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Michael Robinson

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ON THE COVER: GEODIS Park showcases steel as a structural and architectural element, p. 26. (Photo: Tom Harris)

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editor's note

I *may* have mentioned it before, but May is one of my favorite months (see what I did there?).

One reason is that it's Maibock season ("Mai" is German for May, which is the perfect month to drink this style of beer). In the interest of transparency, I'm actually drinking a Märzen, or Festbier, in this photo, which is the go-to beverage for Oktoberfest celebrations. That beer type is traditionally brewed in March, which is the month in which I'm writing this note, so there you go.

Another reason I love May is because every year, the May issue of *Modern Steel Construction* features the winners of AISC's IDEAS² Awards. This program recognizes projects that illustrate the exciting possibilities of building with structural steel—and it did so in a new way this year.

Traditionally, entries were organized by overall project budget, with each monetary range producing overall and merit winners. This time around, the jury of industry experts looked for projects that took full advantage of the specific benefits—like sustainability, cost, speed, reliability, and resilience—that make structural steel the best choice for designers.

This year's winners include two soccer-specific stadiums in St. Louis and Nashville, a new terminal lobby and international arrivals addition at Nashville International Airport—including a sweeping canopy inspired by the contours of a guitar—a pedestrian bridge at an Emory University medical facility in Atlanta, a mixed-use building at New York University that stacks residential space atop athletic and performing arts facilities, and an awe-inspiring atrium at a high-tech company headquarters in San Jose, Calif. Find out about all of them starting on page 26.

Full disclosure: Not only are the projects fantastic, but it's also pretty nice to receive a cluster of detailed project descriptions and beautiful images all at once. It makes me want to run awards programs on a regular basis. Oh, wait. We already do that.

In addition to the IDEAS² Awards, AISC and the National Steel Bridge Alliance (NSBA) also recognize superior steel bridges via the Prize Bridge Awards, a program that was launched in 1928 as the Prize Bridge Competition as a way to showcase steel bridge excellence. Today's Prize Bridge Awards recognize bridges on a biennial basis, and we'll be featuring the winners of the 2024 competition in the July issue.

And then there's the Forge Prize, an annual competition that celebrates emerging architects who create visionary designs that embrace steel as the primary structural component while exploring ways to increase project speed. For example, last year's overall winner was a design concept that would use structural steel to reinvent the gas station experience for the electric vehicle age and its requisite charging wait times. You can read about this year's winners in the August issue.

At the end of the day, *Modern Steel Construction*'s mission is two-fold: One, we provide practical technical information that helps you get the most out of your steel projects. And two, we showcase successful and attractive projects and design concepts—and we work to highlight the best of the best when it comes to the latter goal.

For the full archive of IDEAS² winners—including predecessor programs dating back to the 1960s—visit **aisc.org/ideas2**. And for more on all of the awards mentioned here—as well as the plethora of awards we give to industry experts and students—check out **aisc.org/awards**. Our industry has plenty of people and projects to celebrate, and our awards programs help encourage those that go above and beyond to reach even higher and push even farther. Here's to all of our winners! Prost!

Geoff Weisenberger
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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**.

Existing Shape Size Search

I am developing an as-built analysis model and have come across a beam size I cannot find in the 16th Edition *Steel Construction Manual* tables. Did I come across an obsolete wide flange beam size?

It is likely that you have come across an obsolete shape size. Consider the following questions to help narrow your search:

- When was the building constructed?
- Are the flanges of the shape tapered? (perhaps it is an S-shape)
- If you field-measured the beam, what is your confidence in the accuracy of your measurements?

The answers to these questions may help you narrow the search. Section properties for historic, obsolete, or discontinued shapes can be found in one of three main places:

Historic AISC Manuals (available to AISC members): An old *Manual* from the time period of the structure may include the properties for the shape. Historic manuals are available at **aisc.org/oldmanuals**.

AISC Design Guide 15: *Rehabilitation and Retrofit*: Chapter 5 of Design Guide 15 includes reference data (cross-sectional dimensions and properties) for steel shapes (wide-flange or I-shaped cross sections) that have been discontinued from 1887 to present day. Similar data are included for wrought iron cross sections, which were phased out around 1900. This data is also contained in an Excel version in our historic shapes database, which can be downloaded for free at **aisc.org/shapesdatabase**.

Historic Shape References: Historic shape references are the shape catalogs of the various producers at the time. Many historic references can be found at **aisc.org/oldshapes**.

Be cautious with field measurements. For many reasons (such as presence of corrosion, the accuracy of the measuring instruments, and physical access to the section), measurements taken in the field may vary dramatically. Shapes have dimensional tolerances, so the section dimensions are inherently allowed to vary a bit during manufacturing. All of that to say it is unlikely one will find a perfect match for all the section properties. It is usually best to pick a section property or two that can be measured confidently, say the depth and flange width, and then find a section that best matches those measurements to start.

Yasmin Chaudhry, PE

Third-Party Inspection

When the owner hires a third-party inspector to perform inspections (Quality Assurance) in a fabricator's facility, does the third-party inspector have to provide the fabricator with a report of the findings from the inspection?

Yes, as a fabricator, you must receive a copy of all third-party inspections performed in your shop. *The Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-22, download at **aisc.org/standards**) states in Section 8.5.5:

"The fabricator, erector, ODRD, and the owner's designated representatives for construction (ODRC) shall be informed of deficiencies that are noted by the inspector promptly after the inspection. Copies of all reports prepared by the inspector shall be promptly given to the fabricator, erector, ODRD, and ODRC. The necessary corrective work shall be performed in a timely manner."

The *Code* uses the term "promptly" with no explanation in Section 8.5.5 regarding what "promptly" means. To help to clarify this, Section 8.5.2 states:

"Inspection of shop work by the inspector shall be performed in the fabricator's shop to the fullest extent possible. Such inspections shall be timely, in-sequence, and performed in such a manner as will not disrupt fabrication operations and will permit the repair of nonconforming work prior to any required painting while the material is still in-process in the fabrication shop."

This clarifies the inspection should take place in a manner that will not disrupt work in the shop and that it is performed timely so you can repair deficiencies the third-party inspector discovers.

Section N7 of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360-22) states, "Identification and rejection of material or workmanship that is not in conformance with the construction documents is permitted at any time during the progress of the work. However, this provision shall not relieve the owner or the inspector of the obligation for timely, in-sequence inspections. Nonconforming material and workmanship shall be brought to the immediate attention of the fabricator or erector, as applicable.

"Nonconforming material or workmanship shall be brought into conformance or made suitable for its intended purpose as determined by the EOR.

"Concurrent with the submittal of such reports to the AHJ, EOR, or owner, the QA agency shall submit to the fabricator and erector:

(a) Nonconformance reports
(b) Reports of repair, replacement, or acceptance of nonconforming items"

Larry Kruth, PE

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

STEEL SOLUTIONS CENTER

Filler Plate Thickness

Section J3.9 in the 2022 *Specification*, which addresses high-strength bolts in slip-critical connections, includes an h_f factor for fillers equal to 1.0 for one filler between connected parts and 0.85 for two or more fillers between connected parts. Section J5.2 includes a reduction in the bolt shear strength in bearing-type connections based on the thickness of the filler plate. Is it correct to say that for slip-critical connections, there is no reduction in bolt shear strength due to filler thickness?

No. A slip-critical connection does not resist movement of the plies through bolt shear strength. A slip-critical connection resists movement of the plies through friction. The slip resistance is not affected by the thickness of the fills as demonstrated in the research linked below.

Specification Section J3 states, "Slip-critical connections shall be designed to prevent slip and for the limit states of bearing-type connections." Designing "for the limit states of bearing-type connections" would include consideration of *Specification* Section J5.2, which reduces the bolt shear strength in a manner that is dependent on the thickness of the filler.

It is often the case that the slip resistance of the joint will govern. However, the presence of thick fills and/or the use of Class B faying surfaces can alter this relationship.

The *Specification* Commentary states, "Fillers in Slip-Critical Connections. Borello et al. (2009) indicated that filler thickness did not reduce the slip resistance of the connection. Borello et al. (2009) and Dusicka and Lewis (2012) indicated that multiple fillers reduced the slip resistance. It was determined that a factor for the number of fillers should be included in the design equation. A plate welded to the connected member or connection plate is not a filler plate and does not require this reduction factor."

The Borello research can be viewed for free at **www.ideals.illinois.edu/items/13597**.

Larry Muir, PE

Yasmin Chaudhry (**chaudhry@aisc.org**) is a senior engineer in AISC's Steel Solutions Center. **Larry Kruth** is AISC's former vice president of engineering and research, and **Larry Muir** is a consultant to AISC.

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**.

The opinions expressed in Steel Interchange do not necessarily represent an official position of the American Institute of Steel Construction and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principles to a particular structure.

steel quiz

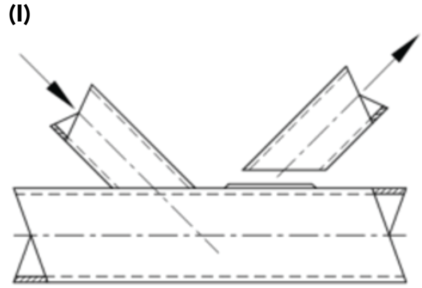
Why did the hollow cylinder become a magician? Because it could make things disappear inside itself, leaving everyone amazed! We think you'll be amazed by the newly updated AISC Design Guide 24: *Hollow Structural Section Connections*, 2nd Edition. This updated guide includes many new connection types, a dozen new examples, and greatly expands upon the background discussion for each connection. Download your copy today at **aisc.org/dg** and test yourself with Part 1 of a two-part quiz on HSS.

1 What is the ideal branch-to-chord thickness ratio for HSS-to-HSS connections?
a. 2:1
b. 1:2
c. 1:1
d. 1:3

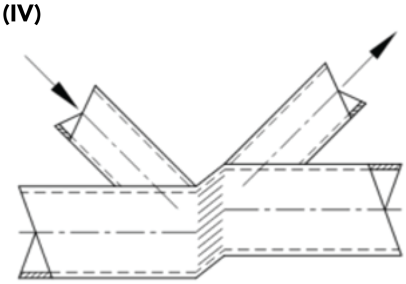
2 Of the following options for different HSS sections, which designation is formatted properly?
a. TS8×8×¼
b. HSS8×10×0.375
c. HSS10.000×0.625
d. Pipe 8×0.322
e. None of the above

3 Match the limit state (failure mode) for HSS-to-HSS connections with the appropriate image, below.
a. Chord plastification
b. Shear yielding of the chord
c. Chord sidewall failure
d. Local yielding of branch in tension due to uneven load distribution
e. Punching shear of the chord
f. Local yielding of branch in compression due to uneven load distribution

(I)



(IV)



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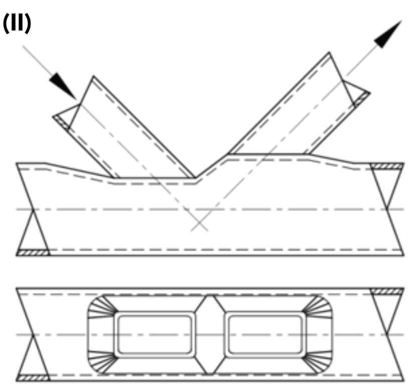

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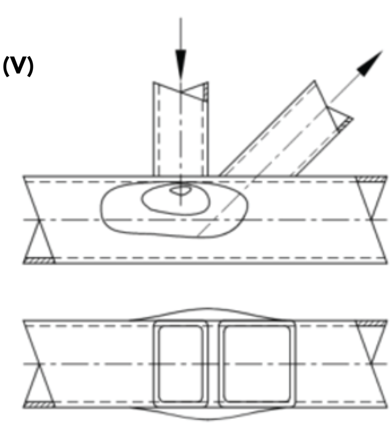

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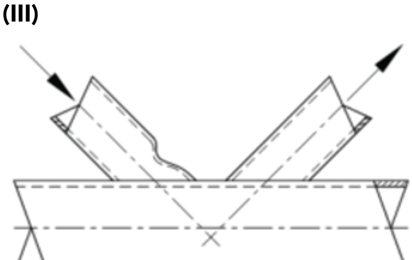
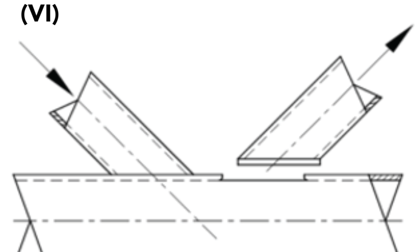


(VI)



TURN TO PAGE 12 FOR ANSWERS

Answers reference the recently published Design Guide 24. Download your copy today at **aisc.org/dg**.

1 **b.** To maximize the strength and stiffness of HSS connections, the through member—the chord in a truss-type connection or the column in a beam-to-column or bracing-to-column connection—should be relatively thick. The ideal branch-to-chord thickness ratio is typically around 1:2 (Section 1.2).

2 **c.** HSS10.000×0.625. Choice (a) is incorrect because the term structural tubing (TS) was replaced by hollow structural section (HSS) in the United States in 1997. Choice (b) is incorrect because rectangular HSS should be designated by the long side followed by the short side (both in whole numbers), followed by the nominal thickness as a fraction. Choice (d) is incorrect because pipe should be designated, up to and including nominal pipe diameter size 12, by the following form: Pipe, nominal diameter (in.), and weight class. Choice (c) is correct because decimal numbers to three decimal places are used for the outside diameter and nominal thickness in the designation of round HSS (Section 1.3).

3 **a.** II **b.** IV **c.** V **d.** I **e.** VI **f.** III
Chapter 2 of Design Guide 24 discusses limit states for HSS connections in detail. The limit states pictured in this question are also found in Figure C-K3.1 of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360-22).

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**.

Bolted Connection Design – A Primer

BY DILLON ALEXANDER, RICHARD M. DRAKE, SE, AND JENNIFER A. MEMMOTT, PE

Tighten up your understanding of the basics of bolted connection design found in the 2022 AISC *Specification for Structural Steel Buildings*.

A HOST OF FUNDAMENTAL PRINCIPLES and limit states dictate bolted connection design, and all are found in the *Specification for Structural Steel Buildings* (ANSI/AISC 360-22).

Specification Chapter J contains most of the requirements for connection design, including those for connecting elements, connectors, and affected elements of connected members. The example connection in Figure 1 shows what comprises each of these connection components.

The connecting elements are the added structural steel components necessary to transmit loads between structural steel members. In the Figure 1 example, they include:

- The splice angles connecting the brace flanges and the gusset plates.
- The splice plates connecting the brace webs and the gusset plate.
- The gusset plates connecting the splice plates, splice angles, and the beam flanges.
- The transverse stiffeners connecting the beam flanges and web.

The connectors are the added structural steel components necessary to transfer loads between the structural steel members and the connecting elements. In the Figure 1 example, they include:

- The bolts between the brace flanges, the splice angles, and the gusset plates.
- The bolts between the brace webs, the splice plates, and the gusset plates.
- The welds between the gusset plates and the beam flanges.
- The welds between the transverse stiffeners connecting the beam flanges and web.

The affected elements are the elements of the structural members that transfer loads through the connection to another structural member element. In the Figure 1 example, they include:

- The brace flanges.
- The brace webs.
- The beam flanges.
- The welds between the transverse stiffeners connecting the beam flanges and web.

Specification Section J1 requires that every connection component be proportioned so the design strength or allowable strength equals or exceeds the required strength. There must be a continuous load path between members that meets all limit states.

For LRFD: $R_u \leq \phi R_n$
For ASD: $R_a \leq R_n/\Omega$

Fig. 1.

Bolt Types

Common bolts: ASTM A307 bolts, known as common bolts, are also known by a variety of other names, including unfinished bolts, rough bolts, ordinary bolts, and machine bolts. They are not listed in the 2020 RCSC *Specification for Structural Joints Using High-Strength Bolts*. They are seldom used today, usually only for lightly loaded applications such as girts, purlins, ladders, stairs, and handrails.

Common bolts cannot be tightened to a predictable tension in the bolt. They must be installed to wrench-tight condition, where the plies have been brought into full contact and each bolting assembly has at least the tightness attained with either a few impacts of an impact wrench, resistance to a suitable non-impacting wrench, or the full effort of an ironworker using an ordinary spud wrench, such that the nuts don't loosen under ordinary service. The plies do not need to be in continuous contact.

High-strength bolts: High-strength bolt requirements are addressed in AISC *Specification* Section J3.2, which groups together bolts with similar material strengths:

- Group 120 bolts include ASTM F3125, Grade A325, and F1852 (tension-controlled), the most commonly specified bolts.
- Group 144 bolts include ASTM F3148 Grade 144 and are only available as proprietary products.
- Group 150 bolts include ASTM F3125, Grade A490, and F2280 (tension-controlled), commonly specified when additional bolt strength is needed.
- Group 200 bolts are not commonly available in the United States, and designers should not specify them unless their availability is confirmed.

High-strength bolts may be slip-critical, pretensioned, or installed to a snug-tight condition. High-strength bolts must be pretensioned in the following occurrences:

- When required by *Specification* Section J3.2(b).
- When required by the AISC *Seismic Provisions for Structural Steel Buildings* (AISC 341).
- When specified on the design drawings by the engineer of record.

If bolts are not specified as slip-critical or pretensioned, they will be installed as snug-tightened.

The pretensioning force (P_b) creates a normal force (N) between the connected materials. (Figure 2). AISC defines the minimum bolt pretensioning force as approximately 0.7 times the tensile strength (F_u) of the bolt material times the gross cross-sectional area (A_g) of the bolt. (See AISC *Specification* Table J3.1)

$$P_b \approx 0.7\ F_u A_g$$

When an external load (P) is applied, a frictional resistance (F) to the external force is developed. (Figure 3).

$$P \leq F = \mu N$$

Where μ is the coefficient of static friction between the connected parts.

Several methods for pretensioning high-strength bolts are prescribed in the RCSC *Specification*, found in Part 16 of the 16th Edition *Steel Construction Manual*.

Size and Use of Bolt Holes

Specification Section J3.3 includes many requirements for bolt holes that are fundamental to economical bolted connection design.

Nominal bolt hole dimensions: The bolt hole size is used in the calculation of several limit states, including bearing, tearout, and block shear. *Specification* Table J3.3 provides standardized nominal hole dimensions (h) for each bolt diameter (d) to ensure that the bolt hole dimension used in the engineering calculations is the same size punched, drilled, or mechanically guided flame-cut by the fabricator. The table includes hole dimensions for Standard, Oversize, Short-Slotted, and Long-Slotted holes. Standard holes and short slots are the most used in practice.

- For Standard holes with bolt diameters ⅞ in. and less: $h = d + \frac{1}{16}$ in.
- For Standard holes with bolt diameters 1 in. and larger: $h = d + \frac{1}{8}$ in.

Edge distance: Edge distance (L_e) is the distance from the center of a bolt hole to the adjacent edge of a member, in any direction. Edge distance requirements are important to ensure that there is sufficient steel on all four sides of a bolt hole to allow force transfer around the hole and to the bolt.

AISC *Specification* Table J3.4 defines the minimum edge distance for standard holes. *Specification* Table J3.5 defines the additional edge distance required for Oversize, Short-Slotted, and Long-Slotted holes.

Spacing: Spacing (s) is the distance from the center of a bolt hole to the center of the adjacent bolt hole, in any direction. AISC *Specification* Section J3.4 requires a minimum center-to-center distance between bolt holes of $2\frac{2}{3}d$ to allow room for tools used to tighten the bolts. The *Specification* prefers a center-to-center distance of $3d$. Based on fabricator tooling considerations, the industry standard bolt spacing is 3 in. in any direction.

Specification Section J3.7 requires a maximum center-to-center distance between holes of 12 times the thickness of the connected part, not to exceed 6 in.

Bolted Connection Limit States

Shear strength: AISC *Specification* Section J3.6 defines the nominal shear strength of the bolt as the nominal shear stress (F_{nv}) of the bolt material times the unthreaded area (A_b) of the bolt shank.

$$R_n = F_{nv} A_b$$

The nominal shear stress of the bolt material is tabulated in *Specification* Table J3.2.

For common bolts, the shear stress values assume that the shearing of the bolt is through the threaded part of the shank (threads not excluded). For high-strength bolts, separate shear stress values are provided for when shearing of the bolt is across the threaded part of the shank (threads not excluded) and when the shearing of the bolt is across the unthreaded part of the shank (threads excluded). It is common practice to assume that the threads are not excluded and to use the lower stress values, unless designs ensure that the threads will be excluded.

Tension strength: *Specification* Section J3.7 defines the nominal tension strength of the bolt as the nominal tensile stress (F_{nt}) of the bolt material times the unthreaded area (A_b) of the bolt shank.

$$R_n = F_{nt} A_b$$

The nominal tensile stress of the bolt material is tabulated in *Specification* Table J3.2.

For common bolts and high strength bolts, the tensile stress values assume that the tension strength is limited by the threaded part of the shank (threads not excluded).

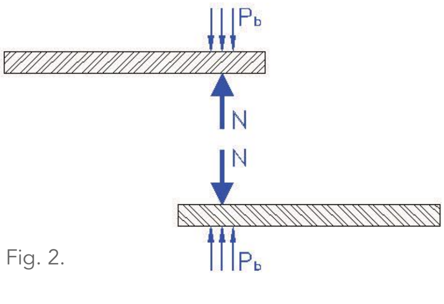


Fig. 2.

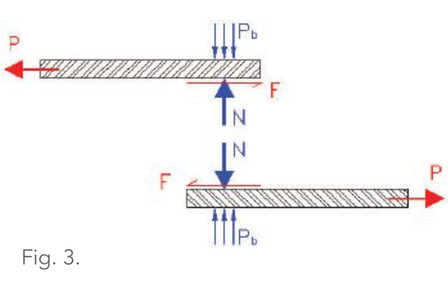


Fig. 3.

Slip resistance: *Specification* Section J3.9 defines the nominal slip resistance strength of the bolt as the mean slip coefficient (μ) times the pretension force (T_b) times several adjustment factors (D_u, h_f, n_s).

$$R_n = \mu D_u h_f T_b n_s$$

Where:

μ = values are specified based on the surface preparation of the connected parts.

D_u = is a statistical multiplier, usually taken as 1.13.

h_f = filler factor, taken as 1.00 unless there are two or more filler plates between the connected parts.

T_b = pretensioning force specified in *Specification* Table J3.1.

n_s = number of slip planes affected by the pretensioning force.

Bearing strength: *Specification* Section J3.11 defines the nominal bearing strength of the connected material at bolt holes. To prevent excessive hole elongation, the diameter of the bolt shank is treated as if it is bearing on the connected steel material.

The nominal strength is defined as a bearing area times a material strength. The bearing area is defined as the bolt diameter (d) times the thickness (t) of the connected material. The material strength is defined as 2.4 times the tensile strength (F_u) of the connected steel material.

$$R_n = (dt)(2.4F_u)$$
$$R_n = 2.4dtF_u$$

The 2.4 has been established by research to limit the elongation of the bolt hole caused by the straining of the ductile connected steel material adjacent to the hole in the direction of loading.

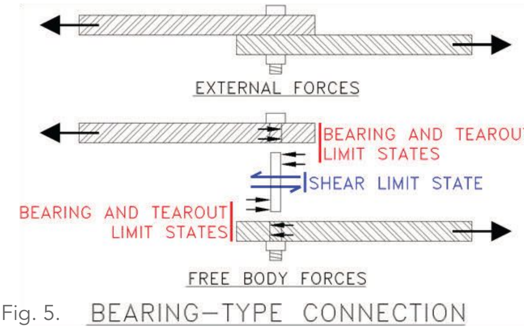


Fig. 5.

