Modern Steel Construction

September 2023

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
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Modern Steel Construction

September 2023

features

columns

ON THE COVER: Las Vegas' Sphere is spectatular inside and out, thanks in part to its massive steel exoskeleton, p. 26. (Photo: AISC)

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Remember the late-1960s TV show *Get Smart*?

I do. Well, kind of.

It was on the air before I was born, but I recall my parents enjoying the reruns, and the humor was goofy enough when I watched episodes in grade school. (And the show's star, Don Adams, was more familiar to me and my generation as the titular character in the animated series *Inspector Gadget*.)

The irony was that Adams' character in the spy-themed *Get Smart*, as agent Maxwell Smart, wasn't exactly smart, but rather bumbling and ridiculous—more Inspector Clouseau than James Bond. But he was one of the good guys and did his best to always do the right thing.

Whether you're a college student or a seasoned professional, if you're looking to get smart—or rather smarter—when it comes to getting better at your role in the structural steel supply chain, AISC's wide range of educational options can help you do so.

Turn to the article "A Portal to Learning" on page 58 of this issue and take a journey through the portal—i.e., the AISC Learning Portal at **aisc.org/learning**. This online one-stop shop was introduced last year by AISC to provide access to all the continuing education content we have to offer. For example, you can access our more than 125 PDH-ready On-Demand Courses in the form of select NASCC: The Steel Conference, past daytime webinars, and the Steel Academy. Or perhaps you'd like to view a specific past Steel Conference session. Good news: Nearly all our conference sessions dating back to 2005 are available for free. There is also a slew of specialty topics, the full library of AISC's Design Guides, a searchable database of past speakers, and plenty of exam prep resources.

When it comes to in-person learning options, "Faculty-Led Fun" on page 54 highlights AISC's faculty-led field trips to local steel facilities, which provide students with more memorable educational experiences that can be achieved in a classroom (visit **aisc.org/fieldtripgrants** for more). Several of these visits took place on SteelDay last year, and the same plan is in place for this year's SteelDays, taking place October 17–20 (visit **aisc.org/steelday** for more). While these trips are geared toward college students, keep in mind that if you're ever interested in visiting a steel facility in your area, almost any AISC member fabricator or other facility type would be happy to host you. Just reach out to them (you can search for member companies at **aisc.org/fabricator**).

In a similar vein, "The Transformative Power of Hands-on Learning" on page 50 documents a collaboration between Purdue University students and a local ironworkers organization, where the students are able to learn practical skills in a controlled lab setting, gain a better understanding of the industry, build relationships that can help them out after graduating, and value teamwork.

For a real-life successful case study in lifelong learning, this month's Field Notes column "Learning to Lead" on page 22 delves into Ruby+Associates president and CEO Tricia Ruby's college experience (at Purdue) and how her human factors engineering background, love for math, and business acumen took her to the top of the engineering firm her father started.

AISC's learning opportunities are plentiful and will keep you from becoming the type of person that talks into a shoe or, in the precise world of steel design and construction, makes "Missed it by *that much!*" your catchphrase like Maxwell Smart.

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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**.

Evaluation of Historical Buildings pre-1900

We are evaluating an existing building that was built in 1893. It appears to be steel framed with 9-in. clay book tile floors and slab over the top at the floors and 3-in. clay tiles at the roof. The joists are bowed out and require repairs/reinforcing. We have the following questions:

1. **Regarding the weldability of the existing material and getting samples for testing, is there any non-destructive testing that can be done on-site to determine this, or will a piece of steel need to be cut from the existing steel joists and tested?**
2. **Is there an estimate for the steel type or strength in a building from this time period?**
3. **Are there any resources on the capacity of the clay tile floor systems?**
4. **Can steel members that have experienced plastic deformation be repaired by welding on angle reinforcement?**

It is not advisable to weld to steel from the 1890s without understanding its chemical composition. I'll answer your questions one at a time.

❶ The construction date of this building is right in the middle of the transition period between wrought iron and structural steel. In 1890, structural wrought iron was commercially dominant, and by 1894, it had been replaced by structural steel. Design Guide 21: *Welded Connections—A Primer for Engineers* explains this further in Section 5.4.5.

The July 2013 Steel Interchange item "Historic Cast Iron" also provides information on how to tell if the existing material is steel or wrought iron.

In addition, Appendix 5 of the 2022 AISC *Specification* applies to the evaluation of the strength and stiffness of existing structures by structural analysis, by load tests, or by a combination of structural analysis and load tests where specified by the engineer of record or in the contract documents. Section 5.2 covers Material Properties, and Chemical Composition is covered in Section 5.2.3. The Commentary provided for this section contains a good discussion of these provisions.

Back to Design Guide 21, Section 2.4 discusses welding to existing members and the general process for determining weldability. Methods exist in the petroleum industry that can determine chemical composition without removing a sample, and they could be used for structural steel. You can see an example from Thermo-Fisher Scientific at **tinyurl.com/pipelineandprocess**.

It is common to take a sample of the steel (typically a 1-in.-diameter core) for chemical composition and metallography where weldability is a concern. A metallography analysis is useful to examine the metal for possible unsound features, which would not be done with just composition testing. This is explained more in the Commentary to Section 5.2.3 in the 2022 AISC *Specification*. Also, Design Guide 21 recommends that in addition to chemistry, a simple bend tab test can be done in the field to determine weldability.

Also, the recently released 2022 AISC *Seismic Provisions for Evaluation and Retrofit of Existing Structural Steel Buildings* (ANSI/AISC 342) contains a wealth of information on material properties for existing steel and welding to existing steel. Most applicable to your question are Sections A5 and B3, particularly the Commentary to those sections (look at the Commentary to Section B3.2).

Here are a few more references that can help answer questions about welding to historic steel:

- The April 2007 *Modern Steel* article "Building Retrofits: Breathing New Life into Existing Structures."
- The August 2011 Steel Interchange item "Welding to Historic Steels."
- The 2021 NASCC: The Steel Conference session "Welding of Obsolete and Historical Structural Steels" (you can search for it at **aisc.org/education-archives**).
- The first quarter 1988 AISC *Engineering Journal* article "Field Welding to Existing Steel Structures" is also useful.

❷ There was no commercially dominant manufacturing standard for steel during this period. AISC Design Guide 15: *Rehabilitation and Retrofit* is a valuable resource. Table 4-1a summarizes various historic steel specifications and lists the requirements for yield and tensile strength. However, keep in mind that this table only goes as far back as 1900. The new *Seismic Provisions for Evaluation and Retrofit of Existing Structural Steel Buildings* contains a lot of information about the material properties of historic metals. Default material properties are addressed in Section A5.2.

You can also refer to Appendix 5 of the 2022 AISC *Specification* for requirements on determining material properties in the evaluation of existing structures.

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**.

❸ Several historical references tabulate the capacities of clay tile floor systems. A good reference for the types of different blocks and some tables on capacities is a 1915 *Natco Hollow Tile Fireproofing* publication, which you can access at **tinyurl.com/natcocatalogue**. (You may want to confirm the 9-in. clay book tile. While the Natco publication includes a 9-in. tile for arches, I do not see a 9-in. book tile.) If the system is an arch, you should be careful not to eliminate the compressive reaction necessary for the arch and destabilize the system.

Another resource on the capacity of clay tile arch systems is historic building manuals like the 1921 *Pocket Companion* by the Carnegie Steel Company (see the information starting on page 303): **aisc.org/publications/historic-shape-references/#28349**

Another good reference is the December 2007 *STRUCTURE* magazine Engineer's Notebook article "Antiquated Structural Systems Series," which you can access at **www.structuremag.org**.

Finally, the historic *Kidder-Parker Handbook* also has information on clay tile arches. You can typically purchase it on used bookstore sites.

❹ You could completely remove plastically deformed steel and weld (assuming the material is weldable) in a piece of new steel and then treat the final member as if it has never been plastically deformed. You could also splice in new material (welded to not-plastically deformed material) such that it bridges the plastically deformed steel and then treat the final member as if it had never been plastically deformed.

The plastic deformation you describe could involve cold working. Many engineers tend to avoid welding cold-worked steel. However, welding cold-worked steel is not explicitly prohibited and is relatively common when one considers that the corners of rectangular hollow structural sections (HSS) are cold-worked. Additionally, if the current geometry is not acceptable, obtaining acceptable geometry may involve (or may have in the past involved) further cold working. Keep in mind that each repeated cycle of cold working will reduce ductility. Unless you intend to entirely neglect the plastically deformed section, your knowledge of the history of the plastically deformed section may be a consideration. The Federal Highway Administration produced a manual to address heat straightening, heat curving, and cold bending of bridge components that addresses, among other things, the repair of steel members damaged when hit by vehicles. It may be a helpful reference to review: **fhwa.dot.gov/bridge/pubs/hif23003.pdf**.

Yasmin Chaudhry, PE

Change to Standard Bolt Hole Size in the 2016 AISC *Specification*

We noticed in the 2016 AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) that the standard hole sizes provided in Table J3.3 for 1-in.-diameter or larger bolts increased from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. Why did the standard hole sizes for these larger bolt diameters increase by $\frac{1}{16}$ in.?

The Commentary states: "To accommodate manufacturing process tolerances and provide fit and rotation capacity proportional to the size of connections typically using large diameter bolts, the size of standard holes for bolts 1 in. in diameter and larger was increased to $\frac{1}{8}$ in. over the bolt diameter. The size of standard holes in S.I. units already provided sufficient tolerance and were not increased…"

The above statement reflects the two reasons for the change.

1. We received numerous reports of bolts larger than 1 in. in diameter that satisfied the manufacturing tolerances but were too large to fit into the previously designated "nominal hole dimensions." The ASME B18.2.6 standard allows swells and fins on bolts that sometimes cause them to not fit in the holes. Having bolts that were larger than the holes they were intended to occupy had and could continue to cause problems on projects. The change in the 2016 AISC *Specification* addressed this issue.
2. We received no reports of 1-in.-diameter bolts that satisfied the manufacturing tolerances but were too large to fit into the previously designated "nominal hole dimensions." However, since we were increasing the hole size for bolts larger than 1 in. in diameter, it seemed reasonable to consider an increase for other bolt diameters as well. As indicated in the Commentary, "The sizes of standard holes in S.I. units…" were larger than those using imperial units. This fact, including the successful use of these large holes in Europe and elsewhere, was considered when this change was being debated.

The 2020 *RCSC Specification* Commentary states: "The change was supported by research by Allan (1967), Allan and Fisher (1968), Fisher and Beedle (1964), Chesson et al. (1964), Hoyer (1960), and Borello (2009). Allan and Fisher (1968) showed that even larger holes could be permitted for high-strength bolts without adversely affecting the bolt shear or member bearing strength."

Carlo Lini, SE, PE

Carlo Lini (**lini@aisc.org**) is director and **Yasmin Chaudhry** (**chaudhry@aisc.org**) is a staff engineer, both with AISC's 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**.

STEEL SOLUTIONS CENTER

This month's Steel Quiz focuses on updates to the newly published 2022 AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341-22); download your free copy today at **aisc.org/standards**. The questions and answers were developed by Jack Zheng, an AISC intern and student at the University at Buffalo.

1 **True or False:** When evaluating the transfer of tension between the pile cap and piles of H-piles, the connection is only designed for the minimum required tension force on the pile.

2 To determine the expected strength for a composite member or adjoining member, R_c is used as a factor to account for the expected concrete compressive strength. The value of R_c should be:
a. 0.7 **b.** 1.0 **c.** 1.3 **d.** 1.5

3 **True or False:** Structural steel trusses are permitted to be used as the "beam" in an ordinary moment frame (OMF).

4 **True or False:** Chords, collectors, truss diaphragms, and their connections are part of the seismic force-resisting system (SFRS).

5 **True or False:** Appendix 1 on Design Verification Using Nonlinear Response History Analysis can be used on both ordinary and special seismic force-resisting systems.

6 **True or False:** Ordinary concentrically braced frames (OCBF) above seismic isolation systems are exempt from certain requirements in Section F1 of the *Seismic Provisions*.

7 Which system added to the 2022 *Seismic Provisions* is an alternative to coupled reinforced concrete shear walls or special plate shear walls (SPSW)?
a. Composite plate shear walls-concrete encased (C-PSW/CE)
b. Composite ordinary shear walls (C-OSW)
c. Coupled composite plate shear walls-concrete filled (CC-PSW/CF)
d. a and c

TURN TO PAGE 14 FOR ANSWERS

STEEL SOLUTIONS CENTER

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

steel quiz ⋮ ANSWERS

1 **False.** Section D4.3 now includes additional requirements for H-piles consistent with *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE/SEI 7-22). Section D4.3 requires that for H-piles, the connection between the pile cap and piles be designed for a tensile force not less than 10% of the pile compression capacity (with an exception). As stated in the Commentary to Section D4.3: "Because piles can be subjected to tension caused by overturning moment, mechanical means to transfer such tension must be designed for the required tension force, but not less than 10% of the pile compression capacity."

2 **c.** 1.3. Section A3.2 of the 2022 *Seismic Provisions* now includes the factor, R_c, to account for the expected strength of concrete. The expected compressive strength can be determined by, $R_c f'_c$, which is the specified concrete compressive strength, f'_c, and the factor to account for the expected strength of concrete, R_c. R_c shall be taken as 1.3.

3 **True.** The 2022 *Seismic Provisions* is revised to include the option for an ordinary truss moment frame. In Section E1, structural steel trusses are permitted to be used as beams in an OMF. Additional requirements for this system are outlined in Section E1.7.

4 **True.** Chapter B of the 2022 *Seismic Provisions* clarifies that chords, collectors, and truss diaphragms are part of the seismic force-resisting system and shall be subjected to the applicable requirements in the *Seismic Provisions*.

5 **False.** The scope of Appendix 1, which is a new appendix in the 2022 *Seismic Provisions*, is currently limited to special systems consisting of structural steel or structural steel acting compositely with reinforced concrete. As explained in the Commentary, these systems are chosen in part because (a) they are the ones typically being designed and evaluated using nonlinear response history analysis, and (b) the modeling of these systems, while complex, exhibits behavior that is reasonably well replicated by analysis.

6 **False.** Section F1.7: Ordinary Concentrically Braced Frames Above Seismic Isolation Systems has been removed from Chapter F of the 2022 *Seismic Provisions*. The Commentary explains that although base isolation is expected to improve the performance of the system, it was decided that there is not sufficient research on OCBF above seismic isolation systems to warrant alterations to the OCBF provisions as previously presented in Section F1.7.

7 **c.** Coupled composite plate shear walls-concrete filled (CC-PSW/CF). The 2022 *Seismic Provisions* introduces a new system, coupled composite plate shear walls-concrete filled (CC-PSW/CF), in Section H8. This system can be used as an alternative to coupled reinforced concrete shear walls or special plate shear walls (SPSW), particularly when large seismic demands on walls result in large amounts of reinforcement and/or very thick walls.

Drop It in the Slot

BY BO DOWSWELL, PE, PHD, AND CARLO LINI, SE, PE

Following these tips on slotted HSS brace design can help ease their erection in the field.

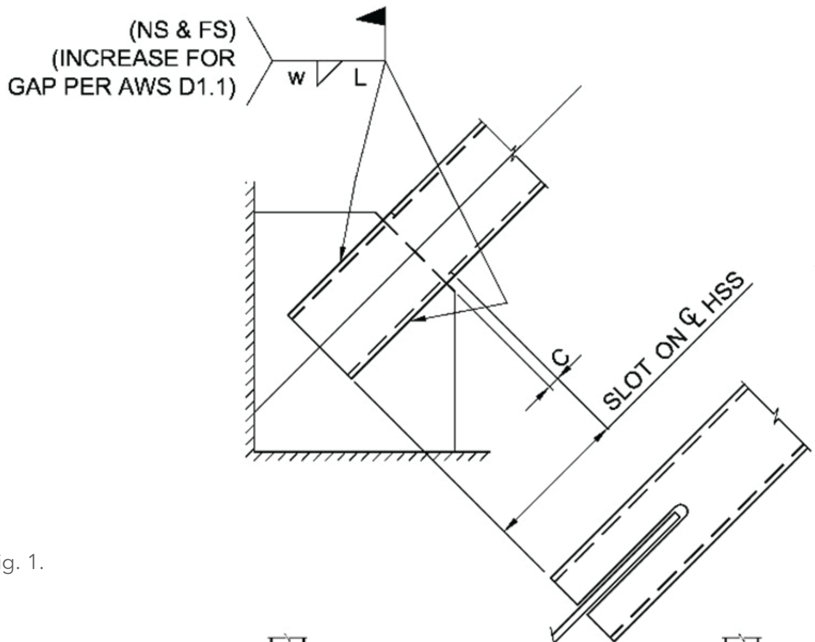
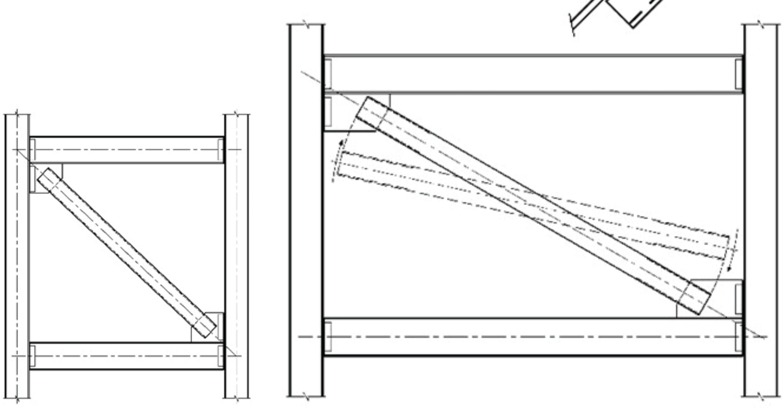


Fig. 1.



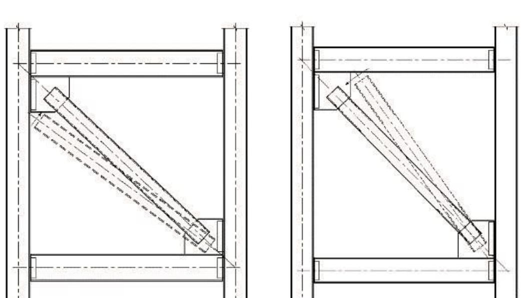


Fig. 2.

Fig. 3.

SLOTTED HOLLOW STRUCTURAL SECTION (HSS) braces have a lot going for them.

They can simplify construction, they take advantage of all the benefits of HSS, they require a relatively low number of components, they are a great option for architecturally exposed structural steel (AESS) applications, and they offer some field flexibility.

Of course, there are several things to consider when working with this brace type (see Figure 1 for a sample configuration). Following is a look at some of the key considerations that can simplify working with slotted HSS braces in future steel-framed projects.

Erection

When implementing slotted HSS braces, erection clearance must be considered in the detailing of the slot length. Several erection situations are shown in Figure 2, where a vertical swing is required to bring the brace into the proper position. Due to the tight clearances, the brace in Figure 2a cannot be erected without unbolting one of the beams, which is unsafe and costly and can have a negative impact on the schedule. Figure 2b shows a brace with a shallow angle, which naturally allows clearance to rotate the brace in place for erection. The braces in Figures 2c and 2d must be inserted over the lower gusset plate and lowered beyond the final position of the brace to provide adequate clearance for the upper end of the brace to be rotated into its final position. This requires more clearance between the brace and the beam and/or column and longer slots than required for the brace in Figure 2b. Where this extra clearance is not provided, the slot length is likely to be extended by flame cutting in the field, which can produce low-quality cut edges, (Figure 3). In some cases, tapered gusset plates may be the best solution to provide erection clearance for slotted HSS braces.

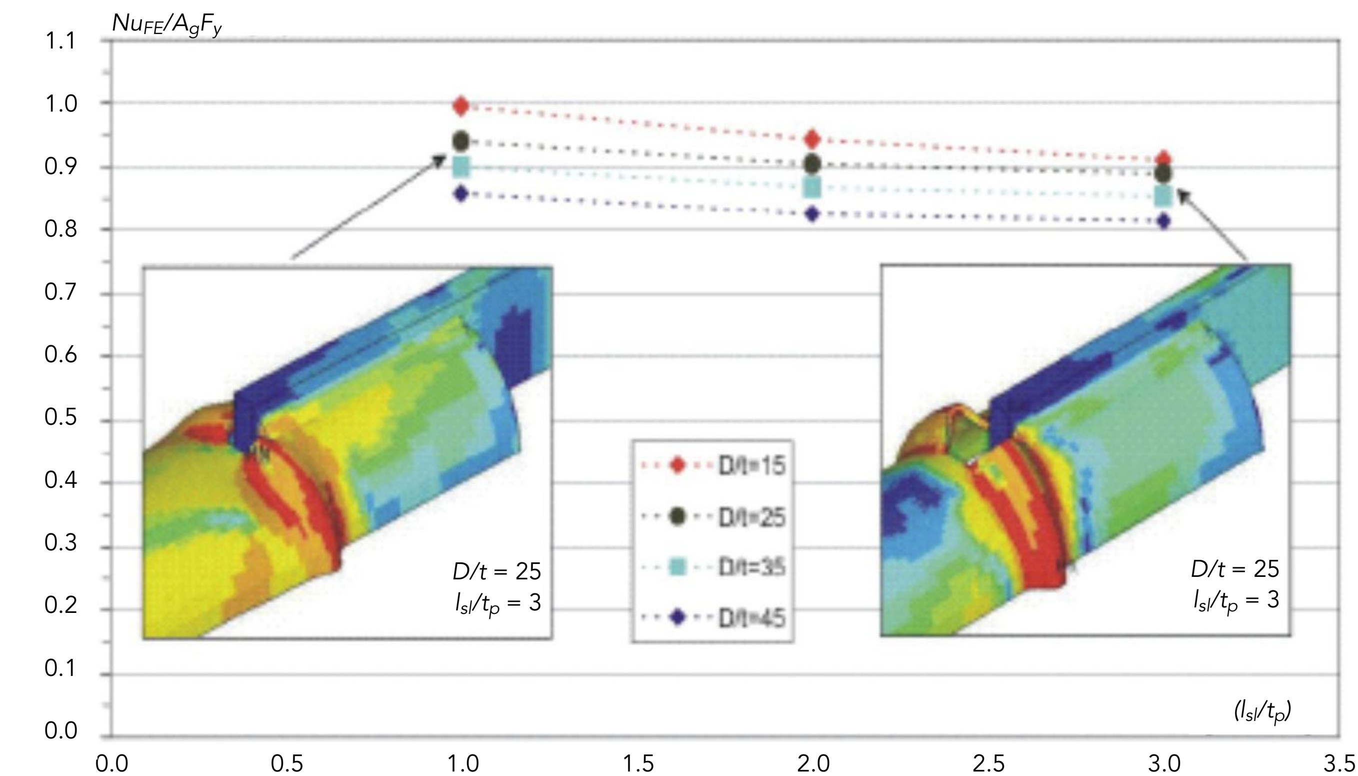


Fig. 4.

