Modern Steel Construction

February 2021

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RYZA GARBACZ
Managing Director
"The Peddi XDM-630 has increased our production by 30%. By implementing layout marking, NEACH reduced project schedule times by 2-3 weeks on a 12 week schedule. We now have better quality and increased schedule flexibility, which means more customers. There's no more profile outsourcing as we can rely on ourselves to meet project deadlines. I know my exact hourly machine cost, which is driving my profit margin as well."
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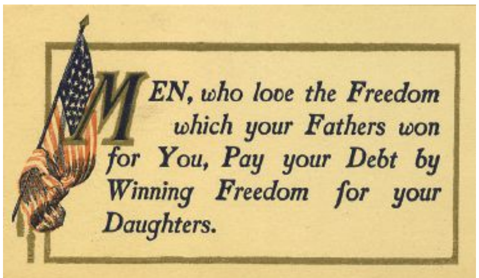


NINE STEEL BRIDGES that are still in service today were open to traffic when it happened.

5,189 SUCH BRIDGES were already open when the Nineteenth Amendment finally granted women the right to vote in 1920.

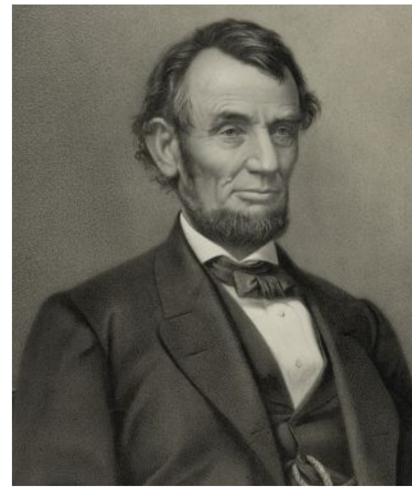
1933
Police drag the Charles River after a "cod-napping" in the Massachusetts State House.

At least **13,525 STEEL BRIDGES** that are still in service today were already open to traffic.


Scott D Flickr

1830 · 1840 · 1850 · 1860 · 1870 · 1880 · 1890 · 1900 · 1910 · 1920 · 1930 · 1940

1863
President Abraham Lincoln delivers the Gettysburg address.



63 STEEL BRIDGES that are still in use today were already open to traffic.

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ON THE COVER: Steel and people do some stretching at UCHealth's newest sports rehabilitation facility, p. 26. (Photo: Caleb Tkach, AIAP)

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editor's note

Usually around this time of the year, I spend a lot of time reminding people to book their flights to NASCC: The Steel Conference. And I like to tell people who can't make it to the conference in person that our streamed sessions are the next best thing to being there.

But this year, our entire conference—more than 150 sessions—will be offered *only* online. As much as we'd like to meet in person, we just can't find a way to bring more than 5,000 professionals together safely during the pandemic.

The 2021 virtual conference will be held during the week of April 12, and we'll offer sessions ranging from an in-depth look at shear connection beam reinforcement to innovative railroad bridge solutions. We'll have sessions for engineers, architects, fabricators, erectors, and detailers.

We'll have more than two dozen sessions as part of the World Steel Bridge Symposium, 18 sessions in the QualityCon conference for those interested in certification and quality management issues, and nine educational sessions specifically for detailers. We'll offer sessions on legal issues, design and analysis, technology, architecture, and constructability.

While we won't have an exhibit hall for you to explore, we will offer the opportunity to set up one-on-one appointments with the companies that normally exhibit.

Registration for the week-long event opens February 8. The fee to attend all of the sessions is just $200 for AISC members (with discounts for multiple attendees from the same company), and the conference offers the opportunity for 23 professional development hours.

In short, we'll offer the same high-quality sessions, excellent speakers, and practical information you've come to expect from AISC and the Steel Conference. To see the full schedule and to register, simply visit **aisc.org/nascc**.

If, like me, you're a long-time attendee (I haven't missed a Steel Conference since 1990!), you'll miss catching up with old friends and listening to the stories from industry luminaries as we sit around tables at the conference dinner or in comfortable chairs at a local watering hole (darn, and we were going to be in Louisville this year, a city renowned for its refreshing beverages!).

But please join us virtually this year, and we hope to see you next year in Denver—in person! We've already begun planning the 2022 conference, and if there are specific topics you'd like to see on the roster, please drop me a note at **melnick@aisc.org**.

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

steel interchange

*All mentioned AISC codes and standards, unless noted otherwise, refer to the current version and are available at **aisc.org/specifications**.*

Mild Steel Shims

The *Specification for Structural Steel Buildings* (ANSI/AISC 360), in Section M4.4, indicates that "Shims need not be other than mild steel, regardless of the grade of the main material." There does not appear to be a clear definition of mild steel provided in any AISC documents. It does appear that shims conforming to ASTM A1011 Commercial Steels (CS grades) are readily available. Do these A1011 shims satisfy the intent of Section M4.4?

Yes. As indicated in the User Note to Section A3.1b, unidentified steel is commonly used for shims where the specific mechanical properties and weldability are not of concern. A wide range of steel materials has successfully been used as shims in practice.

Note that Section M4.4 addresses conditions where compression is transferred through bearing between the column and the base plate and the compression only needs to pass through the shims. The use of unidentified material or commercial steels without defined tensile strengths is not appropriate for fillers that must transfer loads in other situations, such as those addressed in Section J5 of the *Specification*.

Larry S. Muir, PE

Channel Gage

The AISC *Steel Construction Manual* recommends, for a C8×11.5 C-shape, that the workable gage is equal to 1⅜ in. The flange width is 2¼ in. That means the edge distance will be ⅞ in. However, the minimum edge distance for a ¾-in.-diameter bolt per Table J3.4 in the AISC *Specification* should be 1 in. Is the workable gage listed for C8×11.5 incorrect?

No, the workable gage is correct. The footnote g in Table 1-5 in the AISC *Steel Construction Manual* indicates: "The actual size, combination, and orientation of fastener components should be compared with the geometry of the cross section to ensure compatibility." It is up to the user to ensure that fit-up will not be an issue while also making sure that the *Specification* requirements have been met. More generally, the workable gages listed in the *Manual* are recommended values. In the interest of standardization and reduction of possible errors in matching connections, one should use the recommended values when possible unless a fabricator has indicated a preference for a different value. Other gages that provide for entering and tightening clearances and edge distance and spacing requirements can be used when necessary.

I also believe that you may not be interpreting the requirements in Section J3.4 correctly. The requirement in Section J3.4 states: "The distance from the center of a standard hole to an edge of a connected part in any direction shall not be less than either the applicable value from Table J3.4 or Table J3.4M, or as required in Section J3.10."

Table J3.4 includes a footnote that states: "If necessary, lesser edge distances are permitted provided the applicable provisions from Sections J3.10 and J4 are satisfied, but edge distances less than one bolt diameter are not permitted without approval from the engineer of record."

In addition, the user note included in Section J3.4 states: "The edge distances in Tables J3.4 and J3.4M are minimum edge distances based on standard fabrication practices and workmanship tolerances. The appropriate provisions of Sections J3.10 and J4 must be satisfied."

So it is possible to use a ¾-in.-diameter bolt with an edge distance less than 1 in. However, if you decide to use a smaller edge distance, you will still need to meet the applicable requirements in Section J3.10 and J4 of the *Specification*. In addition to this, you should reach out to the fabricator to ensure that constructability will not be an issue.

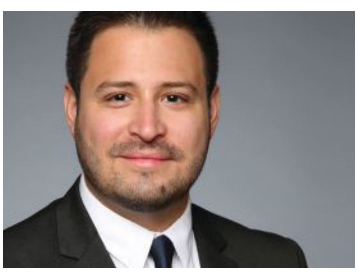
Jennifer Traut-Todaro, SE

Theoretical Cutoff Point

We are looking to reinforce a steel column experiencing a localized section loss of approximately 20%. We have proposed attaching steel plates with bolts to the column flanges to reinforce the damaged region. Does AISC provide any guidance on the length that the reinforcement plate needs to extend past the damaged part of the column section in each direction? And are there any limitations to bolting the reinforcement plate near the region where the column flanges are experiencing section loss?

While there are no limits in the AISC *Specification* for the type of reinforcement you've described, there are dimensional requirements for welded beam cover plates, in Section F13.3.(e). However, this section is not strictly applicable to columns. From mechanics, we know that the load in the plate needs to be transferred (developed) into the original column on each side of the damaged area. This was discussed in the AISC webinar "Design of Reinforcement for Steel Members, Part 2" (available via a search at **aisc.org/education-archives**). The design method beginning on Slide 43 can be used to calculate the required development length beyond the theoretical cutoff point.

Bo Dowswell, PE, PhD



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

3D Models and Communication

Where can I find guidance on communicating between engineers and fabricators using 3D steel models only (no shop drawings)?

There's no official, codified guidance specific to model review, but Section 4 of the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303) governs Approval Documents, and you should defer to that section first.

We strongly recommend keeping 3D models and communication within the same software review suite. So if you're using, say, Tekla to detail a project, then the person doing the approval should be using Tekla In-Model Reviewer. (There are other options from SDS/2 and Autodesk that will facilitate this kind of communication as well—using software dedicated to review and approval.) While it may sound obvious, it's paramount to use software dedicated to reviewing and approval that allows annotations, markups, notes, and other communications that couldn't otherwise be possible. There is more information about In-Model Reviewer and more 3D modeling information in AISC's *BIM/VDC Guide for Structural Steel* (available at **aisc.org/bim**).

Beyond that, when entering into the 3D world, it is essential to have a well-developed BIM execution plan (BxP) that establishes roles, how parties will communicate, and how often they will communicate. There are many options, but BIMforum is a good place to start: **https://bimforum.org/bxp**.

Luke Faulkner

Random Basis

I have a question about the requirements in Section N5.4 of the AISC *Specification*. For inspectors assigned "observe" tasks, this section defines observe as: "The inspector shall observe these items on a random basis. Operations need not be delayed pending these inspections." Does AISC provide a recommendation for how often "random" inspections should occur?

The Commentary to Section N5.4 provides a discussion on the intention of "Observe" and "Perform" pertaining to weld inspections and AWS D1.1 requirements. I have copied some of this relevant language below:

"'Observe' tasks are as described in clauses 6.5.2 and 6.5.3. Clause 6.5.2 uses the term 'observe' and also defines the frequency to be 'at suitable intervals.' 'Perform' tasks are required for each weld by AWS D1.1/D1.1M, as stated in clause 6.5.1 or 6.5.3, or are necessary for final acceptance of the weld or item. The use of the term 'perform' is based upon the use in AWS D1.1/D1.1M of the phrases 'shall examine the work' and 'size and contour of welds shall be measured'; hence, 'perform' items are limited to those functions typically performed at the completion of each weld."

"The words 'all welds' in clause 6.5.1 clearly indicate that all welds are required to be inspected for size, length and location in order to ensure conformity. Chapter N follows the same principle in labeling these tasks 'perform,' which is defined as 'Perform these tasks for each welded joint or member.' The words 'suitable intervals' used in clause 6.5.2 characterize that it is not necessary to inspect these tasks for each weld, but as necessary to ensure that the applicable requirements of AWS D1.1/D1.1M are met. Following the same principles and terminology, Chapter N labels these tasks as 'observe,' which is defined as 'Observe these items on a random basis.'"

"The selection of suitable intervals as used in AWS D1.1/D1.1M is not defined within AWS D1.1/D1.1M, other than the AWS statement 'to ensure that the applicable requirements of this code are met.' The establishment of 'at suitable intervals' is dependent upon the quality control program of the fabricator or erector, the skills and knowledge of the welders themselves, the type of weld, and the importance of the weld."

Jonathan Tavarez, PE

steel quiz

This month's Steel Quiz focuses on *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* (ANSI/AISC 358), available at **aisc.org/specifications**.

1 **True or False:** The thickness of doubler plates used in special moment frames shall not be less than ¼ in. (6 mm).

2 **True or False:** A reduced beam section's uncut flange width should be used conservatively when checking the width-to-thickness ratio limitations found in *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341) Table D1.1.

3 **True or False:** T-stubs to be used in double-tee connections are to be cut only from ASTM A992/A992M material.

4 The flange cut of a reduced beam section (RBS) connection must be increased due to changes in structural demand, but the horizontal distance from the face of the column flange to the start of the RBS cut, *a*, is kept consistent. **True or False:** Because the plastic section modulus Z_{RBS} is not dependent on the length of the cut, *b*, the column-beam moment ratio will remain unchanged.

5 **True or False:** Increasing the number of shear bolt rows in a double-tee connection decreases the column-beam ratio.

6 **True or False:** An extended shear tab is recommended to be used in double-tee connections.

7 **True or False:** A welded unreinforced flange-welded web (WUF-W) connection is designed such that the plastic hinge is located at a distance of *d*, the beam depth, away from the column face.

8 **True or False:** RBS cut-outs are only to be used in RBS moment connections with rolled or built-up wide-flange shaped columns.

9 **True or False:** Due to limited testing of connections in assemblies subjected to biaxial bending of the column, flanged cruciform section columns, built-up box columns, and boxed wide-flange columns are permitted to be used for only two prequalified connections: The ConXtech ConXL moment connection and the SidePlate moment connection.

TURN TO PAGE 14 FOR THE ANSWERS

steel quiz ANSWERS

1 **True.** AISC 358 expressly does not state this, but it does refer the reader to the AISC *Seismic Provisions* for doubler plate requirements (these can be found in Section E3.6e.3, which limits the thickness to ¼ in.).

2 **False.** AISC 358 Section 5.3.1(6) requires the calculation of the width-to-thickness ratio for the flanges to be based on a value of b_f not less than the flange width at the ends of the center two-thirds of the reduced section, provided that gravity loads do not shift the location of the plastic hinge a significant distance from the center of the RBS.

3 **False.** AISC 358 Section 13.5 states that the T-stubs shall be cut from sections conforming to ASTM A992 or ASTM A913 Grade 50, and Section 13.1 states that the top and bottom T-stubs must be identical.

4 **False.** Section 5.4 of AISC 358 provides column-beam relationship limitations and refers the reader to the AISC *Seismic Provisions* for the limiting column-beam moment ratio. When considering what would affect the sum of the expected flexural strengths of the beams, it is true that the plastic modulus, Z_{RBS}, is not dependent on the length of the cut, *b*. Thus, M_{pr} would remain unchanged. However, the additional moment due to shear amplification from the center of the RBS to the centerline of the column, M_{uv}, is dependent on both the length of the cut and the distance from the beginning of the cut to the column flange. In this case, keeping *a* consistent and increasing *b* would increase the moment arm. So M_{uv} may change significantly enough to change the sum of M^*_{pb} and the column beam ratio. See Section E3.4a in the AISC *Seismic Provisions* for more information on the column-beam moment ratio.

5 **True.** Section 13.6 of AISC 358 states, in Step 5, that the plastic hinge is assumed to form at the shear bolts farthest from the face of the column. A further distance due to increased bolt rows will increase M_v, the additional moment due to shear amplification, from the plastic hinge's location to the column centerline and will increase the sum of the projections of the expected flexural strength of the beams. Increasing this distance decreases the resulting column-beam ratio. See Section E3.4a in the AISC *Seismic Provisions* for more information on the column-beam moment ratio.

6 **True.** This recommendation is made in the user note of Step 20 in Section 13.6 of AISC 358: "Because of the large setback required, the shear connection will most likely need to be designed as an extended shear tab. Most importantly, the length of the shear connection, L_{sc}, should be determined so as to fit between the flanges of the T-stubs allowing ample clearance."

7 **False.** Inelastic rotation is developed primarily by yielding of the beam in the region adjacent to the face of the column, whereas the protected zone consists of the portion of the beam between the face of the column and a distance one beam depth, *d*, from the face of the column. The Commentary to Section 8.1 provides additional information, saying, "The protected zone for the WUF-W moment connection is defined as the portion of the beam extending from the face of the column to a distance d from the face of the column, where *d* is the depth of the beam. Tests on WUF-W moment connection specimens show that yielding in the beam is concentrated near the face of the column, but extends to some degree over a length of the beam approximately equal to its depth."

8 **False.** Section 10.1 of AISC 358 states that the ConXtech ConXL moment connection beams may include RBS cut-outs, if necessary, to meet strong-column/weak-beam criteria.

9 **False.** The Commentary for Section 2.1 of AISC 358 states: "Although there has been only limited testing of connections in assemblies subjected to biaxial bending of the column, the judgment of the CPRP was that as long as columns are designed to remain essentially elastic and inelastic behavior is concentrated within the beams, it would be possible to obtain acceptable behavior of beam-column connection assemblies subjected to biaxial loading. Flanged cruciform section columns, built-up box columns, and boxed wide-flange columns are permitted to be used in assemblies subjected to biaxial loading for those connection types where inelastic behavior is concentrated in the beam, rather than in the column."

Many thanks to Mark Noel of Zenith Consulting Engineers, Ltd., who contributed this month's questions and answers!

STEEL SOLUTIONS CENTER

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


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steelwise

OFF THE WALL

BY JIM CASPER

A curtain wall engineer provides tips to structural engineers for streamlining curtain wall attachment design.

Jim Casper (jcasper@enclos.com) is an application engineer with Enclos. **Samuel Pond**, formerly with Enclos, contributed to this article.

UNITIZED CURTAIN WALLS have become increasingly popular for steel-framed buildings because of characteristically short lead times, high quality, and efficient installation as compared to traditional building envelope enclosures.

Of course, these advantages are predicated on proper integration with the building's framing system. The structural engineer of record (EOR) and the façade specialty structural engineer (SSE) often have limited opportunities to collaborate. But with a better understanding of how façade systems behave, the structural design community can develop structures that economically incorporate curtain wall attachment details and accommodate the nuances of unitized curtain walls in the design, analysis, and detailing of the structure.

What Is a Unitized Curtain Wall?

First, let's take a brief look at what unitized curtain walls are and why they are used. Simply put, unitized curtain walls are composed of thin, aluminum-framed wall units with infills of glass, metal panels, or other substrates. They are not freestanding, they are non-load-bearing, and they do not resist lateral movement of the structure or the façade itself—and they perform best with the weight of a unit supported at the floor slab at the top of the unit, thus carrying self-weight as a small tension in the mullions.