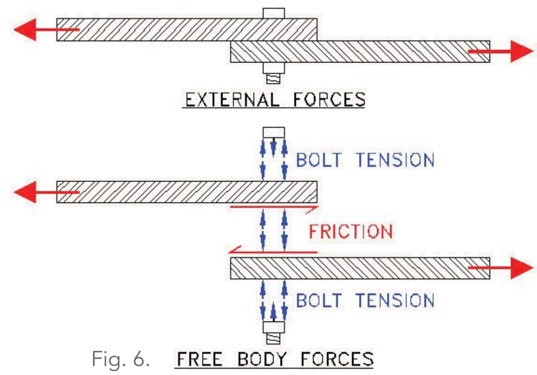


Fig. 6.

Tearout strength: *Specification* Section J3.11 defines the nominal tearout strength of the connected material at bolt holes. To prevent the bolts from tearing out between the bolt holes and between the edge bolt hole and the connected material edge, assume that the connected material fails in shear in the direction of load radiating from opposite edges of the bolt holes. (Figure 4).

L_c is defined as the clear distance in the direction of force from the edge of the bolt hole under consideration to the edge of either the next hole or the edge of the connected material edge.

- For edge bolts: $L_c = L_e - h/2$
- For other bolts: $L_c = s - h$

The nominal strength is defined as a shearing area times a material strength. The shearing area is defined as two times the clear distance (L_c) times the thickness (t) of the connected material. The material strength is defined as 0.6 times the tensile strength (F_u) of the connected steel material.

For edge bolts and other bolts:

$$R_n = (2L_ct)(0.6F_u)$$
$$R_n = 1.2L_ctF_u$$

Edge bolts and other bolts will have different values because they will have different clear distances (L_c).

For bolts in shear, the effective strength of an individual bolt may be taken as the lesser of the bolt's shear strength or the controlling bearing and tearout strength at the bolt hole. The strength of the bolt group may be taken as the sum of the effective strengths of the individual fasteners.

Connection Types

Bearing-type connections: High-strength bolts may be installed to the snug-tight condition and used in bearing-type connections. The shear, bearing, and tearout limit states must be considered to ensure force transfer between the connected parts. (Figure 5).

Slip-critical connections: Only high strength bolts may be used in slip-critical and pretensioned connections. The shear, bearing, tearout, and slip-resistance limit states must be considered to ensure force transfer between the connected parts. (Figure 6).

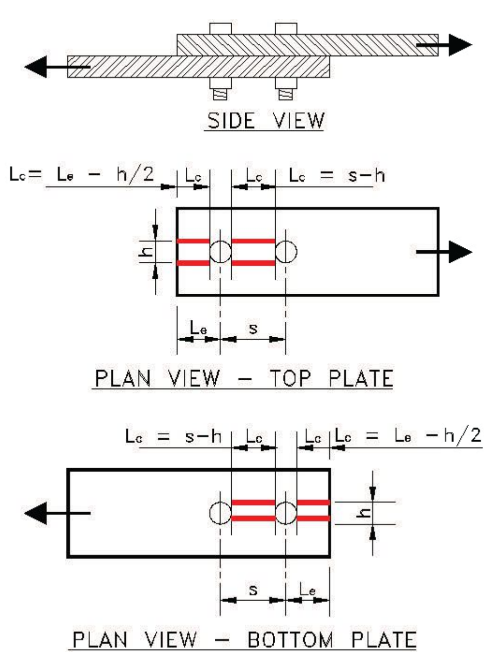


Fig. 4.

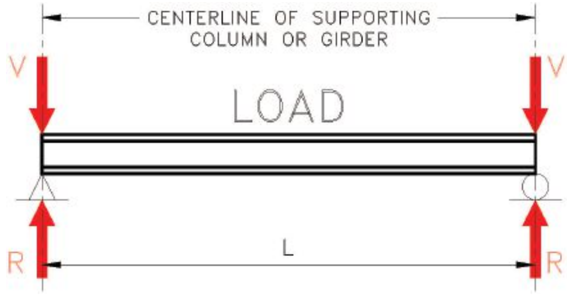


Fig. 7.

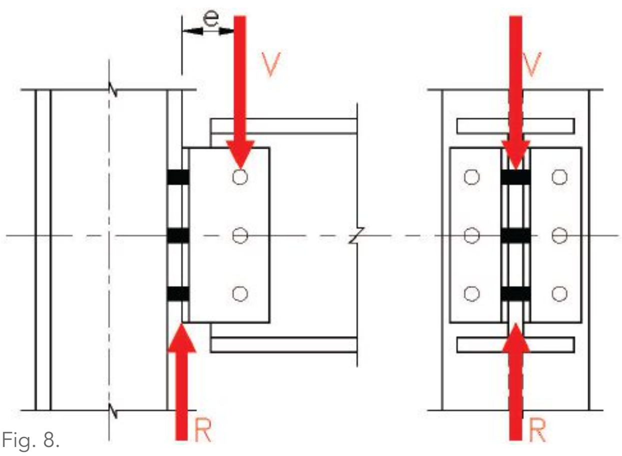


Fig. 8.

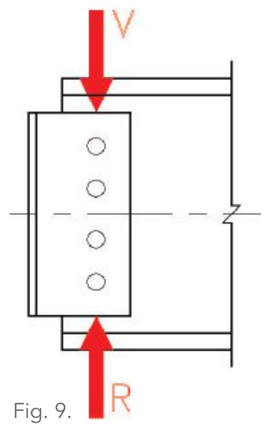


Fig. 9.

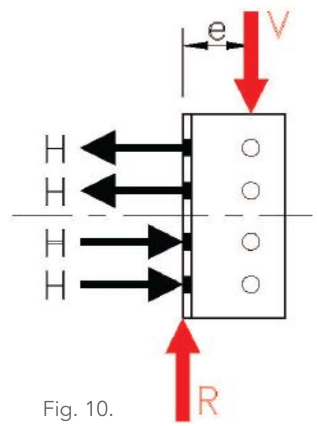


Fig. 10.

Combined Shear and Tension and Fasteners

Loadings through the center-of-gravity of a connection can put individual bolts into a condition of simultaneous shear and tension loading. The design concept for this loading is that if some bolt strength is used for shear, it is not available for tension. The AISC *Specification* provides different interaction relationships for bearing-type and slip-critical connections.

Bearing-type connections: *Specification* Section J3.8 address combined bolt tension and bolt shear in bearing-type connections. For this type of connection, a bolt's tensile strength is reduced by the presence of simultaneous applied shear forces on the bolt. An elliptical interaction relationship (see Fig. C-J3.2 in the commentary) is approximated in the *Specification* by three straight lines:

- If the applied shear force is low, the bolt is considered as loaded in tension only.
- If applied tension force is low, the bolt is considered as loaded in shear only.
- For other situations, the available tensile stress is reduced to account for the effect of simultaneous shear stresses.

Limit states to consider in design of bearing-type connections are shear, bearing, tearout, and combined tension and shear.

Slip-critical connections: *Specification* Section J3.10 addresses combined bolt tension and bolt shear in slip-critical connections. For this type of connection, the slip resistance of a bolt is reduced by the presence of simultaneous applied tension forces on the bolt.

- The external tension force reduces the pretension force.
- This reduced pretension force results in a reduced normal force and therefore, a reduced slip resistance.

Limit states to consider in design of slip-critical connections are shear, bearing, tearout, slip resistance, and combined tension and shear.

Connection Design Examples

Beam end connection: In basic structural analysis, beams are analyzed by assuming that the shear transfer occurs at the reaction location. (Figure 7). In practice, there are connecting elements and connectors to transfer loads from the beam to the supporting column or girder. (Figure 8). This connection is really two separate connections, connection of beam web to double angles and connection of double angles to the column flange.

Beam to double-angle connections: The transfer of the beam reaction shear (*V*) to the connecting element goes through the center of the four connecting bolts. (Figure 9). There is no eccentricity in this connection between the beam end shear (*V*) and the double-angles' reaction (*R*). All the bolts are equally loaded in double shear.

Limit states to consider in design are shear in the beam web, bearing on the beam web, bolt shear, shear in the double-angle legs, and block shear rupture of the angle or beam.

Double-angle to column-flange connection: The transfer of the beam reaction (*V*) by the connecting element from the beam web to the column flange involves an eccentricity (*e*). (Figure 10).

To keep the connection in static equilibrium, designers can take moments about the center of gravity of the bolt group. The moment created by the shear load (*V*) times the eccentricity (e) must be balanced by horizontal reactions (H) at the column flange times their eccentricities. When evaluating H, assume plastic behavior in the bolts and the neutral axis at the center of gravity of the bolt group (see Case II, Part 7 of the *Manual*). In this case, all bolts resist their share of shear, while only the bolts above the center of gravity are assumed to resist tension. This case results in a direct solution slightly more conservative than another approach to shear and tension on bolts in the *Manual* (Case I, Part 7). Either case may be used for design.

Limit states to consider in design are flexure in the double angles, shear in the double angles, combined shear and tension (including effects of prying action) on the upper bolts, bearing on the double-angle legs, block shear rupture of the angles, and bearing on the column flange.

Read More

For a more in-depth look at bolted connection design, see AISC Design Guide 17: *High-Strength Bolts – A Primer For Structural Engineers* available at **aisc.org/dg**. ■

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Making His Own Name

INTERVIEW BY GEOFF WEISENBERGER

David J. Odeh's father helped steer him into engineering and to the family company, where he has become a widely respected voice in his own right.

DAVID J. ODEH stops short of calling his choice to enter the family profession and later join the family business inevitable. It was, though, a path that intrigued him from a young age the more he saw it up close.

Odeh's father, M. David Odeh, is a lifelong structural engineer and founded Odeh Engineers in 1978. First, the younger Odeh took up his dad's profession. Later, after a trip to the West Coast for graduate school and a couple stops at other firms, he joined his father's company in 1998. He remains there now as a principal and helped oversee WSP's acquisition of the firm in 2022. He has long since made his own name in the engineering world.

Recently, Odeh was a keynote speaker at SEICon24 in San Antonio and discussed one of his current projects: A film called *Cities of the Future: Reimagining our World*, presented by ASCE and produced by MacGillivray Freeman Films. The 40-minute film was released in February 2024 and will become more widely available over the rest of the year.

Odeh spoke with *Modern Steel Construction* about his career, working for his father's company, the film and more.

What got you into engineering?

I always tagged along with my dad to construction sites as a kid. I loved big machines as a little kid, and I really wanted be a bulldozer driver—still do. My mom and dad were both really nurturing to me and my interests and what I wanted to do. I worked with my dad after school, and I really fell in love with programming computers and digital tools.

I grew up in the 1980s when personal computers were becoming really popular, and I discovered that you could really apply everything I loved about computer programming and digital tools to structural engineering. It became a great path for my academic studies and later in my career as an engineer.

Early in your career, or even growing up around engineers, were there certain buildings or structures that inspired you or were memorable for you?

I've always loved how historic and new architecture come together. My hometown of Providence, R.I., is a unique city because it's blessed with some incredible old buildings, like our historic state house. We have some very beautiful Art Deco buildings from the 1920s and 1930s. It has an amazing history of different types of structures and new buildings that are being built every year. A lot of my fascination with structural engineering was driven by the idea that I could have a part in building these buildings, making them happen or giving them new life.

One of my dad's projects back in early 1980s was the transformation of Providence's historic railroad station into offices and restaurants—a mixed-use complex. It involved all sorts of historic studies of the old steel framing, rivets, and beautiful structures, and then preserving and reusing them. They added new floors inside the building and changed the roof profile for some of the buildings.

Seeing the process of that transformation was really fascinating, and it inspired me to do this for my career and make a difference in cities and in the fabric of our urban infrastructure.

What's it like working in the family business, and was it inevitable that you would eventually work in the family business?

I don't know that I would say inevitable, but was certainly something that I always had on my mind. I went to grad school at the University of California and worked in a different market, and I think that was important for me and my career to learn from other companies. I worked at a couple other companies before I worked with my dad, and that really informed a lot of my knowledge and technical practices. It gave me a great perspective. It was really critical to our later success as a company.

My dad is an incredible mentor to me and a wonderful person. He really gave me the freedom to help build the business in a way that we could feel like we were both engaged and it was about both of us. It wasn't just about his legacy. It was about creating something for the two of us. I owe him an incredible debt for that.

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**.

That's what I think made us successful—the ability to explore new things, explore new ideas, and not just kind of go down one path. Odeh Engineers became really well-known 15–20 years ago. He was starting to use digital design tools and our custom-developed technologies, like 3D visualization systems. We were one of the early adopters of building information modeling. We developed our own software to link building information modeling tools and structural analysis tools. All that was on the cutting edge of the way the structural engineers practice.

It made it really exciting for us, and it also shined a light on our firm, even as a small company. Many people in the industry started to recognize us as innovators who could help the profession advance in the way that we practice. My dad created that unique environment, and then the two of us worked together to build this practice where our team could thrive.

How has the firm evolved and expanded, and how did you become part of WSP?

We started in Providence, and we attracted some really great clients in other parts of the country, particularly in the Boston area, which is a center for architecture and structural engineering. We kept growing and never diminished our goals to take on larger and larger projects. We frequently worked with WSP, and got to know them well.

John Horner

Odeh Engineers designed the tallest building in Cambridge, Mass.

About five or six years ago, we worked together on the tallest residential tower in Boston and the city's tallest building project in some time. It's called One Dalton. We worked not only with WSP's great mechanical, electrical, and plumbing team, but with their structural engineers in New York City. They're well-known and fantastic structural engineers. They were the engineers for great projects, such as One World Trade Center and some of the tallest and most slender structures in the world.

Working together on this Boston project really helped us to get to know each other and learn from each other. We developed a great relationship and decided that we wanted to come together as one firm. That was October 2022. We decided to bring Odeh Engineers to its next stage, which was to become part of the WSP organization.

A big reason why we decided to do it was a continuous drive for growth for our firm and staff. We wanted to give them a newer and bigger platform to grow in their careers. We wanted them to have new challenges and work on the most challenging and complex structures in the world and not be limited by what we do in our region or our specific office. We can learn from a global network of structural engineers.

What are some of your more memorable steel frame projects that made you proud or were a significant challenge?

I had the privilege of working on so many great cool projects over the years. Using structural steel to solve really challenging architecture problems and create elegant solutions for those challenges has been fun.

One of those was transforming Providence's old power plant into a coworking space called South Street Landing. That building is a steel-framed structure from the 1920s. We recently converted it into an academic center. The building was a classic structural steel power plant that almost looks like a cathedral inside. It once housed massive turbines. It had huge bridge cranes inside, some of which were preserved in place. We added multiple steel frame floor levels inside and on top to create penthouse levels—all while doing a lateral force resisting system upgrade to the structure to bring it up to modern codes and then augmenting its foundations to support all these new floors.

It was a real challenge. It took many years and involved all sorts of great technologies. It was one of the first times we used point clouds and laser scanning to scan all the existing structural steel. We had some existing drawings for the building but the single source of truth really needed to be a point cloud so we could see where that steel was.

That's really one of my favorite projects. We finished it a few years ago. It has totally transformed that part of Providence.

Another one that comes to mind is a much more recent project up at Massachusetts Institute of Technology, on Kendall Square in Cambridge. We designed what is today the tallest building in Cambridge, which is not a huge hurdle. It's not like New York, but we're proud of it.

It's a hybrid structure built with a composite system of steel and concrete. It's a cool use of structural steel, because this building's special feature was a long cantilever over a park that had to be accomplished for a variety of reasons. The cantilever is at the fifth floor of the structure. It sticks out almost 50 ft over the park and has about 30 stories on top of it.

We came up with this hybrid composite steel truss system that was used to avoid having shoring on the cantilever when they built the upper parts of the tower. That was important to make the project a success, to build it within the desire time frame so it opened on time, and to avoid impacting the park below that cantilever. There was really careful analysis and modeling to make it a reality.

What went into your involvement in the ASCE-sponsored movie, and what do you expect to be viewers' main takeaways?

I've been deeply involved in an ASCE project called Future World Vision for about five years now. It's a little different than what the engineering profession has seen. It's an initiative to help engineers visualize what will happen to infrastructure in the long-term future—not just what will happen in five years or 10 years or what we need to design for today.

It looks at how buildings, structures, and infrastructure systems need to adapt to cope with trends that could disrupt society. Think of climate change, renewable energy, autonomous vehicles, aerial vehicles, and even policy and funding issues. How will these things come together in the future to shape the cities we're designing today?

That's what Future World Vision is about. It's group of professionals that came together to create scenarios of future cities that aren't necessarily a prediction of what the future will be, but that try to really understand what the boundaries of the future might look like and what we really should be thinking about today.

It's not science fiction. It's based on real ideas our brightest minds are working on today that could help build a better world for the future. The first step in that process was creating these scenario cities. We created a virtual reality world called Mega City 2070. You can see it online at **futureworldvision.org**. You can download it and immerse yourself in what a large-scale, vertically integrated city might look like in 50 years.

The next step in our program was the movie. This film takes the ideas of Future World Vision, shows what engineers are doing today, and how they're building the technologies on display in the Mega City.

It introduces viewers to the engineers working on these things and showcases the technology available now, such as aerial vehicles, advanced materials, new ways of building structures, using robotics, and new ways of thinking about infrastructure. The movie brings all that home for the audience.

Based on that, it seems like adapting current large cities to some of those technologies will be a challenge?

That's part of the challenge of Future World Vision to engineers. We ask them to visualize a future city in 50 years, but tell the story of how we get from today to what you're envisioning in 50 years. What are the steps that we must take? It's not going to happen overnight and it's going to require preserving and perhaps building on top of, around, or augmenting existing infrastructure.

That's a critical part. You'll see that in the visualizations of the Mega City that appear in the movie. We hope that inspires engineers to think a little differently about the way they work. ■

*This article was excerpted from my interview with David. To hear more from him, find the May 2024 Field Notes podcast at **modernsteel.com/podcasts**.*

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

Conquering Delay Damage Claims

BY EDWARD SEGLIAS

Steel fabricators' best response to claims of shop delays is to highlight and clarify the unique nature of their work.

STEEL FABRICATION is unlike most other trade work in the construction industry.

It's performed off-site under controlled conditions and at a fabrication facility that carries substantial direct and fixed costs for labor, materials, equipment, and overhead. Further, unlike on-site trade contractors, fabricators typically lock in production dates for multiple projects months, if not years, in advance of actual delivery.

All these factors mean that project delay or disruption will affect steel fabrication differently than other on-site work, where costs are heavily weighted in on-site labor, equipment, and material.

But the construction community does not always understand the foregoing distinctions. Instead, when steel fabricators assert delay claims, construction industry constituents—like owners, general contractors, and design professionals—often fail to recognize the differences between a fabricator's off-site costs and those of an on-site trade contractor. That's a mistake. And because of it, steel fabricators have in many instances borne a more difficult burden of proof when presenting meritorious claims for delay and disruption.

Recently, I organized a group of steel fabricators and consultants and collaborated on a paper now appearing in the Winter 2024 edition of the *Journal of The American College of Construction Lawyers* (Volume 18, Number 1). The paper sets out the case that fabricator shop overhead claims differ from delay claims presented by on-site contractors. The thrust of the paper argues the usual judicial approaches to delay claim analysis simply are not adequate to understand delay or disruption impacts to steel fabricators.

In fact, it is better to think of steel fabrication like traditional manufacturing, where the costs of production are significant and account for a much greater percentage of the final product sales price.

On-site contractors, though, carry almost no off-site costs.

So how can the construction community's perception of the cost impact of delay on the steel fabricator be changed? To begin, the construction community must understand that steel fabricators do not merely sell steel. They sell project-specific custom fabrication services in plants that are organized to meet the scope, schedule, and quality requirements of multiple projects.

In other words, steel fabricators "sell" their capacity of labor, equipment, and shop space to produce a specific product. As a result, shop costs include direct costs and indirect costs, which must be absorbed by each specific project in the production schedule.

Consider the following example: If a fabrication shop has 60 employees working 2,000 hours per year, its theoretical capacity is 120,000 hours per year. These hours are then allocated to projects on a shop production schedule based on the volume and complexity of each project.

But the theoretical production capacity of the shop is limited in determining how to schedule projects and allocate resources. Fabricators can sometimes increase their capacity and accelerate production for a project by working overtime. However, even overtime hours are finite, and productivity often decreases during periods of extended overtime.

Given the finite production capacity, each shop has a limited bank of hours from which it can draw to fabricate steel each year. A fabricator's capacity will be governed by the size of its labor force, available space, and fabrication equipment, which are typically the largest assets and cost components of any production facility.

With each project under contract, a steel fabricator sells a portion of its monthly or yearly production capacity. As with any complex project, steel fabrication is usually planned months in advance, with a portion of the shop reserved on the production schedule for a specific project. After a job is booked, the fabricator sells its remaining shop hours and builds out its production schedule.

Project delays or other events beyond the fabricator's control can significantly affect shop costs. For example, design changes, slow and incomplete approvals of shop drawings, coordination with design needs of other trades, and changes in material sizes are frequent causes of delay to fabricator schedules. In turn, these events may result in unabsorbed shop costs that directly impact the fabricator's projected revenue for a particular project.

When these types of impacts extend the planned fabrication windows for complex jobs, a shop may not have the flexibility or ability to fill that now-vacant time with work from other projects. As a result, a fabricator may be subject to significant periods of downtime without income-generating work to absorb payroll and other fixed costs. And when work is rescheduled, the fabricator now runs the risk of overlapping that work with other scheduled projects, requiring overtime and causing other shop inefficiencies and costs.

A time impact to a fabricator has the potential quickly to generate: (i) extended direct costs for an idle labor force and equipment; (ii) overtime and inefficiency from stacked jobs; and (iii) damages and costs on other projects from the overlap; and (iv) lost profits.

Courts, arbitrators, and construction professionals may not appreciate the full extent of these time-impact damages. Increased shop fabrication costs are not limited to the unabsorbed home office overhead costs of on-site contractors, which are indirect and typically subject to strict proof requirements. Rather, increased fabrication costs represent significant *direct* costs relating to a specific project, despite the fact that they are incurred off-site and arise from the same labor force and equipment used on other projects.

Courts and project participants must understand how steel fabricators operate to avoid mischaracterizing a fabricator's time-related damages claim simply as indirect unabsorbed home office overhead, and therefore impose an inapplicable damage analysis to off-site direct shop costs. Fabricators should advocate for themselves by explaining how they operate to courts and customers, which should help reduce the potential for mischaracterization.

Learn More

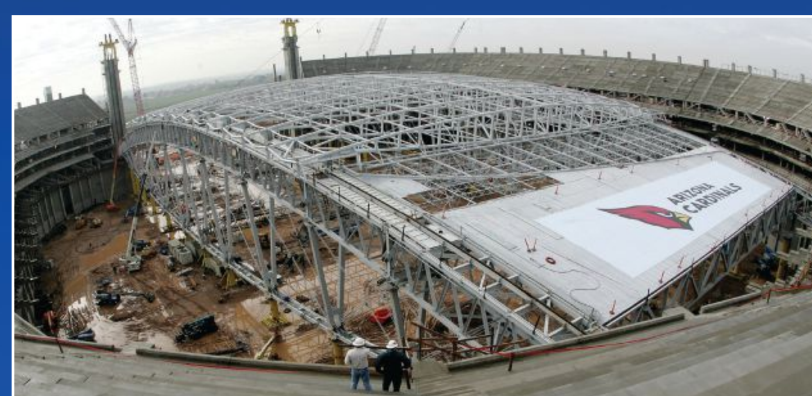
For more information about this important issue, please see the article titled "Recovering Fabricator Shop Losses for Delays: Why Traditional Damage Methodologies are Inadequate for Steel Fabricators," which recently was published in the *Journal of the American College of Construction Lawyers*. ■

Edward Seglias (**eseglias@cohenseglias.com**) is AISC's General Counsel and the co-CEO of Cohen Seglias. He specializes in construction law.

