach for stair placement, and returning with another crane to set stair framing inside the masonry walls was simply not an option. Thus, all levels of the building had to be erected in a single sequence before moving the crane.

The overall project went smoothly thanks to early conversations

above: Stairs that typically bear on masonry walls had to be put in place first and were hung from the primary structural framework.

below: The framing system incorporates 600 tons of steel in all.

between structural engineer SCHRADERGROUP and the steel team to review design standards, preferred connections, and job expectations. This approach created an amicable, collaborative team environment with open lines of communication, which helped ensure an efficient submittal process, with field issues being addressed directly with the engineers and resolved quickly. In addition, early coordination of delegated design requirements and loading conditions streamlined the detailing and approval process, and SCHRADERGROUP also provided the actual connection load/reaction values, resulting in economical connection design.

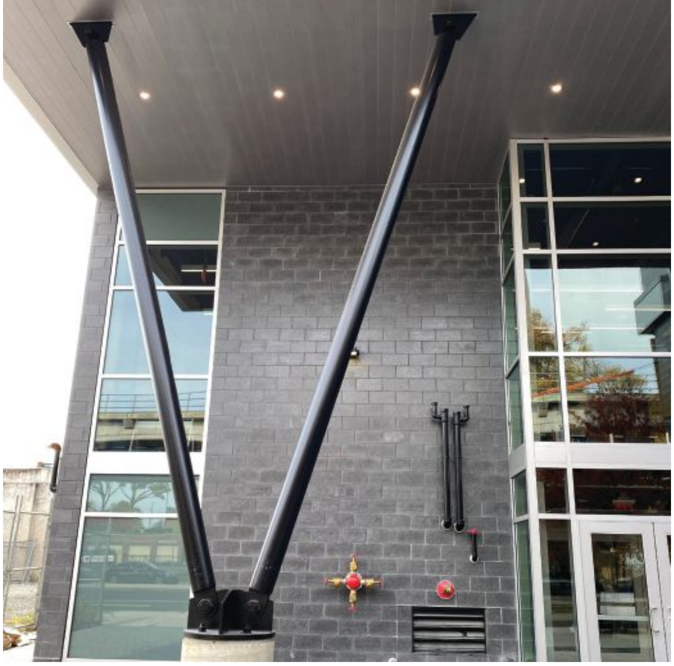
Further facilitating an efficient process, the design and construction teams worked together to review and understand the impact of the site constraints and logistics during bidding, which turned out to be extremely beneficial in preplanning the means and methods of the erection process. Creating erection sequencing, crane lift plans, and crane layout plans early in the project—and coordinating these procedures with the general contractor so that they understood the erection sequence—enabled the contractor to schedule the work of other trades around the steel structure.

Thoughts on AESS, Constructability, and Collaboration

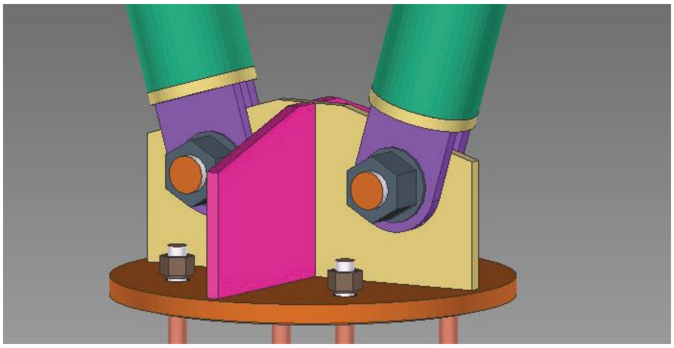
For the engineer of record (EOR), using AESS requires significant coordination with the architect to ensure that the desired appearance is achieved, and AISC's categorized approach is helpful when you're considering AESS for your project (see "Maximum Exposure" in the November 2017 issue at **www.modernsteel.com** for more on the various AESS levels). However, it isn't the end of the road for engineers and specifiers. As an engineer, you must have cross-discipline knowledge and/or perform research into the realms of interior design, paint finishes, intumescent coatings, spray-applied fireproofing, and the like. The EOR is an integral part of this design and specification process.

As the old structural engineering adage goes, "Strength is important but otherwise unnecessary." From that grows a design philosophy of focusing on piece and detail repetition, fabrication simplicity, and constructability. Of course, your structure must withstand all the natural and human-made forces to which it is subjected over its life. But you should put ample time and attention into designing your structures so that they are easy to detail, simple to make, and quick to erect.

You should also adjust your mindset once you move from the design phase to the construction phase of a project. You're now a member of the construction team, working as the liaison and advocate to ensure your project comes to fruition. For the CATC project, that meant working directly with the fabricator on design and fabrication issues and allowing them to develop connections based on their own standard shop practices. There are lots of ways to put all the pieces together, and you, as the EOR, should always be open to anything permitted by AISC and, more importantly, in line with the fabricator's standard practices.



One unique aspect of the steel framework is the two-story V-shaped column supporting a canopy roof over the north entrance to the building.



Framing Advantages

Beyond the architectural desire for exposed structural framing, selecting structural steel provided several benefits for the project:

- Despite the building's numerous masonry walls, there was no mixing of structural systems (e.g., structural steel on masonry bearing walls), which ultimately allowed the erector to complete their work without relying on, or waiting for, any other trades.
- This building occupies most of the project site in a dense urban location, leaving little to no room for material staging. A structural steel framework facilitated constructability without requiring a lot of site area for staging or scaffolding.
- Thorough analysis and planning for crane scheduling and erection sequencing within the various site constraints resulted in a successful process for erecting the building from one end to another and pull the crane out once complete.
- Even though the building's programmatic requirements demanded considerable dimensional variability, the team was able to select structural steel sizes and shapes that were readily available, allowing faster material procurement and fabrication.
- In some instances, in-shop prefabrication of multi-piece steel assemblies created a means to speed up erection/construction.

Addressing AESS

With all the exposed elements in the building, the AESS requirements added another level of complexity and coordination, both in the shop and at the site. The projection specifications required an AESS Level 1 (Basic Elements) finish for designated elements, along with additional requirements for both shop and field welds. Welds had to be neatly installed, ground to a smooth finish, and properly prepared to receive field-applied finish coatings (these included high-performance alkyd paint, epoxy coatings, and intumescent paint in some locations).

Flying V

One unique aspect of the steel framework is the two-story V-shaped column supporting a canopy roof over the north entrance to the building. There were five pieces involved in the V-column sequence, with the left-most section shop attached to the roof beam. This section, along with two other roof pieces, were all trapezed together at the same time. The right leg of the column was set independently after all of the other elements were in place.

At the foundation level, the column assembly bears on an exposed concrete pier integrated into a planter bead with a surrounding seating wall. The geometry and base condition required a well-orchestrated erection with a series of temporary cable supports and ties until all the pieces were connected.

With this and the rest of the exposed steel elements, CCP's new facility elevates the structural framing system to become a feature element in its quest to elevate Philadelphia and its neighborhoods. ■

Owner
Community College of Philadelphia

General Contractor
Ernest Bock and Sons, Inc.

Construction Manager
Greyhawk

Architect and Structural Engineer
SCHRADERGROUP

Steel Fabricator, Erector, and Detailer
Mid-Atlantic Steel, LLC/
East Coast Erectors, Inc. (AISC Certified Fabricator & Erector),
New Castle, Del.

Tom Forsberg (**tforsberg@sgarc.com**) is a principal at SCHRADERGROUP, and **Melissa Boulden** (**mboulden@midatlanticsteel.com**) is vice president of project development and director of engineering with Mid-Atlantic Steel, LLC.

Best Bridge Practices

BY BOB FORAND, PE, AND JOHN KURETSKI, PE

All images courtesy of BCC Engineering

The new Gandy Boulevard Bridge used 1,980 tons of weathering steel to traverse 9th Street North and a critical utility corridor to serve as a gateway between Tampa and St. Petersburg.

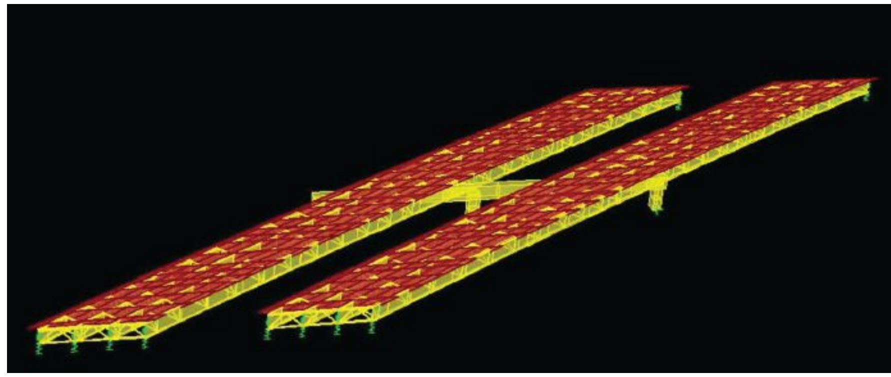
Smart fabrication tactics and design changes reduce the size, impact, and budget for a one-of-a-kind steel bridge spanning a major arterial and critical utility corridor in St. Petersburg, Fla.

BEST PRACTICES IMPLEMENTED CORRECTLY result in the best bridges.

Coupled with a robust Florida Department of Transportation (FDOT) Work Program involving major urban improvement projects, the design-build arena in Florida has pushed the engineering industry to redefine what is possible and always strive to achieve the best bridge solution.

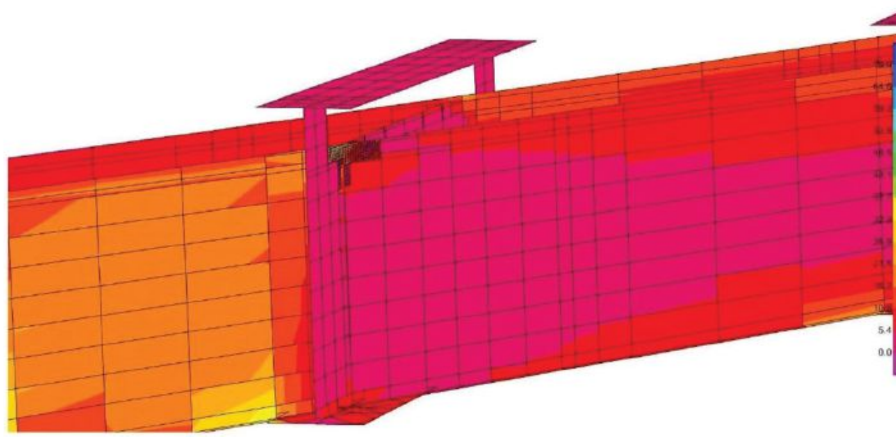
This has effectively placed innovative structural steel bridges at the forefront of Florida's transportation projects. The $93 million SR 694 (Gandy Boulevard) project in St. Petersburg is a recent example of this dynamic. The new bridge incorporates nearly 2,000 tons of weathering steel to traverse 9th Street North and a critical utility corridor. It is an important link in the Gandy Boulevard thoroughfare over Old Tampa Bay between St. Petersburg and Tampa—and a forward-thinking design and fabrication team helped ensure the project was as efficient as possible.

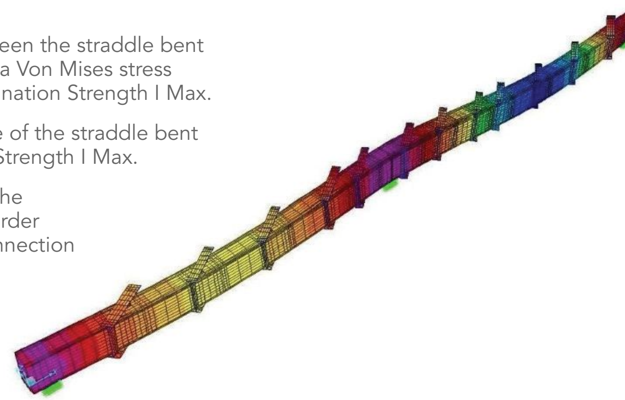
Gandy Boulevard is an east-west principal urban arterial highway, a major hurricane evacuation route, and part of the Florida Intrastate Highway System (FIHS). It traverses sensitive environmental areas and a critical Progress Energy utility corridor, with segments exceeding an average annual daily traffic (AADT) of 60,300 vehicles. A January 2000 study indicated that eight of the nine intersections in the area operated below the acceptable level of service during peak hours, 819 crashes took place in only five years, and four intersections and one roadway segment had abnormally high safety ratios. Coupled with an expected population increase of over 12% in the area, FDOT commissioned this design-build project to improve safety and capacity by converting the four-lane at-grade facility into a six-lane controlled access facility with grade-separations, interchanges, and frontage roads. BCC Engineering, the project's prime designer and structural engineer of record, An isometric model view of the bridge.



used several design innovations, including simplifying movements using direct ramp connections, reworking interchange designs to improve the level of service, and reducing the total bridge area. This resulted in both improved safety and over $17 million in total cost savings to FDOT.