Slot Length

Slots are typically fabricated with a 1-in. minimum clearance beyond the edge of the gusset plate (dimension *c* in Figure 1). Because a 1-in. clearance is often inadequate for the required erection clearance, many fabricators prefer to use a standard clearance of 2 in. However, there are cases where the 2-in. clearance will not allow the brace to be maneuvered into its final position. Therefore, the slot length should be carefully evaluated by the detailer. The third quarter 2012 AISC *Engineering Journal* article "Satisfying Inelastic Rotation Requirements for In-Plane Critical Axis Brace Buckling for High Seismic Design" (**aisc.org/ej**) notes that the required clearance dimension can be as high as 6 in. Because the HSS wall is an unstiffened element over the non-welded portion of the slot length, it is more susceptible to local buckling than the other segments of the member. Therefore, the slot length should be limited to a reasonable distance—especially for seismic applications.

Localized Slot Buckling

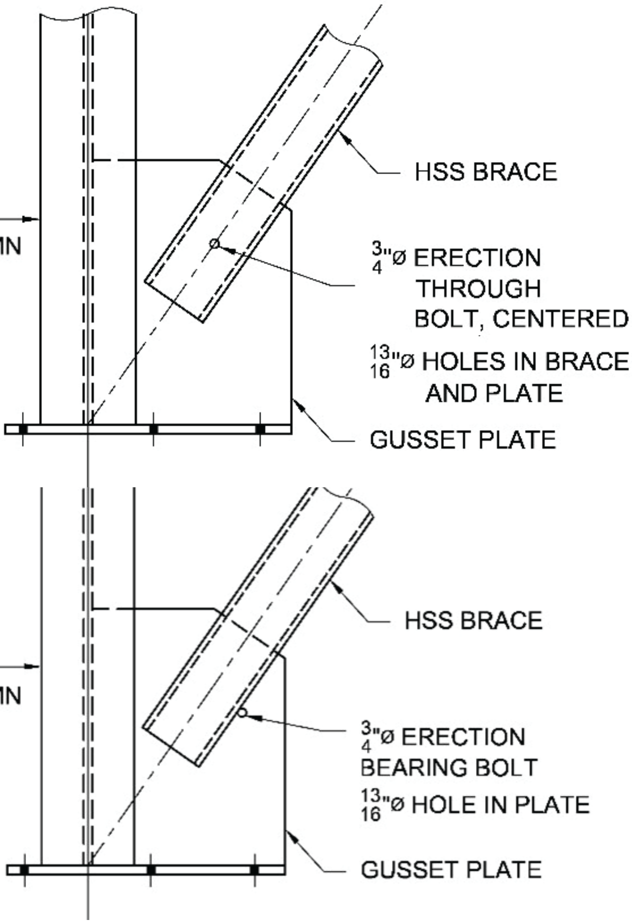
Martinez-Saucedo, in his *Slotted End Connections to Hollow Sections* PhD dissertation at the University of Toronto, developed finite element models for round HSS braces in compression with slot clearance-to-diameter ratios, c/D, of 0.153, 0.305, and 0.458. The results showed that, for a slenderness, D/t, of 45, the slot buckling strength is 81% of the member's gross yield strength, A_gF_y, when c/D = 0.458. This is shown with the other data points in Figure 4, where c/D = 0.458 corresponds to l_{sl}/t_p = 3 on the horizontal axis. The slenderness of 45 is slightly greater than the limiting width-to-thickness ratio, λ_r, in the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360, **aisc.org/specifications**), Table B4.1a, for members subject to axial compression. In many cases, the 19% reduction is less than the reduction in critical stress due to global flexural buckling of the brace.

A design method for round HSS braces can be developed using the data from Martinez-Saucedo and observing that the local deformation is characterized by two C-shaped patterns around the remaining perimeter that form a partially fixed flexural buckling mode over the slot clearance length. This data indicates that an appropriate effective length for the localized flexural buckling is 0.65*c*. This results in a maximum slot clearance length equal to $0.44t(L_c/r)$, where *t* is the HSS wall thickness and L_c/r is the slenderness ratio of the brace for global flexural buckling.

For rectangular HSS braces subject to compression, the maximum slot clearance length can be calculated by limiting the local buckling strength at the slot to the local buckling strength of the non-slotted portion of the brace. At the non-slotted portion of the brace, the wall is a stiffened element with an infinite length. At the slot, the wall is an unstiffened element with a finite length. When the two buckling strengths are equal, the slot clearance length is 50% of the largest HSS width. This method is conservative because it neglects the reduction in critical stress due to global flexural buckling of the brace.

Slot Width

For standard HSS connections, a slot width $^1/_{16}$ in. wider than the gusset plate is usually adequate. Heavy HSS braces with long slots may require a slot width $^1/_8$ in. wider than the gusset plate. Several fabricators use a slot width $^1/_8$ in. wider than the gusset plate as standard practice for all HSS sizes and slot lengths. The January 2007 Steel Interchange question and answer "HSS Slot Tolerance" (**www.modernsteel.com**) indicates that the kerf width tends to increase the slot width, but the distortion due to thermal cutting can cause the slot to close slightly.



(a)

(b)

Fig. 5.

Welds

Per AWS D1.1: *Structural Welding – Steel* (**www.aws.org**), Section 5.22.1, the weld size should be increased by the erector for any gap exceeding $\frac{1}{16}$ in. Many engineers will oversize the weld to compensate for the gap between the HSS wall and the gusset plate. However, in the design stage, the true gap width is unknown due to shop tolerances on the slot width and the possibility that the brace will be erected with one side of the slot in contact with the plate, causing a large gap on the other side. The best practice is to provide the calculated weld size on the drawings, with no increase for potential gaps. The weld note in Figure 1 can be used to inform the erector of the requirement of AWS D1.1 Section 5.22.1. Although a quality erector will know about this requirement, this note is helpful in conveying the weld design process to the checker, approver, and engineers who may be designing retrofits to the structure.

Erection Aids

The final connection for slotted HSS braces is made by field welding, which requires erection aids to hold the member in place until a significant portion of the welding is complete. Two common erection aids are discussed in the January 2012 article "Structural Steel Erection Aids" (**www.modernsteel.com**). For the connection in Figure 5a, a long bolt or threaded rod passes through shop-fabricated holes in the brace and gusset plate. Oversize holes can be used to provide easier fit-up. For the connection in Figure 5b, the brace rests on a bolt at the bottom of the brace.

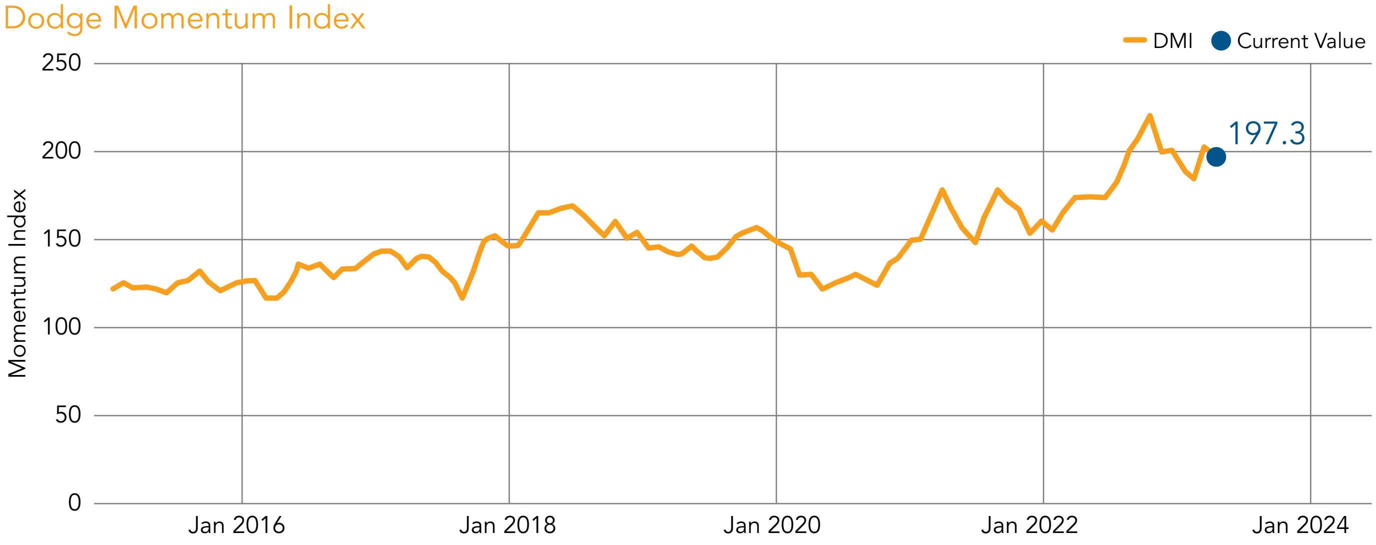
Again, slotted HSS braces provide several benefits, and there's a lot to consider when implementing them as part of a steel framing system. Following the guidance provided here can help ensure that future projects involving these braces will run more smoothly. ■

Bo Dowswell (**bo@arcstructural.com**) is the president of ARC International, LLC, and a frequent contributor to *Modern Steel*'s Steel Interchange.
Carlo Lini (**lini@aisc.org**) is director of AISC's Steel Solution Center.

Insight via Indicators

BY BRIAN RAFF

Keeping an eye on the right economic indicators helps AISC gain a better understanding of the projected construction market—and it can help you too.



IN ORDER TO NAVIGATE the present and predicted future of the steel design and construction industry, AISC relies on many economic indicators.

One of the most important is the Dodge Momentum Index (DMI), which tracks nonresidential building projects going into the planning stage, an indicator that leads construction spending by about 12 months.

How the DMI Works

The DMI is designed to provide insights into the overall health and growth potential of the construction sector in the U.S. Understanding its significance requires looking at its purpose, how it is calculated, and its implications for the construction industry.

1. **Leading Indicator.** The DMI is considered a leading indicator of future construction activity. It tracks the initial planning stages of nonresidential building projects, such as commercial, institutional, and industrial structures. These early-stage projects are often strong indicators of the future demand for construction services and materials.
2. **Project Pipeline.** By measuring the number of projects entering the planning phase, the index provides valuable information on the size and scope of the future construction pipeline. A rising DMI indicates increasing project planning activity, which suggests potential growth in construction spending over the coming months.
3. **Economic Sentiment.** The index reflects the confidence of developers, architects, and other stakeholders in the construction industry. High levels of the DMI signal optimism and positive economic sentiment within the sector, while declining numbers may indicate concerns about economic conditions.
4. **Construction Employment.** As the index reflects the potential future demand for construction projects, it can also influence construction employment. A rising momentum index may lead to increased hiring within the construction industry to meet the anticipated demand.
5. **Materials and Labor Demand.** The index's predictive nature can impact the demand for construction materials and labor. When the momentum index is high, contractors and suppliers may experience increased demand, potentially leading to changes in material costs and labor rates.
6. **Business Planning and Investment.** Construction firms, suppliers, and other industry players use the DMI as a valuable tool for strategic planning and investment decisions. It helps them gauge market conditions, assess future opportunities, and allocate resources effectively.
7. **Economic Indicator.** The DMI offers insights to economists, policymakers, and analysts studying the overall health of the economy. As construction is a significant sector that influences various other industries, trends in construction activity can reflect broader economic trends.
8. **Regional Variations.** The DMI can also shed light on regional variations in construction activity. Different areas may experience distinct economic conditions, and tracking the momentum index can help identify areas with higher growth potential.

9. **Real Estate Market.** The DMI can influence the real estate market. Commercial real estate developers and investors often refer to the index to understand potential future supply levels and plan their investment strategies accordingly.

Current Outlook

The DMI itself factors in all of these considerations and is represented as a number. So what is the current number? According to the most recent data, the DMI declined 2.5% in June to 197.3 (for some perspective, the overall DMI in 2000 was 100) from the revised May reading of 202.4. Dodge suggests avoiding "looking at any one given period or month as a discrete element. The value in the DMI is reflected as a trend over time, serving as a leading indicator for nonresidential building activity." Over the past year, the DMI has been chaotic, which could indicate that the nonresidential construction market will follow suit for the next year.

"A deceleration in institutional planning caused the Momentum Index to decrease in June," said Sarah Martin, associate director of forecasting for Dodge Construction Network. "Project activity in this segment pulled back from the robust highs of the last three months but continued to dwarf year-ago levels. In contrast, growth in the commercial segment may be fleeting, as the continued elevation in interest rates and increasingly tight lending standards weigh down the sector in the latter half of the year."

Commercial planning in June remained afloat alongside an uptick in data center and hotel planning projects. Institutional planning, on the other hand, was driven lower by a decrease in education and healthcare activity. Year over year, the DMI remains 25% higher than in June 2022. The commercial and institutional components were up 17% and 39%, respectively.

The DMI plays a valuable role in providing data-driven insights into the construction industry's future prospects and offers valuable signals about the overall direction of the construction sector. DMI and other economic data is available via AISC's Structural Steel Specialists, who offer complimentary data briefings for architects, engineers, and others in the industry. Contact your local Specialist (check out **aisc.org/steelspecialists**) to learn more about market trends in your specific region. ■

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

Learning to Lead

INTERVIEW BY GEOFF WEISENBERGER

Ruby+Associates' president and CEO Tricia Ruby didn't expect to work for the firm her father started. But now she runs it, complementing its engineering expertise with her business and leadership know-how.

WHEN TRICIA RUBY decided to go to Purdue University, which is well-known for its engineering program, she went with the explicit intent of not being an engineer.

Her plan didn't go so well, and she eventually ended up graduating with a degree in industrial engineering.

She also didn't intend to ever work for her father, Dave Ruby, the founder of one of the country's top structural engineering firms, Ruby+Associates.

That plan also didn't quite work out, and she eventually went to work for her father—and now she runs the company. And she loves it.

Funny how when things don't go according to plan, they sometimes end up working out for the best.

In a recent conversation with Tricia, we discussed her management philosophy, how math has been a constant theme in her life, what it's like working with her father, and more.

What did you want to be when you were growing up?

I dreamt of being an Olympic sprinter and a soccer player—not really a career path that was available to me. And I loved math, but I didn't think a lot about the "What do you want to be?" question. I remember when I was a senior in high school, and that's when that question started coming up, and I was like, oh, am I supposed to know that? I thought that was really overwhelming. I remember thinking that I wasn't going to be an engineer. I wasn't going to be my dad. I was going to be the opposite, whatever that was. I actually went to Purdue to *not* be an engineer. I got accepted to the liberal arts college. I had no idea what I was going to be and, of course, I was going to the university that graduates the most engineers in the country, which I maybe didn't really realize at the time. And I asked my dad, "Why did you send me off to this university that graduates so many engineers knowing I wasn't planning to be an engineer"? And he said, "Well, I knew you'd come around." His approach was never "Thou shalt be an engineer." I think he knew that probably wouldn't have been the right strategy, but he knew I loved math. And he told me, "You always asked, 'Why?' every time I helped you with homework. You didn't want to just know the answer; you wanted to know *why* it was the answer. That's how engineers think." Math was my favorite subject for my entire life—like I would make up long division problems as a kid. I didn't have a math class my first semester in college, and it almost broke me. I went to my counselor about three weeks in and told him I didn't know what to do without a math class, but I was already taking too many credits, and I couldn't get into a math class until the following semester. So that's what started me on the path to transferring into engineering. I ended up studying industrial engineering, and I was interested in human factors engineering. I'm left-handed, and the world isn't designed for left-handed people. And so the whole idea of human factors and how design affects different people was really what got me interested in industrial engineering.

And industrial engineering is focused really on manufacturing. I love manufacturing and was a manufacturing engineer

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**.

after graduation. Now, when I talk to fabricators, they're manufacturers, so I feel totally at home visiting clients in a fab shop. I love the smell and look of a plant. I feel at home there.

I'm wondering if any time you walk into a fabrication shop, you start thinking about how you would lay it out.

That's definitely how my brain works. It's how I think when I walk up to a buffet. I think about the flow of people and how they can most efficiently be moved along. I do the same thing at airports. I think about that kind of thing everywhere I go. If I'm in a fab shop, I'm looking at the flow of material and the inventory and the process—I can't get that kind of thinking out of my brain.

Everything, everywhere you go sort of becomes a challenge or a problem to solve! So when did you eventually go to work for your dad at Ruby+Associates?

I didn't think I'd ever work at Ruby+Associates. The company experienced an embezzlement back in the early 2000s. I was staying at home with my first child at the time, and I offered to come home to the Detroit area to help my dad for a couple of weeks. I was living in Atlanta at the time, and I came back pretty much over the Christmas holiday, so that was very convenient, and we were planning on being back here anyway.

I started helping at the company, and probably a month later, I realized that this was going to be the next phase of my life. And I felt like all of my experience in my previous jobs as an industrial engineer really helped prepare me for what I'm doing now in terms of big-picture thinking. I was always a very keenly aware employee, and I always wanted to be a decision-maker. So in any situation that I'm in, I don't feel like it just happened to be that way. Whatever situation you're in is because decisions were made by people for it to be that way. Somebody decided that the chair you're sitting on needed to be a certain way. Somebody decided on the paint color of the hotel room. And I've always thought that if I could be in the room making decisions, then that's where I ultimately wanted to be.

And when it comes to running a company, all of your decisions affect your employees, and I've always been mindful of that. I like to stick to a very employee-centric decision-making process. If it's something that's better for them, then it's better for the company.

I think that's a good management style. Speaking of which, you're now the president and CEO of Ruby+Associates. What has been the most pleasant surprise about working for a company that your dad started?

There are a couple of things, but the first is just getting to experience my dad from a different perspective. Before I started working here, he was my dad. He was my soccer coach, he was the guy that helped me with my homework, and he was always my biggest cheerleader. Whenever I did poorly on an exam in college, I'd call him, and he'd tell me, "You're going to be fine." He was always very encouraging. But it really wasn't until I started working with him that I realized what an incredible background and résumé he has. Whenever we moved when I was a child, it was always aligned with his career. For example, we came to Chicago, where he worked on the John Hancock and Sears Tower. As a kid, I didn't really get how iconic that was, and I didn't truly appreciate it until I started working with him.

And the other really pleasant surprise, now that I've taken over Ruby, is how much he's trusted me with the company. You'll hear a lot of nightmares of founders that won't go away, or they'll create roadblocks or they'll undermine the next generation, and my dad just hasn't been that guy. He's one of my best employees. He recognized that I bring a different perspective. Obviously, I'm not a structural engineer, but I have a much better business mind, and he really appreciates that and values it and sees the benefits of it.

That sounds like a good, healthy working relationship. How long have you been the president and CEO of Ruby? And what was your first day like in that role?

I've been leading as president and CEO since 2011, but I didn't want the CEO title right away. And a year later, everyone was, like, alright, Tricia, you have to take the title, so I did. And I think that I wanted that year without the title because I was really unsure of the acceptance that I would get as a non-structural engineer. I had the support of our leadership team, but I was really self-conscious about not having that pedigree. I remember going to an ACEC (American Council of Engineering Companies) meeting, and I'd say, "Well, we're a structural engineering firm, but I'm not a structural engineer," and one of the first people I talked to basically said, "Just so you know, none of us practice anymore. If you're a leader at a larger engineering firm, you're most likely not doing that much design work anymore since there's too much to do on the leadership side." So that made me feel a lot better. Still, I remember feeling like I had a big target on my back—but I think I'm the one who put that target there. I've had nothing but total support from everyone else.