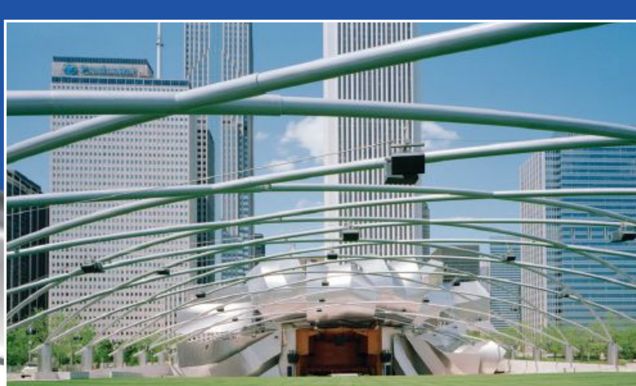
Winners Choose Chicago Metal To Curve Steel

2015 IDEAS² Merit Award - 73 pieces of curved 8” sch 40 pipe totaling 35 tons for Circuit of the America Observation Tower. Austin, TX

2014 SEAOI Best Project - Elliptically curved trusses rolled from 5” and 8” diameter AESS pipe for Institute of Environmental Sustainability at Loyola University. Chicago, IL



2007 IDEAS² National Winner - 400 tons of 12” square tubing curved for the retractable, lenticular room trusses at the University of Phoenix Stadium. Phoenix, AZ



2005 EAE Merit Award - 570 tons of 12”, 14”, 16”, 18” and 20” pipe curved for the Jay Pritzker Pavilion. Chicago, IL

2003 IDEAS² National Winner - 300 tons of 5” square tubing curved 45° off-axis for the Kimmel Center. Philadelphia, PA

Call us at 866-940-5739 to make *your* next project a winner!

2015 AIA Distinguished Building Award - HSS 8” pipe featuring an ellipse curvature with multi-radius bends for the structural ribs for CTA Cermak-McCormick Place Station. Chicago, IL

2012 IDEAS^2 Merit Award - 133 tons of 16” pipe curved for the Rooftop Tiara of the Great American Tower at Queen City Square. Cincinnati, OH

2020 IDEAS^2 National Winner - 920 pipe members rolled from 1300 tons of 14” pipe creating 38 super-trusses for the iconic canopy at Hartsfield-Jackson Atlanta Intl Airport. Atlanta, GA

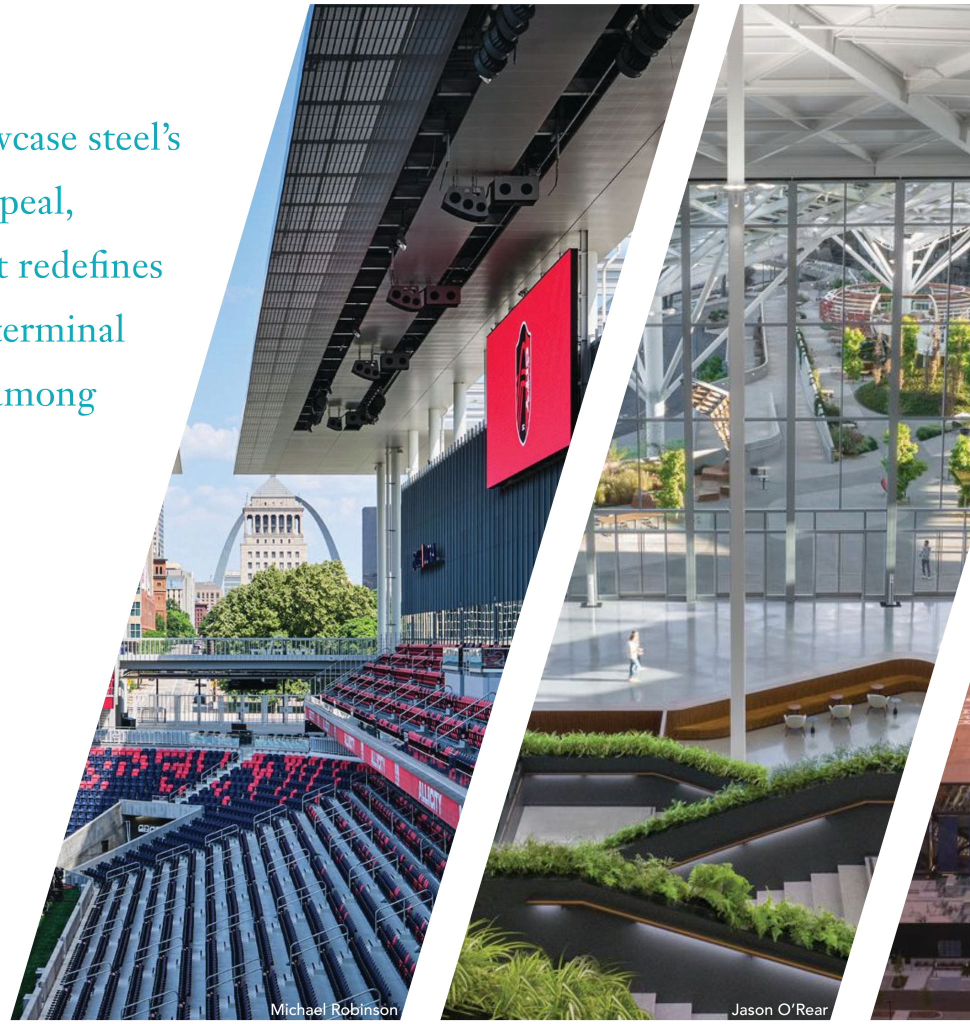
2007 NSBA Special Purpose Prize Bridge Award - 152 tons of 18” pipe curved in our Kansas City plant for the Highland Bridge. Denver, CO

2024 IDEAS^2 Excellence in Engineering Award - Curved W36x182 beams the hardway against their strong axis and W36x135 members in a complex compound reverse s-curve (multi-radial) easyway against the weak axis at the Nashville International Airport. Nashville, TN

2010 NCSEA Award Winner - 200 tons of beams, channels and angle for the roof of the University of Illinois at Chicago Forum. Chicago, IL

Two soccer stadiums that showcase steel's architectural and structural appeal, a vertical campus building that redefines mixed-use, and a new airport terminal that honors its home city are among the six structures to win 2024 AISC IDEAS² Awards.

Super Six



Michael Robinson

Jason O'Rear

SIX NEW STRUCTURES have joined a reputable and respected club: winners of an Innovative Design in Engineering and Architecture with Structural Steel (IDEAS²) Award.

Presented annually by AISC, the IDEAS² awards recognize projects that illustrate the exciting possibilities of building with structural steel and highlight how steel can help express architectural intent while harnessing its unique advantages for simple and complex structural systems.

The 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

All entries must meet the following criteria:

- New buildings, expansions, and renovation projects (major retrofits and rehabilitations) are eligible. There is also a category for sculptures, art installations, and non-building structures.
- Building projects in the 2023 competition must be in the U.S. and must be completed between January 1, 2021, and September 30, 2023.
- A significant portion of the framing system of a building must be wide-flange or hollow structural steel sections (HSS).
- Most of the steel used in the project must be domestically produced.
- The project must have been fabricated by a company eligible for AISC full membership. Projects with a unique or distinctive feature fabricated by a company eligible for AISC full membership will also be considered.
- Pedestrian bridges entered in the competition must be an intrinsic part of a building and not standalone structures. We encourage members of project teams for standalone bridges to enter the 2024 National Steel Bridge Alliance's Prize Bridge Awards.

Previously, awards were based on budget categories. The 2024 jury, though, wanted to find projects that took full advantage of specific benefits—sustainability, cost, speed, reliability, and resilience—that make structural steel the best choice for designers. Many winners are landmark structures, but the awards program also honors smaller, less well-known projects. All winners share a commitment to innovation and imaginative design.

Tom Harris
Jordan Powers
Turner Construction Company

Two projects won awards for excellence in architecture, two more won excellence in engineering, another won excellence constructability, and another won excellence in sustainable design and construction. Another category, excellence in adaptive reuse, did not have a winner this year.

The 2024 winners are a mix of aesthetically appealing structures and captivating additions to existing buildings. Two new structures are stadiums that house new Major League Soccer teams, one in St. Louis and one in Nashville, Tenn. Each venue sought to inject more life into a neighborhood and create an inviting community space, with steel an instrumental piece in the latter part.

Nashville is home to another winner: the new terminal lobby and international arrivals facility at Nashville International Airport. The primary element of the project is a new roof that pays homage to the Music City and creates an inviting space for passengers.

Elsewhere, a new corporate headquarters in Santa Clara, Calif., with glass walls from ceiling to floor is an innovative workspace with ample natural light and aesthetically appealing exposed steel. Creative and complex engineering allowed several different facilities—from a gym to host basketball games to student residences—to fit into one New York University building. Finally, a pedestrian bridge linking a new hospital with an existing one demonstrates clever engineering and was erected in little time.

Those six projects were deemed winners by a six-person jury:

- Eddie Jones, FAIA, founding principal, Jones Studio
- Max Puchtel, SE, PE, LEED Green Associate, director of government relations and sustainability, AISC
- Larry Rickels, PE, principal, Datum Engineers
- Brian C. Smith, vice president, Doing Steel Fabrication
- Jay A. Taylor, SE, PE, Hon AIA Sea, senior principal (retired), Magnusson Klemencic Associates
- Hannah Valentine, PE, structural steel specialist – Los Angeles, AISC

Read on to learn more about and see fantastic images of all this year's winners.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION AISC FOUNDED 1921

2024 IDEAS² AWARDS

Michael Robinson

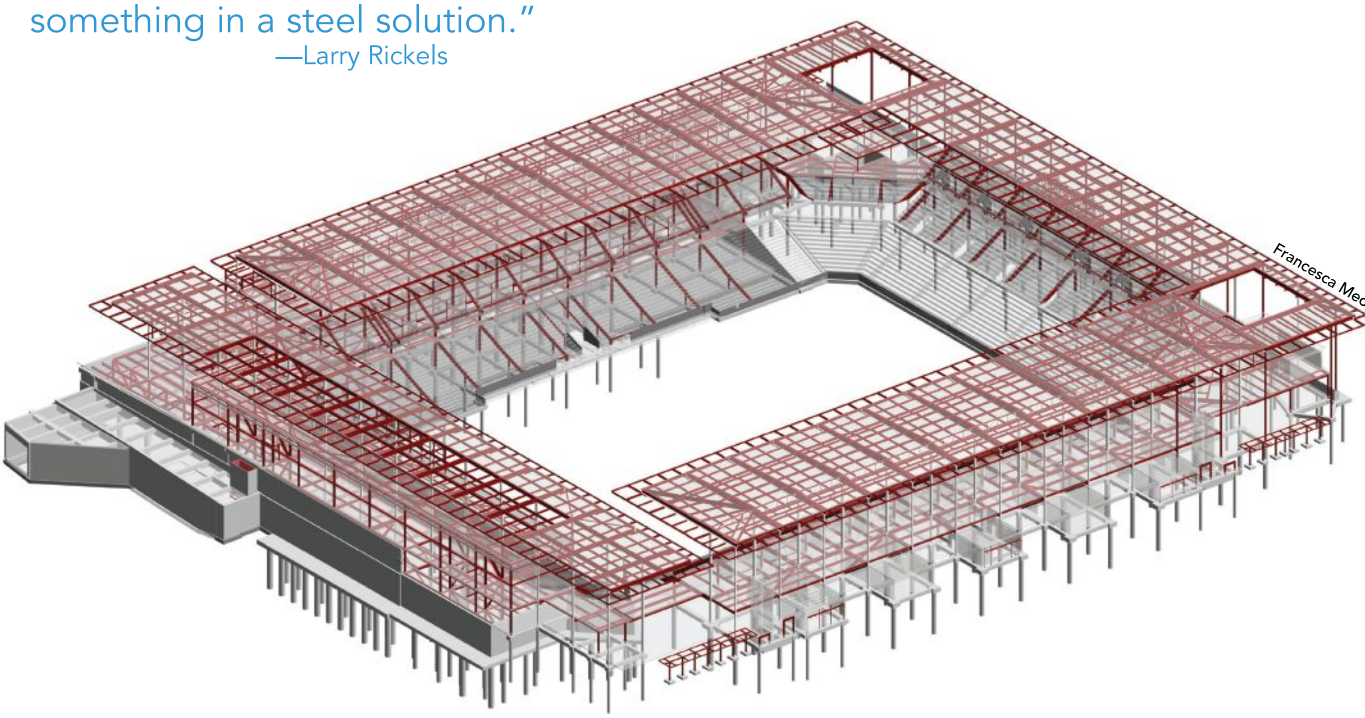
Michael Robinson

"It looks extremely efficient with its sharp edges on the roof, thin columns, and long cantilevers. It's sleek and unadorned. We're always impressed with how thin you can make something in a steel solution."
—Larry Rickels

2024 IDEAS² AWARD

EXCELLENCE IN ARCHITECTURE

CITYPARK, St. Louis


Francesca Meola

THE OWNERS of St. Louis CITY SC, a new Major League Soccer franchise in St. Louis, envisioned more than a stadium when considering their club's future home venue. They aimed to create a vibrant mixed-use stadium district in the city's Downtown West neighborhood that impacted the area beyond game days.

Their vision birthed 22,500-seat CITYPARK, designed to fit comfortably into its urban neighborhood. The stadium is across the street from historic Union Station and at the end of the Gateway Mall, linking the stadium to the Gateway Arch and Mississippi River through a stretch of green and public spaces. Its compact, transparent form allows views into the pitch from surrounding streets and views of the city from the seating bowl. The main concourse aligns with the west end of the Gateway Mall, extending the urban fabric into the stadium.

The stadium exterior features glass, metal panels, and stone walls. Open concourses promote movement and social spaces, with ground-floor retail and gathering spaces further integrating the venue into the neighborhood. All four sides of the stadium are open and inclusive, welcoming fans from every direction. The stadium corners' openness serves a dual purpose: draw people together during games and create flexible plazas for non-gameday community events. Both align with the vision of enhancing Downtown West.

The design features a flat portico, cut-out corners, and slender columns framing the upper seating bowl. A flat canopy was fabricated from material that reflects light similarly to the Gateway Arch. The canopy, spanning 120 ft with a 25-ft backspan, protects fans from the elements while letting in daylight, amplifying fan noise, and creating a sense of enclosure to focus attention onto the field. The seating bowl is 40 ft below street level, ensuring no seat is more than 120 ft from the pitch.

The southern portion of the stadium, which extends from the Gateway Mall, is slightly detached from the northern structure, acknowledging its position opposite the Gateway Arch by providing enhanced views from premium seating areas.

CITYPARK exhibits a seamless fusion of structural engineering and architectural design. The design reflects the stadium's urban surroundings and prioritizes openness by inviting the neighborhood inside. The structural engineering complements the architecture with a coordinated system that features steel throughout, creating open, interconnected spaces and fluid exterior forms.

The coordinated structural approach dramatically reduces lateral framing to allow transparency, opens corners to reveal the urban setting, and extends the steel canopy outward to link the stadium to the neighborhood visually. The interplay of engineering and architecture transforms the stadium into a new landmark for downtown St. Louis.

Structural steel met the architectural goal of creating an open and transparent structure with streamlined gravity and lateral systems while ensuring expedited fabrication and erection. Steel framing with slender columns and discreet braces allows the lateral system to disappear, avoiding the imposition of perimeter-braced frames that would obstruct views. Steel trusses and girders enable long canopy spans while keeping structural depth minimal for a thin, lightweight aesthetic.

Steel connections were precisely engineered to eliminate stiffeners and optimize the slender column designs. Steel's lightness reduced foundation loads on the variable rock profiles. CITYPARK was also designed to utilize 100% recycled structural steel. The structural components are designed for easy disassembly and reassembly, allowing for adaptive reuse and reducing environmental impact.

The steel framework comprises trusses spanning to primary tapered girders supporting the canopy roof structure, with steel girders and open web joists at retail and concession levels. Custom connections were designed in close coordination with the architectural team. Integrating lightweight spanning trusses and girders balanced aesthetic aspirations with structural requirements.

Design Decisions

CITYPARK's innovative design and construction addressed complex site conditions while integrating structural and architectural design objectives.

The Downtown West site presented numerous challenges, including intricate rock contours, access constraints, varying perimeter retaining wall conditions, and high seismic design parameters. The stadium's foundation is engineered to adapt to the diverse geotechnical conditions of the site, comprising spread footings, friction piles, and mat foundations. Using steel to reduce the structural self-weight was key to optimizing the foundation strategy.

Using perimeter-braced frames would have detracted from the design intent of a sleek, transparent structure with maximum openness to the surrounding area. The design team, in response, wanted to make the lateral system effectively disappear. Three pieces helped them achieve their goal: Designing the feature columns to act as frames, relying on the rigidity of the seating bowl, and integrating discreet braced frames at the base.

That approach effectively concealed the lateral system within the stadium's structure. The arrangement optimized functional efficiency within the aesthetic framework, further contributing to the stadium's open and streamlined appearance.

The engineering team designed all structural connections to accelerate the schedule and achieve constructability and aesthetic considerations. At critical and repetitive conditions, finite element modeling enabled optimization of design performance, material reductions, and cost savings. All three modeling benefits allowed precise calibration of structural behavior and enhanced the design and construction team's ability to tackle problems quickly.

In one case, on the eve of the mill order issuance, the team learned that the feature interior hollow structural section (HSS) 24-in. columns would not be available in ⅝-in. wall thickness for several months. The final wind tunnel test results were not yet available, creating risk of reducing wall thickness to an unconservative degree.

The design team quickly developed a detail that would strengthen the HSS columns at their peak demand locations, if the final wind tunnel results required it. The fast analysis, collaboration, steel connection, and fabrication flexibility helped maintain the schedule. Ultimately, the strengthening detail was not required.

Close collaboration between the design and steel fabrication teams from conception through construction facilitated mutual understanding and ensured a smooth transition from design to construction, including accelerated submittal review. The teams worked collaboratively through the complexity of the connection details, including fabricated mockups of multiple weld details to ensure the final product met client expectations. The teams also coordinated the timing of mill orders to ensure that the appropriate shapes were available when needed.

Complex Canopy

The canopy and its primary supporting columns—two defining features of the stadium—underwent three major design iterations to arrive at an optimal tapered steel plate girder system that aligned with the architectural vision of a thin look while adhering to budget and constructability considerations. An outrigger system enhances the shallow cantilevered appearance along the entire canopy interior and exterior perimeters, adding to the stadium's aesthetic.

Initially, the team examined a constant depth built-up plate girder system. Cost concerns necessitated a second analysis to economize the design and explore a tapered truss system that used less material. The numerous connections in the second design option increased costs, though, despite the material savings.

A subsequent design iteration led to the final canopy girder design: a tapered built-up plate girder system where the bottom of the girder maintains a constant elevation and the top slopes. The 1½-in.-thick flange plates vary in width along the entire length of the beam, with the overall girder depth ranging from 3 ft at the ends to 6 ft at the center. Outriggers at each canopy end are typically 14 in. deep and 15 ft long, adhering to the desired light and thin appearance.

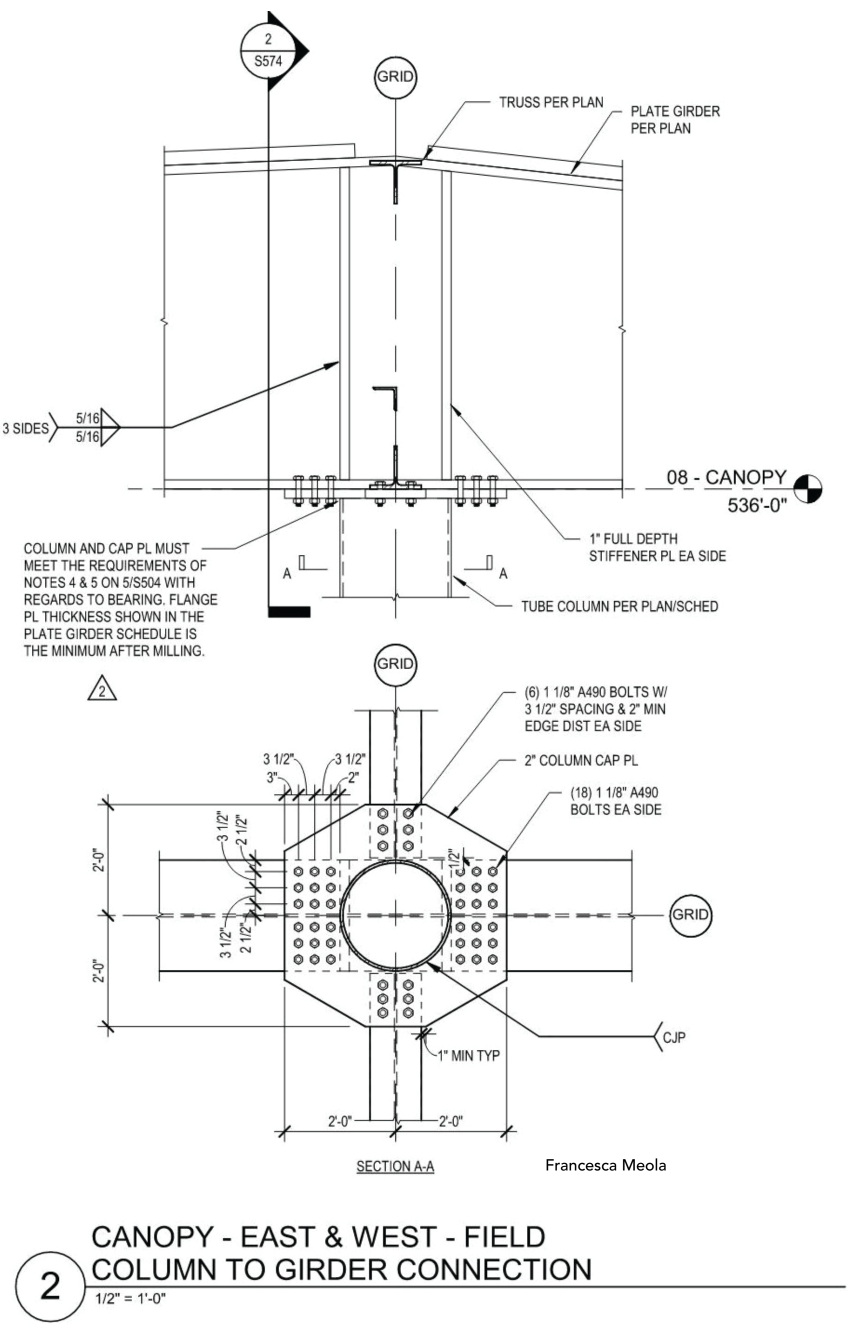
The canopy projects outward from the seating bowl perimeter, bringing diffused daylight into the stadium. Its steel framework, with slender columns spaced at 25 ft by 36 ft typically, supports metal panels defined by the architectural form. Discreet bracing and minimal pipe columns enhance transparency.

The canopy's stability is provided through a combination of steel moment frames and the rigid precast seating bowl, which also aids in efficient load distribution as part of the diaphragm system. While the canopy roof shape is uniform on all four sides, the supporting conditions below vary substantially due to differing program spaces and required close collaboration to locate braced frames in discreet locations throughout the concourses and back-of-house areas.