One of the key design refinements to the FDOT concept involved a reconfiguration of the 9th Street North bridge. Gandy Boulevard crosses 9th Street North using a horizontal curve at a 53° skew, frontage road ramps tie in close to the west abutment, and drainage needs required a retention pond close to the east abutment. The bridge design also needed to accommodate an ultimate section involving a future widening to the inside. These constraints severely limited the ability to modify the bridge skew, vertical roadway profile, and span configuration. The initial FDOT concept carried Gandy Boulevard over 9th Street North and the Progress Energy utility corridor using dual (eastbound and westbound) 6-span, 1,156-ft-long bridges comprised of prestressed concrete Florida-I beams and steel plate girders supported by multi-column piers. However, the spans resulted in a relatively high bridge profile and large footprint. To most efficiently accommodate the project needs and constraints, the general contractor asked the design team to rise to the challenge.

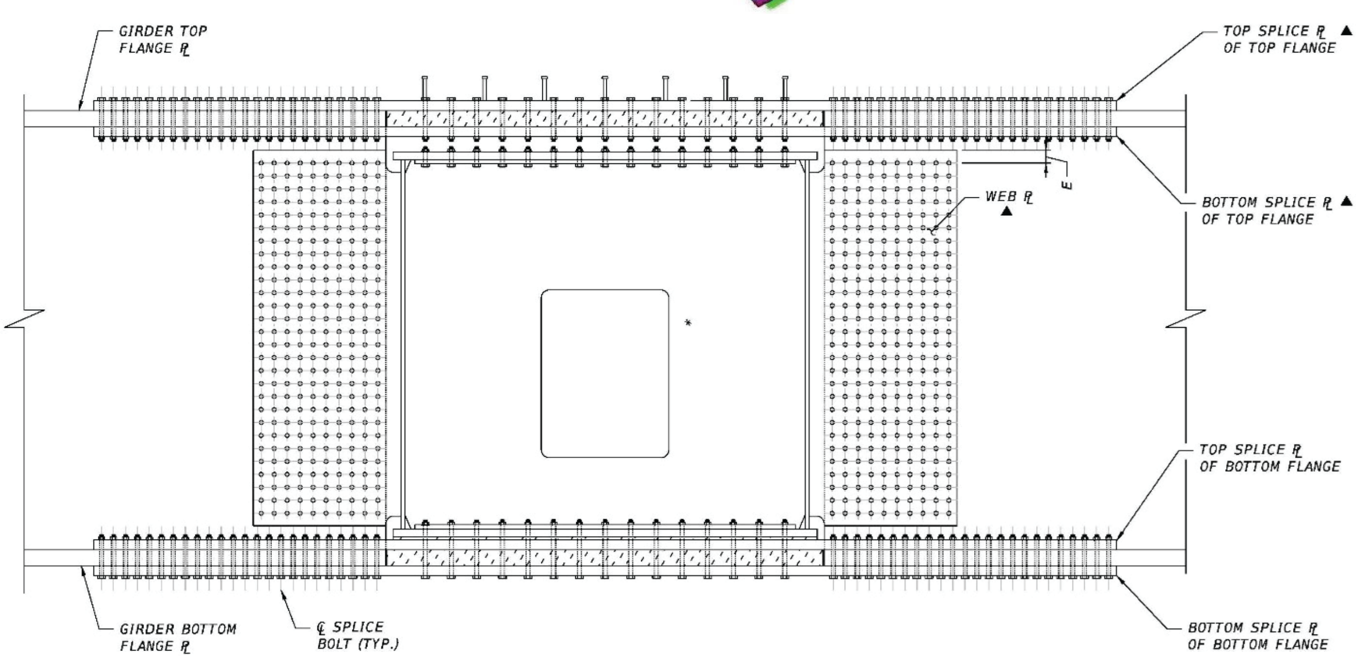




above: A connection between the straddle bent cap and Girder 1 showing a Von Mises stress distribution for load combination Strength I Max.

right: The deformed shape of the straddle bent cap for load combination Strength I Max.

below: This view through the straddle bent cap at the girder tie-in shows the robust connection and matching up of the bottom flanges.



above: The straddle bent is supported by three custom-fabricated 5-ft, 2-in.-diameter disc bearings with a maximum supported service load of over 3,500 tons.

below: Complete shop assembly was key to avoiding fit-up issues and delays at the project site.

BCC developed an alternate solution in the form of a unique two-span continuous straddle bent built normal to 9th Street North. The location of the straddle allowed the superstructure to be redesigned as dual two-span bridges made integral with the straddle cap. The two-span configuration employed conventional steel plate girders that are skew to the straddle and at the end bents. When compared to the original concept, the alternate design maintained the roadway geometry and 53° skew, but it reduced the maximum span length from 313 ft to approximately 262 ft, reduced the web depth from 120 in. to 106 in., eliminated the need for anchor spans to balance the bridge, and reduced the bridge lengths from 1,156 ft to just 515 ft. This resulted in a shortened construction duration, less construction exposure, and reduced cost.

The straddle itself is one of a kind—a variable-depth, highly skewed, integral two-span straddle supporting two separate curved bridges, designed and detailed to support a future widening using longitudinal girders of different depths to match the variable integral depth. The two spans, 97 ft, 6 in. and 118 ft, 3 in., are supported on single multidirectional pot bearings. Design considerations for this non-redundant, fracture-critical support included using ASTM A709 Grade HPS 70W steel for added toughness, increased redundancy factors, and special detailing. Construction considerations included shop assembly to ensure proper fit-up, preassembling girders and straddle bents on the ground, and keeping crane paths and temporary towers from impacting traffic or adding surcharge loads within the Progress Energy utility corridor.

Design

Meeting the project challenges in this way required BCC to closely coordinate with the construction team during the design process and think outside of the box to develop and implement a sound design approach. This approach included the following strategies:

- A grid model was used to develop preliminary plate girder proportions and to size cross-frame members. It was also used to estimate design forces for the bolted and welded connections between the cross frames and plate girders.
- The design of the connections was then completed using custom worksheets developed specifically for the structure.

Bridge Stats

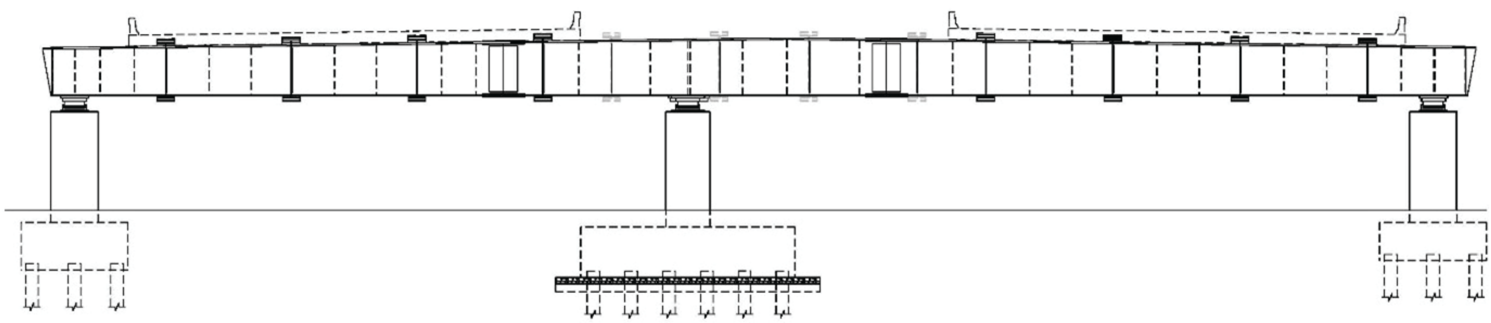
Total structure length
517 ft, 2 in.

Span lengths
262 ft, 2 in. and 255 ft

Width
86 ft, 2 in.

Total steel tonnage
1,980 tons

Coating/protection system
Inorganic zinc coating system for straddle cap and exterior fascia girders

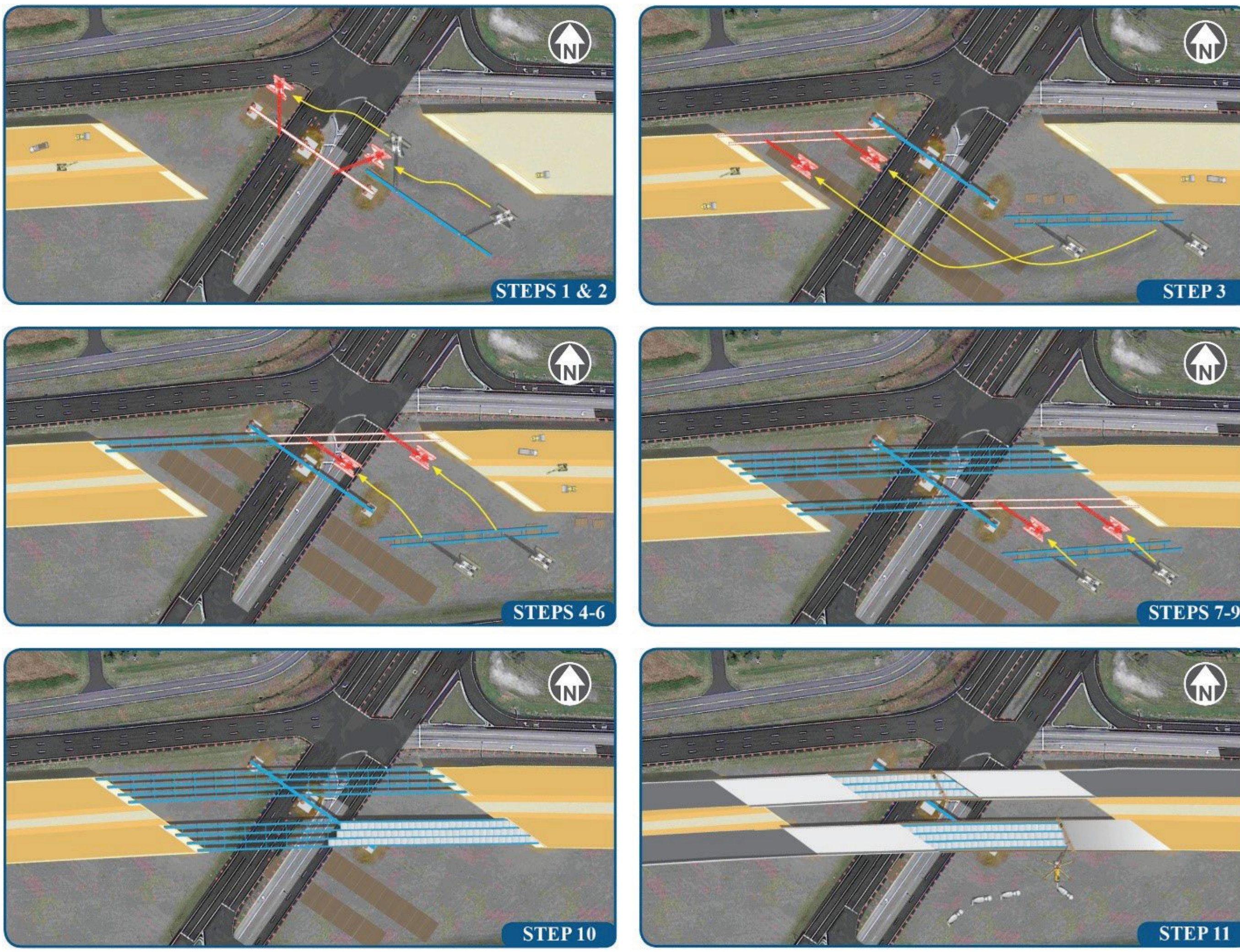


Holding the bottom of straddle bent level complicated the steel design but facilitated the construction of the straddle cap-girder tie-in.