There are a lot of articles out there about leadership, and I feel like courage isn't mentioned nearly enough. If you're putting yourself out there and making decisions every single day, you hope they're the right ones or at least the right ones for what you think is best at that moment. And I think having the courage to put yourself out there is important—the courage to ask for feedback and also the courage to change course if something isn't working. I had an HR consultant friend, and she said those words to me: Leadership takes courage. And when she said that, it changed my entire perspective on what it would take to lead this firm. It's such a simple concept, but I think it's something that I really took to heart and truly believe in. ■

This conversation was excerpted from my conversation with Tricia. To hear more from her, including her thoughts on Detroit, parenting, mentoring, volunteer work, and more, check out the September 2023 Field Notes podcast at ***modernsteel.com/podcasts****.*

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

Reviewing the Action

BY JAKE MAZULEWICZ, PHD

Want to build your team's trust—and expertise? Consider after-action reviews.

DO YOU LEAD your team to learn primarily from successes or from failures?

Many leaders argue that their teams are just too busy to spend time discussing why a successful project went well. They just wrap things up quickly, then dive into the next project.

In these cases, the unspoken insights and unwritten lessons learned from that project rarely ever get shared or discussed. Often, they just get forgotten in the frenzy of working on project after project.

Would you hire an engineer to build a bridge if all that engineer ever studied was how bridges collapse? Would you hire a recruiter to find you a job if all that recruiter ever studied was how people get fired?

The best leaders help their teams learn regularly from their successes, not just occasionally from their failures.

But learning from success happens automatically… doesn't it?

After Action Reviews

Soldiers perform complex, dynamic, often dangerous missions. And they want to learn as much as they can from each one. In the 1980s, leaders in the U.S. Army realized that they needed a practical way to help soldiers share the unspoken insights and unwritten lessons they learned from their missions. They realized that sharing tribal knowledge and applying tacit skills were key to completing their objectives successfully. And since it was the Army, they developed a process—a non-punitive, semi-structured, post-job team debrief called an after-action review (AAR).

AARs have proven so wildly effective that every branch of the military now uses them. And for some units like flight crews and Special Operations Forces, AARs are almost a religion, being referred to as one of the most successful organizational learning methods yet devised.

The Right Questions in the Right Order

The process of leading a basic AAR is simple. Soon after your team completes a project, gather them in a private space for about 30 minutes, and ask these four questions:

1. What did we set out to do?
2. What did we actually do?
3. How did it turn out the way it did?
4. What will we do differently next time?

The order is important. Have you ever had a discussion degenerate into a fact-free "war of opinions?" That's the fate you'll suffer if you start a debrief by asking for opinions. True, questions 3 and 4 are subjective and do indeed ask for opinions. But notice that questions 1 and 2 are much more fact-based. It may seem silly to ask, "What did we intend to do in this job?" But different people have different goals for the same job. The accountant on your team may have intended to maximize revenue. The safety specialist on your team may have intended to reduce the risk of injuries. The team leader may have wanted to finish the job ahead of schedule and under budget. So always start your AARs by obtaining facts with questions 1 and 2 before then gathering opinions with questions 3 and 4.

Now consider this question: "What went well, and what went badly?" This may seem like a great question for a debrief. After all, it cuts straight to the point, right? Here's the problem: This question nudges us to discuss blame, not improvements. And blame stops learning in its tracks. Look at the four AAR questions. There's no hint of fault, failure, or blame in any of them. That's intentional. AARs focus on learning, not blame. Make sure you maintain that focus with every AAR you lead.

Soldiers are fond of sayings like, "No mission plan ever survives contact with reality," or "The planning is more valuable than the plan." And in reality, the percentage of complex missions that go exactly according to plan is nearly 0%. Soldiers and other experts in complex, dynamic systems know that in any given job, there's always a gap between what we plan to do and what we actually do. Notice how question 1 asks about the plan. Some call this "work as imagined." Question 2 asks about the actual job. Some call this "work as done." When you lead your AAR, use questions 1 and 2 to explore this critical gap but not eliminate it.

Three Common Mistakes and How to Avoid Them

1. **Successes vs. Failures.** Some leaders do AARs only for accidents or errors. If you do that, your team will quickly associate AARs with failure. And they'll give short, vague answers to get it over with as fast as possible. So, lead about 80% or more of your AARs for successful projects. That way, your team will learn to trust the process and value the results.
2. **Now vs. Later.** Unspoken insights and lessons learned are the most valuable things a team can discuss in an AAR. Those unspoken ideas have a half-life of hours or less. So if you wait a day or more to lead your AAR, much of the priceless, unspoken wisdom will already have been lost, perhaps forever. As such, you should lead the AAR as soon as the project wraps up.
3. **Leader vs. Facilitator.** Most leaders like to answer questions. Usually, that's a good thing. But not in an AAR. If you give in to the temptation to answer the questions, you'll shut your team down until the only person talking is you. So in an AAR, remember that the leader should be the person who talks the least. Choose your AAR leaders accordingly.

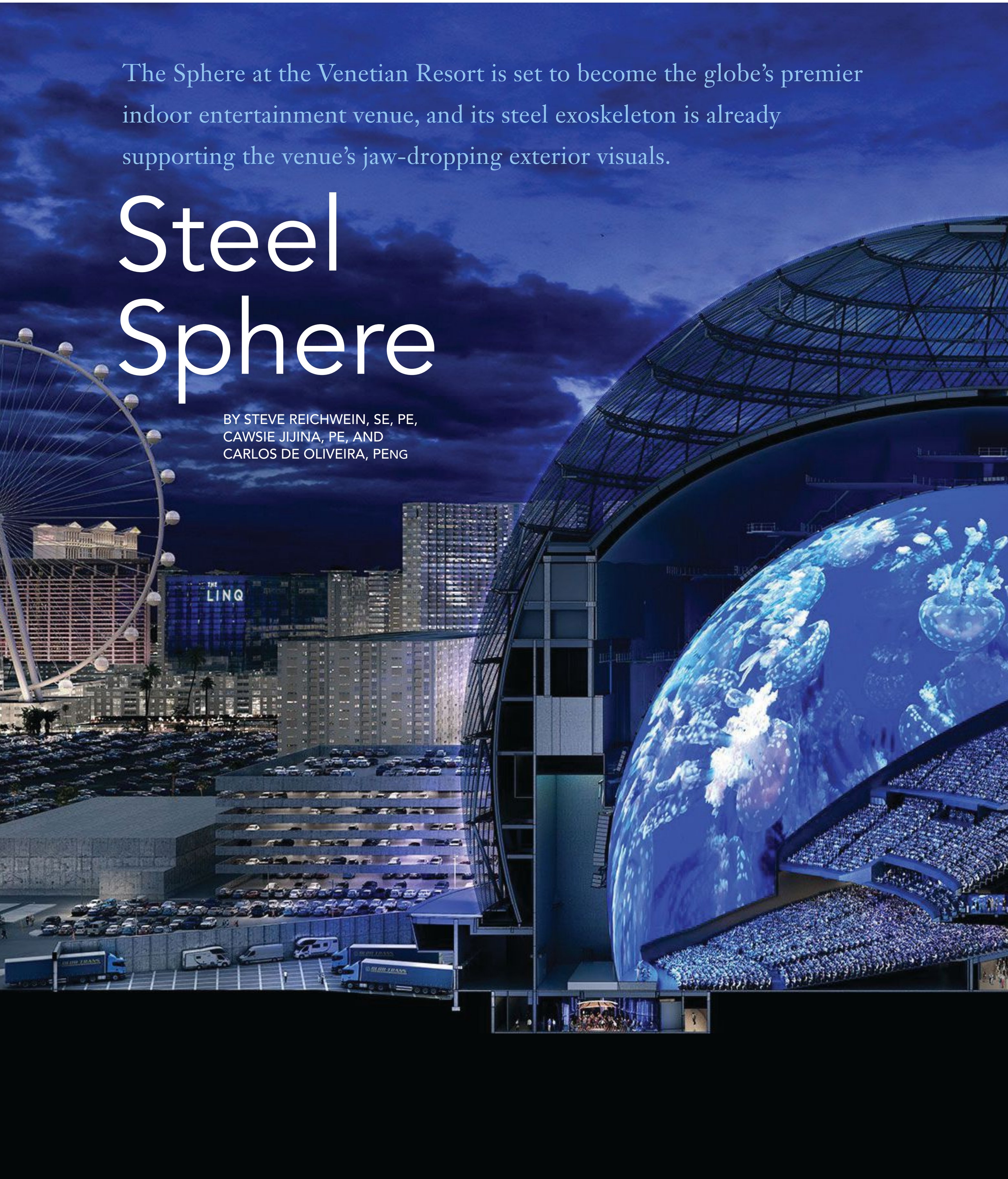
If you want a low-cost, low-risk way to build trust and expertise on your team, you will likely never find a more practical method than leading AARs. If the Army has used them for 40+ years, just imagine what kind of value they could create for your team. ■

Jake Mazulewicz shows leaders in high-hazard industries why errors are signals, not failures, and how to address the deeper problems so everyone can work more reliably and safely. He has a decade of experience in electrical utility safety and has served as a firefighter, EMT, and a military paratrooper. To learn more, visit **www.reliableorg.com**.

The Sphere at the Venetian Resort is set to become the globe's premier indoor entertainment venue, and its steel exoskeleton is already supporting the venue's jaw-dropping exterior visuals.

Steel Sphere

BY STEVE REICHWEIN, SE, PE, CAWSIE JIJINA, PE, AND CARLOS DE OLIVEIRA, PENG



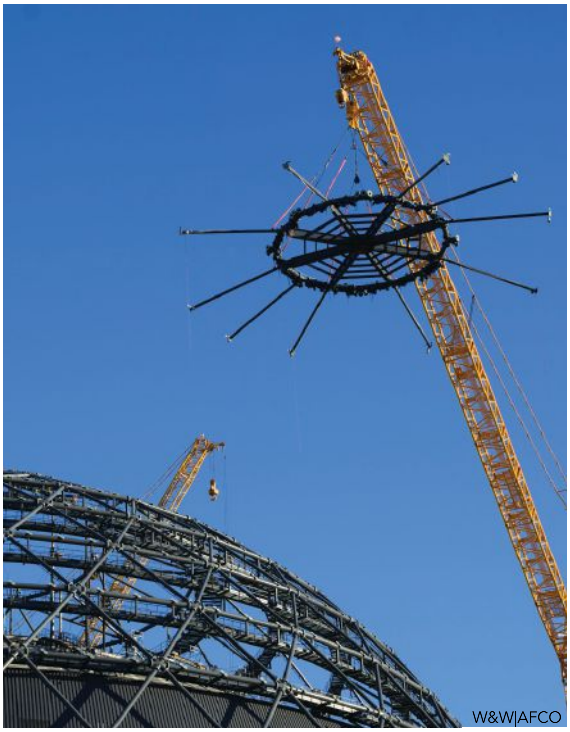
Sphere Entertainment Co.

A cross section of the MSG Sphere at the Venetian.

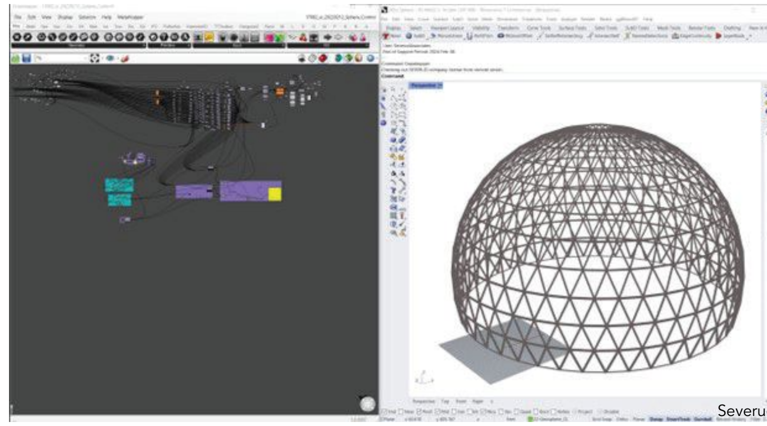
LAS VEGAS' SPHERE at the Venetian Resort isn't just eye-catching—although it *defines* eye-catching—but rather is a feast for all the senses.

Located just east of the Sands Expo and Convention Center, which is set south of Sands Avenue and east of Las Vegas Boulevard, this immersive-experience performance venue has the capacity to entertain a seated audience of up to 18,500. Not only does it feature the largest and highest-resolution LED screen in the world, but it also includes 164,000 speakers and 4D features, including scent and wind. And the exterior is wrapped in 580,000-sq.-ft of programmable lighting.

With approximately 606,000 sq. ft of area encapsulated in a 515-ft-diameter, 325-ft-tall semi-spherical enclosure, the venue is divided into several distinct structural portions: a foundation system composed of drilled shaft piles socketed into cast-in-place concrete caps interconnected by a grid of grade/tie beams (where necessary); the ground-level slab-on-grade, stadia bowl, and main venue superstructure; four cast-in-place concrete shear wall cores and a proscenium shear wall founded on mat foundations supported on piles; a one-story cast-in-place concrete "collar" structure coiling around the southern quadrant of the exoskeleton; the dome roof arch system that supports the 160,000-sq.-ft spheroidal immersive LED display plane; a grillage system that's hung from the roof and supports the media plane, catwalk system, and A/V equipment; a two-story bridge/service Building to the south; and the geosphere exoskeleton that's known as the "Exosphere." Although labeled as distinct structural systems, they all act together to form a cohesive, balanced, elegant, and efficient superstructure, which significantly benefits the overall structural performance of the project. Additionally, a 1,200-ft-long serpentine pedestrian bridge, which is framed with steel box trusses supporting a slab-on-metal-deck walking surface and a metal deck roof above that follows Sands Avenue connects the new venue to the Sands Convention Center. The structure is framed with 28,000 tons of steel fabricated and installed by W&W|AFCO Steel. Originally scheduled to open in 2021, the project, like many others, was delayed by the COVID pandemic but is now scheduled to open by the end of September.



W&W|AFCO

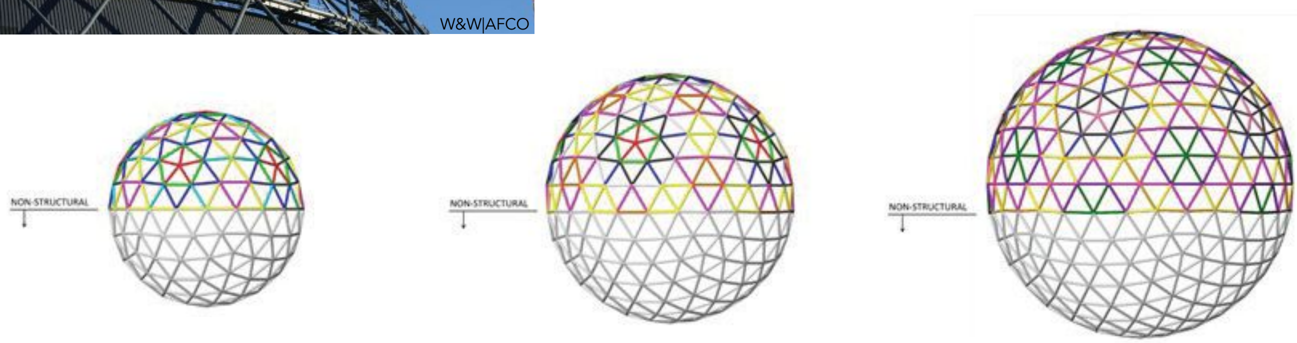


Severud

above: The parametric algorithm of the Exosphere.

left: The Oculus assembly being set.

below: Traditional geodesic spheres optimized for various sizes.



diameter 240 ft – 320 ft

FREQUENCY 4			
piece count types	480 6	node count types	150 8

CAPACITY—up to 7,500

diameter 320 ft – 410 ft

FREQUENCY 5			
piece count types	750 9	node count types	240 10

CAPACITY—up to 7,500–15,500

diameter 410 ft – 480 ft

FREQUENCY 6			
piece count types	1,080 9	node count types	350 12

CAPACITY—up to 15,500–18,000

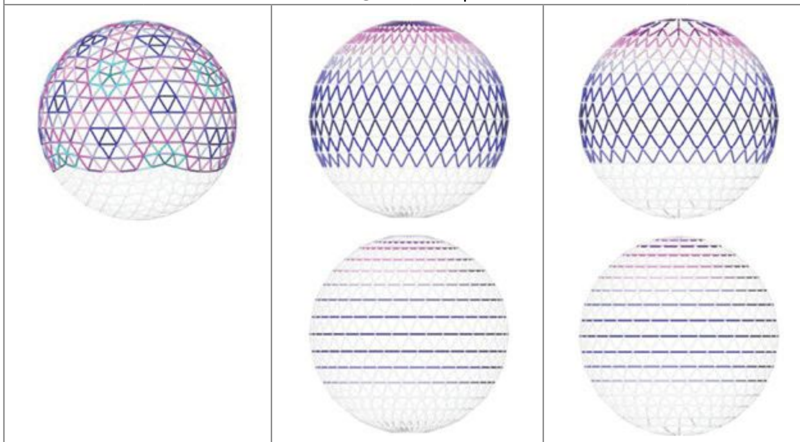
Severud

A Parametric Structural Genome

Access to relevant data is essential for high-quality, fact-based decision making. While engineers have always approached their work in this manner, the modern project workflow has brought about a specific, significant change. Client expectations have grown beyond the concept of a "final" deliverable to now include a continuous influx of data upon which they base key business decisions. Engineers are now purveyors of data just as much as they are consumers of it. In the field of structural engineering, the potential data includes, but is not limited to, the structural steel tonnage associated with various framing configurations, economies of scale projections for repetitive connection types, or the relationship between steel tonnage and occupancy comfort for various serviceability considerations. The relevant data varies for each project. Due to technological advancements within the last decade, however, engineers have a powerful tool to use in all situations to meet the ever-growing demand for data: parametric algorithmic design, a process through which engineers can acquire the data most useful to clients in an efficient manner. Depending on the complexity of the problem, engineers can automate millions of simulations, process data, and have presentation-ready graphics in a matter of hours (for more on the parametric design and optimization of steel structures, see "Evolutionary Optimization" in the December 2021 issue, available at **www.modernsteel.com**).

With regard to the Sphere, the engineering team implemented parametric design early in the design process to help make informed decisions. It's not very often that structural engineers get an open canvas to optimize their structures fully, so this was a great opportunity to do so. While the size of the Sphere was essentially a given, the framing arrangement was free for optimization. To start, the engineering team at Severud looked at more traditional geodesic sphere geometric configurations, following the blueprint laid out by Buckminster Fuller in the early 1900s. Using a computational algorithm, the team optimized various sphere sizes with

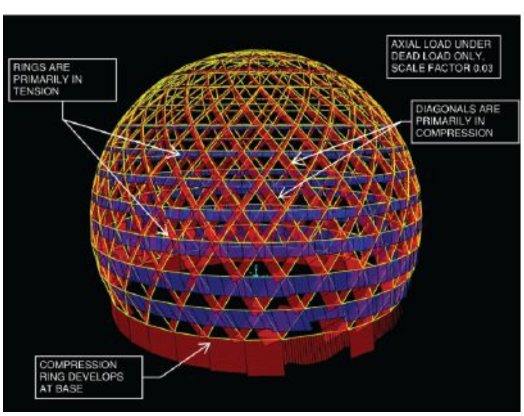
Design Examples						
	GEODESIC		GEODESIC (GRID)		HYBRID (SYMM)	
	w/o APEX	w/ APEX	w/o APEX	w/ APEX	w/o APEX	w/ APEX
tons	2,100	3,500	2,400	3,600	2,600	3,900
count types	1,270 13		1,730 16		1,410 18	
count types	492 14		612 9		416 11	

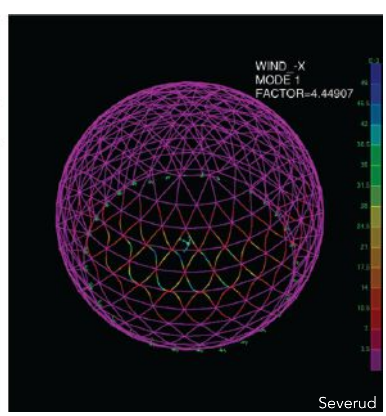


Severud

above: A comparison of the various structural meshes considered in the optimization process.

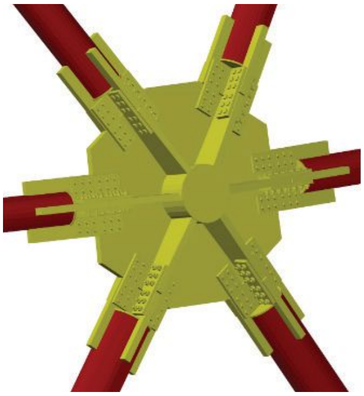
below: Results of the advanced structural analysis and performance.



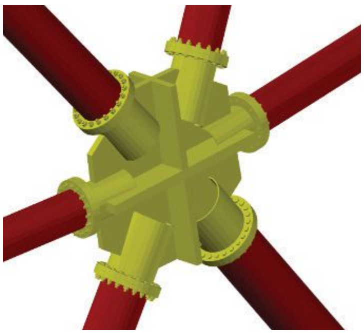


Severud

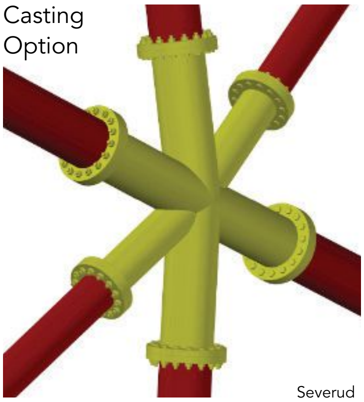
Fabricated Gusset—Option 01



Fabricated Gusset—Option 02



Casting Option



Severud

The Final "Three" node options that were considered.