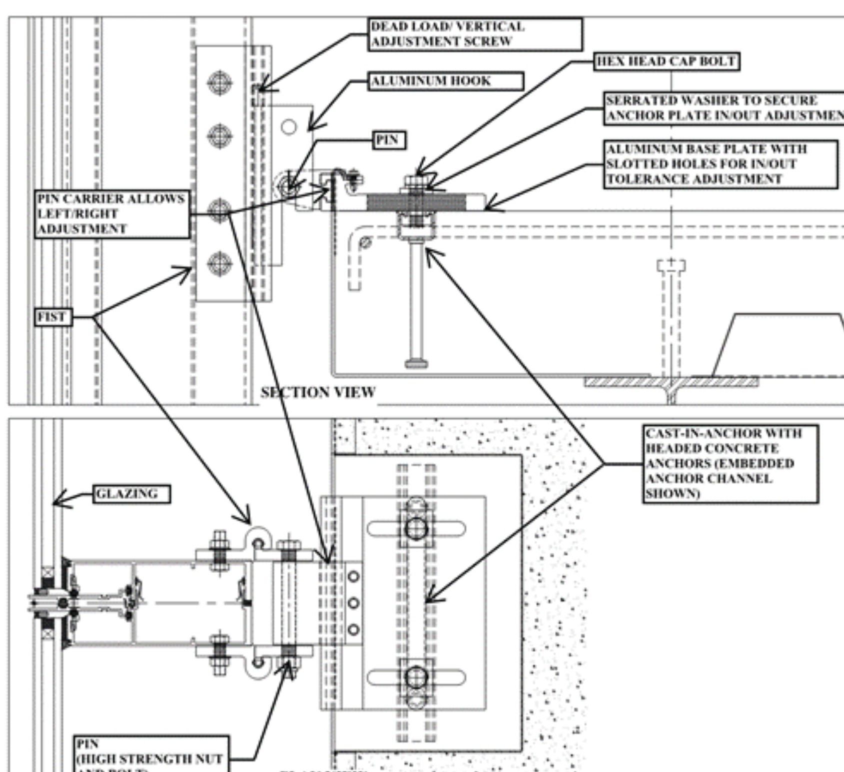


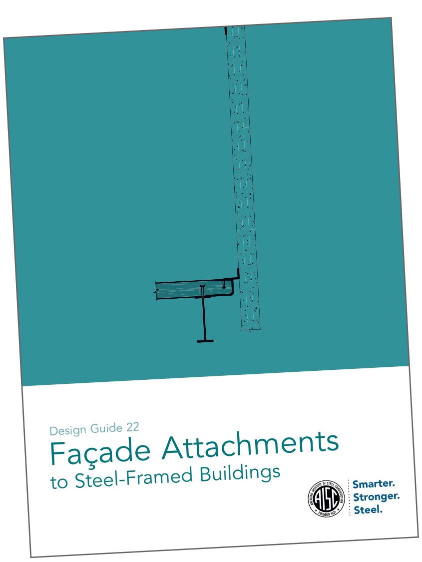
Fig. 1. Conventional curtain wall anchor components.

Figure 1 illustrates a typical top-of-slab curtain wall anchor incorporating common anchorage components. Note that many of the components are extruded shapes that are cut to length and interface with one another. As the curtain wall must fit the building, the anchor is designed to accommodate slab tolerances in three orthogonal directions and rotation about the three axes. Vertical tolerance (slab high/slab low) is accommodated using a set screw. Tolerance perpendicular to the slab edge (slab in/out) is accommodated using a slotted anchor plate. Finally, tolerance parallel to the slab edge (left/right) is accommodated by a slotted pin carrier or cast-in anchor channel. Face-of-slab, top-of-curb, and bottom-of-slab anchors can use the same methodology to accommodate construction tolerance.

Why Unitize?

The unitized, prefabricated approach facilitates early shop fabrication, allowing it to arrive at a job site more quickly. And for this advantage to be fully realized, the design of the main building structure and the cladding strategy must be determined much earlier in the project life-cycle than with other forms of cladding.

Another benefit of a unitized curtain wall is the ability to erect the wall and enclose a building quickly, and a common practice is to employ multi-span curtain wall units. In a single-span scenario, the units cover one floor and interface with a hinge mechanism, while in a multi-span scenario, gravity load is applied to the uppermost floor and laterally supported at the intermediate supports. While a multi-span scenario is advantageous to the SSE because deflections are lower as compared to a single span scenario, the EOR must consider that this approach will support an increased self-weight every other floor and will increase the lateral load (wind load) at the center support. The EOR should, of course, understand the cladding strategy early in the design phase, possibly through a design-assist approach, such that the structural steel framing system is adequate for supporting the façade loads.



Interface with the Steel Framing

AISC Design Guide 22: *Façade Attachments to Steel-Framed Buildings* (available at **aisc.org/dg**) offers a comprehensive guide on attaching façade elements to a steel building structure. The guide addresses many facets of the façade-building interface by covering general design guidelines, responsibilities of the involved parties, construction tolerances, slab edge conditions, and steel spandrel design.

Building Movement

Building deflections are critical for the performance and appearance of a unitized curtain wall, as are the strength and stiffness of both the spandrel beam and the cantilevered slab. A key component of any curtain wall is that floors can behave independently. Effects of static loads, such as the deflection due to curtain wall self-weight, are mediated by the adjustable anchor, but transient movements due to live load deflection, thermal expansion, and column creep must be accommodated by the stack joint between floors.

Thermal expansion is outside the scope of work for the EOR, but limiting the live load slab edge deflection to ½ in. and column shortening to ⅛ in. per floor will preserve the aesthetics of the structure. Another aspect affecting the façade designer is the interstory drift limits, commonly stated as $H/400$ for wind and $0.02 \times H$ for seismic, where H is the story height. Wind and seismic drift are accommodated by the units racking in the plane of the wall. Live load, gravity load, column shortening, and thermal movement are accommodated by the opening and closing of the stack joint.

As panel sizes increase, the effects of building movement on joint size are amplified. Façade costs and appearance are optimized with well-defined expectations of building movement and structural stiffness. If the EOR expects the structure to deflect less than the code deflection limits, then publishing the expected deflections for the SSE will allow smaller façade joint sizes. The most desirable scenario is one in which the joint size is driven by the architect, not the code deflection limits.

Building expansion joints are often present in large commercial or residential projects and can create problems for the SSE. Placing the building expansion joint within a curtain wall unit module is problematic because while the joint is masked, the differential movement between the structures causes problems for anchoring the unit to the building. Additionally, curtain wall anchors will be moving relative to each other, causing alignment problems with the façade. The EOR, SSE, and architect will find that aligning the movement joints with the curtain wall joint to be both convenient and aesthetically preferable.

Here are a few important coordination considerations for the EOR:

- Publish expected deflection and drift values.
- Ensure perimeter structure stiffness requirements for supporting the façade.
- Maintain consistent structure at the perimeter of the building.
- Ensure accessibility to the top of the slab.
- Avoid welding steel anchors to the structure when possible.
- Use cast-in-concrete anchors when possible.
- Provide adequate concrete depth and clearance at the slab edge.
- Develop a cladding strategy early in the project.
- Factor in kicker/torsional brace coordination.

Anchorage to the Building Structure

The degree to which the edge-of-slab is consistent throughout the project has significant implications for the economy of the curtain wall anchor design and the cost of the façade system. The uniformity of the slab depth, dimension to the spandrel beam, size of the structural members, and detailing of the structural connections are within the control of the EOR for most conditions. Uniformity in the base building structure allows high repetition in curtain wall anchor design and detailing, which leads to efficiency in review and coordination to the EOR of loads imposed to the base building structure.

For a unitized curtain wall, the preferred method of anchorage is a top-of-slab anchor, attachments to the top of the slab are easier and safer for field operations to locate, install, adjust, and set than bottom-of-slab connections. In contrast, bottom-of-slab anchors require the field crews to work off swing stages, aerial lifts, ladders, or scaffolding, potentially putting workers at a higher risk of injury.

When the stack joint is located at the floor and a top-of-slab anchor is used, the component congestion at the top of the unitized curtain wall requires the hook and pin components to be located lower in the spandrel area and requires a drop anchor (also known as a gooseneck anchor, as seen in Figure 2). Drop anchors place high prying forces on the structure from lateral wind loads. With the stack at the floor, the curtain wall behaves as a simple span (unless a multi-span approach is employed), possibly requiring steel reinforcement or additional wind load anchors to control deflections.

On occasion, reinforcing the perimeter structure to accommodate the loads imposed or to provide the stiffness necessary to maintain joint size between units becomes the responsibility of the SSE; however, this is outside the SSE's scope. To properly design the perimeter structure, the EOR may gain insight from architectural drawings of anchorage points by assuming anchors will occur at vertical framing modules. A collaborative approach between the SSE and SER to finding a solution is the best course of action.

Cast-in-concrete anchors are preferred because of quick installation and adjustment, and they do not require welding or drilling. If attaching to steel is required, a top-of-steel anchor is preferred due to the working position. Welding curtain wall anchors poses challenges of structural steel element variability, removal of fireproofing, and risk associated with high voltage, fire, and cable tripping hazards. Additionally, weld spatter can cause damage to curtain wall elements installed on lower floors.

Conventional cast-in anchors are plates or channels with headed concrete anchors welded or forged to the underside through which the wind, gravity, and seismic loads are resolved into the building structure. The design of a cast-in-concrete anchor is governed by American Concrete Institute (ACI) 318 Appendix D. If a pre-engineered, embedded anchor channel is to be used, the capacity is determined in accordance with ACI 318 Appendix D, but also

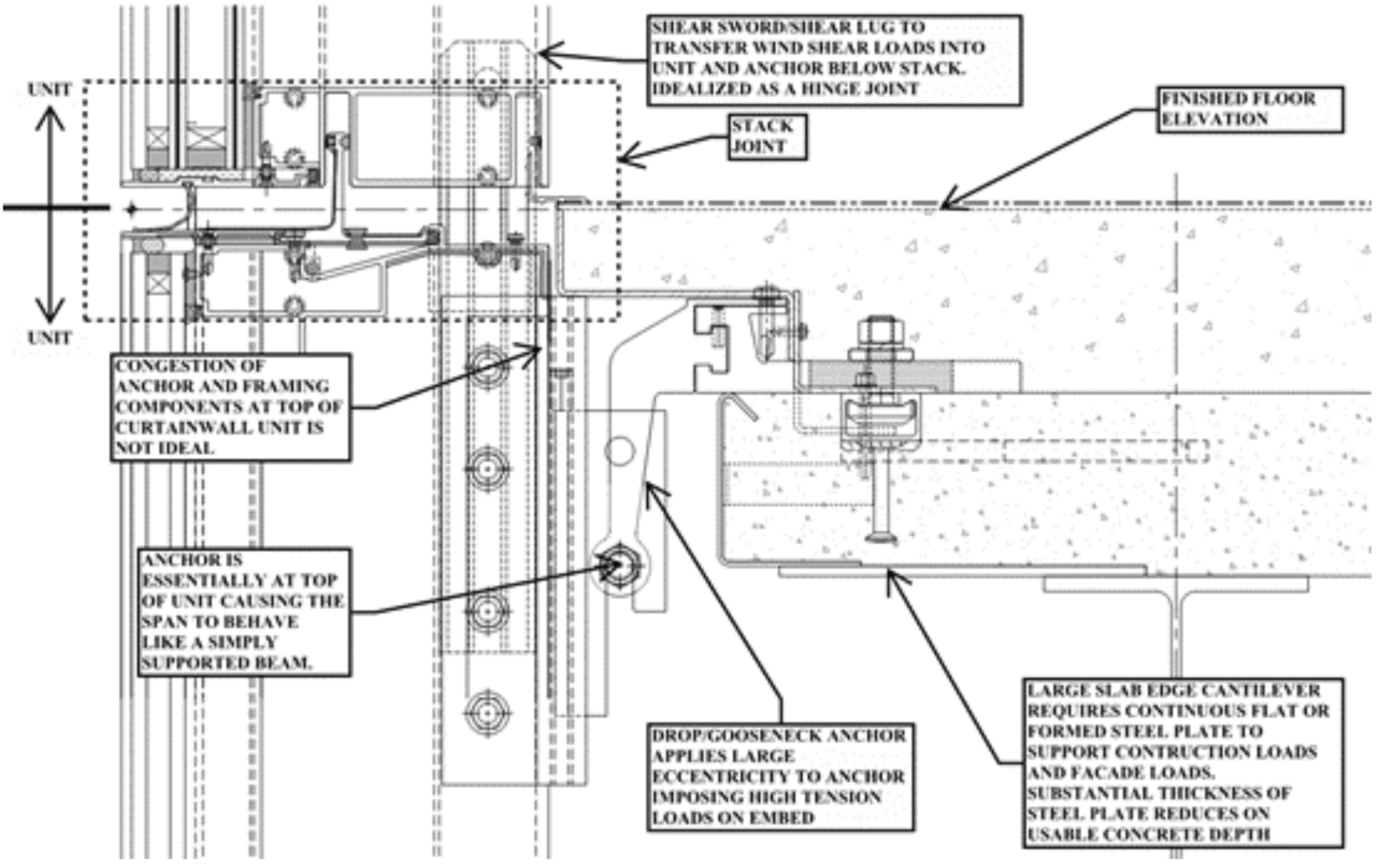


Fig. 2. Challenging anchorage conditions.

may be engineered by ICC-ES *Acceptance Criteria for Anchor Channels in Concrete Elements* (AC232).

The capacity of the cast-in anchor is governed by variables within the control of the EOR: edge distances, available embedment depth, concrete type, and strength. When lightweight concrete is employed, the concrete strength is reduced by 0.85 for sand-lightweight and 0.75 for all-lightweight concrete, severely reducing the capacity of the anchor. Concrete cold joints (construction joints, pour joints, sleeves, block-outs, etc.) are considered as edges and should be avoided in the vicinity of a cast-in anchor. Using ACI 318 Appendix D, the capacity of the concrete almost always controls the design in shear and tension.

AISC Design Guide 22 covers many of the edge-of-slab conditions for building projects. When the spandrel beam is near the anchors, a continuously formed light-gauge steel angle can be provided to form the edge-of-slab and the pour stop. A larger edge-of-slab cantilever requires a heavy-gauge angle, is more expensive than a light gauge option, and also encroaches on the useable concrete depth.

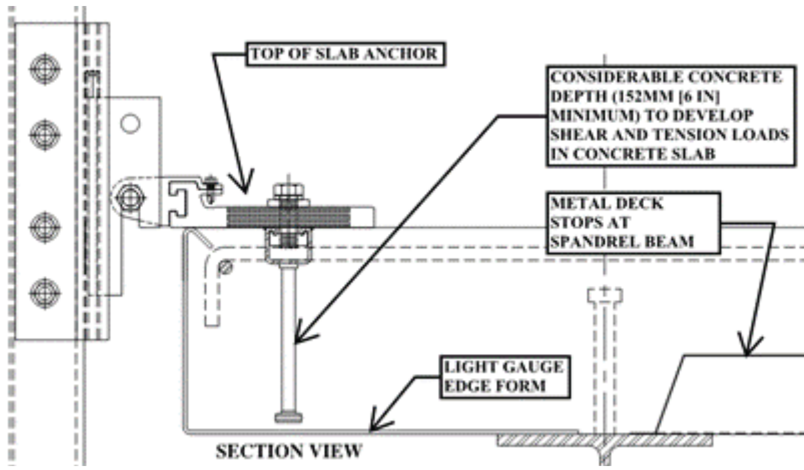


Fig. 3. Preferred edge-of-slab condition.

Figure 3 demonstrates the preferred edge-of-slab condition using a top-of-slab anchor, a cast-in anchor (pre-engineered embedded anchor channel with headed studs), a continuous light-gauge edge form, and substantial concrete depth (6 in.) to develop shear and tension capacity through the headed concrete anchor.

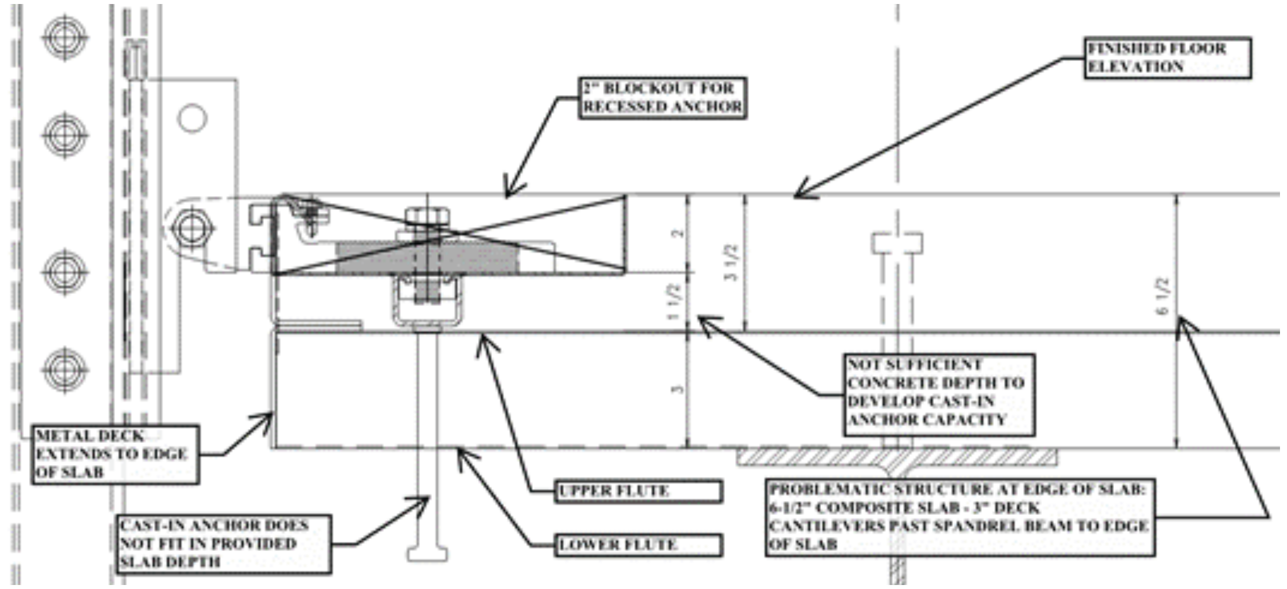


Fig. 4. Cantilevering decking to edge of slab.

Cantilevering the deck past the spandrel beam to the edge-of-slab creates difficulty for placing cast-in curtain wall anchors and achieving required strength. The deck flutes of the cantilevered deck reduce the depth of usable concrete, and a recessed anchor pocket is often used to hide the curtain wall anchor below the finished floor. The concrete block-out further reduces the useable concrete depth. Figure 4 shows the compounding effects of such practice.

Notching the deck and providing a full-depth slab at anchor locations only, as seen in Figure 5, limits capacity for curtain wall anchorage. The walls of the pocket, created by the notching of the deck for the full-depth slab, imposes two additional edge constraints into the ACI 318 Appendix D that significantly reduce cast-in anchor shear and tension capacity. Furthermore, the shear capacity of the anchor used to resist lateral wind loads is affected by the distance constraint imposed by the decking notched at the centerline of the spandrel beam.