- Using the preliminary girder and cross-frame sizes obtained from the grid model, the team created a 3D model of the dual bridges with an integral straddle bent cap using CSiBridge finite element analysis (FEA) software to fine-tune the design and accurately model the initial and ultimate configurations. Staged construction loading was also analyzed to confirm structural adequacy and stability throughout all phases of construction.
- Resulting design forces for shear, flange primary, and lateral bending stresses, as well as deflection values and plate girder constructability checks, were obtained from the more severe of the initial and ultimate configuration FEA models.
- These models also provided information for controlling internal forces for the design and load rating of the integral straddle pier cap, designing two field splices, performing fatigue limit state checks, designing the straddle cap bearing and jacking stiffeners, transverse intermediate stiffeners, and connections (splices) between the plate girders and the pier cap. They also provided data for developing a camber diagram for the straddle cap. In performing fatigue and torsion checks for the straddle bent cap, alternate span loading was considered, such as loading Span 1 of the westbound bridge while simultaneously loading Span 2 of the eastbound bridge.
- After the superstructure's design was deemed satisfactory, the team created and analyzed a 3D shell element model of the integral straddle pier cap to study the distribution of stresses in the cap and verify detailed design calculations per the AASHTO *LFRD Bridge Design Specifications*.

The straddle cap was detailed as a closed rectangular box (with a 2-in. flange extension for welding) of linearly varying depth supported by three rectangular cast-in-place reinforced concrete columns. The straddle cap was modeled using nonprismatic frame elements, and the integral connection between the girders and straddle cap was modeled by coupling the degrees of freedom of each girder with the corresponding degrees of freedom of the straddle cap at the connection point. The bridge deck was modeled with shell elements, while the plate girders were modeled with nonprismatic frame elements, which were eccentrically connected to the shell elements and girder bottom flanges by rigid link elements. Cross frames and diaphragms between the plate girders were modeled with truss elements using standard steel shapes checked in the preliminary grid analysis.

Notably, designing for the ultimate condition resulted in the concrete deck and shear studs not extending the entire length of the straddle bent. To be reasonably conservative, the design of the straddle cap was based solely on noncomposite section properties and grid models of the initial and ultimate configurations created



The erection sequence for the bridge:

Step 1. Construct all substructure elements.

Step 2. Preassemble and final torque straddle cap in assembly area, move into position, and erect. Stabilize straddle bent cap using shim stacks and jacks.

Step 3. Preassemble the north two girder lines of westbound Span 1 in assembly area. Erect using a nightly closure and bolts installed snug tight.

Step 4. Preassemble the north two girder lines and the south two girder lines of westbound Span 2 in the staging area parallel to End Bent 3. Erect the north two girder lines with bolts installed snug-tight. Erect the south two girder lines and the cross frames between the north and south pairs of girders. Install bolts snug-tight. After the first pair of girders was erected with cross frames in each span, the erector was permitted to erect single girders and cross frames.

Step 5. Preassemble the south two girder lines of westbound Span 1 in the staging area between End Bent 1 and Pier 2. Erect and install the cross frames between the north and south pairs of girders. Install bolts snug-tight.

Step 6. Preassemble the north two girder lines of eastbound Span 1 in the assembly area south of eastbound Span 2. Move the preassembled pair into position and erect. Install bolts snug-tight.

Step 7. Preassemble the north two girder lines and the south two girder lines as separate units of eastbound Span 2 south of eastbound Span 2 at ground level. Erect the north two girder lines and install bolts snug-tight. Erect the south two girder lines and the cross frames between the north pair and south pair of girders. Install bolts snug-tight.

Step 8. Preassemble the south two girder lines of eastbound Span 1 south of eastbound Span 2 at ground level. Erect the south two girder lines and install all cross frames between the north and south pairs of girders. Install bolts snug-tight.

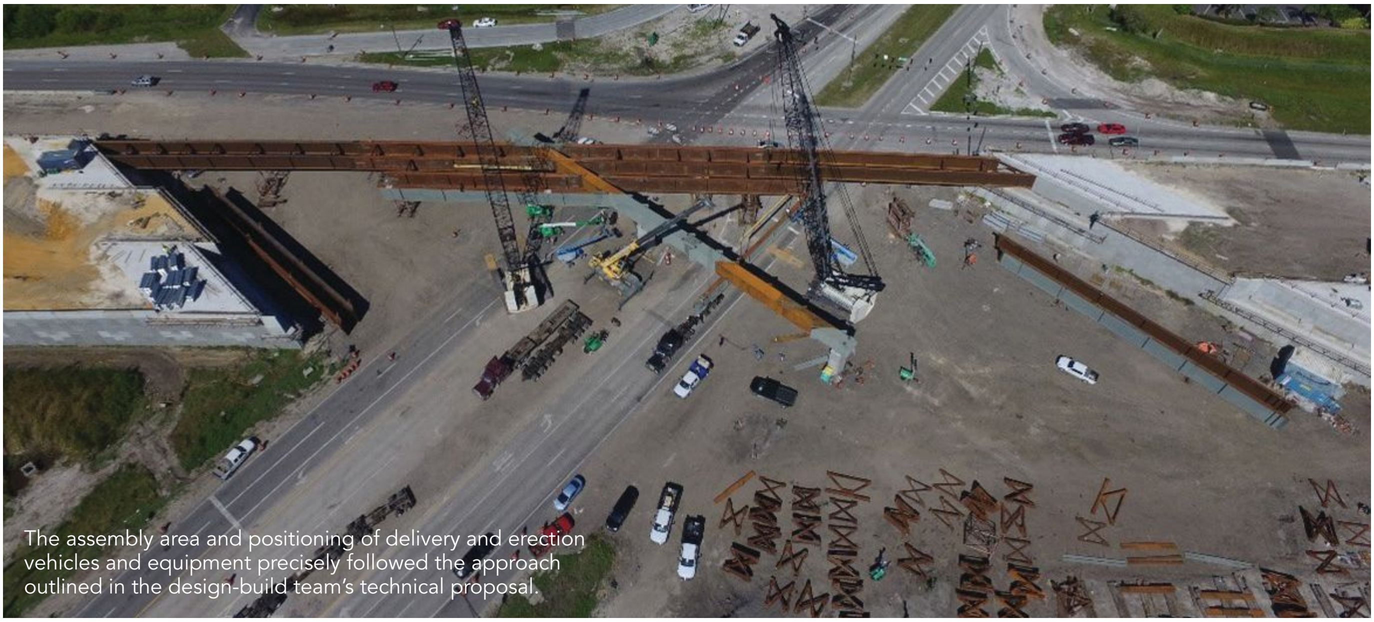
Step 9. Final alignment and final torque all bolts.

Step 10. Install SIP deck forms and overhangs.

Step 11. Form and pour bridge deck per the plan approved casting sequence to ensure compatibility with analysis model and camber diagrams.

using the updated straddle cap section properties. With internal forces from the FEA model, the pier cap was designed using a custom worksheet, and the flange and web plate sizes of the closed box were updated. The straddle cap was modeled as a diaphragm connecting the plate girders of the westbound and eastbound bridges, and the girder design in the grid model was then updated. Controlling plate sizes based on the initial/ultimate configuration models were then used to create an updated 3D FEA model for the final design.

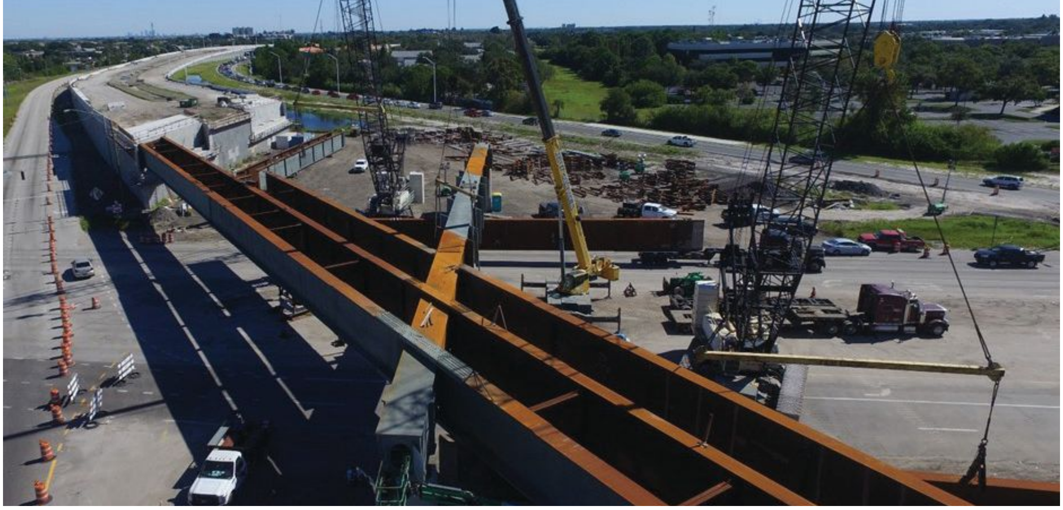
Another important aspect of the analysis and design was the deck pouring sequence. This was also modeled with FEA software using a staged construction analysis, which was limited to the initial configuration constructed by this project. The deck was accomplished in six pours, with limits bounded by the approximate

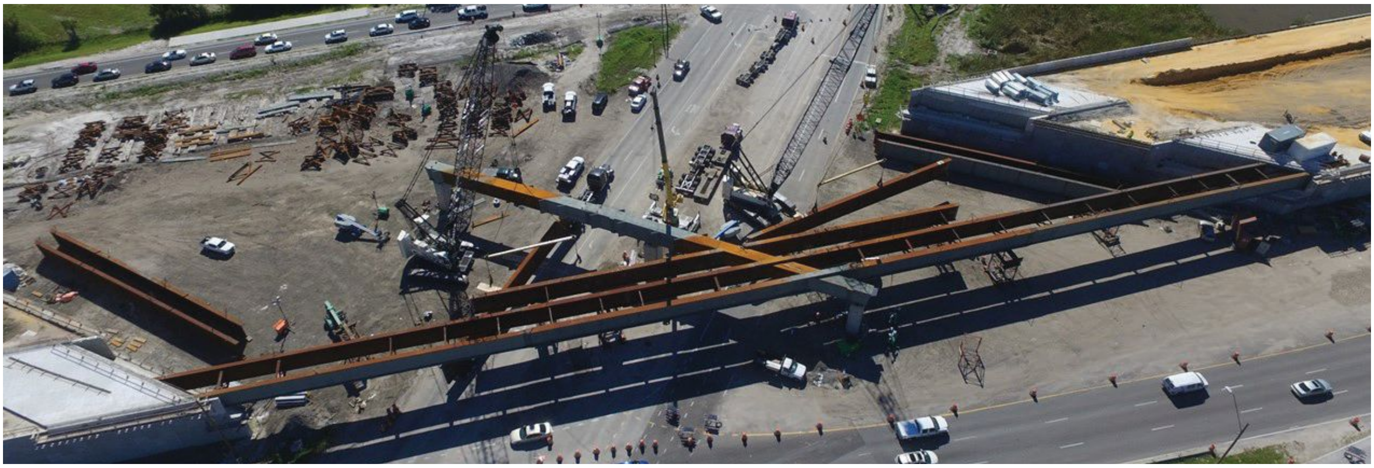


The assembly area and positioning of delivery and erection vehicles and equipment precisely followed the approach outlined in the design-build team's technical proposal.

right: Using two crawler cranes and a mobile crane facilitated erection.

below: Erecting Gandy Boulevard over critical gas transmission lines.





locations of the points of permanent load contraflexure. The aging of the concrete as the pours progressed was simulated by calculating the elastic modulus of concrete using concrete strength gain values from the FDOT *Structures Design Guidelines*.

The staged construction analysis was started by activating the weights of the girders, cross frames and diaphragms, and the straddle cap using the unit weight of structural steel. The weights of the connection plates, studs, stiffeners, bolt, and other elements were added as estimated distributed loads to the girders and straddle cap. Next, the weight of the stay-in-place (SIP) metal forms was added as a uniform line load along the axis of the girders based on tributary width.

The first pour started from End Bent 1 of the westbound bridge. The initial pour at each stage was a wet pour in which only the weight of reinforced concrete was added with a relatively small stiffness (for analysis stability). Successive wet pours began 72 hours after a preceding pour. At the same time, the elastic modulus of the concrete in preceding pours was updated to reflect the 72-hour age difference between successive pours. (It should be noted that the FDOT *Structures Design Guidelines* requires a minimum of 72 hours between successive pours. For this analysis, however, exactly 72 hours was used.) After the last pour was three days old, a stage was added in which the age of all pours was set to 27 days by updating the elastic modulus. This had no effect on analysis results since actual time was not used in the analysis.