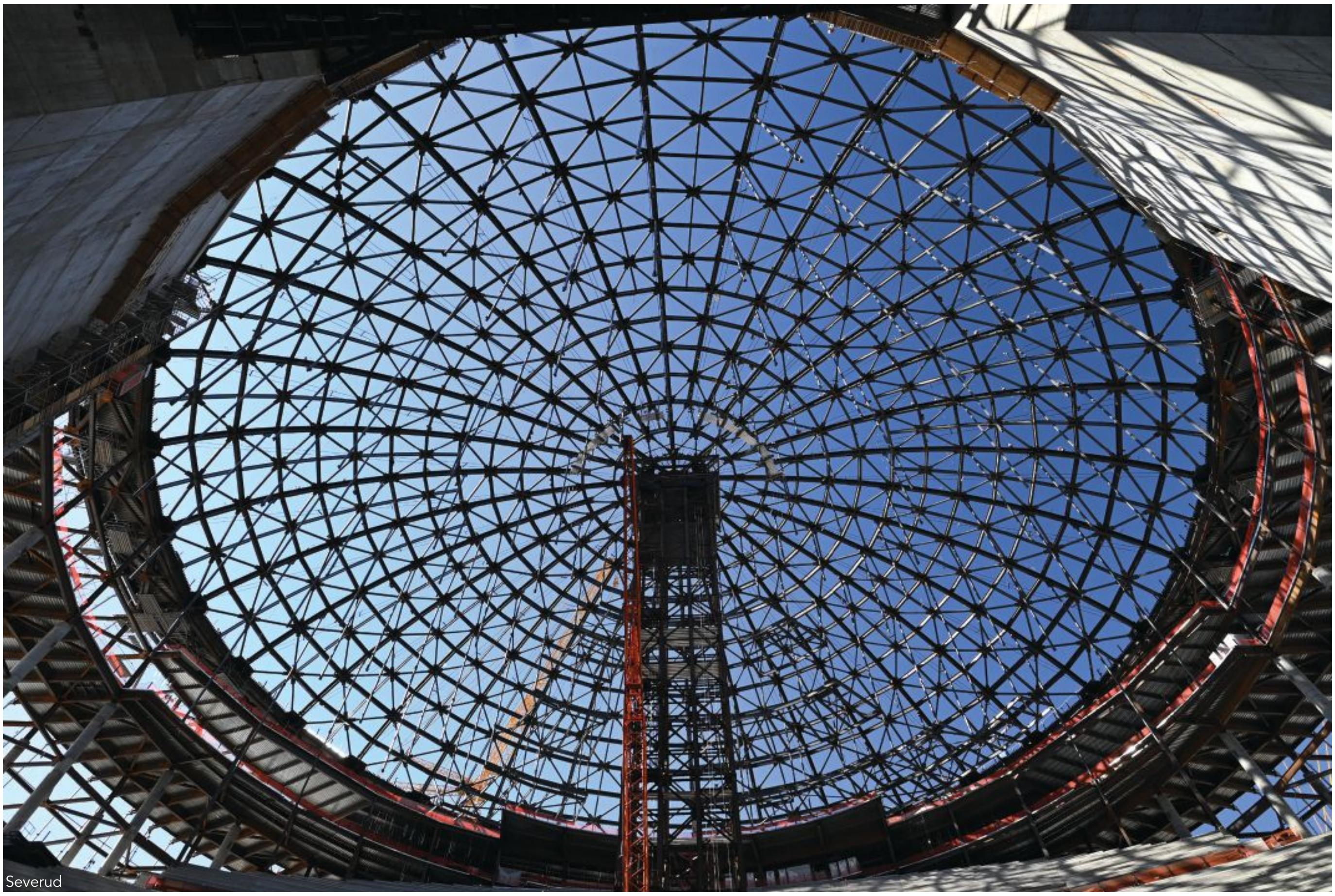
respect to the frequency of tessellations of the icosahedron.

Once the results of the traditional geodesic sphere structures were cataloged, the team began holding conversations regarding fabrication and erection with W&W|AFCO Steel. This open dialog early in the process enabled informed decisions through the incorporation of realistic fabrication and erection considerations and costs into the optimization functions. The outcome of this effort was a more constructable spherical geometry consisting of defined latitudinal rings and longitudinal diagonals (a geodesic grid): the Exosphere. After factoring in costs, economies of scale, constructability, and tolerances, the team concluded that although the finalized Exosphere weighed more than a traditional geodesic sphere design—its framing accounted for 5,000 tons of the 28,000 tons of total steel used in the project—it would cost less and would be more readily fabricated and erected.

With the framing geometry of the Exosphere settled, the next task was to complete a more thorough structural analysis. Creating a long-span grid shell structure such as this one warranted second-order non-linear buckling analysis. To conduct this analysis, Severud exported the refined model into SAP2000 to perform the more advanced analyses; member sizes were further refined until the desired behavior and structural performance was achieved.

Choosing the Right Node

Once the advanced analysis of the Exosphere was completed, the design team could now consider the nodes and member connections. Several options for the nodes were developed, all of which were discussed with W&W|AFCO and the project's owner, Sphere Entertainment Company. In the end, three node types were compared in granular detail and fully resolved, complete with plate thicknesses, weld sizes, and bolt quantities. This allowed W&W|AFCO to provide detailed fabrication and erection estimates for each approach, with casting manufacturer Cast Connex providing detailed conceptualization and costs for the



above: A view of the domed roof framing and compression ring from inside the structure.

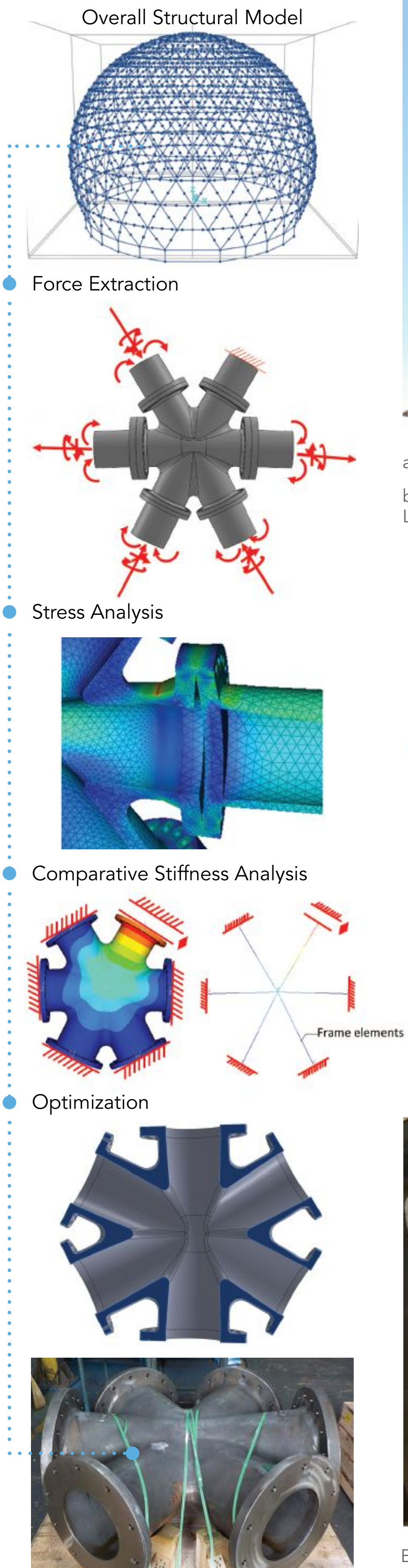
below: The two principal drivers of the Exosphere's design are the angular geometry provided by the nodes and the lengths of the members that frame between the nodes.

cast steel node option. This comparative analysis showed that casting the nodal connections of the Exosphere offered significant technical advantages over conventionally fabricated nodes, including material optimization, improved tolerances, and reduced construction risk.

First, from a material optimization perspective, casting the nodes allowed for more efficient use of material, enabling connection material to be positioned only where it was necessary from a strength, stiffness, and serviceability perspective. The result was a weight savings of more than 40% when compared to the two considered fabricated node options, along with a four- to six-times reduction in the number of bolts required between the fabricated gusset option (which relied upon lap spliced connections to the tubular members) and the cast node option (which made use of end plate connections). The cast nodes also had one-quarter of the surface area of the fabricated nodes, which offered significant savings in coating costs (the exterior steel is protected by a three-part high-performance weatherproof coating).

Another significant advantage offered by the cast node option was related to manufacturing tolerances. The primary structural system of the Exosphere is comprised of straight lengths of API Pipe and round hollow structural section (HSS) members that frame between the nodes. As such, the two principal drivers of the Exosphere's geometry are the angular geometry provided by

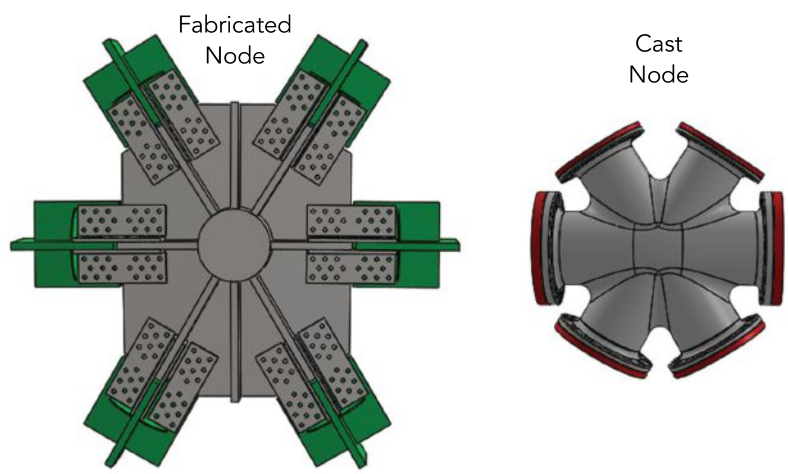
Cast steel node design and optimization.



All images this page except as otherwise noted: Cast Connex

above: A steel-framed pedestrian bridge connects the Sphere to the Sands Convention Center.

below: A direct comparison between fabricated and cast nodes engineered for Exosphere Latitude 3.

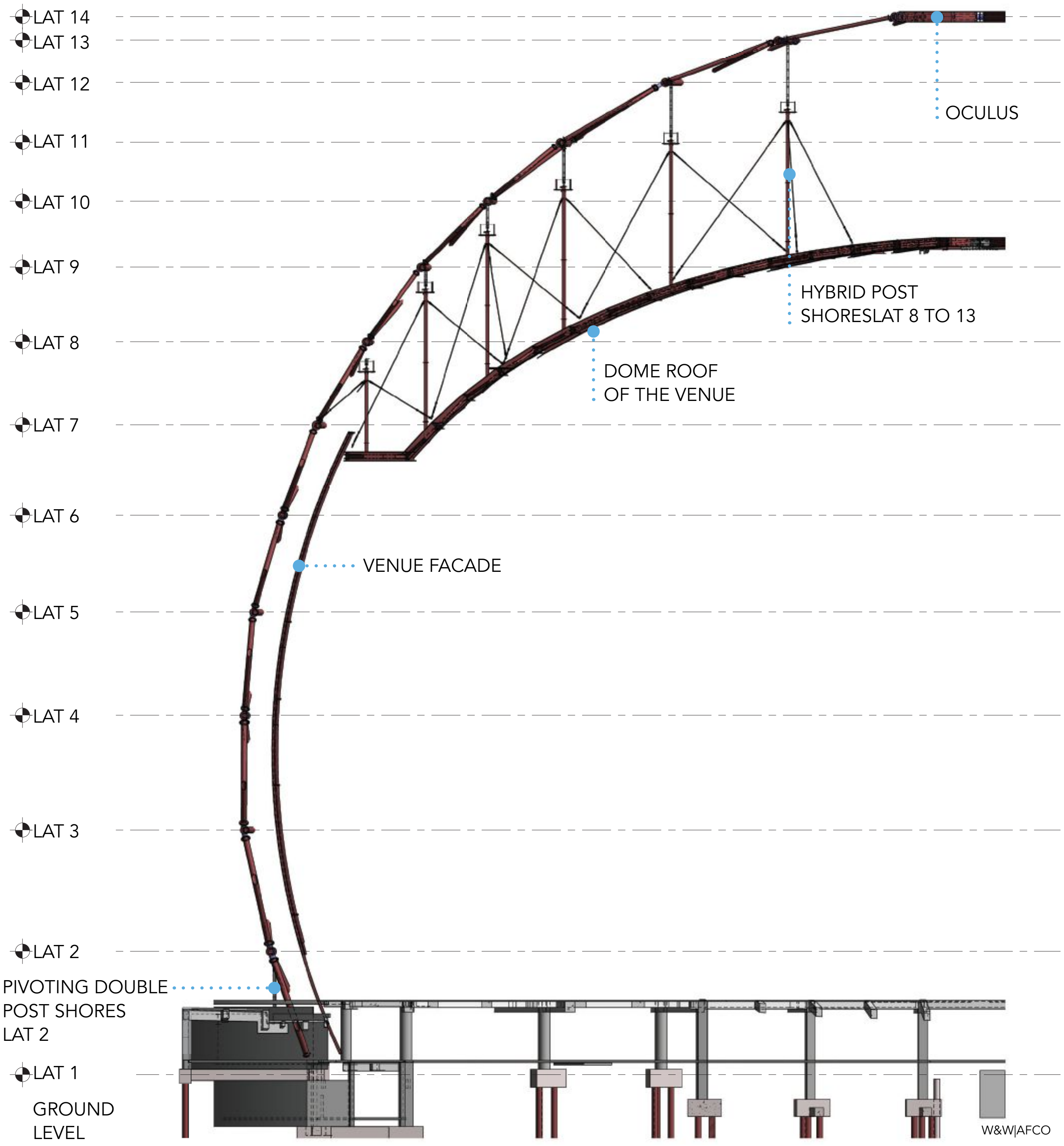


Fabricated Node		Cast Node
12.8 Tons	Tonnage	5.6 Tons
432	Bolts	104
350 ft^2	Coatings	86 ft^2
As-Fabricated	Tolerances	CNC-Precision

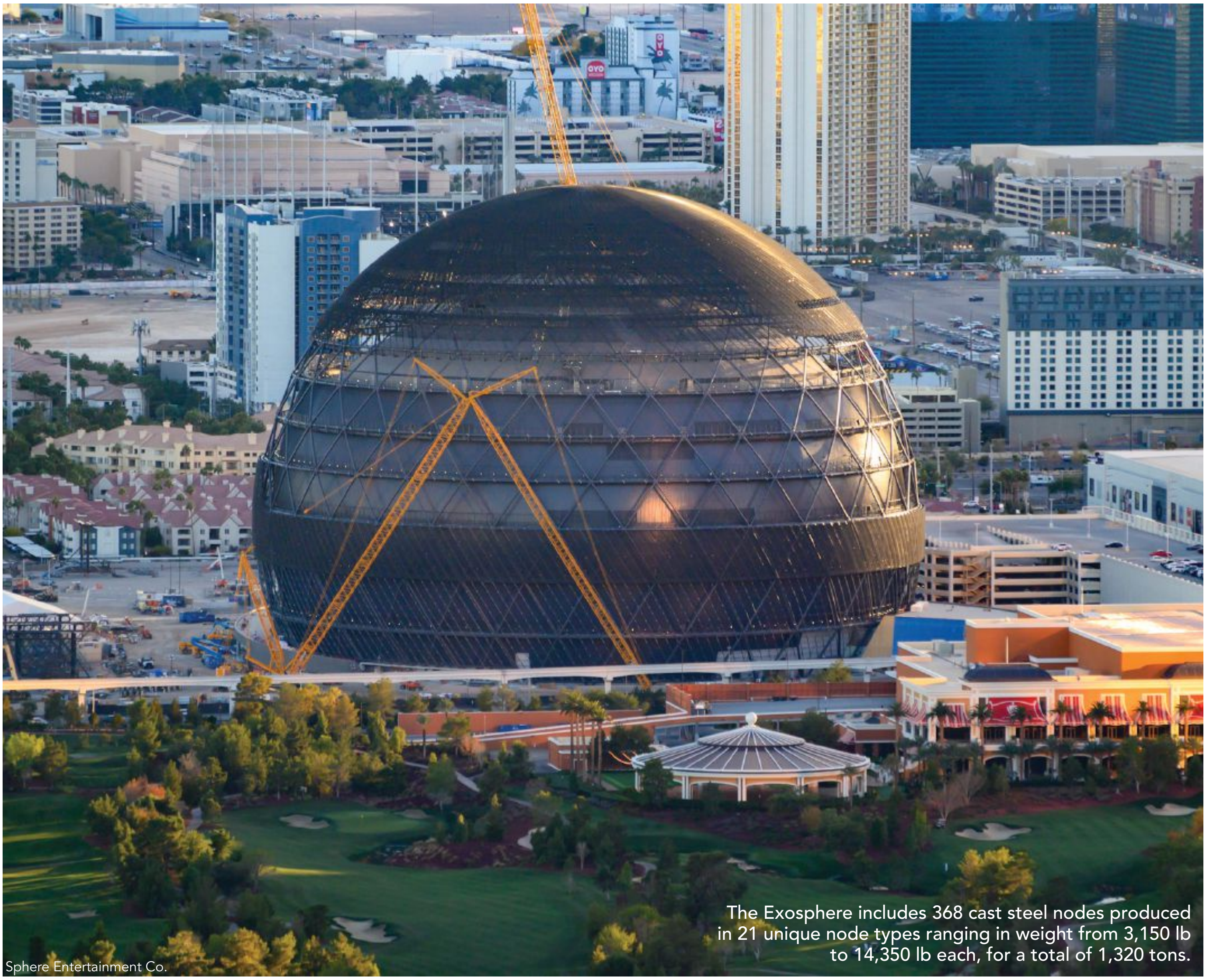
Erector-friendly features incorporated into the cast nodes included “up” arrows for rapid bent assemblits and metrology marks to aid in geometric control and monitoring during construction.

the nodes and the lengths of the members that frame between the nodes. In grid shell structures like the Exosphere, small variations in connection angles or member lengths quickly accumulate and can cause significant deviation away from the targeted geometric form. The fabricated nodes featured large, multi-pass welds that would require significant heat input over multiple welding cycles, which would have resulted in distortion that would have been very difficult to control.

Conversely, the cast nodes designed by Cast Connex incorporated CNC-machining of the end connection faces to a precise canted angle and with each bolt hole precisely located relative to its theoretical spatial position. As such, the tolerances of the cast node option were far more consistent and over an order of magnitude more precise than could have been achieved with the fabricated nodes. This, in conjunction with the ability to use shim plates between the end faces of the nodes and the end plates of



Key elements of the sphere construction, including the various "lats."



The Exosphere includes 368 cast steel nodes produced in 21 unique node types ranging in weight from 3,150 lb to 14,350 lb each, for a total of 1,320 tons.

the Exosphere members, ensured an ability to control geometry during erection. With these advantages, the cast node option was considered to provide a substantial risk reduction for the project relative to the conventionally fabricated nodes. All told, the Exosphere includes 368 cast steel nodes produced in 21 unique node types ranging in weight from 3,150 lb to 14,350 lb for a total of 1,320 tons.

Erection Planning and Construction

One of the benefits of the final geometry chosen for the Exosphere was that it had a full horizontal ring of steel at each latitude. Analysis of the various staged construction approaches showed that once a full ring was completed, that ring and the completed structure below it were very stable and did not require any shoring or temporary support. The plan was to build the sphere one latitude (referred to as lats) at a time, starting at the ground level and ending at the very top center, referred to as the Oculus.

The Exosphere base was a fabricated steel double-pipe node that was anchored to the pile cap with anchor bolts and a shear key. Once fully anchored, the base node provided plenty of strength to start erecting the diagonal pipes that would support Lat 2.

A staged construction analysis was conducted during the design phase to ensure that the diagonals could cantilever temporarily

The sphere base was a fabricated steel double-pipe node that was anchored to the pile cap with anchor bolts and a shear key.

The high-definition exterior LED screen has been dazzling guests even before the venue's opening.

off a completed ring below while waiting for the top ring to be completed. In general, the sequence for the erection of the Exosphere followed suit, where a latitudinal ring would be complete and a set of diagonals would temporarily cantilever to install the next ring above. Minimal temporary shoring off of the venue dome roof below was required in order to control geometry for the more horizontal diagonals exhibiting more of a straight beam cantilever.

The compression oculus was installed as one single piece, and its erection celebrated the topping out milestone for the primary structure of the exosphere. Once the oculus was installed, erection of the mega-panels for the exterior LED screen, known as the trellis, could commence; these panels contain the trellis substructure as well as the fully attached LED system.

Geometry Control

The Exosphere was detailed and fabricated to the ideal design, and all HSS pieces were fabricated short at each end by design and were sent with shim packs to allow for field adjustment of the total HSS length. Staged construction analysis suggested that the final constructed shape could be improved by cambering the sphere, and this was achieved by intentionally shortening or lengthening the HSS members (via the shims) in such a way that the finished

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17. **Square Tube** — INSIDE DIA. — 24" x $\frac{1}{2}$" Tube
18. **Rectangular Tube The Easy Way (Y-Y Axis)** — INSIDE DIA. — 20" x 12" x $\frac{5}{8}$" Tube
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Images this spread: Sphere Entertainment Co.