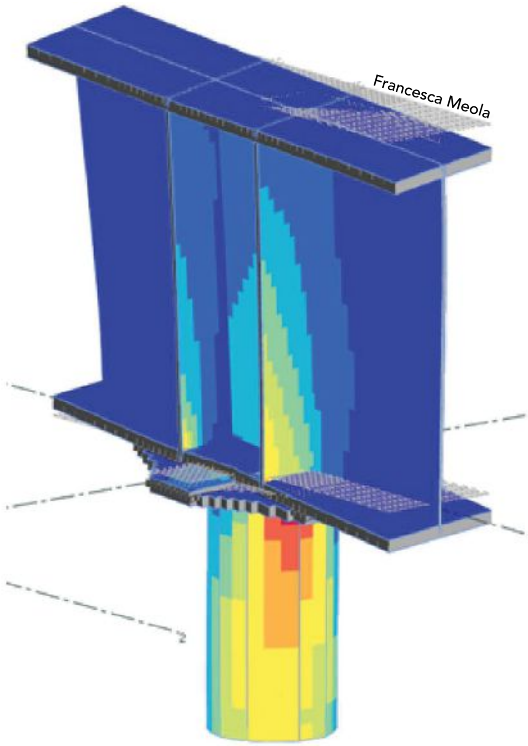
The final design of girder-to-column connections included a bolted connection of the girder to the cap plate over the column, eliminating the need for additional stiffeners in the column. The largest columns, HSS24, are placed along the fulcrum, with HSS16 along the exterior side of the stadium and back support of the canopy.

Corner canopy openings extend the inviting nature of the stadium beyond match days by creating flexible community gathering areas. This collaborative and iterative design process between architectural vision and engineering practicality resulted in community-centric architecture, integrating the canopy with the stadium's overall structural and aesthetic narrative.

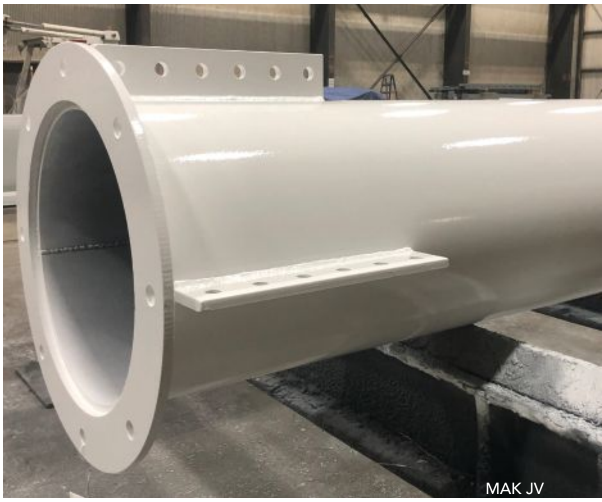
Michael Robinson



Francesca Meola



Francesca Meola



MAK JV

Michael Robinson

Constructability Friendly

CITYPARK's loading dock introduces an uncommon approach to the stadium service area. A tunnel on the south side allows services to enter the stadium below grade, eliminating the typical back-of-house services area at street level.

The team designed the loading dock as an open, column-free space to maximize operational efficiency. A full-height concrete truss supports the tunnel lid for service entry below grade, and a parallel steel truss structure supports the stadium and plaza above. Built-up plate girders, approximately 73 ft long and 4 ft deep, transfer column loads and support sections of the elevated structure. The combination of concrete, steel, and plate girder systems enabled an obstruction-free loading dock space.

Detailing the interface between concrete and steel structures required close coordination, demonstrating an integrated design approach for architectural openness and practical utility.

The corporate constructability program implemented by the Mortenson, Alberici, L. Keeley joint venture (MAK JV) introduced early contractor engagement, which reduced material lead times by expediting the design process and improving design efficiencies.

A notable feature was MAK JV's self-perform and fabricating capabilities covering steel fabrication, steel erection, precast erection, earthworks, and underground utilities, giving MAK JV better control over the project's schedule. MAK JV could store materials on its corporate sites until they were required, streamlining operations and ensuring materials were available when needed.

Constructability reviews began before the construction phase. The construction team engaged with HOK designers to discuss material selection and procurement during the schematic design phase. In the design development phase, MAK JV and HOK refined steel shape selections based on the extended lead times exacerbated by the COVID-19 pandemic.

Members of the MAK JV self-perform team collaborated with the designers during the constructability review, which was key in manufacturing the required shapes and sizes of structural steel and selecting connection types to keep the project on schedule. The team's value engineering exercises helped lock in prices and meet the long lead times associated with materials and equipment procurement.

The design team and MAK JV implemented Procore, Tekla, and Solibri for constructability reviews throughout the project, and also implemented lean principles, such as pull planning, to address the schedule and the construction sequence. Internal coordination for steel fabrication, steel erection, and precast erection, along with progressive 4D schedule modeling, benefited the project schedule.

Self-performance of all the initial construction activities allowed MAK JV to start strong, work through issues with minimal impacts by resequencing, and collaborate with the design team for efficient solutions.

Initially, project specifications called for an architecturally exposed structural steel (AESS) designation. However, close coordination with the design team and the owner allowed MAK JV to understand the owner's true design intent and build mockups.

MAK JV

After viewing the mockups, the owners realized they could achieve the desired look without AESS and for less cost.

MAK JV also ensured quality by closely coordinating with precast fabricators, especially during long lead times. That quality assurance process included having an employee on-site for a month for quality control. The constant communication and collaboration with subcontractors also contributed to the project's success.

CITYPARK exemplifies the expertise and dedication of the project team and CITY SC's commitment to the region. The stadium has left a lasting impact on St. Louis and its residents, who have embraced CITYPARK and the club wholeheartedly. Investment has poured into Downtown West, with approximately $820 million in development and 300 new occupancy permits issued. The stadium and team have become engines of St. Louis' revival.

Owner
St. Louis City SC

General Contractor
Mortenson | Alberici | Keeley (MAK JV), St. Louis

Architect and Structural Engineer
HOK, St. Louis

Architect
Snow Kreilich Architects, Minneapolis

Associate Structural Engineer
David Mason + Associates, St. Louis

Fabricator
Hillsdale Fabricators (AISC Certified Fabricator), St. Louis

Jason O'Rear

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NVIDIA Phase II – Voyager, San Jose, Calif.

THREE-DIMENSIONAL graphics chip manufacturer NVIDIA is in the middle of a multi-step project to overhaul its corporate headquarters in Santa Clara, Calif. The hexagon-shaped Voyager Building is Phase II of the project, which aims to create a workspace that matches NVIDIA's core beliefs and help employees thrive and create in a high-tech environment. The high, cavernous ceilings allow for large, open spaces that invoke the outdoors right next to the more intimate workspaces.

The Voyager building has a 275,000 sq. ft footprint with 700,000 sq. ft of working space to accommodate more than 3,000 employees. It's laid out on a 70-ft triangular grid system that adds a signature look and design to every element. The overall building consists of a two-level, below-grade garage podium under a large exterior shell enclosing multiple seismically separated interior office building structures.

The building's unique design highlights the owner's desire for a meaningful, collaborative space at the center of the building—named "the mountain"—where a dark gray staircase leads to mezzanine levels. The reception "base camp" area is on one side of the mountain, with more conventional offices, dining area, and meeting spaces on the other. The 60-ft-tall ceiling features numerous triangular skylights, and the undulating roof structure lets in enough natural light to the center atrium to give employees a feeling of being outdoors.

Structural steel was the only viable option to meet the owner's desire for the open space with long spans and a seemingly floating roof canopy structure. The design also needed to match the structure of the existing Phase I building at the headquarters campus, its equally impressive smaller sibling next door.

The structural steel was incorporated with other materials, such as glass and wood, to open up the workspaces and provide ample light to the open working areas. The open roof structure was left with exposed steel to express the support structure.

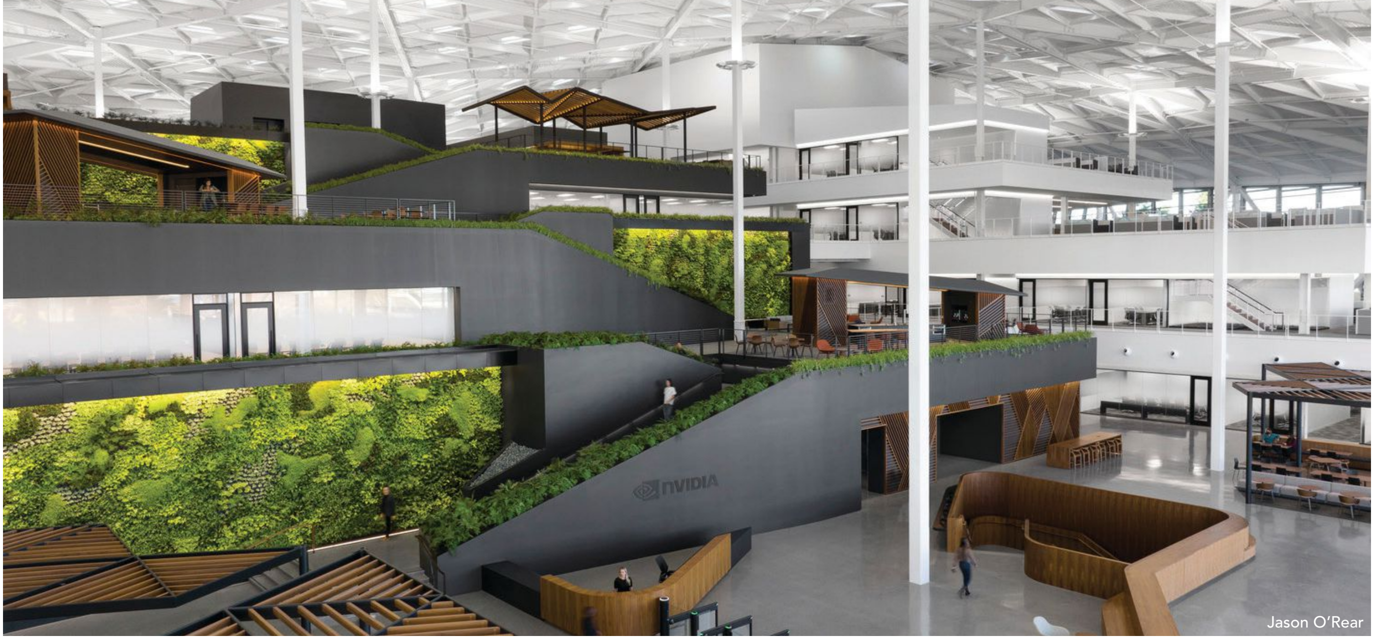
The overall building has three structural design elements: the roof, the office buildings, and the parking structure.

The steel roof structure has buckling-restrained braces (BRBs) at the exterior that are seismically separate from the interior steel structures. The roof framing sits on interior columns with a sliding connection at the top of the column, and the roof consists of insulated metal decking.

Due to the limitation in the length of the braces that could be produced, an intermediate beam breaks the lateral elevation into a multi-level brace frame. Columns and beams are designed for the unbraced middle beam out of plan forces. The BRB frames are supported on the concrete podium structure below.

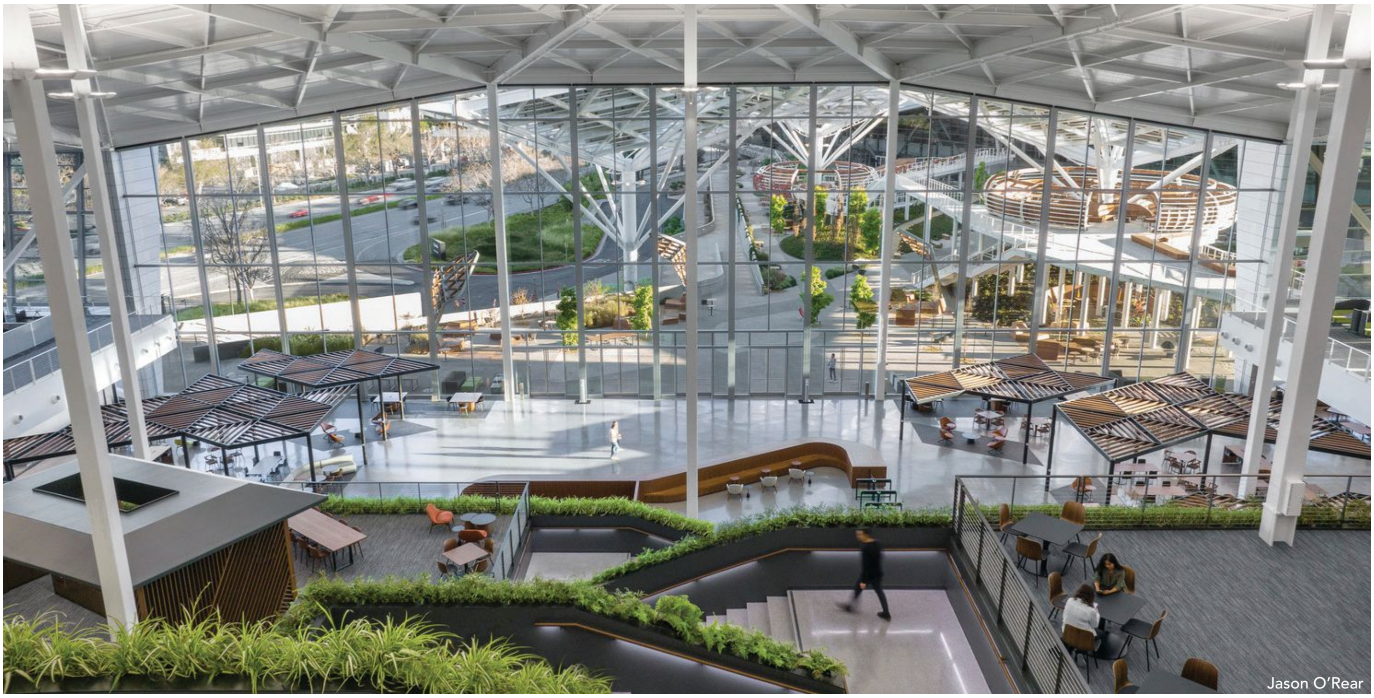
Interior office structures consist of steel framing that rises to four levels at the center. Four independent structures exist under the roof canopy, each entirely seismically independent. The floor consists of concrete-filled metal deck, and the lateral system consists of BRBs.

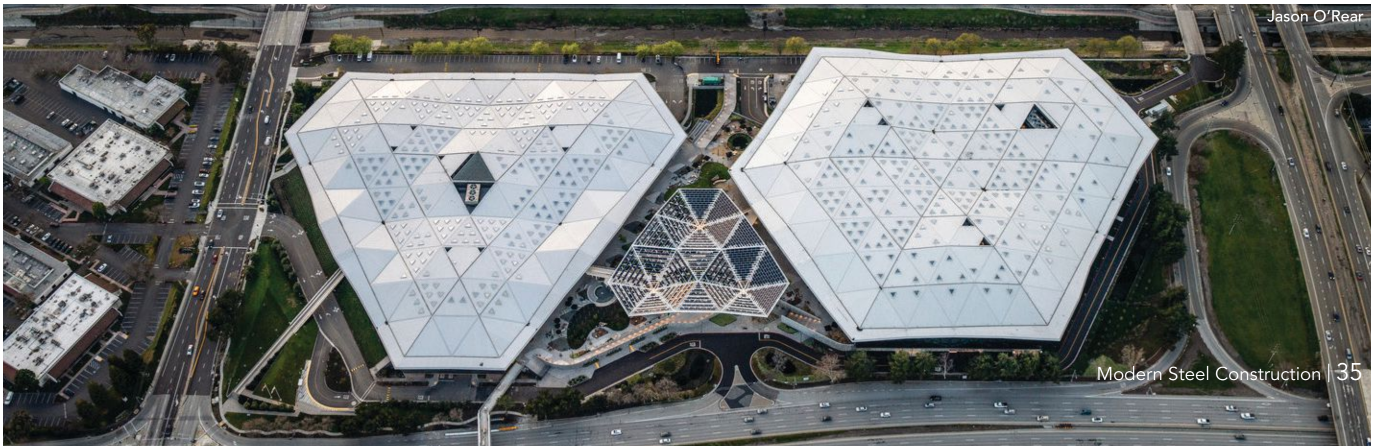
Voyager's parking garage is designed on a 62-ft rectangular grid, with the building above built on a 70-ft triangular grid. Matching the framing and translating it to the concrete parking garage was a significant coordination effort among all design team members.



Jason O'Rear

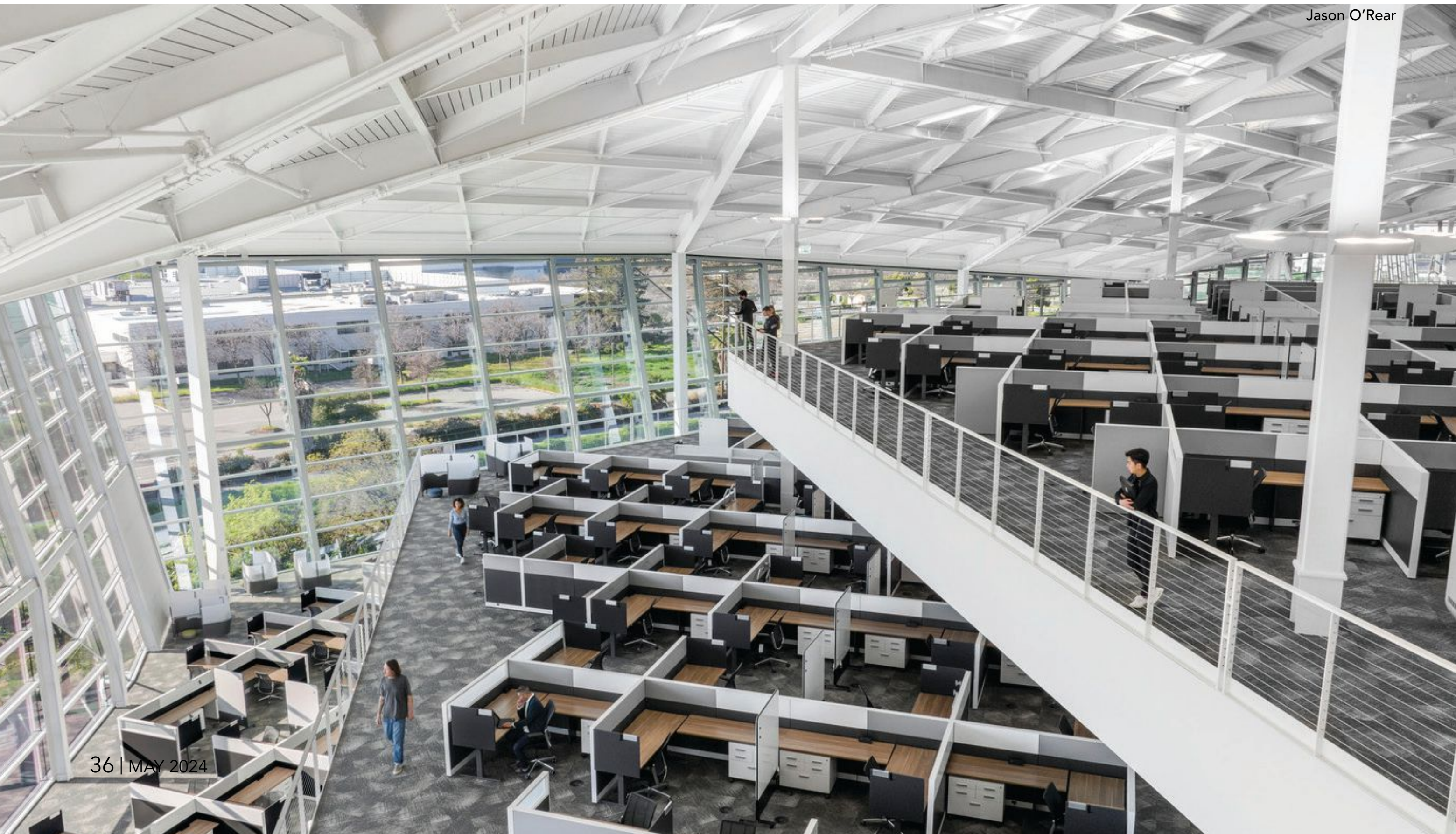
"The apparent complexity of the structure lent itself to prefabrication and a field assembly that was not dependent on the usual orthogonal cut connections, conventional construction techniques, and the structure's thinness and the lightness. It can only be done with steel."
—Eddie Jones

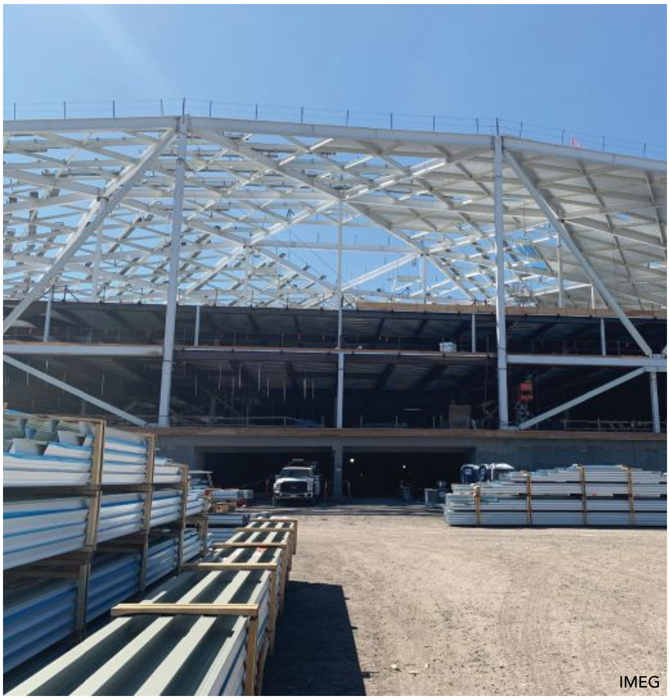

Jason O'Rear


Jason O'Rear

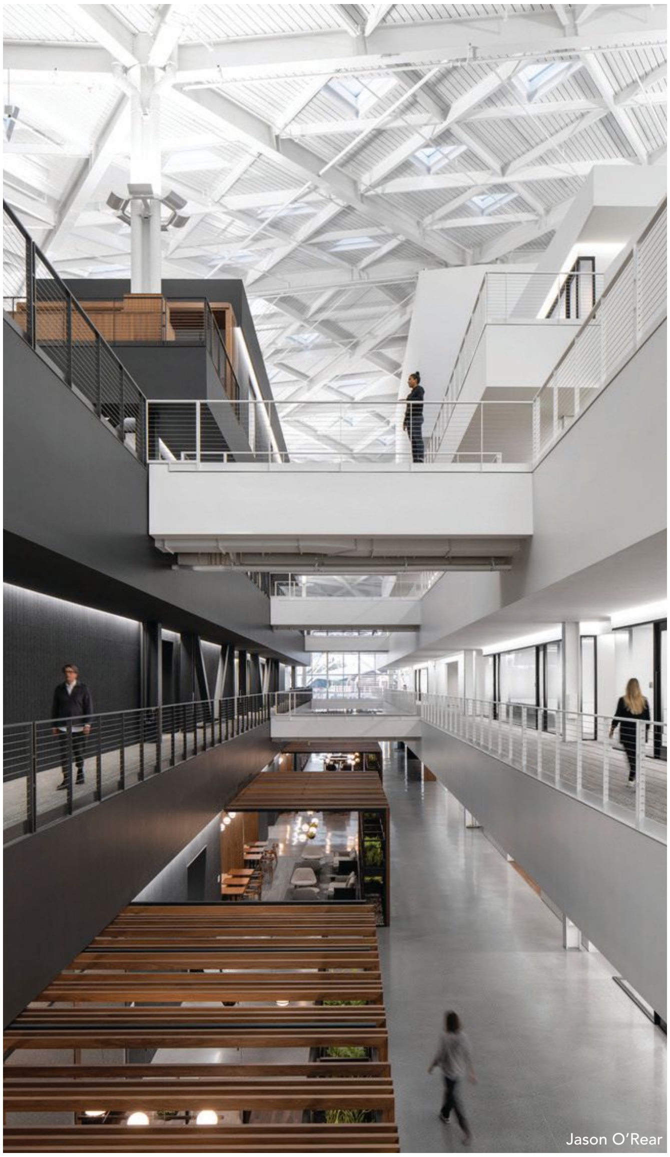
IMEG

Jason O'Rear





IMEG



Jason O'Rear

The exterior shell structure is clad in an all-glass façade with a ring of BRB frames and steel columns supporting a horizontal steel truss roofing system. The BRB frames had a maximum brace length of 57 ft with designed stiffness to handle the seismic demand from the trussed roof system and meet the manufacturer's deflection requirements for the glass façade.