For installing cast-in anchor channels, rebar congestion is a concern for shear walls, columns, and edge-of-slab conditions. Concrete quality at columns and outside corners

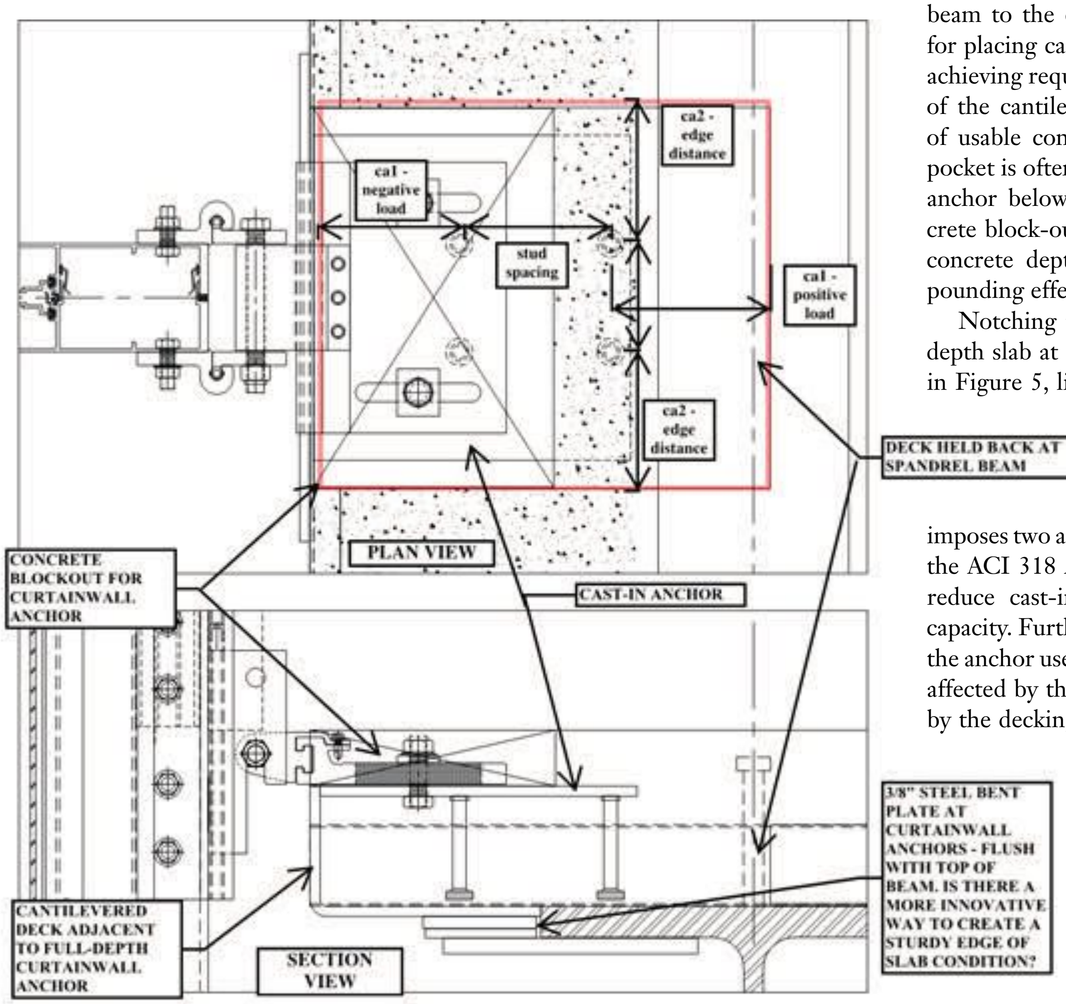


Fig. 5 Cantilevered deck to edge of slab with notched slab at anchor.

can be compromised due to congestion and poor consolidation. When the edge-of-slab is close to the face of the column, providing anchorage through a cast-in anchor is difficult or impossible. The EOR should consider accommodations at these challenging curtain wall anchoring scenarios. Figure 6 illustrates the difficulty of resolving curtain wall loads at column conditions.

In some instances, curtain wall anchors must be attached to the perimeter steel. For most scenarios, wide-flange spandrel beams do not have torsional rigidity to transfer eccentric loads. One method to resolve a torsional load is for the EOR to specify lateral load braces or knee braces, commonly referred to as kickers, to brace the flanges and webs of the spandrel beams at each façade module. The kickers span from the lower flange of the spandrel beam to either the underside of the structural slab (as shown in Figure 7) or to the centerline of the top flange of the adjacent beam. To minimize the number of kickers required, the EOR can orientate purlins to frame into the spandrel beam at spacings that match the façade modules.

When a post-tensioned concrete slab is designed, the EOR should be aware that the façade will typically need to anchor where the vertical mullions intersect the top of the slab. The mullion layout, which may not be consistent throughout the project, and the anchorage method (cast-in or post-installed) should be considered when laying out the reinforcement strands.

Large bolted shear and moment connections often interfere with façade anchorage, and locating such connections should be coordinated with the curtain wall contractor. Likewise, the protected zone of lateral load resistance systems at the perimeter of the structure causes complications for the SSE and façade contractor when trying to anchor to the structure. Additional structure, specific to façade attachment, should be provided in order to efficiently anchor the façade and not affect the performance of the lateral system.

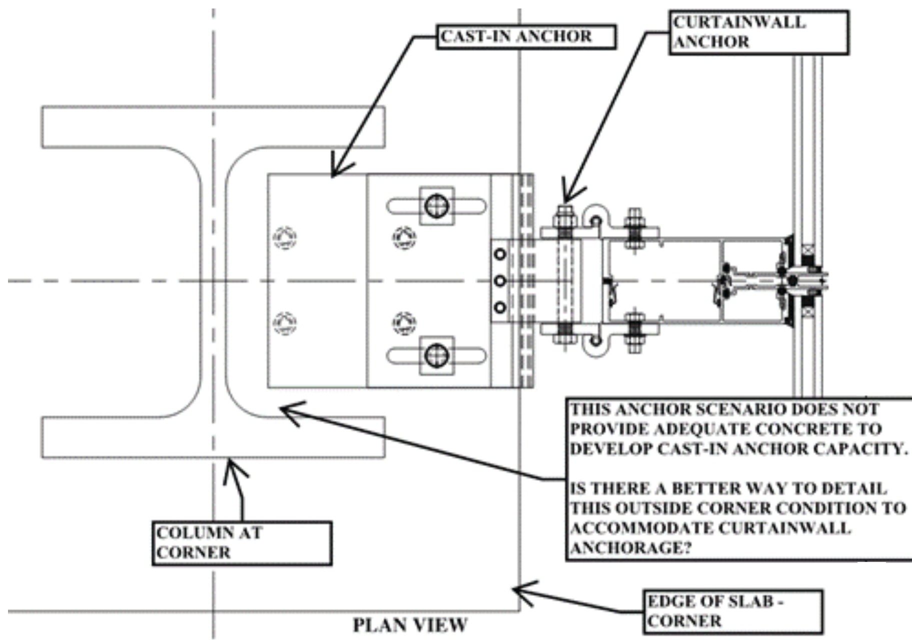


Fig. 6. Anchorage interference at columns.

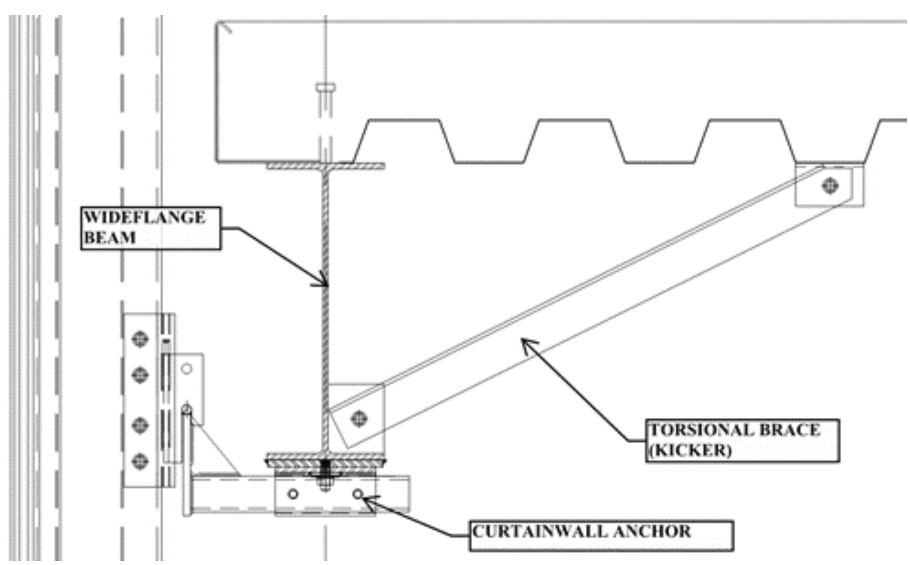


Fig. 7. Torsional brace for bottom-of-beam connection.

The EOR plays a key role in the integration of the building façade with the building structure. Gaining a better understanding of curtain wall attachment considerations and developing a cladding strategy early in the design process can greatly ease the design and construction process when it comes to the curtain wall. ■

This article is a preview of the online 2021 NASCC: The Steel Conference presentation "Meeting Tolerances Where Steel and Façade Collide." For more information and to register, visit ***aisc.org/nascc****.*

field notes

MAKING A MARK

INTERVIEW BY
GEOFF WEISENBERGER

After a quarter-century with a West Virginia steel fabrication business, Mark Trimble brought his knowledge, experience, and enthusiasm to AISC's Chicago headquarters.

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**.

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

MARK TRIMBLE'S INTRODUCTION to building things was as his father's righthand man on household projects. Little did he know at the time that it would prepare him for a career in construction. Now AISC's vice president of membership and certification—after a 25-year career with AISC member fabricator Huntington Steel and Supply in Huntington, W.V.—Trimble talks about his start in the steel fabrication business, his love of music, and going back and forth between big city and small-town living.

What are some of the earliest buildings to inspire you or make you want to work in construction?

It wasn't a building per se but rather the building process. My dad, in his frugal way, was quite the handyman. He would enlist my siblings and me as labor for many of his projects. As the oldest, I was the go-to child when Dad needed someone to hand him the appropriate tool at just the right time. But really, before college, I hadn't had much of an interest in math or science beyond these periodic home remodeling projects.

My real love was music. I played trumpet in the band and sang in our church choir. The decision to pursue engineering was a light-switch kind of choice that I made after my dad asked me one day what I wanted to do when I grew up. So I went to the University of Kentucky in Lexington and studied civil engineering. It turned out to be a great decision.

Tell me about how you got into the steel fabrication business and a bit about your history with Huntington Steel.

The earliest years of my career were somewhat varied. Having benefited from a Kentucky Department of Highways scholarship, my summers between semesters had me working out in the field on highway construction projects. After I graduated, my first real job was designing drainage systems for I-65 interchanges in Louisville. Later, while working for an architectural firm, I designed the site grading and utility portions of the firm's building projects.

In the mid-1980s, I learned of a project near my hometown that involved the expansion of a hospital, and they were looking for an on-site project engineer. I spent almost two years on that job site and learned construction from some real seasoned pros. That project led to other building design and construction projects—some while working for others and others while working for myself.

Mike Emerson, an IBM big system computer salesman at the time—you know, the salesman with the blue suit, red sincere tie, and the black wingtip shoes—was a close friend from my college days and had been tapped to take over the reins at Huntington Steel and Supply from his father-in-law. Mike had been on me to come and work for him, but it wasn't until the very tough recession of the early 1990s that I decided that more stable employment was in my family's best interest.

I hit the ground running at Huntington Steel in part because of my mentor and boss, Roy Maynor (a former executive vice president of Huntingon Steel). Roy was an encyclopedia of steel knowledge and I learned so much from him. My 25 years at Huntington Steel were filled with many challenges and opportunities for learning. My first big task was to learn what was necessary to lead the structural fabrication division, which included estimating, contracts, detailing, project management, and, of course, sales.

But always the one to take on a new challenge, it wasn't unusual for me to take temporary assignments and some more permanent ones as the company morphed to meet the ever-changing needs of its customers. I led shop operations during our search for a new shop manager and later served as vice president of marketing, leading the company's service center division.

What's the coolest project that came through the shop when you worked there?

We did a project for the U.S. Navy, right after 9/11, that had us building hundreds of floating pontoon-like tanks that supported submerged barriers intended to protect our shipbuilding harbors from submarine attacks.

What made you decide to leave the fabrication world and come work directly for AISC?

I had been attending NASCC: The Steel Conference for 20 years and had also been a volunteer, serving on the NASCC Technical Planning Committee. During my time on the committee, my enthusiasm must have caught the eye of the right people, and I was invited to serve as a member of the AISC Board of Directors. Serving as a director, I chaired the conference planning committee, which provided additional insight into the inner workings of AISC.

After serving five years on the Board of Directors, my good fortune continued when Charlie Carter, still somewhat new in his role as AISC's president, came calling. He offered me the position of vice president of certification, and I accepted. It was an easy decision. My respect for AISC has been unwavering, and to be given the opportunity to influence its direction was the perfect way to tie a bow on a wonderful career.

With a recently modified title of vice president of membership and certification, my challenge is to envision where the construction marketplace and the steel industry are heading and guide our programs to meet the needs of that direction.

What's the best advice you've been given in business or in life?

I have received so much great advice over the years, but maybe the best was from my dad, who told me, "You can learn from anyone as long as you are willing to truly listen." Ask questions first, listen to the answers, and then speak. As an example, I learned a hard lesson early in my career: A freshly minted college graduate, full of enthusiasm and confidence, is not really prepared to make the impact he thinks he can. And embarrassingly, it doesn't take long to realize that there is a lot to learn from that seasoned carpenter, ironworker, or fabricator who has been plying their trade for 20 years. That lesson has helped me gain knowledge from almost everyone I come in contact with.

Any good stories related to your trumpet playing?

I was asked very regularly to play *Taps* at military funerals. I can't tell you how many times I would drive to some remote cemetery out in the middle of nowhere, walk up a hill carrying my trumpet, military representatives there would do the honor guard, and then I would play *Taps*. It was always an emotional process, and I was always very nervous because you don't want to mess up something like that.

I understand that you spend most of your time in Chicago now but travel back to Huntington occasionally. What's your favorite thing about Huntington? How about Chicago?

Yes, we try to get back to Huntington once a month. It's like *Planes, Trains, and Automobiles*. Sometimes we fly, sometimes we rent a car, and sometimes we take Amtrak. For Huntington, it's the small-town life. My wife, Teresa, and I live on a brick street lined with large maple and oak trees. It is just fun to sit on the front porch and listen to the sound of birds and squirrels, and maybe watch a deer stroll by.

It's the opposite in Chicago, the urban life. Our condo is on the 25th floor of Harbor Point at the eastern end of Randolph Street, right down the street from AISC's office. We have a spectacular view of Navy Pier and can see the summer fireworks from our window. Enjoying the summer music programs, walking and biking along Lake Michigan or enjoying some Chicago pizza—it's all great fun. ■

To hear more from Mark, including his experiences singing in a quartet with three other engineers, visit ***modernsteel.com/podcasts****.*

business issues

SUSTAIN YOUR FOCUS

BY DAN COUGHLIN

Knowing how to maintain focus during the workday takes practice outside of the workday.

As a professional business educator since 1998, **Dan Coughlin** has worked with serious-minded leaders and managers to consistently deliver excellence. He provides individual and group coaching to improve leadership and management performance. His topics are personal effectiveness, interpersonal effectiveness, leadership, teamwork, and management. Visit his free Business Performance Idea Center at **www.thecoughlincompany.com**.

Dan has presented multiple sessions at NASCC: The Steel Conference. Visit **aisc.org/education-archives** and search on "Coughlin" to access them. And he's presenting more at this year's online NASCC. Visit **aisc.org/nascc** for more information and to register.

IN ORDER TO DO ANYTHING WELL, we really need to pay attention.

That simple sentence has ramifications for today as well as this week, month, year, and decade.

There is so much involved in that one sentence:

- Getting better at the skill of paying attention in order to really focus on one important thing at a time
- Deciding what to pay attention to
- Deciding how long to pay attention to it
- Deciding what nuances within it we want to give special attention to
- Deciding what not to pay attention to

However, no matter how complicated this topic becomes, it still comes back to the main point: We really need to pay attention.

Practice Paying Attention

Getting good at sustaining focus requires practice. Consider soccer. In a typical soccer match, there about a dozen good shots on goal that have a decent chance of going in. That's for both teams combined. The 20 field players touch the ball hundreds of times per game combined, but only a dozen of those touches result in good shots that might get past the two goalies.

To get ready to set up a quality shot in a match, players will practice shooting hundreds and hundreds of times. Imagine practicing something hundreds of times that you might only get to do a handful of times in an actual game. When they practice, players do things that never happen in a match scenario, like pointing their toes down, leaning over a ball that another player is holding on the ground, and striking the ball over and over without it going anywhere.

That's the way it is with being able to pay attention during a workday. You will only be in a state of deep focus for a small part of the day, but you have to be ready for this period.

The practice of mindfulness is a way to improve your skill at paying attention. This involves doing something that you won't actually be doing during the workday, but like soccer drills, it will help you sustain your focus in your work.

Try this exercise for three minutes. Put an object of any kind in front of you. Focus only on that item. Any time a thought or an emotion enters your awareness, just acknowledge it and calmly let it go. Don't engage with that thought or emotion. Little by little, you will develop the ability to calmly stay focused on one thing and let go of any other thought or emotion.

When you put this skill into your workday, you can focus on doing or thinking about something without letting other thoughts or emotions—or urges to look something up on Wikipedia (a workday rabbit hole if there ever was one)—distract you from your activity. You can just acknowledge the thought, choose not to engage with it, and watch it slide out of your awareness. As you stay focused, you can dig deeper and deeper into the topic at hand.

Be Your Best Attention-Giver

Some people are very good at giving attention to creating something that has no immediate practical value—i.e., writing a chapter in a novel, working on a painting, creating a workbook for a seminar, or developing a part of a song (unless being a novelist, painter, presenter, or songwriter is their profession, of course).

Other people are very good at paying attention to practical details in terms of schedules and thresholds: a car's gas tank, taxes that need to be paid, doctor visits that need to be scheduled, and travel plans that need to be executed. Both types of focus are important, but most of us aren't equally effective in both types of focus.

Norman and Mary Rockwell were an example of this. Norman could sit in his studio and concentrate on creating a painting that told a meaningful story. Mary guided the details of their business and home life. Each person brought great value to their marriage and business by applying the type of focus they were best at.

Select Your Area of Focus

A rule of reality is: You can't focus on everything, so choose carefully.

I had cataract surgery on both eyes this past summer. My doctor did a magnificent job. For the first time since third grade, I can see extremely well without glasses. To me, it's a miracle.

And then I started thinking about the extraordinary amount of focus it must have taken the doctor to perfect his skills in order to do what he did for me. He had to choose which areas of medicine he was *not* going to focus on, and then choose the area he *was* going to focus on.

The same is true for you. You can't do everything well at a high or deep level. So what's it going to be? Choose a topic or area that you really want to focus on.

Four Hours

My favorite psychologist, K. Anders Ericsson, used to say that world-class performers could sustain their focus for up to four hours a day while a novice performer could focus for about one hour a day.

Please don't pressure yourself into thinking you need to be able to focus deeply for eight to ten hours a day. That is *not* realistic. However, what you can do in one to four hours a day of deep concentration is rather remarkable. But you need to *allow* yourself to do it—and don't try to cram all of your deep focus for the week into one day. It doesn't work that way. Rather than doing busy work for four days and concentrating deeply for one day, I encourage you to consider carving out one to four hours each day to really focus on a particular topic or activity, and space out the more mundane tasks—or, say, catching up on emails—through the week.

The Task(s) at Hand

Losing focus isn't just a personal issue; it can also be costly to your organization—especially when you're trying to juggle multiple projects at once. All too often, people will start up a new project with a great deal of enthusiasm. But then they are presented with another project, and another, and another. This is when people bring up the concept of multitasking, which many people say they can do—but the vast majority of the time, they don't do it as well as they think they can.