Lat would be built to a target other than the detailed geometry. As additional lats were constructed, the previous lats would slowly deflect toward the detailed geometry.

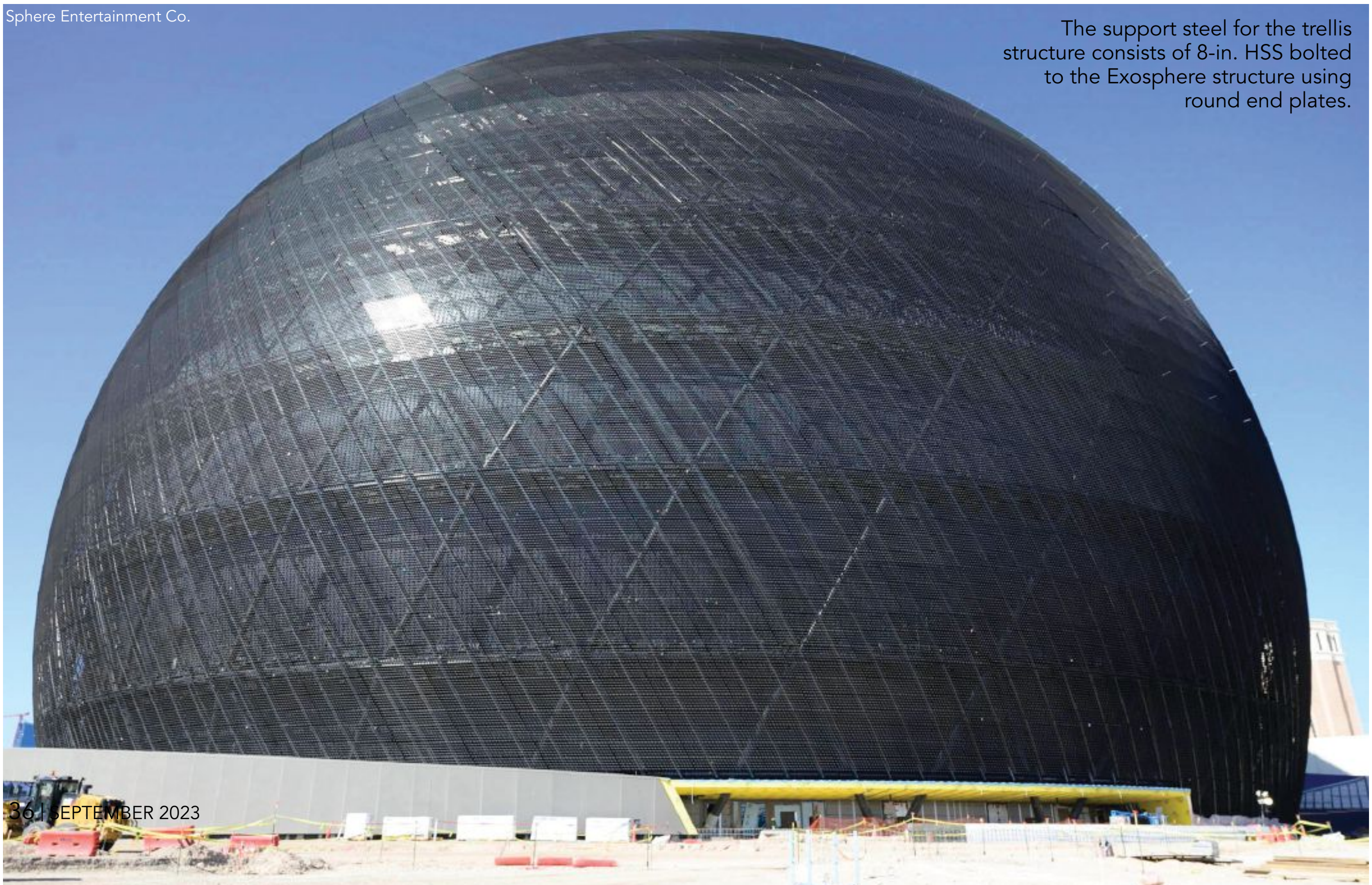
By design, the goal at completion was for the Exosphere's geometry to generally be within 2 in. of the target geometry and for out-of-tolerance between any two adjacent nodes to be less than L/500. By the time the Exosphere was complete, there were only a handful of conditions that exceeded these tolerances, and these deviations from target geometry were carefully reviewed for any structural concerns. Keeping deformations in tolerance was important not only for the Exosphere structure itself but also for the trellis structure attaching to the Exosphere, as deformations would have a direct impact on the trellis connections and could potentially cause LED pucks for the exterior screen to be too far apart, resulting in unwanted lines in the LED picture.

Let There Be LED

After the primary Exosphere structure was completed, the next step was to erect all the steel that would ultimately support the LED light bars that allow the entire structure to become one giant, spherical TV screen. The support steel for the trellis consists of 8-in. HSS bolted to the Exosphere structure using round end


Sphere Entertainment Co.

The Exosphere's framing incorporates more than 5,000 tons of structural steel in all.


Sphere Entertainment Co.

The support steel for the trellis structure consists of 8-in. HSS bolted to the Exosphere structure using round end plates.

Erecting a mega-panel section of the trellis.

Sphere Entertainment Co.

plates. The trellis has a panelized design and could have been erected piece by piece, with the LED system being added after the fact. However, the schedule required a faster method, necessitating a mega-panel installation where the sub-frame and the LEDs were installed on the ground and lifted into place in larger sections.

The Sphere is scheduled to open by the end of the month—with its entertainment schedule being kicked off with a U2 residency—but its exterior LED display has already been wowing passersby with jaw-dropping animations. This amazing facility was envisioned to elevate the entertainment experience to a new level, and thanks to the collaborative process and creative thinking poured into its design and construction, it will stand as an architectural and structural masterpiece as well. ■

Owner
Sphere Entertainment Company

General Contractor
MSG LV Construction, LLC

Architect
Populous

Structural Engineer
Severud Associates

Erection Engineer
Stanley D. Lindsey and Associates, Ltd.

Steel Team

Fabricator and Erector
W&W|AFCO Steel AISC Certified Fabricator

Detailer
Prodraft, Inc. AISC Detailer

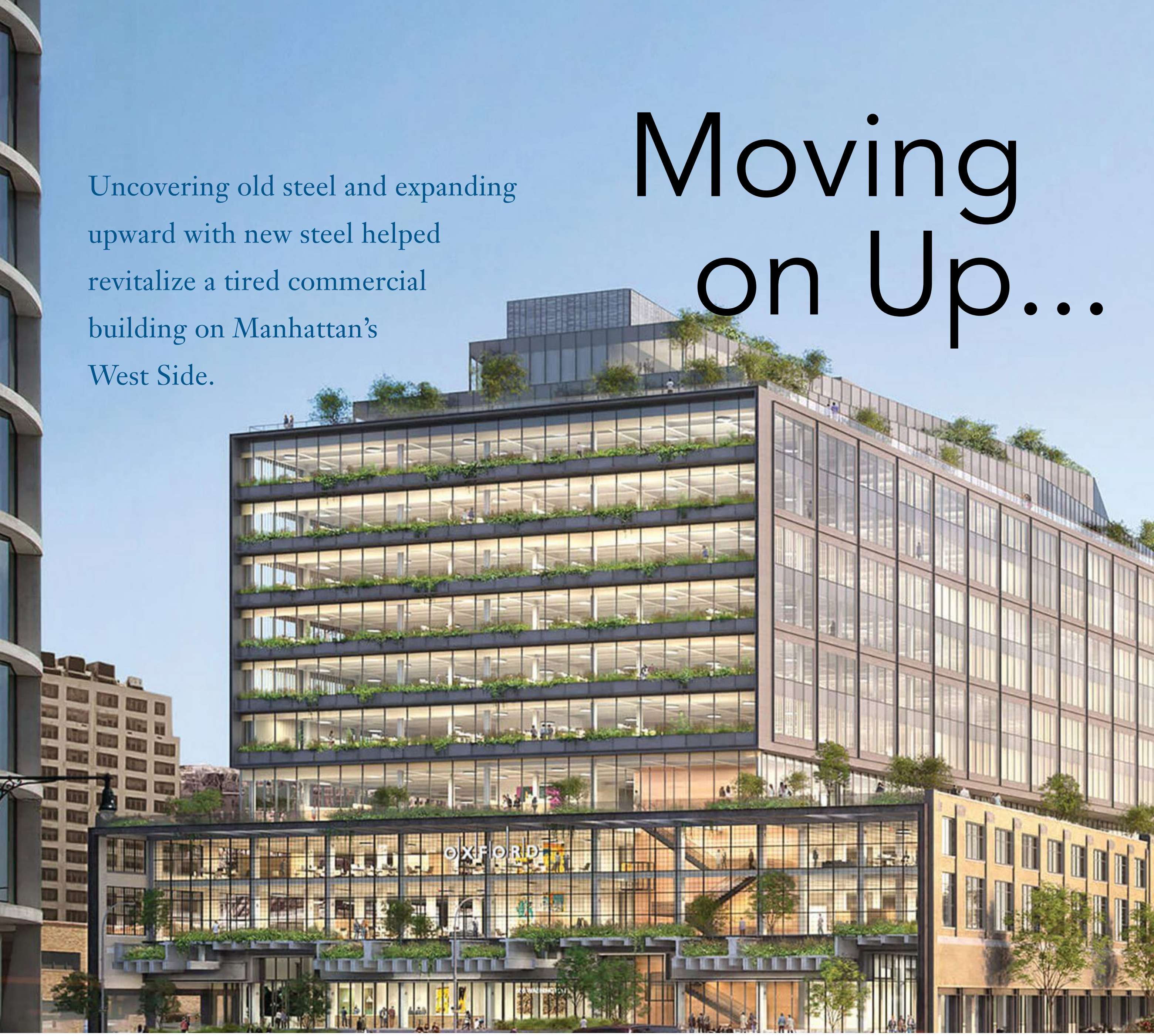
Bender-Rollers
Max Weiss Co. AISC Associate
Chicago Metal Rolled Products AISC Associate

Casting Manufacturer
Cast Connex AISC Associate

Steve Reichwein is as senior associate and **Cawsie Jijina** is a principal, both with Severud Associates, and **Carlos de Oliveira** is a co-founder of Cast Connex.

Moving on Up...

Uncovering old steel and expanding upward with new steel helped revitalize a tired commercial building on Manhattan's West Side.



SOMETIMES, there's nowhere to go but up.

But in order to do that, the project team for a commercial renovation and expansion project on the west side of Manhattan first needed to do some digging in terms of uncovering existing structural steel encased on concrete.

Built in 1934, the existing building, 550 Washington Street, originally served as the St. John's Terminal and storage building for an elevated freight line railway that serviced the docks by the West Side Highway area. The four-story structure is located on the Hudson River, just north of the Holland Tunnel. Thanks to a new eight-story (plus mechanical penthouse) 1,000,000-sq.-ft addition, the existing structure's height has nearly tripled. At the same time, the building's footprint was reduced to approximately 250 ft by 500 ft, with a bridge over Houston Street and the north parcel being demolished to open up the street near the entry and allow for future residential development. The updated, high-performance building now serves as the New York headquarters of a prominent technology company and features green rooftops and open terraces offering views across the Hudson River and of the Manhattan skyline.

The project involved demolition, relocation of an existing Con Edison transformer vault, substantial structural renovations, and new construction over the existing building. Installing new steel in the original structure required multiple surveys to ensure a smooth erection operation, and coordinating all the temporary works to enable construction and protect the public was critical to the safety and success of the project. In addition, the existing building supported a 900-ton Con Edison transformer vault on the roof, which had to be maintained in service through construction as the building transitioned into its next life. The relocation of the vault required the development of a sophisticated temporary steel structure and modifications to the existing steel structure to accommodate the means and methods involved in relocating the vaults.

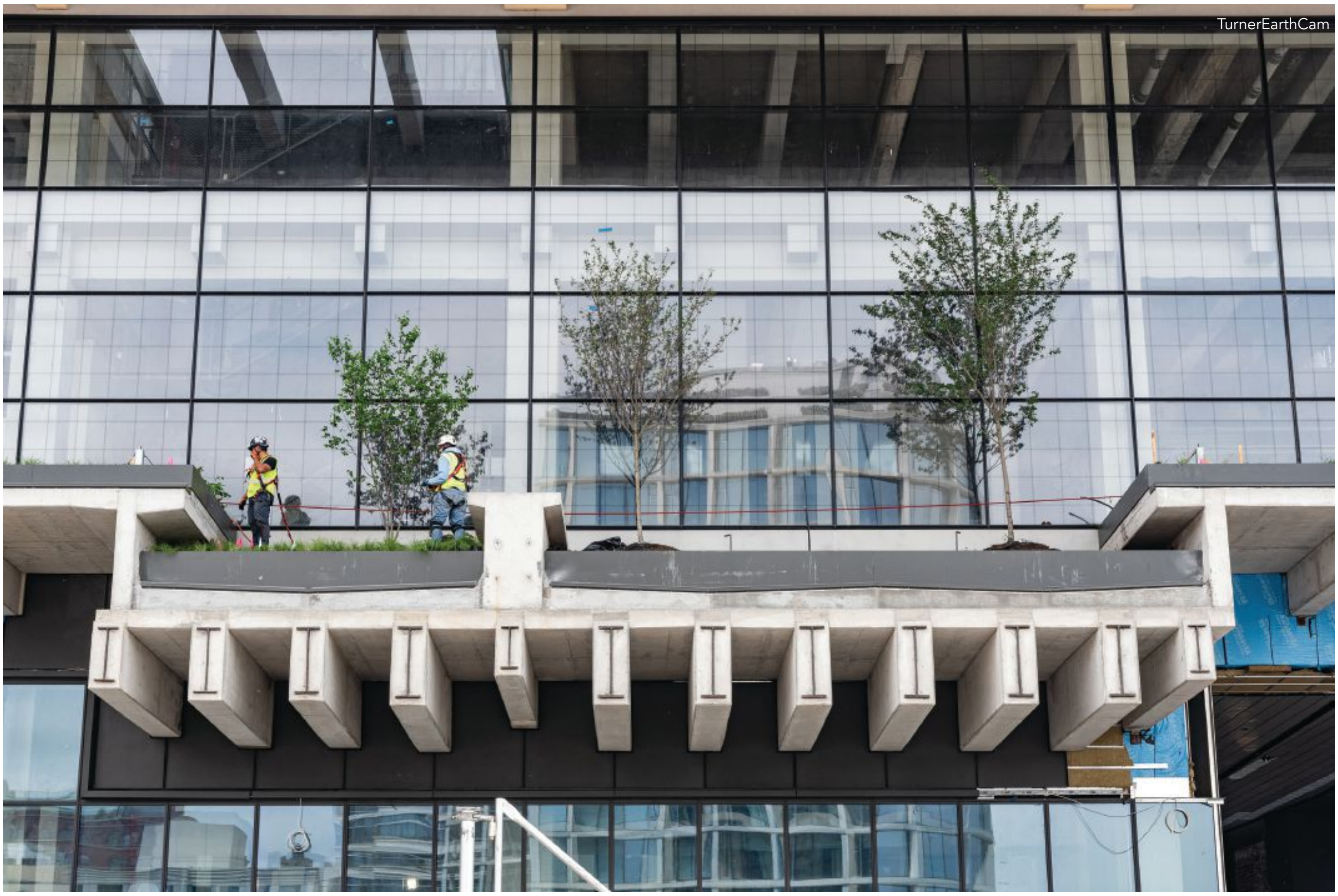
On the West Side

BY SAM BARRETT AND
BARRY CHARNISH, PEng

Thanks to a new eight-story (plus mechanical penthouse) 1,000,000-sq.-ft addition, completed this year, the height of the existing structure at 550 Washington in Manhattan has nearly tripled.

The building's footprint was reduced to approximately 250 ft by 500 ft, with the north parcel being demolished to open up the street near the entry and allow for a future residential development.

above and below: New steel framing being erected above the existing building.



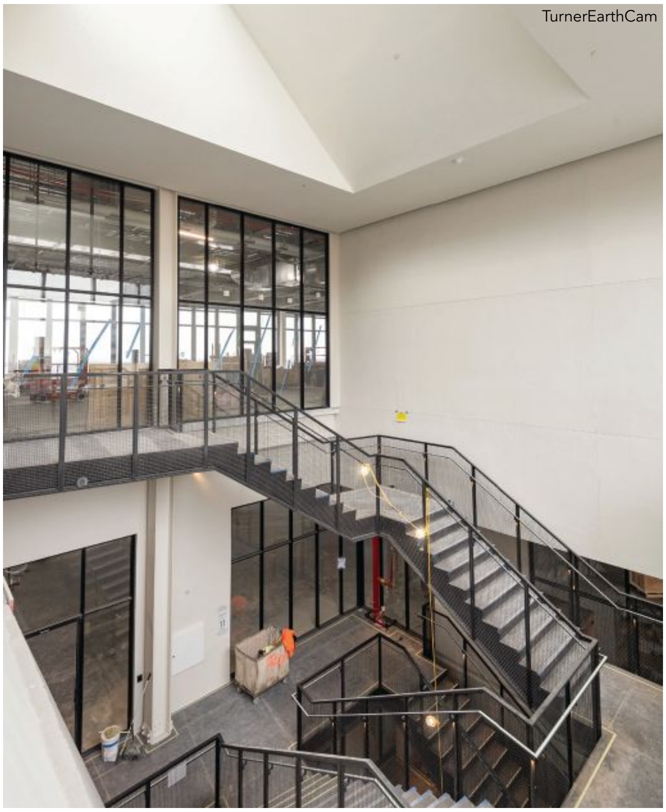
above: The project involved restoring the existing steel framing, in the lower levels—all of which was encased in concrete and required uncovering.

below: The eight-story expansion adds 1,000,000 sq. ft of space.

Urban Archaeology

The project wasn't merely a typical vertical expansion; it also included restoring the existing steel framing, made from wide-flange members with complete flange plates riveted on, in the lower levels—all of which was encased in concrete and required uncovering. Similar to an archeological dig, the new design was adjusted to compensate for the existing structural bones being uncovered daily. Typical floor framing consisted of standard wide-flange shapes, and original columns were built-up riveted sections. At Level 2, heavy riveted steel plate girders were used to support the locomotives and rail cars that entered the terminal building for loading and unloading.

The original design could not take into account the unknowns that would be uncovered during demolition. Each day, as an existing connection was revealed, the team had to quickly act to design, detail, and fabricate pieces to reinforce the existing structure. While the erection team was proactive in getting as much steel uncovered in advance of primary steel erection, the design went through more than 200 revisions over the course of the project. Once the concrete was removed, exposing the connections, the team was able to quickly inspect and design specifications for the fabrication and installation of new steel in a timely fashion. Details were changed multiple times and "on the fly" as existing conditions were uncovered and identified in the field. In all, approximately 7,000 tons worth of new structural steel was installed, including reinforcing steel in the podium, new plate girders and plate columns, and new wide-flange shapes in the vertical expansion. The new columns were generally extensions of the existing columns, though there were some new heavy transfer girders installed at the new Level 5 in order to transfer the perimeter columns down to the existing column locations at Level 4.

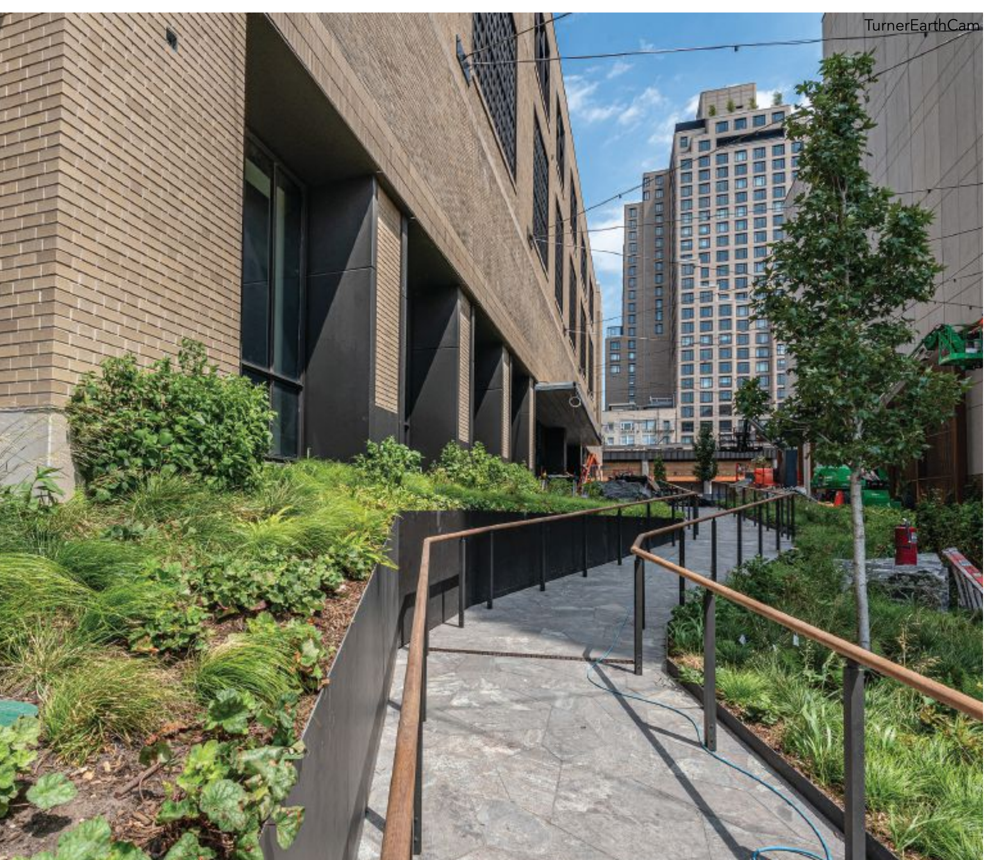


After the project's structural engineer, Entuitive, reviewed all the temporary workshop drawings and conducted site reviews to ensure that all temporary works were constructed according to design specifications, the existing building was reinforced. This included constructing a podium on top of the existing building to support the project's two tower cranes, each capable of lifting 14.5 tons at 275 ft. This approach allowed the redistribution of loads of the vertical expansion and the integration of its precast concrete core. There was generally little reinforcement of the existing columns due to the very high original design loads for the terminal building. The exception was the existing framing on the north end of the building (particularly at Level 2), where parts of the original rail bed and platform structure were expressed architecturally for the main entry to the building. In addition, some existing steel members were modified to provide the openings necessary for the updated MEP systems. The plan was carefully designed to accommodate various elements in as-built conditions and sequence the project to allow the new building framing to rise at the same time crews were working to reinforce the existing steel.