The truss roof structure translates seismic loading from the interior of the building out to the exterior BRB frames, which are supported on the exterior concrete walls and columns. The steel truss roof mimics the equilateral triangular grid system and is supported by up to 60-ft-tall steel columns with a tributary area of 3,100 sq. ft. The undulating roof changes elevation by 30 ft from its lowest to highest points, giving the appearance of rippling water. A cantilever overhang extends more than 30 ft from where the roof meets the exterior façade and is supported by custom tapered W33 steel beams.

The three-level interior office structure was designed to be seismically separate from the exterior shell and was constructed utilizing structural steel and BRB frames, with concrete over metal deck slabs. Seismic isolation was accomplished by providing bearing and slip joints between the interior and exterior beams and columns.

Columns shared by the interior building and roof shell structure were fitted with a bearing pad connection to release any translated seismic loading, allowing the interior and exterior shell structures to move independently and removing any shared seismic loading. The decision to isolate the interior structure from the exterior shell also allowed the interior BRB frames to be downsized, providing reduced steel weights for a more sound and efficient engineering design and reduced cost. Structural engineers also created a custom bearing connection for the roof structure to sit on top of building columns so the exterior brace frames support the lateral load.

The building design also considered the horizontal displacements, including bridges, stairways, and glass panels, which required the structural engineer's coordination with the glass manufacturers on how much deflection would occur during a seismic event so that the connections that hold the glass in place are designed to accommodate the movement.

The design team worked closely with the fabricator from an early design stage, and the fabricator used state-of-the-art 3D modeling software, which helped the design team resolve difficult aesthetic challenges before they showed up in shop drawings or in the field. That close coordination gave all disciplines time to work through any potential clashes and resolutions early, created opportunities to explore LEED options, and gave the fabricator time to prepare the steel for exposed conditions to ensure a flawless product.

Owner's Representative
NVIDIA

General Contractor
Devcon Construction, Inc., Milpitas, Calif.

Architect
Gensler, San Francisco

Structural Engineer
IMEG, San Francisco

Steel Team

Fabricator and Erector
SME, West Jordan, Utah

Detailer
DBM Vircon, Auckland, New Zealand

NASHVILLE'S GEODIS PARK made history the moment it opened.

The 30,000-seat venue, home to Major League Soccer's (MLS) Nashville SC, is the largest purpose-built soccer stadium in the United States and Canada. It's designed to capture Nashville's distinct architectural character and is constructed from structural steel, mass timber, and exposed brick.

GEODIS Park was built to do more than host soccer matches. It's the anchor of a renewal effort in the city's historic but underutilized Nashville Fairgrounds, a well-loved destination known for its 50-year-old flea market, short-track speedway, and municipal fairs.

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EXCELLENCE IN CONSTRUCTABILITY
GEODIS Park, Nashville, Tenn.

It catalyzed more than $500 million in investments in the historic but underserved neighborhood.

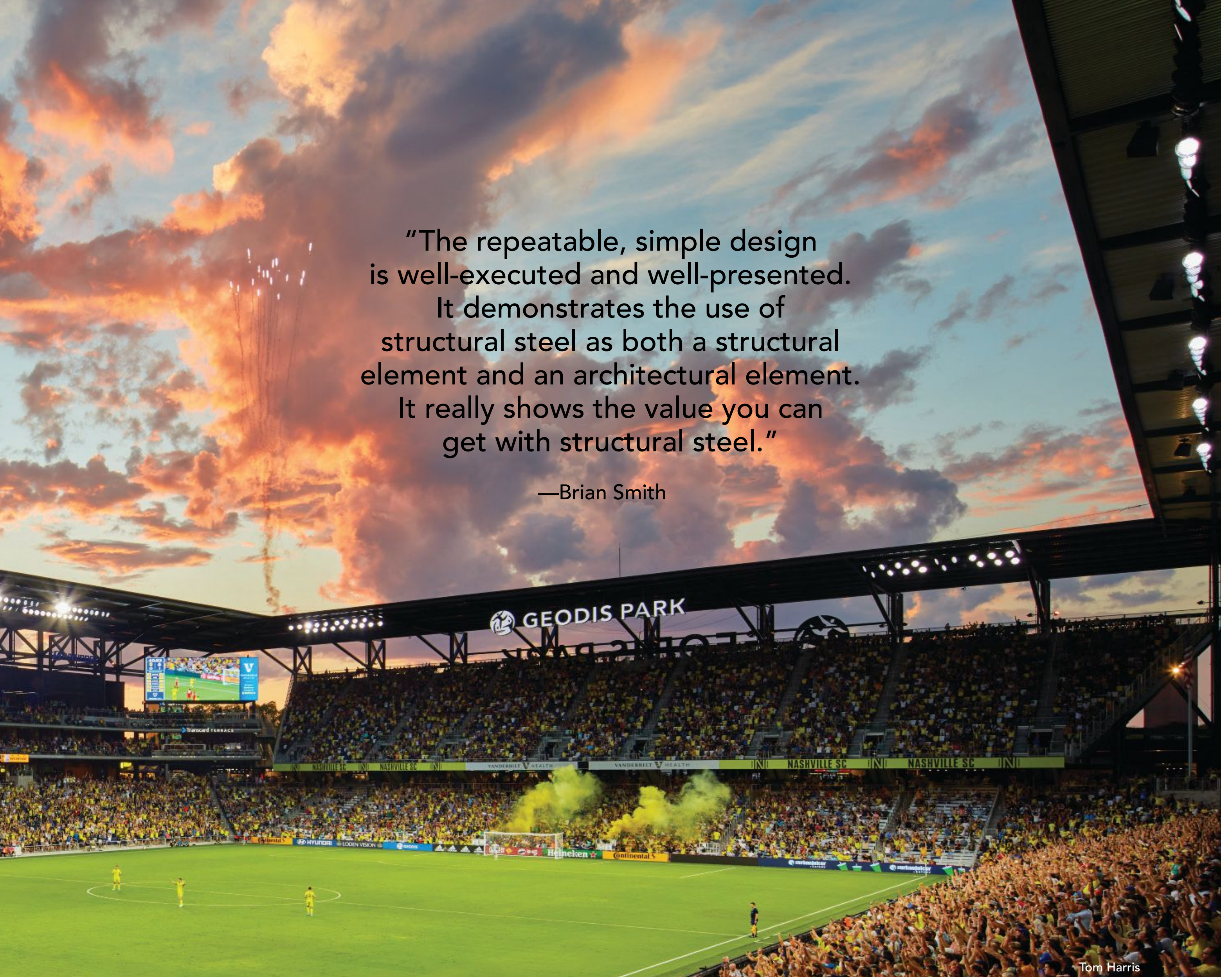
The stadium's carefully crafted exposed steel, mass timber, and exposed brick expresses the city's industrial roots and echoes the industrial architecture prevalent throughout Nashville while improving sustainability and reducing overall construction costs. Limited cladding on the stadium's exterior makes exposed structural steel the dominant architectural material, and the steel gracefully integrates with the dowel-laminated-timber (DLT), precast, and masonry systems.

Structural steel was the natural choice as the primary element of the stadium. It provides the needed strength to support the long spans in the seating bowl, canopy cantilevers, and extra-wide concourses while conveying the chiseled aesthetic sought by the client to reflect Nashville's industrial roots.

The exposed steel elements, in concert with brick and timber, create the public spaces and the dynamic visual form of the structure, and carefully crafted connections give it the desired industrial feel. The innovative and client-responsive structural engineering set a new standard for the design and construction of a complex structural steel building, meeting all client needs and creating a new asset for the city of Nashville while showcasing structural steel.

“The repeatable, simple design is well-executed and well-presented. It demonstrates the use of structural steel as both a structural element and an architectural element. It really shows the value you can get with structural steel.”

—Brian Smith



Tom Harris

Numerous exposed structural steel features greet fans as they enter GEODIS Park, including:

- A 360° steel canopy cantilever that extends 85 ft over the upper seating bowl
- A signature steel X-frame, incorporating W14s for the columns and cross-bracing members, at the stadium canopy around the seating bowl
- A 65-ft-wide concourse with fully exposed steel connections

The stadium’s signature 152,600-sq. ft, 360° main canopy enhances the architectural expression of the stadium with crisp 90° corners at each entry and a rectangular opening over the pitch. It also created significant design complexity that demanded innovative engineering.

Structural steel’s strength permits the graceful and economical 85-ft canopy cantilever that protects 80% of seats from sun and rain. The main canopy girder has a single propped strut supported by the signature X-frame that serves as an elegant hold-down at each grid. These open corner entries are the stadium’s signature architectural features. The main canopy continues 48 ft beyond the last column line, creating a column-free space with a soaring canopy above. The four open corners create a distinctive aesthetic, allowing fans inside the stadium to see the city beyond and fans approaching the stadium to see inside.

Steel provided the flexibility to integrate seamlessly with the other materials chosen for the project, including the precast concrete seating elements, mass timber at the entries, brick throughout the concourse, and other premium spaces. Steel became the foundational workhorse that formed the overall spaces and easily handled the long cantilevers, the complex geometry, and the need to be erected quickly. It nimbly supported exposed timber construction at each entry point and exposed brick masonry throughout the venue.

“The structural steel is the architectural hero of GEODIS Park and honors the industrial heritage of Wedgewood Houston, the neighborhood where the stadium is located,” said Chris Melander, a design architect with Hastings and the lead project designer. “The steel detailing is integral to the stadium’s identity and is celebrated with muscular bolted connections and contoured stiffeners.

“Collaborating with Walter P Moore in an integrated delivery process allowed the design team to influence and tailor the connection design, ensuring their compatibility with the overall design intent. Collaboration helped our team coordinate pathways for stadium utilities without sacrificing the structure’s beauty and created schedule efficiencies by allowing the steel fabrication to begin much sooner than with a traditional delivery method.”

Masterful Modelling

Walter P Moore modeled all connections in 3D early in the project using a self-developed proprietary delivery process called ConnecTID, "Transformative Integrated Design for Buildings," which fueled thorough discussions with the architect regarding the desired architectural expression. The advanced modeling fostered highly detailed coordination across all trades to ensure the aesthetic was achieved. That level of careful and advanced coordination helped integrate conduit, plumbing pipes, and other utilities into the building while maintaining each piece of the structure as an architectural feature.

The project's first challenge was to design and coordinate an efficient exposed structural system that could economically support a modern MLS stadium's many different span and load conditions. Early in the design phase, it became clear that exposed structural steel was the key architectural element. The challenge then became to develop, design, and detail every exposed steel member and connection early in the project so the engineer could fully coordinate every aspect with the architect and other project team members for aesthetic intent and functionality with various trades.

The solution was for the structural engineering team to fully model the structural steel superstructure to LOD400 completeness before procuring steel. LOD400 models are fabrication-ready models typically developed by a steel fabricator and include every part needed for steel fabrication, including bolts, welds, shim plates, stiffeners, and copes.

The fabricator performs LOD400 modeling on most projects after completing architectural coordination. On GEODIS Park, though, early high-fidelity modeling allowed the architect and engineer to visualize and refine every connection during design.

The engineer had to create a space-efficient concourse to accommodate the required concessions, restrooms, and other amenities while allowing free-flowing circulation for 30,000 fans. Conventional braced frames would have disrupted patron flow and consumed much of the limited concourse space.

Instead, the engineer leveraged the steel's strength and adaptability by utilizing moment frames in both directions, maximizing patron circulation while providing the needed strength and lateral stability to support the concourse and canopy. The design team leveraged early high-fidelity detailing to enhance the structural steel expression throughout the concourse, including carefully sculpted raker-to-column connections at each grid.

The design and construction team worked under schedule pressure from the start, seeking to deliver the stadium on an accelerated time frame to enable the owner to host as many games as possible in the stadium's opening season. Land acquisition issues threatened to delay stadium opening until midway through the 2022 soccer season, strengthening the schedule pressure.

ConnecTID facilitated ten weeks of process acceleration from a conventional stadium schedule by overlapping the LOD400 model development with the final design and construction bidding phases. The ConnecTID process and resulting LOD400 model also eliminated delays during construction to resolve coordination problems, because the design team identified and solved those potential problems virtually during the creation of the LOD400 model instead of solving them after discovery in the field.

The ConnecTID process tightly integrated structural steel design, connection design, and advanced 3D modeling to develop high-fidelity, fabrication-ready digital deliverables. It provided tight and accurate steel bids, improved overall coordination, and eliminated nearly all steel change orders costs. Six steel bids ranged from 9% to 20% below budget, with a total spread of 15% between high and low bids.

As a result, steel erection ended four weeks early, and the overall project wrapped up seven weeks earlier than planned. The schedule savings allowed Nashville SC to play the entire 2022 season at GEODIS Park, generating revenue nearly two months earlier than anticipated.

The early and thorough LOD400 detailing allowed design details down to the bolt's orientation and tapered shapes of every stiffener plate to be considered part of the overall architectural intent. Thorough connection design by the structural engineer is uncommon for modern stadiums and makes GEODIS stand out to patrons for its well-crafted appearance throughout.

Having steel as the dominant architectural feature of GEODIS Park meant the exposed steel had to be intentionally designed and detailed to be exposed throughout the stadium. In typical projects, particularly in the eastern half of the United States, connection design is delegated to the steel fabricator and is completed after design team drawings are issued with limited interaction between the connection designer and the design team. In this case, the ConnecTID process began in early design development, as the structural engineer collaborated with the architect on preliminary connection concepts for the critically exposed connections on the project.

The engineer then modeled an entire frame of connections in Tekla for review by the architect. Starting the connection design early in the project allowed for multiple iterations on the exposed connection, with the design team reviewing in Tekla each time to capture the overall impact. The details were then documented on early pricing sets to capture the complexity of the connections for accurate pricing.

Additionally, starting the process early and designing the connections during the design phase allowed coordination with the entire design team. The early coordination helped the team create pathways for the conduit to run inside steel column webs by stopping stiffeners or creating openings in gusset plates. Drainpipes were routed through beam openings, effectively hiding the piping at the leading edge of the bowl rather than having the pipe visually exposed going under beams.

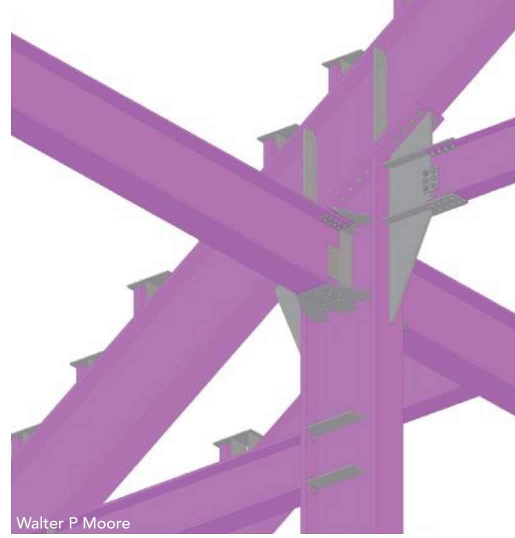
Crafty Constructability

GEODIS Park's steel delivery process combined numerous industry-leading activities to create a modern and streamlined construction process. It stands out as a model for the future of structural steel delivery compared to other stadiums with construction delays and cost overruns.

The ConnecTID process is based on producing more detailed and complete design information that includes fabrication-ready bid documents, meaning the steel fabricator bidders have a clearly defined project scope. In typical projects, the fabricator performs steel connection design and LOD400 modeling. But the GEODIS Park team pulled those services forward to have the engineer of record complete them during the design and bidding phases. These services are typically 3% to 5% of the total steel contract and require the owner's early investment to complete.

The engineer of record providing connection design and LOD400 modeling transformed and accelerated the entire delivery and documentation process. The steel bid documents included a traditional set of construction documents, structural steel specifications, completed connection design (including 3D representation on the drawings for all the complex connections, connection

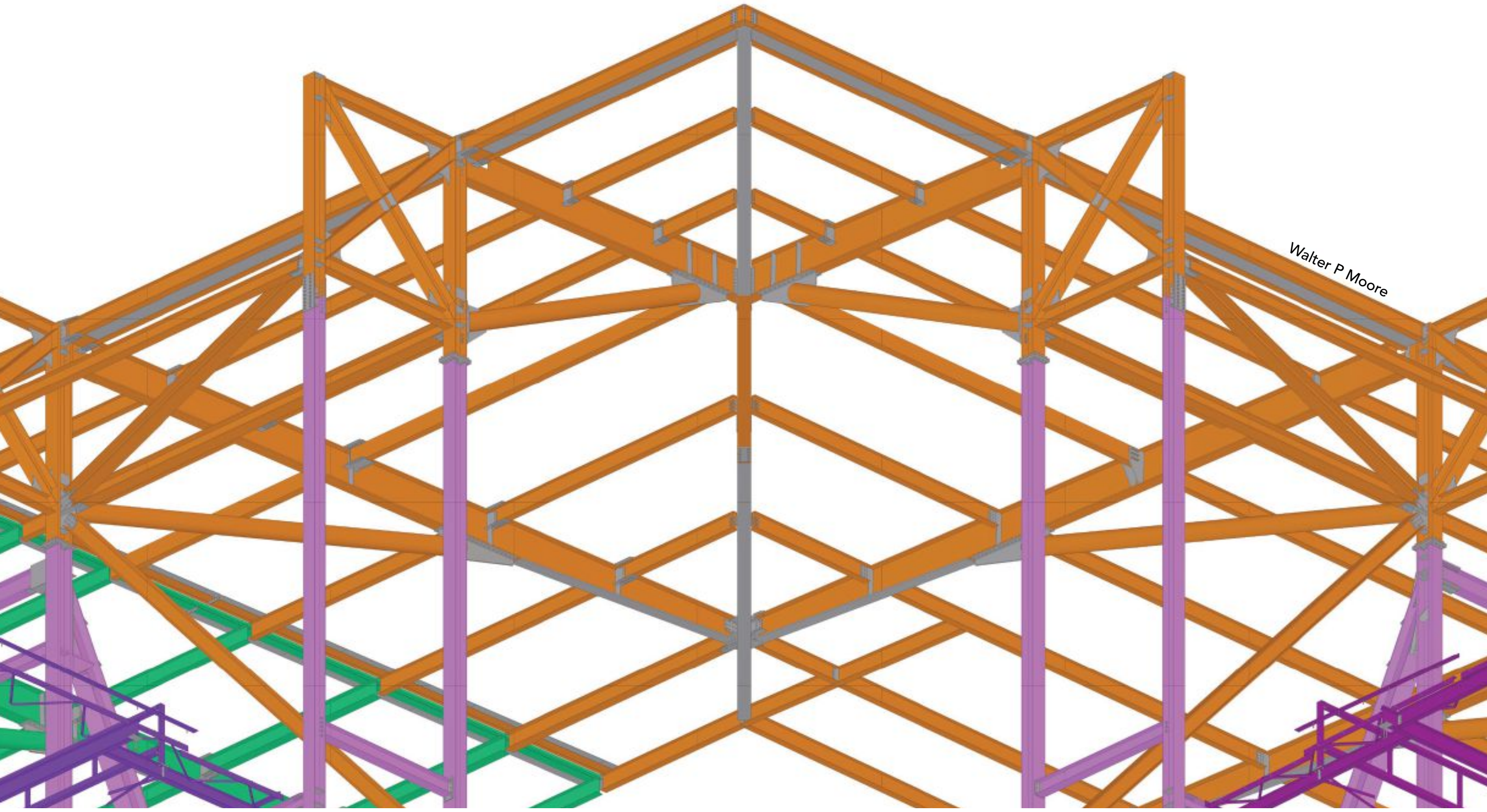
Walter P Moore



Walter P Moore

Walter P Moore

Nashville Soccer Club


Walter P Moore

design for the vast majority of typical beam-to-beam and beam-to-column connections, and the LOD300 Tekla model (called the stick model).

The engineer rapidly transferred the steel members and geometry from the Revit model to a LOD300 Tekla model through a digital-based design process. The LOD300 model helped level-set the steel bidders for a baseline tonnage and piece count. The first half of the LOD400 Tekla model was released as an addendum, allowing fabricators to understand the exact project requirements.

The updated Tekla model also included locations and extents of all four steel finishes: exterior high-performance, galvanized, interior prime only, and interior fireproofed—which eliminated another common source of scope confusion.

The modified process resulted in multiple competitive and qualified bids, ultimately leading to a steel contract 10% below budget value.

Tom Harris

The ConnecTID process completed the LOD400 model early, meaning trade coordination occurred at a higher fidelity immediately. Trade partners coordinated within pre-planned and fully modeled structural pathways. The model helped reduce steel RFIs by 90% from conventionally delivered projects. Most importantly, steel change orders totaled less than 3% of the contract value, about 70% less than what is commonly experienced in other highly accelerated steel projects.

Sustainability Success

GEODIS Park is the first professional stadium in the United States that couples the aesthetic and sustainability benefits of mass timber and structural steel by innovatively marrying them into a hybrid structural system that leverages the strengths of each material. The combination of minimalist steel frames and the long-span DLT decking created a resource-efficient dynamic entry feature that reduced the embodied carbon emissions of the stadium.

The strength and stiffness of steel provided the needed gravity and lateral support with just minimalist steel frames at 27 ft on center, providing ample width to optimize the positioning of entry queues and screening equipment, weather-protecting the equipment, and enhancing the guest experience. A pure timber structure would have been unable to accomplish these programmatic requirements.

Coupling steel and timber allowed each material to play to its strengths in a holistically optimized system. Additionally, the DLT panels do not have the environmental impacts associated with the glues required for CLT panels. The design team crafted hidden connections and utility runs. Fastener holes to connect the timber to the steel beams were pre-drilled in the shop, allowing quick and simple field installation of the timber. Perimeter steel channels conceal the roof slope, providing a clean steel perimeter fascia as the dominant architectural expression as fans approach the stadium.

For more on the GEODIS Park project, see "Southern Exposure" in the June 2023 issue, available at ***www.modernsteel.com****.*

Owner
Nashville Sports Authority

Owner's Representative
CAA ICON

General Pontractor
Mortenson | Messer Construction Co., Nashville

Architects
Populous, Kansas City, Mo.
HASTINGS Architecture, Nashville

Structural Engineer
Walter P. Moore and Associates, Inc., Kansas City, Mo.

Steel Team

Fabricator
LeJeune Steel, Minneapolis

Erector
LPR Construction, Loveland, Colo.

Detailer
DBM Vircon, Tempe, Ariz.

2024 IDEAS² AWARD

EXCELLENCE IN ENGINEERING

Nashville International Airport Terminal Lobby and International Arrivals Facility Addition, Nashville, Tenn.


Matt Good

THE TERMINAL LOBBY and international arrivals area renovations to Music City's main airport took inspiration from an instrument.

A sweeping canopy that anchors the overhauled lobby and international arrivals facility (IAF) at Nashville International Airport (BNA) has multiple guitar-like features and resembles musical airwaves. Designing it brought some challenges. Erecting it while keeping the airport operational brought even more.

The IAF and terminal lobby project aimed to provide additional airport capacity to meet the rapidly increasing domestic and international passenger demand. Structural engineer Magnusson Klemencic Associates (MKA) and the Hensel Phelps/Fentress architect team collaborated to design and build a $436 million renovation and expansion of BNA's terminal lobby, which includes the state-of-art IAF and a central food court featuring world-class retail, dining, and entertainment.