If you choose to stop a project and focus on a different project, that's perfectly OK. Many of us have jobs where this is the norm. But be sure not to try to focus on too many tasks at once. If all you do is keep adding more projects without ever ending any of them, then you are not being effective. And if you find yourself needed to switch your focus from one task or project to another on a regular basis, consider a brief decompression or break between each one, which can help "reset" your focus for whatever comes next.

Like anything, practice and planning make perfect, and focus is no exception. Determine your focusing strengths, practice mindfulness, spread out your deep focus periods, and acknowledge that you don't have to be 100% on 100% of the time when it comes to focusing. ■

Books to Focus on

Over the past few months, I've begun to dig deeper into the concept of sustaining focus. Along the way, I've stepped into a few great books, and I would like to recommend pieces of them.

- *Mindfulness: An Eight-Week Plan for Finding Peace in a Frantic World*, specifically Chapter 1, by Mark Williams and Danny Penman
- *Deep Work: Rules for Focused Success in a Distracted World*, specifically the Introduction and Chapters 1, 2, and 3, by Cal Newport
- *Humility is the New Smart: Human Excellence in the Smart Machine Age*, specifically the Introduction, and Chapters 3, 4, and 5, by Ed Hess and Katherine Ludwig
- *Rapt: Attention and the Focused Life*, specifically the Introduction and Chapter 4, by Winifred Gallagher

A beautiful, modern steel structure sets the stage for a positive rehabilitation experience at a new sports medicine center in Denver.

The new UCHealth Steadman Hawkins Clinic Denver adds 150,000 sq. ft of physical therapy, rehabilitation, and related spaces to the south Denver metro area.

Strong Recovery

BY TOM McLANE, PE, AND CRAIG FISHER, PE

Caleb Tkach, AIAP

Tom McLane is a structural project manager and **Craig Fisher** is manager of engineering and the engineer of record for the UCHealth Steadman Hawkins Clinic Denver project, both with Stewart.

THE NEW UCHEALTH Steadman Hawkins Clinic Denver and University of Colorado (CU) Sports Medicine orthopedic and sports medicine center covers all the bases of physical therapy.

Located in Englewood, Colo., the new facility features an advanced orthopedic clinic, physical therapy and rehabilitation spaces, six operating rooms, advanced MRI and radiology services, training and technology areas, human motion analytics for performance and injury prevention training, a surgery center, indoor and outdoor tracks, and an outdoor turf field. Specialists at the center proudly care for patients of all abilities—from elite professional athletes to weekend warriors and those rebuilding from injuries, accidents, or just regular wear and tear. Athletes from several sports organizations in the area receive care from UCHealth and CU medical teams at the facility, including the Denver Broncos, the Denver Nuggets, the Colorado Avalanche, the Colorado Rockies, and several other professional teams and local high school teams.

The four-story, 150,000-sq.-ft structure, analyzed and designed using ETABS, consists of composite steel construction and is framed with a total of 1,150 tons of steel. The standard column grid is 28 ft by 30 ft; the floor is a composite framing system of steel deck topped with 6.5 in. of normal-weight composite slab supported on steel wide-flange beams, and the lateral system incorporates steel braced frames.

UCHealth assembled a design and construction team early on the project, recognizing that an early relationship between engineer and steel fabricator could render a demanding structure with a critical schedule much more efficient to fabricate and erect. Structural engineer Stewart worked proactively with fabricator Puma Steel, facilitating the integration of automated and preferred fabrication processes into the design. Implementing an interactive mindset helped keep this challenging steel project on schedule.

The floors above and below the operating rooms required a unique vibration design to prevent perceivable movement during surgery in the building's surgical rooms.

Caleb Tkach, AIAP

(AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity*—**aisc.org/dg**—was consulted for the surgery areas.) A ground-floor MRI machine is located on a 12-in. concrete slab next to an exterior wall to allow for the machine's removal when replacement is eventually required. An opening was designed in the outer metal panel and brick wall façade system in anticipation of this replacement.

The site contains expansive soils and shallow bedrock, which required drilled shaft foundations socketed into the sandstone/claystone bedrock. The drilled shafts ranged from 24 in. to 54 in. in diameter due to the gravity loads, uplift, and lateral loading requirements induced by the braced frames. The shafts were socketed into the bedrock 15 ft deep, with top of bedrock only a few feet below the finished floor in some locations. Each caisson had a concrete cap that allowed the steel column base plate anchor bolts to be set after pouring the caisson. This sequence helped ensure the correct anchor bolt placement.

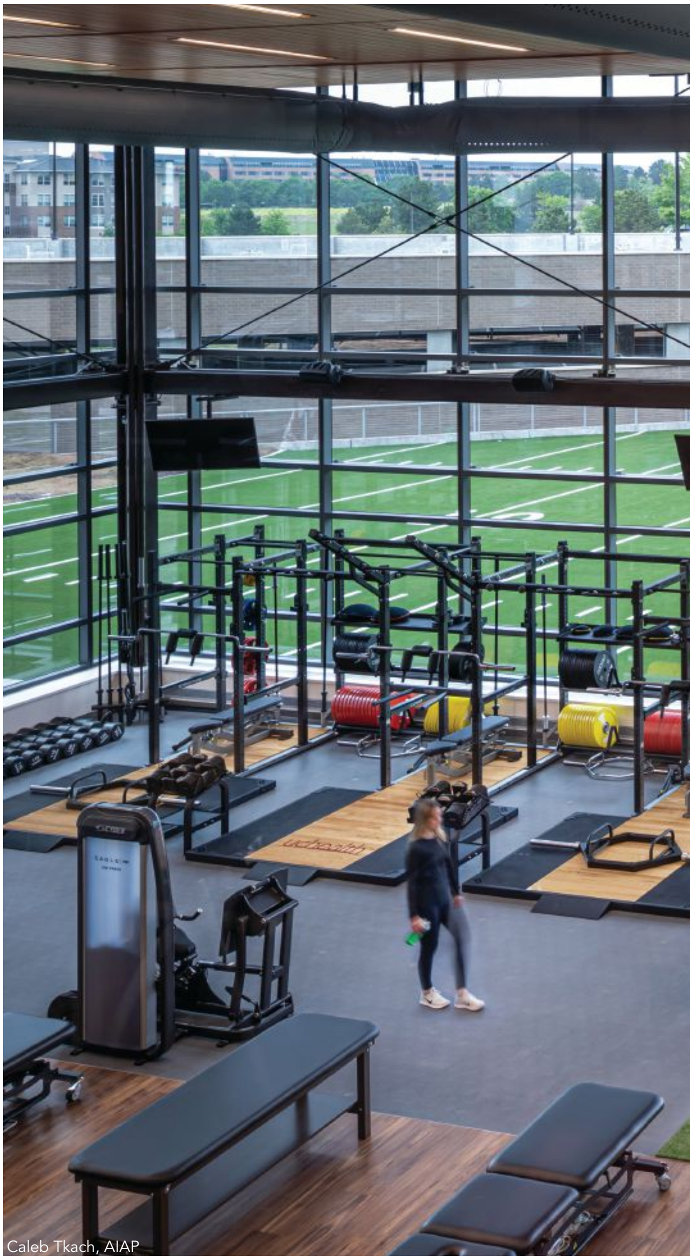
At the perimeter, grade beams with void forms were required to support the external façade system of glass, metal stud, and brick.

above and below: The four-story structure takes advantage of composite steel construction and is framed with a total of 1,150 tons of steel on a standard column grid of 28 ft by 30 ft.

Caleb Tkach, AIAP

above and below: Curved steel roof framing on the ground prior to installation.

right: A glass and steel curtain wall blurs the lines between indoor and outdoor rehabilitation spaces.



Curved W36 roof framing installation in progress.

In place of concrete caps, the grade beams span over the top of the caisson, and the anchor bolts were set into the top of the grade beam. The braced frames required grade beams to tie the drilled shafts together, helping transfer the base shear forces into the drilled shafts. Each braced frame column base plate at a diagonal brace has a shear lug that required special grade beam detailing to overcome the interruption of the top reinforcing steel. Coordination of the shear lug, grade beam dimensions, and grade beam reinforcing was critical since the grade beam needed to resist negative moment over the drilled shaft.

The expansive soils also created detailing challenges with the slab. Isolating the slab on grade from the exterior grade beam and walls was critical to allowing vertical movement between the slab and soils. Without this vertical movement, unintended forces from the expansive soils could crack the slab on grade and connecting structural elements.

The project's most prominent architectural and structural feature is its 185-ft-long, 40-ft-wide signature

UCHealth-branded curved roof. This feature is located on the building's south side and faces the sports performance outdoor turf area. The roof is partially open-air but provides coverage over a mechanical space and also features a clerestory. The framing system consists of conventional steel framing with a moment frame in the short direction and braced frames in the long direction. The curved roof over the enclosed spaces required curved beams consisting of W30×99, W21×44, and C12×20.7. W16×31 beams cantilever 16 ft on the north side to create the overhang of the rooftop mechanical space.

On the building's west side, opposite the main entrance, the curved roof has an opening that is 68 ft long by 24 ft wide and allows natural light to funnel to the main roof level. HSS12×6×½ span the width of the opening and are clad with metal panels. These hollow structural section (HSS) members support the signature aesthetic that UCHealth has designated on recent projects and brace the beams spanning 90 ft on each side of the opening against lateral-torsional buckling. Two curved W36×247 beams span the exterior portion of the curve (one on each side) and support the 6-ft-long cantilevered W16×26 beams outside the span. The beams' east side was connected with a standard shear connection, but the west side of the beams was detailed with Teflon bearing pads at the columns. This detail allowed for temperature movements in the long direction but provided resistance to lateral loads in the short direction. ETABS was particularly useful in calculating the necessary vertical and horizontal deflections from the combination of dead, live, snow, wind, and temperature loads. LPR, the steel erector, chose to erect each beam separately and stick-build the rest of the roof structure.

Two other significant architectural features are the main entrance and adjacent sports performance area. The main entrance features an exterior canopy supported at Level 3 with an 18-ft cantilever consisting of W16×36 beams supporting a wood-pattern metal panel ceiling. The left side of the entrance features another open-air roof, like the curved roof, with HSS12×6×¼ beams spaced at 5 ft on center spanning through the opening. The members are clad with metal panels, which allow for more light to pass through the glass at the main entrance and atrium.

left: Steel framing above a bearing pad prior to installation.

below: Framing for the main lobby during construction. The open, two-story lobby space features exposed steel columns with an AESS 1 (basic elements) finish.

Point-supported glass was specified around the curved atrium façade, which added significant point loads to the roof framing due to the tension in the wall system's vertical cables. There was considerable coordination between Stewart, architect BSA, point-supported glass manufacturer Novum, contractor Haselden, and Puma to locate beams above the cable supports and provide sufficient stiffness for the cables once they were tightened. Adequate stiffness was required in the roof beams to prevent deflections that loosen the cables during tightening. If adequate stiffness hadn't been provided, significant deflection could have prevented sufficient tension in the cables.

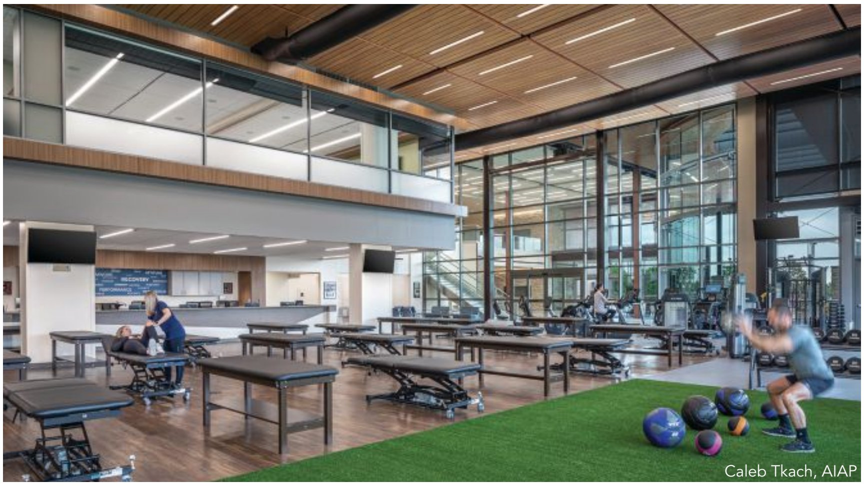
The open, two-story lobby space features exposed steel columns with an AESS 1 (basic elements) finish and wood panels inside the wide-flange members' webs (for details on the various AESS levels, see "Maximum Exposure" in the November 2017 issue, available at **www.modernsteel.com**). The lobby continues into the sports performance area through a full-height glass wall featuring a large projector screen.

The sports performance area features a state-of-the-art gym with equipment for exercising, rehabilitation, stretching, and physical therapy. The steel columns and wind girts in this area are exposed and support glass curtainwall, and 1-in.-diameter A36 rods are used as cross-bracing on the upper half of the space with a moment frame on the lower half to control deflections in the cantilevered metal deck diaphragm. The low roof framing consists of steel wide-flange beams supporting a 3-in. metal deck and wood-pattern metal panels above the girder's bottom flange. This detail allows for the bottom flange of the wide flange shape to be exposed, complementing the exposed steel columns, girts, and rods. The sports performance area transitions from indoor space to outdoor space through three glass garage doors. The inside space has synthetic turf that transitions to the 50-yard-long synthetic-turf outdoor football field, providing a highly functional space for athletes to rehabilitate.

Panelized metal stud framing was used for the façade at most locations around the building's perimeter to speed up the construction and standardize the façade system. Panels were built on-site and erected in large sections on the outside of the slab's bent plate edge in a bypass framing configuration. A ½-in. gap was provided between the bent plate in the edge of the slab and the metal stud's inside face to ease constructability and tolerances.

The façade consists of metal panels, glass, and brick. The brick and metal panels are also vertically supported by the panelized stud system. Relieving angles were field welded to the metal studs to allow for adjustment after installation of the panels, and light-gauge clips were used to attach the panels to the edge of the slab.

The rooftop equipment required an 18-ft-tall screen wall to hide the rooftop units from view, which required HSS8×8×½ posts spaced at 9 ft, 4 in. on center to support the metal panels that clad the screen wall. The posts were cantilevered from the floor beams at the base, which required careful detailing and coordination with the steel fabricator to ensure a connection detail that was constructable and economical. Splices were provided in the HSS posts 3 ft above the column base to increase erection efficiency and reduce construction conflicts. This detail facilitated shop welding the post stub up to the base plate where possible, then field bolting the stub up to the cap plate as necessary. At corner posts or locations where the post load is not in line with the beam below, a new beam framing perpendicular to the beam at the base with a moment connection was required.



Caleb Tkach, AIAP

left: The low roof framing of the the sports performance area consists of steel wide-flange beams supporting a 3-in. metal deck and wood-pattern metal panels above the girder's bottom flange.

These beams and moment connections resist the column base moment without inducing torsion into the wide-flange beams.

Much like the coordinated effort needed to rehabilitate athletes, the facility's successful construction can be credited to the excellent communication between all parties throughout the design and construction processes. The facility also elevates the rehabilitation experience from a sterile medical environment to a modern, attractive, healing space with plenty of natural light and exposed materials. ■

Owner
UCHealth, Aurora, Colo.

General Contractor
Haselden Construction, Centennial, Colo.

Architect
BSA LifeStructures, Raleigh, N.C., and Denver

Structural Engineer
Stewart, Raleigh

Steel Team

Fabricator and Detailer
Puma Steel, Cheyenne, Wyo.

Erector
LPR Construction, Loveland, Colo.

Bender-Roller
Albina Co., Inc., Tualatin, Ore.

Caleb Tkach, AIAP

left: The point-supported glass around the curved atrium façade added significant point loads to the roof framing due to the tension in the wall system's vertical cables, thus requiring considerable coordination between the various team members.

Caleb Tkach, AIAP

below: The building, including the iconic UCHealth-branded curved roof, is visible from adjacent Interstate 25 in Englewood, Colo.

Live Transformation

BY DAVID McLAREN, PE, BRAD FALLON, PE, AND CASSANDRA DUTT

AN EXISTING PARKING deck has been transformed into a three-level, 75,000-sq.-ft, steel-framed entertainment superstructure dubbed THE HALL at LIVE!

In 2018, The Cordish Companies, owners of the LIVE! Casino and Hotel resort in Hanover, Md., celebrated the grand opening of their newest 17-story luxury hotel tower and accompanying 12,000-sq.-ft ballroom space designed by architects Klai Juba Wald. Cordish soon realized the project's success presented an opportunity to expand the development with an on-site, large-scale entertainment venue centered on attracting big-name national acts to the casino resort.

At that time, the northwest corner of the LIVE! development featured a post-tensioned concrete parking deck with open-air loading access to the ballroom. The team envisioned modifying the area, which was conveniently sandwiched between the existing event space and casino, into a permanent yet flexible high-end facility that could soon accommodate 4,500-plus patrons.

McLaren Engineering Group, which provided both structural and civil design and engineering services for the entire LIVE! complex since its original construction in 2012, proposed an innovative approach to reusing the parking deck and constructing an entertainment superstructure above it. Doing so would also accommodate a significantly accelerated project delivery schedule, making THE HALL at LIVE! fully operational in under 24 months from beginning of design to grand opening.

The column-free, three-level, 75,000-sq.-ft, steel-framed entertainment superstructure of THE HALL at LIVE! rivals some of the largest performance venues around the nation.

The Cordish Companies

The undertaking was daunting. The project team was tasked with reusing the existing parking deck structure and repurposing it into the main event space floor, designing and constructing a brand new three-story event space with tiered seating and first-class back-of-house accommodations, and making use of the existing foundations by any means necessary to minimize disruptions to the site. Right-of-way to the network of access roads servicing the casino development always had to be maintained, including a major three-lane casino entrance routed directly below the middle of the proposed project. Lastly, the 24-hour casino and hotel operations could not be disrupted, further restricting the location of any new structural work.

With these constraints in mind, steel was selected as the project's structural material of choice for its superior strength-to-weight ratio, its ability to minimize reinforcement to the existing construction, and aptness to achieve the long spans needed to maximize for a column-free performance space. The majority of the 890 tons of steel used

Maryland's LIVE! Casino and Hotel uses an existing structure as a launchpad for a new steel-framed entertainment venue.