The plan also needed to accommodate COVID. As the project took place at the height of the pandemic, which involved restrictions on all personnel—either on-site, in the shop, or in

New building framing was erected at the same time existing steel was being reinforced.

In all, approximately 7,000 tons worth of new structural steel was installed, including reinforcing steel in the podium, new plate girders and plate columns, and new wide-flange shapes in the vertical expansion.



TurnerEarthCam

The building's exterior spaces also underwent an overhaul.

the office—every part of the team had to adapt to a changing working environment, and engineering and project staff had to keep the information flow intact. As the city was still very much in a work-from-home mode, there was far less traffic on the West Highway and Washington Street than in pre-pandemic days—so much so that on any given day, there could be five to six tractor-trailers of steel awaiting unloading directly next to the building. Additionally, the erector secured a large lay-down yard across the street from the project, which greatly reduced any need for map loading or just-in-time deliveries.

In the end, the project team navigated a tight, tricky site on the edge of Manhattan while also updating existing structural elements to bring new life—and space—to a Great Depression-era commercial building. ■

Owner
Oxford Properties Group, Toronto

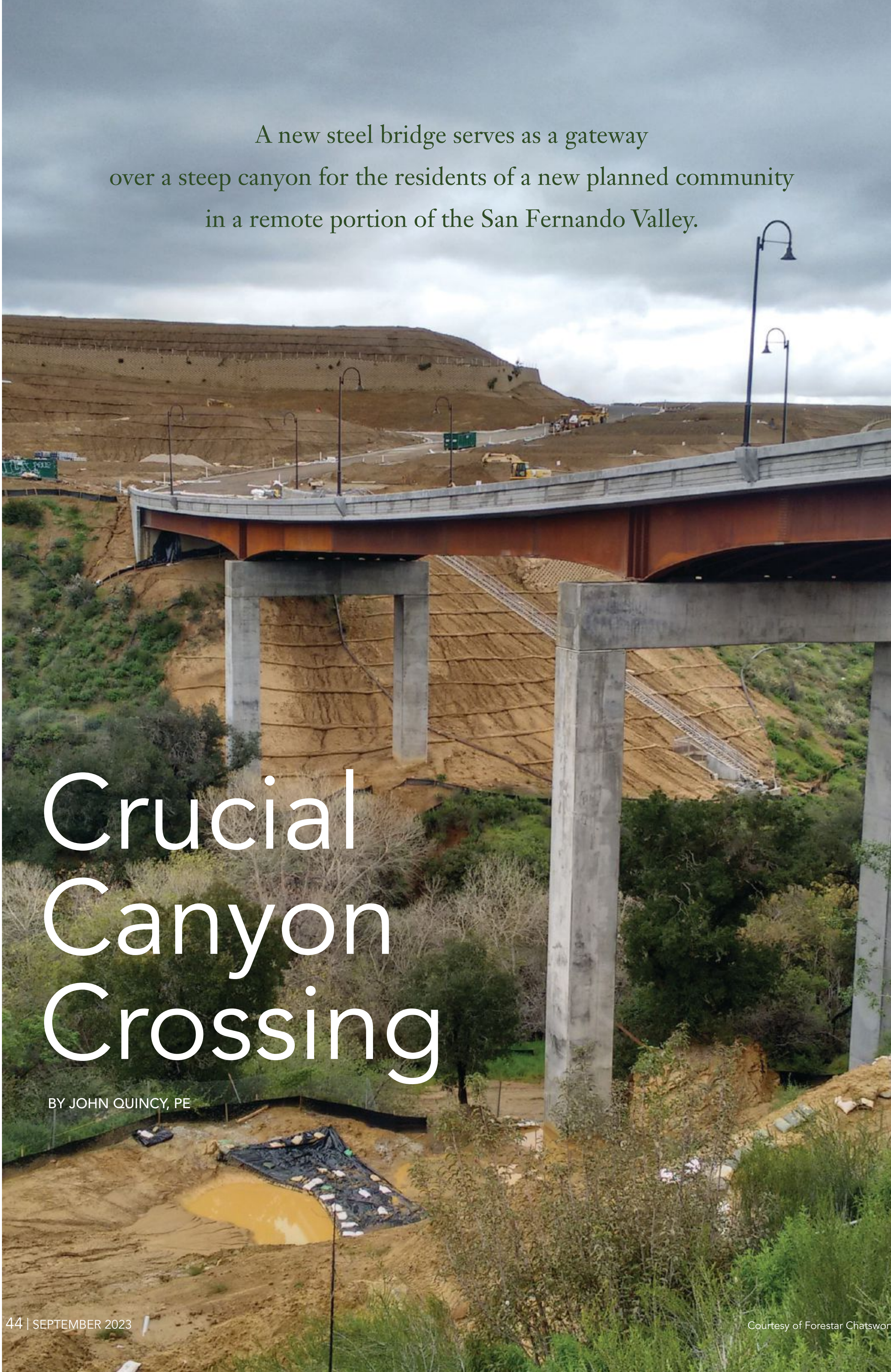
General Contractor
Turner Construction Company, New York

Architects
AAI Architects, P.C., New York
(Architect of Record)
COOKFOX Architects, New York
(Design Architect)

Structural Engineer
Entuitive, Toronto and New York

Steel Fabricator and Detailer
Dave Steel, a Walters Group Company (AISC Certified Fabricator), Asheville, N.C.

Sam Barrett is vice president of preconstruction with Walters Group, Inc., and **Barry Charnish** is a founding principal of Entuitive.

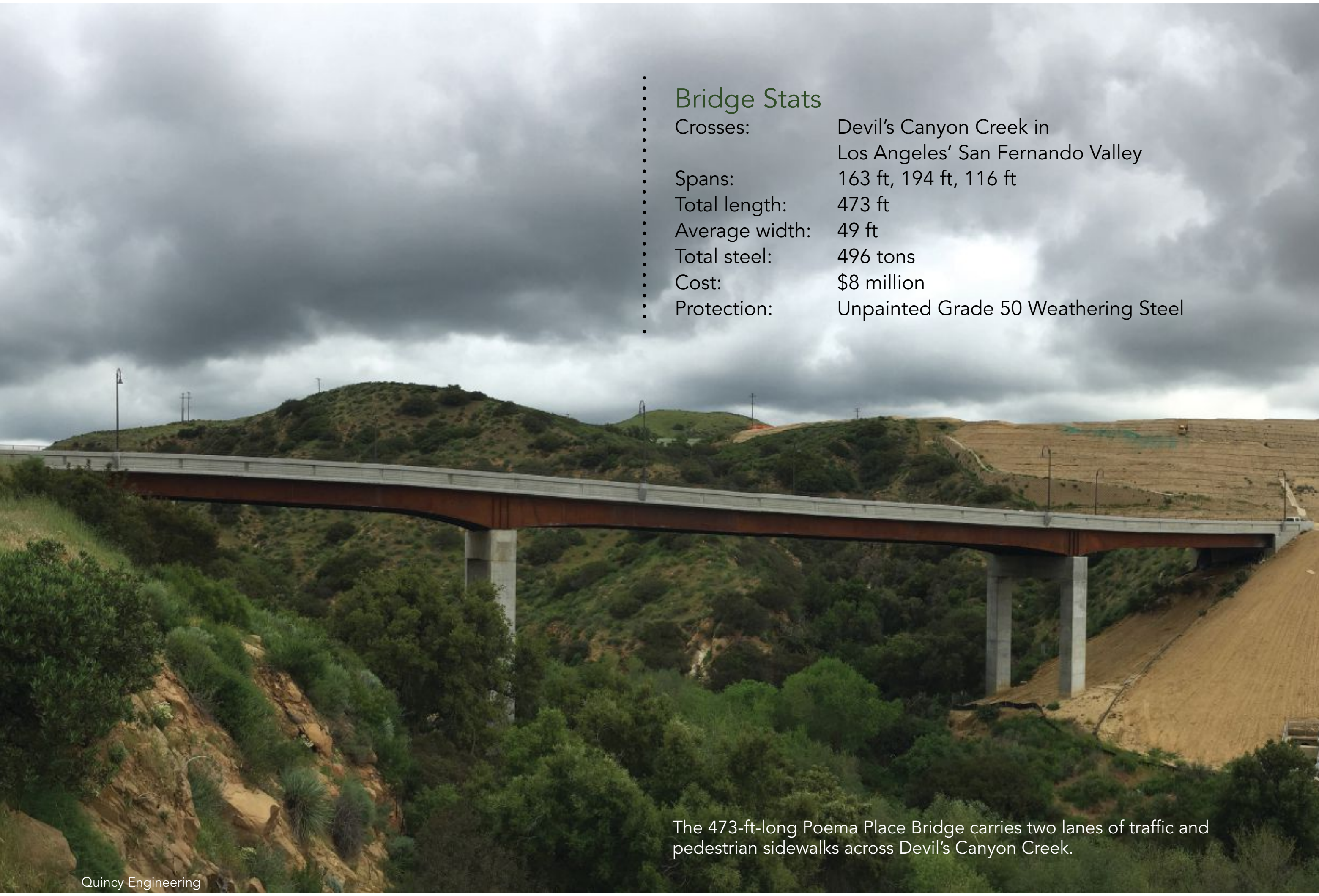


A new steel bridge serves as a gateway over a steep canyon for the residents of a new planned community in a remote portion of the San Fernando Valley.

Crucial Canyon Crossing

BY JOHN QUINCY, PE

Courtesy of Forestar Chatsworth



Bridge Stats

Crosses:	Devil's Canyon Creek in Los Angeles' San Fernando Valley
Spans:	163 ft, 194 ft, 116 ft
Total length:	473 ft
Average width:	49 ft
Total steel:	496 tons
Cost:	$8 million
Protection:	Unpainted Grade 50 Weathering Steel

Quincy Engineering

The 473-ft-long Poema Place Bridge carries two lanes of traffic and pedestrian sidewalks across Devil's Canyon Creek.

NORTHWEST OF BUSTLING LOS ANGELES, in the rolling hills above Chatsworth, is the new master planned community of Deerlake Ranch. The Poema Place Bridge serves as both the gateway to this new development and its primary access over the small but steep Devil's Canyon Creek.

The bridge posed several unique design and construction challenges due to its high visibility and location across an environmentally sensitive canyon in a high-seismic zone.

Protecting the Riparian Zone

The Devil's Canyon Creek, a protected wildlife corridor, is an important site for community members to connect with nature on multipurpose recreational trails. Cyclists, hikers, and equestrians all use this trail system that connects to the regional trail network in the Santa Susana Mountains.

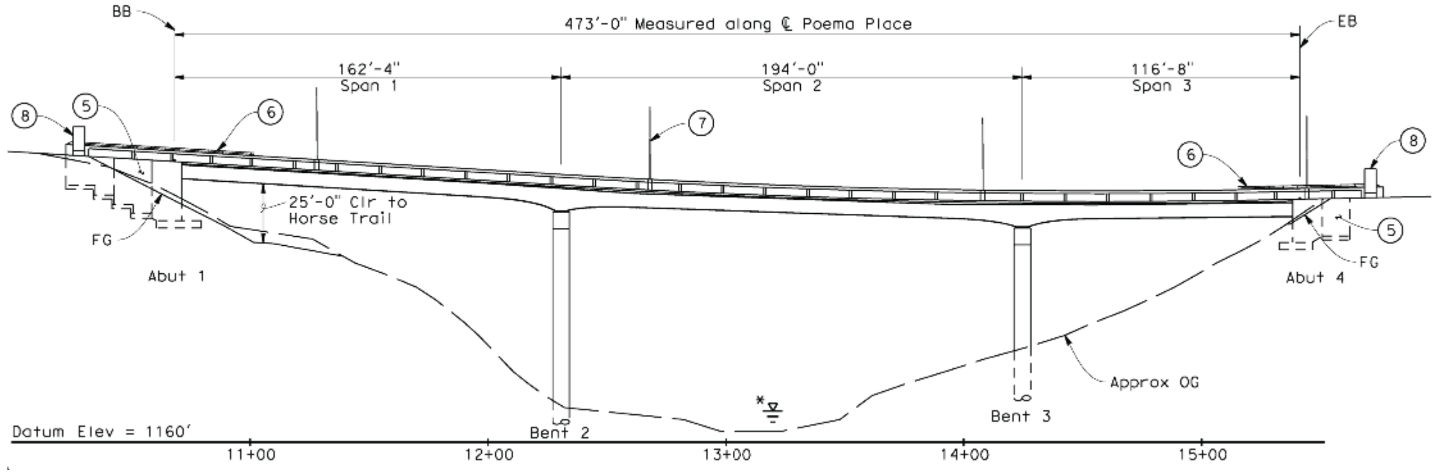
Because construction access and materials staging were excluded from the protected riparian zone—the area along the creek banks—the bridge had to be designed with a long main span that could stretch across the canyon. Consor (formerly Quincy Engineering) worked with bridge construction contractors and fabricators to develop a steel girder configuration that could span over the environmentally sensitive creek. The pier location and foundation type (CIDH piles) were selected based on construction accessibility, equipment size and type, and geologic stability. The bridge is founded on spread footings at the abutments and 7-ft-diameter cast-in-drilled-hole piles at the 80-ft-tall piers, which are located outside the protected zone.

The flexibility and lightweight properties of steel allowed for longer spans, eliminating the need for temporary falsework in the protected areas. The 49-ft-wide bridge consists of spans of 163 ft, 194 ft, and 116 ft for a total length of 473 ft. The steel I-girders vary in depth from 6 ft at midspan to 9.5 ft at each pier. In total, the project's structural steel weighs 496 tons.

Installing the three long spans required 440-ton- and 230-ton-capacity cranes, supplied by steel erector Bragg Crane and Rigging Co. The erection plan called for cranes to be sized and located near the abutments and down the slopes near the piers to erect the long girder elements above the environmentally sensitive areas. The girder segments were erected in pairs, with both cranes working in unison, reaching up to 350 ft over the canyon.

Seismic Resilience and Utility Connection

The Deerlake Ranch developer, Foremost Company, was responsible for building a bridge that connects the new community with the San Fernando Valley. The bridge's open structure allows it to carry all utilities—gas, water, cable, electric, fiber optics, and telephone—across the canyon. Because ownership of the bridge will transfer to Los Angeles County, it had to conform to Caltrans local assistance and bridge design guidelines, which supports seismic resiliency. Due to multiple faults in the area varying in magnitude from



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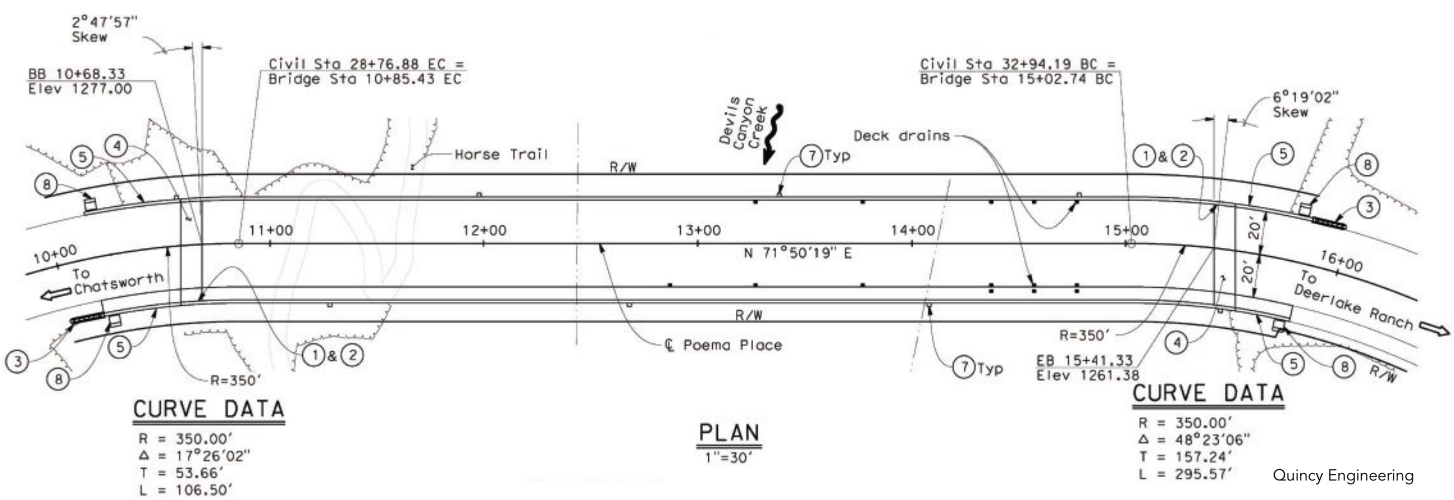
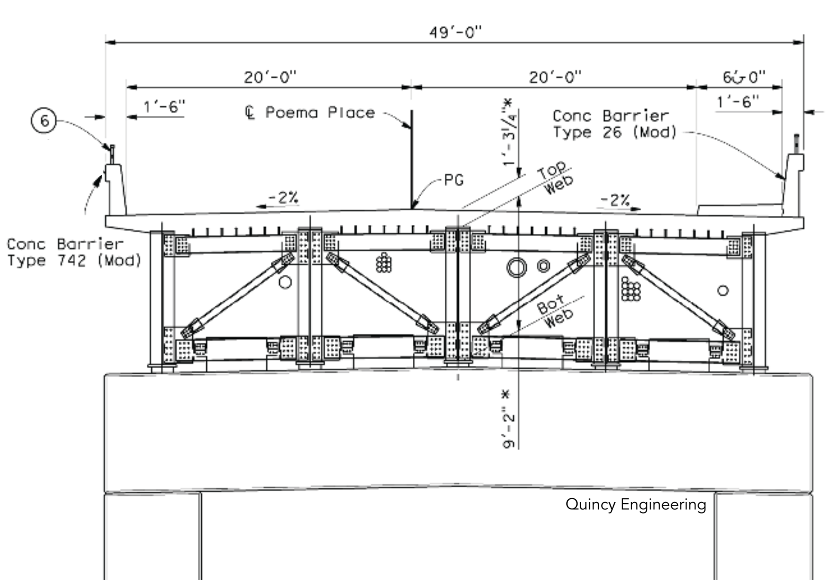


Quincy Engineering

above: Elevation and plan drawings of the bridge.

below: A cross-section drawing.



Quincy Engineering

6.4 to 7.5, it was critical for this vital bridge to maintain access for emergency vehicles and utilities during major earthquakes and minor seismic events.

Opting for structural steel girders over concrete reduced the weight of the superstructure, improving performance during seismic events—and also sped up construction. To provide additional pier strength in the event of an earthquake, 7-ft-diameter cast-in-drilled-hole concrete piles were socketed into the sandstone for vertical support and sufficient horizontal stability. At each pier, two square concrete columns connect to the rectangular pier cap with a pin connection, improving the flexibility of the structure while reducing rebar congestion in the column/cap connection zones.

The project team chose low-maintenance polytetrafluoroethylene (PTFE) spherical bearings that slide longitudinally at each abutment to allow movement for temperature expansion and contraction. The bridge also takes advantage of a unique seismic restraint system that engages the abutments as a restraint during moderate-level earthquakes. This system allows yielding and crushing of multiple steel tube sections, which dissipates seismic energy. Post-earthquake, the steel tubes can be easily removed and replaced, making the bridge ready to sustain another seismic event.


Courtesy of Forestar Chatsworth

Since no construction access was allowed at any time in the environmentally sensitive canyon—which is located in a high-seismic zone and includes a wildlife corridor and multipurpose recreational trail—a relatively long main span was required to traverse the creek, and construction and material staging areas were limited.


Courtesy of Forestar Chatsworth


Courtesy of Forestar Chatsworth

The construction plan called for cranes to be sized and located near the abutments and down the slopes near the piers to erect the long girder elements above the environmentally sensitive areas.