MKA thought beyond the project's practicality. It wanted to create a remarkable visitor experience for the growing passenger count and be bold and beautiful in the design.

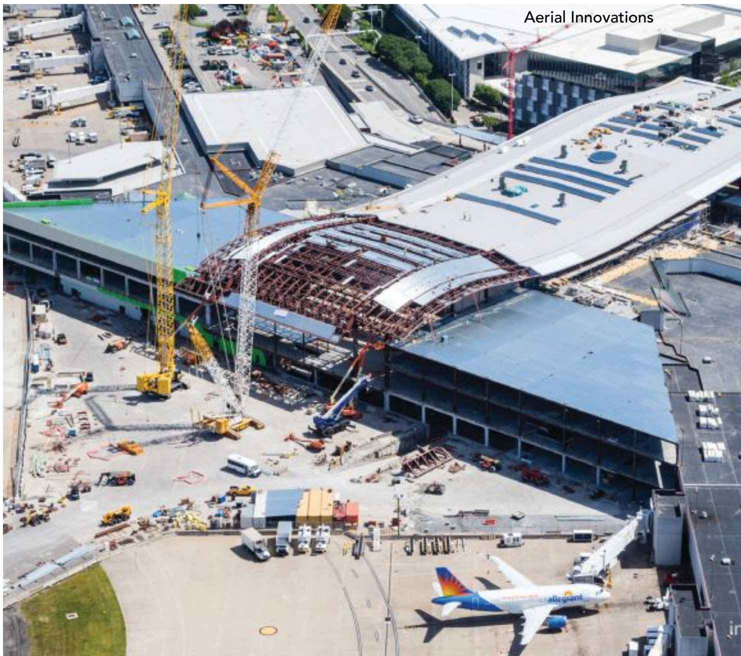
Aspirational renderings of the envisioned expanded terminal contained a grand ticketing lobby with abundant natural light and transparency. That included unencumbered views from the pedestrian bridge entry to the new international gates and a vibrant food court. To achieve this vision, MKA introduced a long-span, structural steel, curvilinear roof design that clear-spans the active roadway and terminal below. The roof design reduced the number of interior columns by 80% compared to a short-span roof design, achieving the architectural vision while significantly reducing the construction cost and schedule.

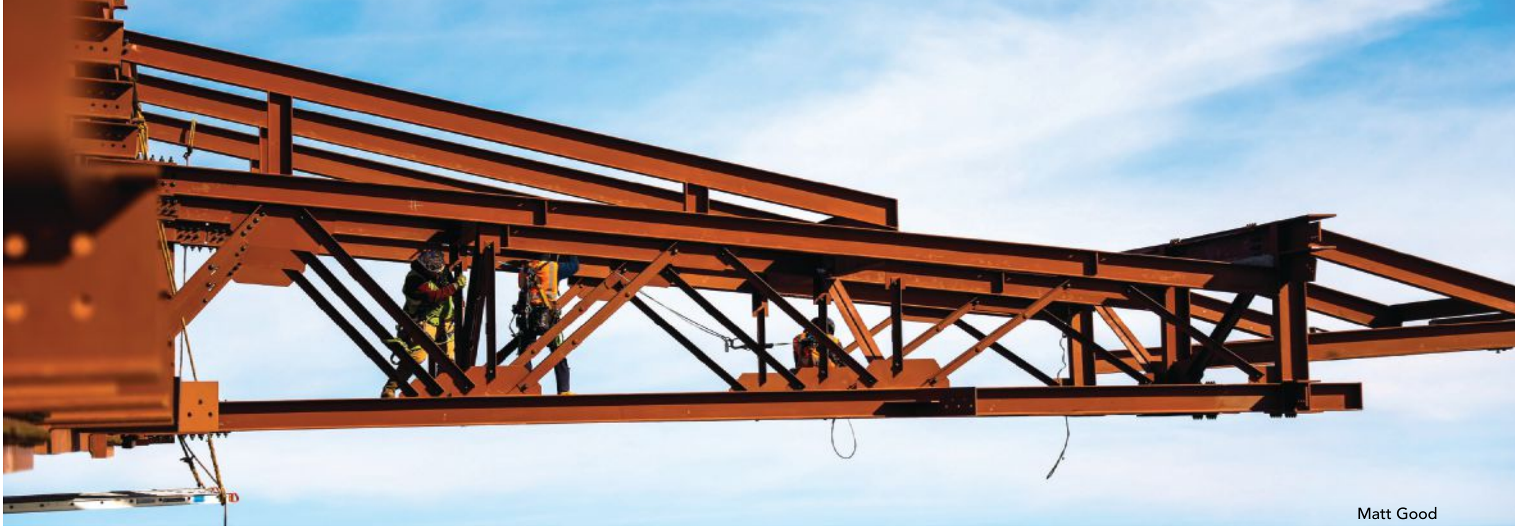
The 151,285-sq. ft structure weighs 1,750 tons and is comprised of twin, 685-ft-long contiguous spine trusses forming a gentle, wavy form symbolic of the Grand Ole Opry's radio waves, which BNA dubbed the "airwave." The terminal roof tapers to a finely pointed edge reminiscent of an airplane wing. Linear skylights throughout the roof evoke guitar frets, while an oculus skylight evokes the guitar's sound hole. The grand entry lobby and airwave roof completely reshape the terminal's form and volume, providing dramatic architectural expression.


Jordan Powers

Steel Success

Steel was the only material with merit because it provided the long spans needed to fly the new roof trusses over the existing roadway and terminal and the gentle, wavy geometric form essential to the desired architectural expression. Equally important, steel offered the most economical solution and the highest strength-to-weight ratio. Steel

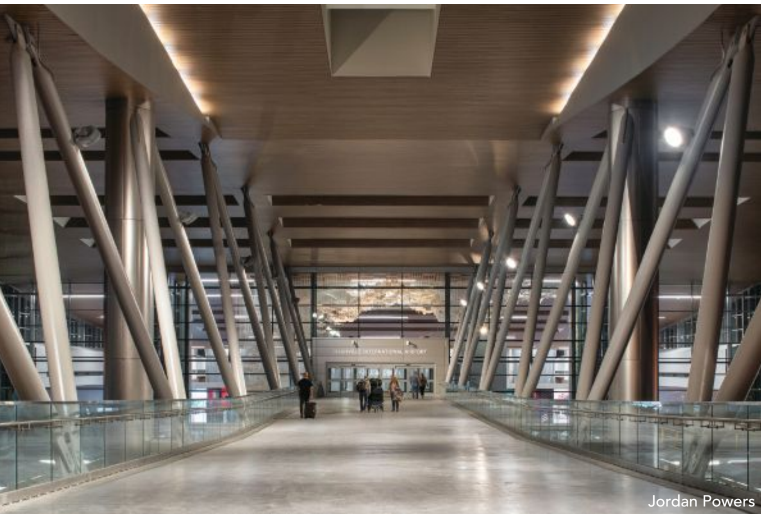

Aerial Innovations



Matt Good

"The team was very thoughtful with the form of the building itself and the roof. Passengers are going to be thinking about engineering as they walk through because it's exposed and visible to them. It means a lot to engineers to have their structures not just seen, but seen elegantly."
—Hannah Valentine

Aerial Innovations



Jordan Powers

Jordan Powers

comprises the airwave roof's moment frame lateral system—from steel trusses to built-up steel plate girders to cruciform steel columns—to provide unparalleled stability during and after construction.

The original bridging documents called for a braced frame lateral system, but MKA understood this system clashed with an architectural design that summoned grand open spaces. MKA prepared an alternate design scheme to show how a moment frame lateral system could capitalize on a more optimized steel design, reduce costs, and deliver on the vision for open and light-filled space.

The entire project capitalized on the power of structural steel long spans to provide maximum drama, views, and elegance with an optimized design. For example, new steel cruciform roof support columns were placed outside the new terminal's perimeter, allowing the ticketing area, passenger screening checkpoint, and food court to be predominately column-free, since no existing columns within the interior spaces were required to support the new roof. The result is tremendous, unobstructed views and intuitive wayfinding throughout.

A mass timber roof structure would have been far more expensive and required long-term maintenance to resist adverse weather. It also needed deeper trusses that would have completely changed the roof's desired slender form.

Likewise, concrete roof girders would have resulted in shorter spans, more support columns, and increased costs associated with bolstering roadway loads. Forming and casting a concrete roof or erecting precast girders were unviable options. With concrete, the roof structure would have been eight times heavier, and the carbon footprint would have increased dramatically if made from concrete.

Airwave Assist

The BNA project had to be completed while maintaining ongoing and uninterrupted operations throughout construction. MKA's novel "airwave" roof traverses the existing terminal and limited disruptions to the 50,000 daily passengers that travel through the airport and on the main roadway. The new roof was the engineering equivalent of a Swiss Army Knife, with several methods that ensured no passenger interruptions and no roadway closures.

The airwave trusses and W36 cruciform columns have fixed base foundations and support the entire roof, and they needed little temporary shoring or bracing throughout steel erection. That meant steel erection could proceed over the occupied terminal and active roadway.

The airwave also acted as an umbrella that provided weather protection while contractors safely demolished the existing roof below. The cost and schedule benefits were substantial, especially because the baggage handling system and electrical components below the departures level had to stay dry and remain fully operational throughout construction.

The existing columns were not needed to support the new roof, meaning workers didn't have to strengthen the existing columns and foundations—another considerable schedule and cost-benefit. Before it was demolished, the existing terminal roof was a safe temporary work platform to facilitate the installation of the new roof's mechanical, electrical, piping, and ceiling supports within. Installation was six times faster than using scissor lifts on the departures level to install these systems.

Once the new, long-span steel airwave roof was in place and weather-tight, the new steel roof trusses were used by the demolition contractor to rig from and safely demolish the existing roof below.

The airwave spans the arrivals roadway with two curvilinear mega-trusses supporting the new pedestrian bridge from the adjoining parking garage to the new Grand Entry Lobby. Hollow structural section (HSS) pipe diagonals laced between the lower bridge girder and the upper roof trusses allow the bridge to meet stringent vibration criteria. Cast Connex attached sleek steel castings to these girders, eliminating the need for bulky, bolt-laden gusset plates that would have restricted views through the glass handrailing on the pedestrian bridge.

The airwave's engineering was innovative beyond its ability to keep the airport open during construction. The steel roof structure was fabricated precisely to create the true roof geometry (for example, the one-and-the-same roof profile shadows the steel profile) and achieve the sleek and iconic airwave form essential to the architectural design intent. Like an airwave that rolls gently through the sky, the light and delicate roof form created by the steel fabricator allows ceiling, roofing, and skylight elements to be attached directly to the steel structure.

Throughout the design process, MKA worked closely with the fabricators and steel detailers to embrace constructability details that performed best. Truss splice locations were positioned so the trusses could be fabricated, shipped to the site, and erected fast, safely, and quickly. Each member fit seamlessly.

Elsewhere, the straight trusses were prefabricated in the shop and shipped to the site. They spanned between and through the spine trusses to complete the roof's undulating form with straight-line-generated geometry, greatly simplifying fabrication and erection. Straight trusses also formed beautiful recesses in the ceiling

Matt Good

Matt Good

finish so light from the linear skylights above could cascade onto the floor below, creating a remarkable, naturally lit space.

As a finishing architectural expression, the truss cantilever reminiscent of an airplane wing allows architectural cladding elements to be attached directly to the structure. Suspended art hangs directly from the structure above to create a phenomenal impression in the entry lobby.

Constructability and Sustainability

Hensel Phelps, Fentress, and MKA involved the steel fabricators and erector early in the project to provide valuable design assist input on prefabrication, connections, and erection.

The 685-foot-long dual spine trusses were designed and fabricated to be only 10 ft deep, facilitating pre-assembly at the fabrication plant and shipping to the site, minimizing cost- and schedule-related issues. In addition, the fabricators suggested MKA incorporate steel castings into the pedestrian bridge design to achieve a clean and simple pinned connection that preserved views while meeting stringent vibration criteria.

The design team working closely with the steel fabricator and erector early on provided insights on refining roof geometric clarity for the radial arcs and tangents of the desired roof form and determining the most cost-effective way to bend and connect the steel roof members. MKA determined at design inception that inserting the two longitudinal steel spine trusses traversing the 685-foot-long airwave roof—from the parking garage to the airfield—would best create the long-span roof form. That solution minimized the number of curved trusses, eased fabrication costs, and enhanced the roof's stability during erection.

Input from the steel erector and fabricator led MKA to change the moment frame connections from welded to field-bolted, minimizing steel erection time and reducing costs. During the design phase, the steel team vetted the tower crane's reach to ensure it could span the occupied roadway and placed a tower crane directly through the roof's oculus skylight opening to facilitate erecting steel above the terminal and roadway.

When expanding and renovating existing facilities, the most effective sustainable design solutions revolve around reusing and repurposing as much of the existing structure as possible, embracing solutions that do not require strengthening or demolishing the existing structure, and avoiding rebuilding with all new materials. The reuse efforts reduced the renovated terminal's carbon footprint by 50%, and all demolished steel was recycled.

Spanning the existing roadway with the airwave roof meant the project team did not need to strengthen the existing roadway, avoiding expensive, time-consuming, and disruptive measures such as roadway-related seismic upgrades, column strengthening, and micropiles.

The project design reused the existing terminal's departures, apron, mezzanine, and basement levels. Further, some of the original roof support columns were simply trimmed off and repurposed to support a video screen wall in front of the passenger screening checkpoint. The new design also employed an existing upper-level office floor as a new mechanical room.

The old terminal building remains, but passengers have little way of knowing as they stroll through the pedestrian bridge, into the column-free grand lobby, and onward to the vast retail and dining area—all with spacious views, natural light, and openness.

For more on the Nashville International Airport project, see "Riding The Wave" in the October 2022 issue, available at ***www.modernsteel.com****.*

Owner

Metropolitan Nashville Airport Authority

General Contractor

Hensel Phelps, Nashville

Architects

Fentress Architects, Denver
TMPartners, Brentwood, Tenn.
Corgan Associates, Dallas (BNA Vision Design Architect)

Prime Structural Engineer

Magnusson Klemencic Associates, Seattle

Foundation Engineer

Logan Patri Engineering, Inc., Nashville

Steel Team

Fabricators

Banker Steel, Lynchburg, Va.
Irwin Steel LLC, Justin, Texas
TrueNorth Steel, Lubbock, Texas

Erector

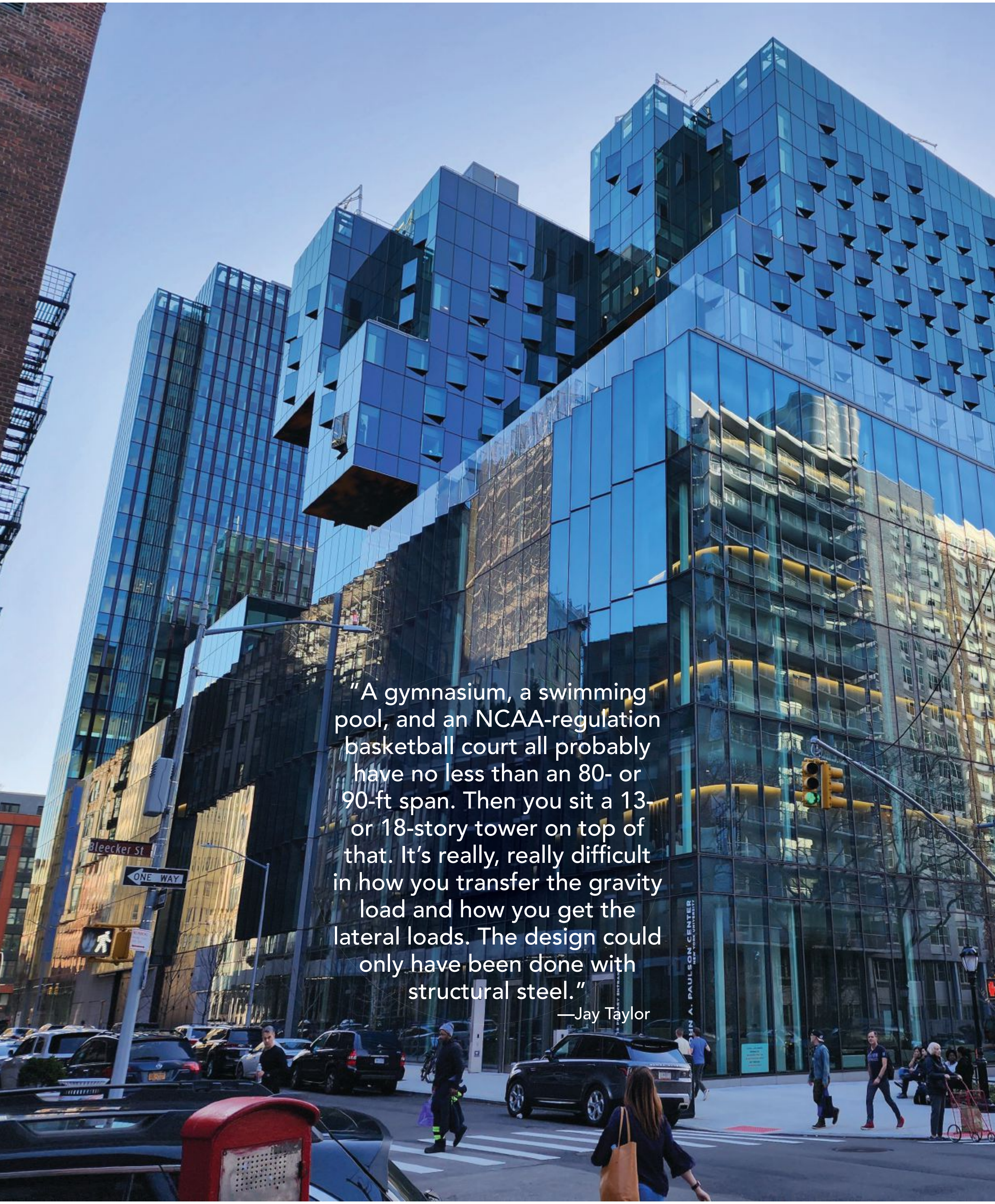
Schuff Steel Company, Euless, Texas

Bender/Roller

Chicago Metal Rolled Products, Chicago

Casting Manufacturer

Cast Connex



"A gymnasium, a swimming pool, and an NCAA-regulation basketball court all probably have no less than an 80- or 90-ft span. Then you sit a 13- or 18-story tower on top of that. It's really, really difficult in how you transfer the gravity load and how you get the lateral loads. The design could only have been done with structural steel."

—Jay Taylor

Severud Associates

2024 IDEAS² AWARD

EXCELLENCE IN ENGINEERING

New York University John A. Paulson Center, New York

NEW YORK UNIVERSITY'S John A. Paulson Center houses a mix of campus spaces rarely, if ever, grouped in one building.

The Paulson Center, which opened in early 2023, combines athletic facilities, classrooms, performing arts spaces, and faculty and student housing in a 735,000 sq. ft steel-framed tower that meets the diverse needs of students, faculty, and neighboring residents. NYU's location in the population-dense West Village neighborhood mandates a vertical campus, and steel's long-span potential allows a wide variety of facilities to be housed in one building.

The five-story performing arts podium anchors the building to its entire city block site, where the Jerome S. Coles Sports Center once stood. The building includes a 350-seat proscenium theater, two additional theaters, instruction and practice rooms, and classrooms. Double walls, floating floors, and dropped ceilings acoustically isolate the venues from noise and vibration.

Two below-grade levels house four regulation NCAA basketball courts—including NYU's new home court—and a six-lane swimming pool. Four floor-deep steel trusses, three at ground level and one at the fifth floor, span 130 ft over the basketball courts to create a 115-ft by 250-ft open space. The trusses transfer columns above and support a hanging running track below with a 25-ft clearance over the courts, which will not interfere with play.

An 18-story faculty housing tower springs from the south end of the podium, while a 13-story dormitory block sits atop the podium's midsection. Two additional levels of rehearsal rooms fill the space between. The residential structures are framed with conventional structural steel and the Girder-Slab floor system, which combines proprietary steel shapes with precast concrete plank. The system allows speedy erection, reduces dead load, and minimizes construction depth.

The building's performing arts spaces required extensive vibration and acoustic isolation between the foundation and the southern two-thirds of the ground floor. Beam pockets, column splices, and complex isolation details provide the necessary attenuation at column bases.

The building's myriad uses occupy architecturally distinct regions, each constructed with an appropriate structural system. A combination of structural steel—including long-span trusses and plate girders—cast-in-place concrete and precast concrete plank supported by proprietary steel shapes minimized the dead load of each component and maximized construction speed.

Take a Load Off

The Paulson Center's main program elements—the proscenium theater and other performance venues, the basketball courts, and the swimming pool—required large open spaces, and their arrangement mandated many column transfers. Performing arts spaces throughout the podium are located directly beneath the faculty tower and student dormitories, resulting in 80 plate girders at the podium roof.

Most of the podium is transferred on the four floor-deep trusses. Structural steel was the logical choice to carry the accumulated loads efficiently without adding significant dead load.

Truss members are box sections, built up from 4- to 6-in.-thick plate. These sections offer maximum lateral stability and high strength, allowing engineers to minimize material quantities further and effectively control deflections, which were limited to about 1 in. for live load. The trusses' openness and smaller member sizes also accommodate occupant circulation by allowing doorways through truss panels—especially critical at the high-traffic ground level. Further, the openings inherent to steel trusses facilitated coordination with the extensive mechanical systems in the building.

Dead load reduction, headroom, and speed of erection were drivers for selecting the Girder-Slab system and structural steel for the residential structures. Conventional wisdom would dictate concrete flat plates, which was considered, but its greater dead load would have increased demands on the transfer system and taken longer to construct.

The proprietary steel tee shapes were combined with conventional structural steel and hollow-core precast concrete plank and kept dead load to a minimum while allowing a faster construction schedule. The tee shapes also help maintain a uniform soffit and reduced floor-to-floor heights.

One of the podium's program and sustainability features is the circulation corridor at the perimeter of each floor, which promotes connectivity between the building's occupants and city residents on the street and provides natural light and passive solar heating. A necessary consequence of the corridors is that students, faculty, and staff spend a lot of time near the exterior walls.

Engineers and architects designed perimeter columns using architecturally exposed hollow structural sections (HSS)—typically HSS14×14 and spaced at 20 ft—fireproofed with intumescent paint. At stair openings, HSS beams supplemented the spandrel framing. Similarly, HSS12×8 exterior columns were used at the residential towers.

Stacking Uses

Stacking the Paulson Center's mixed uses on top of each other was a pivotal piece of the building design and engineering: The residential towers sit atop the performing arts podium, which bears over the below-grade athletic facilities. None of the tower columns and a few interior podium columns extend continuously to the foundation. In fact, there are over 220 column transfers in the building, including the four long-span trusses and 80 plate girders at the podium roof.

The extensive column transfers meant the loads on the columns reaching the foundation were much higher than expected for a building of this size. As a result, high-capacity caissons were drilled to reach and socket into bedrock. Temporary caissons were installed to provide support for the transfer trusses during erection.

The high groundwater elevation at the site necessitated that the caisson-supported perimeter walls and cellar slab be designed as a waterproofed "bathtub" to resist lateral earth pressure and hydrostatic uplift. Consequently, the caissons supporting the slab under the basketball courts are also designed for tension.

The swimming pool and basketball courts prevented extension of much of the lateral bracing directly to the foundation. Instead, loads from the podium were transferred to the perimeter walls at ground level using horizontal steel trusses and concrete diaphragms. That transfer approach increased loads in the ground floor framing and complicated the slab reinforcement and connection designs, especially at the numerous changes in slab elevation.