Short-term transient loads (live loads) were applied after this stage. A similar but separate model was created for constructability and included stages for the addition and removal of deck cantilever forms. In addition, the short-term transient loads applied to this model consisted of construction live loads, including those due to a moving screed operation and concurrent work crew for finishing both on deck and overhangs. Wind loading was also analyzed for both the active work zone (30 mph during deck pour when screed loads and other transitory loads are considered) and inactive work zone cases (three-second gust at a wind speed of 90 mph when transient live loading is not present).

The complexity of all these design considerations was compounded by the fact that, in order to avoid a kink at the slope break line, the bottom of the straddle bent cap was held level and the top sloped. Due to the severe skew and transverse forces, the web depth of the longitudinal girders needed to vary to maintain the bottom flanges flush with the bottom of the straddle bent cap and facilitate the construction of the girder-straddle connection.

Construction

The structure was designed and detailed for the steel dead load fit (SDLF) condition, meaning the cross frames were detailed to attach to the girders in a plumb position when the girders are deflected under the steel dead load only. To further assist in the fit-up of this highly skewed bridge, the contract plans required a complete structure assembly. This prompted steel fabricator Tampa Tank to first assemble it (including steel plate girders, cross frames, and straddle bent) in its Tampa shop to ensure that everything fit together, and then the steel was disassembled and trucked to the bridge site for assembly. The result of these strategies? No unnecessary construction delays or impacts to traffic resulting from fit-up issues, an impressive feat considering the bridge skew and framing complexity.

General contractor Condotte/deMoya Group Joint Venture's erection approach closely followed the approach developed by the design-build team during the technical proposal phase to minimize impacts and expedite construction. The erection team used two 274-ton cranes to handle the weights of the steel straddle cap while minimizing the number of picks and shortening the overall erection duration. The cranes had the capacity to erect the steel straddle cap and a pair of steel plate girders from bent to bent, with minimal use of temporary towers, particularly in the Progress Energy corridor, while operating at a ground pressure of 3,000 psf (less than the legal axle load of a common dump truck) to avoid damage to the roadway or existing buried utilities. The straddle cap was stabilized during erection using jacks and shim stacks supported on the proposed columns. An assembly area was established at the southeast bridge corner to assemble the straddle cap and steel girders, providing a work area completely outside of traffic, thus avoiding utility issues and achieving the most direct crane paths.

Now completed, the project serves as another FDOT steel bridge success story and a safer way of transporting locals and visitors between Tampa and St. Petersburg. ■

Owner
Florida Department of Transportation

General Contractor
Condotte America/deMoya Group Joint Venture

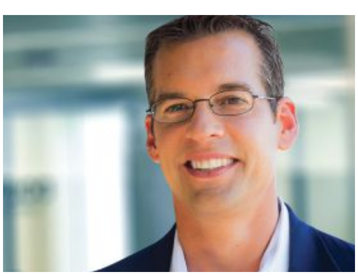
Prime Designer and Structural Engineer
BCC Engineering, LLC

Erection Plan Drawings
Construction Engineering Consultants

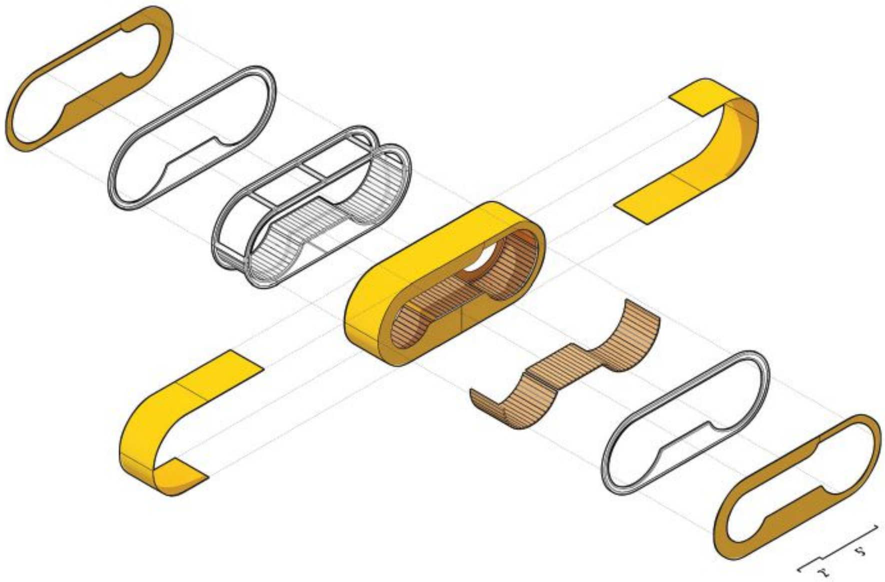
Steel Team

Fabricators
Tampa Tank, Inc./
Florida Structural Steel (AISC), Tampa
R.J. Watson, Inc. (AISC CERTIFIED FABRICATOR),
Alden, N.Y. (disc bearings)

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

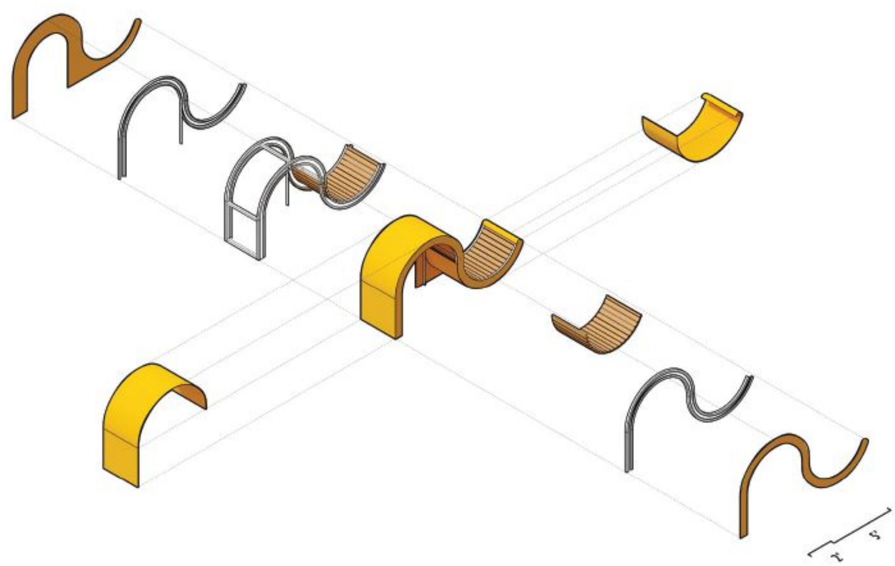


Bob Forand (bforand@bcceng.com) is vice president and **John Kuretski** (jkuretski@bcceng.com) is the engineer of record, both with BCC Engineering's Structures Practice.

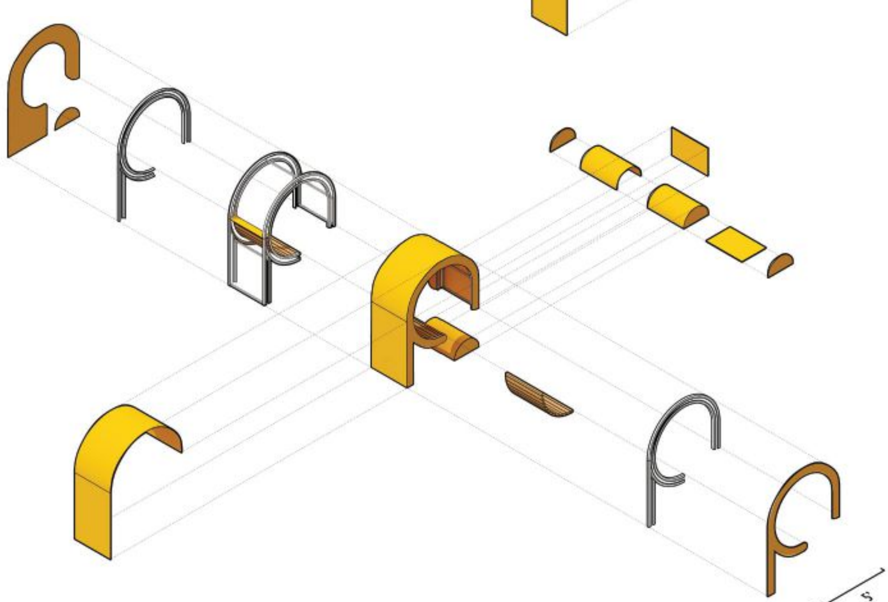


Learning the Loop

BY MARIA MNOOKIN



A new sculpture on Ball State's campus celebrates the school's College of Architecture and Planning and puts its students' skills on full display.




All photos courtesy of Ball State Hands-on-Steel students

ARCHITECTURE PROFESSOR J. Rod Underwood is no stranger to steel.

During his *long* span (pun intended) of over 50 years teaching at Ball State University's College of Architecture and Planning (CAP) in Muncie, Ind., he has frequently taught a course called "Hands-on-Steel."

This elective design studio includes a segment where his students roll up their sleeves, strap on safety gear, and fabricate a steel object. In several cases, the students have created something ornamental that's prominently displayed on campus. The college's "CAP" sign that has stood outside of the college for decades is the very first example of these projects. And for his fall 2021 Arch 498 course, Underwood tasked his students with designing and creating a new sign as a legacy item to celebrate the college's 50th year.

When AISC learned of his plan, we immediately wanted to know how we could help. Thanks to generous funding received from the AISC Education Foundation's Funding the Future campaign donors, AISC was able to provide a monetary grant to help the class's vision come together.

While providing project guidance and administrative support, Underwood stood back and let the students design and create their vision. Exceeding his expectations by a mile, they came up with an ambitious project they called "The Loop," which ultimately took more than one semester to complete. Many of the dedicated fall 2021 students stayed with the project to see it advance further to completion in late 2022.

The Loop's design pays tribute to both the history of the college and its future legacy. At the outset of the project, the students learned that the college used Quonset hut structures to house CAP's earliest classes in the mid-1960s. Those original structures served as inspiration for a new, interactive folly (a decorative, often whimsical structure designed for no practical purpose).

Every aspect of the Loop's design is intentional. The project consists of three separate structures loosely resembling a "C," "A," and "P" to represent the "College of Architecture and Planning" name and that are also meant to signify the three major development landmarks as the college expanded. In addition, the design is reminiscent of the Quonset structures, and the installation is located close to where the original Quonset structures once stood. And the project's bright yellow paint job (consisting of a Rust-Oleum primer and Dutch Boy Maxbond for the final coat) has the double intent of signifying the college's bright future and paying homage to another Hands-on-Steel project, "Balance," designed in 1974, which has become a memorial to the since-deceased student who designed it. The students also considered how future classes could add to or expand upon the project, further addressing the legacy aspect.

When fabricating the steel for the project, the students worked with ⅛-in. steel angle and 12-gauge sheet metal to wrap the faces of each element. The class participated in all aspects of fabrication, learning skills such as cutting, curving, welding, grinding, assembly, priming, and painting steel, performing all work on campus. Students were able to practice both stick and

above: The historic Quonset huts that served as CAP's first home.

right: Working to complete painting on the "C"module.

below: The original CAP sign constructed on Ball State's campus.

CAP students and Rod Underwood with the completed "C" module.

MIG welding with materials donated by AISC member fabricator Alro Steel's Muncie location.

"Alro provided a good portion of the steel elements, and another local fabricator rolled some pieces," explained Underwood. "We used angles with full-cut slots on one leg spaced approximately every inch or inch and a quarter and varied the width, depending on which way the angle was being bent, and then welded against wood templates to control the accuracy of the final curve. We varied the cut spacing depending on the degree of curvature, and every joint has a backup angle between the sheets to control warping and alignment."