Courtesy of Forestar Chatsworth

The bridge serves as both the gateway to a new residential development and its primary access over the small but steep Devil's Canyon Creek.

Courtesy of Google Earth

In addition to the maintenance advantages and addressing the project's aesthetic goals, implementing weathering steel allowed for faster fabrication and erection since no coating system needed to be applied, and it also eliminated the costs associated with a coating system.

The bridge's open structure allows it to carry utilities across the canyon.

Incorporating Aesthetics

As the gateway to a premier residential development and landmark for anyone taking in the views while walking, hiking, or horseback riding the Santa Susana Mountain trails, the bridge's aesthetics were a high priority.

The project team selected weathering steel and its rust-colored patina to provide long-term corrosion protection as well as give the span a rugged aesthetic that blends into its natural context. In addition, the increased girder depth (haunches) at the piers provides an elegant, shallow arch into its long spans.

The completed bridge carries two lanes of traffic, pedestrian sidewalks, and utilities across the canyon—100 ft above the floor in the middle—creating a focal point in this scenic locale. An exemplar of sustainable steel bridge design, the Poema Place Bridge shows how thoughtful material selection, seismic-resilient features, and a commitment to environmental stewardship can create a structure that is both functional and aesthetically pleasing. ■

Owners
Forestar Chatsworth, LLC,
Newport Beach, Calif.
Los Angeles County, Alhambra, Calif.

General Contractor
Beador Construction Company,
Corona, Calif.

Structural Engineer
Consor (formerly Quincy Engineering, Inc.),
Rancho Cordova, Calif.

Steel Team

Fabricator and Detailer
West Coast Iron, Inc. AISC CERTIFIED FABRICATOR
Spring Valley, Calif.

Erector
Bragg Crane and Rigging Co. AISC ASSOCIATE AISC CERTIFIED ERECTOR
Long Beach, Calif.

John Quincy (**john.quincy@consoreng.com**) is Chief Bridge Engineer – California with Consor.

The Transformative Power of Hands-On Learning

BY RYAN MANUEL AND JASON MERCHANT

Purdue University is making a push to enhance its steel construction education through industry partnerships.

THE GROUNDWORK FOR SUCCESS in construction management is established through theory and classroom learning.

Nonetheless, it is the practical exposure that genuinely improves students' understanding and prepares them for real-world challenges. Purdue University's School of Construction Management Technology has always emphasized practical exposure. The School of Construction Management's steel construction education lessons were recently revamped by the authors to leverage industry relationships to enhance student learning. The realization of the vital role of steel construction in a typical construction project sparked a collaboration with Iron Workers Local 22. Students working together with local ironworkers in a controlled lab setting is an invaluable opportunity for them to learn practical skills, understand the industry, build relationships, and value teamwork.

opposite page: Students pose for a picture after a lab session.

Authentic Industry Experience

By working with local ironworkers, students can fully immerse themselves in the actual process of steel construction, which is a unique opportunity. Collaboration with experienced ironworkers exposes students to authentic work processes, techniques, and industry standards, which can be incredibly valuable as they enter the workforce. This practical experience enables students to understand the complexities of steel construction, complementing their academic knowledge and classroom theories. The application of concepts in real time enables students to bridge the gap between theory and practice.

The steel construction learning environment benefits greatly from the industry insights and expertise of ironworkers. Their experience offers students unique guidance and mentorship, assisting them in overcoming challenges and refining their abilities. Students who work closely with ironworkers gain practical knowledge, understand the subtleties of the trade and develop a deeper appreciation for the artistry and skill required in steel construction. Our experience has shown us that adopting this collaborative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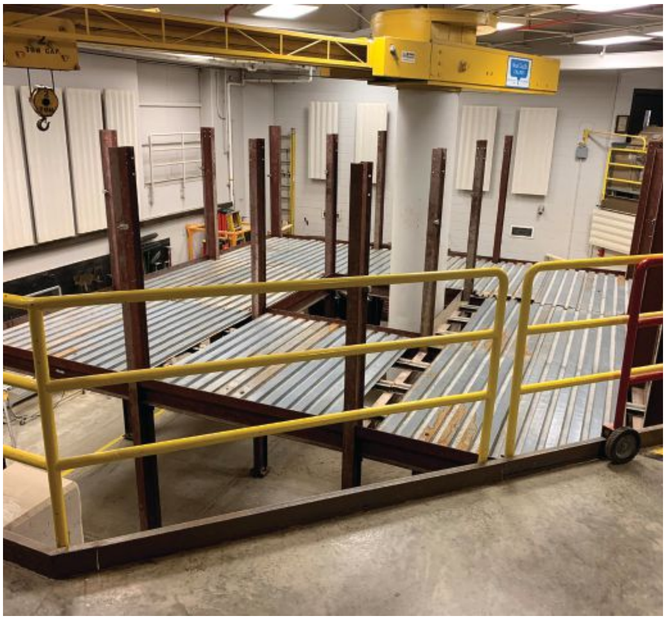
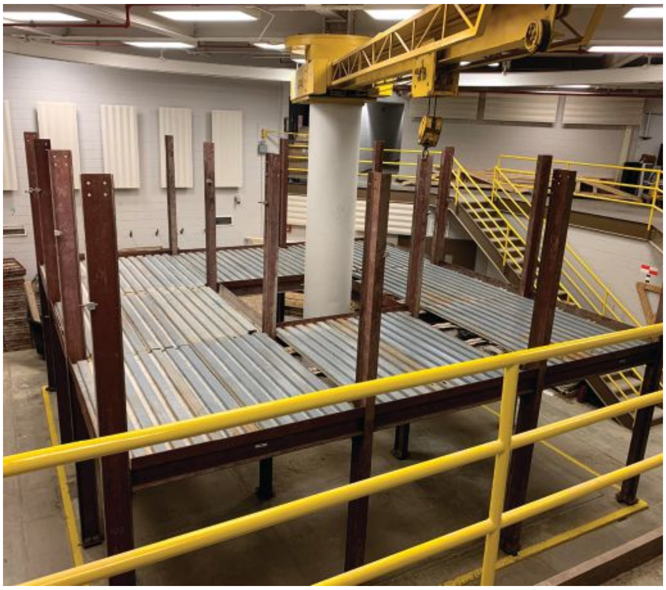
below: A steel structure in the old Knoy Hall Lab.





Steel structure progress in the old lab.

A rendering of the SCMT New Construction Lab

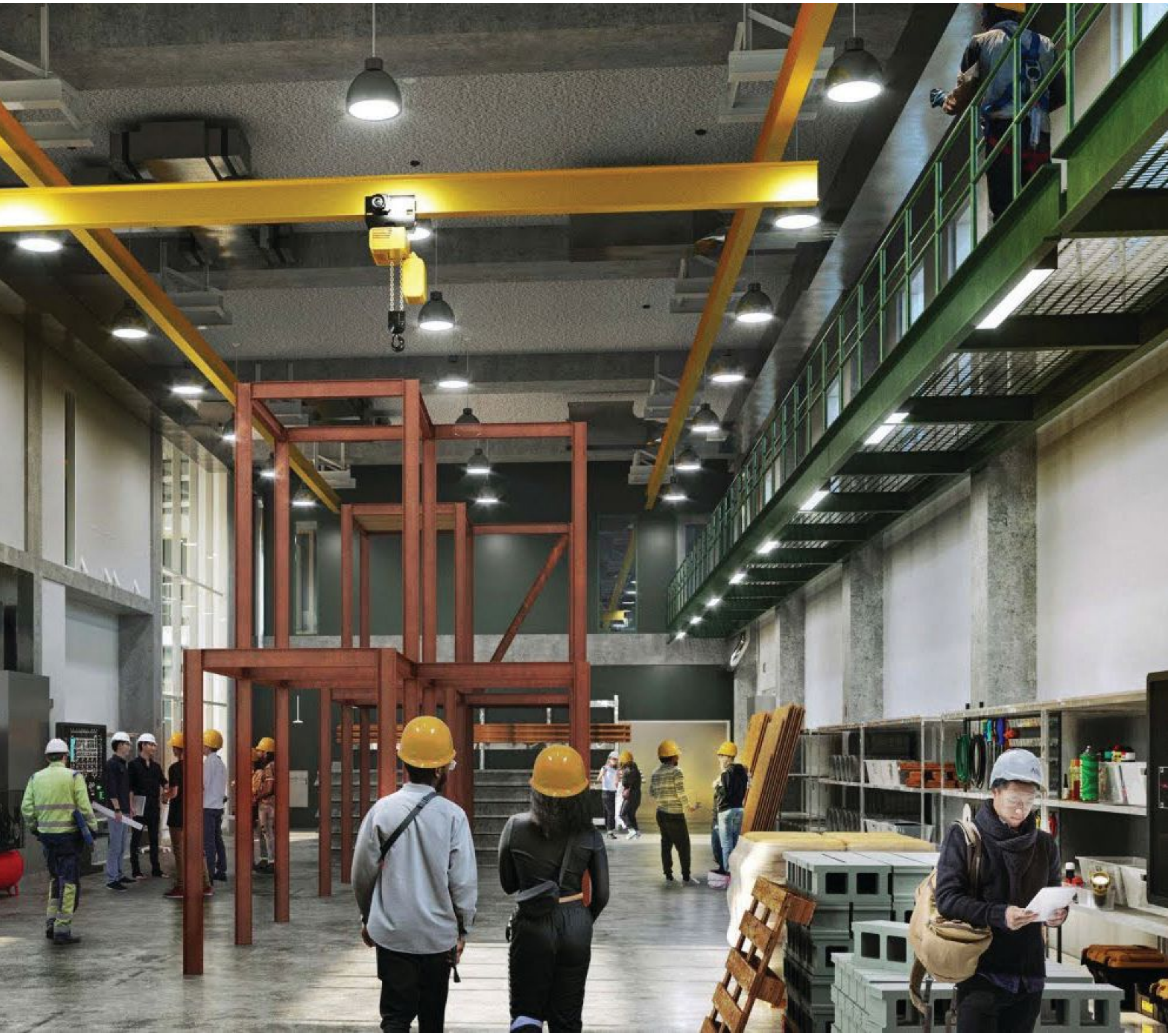
approach to steel construction education not only benefits our students academically but also fosters a sense of professional growth and personal development among them.

Effective Communication and Teamwork

The key ingredients to a successful construction project are effective communication and teamwork, as these traits are the driving force behind every thriving construction project. The collaborative activities that students engage with in our controlled lab environment are designed to mimic real-life scenarios and provide a practical learning experience. Students are taught how to interpret steel drawings, communicate effectively, work in a team, and construct a steel structure with the guidance of instructors and ironworkers. These experiences nurture the interpersonal and leadership skills that are vital for construction managers to thrive in fast-paced work environments. This collaboration promotes critical thinking and adaptability to different working styles by exposing students to diverse perspectives and approaches.

Prioritizing Safety

The construction industry places great importance on safety, and construction management professionals must have a comprehensive understanding of safety protocols and regulations. Ironworkers have extensive knowledge of safety practices in steel construction, and working with them in a controlled lab environment ensures students learn industry-standard safety protocols from the beginning. Hazard identification, risk assessment, and proper use of safety equipment are areas where ironworkers can offer valuable guidance. Instilling a culture of safety in students early on ensures that they prioritize safety in their future pursuits.



Fostering Professionalism

Students in construction management programs must embody the high level of professionalism demanded by the industry. Working with local ironworkers provides students with a one-of-a-kind chance to learn about the realities of construction work, such as adhering to project schedules, managing resources efficiently, and maintaining a strong work ethic.

Practical experiences in steel construction help students connect theory with practice, leading to a deeper understanding. These activities develop problem-solving, safety, communication, teamwork, and professionalism skills in students, preparing them to excel as future construction leaders and contribute to industry growth and innovation. This approach is yielding positive results in creating a comprehensive awareness of the basics of steel construction. And Purdue is working to acquire the necessary steel members to construct an improved steel structure, providing students with a unique experience with different connection types, and additional research will begin in the upcoming academic year. Stay tuned! ■

Ryan Manuel (**rmanuel@purdue.edu**) is an assistant professor of practice, and **Jason Merchant** (**jlmercha@purdue.edu**) is a lecturer, both with with Purdue University's School of Construction Management Technology.

Steel-related field trips provide students—whether traditional or life-long learners—with not just educational opportunities but also memorable experiences.

Faculty-led Fun

BY MARIA MNOOKIN

TAKE A MOMENT and think back to the most memorable and pivotal moments in your education.

Do classrooms, lectures, homework, and exams come to mind? Or do you think of field trips, student group activities, and hands-on projects?

Perhaps your biggest professional "Aha!" moments happened after graduation, at a job site or other professional activity or demonstration. No matter when they occurred, isn't it noteworthy to think about how much those moments may have shaped your career?

There's no better learning opportunity for students studying steel design, fabrication, and construction than seeing the world of structural steel firsthand. We hear this from faculty and students who participate in activities like SteelDay field trips and the Student Steel Bridge Competition (SSBC) year after year (to read about this year's competition, see "Third Time's the Charm" in the August 2023 issue at **www.modernsteel.com**)—not to mention that the participants have *tons* of fun along the way!

Among the many activities held in celebration of last year's SteelDay, AISC connected structural steel faculty with local steel facilities to create more of these pivotal learning opportunities (see "All Hands-on (Steel) Deck" in the January 2023 issue). Faculty had the option of a variety of student tour activities, from fabrication shops and production facilities to job sites, and more. Additionally, AISC provided transportation funding for schools needing extra financial support.

We also worked in conjunction with the Ironworker Management Progressive Action Cooperative Trust (IMPACT) to connect faculty, students, and professionals with local Iron Worker Training Centers to conduct interactive tours. Attendees had the opposite page: Ohio Northern University (ONU) engineering students visiting a fabrication shop for a 2022 SteelDay event.

below: Georgia Tech students at a Gerdau mill tour on SteelDay 2022.

opportunity to try their hand at welding, bolting, flame-cutting, rigging, and climbing steel columns—activities attendees won't easily forget experiencing. Not only did they gain an appreciation for the skill it takes to be an ironworker, but they also learned to consider concepts like constructability in a practical as opposed to merely a theoretical sense.

Due to the success of last year's events, we're planning even more of these activities in 2023. In fact, the AISC Education Foundation has earmarked $20,000 to support a new Faculty-led Field Trips program offered year-round—and we're actively connecting faculty and local steel facilities to help them plan these field trips for future classes.

Tour groups can be as big as 100+ students to as small as a handful of participants, depending on what each steel facility or job site can manage. While the ideal number of students can range from 20 to 50, sometimes the intimate experience a small group receives really makes a huge impact.

"It was a great honor for me to be able to host the Ohio Northern University (ONU) engineering students at our shop for SteelDay 2022," said Jacob Thomas, CEO of Thomas Steel, Inc., in Bellevue, Ohio, and an AISC Board Member. "During the tour, the students had an opportunity to see firsthand what it takes to fabricate structural steel and turn their designs into reality. Experiences like this are critical to bridging the gap between conceptual design and real-world application. We were fortunate enough to have some very large members in the shop at the time of their visit. I always enjoy seeing a student's eyes light up when they see a 3-in. base plate in person. After the tour, we moved to our conference room, where we gave the students a chance to have an open Q and A session with our leadership team. The students were incredibly engaged and asked questions ranging from design techniques to lessons learned in management and leadership. If anything, I wish we had more time to spend together, as I am sure this conversation could have gone on for several more hours."

"I cannot thank AISC enough for setting up this tour and others like it. Not only do they benefit the student's development, but they also promote the best building material available, American structural steel!"

ONU Assistant Professor Seyed Ardakani shared that during their extensive visit, "The students gained valuable knowledge about the history of the company as well as steel processing and fabrication. They were introduced to various processes like shot blasting, CNC cutting and drilling, beam cambering, welding, and painting. The students particularly enjoyed learning about plasma cutters and their limitations, as well as cambering steel beams and trusses. With our small group, students were able to engage in one-on-one discussions with the leadership team, making the experience even more rewarding. I would like to extend my gratitude to Thomas Steel, Inc., and AISC for providing us with this exceptional opportunity!"

above: A Howard University student performs a strength test of sorts at a 2022 SteelDay event.

left: Purdue students on a field trip to a steel fabrication shop.

On the other end of the spectrum, a large group of 75 students from Purdue University's School of Construction Management Technology, led by Professor Ryan Manuel, toured Lenex Steel in Terre Haute, Ind. After being welcomed and given a brief introduction to the company, the students were divided into four groups and toured various areas of the plant, including general fabrication and equipment, robotic welding, and CNC machine demonstrations and were shown a current project and led through a model review, shop drawing, and verification checks for a large column. Students also learned to weld safely in small groups at stations set up in the shop, and they got to keep souvenirs of their finished work. Additionally, each student was also gifted the Purdue "P" in steel that had been cut and painted.

"We can't thank Lenex Steel enough for being so accommodating and hosting our students on this educational fabrication plant tour," expressed Manuel. "They truly made this a unique experience for our students. Special thanks to the AISC for their support in making this possible."

Assistant Professor Ryan Sherman of the Georgia Institute of Technology took full

Working with a oxygen-acetylene torch at an IMPACT SteelDay event in 2022.

advantage of the local opportunities presented in celebration of SteelDay 2022. While arranging a 20-person tour of the Gerdau steel mill in Cartersville, Ga., for his students, Sherman also participated in a tour of a local Iron Worker Training Center.

"The Iron Worker Training Center tour was an excellent opportunity for engineers to gain firsthand experience with an iron worker's wide range of skills," he said. "Participants were able to operate torches, use a virtual welding simulator, climb a steel column, and more. As an educator, one of my goals in participating was to preview the facility for a future student SteelDay event. After visiting, I look forward to sharing this invaluable experience with my students because they will gain a tremendous appreciation for the practical aspects of steel design and construction."

With SteelDay being our industry's largest networking opportunity, it just may be the catalyst to opening more doors to the best learning experiences out there for students and, really, anyone wanting to learn more about our industry. ■

This year's SteelDays (with an "s") will take place October 17–20. Visit ***aisc.org/steelday*** *to learn more. And for more information on AISC's Faculty-led Field Trips program, visit* ***aisc.org/fieldtripgrants****. Finally, if you're interested in providing a student tour of your fabricator shop or mill, please contact AISC's University Programs team at* ***universityprograms@aisc.org****.*

Maria Mnookin (mnookin@aisc.org) is AISC's director of foundation programs.

Step into a new world of steel knowledge via AISC's Learning Portal!

A Portal to Learning

BY BETH PEDOTA

All photos: Chris Jenkins

IT'S COMMON KNOWLEDGE in the engineering community that AISC is the go-to source for continuing education on steel design.

Whether you're looking for professional development hours (PDH) credit or need to brush up on some topics you haven't practiced in a few years, AISC is here to help.

NASCC: The Steel Conference is the premiere, in-person source with nearly 200 technical sessions each year. And virtually, AISC has been delivering timely information by way of daytime webinars and Night School courses for more than ten years—and recently began offering the Flash Steel Conference.

And now, there's an easy way to access all of this educational content: The AISC Learning Portal.

The Learning Portal was introduced last year as a one-stop shop for all the continuing education content that AISC has to offer, providing access to live broadcast events and all the associated materials, such as course handouts and quizzes. Most importantly, your PDH certificates are directly available from the comfort of your own home! In addition to the live events, AISC also offers a treasure trove of recorded content in the form of past live webinars, Steel Conference session recordings, multi-session courses, and more.

PDHs. In a pinch for PDHs for license renewal? Or does your schedule only allow for consuming continuing education at odd hours of the day? AISC offers several on-demand, PDH-earning options at a low cost while providing high value. In the Learning Portal, under Programs, navigate to On-Demand Courses, where you'll see more than 125 options to view recorded presentations and pass the associated quizzes. Our PDH-ready courses include select Steel Conference, past daytime webinars, and the Steel Academy. There is a broad range of topics ranging from load paths to weld details to bridge cross frames to the evaluation of existing steel buildings. And at any given time, AISC even offers a few PDH options for free. Currently, you can check out AISC engineering vice president Chris Raebel's SteelDay webinar with an update on AISC's Need for Speed initiative or 2022 T.R. Higgins winner Amit Kanvinde's lecture on column base connections.

Steel Conference Session recordings. Did you attend the Steel Conference but miss a few sessions? Or were you unable to attend at all? Or do you just have a general case of FOMO? Once

again, the Learning Portal has you covered! The Steel Conference always has so many great sessions that it's inevitable that some you are looking forward to will be at the same time. Good news: Almost all our conference sessions dating back to 2005 are available through the Learning Portal and can be viewed for free. You can find Steel Conference recordings in the Library section under "Conference Recordings and Papers." Select conference sessions are also available for PDH credit. And bridge folks, we have you covered too! The World Steel Bridge Symposium (WSBS) session recordings are located in the same place.

Specialty topics. Were you recently assigned a new project on an unfamiliar topic at work and need some background information? AISC's vast on-demand library is sure to have something to help. Façade attachments? Check out the three-session webinar "Design of Façade Attachments" presented by Alec Zimmer. Steel-Framed Stair Design? Perhaps the two-part webinar series "Steel Framed Stairway Design," presented by Adam Friedman, would help. Vibration analysis? Try "Vibration Serviceability," presented by Brad Davis. How about erection engineering? Well, that depends. Are you looking for low-rise buildings, high-rise buildings, or overall stability information? Just kidding, our three-part webinar series on erection engineering covers all of those areas. Regardless of the topic, there is a very good chance that it's covered in the Learning Portal.