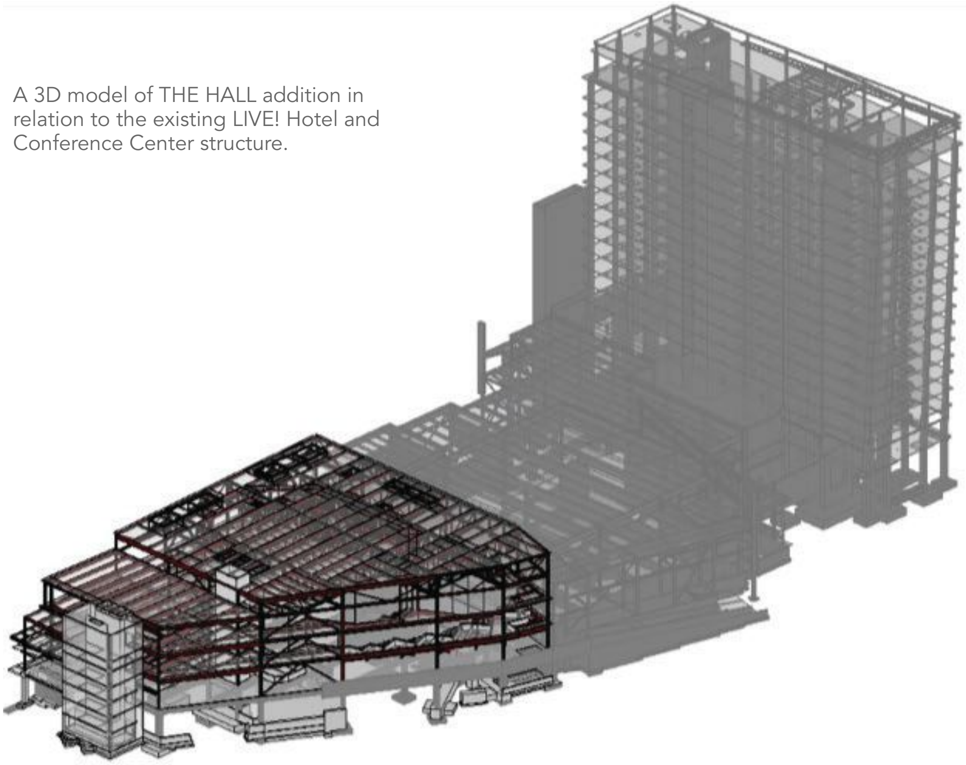
David McLaren is a project executive, **Brad Fallon** is a project manager, and **Cassandra Dutt** is a project engineer, all with McLaren Engineering Group.

was domestically sourced and fabricated locally for the project by fabricator Kinsley Construction, Inc.

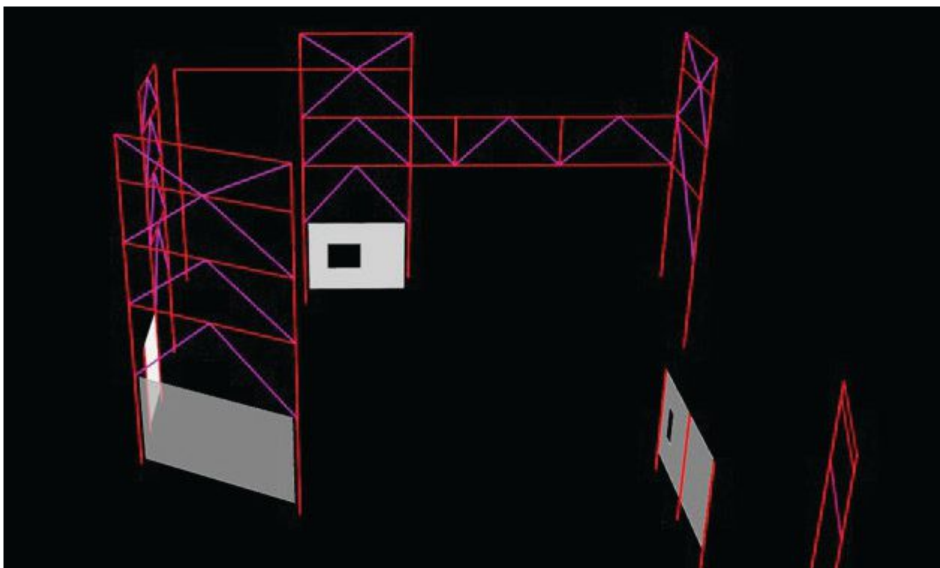
McLaren designed the 75,000-sq.-ft facility using a strategic combination of composite steel framing for the floor spaces and long-span transfer trusses at the roof to create an economical and lightweight framing system. The facility features a 30,000-sq.-ft main orchestra level offering flexible seating configuration, a 12,000-sq.-ft "loge" mezzanine level with traditional fixed seating boxes, and a 15,000-sq.-ft VIP level with tiered stadium-style seating. Each tier of seating was designed to offer audiences unobstructed, column-free views of the built-in performance stage equipped with advanced sound, lighting, and theatrical rigging systems. Behind the stage, the grand entrance lobby features an open three-story atrium and steel-framed monumental stair.

At the onset of the expansion, reinforcement of the existing post-tensioned concrete-framed parking deck was needed to support the proposed superstructure. McLaren devised a foundation system to increase the capacity of the existing spread footings, which were originally designed for one level of structured parking, to adaptively accommodate the new three-level steel-framed performance venue. The existing construction was also stiffened laterally to withstand the wind and seismic forces from the new braced frame system in the superstructure.

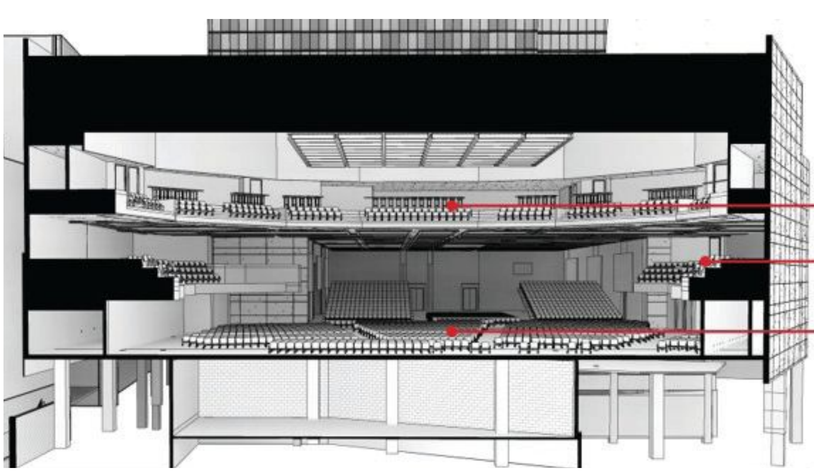
A key project goal was making the performance space column-free to eliminate visual obstructions and maximize flexibility. To accomplish this, McLaren devised a steel truss roof system to hang the tiered basin VIP level seating from above. The trusses clear span the entire 180-ft-wide performance space to create unimpeded views of the stage. As such, supporting columns extending to the roof level were located within the exterior of the structure. Careful to avoid any disruptions or closures to nearby business activity, McLaren teamed up with the general contractor and steel fabricator to limit the truss depths to 12 ft, 6 in. and accommodate bolted field splices to allow for shop assembly of the truss sections and practical delivery to the project site. The lavish VIP level expanse also supports a private bar, lounge, and balcony, all exclusively hung by the steel roof trusses above.



A 3D model of THE HALL addition in relation to the existing LIVE! Hotel and Conference Center structure.



A 3D model of the lateral system.



An architectural 3D cross section of the event space atop the existing parking deck structure.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9	Channel Flanges Out	INSIDE DIA.	All Sizes
10	Channel The Hard Way (X-X Axis)	INSIDE DIA.	All Sizes
11	Tee Stem In	OUTSIDE DIA.	22" x 142 1/2# Tee
12	Tee Stem Out	INSIDE DIA.	22" x 142 1/2# Tee
13	Tee Stem Up	MEAN DIA.	22" x 142 1/2# Tee
14	Angle Heel In	INSIDE DIA.	8" x 8" x 1" Angle
15	Angle Heel Out	OUTSIDE DIA.	8" x 8" x 1" Angle
16	Angle Heel Up	MEAN DIA.	8" x 8"x1" Angle
17	Square Tube	INSIDE DIA.	24" x 1/2" Tube
18	Rectangular Tube The Easy Way (Y-Y Axis)	INSIDE DIA.	20" x 12" x 5/8" Tube
19	Rectangular Tube The Hard Way (X-X Axis)	INSIDE DIA.	20" x 12" x 5/8" Tube
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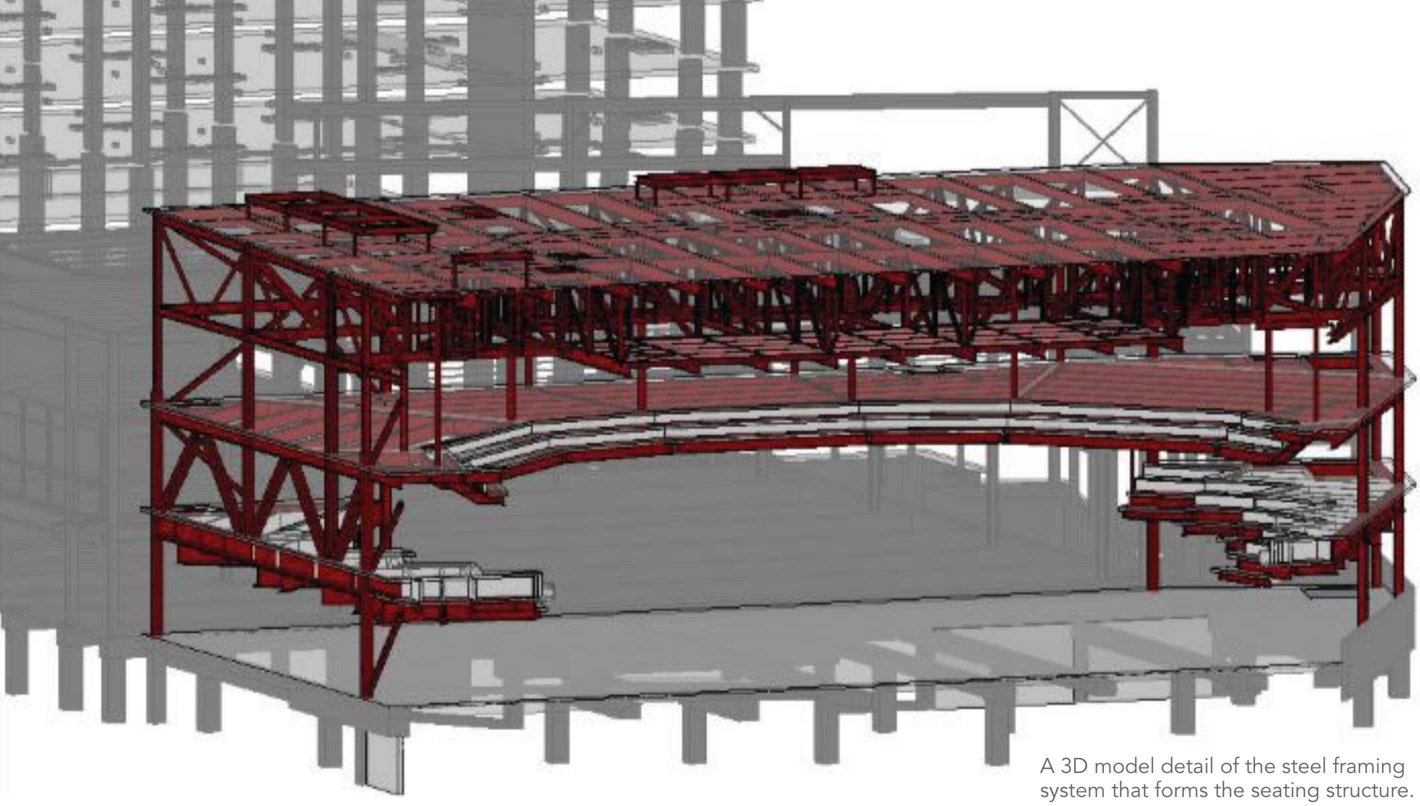


A 3D model detail of the steel framing system that forms the seating structure.

McLaren

The suspended cantilevered seating tiers under construction.

The lower "loge" mezzanine tier flanks the stage area on both sides of the performance space. To accommodate the column-free mandate, the loge level seating employs a clever framing arrangement of cascading cantilevers. The system works by arranging each successive cantilever and fulcrum bay to be framed off the adjacent cantilevered seating box to form the "saw tooth" geometry envisioned by the architect. Since deflections accumulate linearly through the cascading system, the team took great care during the design process to ensure that deflection behavior was tightly controlled.

Considering the known susceptibilities of long-spanning, lightweight structures to motion-induced vibration, McLaren performed a rigorous finite element-based vibration analysis of the seating tiers. The mathematical model-based approach to vibration response directly evaluated the theoretical acceleration response to concert-goer movements (such as dancing and jumping) based on the methodology published by AISC in the recently updated AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity* (**aisc.org/dg**). The analysis ensured the superstructure had adequate stiffness and damping in line with industry-acceptable levels to mitigate any potential patron discomfort. In the end, McLaren's approach to this analysis permitted reduced truss depths and less steel tonnage in the seating bowl framing compared to vibration mitigation techniques using more common empirical approaches.

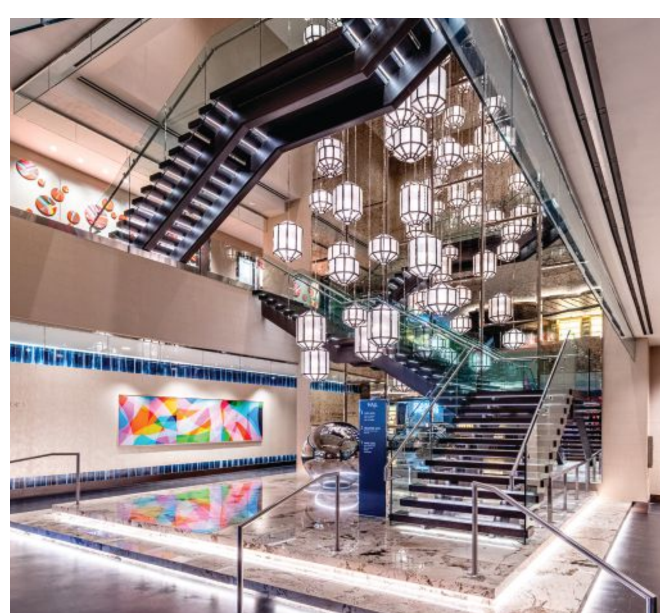
McLaren also drew upon extensive experience working with world-class performance venues and theaters around the world to provide design assistance to the state-of-the-art 7,000-sq.-ft flexible theater grid, catwalk, and rigging support system. Concealed within the depth of the roof truss framing above the main

McLaren

above: Erection of a 174-ft-long truss that supports the suspended seating tiers.

right: Steel-framed monumental stairs at the entrance lobby.

below: A rendering of the completed exterior.



The Cordish Companies

The Cordish Companies

stage and extending over the audience, the advanced entertainment set up rivals some of the largest performance venues around the nation.

THE HALL at LIVE! officially opened in December 2019. Construction was completed on time and without disruption to daily business operations or traffic flow due in part to innovative engineering, thoughtful material selection, and cohesive teamwork. Today, the newly erected entertainment venue sits as one of the largest performance venues in the state of Maryland and is slated to feature marquee musical acts, comedians, championship boxing, and other events. ■

Owner
The Cordish Companies

Construction Manager
Gilbane

Architect
Klai Juba Wald

Structural Engineer
McLaren Engineering Group

Steel Fabricator, Erector, and Detailer
Kinsley Construction, Inc. (AISC Certified Fabricator), York, Pa.


A perspective from the loge seating showing unobstructed views of the stage, which features a state-of-the-art 7,000-sq.-ft flexible theater grid, catwalk, and rigging support system concealed within the depth of the roof truss framing.

The Cordish Companies

Doubling Up

BY KEVIN G. CASEY, SE, PE

Kevin G. Casey (kcasey@bbmstructural.com) is a principal with BBM Structural Engineers.

ADVENTHEALTH KISSIMMEE'S three-story patient tower, which opened in 2015, is already in the process of doubling its height.

The $84 million project is the latest in a series of ongoing improvements to the AdventHealth campus in Kissimmee, Fla., responding to rapid population growth in Osceola County, located immediately south of Orlando. In addition to the 80-bed patient tower, an expanded emergency room opened in 2014 and additional surgical suites opened in 2020. The patient tower expansion, scheduled to open this fall, will bring the hospital campus' bed count to 240. Totaling 123,000 sq. ft, the three new floors will be built directly on top of the existing tower.

"This investment illustrates our commitment to the health of the Kissimmee community," said AdventHealth Kissimmee CEO Sheila Rankin. "We are dedicated to providing whole-person care close to home for the growing population of Osceola County in the years to come."

A framing material change facilitates an enhanced expansion at a Florida Hospital.

Earl Swensson Associates

The existing tower's structural system consists of cast-in-place concrete flat slab supported on a shallow foundation system and a lateral system made of load-bearing concrete shear walls. It was initially designed to accommodate a two-story vertical addition, also framed with concrete.

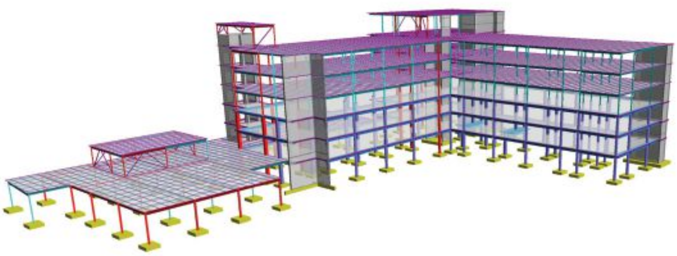
However, hospital ownership eventually increased the proposed addition to three stories. Project architect Earl Swensson Associates requested BBM Structural Engineers to study the feasibility of this revised plan. BBS used RAM Structural System to model the existing structure and foundations with the three-story addition. The existing vertical load-carrying components were checked for capacity, and the existing foundations were also checked for capacity as well as settlement. A vertical extension of the existing shear walls surrounding the elevators and stair walls was found to be sufficient to resist lateral loads and provide sufficient stiffness to maintain drift requirements for the tower.

All criteria were met and the existing structure and foundation were determined to have adequate strength and stiffness to support the new three-story vertical addition—if one major change from the original plan were to be implemented: Change the expansion's framing system from concrete to steel.

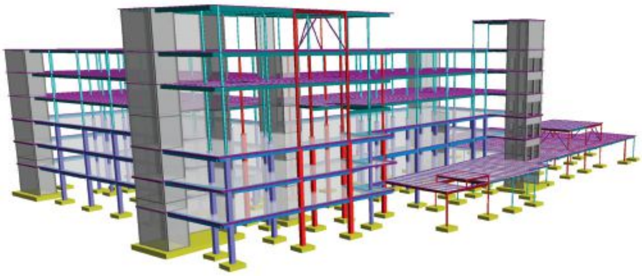
Adding a floor to the original plan also meant adding weight, and the proposed steel framing scheme weighed roughly half of the equivalent concrete framing scheme, thus creating less of a loading burden on the existing framing system and foundations. As a result, the expansion was designed using wide-flange shapes.

above: The addition uses 533 tons of steel in all.

below: A RAM model view looking southwest.



below: A RAM model simulating the two-story clear-height columns at the fifth floor surrounding the existing AHUs.



W18s and W16s were used for floor girders and beams, perimeter spandrel beams were W21s, and column shapes were W12s. The framing system incorporated 533 tons of structural steel in all. Columns were connected to the existing concrete structure by casting concrete pedestals on top of the existing concrete columns. This allowed the steel column anchor rods to be cast in place and facilitated temporary waterproofing while steel erection proceeded.

The structural framing change also meant that the floor system was changed from a concrete flat slab to 2-in. metal deck topped with 3¼ in. of lightweight concrete that provided the required two-hour fire rating and met all strength requirements. A 2-in. layer of monolithic topping was added to the structural thickness to allow for numerous floor depressions—used for patient room bathrooms—whose locations and sizes were still being determined during the design stage.

Steel framing being installed on the existing building.