The podium's centerpiece is the proscenium theater. The podium structure, which also includes additional performance spaces, music instruction and practice rooms, and classrooms, is framed in steel, with concrete fill on metal deck floors. Massive double walls, raised floating floors, and specially detailed dropped ceilings further acoustically isolate the venues from noise and vibration transmitted through the framing from the athletic facilities.

Prescriptive building code lateral requirements do not explicitly address the building's multi-tower configuration. Therefore, wind tunnel testing was conducted to determine appropriate load patterns, and a seismic response spectrum analysis captured the response of the complex structure. The lateral force resisting system includes a combination of braced and moment-resisting frames. Horizontal trusses at the podium roof transfer lateral loads from the towers to lines of bracing surrounding the large open spaces of the theaters.

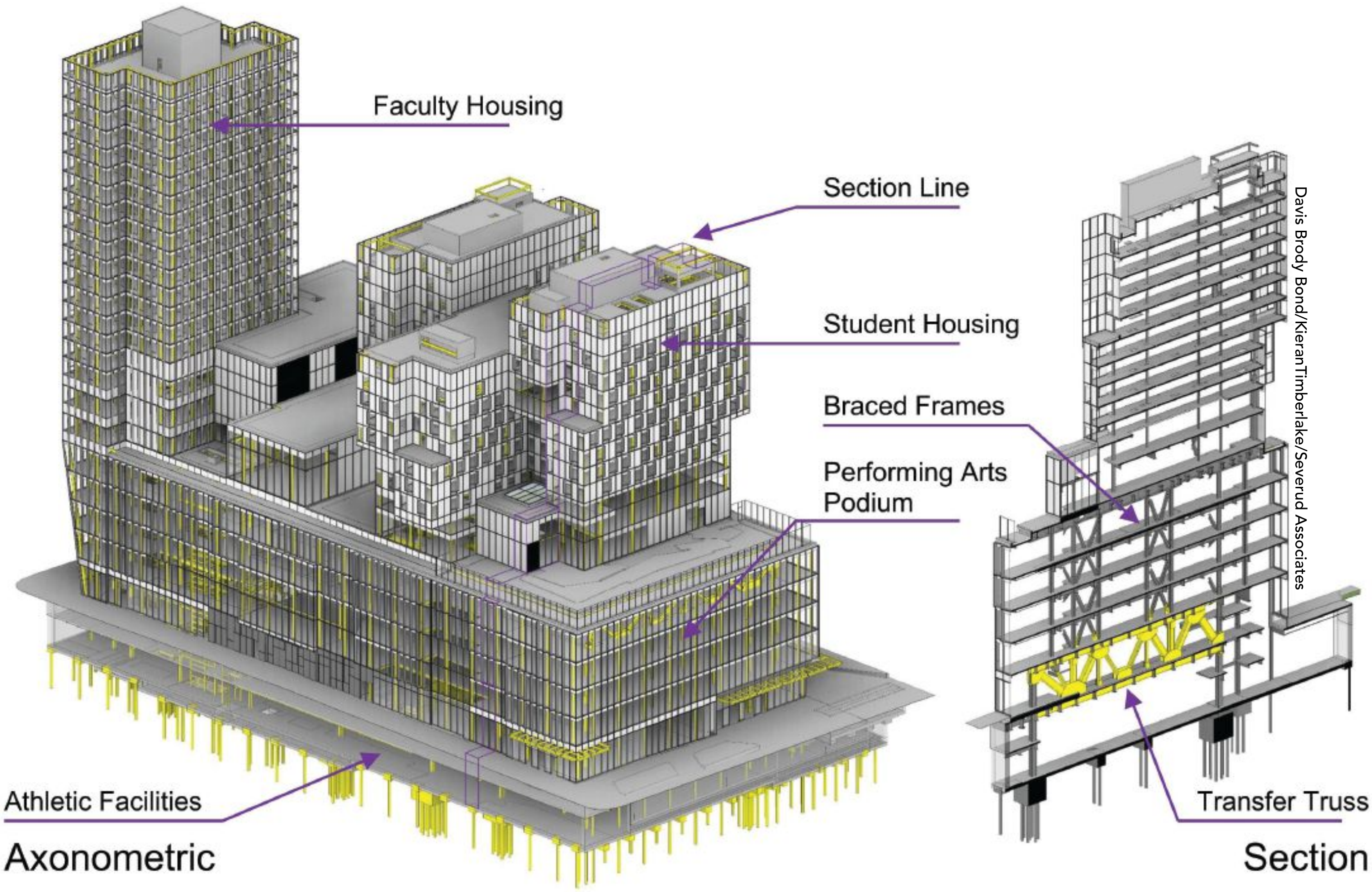
Acoustic isolators between the foundation and the steel framing of the southern two-thirds of the structure attenuate vibrations and noise from subway trains and vehicle traffic. At column bases, layers of polyurethane material are between the top of the caisson cap and base plate and around the pressure slab opening. The same material sits between the base plate and plate washer at each anchor rod, and the assemblage is covered with a cap. Finally, the base plate was grouted and the pocket filled with concrete to create a rigid base for stability and load transfer that would not transmit undesirable vibrations. A similar detail was used at beam pockets.

The column base detail was modified to account for shear transfer where lateral bracing extends to the cellar level. A wide flange steel lug was welded to the underside of the column base plate, which was set into a recess in the caisson cap lined with a similar polyurethane material.

The lateral load transfer at the ground level to avoid the athletic facilities resulted in higher-than-usual shears between the diaphragms and foundation walls. The structural engineers devised an innovative interlocking "sawtooth" connection of the floor slab to the foundation walls—intermittent projections of the underside of the slab cast into wall pockets lined with a polyurethane material—to maintain acoustic isolation.

The combination of the sawtooth slab, beam pocket and column base isolation details, and isolation of column splices in some locations allow the entire superstructure to carry the necessary gravity and lateral loads without creating a path through the framing for unwanted vibrations.

Careful coordination between the architect, structural engineer, and MEP consultant maximized the number of floors—and their ceiling heights—that could be built in the available space. An extensive number of large beam and plate girder openings allowed most of the ductwork, conduits, and piping to occupy the same space as the structural framing. Strategically locating the columns



Davis Brody Bond/KieranTimberlake/Severud Associates

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Severud Associates

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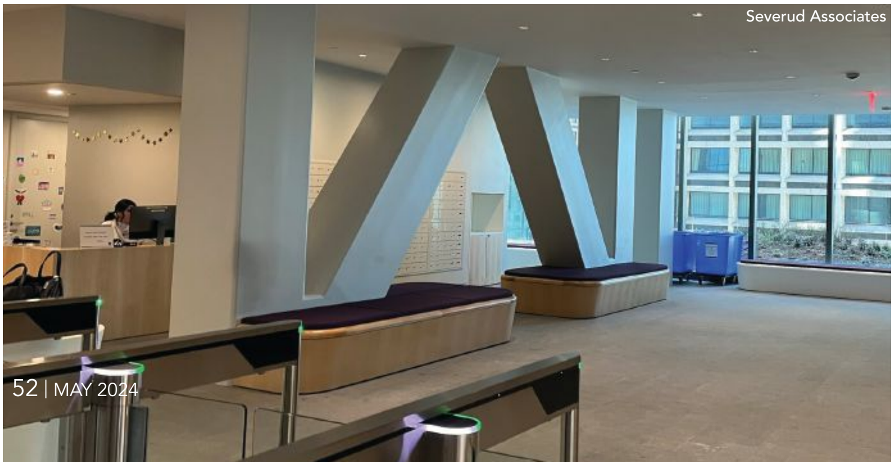
Davis Brody Bond



Severud Associates

at the tower-podium roof interface reduced demands on the plate girders and trusses, which further facilitated accommodation of the mechanical systems while giving the architects the high ceilings they desired.

The orientation of individual elements became critical to limit transfers and minimize loads. For instance, the natural alignment for the swimming pool is longitudinal to the building, while the proscenium theater needed to be across the building's width. Both are located at the same end of the building. The team finessed the specific location of each so that they formed a cruciform shape in projection. Engineers located continuous columns at each of the reentrant corners of the cross.

The four floor-deep trusses and many braced frames provided aesthetic possibilities for the architects. In several locations, the vertical and diagonal members become sculptural elements within a room or are expressed in the wall finishes. The compact size of the members—made possible by using steel box sections at the trusses—gave the architects greater flexibility in choosing the extent and appearance of the expression.

The architectural and client requirements led to extremely tight clearances, which impacted column dimensions, beam and slab depths, and mechanical clearances in the ceilings. Consequently, the structural engineers had to push the bounds of certain materials to optimize the design. The results emphasize the importance of teamwork and coordination between design disciplines and construction trades. Due to the design team's collective efforts, the building delivers NYU's extensive programmatic requirements in a shorter building height than the initial design.

The Girder-Slab system was considered in the early design phase as an option to reduce the floor-to-floor height in the residential towers and increase the number of floors. The building's engineers worked with their counterparts at Girder-Slab to determine appropriate system components and criteria for the corresponding conventional structural steel elements to achieve the fullest benefit. The resulting floor heights are 10 ft at the student dormitories and 9½ ft at the faculty housing tower.

Early in the steel detailing process, the steel contractor developed a modification to the column base isolation detail. The isolation material was applied to the underside and perimeter of the base plate in the shop, after which a steel leveling plate on the bottom and closure plates around the sides were adhered to form a box. That process allowed the entire base isolation assembly to be prefabricated.

On site, the base-isolated columns could be erected in the same manner as a standard column. Once installed, the column bases were grouted in the typical manner, using access holes through the base plate sandwich. The modified detail eliminated the need for additional field labor and helped speed up erection of the steel frame.

The structural engineer worked closely with the steel contractor during the shop drawing phase to supply detailed shear and moment values along the length of each plate girder, which gave the contractor freedom to tailor the flange and web plate thicknesses, widths, and welding to minimize material and labor while still providing the required strength and stiffness.

Sustainable Thinking

The Paulson Center will contribute to NYU's goal to achieve carbon neutrality by 2040 and is expected to achieve LEED Gold certification. Materials from demolition and construction waste were recycled, and the structural steel framing contains over 90% recycled material.

The building is connected to NYU's existing co-generation plant for heating, cooling, and dehumidification, which minimizes its consumption of fuel and potable water. Extensive high-performance glazing—also designed to minimize bird collisions—and the location of circulation corridors at the building's perimeter facilitate passive solar heating in winter, reduce heat gain in summer, and provide year-round natural lighting.

More than 25,000 sq. ft of terraces and green roofs provide natural cooling, capture rainwater for reuse in a 135,000-gallon tank, and reduce the building's heat island effect. The outdoor spaces also promote biodiversity and improve occupant health.

Owner
New York University

General Contractor
Turner Construction Company, New York

Architects
Davis Brody Bond, New York
KieranTimberlake, Philadelphia

Structural Engineer
Severud Associates Consulting Engineers, PC, New York

Fabricator and Erector
W&W | AFCO Steel, Oklahoma City


Severud Associates

THE WINSHIP CANCER INSTITUTE is expanding its footprint in Atlanta with a state-of-the-art new hospital.

The new location, called the Winship Cancer Institute at Emory Midtown, is a 17-story cancer hospital in the heart of Atlanta that brings 450,000 sq. ft of inpatient, outpatient, and research facilities to the Emory University Hospital Midtown campus. It consists of a new cancer care center located directly across the street from Emory's existing hospital, with the two buildings connected by a new pedestrian bridge.

The two-level bridge—designed by Skidmore, Owings & Merrill (SOM) and constructed by Batson-Cook Construction—spans 184 ft with a main span of 134 ft across Linden Avenue, linking the two buildings without impacting the existing hospital's drop-off area and architectural design. Its transparent lower level connects public spaces in both buildings, while the upper level provides patient access and is clad in fritted glass to maintain patient privacy. The bridge also carries major mechanical, electrical, and plumbing services across the street to service the new cancer center.

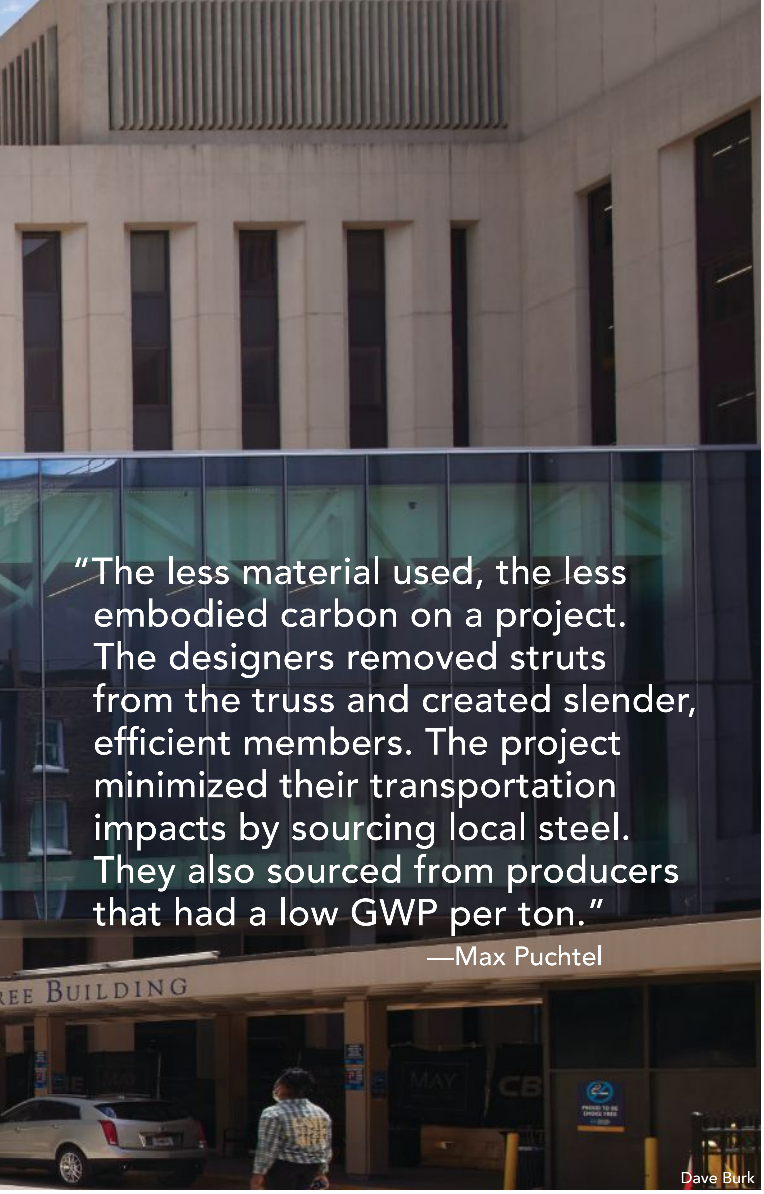
Though the bridge has two levels, the design team determined that the span could be efficiently managed with a single-story truss. The top level of the bridge comprises a structural steel truss at each side, while the lower level is hung from hollow structural section (HSS) hangers at the truss panel points. Besides these efficiency and constructability considerations, this choice also reflected the functional differences between the two levels. The top private level is more enclosed, while the lower public level is as transparent as possible.

The Emory Bridge spans Linden Avenue—a highly trafficked road that functions as an on-ramp to Interstate 85—an exterior courtyard, and a patient drop-off area for the current hospital's Peachtree Building. Ideally, its design would minimize road closures and bring negligible impact to the hospital, which needed to remain open during construction.

The design team chose structural steel because its bridge could be pre-assembled into the largest possible sections on the ground—before being lifted into place and assembled in just a single weekend. One lane of Linden Avenue was a laydown area to assemble the delivered pieces into two large box trusses that could be erected quickly and safely over the road. Two mobile cranes lift the two box trusses into place in one weekend. The sections were bolted together while suspended in the air, and the cranes remained hooked to the trusses until all back welds were complete.

Construction crews hung the bridge's lower level from the trusses, allowing Linden Avenue to be reopened while work remained ongoing.

Where exposed to view, the bridge members are architecturally exposed structural steel (AESS), consisting of square HSS sections connected to a milled steel node at the intersections of



Dave Burk

"The less material used, the less embodied carbon on a project. The designers removed struts from the truss and created slender, efficient members. The project minimized their transportation impacts by sourcing local steel. They also sourced from producers that had a low GWP per ton."
—Max Puchtel


Batson-Cook Construction


Dave Burk

the truss diagonals. The AESS material's aesthetic purposes were another factor in choosing steel because they allowed for the most slender profiles possible. The simple yet elegant detailing puts the structural steel's beauty on full display. The square HSS hangers supporting the bridge's lower level practically disappear behind the enclosure mullions and give that level the appearance of floating.

One of the major design challenges was the bridge's need to connect two buildings at different corresponding elevations. The lower level had to reconcile an elevation change of 4 ft 1 in., while the upper level had a change of 1 ft 4 in.

The design team strategically connected the two springing points with straight and slightly inclined walking surfaces to meet the maximum allowable slope. It then investigated several options for forming the geometry of the structural elements to accommodate these elevation constraints. The solution was to keep the top and bottom chords of the truss horizontal to simplify fabrication, and more importantly, to preserve the clarity and purity of the truss geometry.

Additionally, the chosen configuration maintained a consistent node geometry to facilitate fabrication and provided a regular datum for the attachment of the facade modules. The walking surface's slope was achieved using a slab-on-grade over-shaped geofoam. The bottom level framing, which hangs from the truss, was sloped to follow the walking surface. The lower-level façade units extend down from the bottom of the structure along the bridge to avoid trapezoidal glass elements.

The existing building structure did not have sufficient capacity to support a new bridge and would have required reinforcement. In response, the design team cantilevered the end of the bridge beyond the last support, ensuring that no new loads were imposed on the existing building.

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EXCELLENCE IN SUSTAINABLE DESIGN AND CONSTRUCTION

Pedestrian Bridge at the Winship Cancer Institute at Emory Midtown, Atlanta


EMORY
WINSHIP
CANCER
INSTITUTE
WINSHIP
EMORY
MIDTOWN
Dave Burk


Dave Burk

Batson-Cook Construction

Dave Burk

The construction sequence aimed to minimize the time when highly trafficked Linden Avenue was closed by erecting the largest possible sections.

Trusting the Trusses

The bridge's primary distinctive feature is the upper-level truss that utilizes web members arranged in an innovative geometry, increasing the structure's efficiency.

SOM used several academic and internally developed structural optimization tools to arrive at an efficient structural form and minimize total material usage. One program, Polytop, starts with a design space of a solid 2D continuum of material and iteratively removes material to arrive at a solid-like approximation of the most efficient structural form. The other program, Ground Structure, utilizes a design space of a densely interconnected grid of linear elements and iteratively removes members to arrive at a sketch-like approximation of the most efficient structural form.

The results were combined with an applied rationalization considering the fabrication and construction of the bridge. The resulting geometry consisted of truss bays with skewed X-bracing that is symmetrically oriented about the mid-span of the bridge.

SOM has successfully designed several high-rises with a similar geometry for vertical bracing, including 800 W. Fulton Market in Chicago. However, the Emory Winship at Midtown Bridge is the first constructed example of a long-span structure with this truss geometry.

The truss diagonals were considered AESS, and the design team worked with aesthetic purposes and facilitating construction in mind. The team decided to maintain a consistent outer dimension for all the truss diagonals within each truss bay, ensuring a visual continuity of elements and avoiding connections with members of varying dimensions.

Similarly, the design team minimized the changes in member dimensions between bays to ensure a seamless transition along the truss. At the asymmetric connection of the truss diagonals, the team used a milled steel node to provide a clean, easily repeatable piece for a consistent connection. The resulting truss consists of W12×96 top and bottom chord members, while the truss diagonals comprise HSS4×4 through HSS8×8 elements.

The design team's preferred topology optimization tools determined the most structurally efficient form of the truss, ensuring material is used only where required and minimizing the overall embodied carbon footprint of the bridge. The support points of the bridge were also chosen to reduce the impact on existing structures, allowing them to remain in place and minimizing demolition and waste. ■

Owner
Winship Cancer Institute of Emory University

Owner's Representatives
Turner & Townsend Healthcare

General Contractor
Batson-Cook Construction, Atlanta

Architects
Skidmore, Owings & Merrill (SOM), New York
May Architecture, Atlanta

Structural Engineer
Skidmore, Owings & Merrill, New York

Six experts on robotic fabrication equipment address trends and considerations of a technology that's quickly becoming essential.

Automation Authorities

BY PATRICK ENGEL

Peddinghaus' PeddiBot-1200 cutting machine.

STEEL FABRICATORS are hearing automation and robotic machinery knocking on their shop doors. Many have already let them in—and thrived because of it.

Automated fabrication equipment is no longer an experiment. It's becoming a common piece of a fabrication shop and a helpful tool for fabricators to reach output and profit goals. It has also helped lessen the impact of the trade labor shortage that has gripped fabricators nationwide.

Fabricator questions and caution about robotic equipment persist, though. Implementing it requires buy-in from shop floor workers who might worry the equipment could replace them. One automated machine might be a strong fit for one shop and unnecessary for another. Finding a suitable machine and deciding how much automation to adopt requires careful analysis.

All told, automation is still a burgeoning technology in fabrication shops. But it will only grow as examples of its positive impact become more common. *Modern Steel Construction* asked six people at companies in the automated equipment sales space to provide more insight on the possibilities, technology, and trends in robotics.

What considerations and topics have arisen when you're talking to customers about robotic equipment?

Curt Decker, senior structural engineer, Lincoln Electric: There are several topics customers have asked about when considering robotic equipment and automation.

- Safety: Customers are often concerned about the safety of robots that work alongside humans. They want to know measures to prevent accidents and injuries.
- Cost: Robotic technology can be expensive, and customers want to know if the benefits of using robots outweigh the costs.
- Training: Customers may need to train their employees to work with robots; they want to know what training is required and how long it will take.
- Maintenance: Robots require regular maintenance to run smoothly; customers want to know about the required maintenance and how often it needs to be done.
- Integration: Customers may already have existing systems in place and want to know how easy it will be to integrate robots into their current workflows.
- Data privacy: With the increasing use of robotics in various industries, customers are concerned about the privacy and security of their data. They want to know how robots will collect, store, and use their data.

Adam MacDonald, East Coast Territory Manager, AGT: Leveraging the power of existing data is crucial. Eliminating the need for programming in robotics applications helps fabricators move seamlessly from a 3D model to the shop floor when using automation. That requires good software.

Ben Morrall, President, Voortman Steel Group: Robotics in processing, fitting, and welding are assisting in increasing fabricators' total output. Many of our customers have access to more work than their operations can currently support. Hiring personnel to support the increased workload isn't feasible with current market conditions, so the next logical step is to automate as much of the fabrication process as possible through robotic processing, fitting, and welding solutions.

Meg Hamann, Specialty Products Manager, Peddinghaus: As with any purchase, a prospective client's priority is ensuring their investment will be profitable. While this consideration is not specific to robots, we work with many in our industry who are researching this technology for the first time. For this reason, we provide customers with all the information they need to help them confidently make the right decision for their business.

Ultimately, fabricators are looking for an operator-friendly, accurate, speedy, and durable robot with the potential to grow their business. Whether organizing field demonstrations or preparing custom time studies, we work closely with potential buyers to ensure we answer all their questions.

Danny Steyn, President, Ocean Machinery: This goes back to the Industrial Revolution: As labor rates continue to rise, companies producing with manual labor will be marginalized by those using automation. But now automation in all forms, including robotic welding, is becoming affordable to even the smallest fabricators.

John Tutino, Sales Specialist, Beamcut Systems (Machitech Automation): The tools we can offer today to make fabricators more productive and efficient were unavailable years ago. By demonstrating this new technology and a return on investment, they are pleasantly surprised and wonder why they didn't update their shop sooner.