Design Guides. Are you looking for an introduction to one of AISC's design guides? The Learning Portal can help here as well. AISC's most recent offering in its Design Guide library is Design Guide 38: *SpeedCore Systems for Steel Structures*. Purdue professor Amit Varma co-authored this Design Guide and presented on SpeedCore (**aisc.org/speedcore**) for his T.R. Higgins lecture, and you can access his presentation via the Learning Portal. Design Guide 37: *Hybrid Steel Frames with Wood Floors* also has a corresponding presentation given by two of the authors, Michelle Roelofs and John Hand. And last year, the second edition of Design Guide 27: *Structural Stainless Steel* was published, coinciding with the publication of a new standard, the AISC *Specification*

AISC Learning Portal

Smarter. Stronger. Steel.

for Structural Stainless Steel Buildings (ANSI/AISC 370). The corresponding three-part webinar was presented by several speakers, including the Design Guide's authors, Nancy Baddoo and Francisco Meza.

Speakers. Are you looking for information from a specific speaker? The Learning Portal is chock full of presentations from award-winning speakers. Experts on all things steel Lou Geschwindner and Bo Doswell, connection design aficionado Carol Drucker, welding guru Duane Miller, and seismic design whiz Rafael Sabelli are just a few of the subject matter experts whose knowledge you can access. Geschwindner, Drucker, and Miller have all won the AISC Steel Conference Speaker Award and provided a corresponding keynote presentation (all available via the Learning Portal, of course). The list of T.R. Higgins Lectureship Awards is long, but, as you may have guessed, Higgins lectures are also available on the Learning Portal, as well as several other presentations by the award winners. Recent Higgins award winners include Bo Dowswell, presenting on gusset plates, Ron Ziemian on structural stability, Robert Connor on fracture-control plans for steel bridges, and Todd Helwig on bracing of flexural members.

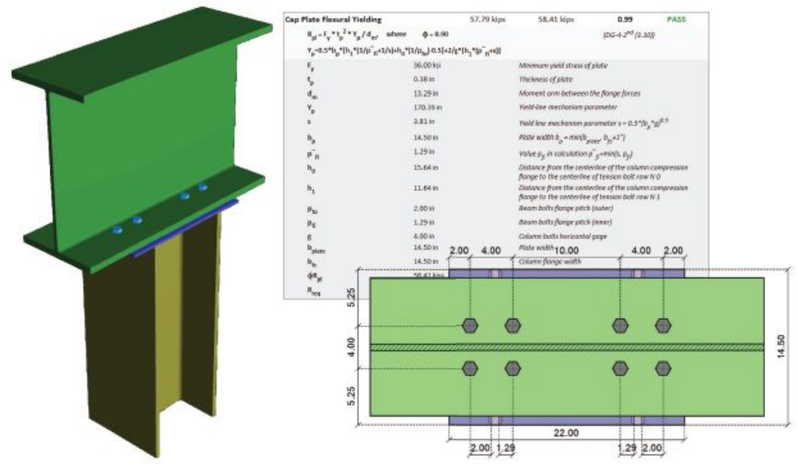
Exam prep. Are you looking for resources to prepare for the SE exam? The Learning Portal has plenty of resources for you! In addition to the courses already mentioned, AISC offers Steel Academy, a collection of self-paced eight-session courses that does a deep dive into a single topic. Need a refresher on the fundamentals of steel design? Try "Basic Steel Design," presented by Lou Geschwindner, which covers tension members, compression members, bending members, combined compression and bending, stability analysis, and design of composite flexural members. If you need help with the lateral portion of the exam, try "Fundamentals of Earthquake Engineering for Buildings," presented by Rafael Sabelli. Not only does this course review seismic concepts, but it also goes over steel-specific behavior. Maybe you just need some help navigating the AISC *Steel Construction Manual* faster. When taking the SE, every second counts! Carol Drucker's "Secrets of the Manual" will help you take advantage of the various design aids throughout the *Manual*.

AISC's new Learning Portal was designed with the user in mind and will hopefully help you achieve your goals, regardless of where you currently are in your career. So head over to **learning.aisc.org** and discover all the resources AISC's Learning Portal provides! ■

Beth Pedota
(**pedota@aisc.org**)
is a senior engineer
in AISC's Continuing
Education department.

new products

This month's New Products section features three software solutions for different stops along the steel design and construction journey: one for connection design, one for finite-element modeling, and one for creating rigging plans.

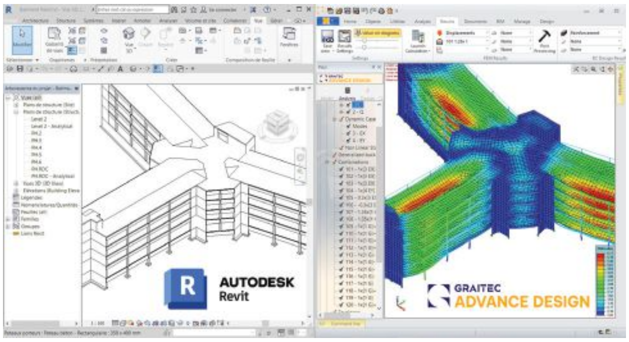


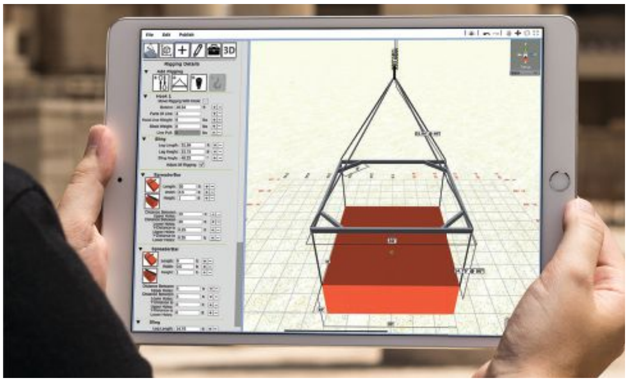
RISAConnection 14

Earlier this year, RISA released Version 14 of RISAConnection, which includes the addition of beam-over-column moment connections for the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360). This connection type uses guidance from AISC Design Guide 24: *Hollow Structural Section Connections* and supports applied axial load onto the column (from the beam), strong axis bending moment (bending perpendicular to the beam's length), and shear forces in either direction. For more information and to start your free 10-day trial, visit **www.risa.com**.

Graitec Advance Design

Advance Design is an easy-to-use finite-element modeling (FEM) structural analysis solution dedicated to structural engineers operating in a BIM environment. It enables intelligent model-based workflows for engineers and construction professionals, acting as a BIM platform and guaranteeing the continuity of geometric and analytical data through model transfers all along the design cycle. Analysis results are also stored in the digital model and are part of the BIM process. For instance, they can be used to start a rebar design or a steel connection process directly from Revit. Modeling is intuitive thanks to a complete library of structural elements, advanced wizards, and automatic load generators. These customizable elements adapt to any situation, including numerical eccentricities, braces, ties with initial pre-stressing, and complex loading systems. For more information, visit **asti.com/products/advance-design**.





AIA Software Rigging Designer

A1A Software has released Rigging Designer, a new application-based tool for anyone who needs to create rigging plans. The stand-alone application, available in the A1A Product Suite, provides detailed documentation for pre-lift planning while also being easy to use on the go for planning in the field. The software is pre-loaded with options for 3D equipment, such as mobile cranes, excavators, forklifts, overhead cranes, or gantries. A library of more than 1,300 3D objects includes common loads lifted in construction and industrial applications and common buildings. Users can also create their own objects to be lifted by entering the dimensions. To create a rigging plan, simply input the center of gravity, pick points, hitch type, sling type and lengths, and other gear such as lifting beams, spreader frames, snatch blocks, or swivels. Rigging Designer will also calculate sling angles and dimensions for rigging gear. For more information, visit **www.3Dliftplan.com**.

AWARDS

Nominate Someone Extraordinary for a 2024 AISC Award

AISC is now accepting nominations for its award programs that honor remarkable people.

Each year, AISC presents Lifetime and Special Achievement Awards to exceptional industry professionals, designers, and educators. The 2024 winners will receive special recognition at NASCC: The Steel Conference in San Antonio, Texas, March 20–22, 2024.

"The leaders driving today's innovation are what make the design community and domestic fabricated structural steel industry so special," said AISC President Charles J. Carter, SE, PE, PhD. "They deserve the spotlight, and AISC is honored to provide one!"

In addition to the Lifetime and Special Achievement Awards for educators, AISC presents the Terry Peshia Early Career Faculty Awards to tenure-track faculty who demonstrate exceptional promise in the areas of structural steel research, teaching, and other contributions to the structural steel industry.

To learn more or submit a nomination, please visit **aisc.org/individual-awards**.

Nominations are due October 1, 2023.

What are AISC's individual awards?

Lifetime Achievement Awards honor individuals whose long-term, dedicated service to AISC and the industry as a whole have made a difference in driving innovation forward.

Special Achievement Awards recognize singular achievements in design, construction, education, and research.

In truly remarkable cases, AISC will also present its most prestigious awards.

The J. Lloyd Kimbrough Award honors living engineers and architects who are universally recognized as the pre-eminent steel designers of their era. Past winners of the Kimbrough Award include Ludwig Mies van der Rohe (1961), Othmar A. Ammann (1964), Fazlur R. Khan (1973), and Leslie E. Robertson (2001). The award was most recently presented in 2022 to David I. Ruby of Ruby + Associates.

The Robert P. Stupp Award for Leadership Excellence is a special honor for those who have demonstrated unparalleled leadership in the steel construction industry. AISC has presented it to only ten individuals since 1998, including David Zalesne of Owen Steel Company (2023), Duane K. Miller of The Lincoln Electric Company (2016), Daniel R. DiMicco of Nucor Corporation (2012), and Robert D. Freeland of Havens Steel Company (2002).

The Geerhard Haaijer Award for Excellence in Education recognizes those who, through research and teaching, have had a profound and lasting impact on advancing the use of structural steel framing in the construction industry. Only nine individuals have won the Haaijer Award since 1999; they include Theodore V. Galambos of the University of Minnesota (1999), Lynn S. Beedle (2003) and John W. Fisher (2006) of Lehigh University, and Bruce R. Ellingwood of Colorado State University (2018). The award was most recently presented in 2023 to Michael Engelhardt, PE, PhD, of the University of Texas at Austin.


Chris Jenkins

People & Companies

AISC is pleased to present the first AISC Honorary Member Award since 2013 to **Lawrence F. Kruth, PE**, for nearly five decades of service in the structural steel industry.

In addition to spending close to 40 years at Douglas Steel Fabricating, Kruth served as AISC's vice president of engineering and research for six years and devoted his career to safety volunteer work.

Kruth is only the 14th person to receive honorary membership, and his name sits among other major contributors to AISC and to the steel industry as a whole. When he found out he had received the Honorary Member award and saw the recipients that came before him, Kruth felt honored to be "in the same class," he said.

"It is a great honor to have received that same award as the late Fernando Friás, a founding member of the Mexican Institute of Steel Construction," Kruth said. "I knew Fernando for many years since he served as an advisory member to the AISC Committee on Specifications. One of his most notable accomplishments for me was translating the AISC *Specification* to Spanish for use in Mexico."

Throughout his years of service, Kruth helped develop and refine several of AISC's safety initiatives, including a program that helps almost every person on staff receive CPR training and certification. He is held in high esteem for his expansive knowledge of safety, contractual matters, connection design, and quality control and assurance.

"I'm very pleased to see Larry recognized with this award," said AISC President Charlie Carter. "He has been a tireless resource and volunteer for AISC—even more so when he joined the staff. The entire design community and steel construction industry has benefitted from Larry's contributions."

AWARDS

There's Still Time to Submit Projects for AISC's IDEAS², NSBA's Prize Bridge Awards!

Do you have an award-worthy building or bridge project? There's still time to enter it into this year's AISC IDEAS² Awards or NSBA's Prize Bridge Awards competitions. The deadline for both programs is September 30.

AISC's Innovative Design in Engineering and Architecture with Structural Steel (IDEAS²) Awards recognize outstanding projects that illustrate the exciting possibilities of structural steel. They are the industry's most prestigious design honor for building structures.

Previously, awards were given based on the size of a project. AISC has now updated the competition to focus more on innovation regardless of the project's budget.

"There's so much innovation in the design community and industry today across all budgets," said AISC President Charles J. Carter, SE, PE, PhD. "Dollars are no longer the best way to categorize structures. Instead, we're looking for the best projects in the country that highlight specific unique advantages of working with structural steel—things like sustainability, adaptability, cost, speed, reliability, and resilience."

The judges will present IDEAS² Awards for:

- Excellence in Engineering—for projects that take full advantage of the flexibility of a steel structural system and demonstrate the use of new design and construction techniques
- Excellence in Architecture—for projects that use structural steel to create breathtaking structures that inspire and serve the communities around them
- Excellence in Sustainable Design and Construction—for projects that use design and construction methods that reduce a project's carbon footprint
- Excellence in Adaptive Reuse—for projects that capitalize on how easy it is to use steel to give a structure a second life
- Excellence in Constructability—for projects that utilize innovative design, project management, and construction methods that simplify, economize, and speed up the design and construction of steel buildings

What's at stake? Winners will be invited to present their project to the industry at the Architecture in Steel Conference, which is incorporated into NASCC: The Steel Conference (March 20–22, 2024, in San Antonio, Texas). They'll also be featured in the May 2024 issue of *Modern Steel Construction* magazine and in other AISC media throughout the year.

The IDEAS² Awards showcase the innovative use of structural steel in:

- the accomplishment of the structure's program
- the expression of architectural intent
- the application of innovative design approaches to the structural system
- leveraging productivity-enhancing construction methods

IDEAS² Awards don't only go to high-profile projects. In recent years, AISC has honored everything from public transit projects to monumental stairs to jaw-dropping high-rises. We're looking for innovation and imaginative design in all its forms!

Visit **aisc.org/ideas2** for more information and to enter.

New to the Prize Bridge Awards program this year is a special award to celebrate owners who are on the cutting edge of innovation. This new Owner of the Year award is specifically for the DOTs, counties, cities, tollways, and other owners around the country whose innovative steel project(s) move the industry forward.

"We're looking for outstanding bridges that showcase and celebrate the innovative use of structural steel," said Carter.

The panel of industry-expert judges will also consider entries in several categories defined by bridge size and function, weighing each project's innovation, economics, aesthetics, design, and engineering solutions. The judges will also consider innovation, advancement of the industry, economics, design, design/research, engineering solutions, and project delivery methods when evaluating submissions, and they will give higher priority to projects by in-house design and/or research teams.

NSBA will also present the Bridge of the Year award to the most significant recently completed bridge in America. The judges will select three finalists from all bridges entered in the competition. The teams behind those three projects will have the opportunity to present their projects to the industry during the first session of the World Steel Bridge Symposium in San Antonio, Texas (March 20–22, 2024) before the audience votes to choose a winner!

Eligible bridges must be:

- Built of structural steel produced and fabricated in the United States
- Located in the U.S., defined as the 50 states, the District of Columbia, and all U.S. territories
- Completed and opened to traffic between September 9, 2021 and August 31, 2023.

Any team member from an eligible bridge project may submit it for award consideration at **aisc.org/prizebridge**.

Hadley Fruits

HDR

BOARD OF DIRECTORS

AISC Board of Directors Appoints Four New Members

The AISC Board of Directors appointed four new board members at its most recent meeting in Middleburg, Va.

The board voted to approve Corey Yraguen (Precision Build Solutions, LLC), Margaret Williams (A. Lucas & Sons Steel), Kelsey DeLong (DeLong's, Inc.), and Todd Weaver (Metals Fabrication Company, Inc.), who were nominated to fill vacant seats through the end of their terms.

Yraguen is the CEO and president of Precision Build Solutions, LLC (formerly Tampa Tank/Florida Structural Steel) in Gibsonton, Fla. He also serves on the Rev1 Energy Board of Directors and the Precision Build Companies Board of Members.

Williams is the CEO of A. Lucas & Sons Steel in Peoria, Ill., where she has also served as president since 2006. She is a visiting professor at and alumna of Bradley University, from which she holds two Bachelor of Science degrees in construction and political science.

DeLong is president and a third-generation co-owner of DeLong's, Inc., in Jefferson City, Mo. She received a Tax LL.M. from Washington University School of Law, a J.D. from Washburn University School of Law, and a B.S.B.A. in finance from the University of Missouri-Columbia. She is currently attending Harvard Business School's Owner/President Management program.

Weaver is the CEO, president, and owner of Metals Fabrication Company, Inc., in Airway Heights, Wash., where he has served since 1989. He also serves as a board member and executive team member for the West Plains Chamber of Commerce.

Letter to the Editor

Of Threads and Lubrication

A colleague alerted me to the response by Larry Kruth regarding the effect of threads within the grip upon bolt breakage during installation in the July 2023 Steel Interchange item "Minimum Thread Requirement within the Bolt Grip" (**www.modernsteel.com**). In his response, Larry says, "...the most common cause of bolts breaking during installation is over-lubrication." In general, I don't believe this to be true for standard hex-head bolts. The basis for his statement is his experience with "twist-off bolts," which rely upon the torque-tension relation of the fastener. The manufacturer tunes the lubrication and the shear strength of the splined to produce the required tension.

Larry indicated that he has experienced situations where the lubrication reduced the torque required to produce the bolt tension such that bolts were tensioned above their tensile strength prior to shearing the splined end of the bolt. This certainly is a problem and should be caught during the preinstallation verification test of the fastener assembly. The bolts should have been returned to the supplier since they did not meet the requirements of the *RCSC Specification for Structural Joints Using High-Strength Bolts* (**aisc.org/specifications**). The Commentary of the *RCSC Specification*, on page 16.2-19, states that the lubrication of twist-off bolts may only be applied by the manufacturer. Lubrication of these bolts should not be done in the field; it is the responsibility of the bolt supplier.

The proper answer to the question asked concerning threads in the bolt grip is:

Yes, too few threads in the grip reduce the ductility of the fastener, causing the strain in the threaded length in the grip to exceed the fracture strain. The solution is to increase the number of threads in the grip by adding an additional washer at each end of the bolt. Adding a washer under the bolt head may cause the threads to be in the shear plane under the nut and should be checked if the connection was designed with threads excluded from the shear plane. Some inspectors incorrectly require that the bolts extend a minimum length beyond the nut, which reduces the number of threads in the grip. Research has shown that a bolt needs to extend only to the face of the nut, not stick out. Threads extending beyond the nut do not influence the performance of the fastener.

Loss of lubrication due to improper storage of the fasteners reduces the bolt's ductility. The loss of ductility is caused by the larger torsional forces transmitted by bolt threads from the rotation of the nut, causing the bolts to fracture during installation. The *RCSC Specification* allows standard hex head bolts to be cleaned and relubricated, followed by an installation verification of the fastener assembly, and page 16.2-19 lists the fastener assembly that may only be relubricated by the manufacturer since the acceptability of their installation is dependent upon specific lubrication. As noted on page 16.2-9, nuts used for plain Grade 150 (A490) are often specified with a lubricant to reduce the tightening effort and increase their ductility.

—Karl H. Frank

Professor Emeritus, University of Texas

Response from Larry Kruth:

Thank you, Karl, for your expansion on the issue of having too few threads in the grip. Presently, neither AISC nor RCSC has a requirement for having a minimum number of threads in the grip. I agree that too little lubrication may cause a loss of ductility in fasteners.

I agree that if over-lubrication is discovered during preinstallation verification testing of a fastener assembly using tension-control (TC) bolts, the bolts should be returned to the manufacturer. What I have experienced, and what ironworkers have related to me, is that even after performing preinstallation verification testing of TC bolts and having them successfully pass this testing, they have experienced TC bolts breaking during installation. This is due to the fact that twist-off type bolts may have considerably lower pretension in cold weather and considerably higher pretension in hot weather. It's the same amount of lubrication in both cases, but the behavior of the lubrication changes, potentially causing the bolts to break.

To advertise, contact Geoff Weisenberger: 312.493.7694 | **weisenberger@aisc.org**. Search employment ads online at **www.modernsteel.com**.

advertiser index

Blake Marvin, HKS Inc.

Looking Back at (Really) Long Spans

SEPTEMBER SERVES as a shift.

Summer is coming to an end, fall is just around the corner, school is recently back in session, and, of course, football season has just started.

Speaking of the latter, 14 years ago, the Dallas Cowboys started playing football in their new home, AT&T Stadium. Staying true to the mantra "Everything is bigger in Texas," the stadium sported the world's longest single-span roof structure, supported by twin steel box arch structures (each weighing 3,250 tons) that spanned nearly a quarter-mile between abutments, the world's largest operable glass doors—180 ft wide by 120 ft high—at each end of the structure, the world's largest center-hung video display board (at 25,000 sq. ft), and one of the world's largest dome structures, with a roof area of 660,800 sq. ft.

To take a trip down football memory lane and read about the project, check out "Going Long" in the December 2008 issue and the IDEAS^2 Awards coverage in the May 2010 issue, both available in the Archives section at **www.modernsteel.com**. And if you want to read about the NFL's newest spectacular structural steel stadium roof, check out the coverage of SoFi Stadium, home to the Los Angeles Rams and Los Angeles Chargers, in the 2023 IDEAS^2 Awards coverage in the May 2023 issue. ■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