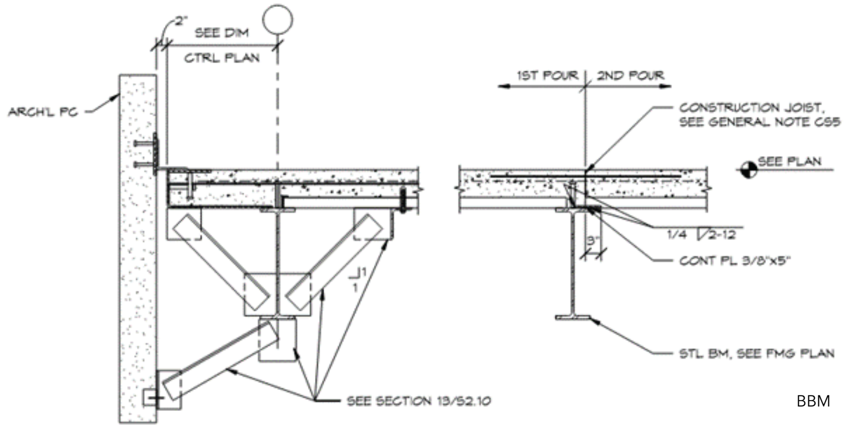
Construction of the tower addition began in late 2019. One of the greatest challenges of the project was working around the existing third-floor roof air-handling units (AHUs) and ductwork, which had to remain in operation until the new penthouse and mechanical equipment were connected to existing risers and brought online. Two structural models were used to simulate this phasing. One model simulated the columns surrounding the existing equipment being designed for a two-story clear height with beams omitted where clashes with the existing mechanical equipment were identified. The general contractor, Brasfield and Gorrie, performed laser scanning on the existing mechanical equipment and ductwork inserted into the structural model to identify conflicts with framing.

The initial design planned for the architectural precast and glazing system surrounding two exterior sides of the existing 4th-floor mechanical equipment be temporarily left out and constructed after completion of the new penthouse. This was done in order to allow for airflow to the existing AHUs and provide access for mechanical equipment removal.

During the design of the precast façade, the general contractor requested the omitted architectural precast be installed. This design change facilitated the alignment of the new precast façade with the existing precast façade. Thanks to the flexibility of steel, the framing in the affected area was modified to allow this change to proceed after verifying that the airflow to the existing AHUs was sufficient. A 5-ft-wide section of perimeter slab was added in the intermediate phase. This perimeter slab section resisted the eccentric loading of the façade and removed the need to design the steel spandrel beams and their connections for torsion.

The tower topped out this past November, and the new addition is on schedule to begin receiving patients this fall. The existing three floors of the hospital remained fully operational during

A section at the construction joint in the fifth-floor slab.



BBM

construction. And by changing the framing scheme from concrete to steel, the vertical expansion ended up being bigger and better than originally anticipated. ■

For more images of the project, visit the Project Extras section at www.modernsteel.com.

Owner
AdventHealth

General Contractor
Brasfield and Gorrie

Architect
Earl Swensson Associates

Structural Engineer
BBM Structural Engineers

Steel Team

Fabricator and Detailer
Dixie Southern Industrial, Inc. (AISC Certified Fabricator), Polk City, Fla.

Erector
Curry Steel (AISC Associate), Polk City, Fla.

BBM

Careful coordination was necessary to work around existing AHUs and ductwork.

Design-build delivery of a new steel station keeps the LIRR trains running.

All Aboard

BY KEITH ITZLER, PE

Keith Itzler is a vice president based in Dewberry's New York City office.

SET ALONG THE MAIN LINE of the Long Island Rail Road (LIRR), Wyandanch Station has been a busy hub for New York commuters since it opened in 1875.

The station is located in the town of Babylon in western Suffolk County, approximately an hour's train ride from Penn Station. With steadily increasing use through the years as part of the nation's busiest commuter train system, Wyandanch Station was rebuilt in 1958 and again in 1987.

LIRR's Ronkonkoma Branch, of which Wyandanch is a part, has doubled in ridership over the past 25 years and the station now serves more than 4,000 commuters each day. With this growth in mind, as well as a commitment to partner with local communities in promoting transit-oriented development, the LIRR recently completed a major design-build development project to improve customer service, involving major track improvements at Wyandanch as well as the construction of a new 3,000-sq.-ft steel-framed station. The expedited project was completed in several phases to minimize the impact on daily train service.

left: Steel-framed elevator towers and a pedestrian bridge with "Arts for Transit" window treatments reflect the traditional American Craftsman architectural style.

below: Members of the design and construction team were on site during installation of the steel frame for the new pedestrian bridge. The bridge was shop-fabricated, assembled adjacent to the site, and hoisted into place to minimize time needed for track closures.

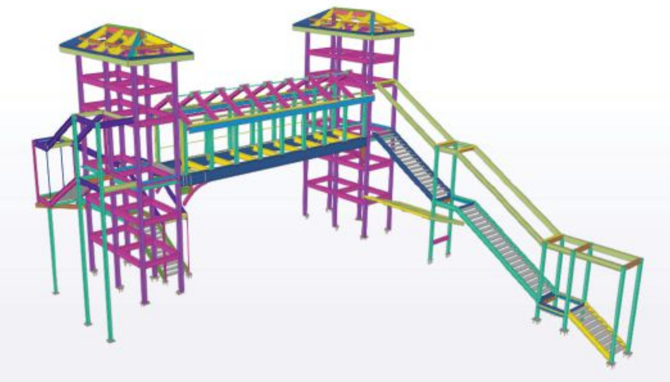
Photos courtesy of Dewberry

LIRR turned to the design-build team of structural engineer Dewberry and general contractor L.K. Comstock and Company, Inc., to design and construct the station and related facilities. These stations are part of the program that created a second track on the Ronkonkoma Branch of the railroad from Farmingdale Station to approximately one mile west of the Central Islip Station. This 18-mile stretch includes six stops in central Long Island, including the Wyandanch Station and Pinelawn Station.

The Heart of Revitalization

The new Wyandanch Station has achieved several major objectives for the LIRR and the surrounding community. While completion of the second track has expanded train service, added flexibility for the reverse commute, and minimized disruption due to disabled trains, the new station represents a milestone in LIRR's ongoing program to upgrade, modernize, and beautify its inventory of station facilities. The station also anchors a major Wyandanch revitalization effort known as Wyandanch Rising, which is aimed at bringing civic prominence and transit-oriented development to the community. LIRR partnered with the Town of Babylon and Suffolk County on the station's location and design.

The design-build delivery method and an accelerated schedule that featured the use of preassembled steel components enabled the LIRR to open the new stations in Wyandanch and Pinelawn in approximately a year and a half from the start of design. The Dewberry/Comstock team worked closely with the railroad to develop four design packages to fast-track delivery and minimize track outages.



above: A 3D structural model of the steel framing. The elevator towers use HSS8×8×½ columns and HSS12×8×½ horizontal framing. The bridge framing consists of W24×94 girders with W12×26 infill beams for the floors, HSS8×6×3/8 verticals and HSS8×4×5/16 horizontals for the side walls, and HSS8×8×5/16 rafters and C15×33.9 eaves for the roof.

below: Each elevator tower structure was shipped to the job site from fabricator J. A. McMahon in two halves that were welded together adjacent to the site and then erected as one unit on a weekend general outage for the trains.

below: The platform canopies feature exposed steel members, some of them curved, that facilitate the American Craftsman-style architectural aesthetic.

Celebrating Tradition

The new station offers numerous amenities, as well as two 12-car-long platforms featuring an innovative snow-melt system, a fabricated steel pedestrian overpass with elevators, stairs, canopies, and platform shelters.

Framed with 144 tons of structural steel in all, the station and canopies were designed in an elegant and welcoming American Craftsman style that echoes late 19th-century architectural tradition. Steel proved to be the material of choice for many of the significant design features, for both aesthetic and practical reasons. The use of exposed curved steel tube members for knee braces in the canopies, for example, was ideal for helping drive the aesthetic of the canopy construction.

In order to meet the expedited construction schedule, the pedestrian bridge frame and deck were assembled and then hoisted into place over one weekend. The lightweight but durable steel construction of the bridge and canopies facilitated this process. Using structural steel as a material also allowed for the detailing that is an integral part of the American Craftsman style of design.

Strength and Durability

Hollow structural sections (HSS) were used for the steel elevator towers, which were essentially freestanding elevator shafts. The towers were designed as 3D moment space frames, without bracing, to allow for unobstructed views into the glass elevator cabs through the elevator tower windows and allow for the construction of the masonry shaft walls. The use of HSS sections was driven by their inherent ability to resist out-of-plane bending due to wind loads and torsional loading associated with the brick face of the towers. The welded space frames also provided the structure with enhanced lateral stiffness properties considering wind and seismic loading.

All HSS connections were fillet welds and partial-penetration welds, which were reviewed with the fabricator for constructability during the design phase. To the extent practical, considering trucking considerations, tower sections were fabricated in the shop, thus minimizing field welding. Similar to the pedestrian bridge span, the towers were hoisted into place during only one scheduled weekend train service shutdown.

Longevity and corrosion control were also important considerations in the design. Steel platform guardrails were metalized or thermal spray-coated to prevent corrosion in the harsh winter climate. Similarly, exposed structural elements were coated with a high-performance, three-coat painting system to extend the time required before repainting is needed. Thanks to this protection, the framing remains exposed, putting the station's styling

on full display to the thousands of daily commuters it serves. ■

*For more images of the project, visit the Project Extras section at **www.modernsteel.com**.*

Owner
Long Island Rail Road

General Contractor
L.K. Comstock and Company

Architect
Urbahn Architects, PLLP

Structural Engineer
Dewberry

Steel Team

Fabricator
J.A. McMahon, Inc. AISC CERTIFIED FABRICATOR

Erector
Seiko Iron Works, Inc. AISC CERTIFIED FABRICATOR & ERECTOR, Queens, N.Y.

Bender-Roller
Kottler Metal Products, Inc. AISC ASSOCIATE, Willoughby, Ohio

Bent on Innovation

BY RONALD "RONNIE" D. MEDLOCK, PE, MICHAEL P. CULMO, PE, AND TIMOTHY FIELDS, PE

A new straddle bent solution demonstrates its success on a Connecticut Interstate interchange project.

MODERN HIGHWAY INTERCHANGES often require complex bridge geometry to safely divert traffic from one roadway to another.

This is especially true for interchanges where two limited-access highways converge. These interchanges often have ramp configurations with higher travel speeds, resulting in flatter curves and braided geometry. Braided ramp geometry leads to the need for straddle bent caps where one ramp crosses over another roadway at a severe skew angle.

The I-91 Interchange 29 in Hartford, Conn., is an example of a high-speed highway interchange. The original interchange, built in 1990, connects Interstate 91 with Connecticut Route 5/15, which acts as a connector highway to Interstate 84 eastbound. The key feature in the interchange revolves around the connection between Interstate 91 northbound and Route 5/15 northbound. The interchange ramp is a steep, narrow single-lane with a traffic weave where the ramp meets Route 5/15. The proposed ramp is a two-lane high-speed ramp with greatly improved geometry and a flatter grade, and crosses Route 5/15 southbound at a severe skew in a braided configuration.

The design team investigated several ramp structure options, including tunnel-like configurations and long-span bridge options. Figure 1 depicts the crossing of these two roadways and the area in which vertical clearance was required between the two roadways. Cantilever post-tensioned concrete hammerhead bents were used in the final design, where there was ample vertical clearance for traffic to travel under the bent caps. A single straddle bent was used where the two roadways converge. The spans supported by the straddle bent cap are 215 ft on either side of the straddle bent.

The AASHTO *LRFD Bridge Design Specifications* contain provisions for the design of fracture-critical elements; however, many bridge owners shy away from fracture-critical designs. In 2012, the Federal Highway Administration (FHWA) issued a new Fracture Critical Policy. The policy included the designations of load path-redundant members (LPRMs), internally redundant members (IRMs), and system redundant members (SRMs) to address the design and asset management requirements for members like straddle bent caps.

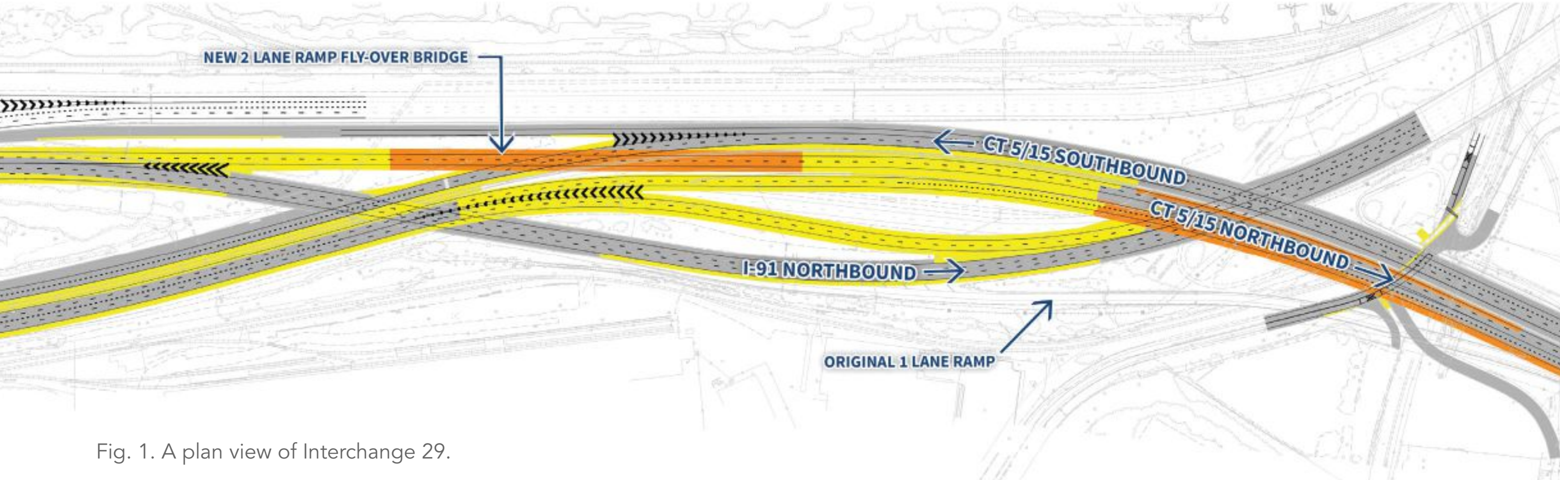


Fig. 1. A plan view of Interchange 29.

The design of the Interchange ramp bridge straddle bent was based on providing load path redundancy. The concept was to design a cap with three I-girders bolted together with diaphragms, essentially providing a multi-girder bridge supporting another bridge. Figure 2 shows the details of the cross-section of the straddle bent. The concept for the design was multifaceted, with load path redundancy being the primary reason. The idea was that the fracture of one flange would not lead to the collapse of the entire straddle cap. The second reason was to facilitate shipping and erection. The straddle beam could be shipped and erected in one piece, two pieces, or even three pieces—providing flexibility to the contractor and erector. If a large crane was available on-site, it could be erected as one complete girder. If crane sizes were limited, the cap could be erected in three pieces.

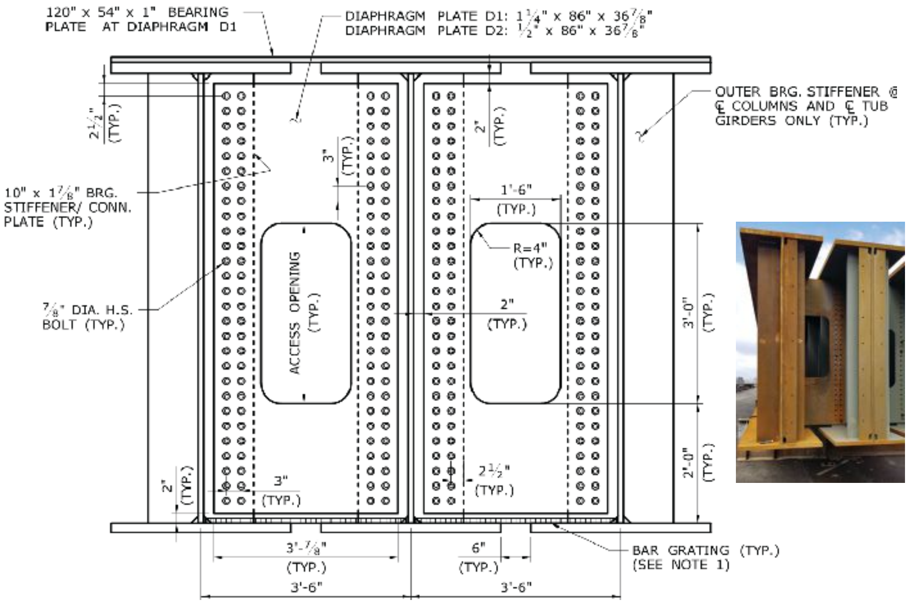


Fig. 2. A typical cross section of the straddle bent.

The spacing of the beams was set to provide ample access for future inspections and maintenance. The area between the beams is approximately 90 in. by 42 in. A small gap was detailed between the flanges to allow for airflow to keep the girders dry, and standard steel grating was placed on top of the bottom flanges to prevent maintenance tools from falling to the roadway below. Sealing plates were used on the top to prevent the ingress of water and snow, and access hole sizes and elevations were set to facilitate inspection and repairs.

One might question the efficiency of the three-beam design when compared to a closed box girder design. The reality is that the area of flange steel is slightly less than an equivalent box section. The third web provides added flexural resistance, thereby leading to a small reduction in the flange area. The addition of a third web does result in a small increase in the steel area for shear, but the cost differential is minor when based on the unit weight of the steel. The design team's thinking was that even if the straddle beam was slightly more expensive than an equivalent box section, the benefit of load path redundancy and the elimination of a fracture-critical designation were worth the potential increase in cost.

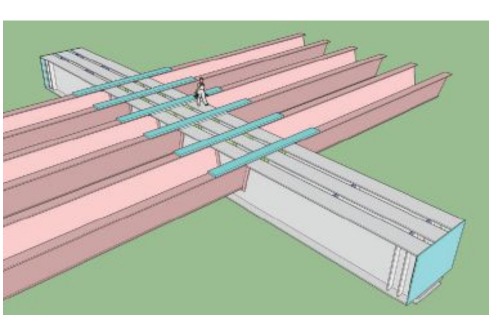
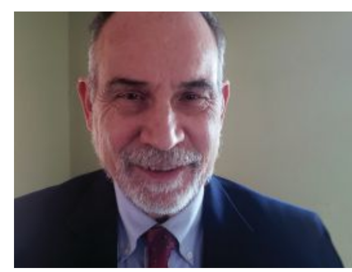


Fig. 3. A concept for an integral three-girder cap.