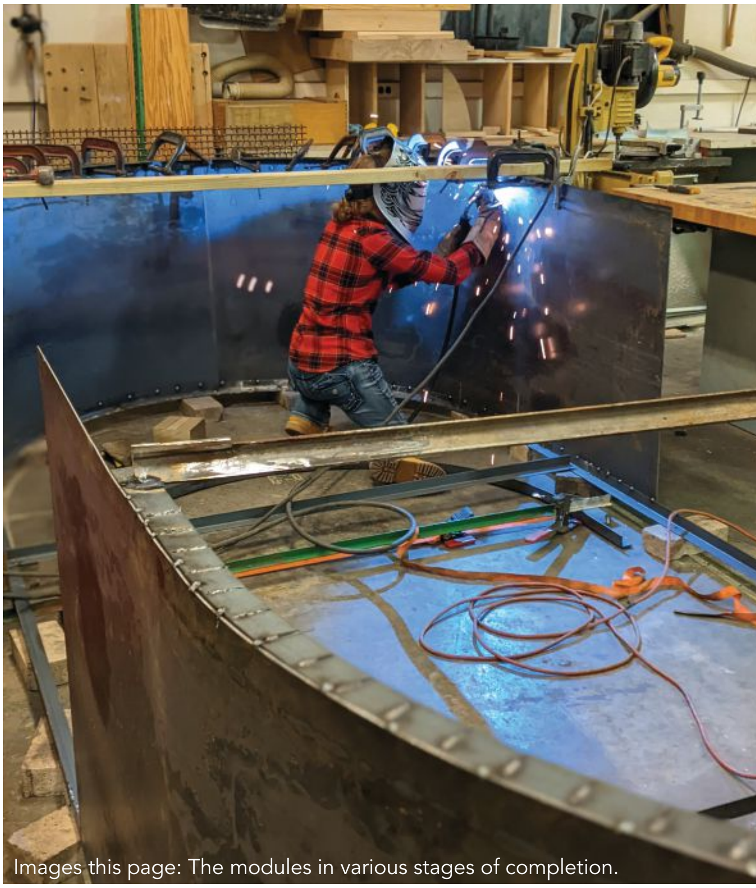
Having obtained both a civil engineering and architecture education, Underwood fully appreciates how these two professions must come together on projects.

"The project became more about understanding the complexity of fabrication and opened their eyes to the difficulty in what they initially deemed simple construction," he observed. "This actual experience in doing what they are frequently asking others to do has been enlightening."

Another lesson Underwood hopes to convey is that respect for other professions mutually benefits all parties throughout a project.

"This course, specifically, is one of our efforts to enhance respect, not only for the engineers but also for the contractors who bring both our efforts to fruition," he noted.

And in an excellent example of "practice makes perfect," Underwood observed that the students' skills actually improved as the project progressed.



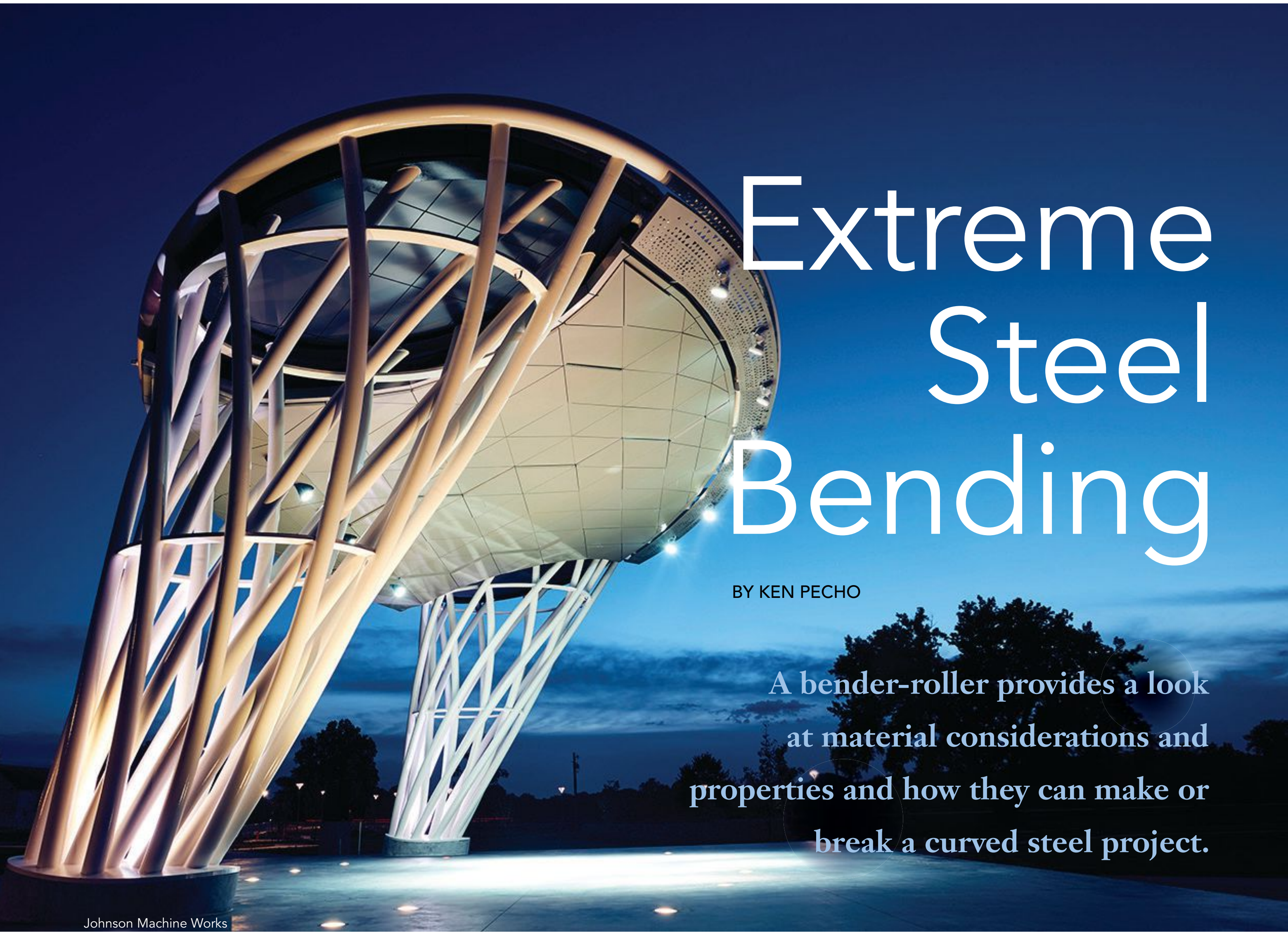
Images this page: The modules in various stages of completion.

The students conveyed what they gained from the project in their final report, noting, “One of the biggest rewards from this project was a greater understanding of steel as a material. Working with steel and learning to weld put the fabrication challenges of our work as architects and designers in perspective, allowing us to further refine our steel designs in the future to accommodate those that need to build the project.”

Commemorating the past and signifying a bright future, The Loop is not only a testament to the CAP’s longevity and success but also an example of the students’ dedication and creativity and a showcase of the skills they’ve learned. ■

*Visit **ballstatecap.com/steel-structures-for-campus** for more information on the project. And to learn more about Funding the Future and other AISC Education Foundation programs, visit **aisc.org/giving**.*

Maria Mnookin (**mnookin@aisc.org**) is AISC’s director of foundation programs and a proud graduate of Ball State University’s Miller College of Business, a neighboring building of the CAP.

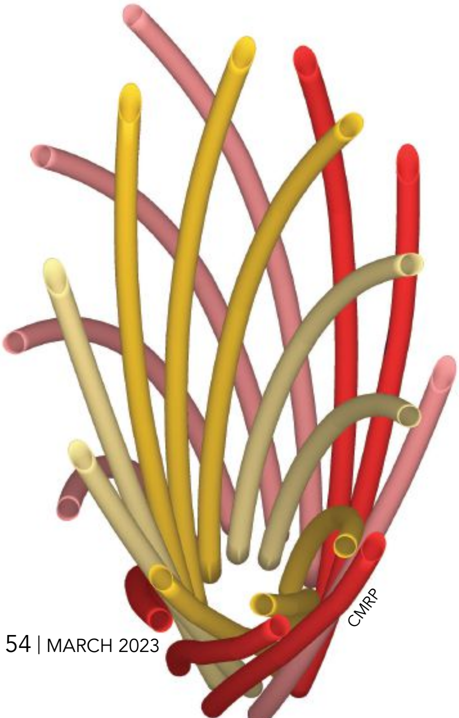


Extreme Steel Bending

BY KEN PECHO

A bender-roller provides a look at material considerations and properties and how they can make or break a curved steel project.

Johnson Machine Works



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WHEN I WAS FIRST APPROACHED with the topic of "extreme bending" for an NASCC: The Steel Conference presentation, my mind immediately envisioned jumbo rectangular tubes and heavy beams (like HSS20×12 rectangular tubes and W40×211 beams) being pulled through massive bending dies on the largest of our three roll section benders, all being curved into some insanely challenging geometry like a helix or a parabolic conic section.

I would talk about how our extreme rolling machines twist and bend massive structural steel members with the grace of a fine sculptor!

But as I continued to ponder the idea, it became apparent to me that the sheer size and geometry of a curved member alone don't define extreme bending. Rather, it is defined as the scientific approach to considering and analyzing—to what some might consider an extreme level of detail—a specified curved structural steel member. This approach focuses on material types and their mechanical properties, the condition the material is in during the bending process, the geometry of the bend and how severe the bend radius is, and whether the bend can be achieved through current bending technologies.

Here, we'll provide a quick look into the most important factors bender-rollers must consider when reviewing a project request. When it comes to structural projects, the most typical materials are mild carbon steel, stainless steel, and aluminum.

Once a material is chosen, the bender-roller must determine the viability of the curve and the likelihood of its success based on the material's characteristics. Bender-rollers understand that when performing a curve, we are slightly altering the material's mechanical properties, inducing stresses, straining its inelastic fibers, and ultimately increasing hardness and strength while reducing ductility and formability. It is our intent to only work the material as much as is needed to achieve the desired bend geometry. Severely overworking a member due to insufficient machine strength or the inability to hit a specific geometry through applied machine forces can have negative effects on its ductility—and in some cases, may cause the member to fracture or rupture.

In the Range

Structural steels are primarily mild carbon steels. This steel type is extremely strong yet ductile enough to be easily curved into a specified shape. It all starts with the elastic range. In a material's elastic range, forces can be applied to the member, but when removed from this range, any deformation regresses and the member's original shape is restored. Beyond a material's elastic range is the plastic range, and this is where the curving process takes place. As bender-rollers induce a radius into a member, we intentionally set a permanent plastic deformation into the material. Two important material properties to consider when curving a member in the plastic range are yield strength, the point where permanent plastic deformation starts, and tensile strength, the point at which a material's failure starts to occur. A lot can be ascertained from looking at the relationship between the two.

By analyzing the yield and tensile points along the curve (and following the curve from point to point), the shape and slope of the curve, and the difference between yield and tensile points, you can get a better understanding of how the material reacts to bending forces and how it behaves during the bending cycle. Many bender-rollers will get calls from engineers asking what the minimum achievable bend radius is for a specific member size and shape. While a minimum bend radius is typically tied to a bender-roller's equipment and individual capabilities, the strain ratio of a member can be used to predict the approximate limits of the bending radius.