Another benefit of investing in robotic plasma cutting is replacing other older machinery, such as drill lines, angles lines, and bandsaws, which can open more usable floor space for their operations and reassign machine operators for better use.

Has robotics technology in your equipment changed in the last few years?

Decker: Robotic technology is constantly evolving and improving. In the last year, there have been several advancements in our robotics technology.

We have increased the use of artificial intelligence and machine learning algorithms to improve the performance and capabilities of robots. More advanced sensors and cameras have been developed, and they help robots perceive and interact with their environment more effectively. Also new in the marketplace are robots that are more flexible, adaptable, and can be reprogrammed to perform different tasks. The industry has seen an increased use of collaborative robots (cobots) that work alongside humans in a shared workspace.

We can expect to see even more advancements in the coming years.

Hamann: Robotic technology is always evolving. The machines themselves may not change drastically from year to year, but the software that drives them is constantly improving. Peddinghaus implements significant, regular software updates by utilizing our nearly 10 years of field experience in robotic cutting, fitting, and welding processes, as well as valuable customer feedback.

MacDonald: At AGT, we now have SnapCam 3D Vision on all our systems. It allows the vision system to compare the geometry from the 3D model to what it sees on the shop floor with the quality control inspector.

Morrall: The robotic technology itself has largely stayed the same, but the requirement for manual programming has changed significantly for us. We use Digi-Steel (a workshop management software) to completely review the building model and create all the required information for the robotic systems to complete their tasks without any manual intervention required.

Steyn: Robotic welding software is continuously advancing. And the improvements in our products are mainly attributed to the continuous refinement of coding, and the continuous addition of new welding recipes and parameters.

Tutino: After some time, you feel comfortable with the stability of the design of the machinery. Therefore, hardware or mechanical changes are limited. What changes more frequently are adding features to the software to optimize the machine's capabilities. What is interesting is that we receive suggestions/ideas from our customers. Not only does the software update improve their throughput, but it also helps us provide a better machine that all customers can take advantage of.

Curt Decker | Lincoln Electric

Meg Hamann | Peddinghaus

Adam MacDonald | AGT

Ben Morrall | Voortman Steel Group

Danny Steyn | Ocean Machinery

John Tutino | Beamcut Systems

Beamcut Systems' BC25 cutter.

How have fabricators responded to increasing robotics use?

Decker: Some fabricators have embraced robotic technology and heavily invested because they see its potential to increase efficiency, reduce costs, and improve quality. These fabricators have integrated robotic systems like our Lincoln Electric PythonX and Zeman products into their production lines and have trained their employees to work alongside them.

Other fabricators have been more cautious about adopting robotic technology due to concerns about cost, complexity, or the potential impact on their workforce. Some have started with smaller, more affordable cobots like our Cooper CRX and Cooper GoFa cobots and gradually scale up as they become more comfortable with the technology.

Overall, the response to the increase in robotic use in fabrication has been mixed, with some fabricators fully embracing the technology and others taking a more cautious approach. However, as the benefits of robotic welding become more apparent and the technology continues to improve, more and more fabricators will likely adopt robotics in their operations.

MacDonald: Many fabricators recognize the importance of advancements in automation. Faced with a labor shortage, they seek competitive pricing while raising labor rates and offering attractive benefit packages to attract potential employees. Additionally, technology holds appeal and is easily adaptable for the incoming workforce.

Morrall: Robotics have been available for over 15 years in many of the applications. Fabricators are now looking at the systems as proven technology worth considering.

Hamann: Today's users are reaping the benefits of innovative technology. However, as robots become more prevalent in the modern fabrication shop, fabricators recognize they will soon transition from optional to a requirement for those who want to remain competitive in the marketplace.

Steyn: As with the introduction of any new technology, there are always supporters and there are always detractors who think it's the end of the world. However, any new solution on the market only succeeds if it yields sensible financial returns and meets the exacting demands of the customers. If it doesn't, it disappears forever. Ultimately, we are all end users and understand things that will make our lives easier.

Tutino: From our experience, our customers have increased productivity and, most importantly, lower rejections due to the machinery's accuracy. It has allowed them to explore new industries to offer their services or capabilities. They could not do so in the past because the complexity of the cut requirements was too difficult to cut manually or the inability to meet their client's lead time. By adding the robotic plasma-cutting system, they are more competitive in bidding for projects and have more significant opportunities for growth.

Is there a specific size or shop where your equipment is most applicable?

Decker: The applicability of robotic equipment depends on several factors, including the specific needs of the shop or facility, the type of work, and the available budget. It's important to evaluate the options with care and choose the equipment that best meets the needs of the business.

In many cases, fabricators can better use space within a fabrication facility by implementing robotic automation like our PythonX and Zeman systems. For shops that need more mobility, our Cooper cobots provide flexible alternatives to a stationary cell.

Hamann: Peddinghaus machinery is designed for fabrication shops of all sizes. Regardless of whether our customer is venturing into CNC equipment for the first time or adding capacity to an existing system, we proudly offer solutions for all fabricators.

MacDonald: We offer many robotic welding systems at various price points. Big or small, we can help you make a difference.

Morrall: Shop size is not a big factor in adopting robotics. Our approach is all based around the customer's application and goals. We have installed solutions for a wide range of customers with immensely different output requirements.

Steyn: Our Ocean Challenger robotic welder suits the medium-sized structural steel fabricator that typically has more than 20 shop floor employees. Still, many installations are currently working in smaller and larger shops than that, and several shops have more than one.

Tutino: No. We offer machinery of different sizes, which are customizable to meet the needs of the many industries we serve of different shop sizes. There are many instances where we sell entry-level starting point equipment to keep the cost down. Later, we add other equipment to increase their productivity even more.

What do you want to tell people considering adding more robotic equipment to their shops?

Decker: If you're thinking about adding more robotic equipment to your shop, there are a few things to keep in mind:

- Evaluate your needs: Before investing in robotic equipment, evaluate your needs and determine which tasks or processes would benefit most from automation. Consider factors such as production volume, labor costs, and quality control. How will the increased production of robotic automation impact downstream operations? Can you resolve any potential issues with additional automation solutions such as material handling?
- Plan for integration: Integrating robotic equipment into your existing workflow can be complex. Consider factors such as space requirements, employee training, and software integration. Make sure your equipment provider can scale with your needs.
- Consider the long-term costs: Robotic equipment can be a significant investment, and the long-term costs include maintenance, repairs, and upgrades. Confirm your integration partner has resources to support you.
- Involve your employees: Introducing robotic and automated equipment into your shop can be a significant change for your employees, so they must be involved in implementation.


The Ocean Challenger automated welder.

The Voortman Fabricator automated stitching and welding system.

Provide training and support to help them adapt to modern technology and ensure that they feel comfortable working alongside robots.

- Choose a partner you can trust: Many types of robotic equipment are available, each with its strengths and weaknesses. Research your options carefully and choose the equipment and service partner that best meets your needs and supports your company post-sale.

Hamann: The time is now. Over the past few years, automation technology has become extremely popular in the structural steel industry. Robots provide fabricators with additional output they need but sometimes struggle to achieve in a contracting skilled labor market. Those who have already invested in robotics are realizing an immediate increase in output and efficiency, making them rapidly more profitable.

MacDonald: Do your research and find an integrator focused solely on the robotic application you want to implement. The integrator will be more focused and give you the training and service you deserve.

Morrall: Robotic processing and fabrication are here to stay and getting more versatile every day. In typical applications, one of our robotic systems can do the job of five people with one operator. Additionally, scaling up output doesn't necessarily mean you need more operators. Sometimes, one operator can run multiple systems.

Steyn: All investments must be made with the owner firmly focused on ROI. It's easy to be seduced into purchasing a solution that is too expensive for a shop and takes too long to show a return. In our opinion, for our industry, all capital investments should show an ROI of under 2.5 years.

Tutino: Some fabricators may fear that a robotic system is too complicated to work with, or they believe that having cheap labor is the answer. Sometimes, the challenge is convincing them that this fear or their thinking of cheap labor is far from the truth. In addition, the labor pool available today is changing and becoming more limited as older workers retire without droves of young employees coming to replace them. Therefore, companies must pivot their operations by updating with new CNC/robotic machinery to stay competitive. ■

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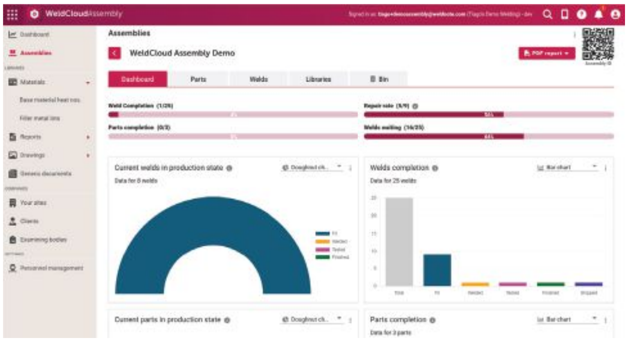
This month's New Products section features a new welding production traceability software, a portable welding system and the latest version of a robotic welding arm.



ESAB/InduSuite WeldCloud Assembly

InduSuite recently introduced WeldCloud Assembly, a cloud-based digital application that provides welding professionals with a completely new level of production traceability. Key functions include the ability to record weld session data directly from a welding power source and enable immediate comparison to Weld Procedure Specification (WPS). If a weld is outside the WPS, the system can send an alert so that users can immediately repair the weld and begin identifying the root cause of problems.

The app's Global Dashboard provides insight into four areas of project management: current production state of a project, percentage of welds completed, repair rate and welds waiting. It complements the current products in the InduSuite platform, including WeldCloud Notes and WeldCloud Productivity.

WeldCloud Assembly digitizes the process for speed and accuracy. With the Universal Connector or WeldCloud-enabled power source, welding data for virtually any brand of welder can be recorded and analyzed. By capturing data and linking it to the WPS, users can give their customers greater quality confidence. For more information, visit **www.esab.com/us**.

Lincoln Electric Flextec 350X PC / DLF-82 Ready-Pak

The Flextec 350X PowerConnect / DLF-82 Ready-Pak® is the perfect 350A fabrication shop pulsed MIG system. Utilizing the tough and reliable Flextec® 350X PowerConnect multi-process power source, the Ready-Pak® combines the DLF-82 wire feeder for a 350A system that is simple and reliable. It has the benefit of pulsed MIG capability, as well as true multi-process support.

Some of its key features:

- Lincoln Ready-Paks are fully assembled—just connect power and add wire and shielding gas
- Includes an assembled inverter and a wire feeder cart
- Simple to use—for synergic setup, choose the desired weld process, wire type, wire diameter, and gas type
- Synergic weld modes are controlled by one knob. Set higher wire feed speeds for thicker materials and lower wire feed speeds for thinner materials. Voltage is automatically adjusted
- Pulsed MIG support—lower spatter, greater puddle control, and a more forgiving MIG process
- Supports input power ranging from 200-575V, single or 3-phase

To learn more, visit **www.lincolnelectric.com/en/products**.

Vectis Automation UR20 Cobot

Vectis Automation is ecstatic to offer the long-reach UR20 arm onto our integrated Cobot Welding & Plasma Cutting Tools. For structural steel fabricators, this arm will bring 18 in. of additional reach radius (36 in. diameter increase), greatly broadening the range of weldments and weld inches that will be achievable in a given easy-to-program setup.

This long-reach arm can be integrated with a wide array of leading power sources, torch options, deployment methods like our flexible Rover, and Vectis' existing welding feature toolbox like ArcPilot through-the-arc seam tracking, Touch Sensing, and MultiPass offset welding. These cobot tools are being used in structural steel shops across the country to offload the boring arc-on time, so skilled welders can focus on the weld joints that really need that skill level. Visit **https://vectisautomation.com/product-overview** to learn more.

ENGINEERING JOURNAL

Second-Quarter 2024 *Engineering Journal* Now Available

The second-quarter issue of AISC's *Engineering Journal* is now available at **aisc.org/ej**. It includes papers on lateral force distributions in braced-moment frames, adopting the latest *Specification for Structural Steel Buildings* (ANSI/AISC 360-22) for offshore design, investigating steel plate washer thickness for column anchor rods, and an innovative steel deck system for highway bridges.

Here are highlights of a few papers.

Lateral Force Distributions in Braced-Moment Frames
Ralph M. Richard, Eric Keldrauk, and Jay Allen

Braced frames intended to resist wind and seismic loads traditionally have been analyzed and designed as trusses with all joints modeled as pins, such that only the braces provide lateral force resistance. However, frames with gusset plate connections create a rigid joint zone between frame beams and columns, effectively resulting in moment frame behavior, particularly at larger drift angles when braces have yielded or buckled. This paper describes the force distributions for buckling-restrained braced frames (BRBF) subjected to story drift angles, where the lateral resistance of the frame comprises both brace and moment frame action.

The Adoption of AISC 360 for Offshore Structural Design Practices
Albert Ku, Farrel Zwerneman, Steve Gunzelman, and Jieyan Chen

The offshore design standards for U.S. practices refer to AISC Specifications when designing structural components with nontubular shapes. Although the American Petroleum Institute (API) has partially adopted the 2010 AISC *Specification*, the current offshore practice is still primarily dominated by the 1989 AISC *Specification*.

The key issue hampering the offshore community's full adoption of the 2010 *Specification* is the relative ease of accounting for second order effects in the 1989 *Specification*. An API task group formed in 2019 studied the issue, and its findings are summarized in this paper. By illustrating the key code check process in two examples with an easy-to-understand format, this paper should help offshore structural engineers better understand the latest *Specification* and serve as a communication path between the offshore structural community and AISC.

Investigation of Steel Plate Washer Thickness for Column Anchor Rod Applications
Paul A. Cozzens, Gian Andrea Rassati, James A. Swanson, and Thomas M. Burns

Since the 13th edition, the AISC *Steel Construction Manual* has included provisions regarding the recommended minimum plate washer thickness used in a column base plate and anchor rod assembly. Each plate washer must have sufficient strength and stiffness to develop the anchor rod to which it is fastened without succumbing to pull-through, flexural, or cracking failure.

Laboratory tensile testing of an anchor rod, nut, and plate washer assembly was conducted at the University of Cincinnati to study plate washer performance. The testing investigated the capacity of ASTM A572/A572M Grade 50 plate washers using the recommended minimum thicknesses as listed in Table 14-2 of the 15th edition *Manual*, with anchor rods having ¾, 1, 1½, 2, and 2½-in. diameter. A total of 94 tests were conducted, after which the plate washers were visually assessed for signs of failure, including measurement of permanent out-of-plane deformation. The findings are discussed in this paper.

Innovative Steel Deck System for Highway Bridge Applications
Judy Liu

This study, currently under way at the University of Kansas, is led by Dr. William Collins, Associate Professor in the Department of Civil, Environmental, and Architectural Engineering. Dr. Collins's research interests include fatigue and fracture of metallic structures; bridge design, fabrication, construction, and performance; and evaluation and preservation of historic structures.

Dr. Collins's accolades include AISC's Milek Fellowship, which is supporting the research on innovative steel deck systems for highway bridge applications. Selected highlights from the work to date and preview of future research tasks are presented.

People & Companies

SMX Industrial Solutions has named **Neal Glassett** its Vice President and Chief Financial Officer. Glassett brings a wealth of experience and expertise in financial management, strategic planning, and business development to his new role. He has a proven track record in driving financial success for companies in various industries, and his appointment reinforces SMX Industrial Solutions' commitment to sustained growth and operational excellence.

The Earthquake Engineering Research Institute awarded its George W. Housner Medal for 2024 to University of Michigan civil and environmental engineering emeritus professor **Robert Hanson** in recognition of his contributions to earthquake hazard reduction through education, research, international cooperation, and public service. The Housner Medal recognizes individuals who have made extraordinary and lasting contributions to public earthquake safety through the development and application of earthquake hazard reduction practices and policies. It is EERI's most prestigious award.

The Steel Bridge Task Force named **Justin Ocel**, PE, PhD, at the Federal Highway Administration's (FHWA) Resource Center, the recipient of the 2024 Richard S. Fountain Award. The Fountain Award was established in 2001 to recognize leadership in steel bridge research and outstanding efforts to advance AASHTO specifications.

O'Donnell & Naccarato (O&N) announced a strategic reorganization of the firm's leadership that will serve under CEO **Anthony Naccarato**. **Dennis Mordan**, SE, PE, is president, **Melissa Pastras-Brugler** is chief financial and human resources officer, **Scott Bauer** is vice president and chief engineering officer, **Michael Herrmann** is vice president and chief marketing and administrative officer, and **Paul Panzarino** is vice president.

2024 AWARD WINNERS

AISC Honors 10 Recipients of Annual Awards

AISC honored 10 leaders in the design, construction, and education fields with its annual individual awards at this year's NASCC: The Steel Conference.

"It's getting crowded on the cutting edge," said AISC President Charles J. Carter, SE, PE, PhD. "These 10 people have made extraordinary contributions to the present and future of America's built environment."

AISC's Lifetime Achievement Awards recognize living individuals who have made a difference in the success of AISC and the structural steel industry. The 2024 Lifetime Achievement Awards went to:

- Senior Engineer Heather Gilmer, PE, of Pennoni for her significant contributions to the steel bridge industry.
- President Robert E. Shaw, Jr, PE, of Steel Structures Technology Center, Inc. for his work educating designers and fabricators on bolting and welding, his creation of the Student Steel Bridge Competition, and his continuing work on numerous AISC and industry committees.
- Professor of Civil Engineering Ronald D. Ziemian, PE, PhD, of Bucknell University for his contributions to AISC and the structural steel industry through his research, teaching, service on committees, his speaking engagements, and his many articles and papers on the stability of steel structures.

Five people earned Special Achievement Awards in 2024:

- Caroline R. Bennett, PE, PhD, Charles E. & Mary Jane Spahr Professor and Chair at the University of Kansas, for advancing knowledge about the behavior of hot-dipped galvanized steel structures.
- Iowa State University James L. and Katherine S. Melsa Dean of Engineering W. Samuel Easterling, PE, PhD, F.SEI, Dist.M.ASCE, for Steel Diaphragm Innovation Initiative (SDII) research that drove impactful changes to standards governing the use of metal deck diaphragms in steel structures.
- Virginia Tech Professor Matthew R. Eatherton, SE, PhD, for Steel Diaphragm Innovation Initiative (SDII) research that drove impactful changes to standards governing the use of metal deck diaphragms in steel structures.
- Jerome F. Hajjar, PE, PhD, CDM Smith Professor and Department Chair at Northeastern University, for Steel Diaphragm Innovation Initiative (SDII) research that drove impactful changes to standards governing the use of metal deck diaphragms in steel structures.
- Johns Hopkins University Hackerman Professor of Civil and Systems Engineering Benjamin W. Schafer, PE, PhD, for Steel Diaphragm Innovation Initiative (SDII) research that drove impactful changes to standards governing the use of metal deck diaphragms in steel structures.

AISC also recognizes those who build a brighter future by supporting tomorrow's leaders. This year, the Institute presented the Terry Peshia Early Career Faculty Award to:

- Onur Avci, PE, PhD, assistant professor and Herbert P. Dripps Faculty Fellow at West Virginia University, for exceptional promise and continued excellence in structural steel research, teaching, and service to the industry.
- Assistant Professor Machel Morrison, PhD, of the University of California, San Diego, for exceptional promise and continued excellence in structural steel research, teaching, and service to the industry.

AISC also presented its highest design honor, the J. Lloyd Kimbrough Award, to Michael A. Grubb, PE; the T.R. Higgins Lectureship Award to Benjamin W. Schafer, PE, PhD; and the Milek Fellowship to Mohannad Zeyad (M.Z.) Naser, PE, PhD.

The Milek Fellowship and Higgins Award are presented annually. Only 13 people have been honored with the Kimbrough Award since 1941.

AISC

Nominations Sought for 2025 Higgins Lectureship Award

AISC is now accepting nominations for its T.R. Higgins Lectureship Award, which includes a $15,000 cash prize. The annual award recognizes a lecturer-author whose technical paper(s) are considered an outstanding contribution to engineering literature on fabricated structural steel.

The submission deadline is July 1, and nomination(s) can be sent to AISC's Martin Downs at **downs@aisc.org**. Nominations must include the following information:

- Name and affiliation of the nominee (past winners are ineligible)
- Title of the paper(s) for which the individual is nominated, including publication citation. For papers with multiple authors, name the principal author
- Reasons for nomination
- A copy of the paper(s) and any published discussion

The author must be a U.S. permanent resident and available to fulfill the commitments of the award. The paper(s) must have been published in a professional journal between January 1, 2019, and January 1, 2024. The winner is required to attend and present at NASCC: The Steel Conference April 2–4, 2025 in Louisville, Ky., and also give a minimum of six presentations of their lecture on selected occasions during the year.

The award will be given to a nominee based on their reputation as a lecturer and the jury's evaluation of the nominated paper(s). Papers will be judged for originality, clarity of presentation, contribution to engineering knowledge, future significance, and value to the fabricated structural steel industry.

advertiser index


Emily Baker/Isabel de Oliveira/Caleb Rothell

Sculptural Steel Success

A STUNNING STEEL SHADE structure intended for the trailhead of the Razorback Greenway in Northwest Arkansas has won AISC's 2024 Forge Prize.

The Forge Prize, established by AISC in 2018, recognizes visionary emerging architects, architecture educators, and graduate students for design concepts that embrace innovations in steel as a primary structural component.

The structure, called Mile Zero, uses a Spin-Valence space frame system to cut, pull, and fasten uncoated weathering steel sheets into a modular system with structural depth. Mile Zero is a collaboration between Emily Baker, Vincent Edwards, and Edmund Harriss of the University of Arkansas; Princeton University's Isabel Moreira de Oliveira; West Virginia University's Eduardo Sosa; and Fayetteville, Ark.-based artist Reilly Dickens-Hoffman—and they'll share the $10,000 grand prize.

Baker developed the Spin-Valence system when she was in graduate school. It's based on the Japanese art of kirigami, which uses folding and cutting to create 3D objects out of a flat material. A video of the Spin-Valence system's deployment and additional press photos are available here.

Baker and her collaborators intend to bring the design to fruition to replace the simple bollard that currently marks the beginning of a multi-use trail that spans more than 40 miles. They envision the structure, with its interplay of light and shadow, as a welcoming space for people to enjoy the outdoors together—or perhaps as a backdrop for a group photo to commemorate a long bike ride on the Greenway.

In the second phase of the Forge Prize competition, the design team partnered with Hillsdale Fabricators Chief Structural Engineer Tony Diebold, PE, to further develop their idea.

"Once [Baker] described the whole Spin-Valence concept to me, I thought it was pretty innovative and seems like it could be a really interesting structural piece—but also architectural," Diebold said, noting that the design also presented a different challenge than he's used to. "Being an engineer, I like straight lines, and everything was cattywampus."

Baker visited Diebold at Hillsdale's shop in St. Louis as part of the process, further developing a relationship that all involved hope will lead to the structure taking shape in the real world.

"Arkansas is going to be the big winner in the long-term," said Forge Prize judge Reed Kroloff, Rowe Family College of Architecture Endowed Chair and dean of the Illinois Institute of Technology College of Architecture. "We thought the shade structure was remarkably innovative in the way that it took steel and used it in such an interesting fashion, with the folding and stacking. [The jury] thought it had great promise for steel as a building material."

The Forge Prize jury was comprised of Kroloff; Samantha Flores, AIA, vice president and director of the innovation and research team at Corgan; and Paul Makovsky, editor in chief of *ARCHITECT*, the journal of the American Institute of Architects. They named Mile Zero the winner over two other finalists. ■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and International Arrivals Facility Addition
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Pick-Up Zone
8-15
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