The design team investigated two options for the detailing of the straddle bent. The first option was where the beam was integral (framed into) the steel superstructure. The other was to have the continuous steel girders be supported on top of the straddle beam. Figure 3 shows the integral option that was studied. This option proved to be feasible, though





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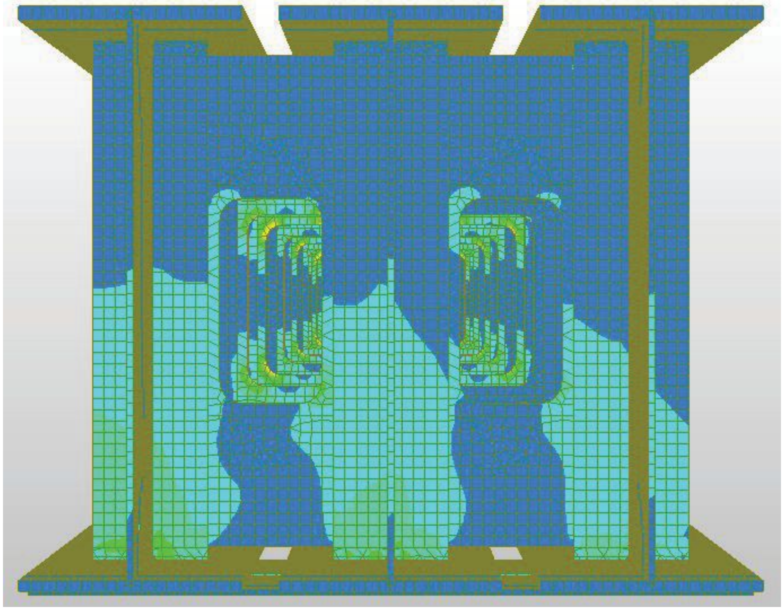


Fig. 4. A 3D FEA model showing stress distribution in the cap.

Fig. 5. Box assembly (shown here from a different project) is slow and laborious. Above, a box is being built around internal elements; below, note the effort required to rotate a box during fabrication.

the detailing and estimated cost for fabrication were considered to be higher than the non-integral option.

There was sufficient vertical clearance at the straddle bent location to allow the bent cap to be placed under the continuous steel trapezoidal box girder superstructure, which greatly simplified the detailing of the straddle bent and the superstructure girders. The integral framed design offers the benefits of increased vertical clearance. However, the detailing can get quite complicated, and costs would be higher. In order to provide stability of the three-beam cap, multiple bearings were used at each end to provide lateral restraint to the torsional movement. The supported beams were connected to the bent cap beam with a single bearing at the middle beam in the bent cap. A 3D analysis was developed that modeled the internal diaphragms and the stiffness of the superstructure to ensure that the three beams would work together to provide the required resistance. Figure 4 shows the FEA results for the diaphragms showing the stress distribution, with the stress contours indicating that the internal plate diaphragms can successfully distribute forces to all three girders.

Fabrication

High Steel Structures, LLC (High Steel) fabricated the bent cap and found it both relatively easy to fabricate and, given the ease of fabrication, cost-effective compared to traditional bent cap boxes. High Steel estimates that three-girder caps are about one half the cost of traditional boxes. Computer numerically controlled (CNC) drilling is the key to the economical fabrication of the three I-girder caps.

The greatest savings in the three I-girder caps are in the fabrication operations. With traditional boxes, it takes considerable effort to join all four sides so that the webs and flanges are properly fit to each other and to the internal diaphragms and other internal elements. As shown in Figure 5, fabricators typically assemble one web to one flange, add the diaphragms, add the second web, and then finally add the second flange to close the box, adjusting elements using heat along the way to help achieve fit. These steps take considerable time and effort. By contrast, the three I-girder webs and flanges are joined using typical I-girder fabrication, which is much simpler.

Boxes are usually painted on the inside, primarily to help facilitate in-service inspection. To help reduce work inside the box, webs and flanges are precleaned, masked, and painted before the box is built, and then any needed touch-up painting is performed after the box is built. Other tasks are also particularly challenging to accomplish inside of boxes, especially welding, which requires dragging welding guns and leads through boxes and heightened ventilation to removed welding fumes.

Complicating the traditional box building process, box web-to-flange corners often have complete joint penetration (CJP) welds, whereas I-girder webs and flanges are joined with fillet welds. The CJP welds require more steps to make, as compared in Table 1.

Table 1. A comparison of web-to-flange CJP welds to web-to-flange fillet welds.

Step	Web-to-Flange CJP Corner Weld	Web-to-Flange Fillet Weld
Bevel web	Needed	Not needed
Fabricate continuous backing and attach to web	Needed	Not needed
Fit web to flange	Needed	Needed
Weld	Ten to fifteen passes (assuming a 1-in.-thick web)	Two passes done simultaneously, one each on either side of web (assuming a 5/16-in. fillet weld)
Perform ultrasonic testing	Needed	Not needed
Perform magnetic particle testing	Not needed	Needed

Note that the CJP welds require many more passes to make than the fillet welds, are usually single-pass, and are done simultaneously, saving time.

Figure 7 shows an exploded view of the three-girder cap. The exploded assembly looks more complicated than a box, but from a fabrication standpoint it is much less so because of what it takes to fit the parts. As described above, fitting welded diaphragms in boxes is painstaking and complicated. In the three-girder cap, fitting is accomplished by pinning diaphragms and girders to align the connections and then bolting them. The key, then, is accurately making the holes such that holes line up readily.

An older method of making holes is to assemble the parts to be joined and then drill the holes with the parts together, either drilling one time through blank steel in both parts or starting with sub-size holes in the individual parts and then reaming the holes to final size with the parts together. These methods are still useful in fabrication, but today's CNC equipment is much more productive for many applications, and it is CNC processing that makes the three-girder cap economical. Using CNC equipment like the plate processor, the three-girder cap connections were made with this workflow:

- Cutting and drilling programs were produced for the connection plates and for the diaphragms. The same bolt hole pattern information was used in the connection plates and associated diaphragms to help ensure the parts will fit.
- Connection plates were installed in the girders in the shop during girder building.
- Later, in the yard, the girders were supported in the no-load condition next to each other.
- Diaphragms were brought to the girders, and pins were used to align the connection.
- Some bolts were used to hold the girders together.
- Bolts holes throughout the connections were checked for proper alignment

Fig. 6. Traditional box web-to-flange CJPs require backing, bevels, and multiple passes (above), while I-girder web-to-flange welds do not require bevels and backing and are usually done in one pass (below).

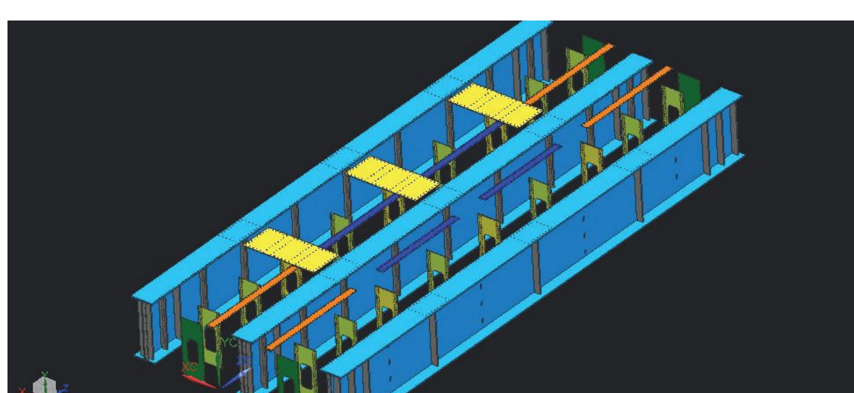


Fig. 7. A model view of a diaphragm-to-girder assembly.

Fig. 8. A CNC plate processor (left) was used to make the three-girder cap plate diaphragms and connection plates (right).

As shown in Figure 8, the diaphragms fit neatly and accurately between the girders.

Some fine adjustments of the girders were needed to build the cap. AASHTO/AWS D1.5 provides girder camber and sweep tolerances (represented at left in Figure 9), but these tolerances are intended for traditional bridge construction. Bridges have much wider spacing are more tolerant of girder camber and sweep variations than the three-girder cap. Pinning the diaphragms is effective for pulling the girders together into the correct and needed final orientation, but first, the girders must be relatively close, and tighter tolerances are needed. As indicated by the markings on the girder flange shown in the right image of Figure 9, High Steel made some girder sweep corrections to get everything to fit. Generally, it is normal for fabricators to make such fine adjustments needed to get things to fit, but because D1.5 tolerances are not sufficient for this assembly, it is recommended to include a note in the plans indicating that the tighter-than-normal camber and sweep tolerances are probably necessary for these girders. Further, if the girders are to be shipped separately and assembled in the field, then it is prudent to check the fit of assembly at the shop.

In addition to the cost and time savings associated with the three-girder cap, there is also a safety advantage in its fabrication. Boxes are confined spaces and thereby pose a safety risk. Fabricators effectively manage this risk by being prepared for the eventuality that a coworker has a health emergency while inside the box, but it is preferable to avoid the risk entirely.

From the standpoint of fabrication, the three-girder cap is relatively easy to fabricate and much more cost-effective than a traditional welded box bent cap. This reality depends on the use of CNC processing to make connection plates and diaphragm such that they will fit without drilling or reaming in assembly. Subdrill and ream processing is not inherently bad, but this process would be difficult and costly to execute within the assembled cap. Tighter-than-normal tolerances are needed for the girders; just how much depends on

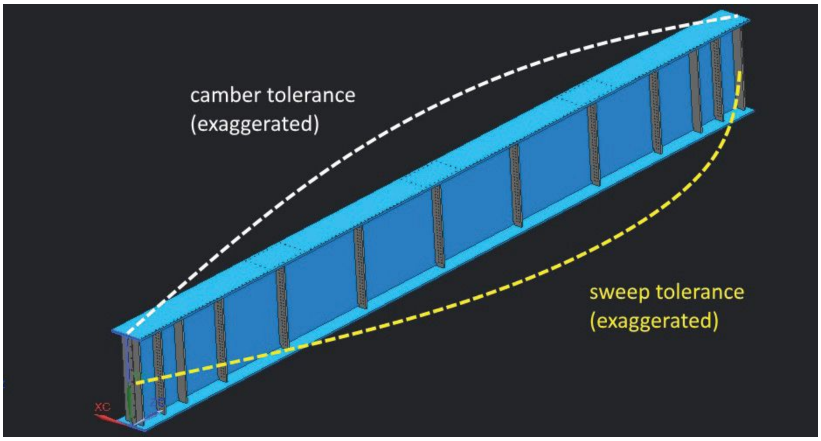


Fig. 9. A representation of girder camber and sweep tolerances, shown at left; the curves are greatly exaggerated so that they are apparent in this graphic. Shown at right is an indication of heating to make a girder sweep adjustment.

Fig. 10. Erection of the cap.

Fig. 11. Completed erection of the framing.

the girder spacing and the girder connection plate spacing. Regardless, proficient bridge fabricators will recognize this need as they make plans to build these boxes.

The construction of the bridge has progressed smoothly. Two of the three girders were shipped assembled, and the third girder was shipped separately and then attached in the field. The entire straddle cap assembly was erected in one piece during a short overnight road closure, as shown in Figure 10. The erection of the superstructure trapezoidal girders followed shortly after that.

At this time, the entire superstructure erection is complete, as shown in Figure 11. The use of the triple I-Girder straddle cap has proven to be a successful design. The design is cost-effective, provides load path redundancy, and facilitates the shipping and erection process. This concept is flexible and can be applied to all typical straddle bent designs, including integral bents. Elimination of a fracture-critical designation will save the owner costs over the long-term due to the elimination of fracture critical member inspections. ■

Owner
Connecticut Department of Transportation

General Contractor
O&G Industries/Barletta Heavy Division, Joint Venture

Structural Engineer
CHA Consulting

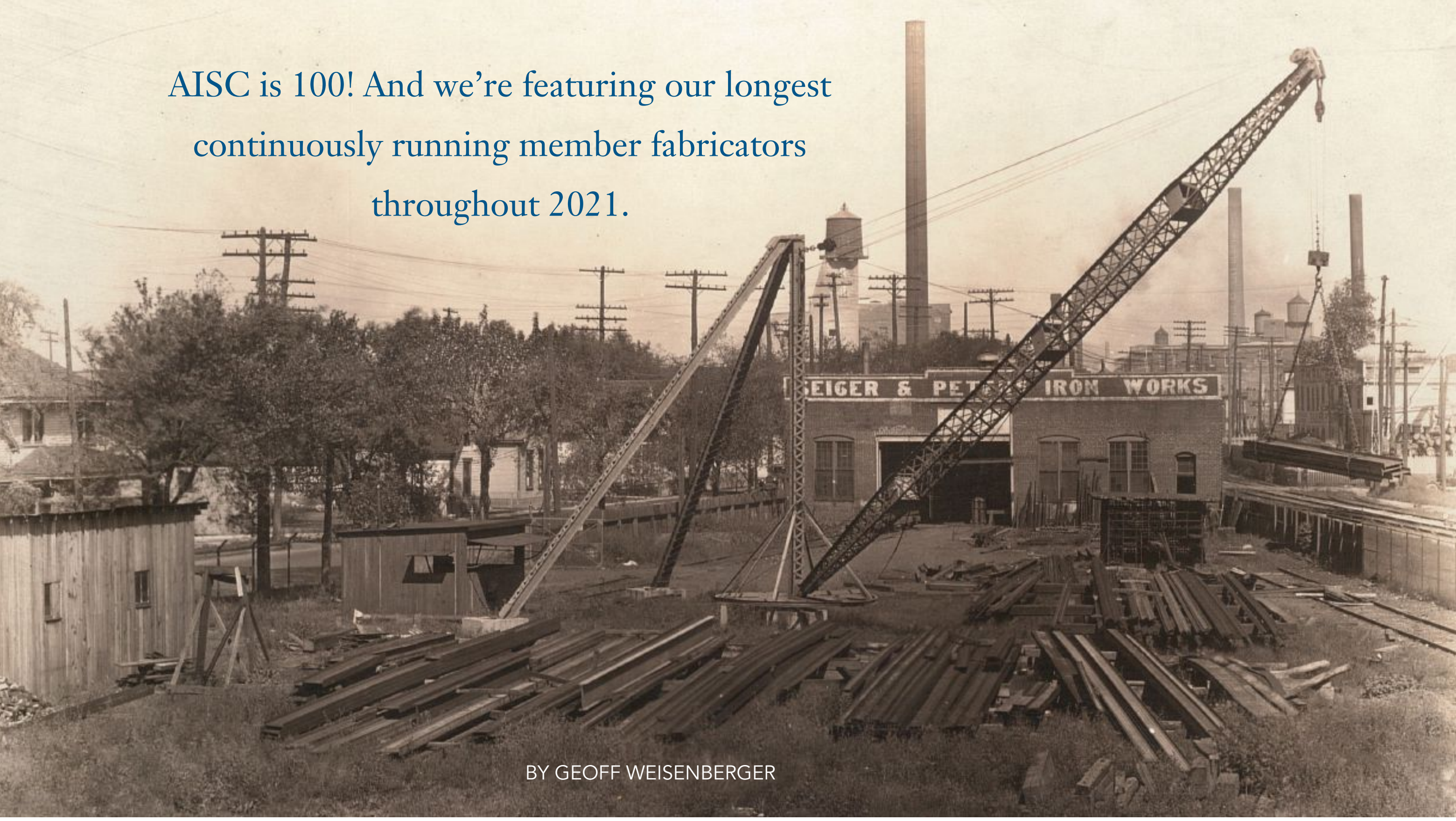
Steel Team

Fabricator
High Steel Structures, LLC (AISC Certified Fabricator), Lancaster, Pa.

Erector
Hartland Building and Restoration Co. (AISC Certified Fabricator & Erector), East Granby, Conn.

Detailer
ABS Structural Corp. (AISC Detailer), Melbourne, Fla.

Century Club: Geiger and Peters



AISC is 100! And we're featuring our longest continuously running member fabricators throughout 2021.

BY GEOFF WEISENBERGER

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

CELEBRATING 100 YEARS 1921–2021

IN CELEBRATION OF AISC turning 100, throughout the year we are highlighting member fabricators that are even older than we are.

This month's century clubber is **Geiger and Peters**, which was founded in 1905 and whose president, Steve Knitter, is AISC's current board vice chair. (For more on Steve, you can listen to the *Modern Steel* Field Notes podcast "There and Back Again" or read the transcript in the July 2020 issue. You can also view articles related to AISC's 100-year celebration in the "100 Years of AISC" section. All of these items are available at **www.modernsteel.com**.)

Answers provided by Knitter:

Tell us a bit about Geiger & Peters' early history.

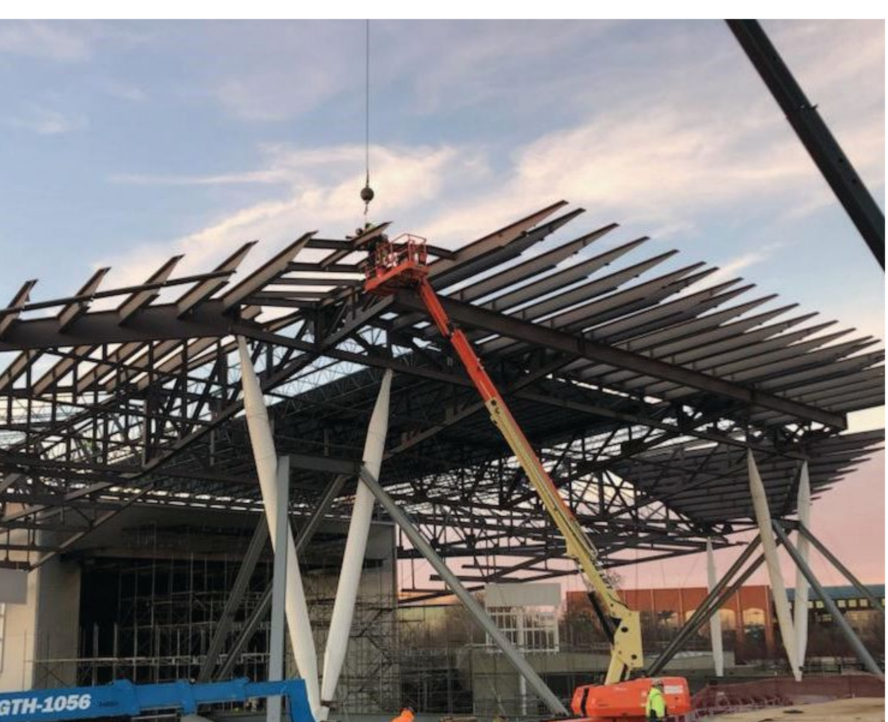
Geiger and Peters (G&P) was started in 1905 by two German immigrants, Carl Peters and John Geiger. They started with ornamental ironwork, then added steel construction services. After surviving WWI by falling back on ornamental ironwork, the next several years saw much success and multiple expansions. With the Great Depression putting stress on small businesses throughout the country, the Geiger family sold their holdings to the Peters family in 1931. Since there was already good name recognition for G&P, the name remained the same. The company stayed busy during WWII with transit buildings shipped to the Allied Forces overseas, aircraft manufacturing plants, and an Army Training Center later to be known as Camp Atterbury in Indiana.

opposite page: The G&P shop in the early 1900s.

above: The shop today.

How has the company weathered challenges over the years?

G&P has stayed conservative with its earnings and continually invests in equipment and people. In my 25 years here, I've learned that we are in a cyclical industry and you always have to plan for the next change. I took over as president during the last recession. And after being in that position for a while making the big, tough decisions, it's hard to not continually think about when the next big, tough decision will have to be made and how to be better prepared for it.



above: The Liberty Theater in Terre Haute, Ind., one of G&P's earliest marquee projects. It opened in 1918.

left: A current G&P project, the Amphitheater at White River State Park in Indianapolis.