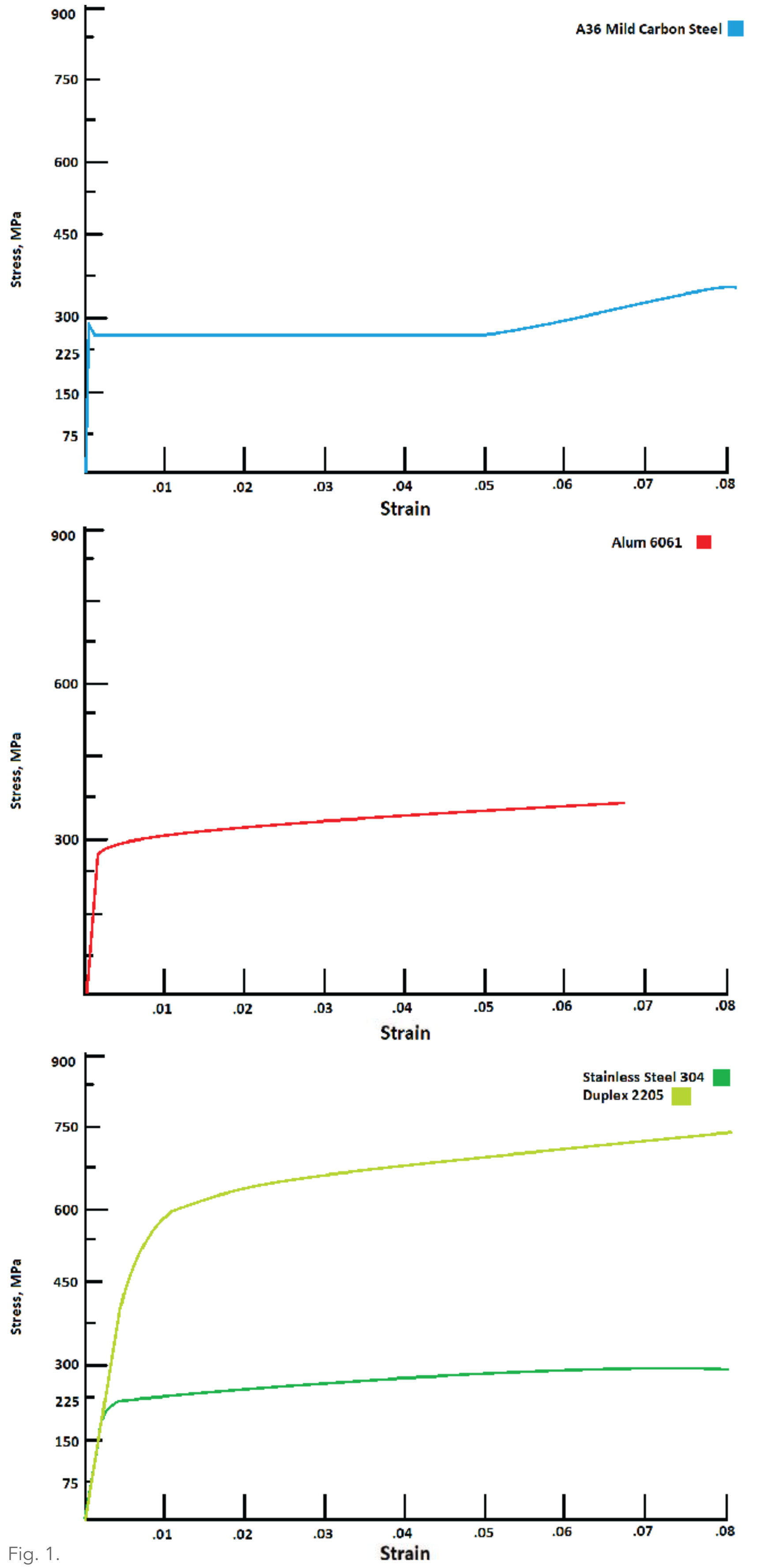
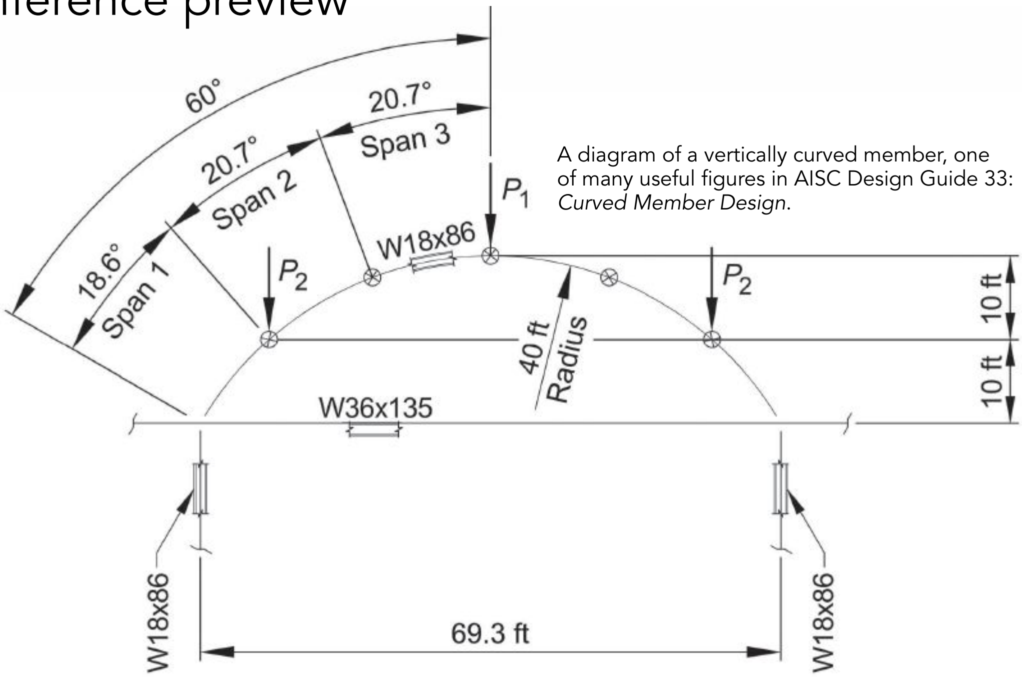


Fig. 1.



A diagram of a vertically curved member, one of many useful figures in AISC Design Guide 33: *Curved Member Design*.

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Consult the Guide

AISC Design Guide 33: *Curved Member Design* (**aisc.org/dg**) provides solid guidance on these considerations through equations and tables showing the maximum strain magnitude a member can undergo before the quality of the curve becomes questionable due to impending overstraining and undesirable changes in the material's mechanical and physical properties. Simply put, the more severe or tighter a bend's radius and resulting curvature, the greater amount of stress the inner and outer extreme fibers undergo. And once the bending forces are released, residual stresses persist throughout the cross section, mechanically increasing the member's hardness and strength. And this can cause a loss in ductility and formability. The good news is that structural steel can be taken pretty far into the plastic range before serious strain hardening takes place, and this can be seen in the stress-strain curve where the line appears to plateau (Figure 1, previous page); this is why it is easily curved when compared to other stainless steels and aluminum.

At the end of the day, curving steel, given the factors that need to be considered and the balance of pushing a member to its limits while still maintaining its strength in integrity, is itself an extreme process. And resources such as Design Guide 33 and the members of AISC's Bender-Roller Committee—who are happy to answer your questions (and are all listed at **aisc.org/benders**)—can provide a better understanding of the bending-rolling process and help you optimize your next curved steel project. ■

For a more in-depth look at the bending-related characteristics of different types of metals and a deep dive into their atomic-level properties, check out the session "Extreme Steel Bending: A Focus on Materials" at NASCC: The Steel Conference, taking place April 12–14 in Charlotte. You can learn more about the conference and register at ***aisc.org/nascc****.*

Ken Pecho (**ken@cmrp.com**) is a sales/project engineer with Chicago Metal Rolled Products.


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Fitting the Bill

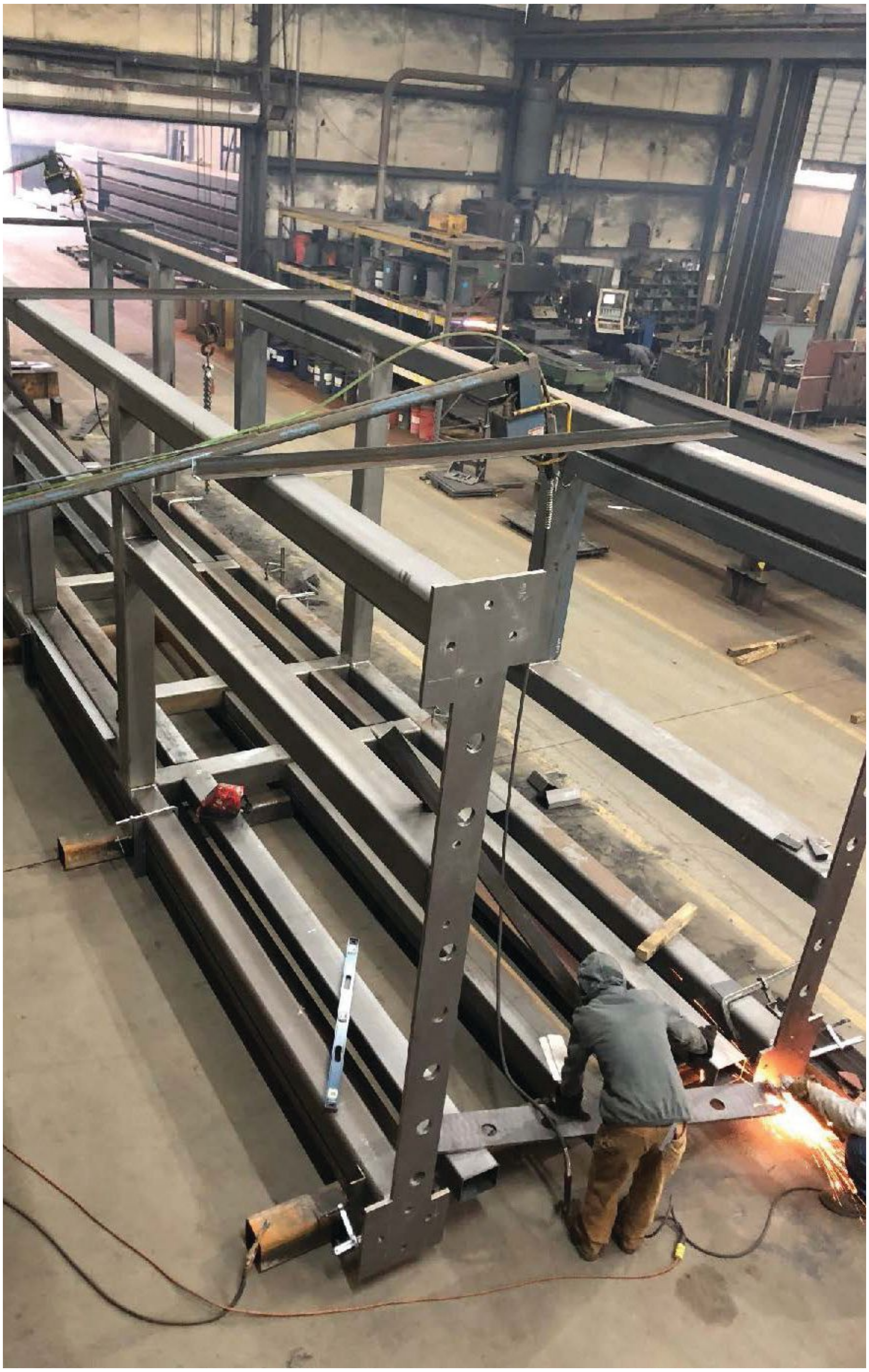
BY ADAM MacDONALD

A case study on training layout/fitter personnel can help you determine how to best develop this role in your own fabrication shop.

WHILE WE'RE (MOSTLY) through COVID, the steel industry is currently working through its own pandemic.

According to several estimates, we are expected to see a shortage of 400,000 welders by next year. This is roughly the size of the entire U.S. welding workforce in 2019.

While I believe we will overcome the welder shortage with robotics and other means, we haven't been very good at replicating the skill set of the less glorified but typically more complex position of layout/fitter. Sure, there's technology out there that helps aid this role, but none truly replaces it. On top of that, our current education system doesn't provide the coursework or tools to produce students for this important role in steel fabrication. And like welders, finding and retaining talent for this role is a growing problem.



We're hoping our session at the upcoming NASCC: The Steel Conference can help. We'll discuss why this position can be so difficult to fill and provide ideas on how to change the image of this crucial role to make it more attractive for prospective employees. This includes a strategy to effectively find and recruit talent while demonstrating the key characteristics needed to fill this role, as well as a holistic approach to delivering the essential tools that fit your workshop. Throughout this session, we'll ask some frank questions about how you currently operate—and whether your shop's mindset is sustainable when it comes to younger generations. The goal is to bring a more forward-thinking approach to how we can address this shortage.

In fact, this approach is based on a real-life scenario. In 2020, we were awarded a renovation project that included a 70-ft-tall elevator tower with extremely tight tolerances and an aggressive delivery schedule. The project was headed by a veteran layout/fitter and two 18-year-old apprentices. The training program we'll be discussing was used in the fabrication of this tower, and the project was completed successfully and on time and even beat the required tolerances. Both apprentices took ownership of their development, and the training they received put them on a fast track to becoming highly productive contributors moving forward.

Consider attending this highly interactive session. We'll help you take an honest look at your current situation—with the goal of returning to your shop with a strategy that works for your team and adding layout/fitter personnel that will provide you with long-term commitment and quality work. ■

For more on training and retaining layout personnel and fitters, check out the session "Implementing a Training Program to Teach the Craft of Layout and Fitting" at NASCC: The Steel Conference, taking place April 12–14 in Charlotte. You can learn more about the conference and register at ***aisc.org/nascc****.*

Adam MacDonald
(**amacdonald@mccombs-steel.com**)
is vice president of production
with McCombs Steel.

Come to QualityCon at this year's NASCC: The Steel Conference and learn how to avoid common bolt pitfalls and the associated corrective action requests.

Bolts and Nuts and Washers, Oh My!

BY LARRY MARTOF

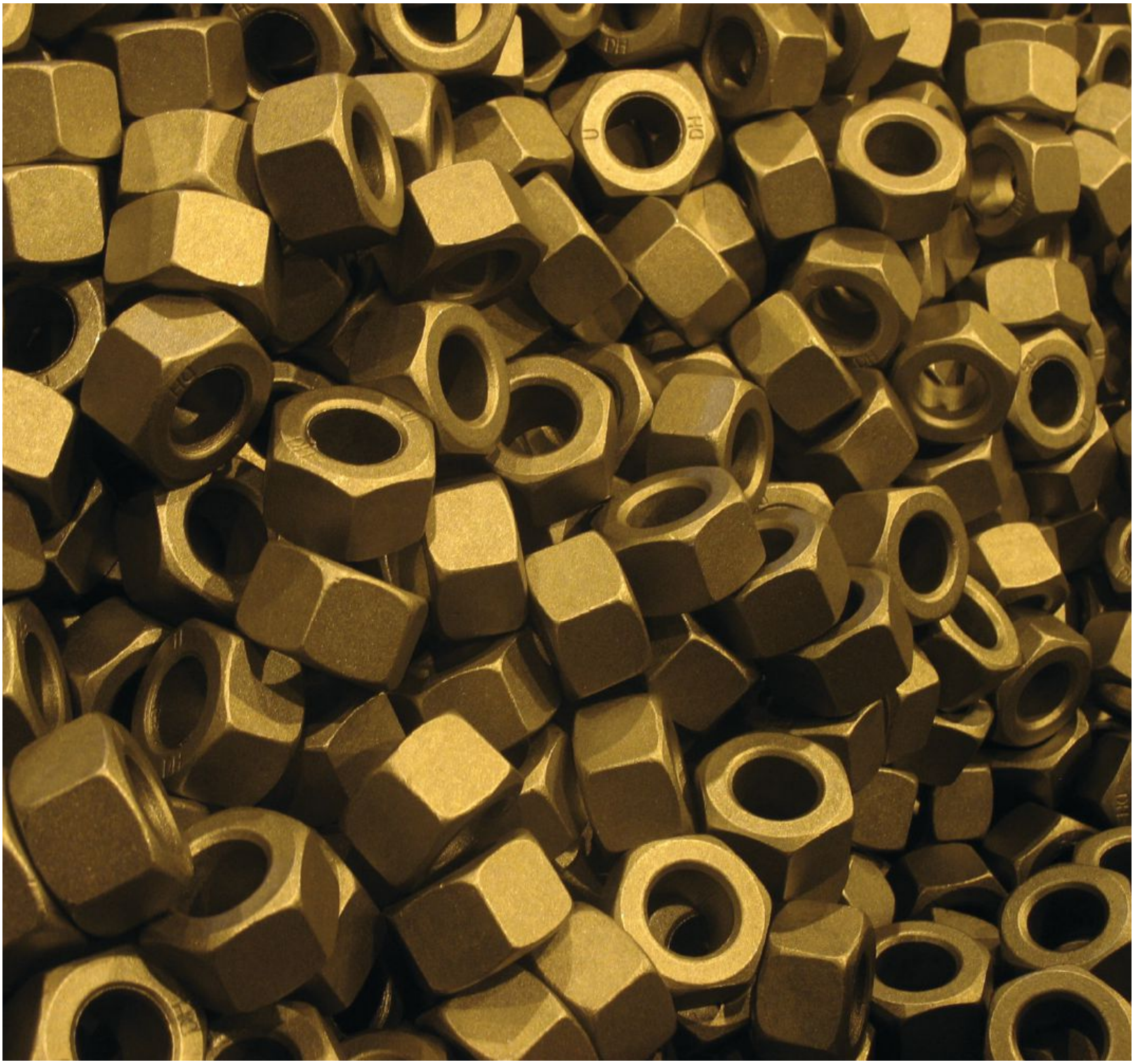
WHO'S READY for a story about bolts?

Let's journey down the yellow brick road through slots and holes into the land of connections.

Along the way, we'll give structural fasteners a brain, find out how to keep them from rusting up solid, and courageously take on the combined method. We will even overcome the wicked calibrated wrench. The wizard will lead us beyond others' corrective actions and into the merry old land of lessons learned.

No, this isn't a beloved classic from the Golden Age of Hollywood but rather a session at the upcoming QualityCon portion of NASCC: The Steel Conference. At last year's QualityCon, we explored the changes to the *RCSC Specification for Structural Joints Using High-Strength Bolts* (**aisc.org/specifications**). This year's QualityCon features two sessions dedicated to bolts. One will focus on gaining an understanding of how connections are designed and why engineers choose specific methods for and types of bolts. The other will focus on what we, as QMC auditors, have seen in AISC Certification audit corrective action requests (CARs) and other potential pitfalls that have been observed during certification audits.

When we look at the top three most frequently written CARs, we see calibration, bolting, and welding. Our interpretation of this data is that fabricators and erectors are struggling with the new *RCSC Specification* when applying it to their shop and field practices. The new combined method has caused folks to veer off the yellow brick road and get lost in the land of flying



monkeys and failed connections. Everybody likes rewatching a classic, so this year we'll review the installation methods but also include results from audits we've conducted. In addition to the CARs mentioned above, one common thread we've noticed is confusion with the markings and increments on the dials of the various tension calibrators that shops use. Another common problem? Understanding and implementing proper fastener storage practices.

Lions, tigers, and bears can be scary, but bolting doesn't need to be. Come join us at this year's NASCC: The Steel Conference and enjoy our bolt-focused QualityCon sessions, where we'll unravel the mysteries of bolting and all find our way back home. No ruby slippers or little dogs required. ■

For more on nuts and bolts from a quality standpoint, check out the session "Let's Go Nuts" at NASCC: The Steel Conference, taking place April 12–14 in Charlotte. You can learn more about the conference and register at ***aisc.org/nascc****.*

Larry Martof (**martof@qmcauditing.com**) is director of Quality Management Company, LLC.

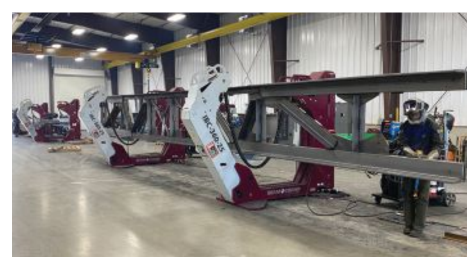
This month's New Products section includes a beam-synching system for easier erection, an updated version of a flexible roof framing solution, a steel infrastructure software package, and updates to a suite of engineering software products.

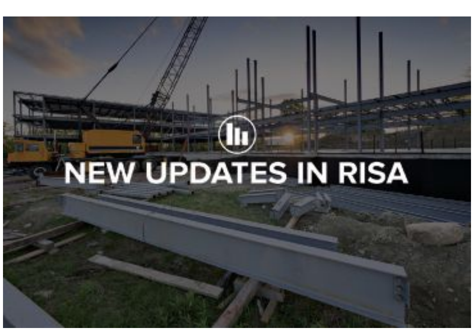
QuickFrames Drop-in Frames

Drop-in Frames are a new, fully assembled version of QuickFrames' classic Adjustable structural support roof frames. Designed for fabricators and erectors who are accustomed to dropping in frames before the roof deck is down, these new frames deliver the convenience of fully assembled frames while still allowing for adjustability in the field. This prevents some of the most frustrating hassles and expenses on new construction projects, including changes in mechanical locations, measurements, and equipment sizes. When traditional angle iron frames are welded in and changes occur, they must be cut out or abandoned. With Drop-in Frames, you can simply detach the rail system, attach new bolt-in connectors and install the frame elsewhere. Built to work with steel joists or beams with metal decking, the frames can save fabricators valuable shop time for more profitable projects rather than fabricating frames themselves. For more information, visit **quickframes.com/structural-frame-products**.

BZI Beam Champ System

The Beam Champ System, invented by InnovaTech, a division of BZI, wirelessly syncs two or more units together to rotate a single beam. The beam is then cradled on a chain and rotated as the chain moves. The system is designed to eliminate several problems associated with other branded beam rotators, and solutions include the vertical jaw arm, which opens to facilitate the placement or removal of a beam, and the support arm, which holds the beam in place while workers weld or configure the beam. For more information, visit **www.bzisteel.com**.



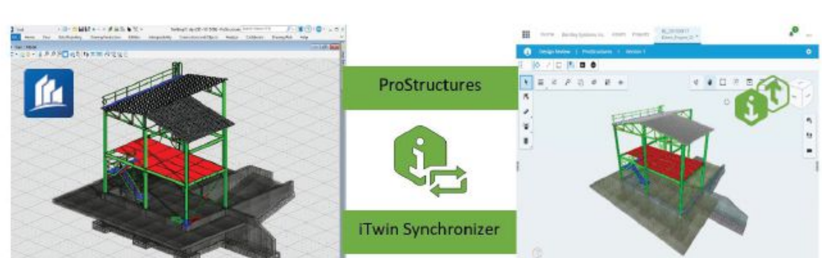


RISA

RISA's integrated suite of tools includes RISA-3D, RISAFloor, and RISAConnection. New product updates scheduled for 2023 will incorporate full compatibility with *IBC* 2021, including specific updates for CFS S100-2016 (with Supplements 1 and 2), as well as CFS S240/S400-2020. Additionally, steel connection designers will see the addition of continuous beam-over-HSS/wide-flange column connections. For more information, visit **risa.com/products**.

Bentley ProStructures

ProStructures, Bentley's comprehensive design application, allows structural engineers, steel detailers, and steel fabricators to develop models and documentation for infrastructure projects. All drawings and bills of material are directly produced from the 3D model and linked back to the models, maintaining fidelity and accuracy. This approach increases efficiency and minimizes errors through a streamlined process of creating project documents. ProStructures includes iTwin Synchronizer, which enables users to exchange information with the iTwin Platform, Bentley's open platform for infrastructure digital twins. Digital twins facilitate remote collaboration across geographically dispersed teams by providing a shared understanding of an entity's appearance when represented digitally. Revisions or changes in a project happen for several reasons, including design errors, clashes, or site conditions. Bentley's Issue Resolution service provides a central repository to capture, document, manage, and resolve all project revisions. For more information, visit **www.bentley.com**.



AISC NEWS

AISC Congratulates Larry Kruth and Cindi Duncan on their Retirements

This year marks a new chapter for two outstanding leaders at AISC: retirement!

Vice president of engineering and research Lawrence F. Kruth, PE, has spent more than four decades in the structural engineering world. He spent almost 40 of those years at Douglas Steel Fabricating Corporation in Lansing, Mich., where he served as a vice president and member of the Board of Directors. He retired from Douglas Steel in 2015 and joined AISC as the vice president for engineering and research the following November. He's held that position since then and is succeeded by Christopher Raebel, SE, PE, PhD.

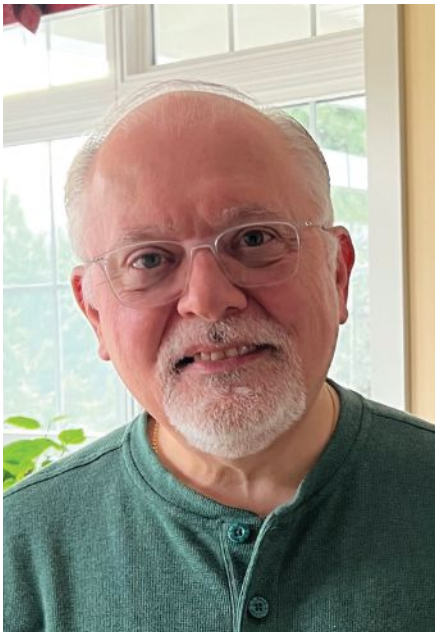
"Larry brought a unique skill set to AISC," said AISC President Charles J. Carter, SE, PE, PhD. "He had decades of experience as a steel fabricator, he was well-respected as an engineer in the design community, he was a long-time volunteer on AISC's technical committees, and he had even served on AISC's Board of Directors."

While Larry is an expert in contractual matters, connection design, and quality control and assurance, he was perhaps best known for his work on safety. "Larry helped breathe new life into AISC's safety programs both for the industry and also for our staff," Carter said. "One of his legacies, for example, is an ongoing program at AISC to make sure almost every staff member is CPR-certified."

Senior director of engineering Cynthia Duncan also retired at the end of the year. She joined the Institute in 1985—as AISC'S first engineer of her gender—and has been integral to the development of all AISC standards, specifications, and manuals since then. Cindi left AISC for a few years in the mid-1990s to raise her family before returning to lead AISC's specifications and publications work.

"Cindi was already a staff engineer at AISC when I started in 1991," said Carter. "Cindi changed AISC. She was a trailblazer, and her success paved the way for a generation of women who are now leaders at AISC. But more importantly, Cindi led the way to a more professional standards development process. She helped us become a better organization by emphasizing proper committee methods first and foremost. Her work to consolidate, coordinate, and streamline our standards was integral to our ANSI accreditation."

Both Kruth and Duncan discussed their lives and careers in *Modern Steel* Field Notes columns, Kruth in the February 2023 issue and Duncan in January 2022. Raebel was also featured in Field Notes (January 2023). You can read all of these columns (and listen to the related podcasts) at **www.modernsteel.com**.



People & Companies

AISC has named Fernao A.O. Cesar, director of marketing–Gerdau Long Steel North America, to its Board of Directors. He brings more than 15 years of experience in the steel industry, both in Brazil and the U.S.

"Interacting with the fabrication community as a supplier over the last years has been an amazing experience," said Cesar. "Now, I am looking forward to contributing to the advancement of steel construction in a new capacity as a member of the AISC Board."

With AISC embarking on a reinvigorated market development program, Cesar's experience in both sales and marketing is expected to be invaluable. "Fernao has been helping steel fabricators at Gerdau for years, and that gives him uniquely valuable insights into what they need in today's market," said Stephen Knitter, AISC's Board chair and president of steel fabricator Geiger & Peters in Indianapolis. "It's a pleasure to welcome him to the Board, and I look forward to working with him!"

Cesar is well-known and respected, particularly for his expertise in market intelligence and forecasting. He previously led Gerdau's U.S. innovation program. He earned a bachelor of engineering (materials engineering) degree from the Universidade Federal de São Carlos, Brazil, a master's degree in business economics from Fundação Getulio Vargas, Brazil, and an MBA from Michigan State University.

"AISC's successes are driven by the diverse and deep experience of our volunteers. This starts with our Board, which represents the combined expertise of the American fabrication industry as well as leading steel manufacturers and distributors," said AISC President Charles J. Carter, SE, PE, PhD. "I'm looking forward to working with Fernao and know he'll be an invaluable contributor to AISC and the steel industry."

SEAA NEWS
SEAA Announces Daniel "Rudy" Ruettiger as Keynote Speaker of its 2023 Convention

The Steel Erectors Association of America (SEAA) will hold its annual Convention and Trade Show March 28–31, 2023, in St. Augustine, Fla., at the World Golf Village Renaissance Resort. Former Notre Dame football player Daniel "Rudy" Ruettiger will give the Keynote Presentation.

"We are thrilled to have Ruettiger share his personal experiences with our attendees," said R. Pete Gum, SEAA's executive director. "More than just an exceptional athlete and motivational speaker, Ruettiger is also an entrepreneur with insights that members can apply to their own businesses," said Gum.

2023 marks 30 years since Tristar Productions immortalized Rudy's life story in the blockbuster film named for him (Rudy). It's a story of adversity and triumph about the Notre Dame football player who sacked the quarterback in the last 27 seconds of the only play in the only game of his college football career. Today, Rudy Ruettiger is an Emmy Award Winning motivational speaker, author, and producer.

The convention will feature ten additional education sessions for owners, managers, and field personnel. This includes panel discussions with the 2023 Project of the Year, Safety Excellence, and Craft Training Excellence Award Winners and a panel discussion on current trends in structural fastening with representatives from several fastening suppliers. Other sessions will cover succession planning, fall rescue planning and execution, risk management solutions for crane operations in steel erection, and a session highlighting changes to the RCSC bolt code.

The trade show provides erectors and fabricators a chance to see the latest products, services, and innovations they need for a safer and more productive work site.

"We will have more than three hours of dedicated trade show time at indoor and outdoor booths, with hands-on presentations from exhibitors for a highly-engaged trade show experience," said Carrie Gulajan, SEAA's events committee chairperson.

Excursion highlights include the George R. Pocock Memorial Golf Tournament hosted by the Slammer and Squire Golf Course, a fishing tournament along the Intercostal Waterway, and a tour of the historic Lightner Museum.

Learn more about SEAA's annual convention and trade show at **seaa.net/events**.

MEMBERSHIP
AISC Approves New Members

The AISC Board of Directors has approved the following companies for AISC full or associate membership.

Full

Capitol Engineering Co., Phoenix
Construction Specialties, Lebanon, N.J.
Eastern Steel Works, Inc., Seagrove, N.C.
Intermark Steel, LLC, Price, Utah
KDM Steelworks, Inc., Loveland, Colo.
Martin's Metal Fabrication and Welding, Inc., Vacaville, Calif.
VM Ironworks and Structural Steel Corp., Palm City, Fla.

AISC ASSOCIATE AISC DETAILER **Associate**

3-D Steel Detailers, Evanston, Wyo. *Detailer*
Akyapak USA, LLC, Tampa, Fla. *Bender-Roller*
E. L. Construction, LLC, Atoka, Okla. *Erector*
ESS Detailing Services, LLP, Maharashtra, India, *Detailer*
GEN Engineering, Inc., Lewes, Del. *Detailer*
Oasis Metal Manufacturing, LLC, Dubai, U.A.E., *Non-Structural Fabricator*
SFR Structures, Newmarket, Ont., Canada, *Detailer*
United Structure Detailing, Inc., Los Angeles, *Detailer*

NASCC
Have You Registered for NASCC?

NASCC: The Steel Conference is heading to Charlotte, N.C., April 12–14.

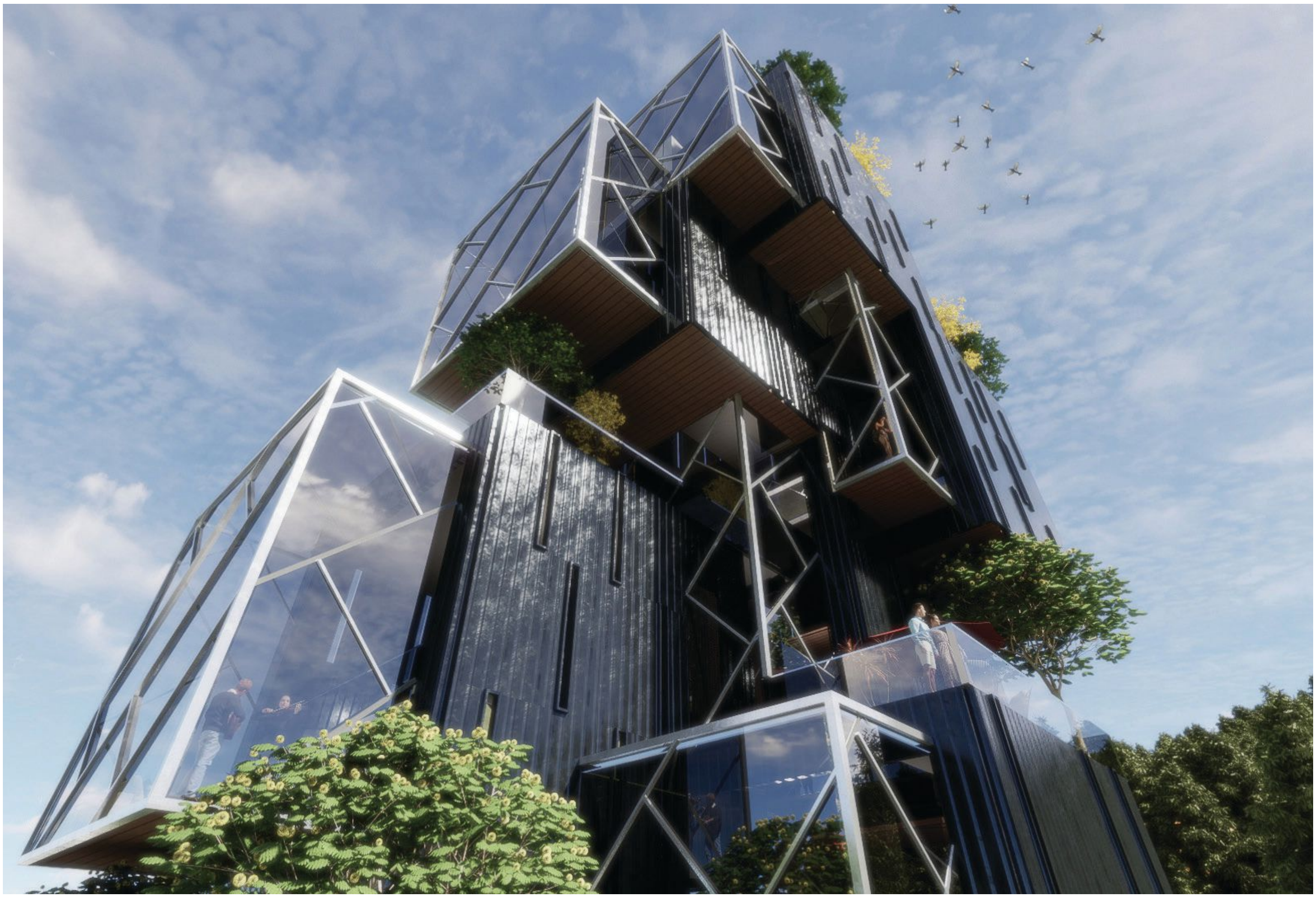
Register today to get the best price on the industry's top educational event, featuring 200 sessions full of must-have practical information that you can implement as soon as you get home, an exhibit hall packed with more than 250 innovations you need to know about right now, and a chance to network with thousands of the world's best designers, fabricators, erectors, and other steel fans.

The Steel Conference is the must-attend educational event of the year and focuses on providing actionable information you can put into practice right away. Here are just a few of the things you'll learn at this year's conference—while earning up to 17 PDHs!

- How designers can cut the carbon footprint of a structural system
- How to save time and money on steel bridge fabrication by using a single coat of inorganic zinc primer as a corrosion-protection system
- What you need to know about welding ASTM A913 steel, whether you're specifying it or doing it yourself
- How to analyze unbalanced loads on steel deck
- What fabricators wish engineers knew about hollow structural sections (HSS)
- How to avoid common mistakes as a new connection designer
- How to tackle coordination issues with roof and floor penetrations
- How the team behind a largely exposed AESS structural system handled fire engineering—and why it may not need to be fireproofed
- How good detailing can make—not break—your project

The Steel Conference also incorporates six specialty conferences: the World Steel Bridge Symposium, QualityCon, Architecture in Steel, SafetyCon, the SSRC Annual Stability Conference, and the NISD Conference on Steel Detailing. For more details on the Steel Conference and these specialty conferences—and to register—visit **aisc.org/nascc**.

advertiser index



Forge Finalists

WHO WILL WIN AISC'S 2023 Forge Prize—and $10,000?

Will it be a groundbreaking idea to convert gas stations to electric charging stations? Or perhaps a self-sustaining micro-city concept? Or will it be a transit center designed for a future that includes rideshare by electric airplane? Find out during a live-streaming event in March.

"The Forge Prize is particularly exciting because it gives the next generation of great design innovators a chance to dream big and imagine how steel can bring about a bright future," said Alex Morales, AISC's senior structural specialist leading the competition. "Based on these three finalists, it's clear that the future of visionary design is in good hands. I can't wait to see what their initial concepts turn into after they work with a steel fabricator to refine them!"

AISC's annual Forge Prize competition celebrates emerging architects who create visionary designs that embrace steel as the primary structural component while exploring ways to increase project speed.

These three finalists each take home $5,000 from the first round. They'll work with a steel fabricator before presenting their final concepts to the judges during a live YouTube event in late March. At stake: the $10,000 grand prize and an invitation to present before an audience of the industry's best minds at NASCC: The Steel Conference, taking place April 12–14 in Charlotte.

For more information about the Forge Prize and this year's finalists, visit **www.forgeprize.com**. For more information about (and to register for) NASCC, visit **aisc.org/nascc**. And to view the live YouTube event, go to **youtube.com/@AISC** (more information about the event will be posted soon at **www.modernsteel.com** and **www.aisc.org**).


KOBELCO
ARCMAN™
Welding Robot System
High Quality Welding for Structural Fabrication
<Capabilities>
· Full Penetration Welding
· Multipass Welding
· Automatic Slag Removal