How long has G&P been involved with AISC and taken advantage of its resources?

G&P has been a member since the early years of AISC, and we were also an early adopter of the certification program. Focusing on shop technology and continual improvement works hand in hand with knowing the AISC codes and standards as they have evolved over the years. When G&P started offering steel design as one of our services in the 1950s, our relationship with AISC only grew stronger. During the design-build boom of the 1990s, the Steel Solutions Center was a great resource for us to compete with concrete designs. AISC remains our go-to resource for the industry. ■

Collins Engineers used drones to inspect the Blatnik Bridge in Duluth, Minn.

Collins Engineers

Send in the Drones

BY GEOFF WEISENBERGER

THEY'RE UP THERE.

Unmanned aerial vehicles—better known as drones—have been occupying the airspace far above our heads for a few years now for both personal and commercial endeavors.

When it comes to construction, their primary tasks thus far have been site inspection, marketing purposes, and job progress updates. However, their usage is far from widespread at this point. We recently asked a handful of drone and inspection companies their thoughts on how steel bridge and building teams can take advantage of drones on their projects.

What are the primary benefits of using drones on steel construction projects? Are you seeing increased usage on these projects?

Skyward, a Verizon Company: The primary benefits of using drones are the high quality of data, ease of inspection, and lower cost. Drones equipped with sensors can provide far superior data to the human eye. And drones are less likely to require traffic to be shut down compared to aerial lifts, for example. Drones are also typically much cheaper than lifts, airplanes, or helicopters, which means infrastructure can also be inspected more frequently and more cost-effectively.

DroneDeploy: The primary benefits of using drones on steel construction projects are increased job site safety, project efficiency, and cost savings. With the right software, workers and supervisors can monitor projects in real-time and better manage and oversee subcontractor work without even stepping foot on the construction site. Also, virtual cloud-based mapping capabilities help streamline claims adjustments and help reduce or eliminate the risk of change orders that impede site progress.

We have seen marked growth in the construction industry overall in the past few months, partially driven by new pandemic usage. In April, as the economy slowly began to reopen after initial COVID-19 lockdowns, we saw a 90% increase in drone users among surveyors and a 56% increase in the construction industry. Since then, construction flights have increased by almost 32% year over year from 2019.

In addition, during winter months, drone technology makes construction sites safer by allowing workers to avoid dangerous conditions and keep teams out of harm's way.

DJI: The primary advantage is their ability to observe, capture, and process the data efficiently. The birds-eye-view of a drone camera allows it to capture larger swaths of data with better coverage than a terrestrial solution, which makes it ideal in construction projects where data is often required to be captured several feet from the ground. Since drones are not limited in mobility and are not subjected to the obstacles on the ground, such as moving trucks or construction equipment, they have the ability to fly farther and capture data over a larger area.

With advanced drone cameras and aerial Lidar [a combination of 3D and laser scanning used for measuring distances], drones are now equipped with sensors that can capture precise 3D models of construction sites. With these advances, the usage of drones in construction and inspection have skyrocketed over the last five years. There has been a marked adoption of drone technology in construction, bridge inspection, and surveying.

FlyAbility: Indoor drones like FlyAbility's Elios 2 are helping with bridge inspections by providing quick access to high-quality visual data of hard-to-reach places, like the underside of the bridge. Without a drone, inspectors have to use a snooper truck to view the underside of a bridge, which can be very costly. With a drone, no one has to use rope access or sit in the bucket of a snooper truck to get access to the underside of a bridge. Drones can also provide inspectors with access to tight spaces between beams and girders underneath bridges that would not otherwise be accessible.

Are there anticipated future uses for construction drones that perhaps haven't been developed or widely implemented yet?

Atlas Evaluation and Inspection Services: For bridge inspections, there are a lot of remote locations. Typically you access this location for inspections by having some kind of barge and bucket truck, which is time-consuming. With drones, the process could be easier. For building inspections, you are often waiting for access to the inspection area. In turn, this creates logistical issues. Drones have the possibility of making inspection of buildings more efficient. And for welding applications, it is critical to be able to measure accurately. Modern technology permits us to do that using various laser triangulation methods. Drones could assist with this, as well.

DroneDeploy: As the construction industry expands, we're likely to see drones act in tandem with other robotics on the job site to create a fully informed ecosystem. For example, we recently announced some of our work with Boston Dynamics and Brasfield and Gorrie with the release of 360 Walkthrough, which allows DroneDeploy to act as a single-solution platform, offering 360° camera perspectives right alongside aerial drone capture. This is helpful in allowing teams to inspect any location from multiple perspectives and generate both interior and exterior models.

DJI: While Aerial Lidar technology has been used for several years in construction sites, a mature workflow and efficient pipeline have yet to be widely implemented. Most systems today require several steps before a 3D model is generated. With Lidar manufacturers being different from drone manufacturers, the integration of such systems has been complex and in many cases, this complexity has transferred to the end-user. Furthermore, aerial Lidar technology has been traditionally cost-prohibitive in comparison to aerial camera technology, hence reducing the ROI for such systems. These reasons have reduced the widespread implementation of this technology in construction.

A new age of smaller, lighter, and significantly cheaper Lidar sensors are beginning to enable change in aerial Lidar technology. With Lidar sensors being commoditized by the autonomous car industry, more players can be expected to enter the aerial Lidar market with cheaper and simpler solutions.

FlyAbility: The addition of new payloads presents one way that drone technology will continue to develop for bridge inspections in the future. Sensors for measuring the thickness of a material or for conducting ultrasonic testing could possibly be developed for drones being used in bridge inspections, and more nuanced thermal sensors for conducting infrared imaging could be developed for finding defects in the concrete parts of bridges.

In addition, as software made to process data collected by drone continues to develop, we'll be able to create more and more detailed 3D maps and orthomosaics of assets, providing highly accurate measurements that both create a record of an asset like a bridge over time and can be used in the field to make determinations about defects and possible maintenance needs. Another software development that has just arrived is the ability to pinpoint the location of a defect using a sparse point cloud. Until recently, an inspector may notice a defect in their drone footage but then have to use several approximations to determine where exactly the defect is. Flyability just released Inspector 3.0, software that allows inspectors to know the location of defects discovered while flying.

Drone and inspection companies provide their thoughts on the potential of drones in the steel construction industry, particularly for bridge inspection.

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

Engineers' Perspective

Barritt Lovelace, PE, with Collins Engineers and Jennifer L. Wells, PE, a Minnesota DOT bridge inspection engineer, weigh in on their experience with drones:

What are the primary benefits of using drones on steel construction/bridge inspection projects?

Primary benefits include improved deliverables, data quality, reduced overall inspection costs and improved safety.

Are you seeing increased usage on these types of projects?

We are using drones more and more projects and it is becoming standard equipment for an inspection team.

Are there anticipated future uses for construction drones that perhaps haven't been developed or widely implemented yet?

Autonomous flight planning with obstacle avoidance is just becoming available and will improve the workflow dramatically.

What are some of the main reasons people are resisting drone usage?

The main resistance is just based on the comfort level with these new methods. Since this is a relatively new technology, many bridge owners want to use the drone alongside traditional inspection methods and reporting. Once there is a comfort level and we can start to use the drone to replace some of the traditional methods, then we can start to take advantage of the cost savings. FHWA is very supportive of the technology and is actively encouraging bridge owners to use the technology to improve inspections.

How can drone users get a good ROI?

I think this is a common concern, especially when looking at hardware costs. However, the cost of hardware for an inspection is very low when compared to under-bridge inspection vehicles, traffic control, and labor costs. Plus, there are consumer-level drones now that are adequate for routine inspection purposes.

What challenges should potential users brace for up front?

The learning curve is a challenge, especially when it comes to post-processing the data and making it useful. Also, understanding air space and flight requirements takes training. To be proficient with a drone, one must use it often. Data storage and retention needs should also be addressed.

What's the most common takeaway you hear from construction professionals the first time they use a drone on a project?

The amount of data you can collect in a short amount of time is the main takeaway.

What are some of the main reasons people are resisting drone usage?

Skyward: I've found that a surprising number of people still view a drone as a toy rather than a sophisticated work tool. Many people don't understand everything drones can accomplish. We've seen that a few factors ease the way to drone adoption: an enthusiastic executive sponsor, a person dedicated to overseeing day-to-day operations, an initial use case that shows fast return on investment, and standardized training and operational procedures.

DroneDeploy: People are resistant to drone usage due to concerns surrounding safety and adequate training. As with any emerging technology, companies must first invest in the necessary resources and training for their staff; otherwise, they risk potential safety hazards or misuse of the technology.

DJI: Drones are fairly new technology compared to laser scanners and terrestrial Lidar mapping solutions that have been used for decades in construction and inspection industries. New technologies traditionally see a slower adoption rate in mature industries where existing solutions have worked well. With the new sensor technologies being paired with drones, the adoption of drones in this industry is imminent.

Traditional sensors used in construction and inspection cannot be directly transferred to drones due to size and power limitations that drones are subject to. This limitation has not made the adoption of drones very straightforward. Independent sensor technology has been developed for drones that is more recently beginning to converge with terrestrial sensor technology. Due to this, increased adoption can be expected in the future.

FlyAbility: The primary challenge to adoption is often institutional culture. Drones are still a relatively new technology, and when innovators try to encourage adoption at scale across a large organization, they can face internal pushback.

Another challenge is in investing the time needed to build a drone program. Drones can't simply be added onto existing processes as another inspection tool—their use needs to be supported by documentation, training, and SOPs (Standard Operating Procedures) to make sure their use is successful and safe.

A drone flying by the High Bridge in St. Paul, Minn., during an inspection project performed by Collins Engineers.

If people are hesitant due to cost, how do you assure them that they'll get a good ROI?

Skyward: We advise starting small with one use case that will save money, make money, increase worker safety, or all of the above. Use cases that replace a plane or helicopter with a drone are often a great place to start, but there are many other use cases that may be less obvious. For example, the West Virginia Department of Transportation began using drones for stockpile volumetrics, which can be time-consuming and dangerous using traditional methods—and doing so helped them save $343,000 in a single month.

DroneDeploy: An initial investment into drones (both hardware and software) is less than $10k. You could potentially find one issue on one site, and the investment has paid for itself. In a recent example, a Texas contractor reduced inspection labor costs by 98% on one project with the help of drones and our software.

DJI: Typically, large-scale deployment of several drones is not necessary to see the value of drones in the construction and inspection industry. Construction companies have implemented smaller pilot programs to evaluate the value of such solutions before they commit to a large investment. A similar approach can be suggested to evaluate the ROI.

Drone service companies also provide drone solution programs that allow the leasing of drones for surveying and mapping. Such services also provide small scale evaluation of drone solutions at construction sites.

FlyAbility: Bridge inspections present a unique challenge: In order to properly inspect a bridge, you have to be able to see underneath it.

Inspectors traditionally address this challenge by using a snooper truck, which allows them to stand in a bucket and view the underside of the bridge.

But snooper trucks are incredibly expensive and also potentially dangerous for inspectors. Using a drone, an inspector can collect visual data about the conditions under a bridge, replacing the need for them to stand in a snooper truck bucket to look at the same area. Just getting rid of the need for a snooper truck presents a huge savings.

But drones can also help save money in bridge inspections by lowering the cost of liability insurance, decreasing the amount of inspection personnel needed for each inspection, and speeding up the inspection process, which means shorter delays in traffic and less overall money spent on the inspection.

Steelwork evaluation and project development for Pittsburgh's 2500 Smallman project (see "Under the Boardwalk" in the June 2020 issue in the Archives section at **www.modernsteel.com**) were documented through drone video footage, which in turn was used by the property's realtor to market the building.

What challenges should potential users brace for up front?

Skyward: Challenges vary by use case, and we always advise working up to the more complex types of flights. Bridge inspections in particular can be fairly complex and require drone pilots to have a high level of proficiency. Flying a drone on the underside of a bridge requires a low-light camera or a spotlight and thus may require a drone with a top-mounted gimbal. It's likely the drone will lose its GPS connection, and this type of project may require extremely accurate pinpoint locations. This is stressful flying, and the pilot may have to turn off the collision avoidance system to get close enough to the cross-members and bolts to capture usable data.

DroneDeploy: For smaller businesses and industry professionals, the startup costs of drones may be a deterrent, along with the training and certifications needed to safely operate a fleet. The FAA's Part 107 exam is typically the biggest step for construction companies, but even that exam doesn't tend to be a substantial barrier for potential pilots.

DJI: The upfront challenges of using drones can be correlated to the expectations of using these solutions. It can be generally said that drone-based solutions are not meant to replace traditional solutions, but rather provide more data that will enable better decision making. For example, drones can be deployed on a daily basis at a site to provide progress data that may not have been available through traditional methods. Drone-based photogrammetry is not meant to replace terrestrial scanning, but rather provide a 3D aerial map of the site that will allow for better Inventory Management or identifying errors before they become a problem.

With a clear understanding of expectations, training to fly drones at a complex site, and understand the new workflow to collect, extract, and process the data, the up-front challenges can be minimized.

FlyAbility: Here are some of the most common challenges:

- Insourcing vs. outsourcing. Do you build your own drone program or hire a 3rd party?
- Training. Teaching your staff how to fly and how to use the drones.
- Regulations. Navigating regulatory concerns, both regarding the general concern of getting your pilots Part 107-certified and the specific concerns of making sure you can fly in a specific place at a specific time for a given bridge inspection/mission.
- Culture. Convincing everyone that new technology is worth using and that change can actually help them.

Atlas: Drone technology is there, but it will take time before the construction codes catch up with the technology. People who use the technology need to be trained. There are also security issues when you consider the confidential nature of some infrastructure sites as they are being constructed. These hurdles have held back certain entities from allowing drone usage.

What's the most common takeaway you hear from construction professionals the first time they use a drone on a project?

Skyward: A very common pitfall for new drone operators is not checking the data they've captured until they're back at the office. Checking to make sure you've captured the data you need at the job site will save time and frustration. It's also essential to understand the end deliverable that designers, engineers, or modelers hope to get from the data you are collecting—and that you have the hardware, software, and planning tools to support that.

DroneDeploy: The most common takeaway we hear is praising the increased level of job-site information and insight. Construction companies that have adopted drones and drone software experience increased efficiency, enhanced safety, and faster operations. Drone data also offers more informed decision-making while minimizing safety risks. We once heard from a customer who noted that "seeing the project plan docs overlayed on top of the drone data feels like someone just gave me $1,000."

DJI: The most common takeaway is how a drone-based mapping solution was able to make data much easier to collect and how the data was turned into key operational insights. These insights have helped a higher level of business intelligence that allowed for better decision-making models and increased operational efficiencies.

FlyAbility: In bridge inspections, we often hear that the drone was able to do more than they anticipated. It can provide better lighting than they thought possible; higher quality images than they thought possible; comprehensive visualization of hard-to-reach areas that they're used to not being able to see well; access to places they can't usually reach. They're also pleased by how much faster the drone makes the bridge inspection process, and that this increase in speed means a decrease in overall cost. ■

Answers were provided by the following company representatives:

***Atlas Evaluation and Inspection Services (AEIS)**—Nagesh Goel, co-founder and president*
***DJI**—Arjun Menon, engineering manager, North American operations*
***DroneDeploy**—Jono Milin, co-founder*
***FlyAbility**—Zacc Dukowitz, content marketing manager*
***Skyward, a Verizon Company**—Rodney Murray, professional services training and consultants*

conference preview

STREAMLINED DESIGN

BY DOMENIC COLETTI, PE

A forthcoming document provides guidance on streamlining the design process for routine steel girder bridges.

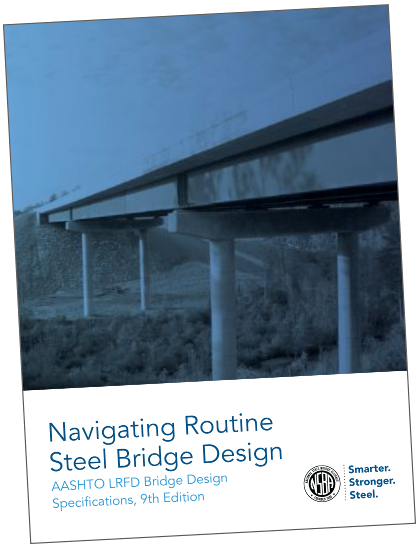
Domenic Coletti (**domenic.coletti@hdrinc.com**) is principal bridge engineer with HDR, Inc.

EVERY INDUSTRY has its workhorse.

For steel bridges, this role is played by "routine steel I-girder bridges," straight bridges with little or no skew, span lengths up to 200 ft, and routine framing and girder configurations. These "workhorse" bridges constitute a large part of the bridge inventory in the U.S. and can, and should, be effectively designed using relatively simple and quick methods based on line girder analysis. And a new design guide published by AISC and the National Steel Bridge Alliance (NSBA) is dedicated to this bridge type.

Prepared by HDR and MA Grubb and Associates, *Navigating Routine Steel Girder Bridge Design* is an innovative design aide intended to provide bridge designers an interactive filter and guide for navigating the provisions of the AASHTO *LRFD Bridge Design Specifications*, 9th Edition (AASHTO *LRFD BDS*) that are specifically applicable to the design of routine steel I-girder bridges. The guide is unique in that it is not intended to be a "static" printed reference document in its ultimate form, but rather will evolve into an interactive, web-based format.

Initially, the guide will be released in PDF format. This version will provide technical content, including a "Determination of Applicability" to routine steel I-girder bridge design for each Article of Section 6 (Steel Structures), as well as many Articles in Sections 1 (Introduction), 2 (General Design and Location Features), 3 (Loads and Load Factors), and 4 (Structural Analysis and Evaluation), of the AASHTO *LRFD BDS*. The guide will also include a discussion of each Article that explains why it is, or is not, applicable and provides suggestions for implementing the applicable Articles in ways that should result in a simpler design effort and more economical bridges.



The guide includes an outline of the basic tasks involved in designing superstructures for routine steel I-girder bridges, presented in a flowchart format. The PDF version will use extensive internal hyperlink referencing to allow the reader to walk through the steps of the design and quickly navigate to the Determination of Applicability and Discussion of the pertinent AASHTO Articles associated with each task. It will also include extensive external hyperlink referencing to a virtual library of previously published free design guides, such as the AASHTO/NSBA *Steel*

Routine steel I-girder bridges—i.e., straight bridges with little or no skew, span lengths up to 200 ft, and routine framing and girder configurations—are the subject of a new guide from NSBA: *Navigating Routine Steel Girder Bridge Design*.

Bridge Collaboration Guidelines and Guide Specifications (available at **aisc.org/nsba**), the FHWA *Steel Bridge Design Handbook*, and others, and free design software, such as NSBA's SIMON line girder analysis program and Splice bolted field splice design spreadsheet (both available at **aisc.org/nsba/design-resources**).

The guide will be of value to design checkers as well. The outline of basic tasks can serve as a checklist when verifying that the necessary design tasks have been addressed. In addition, the Determinations of Applicability and Discussions can be used to clarify questions about the correct interpretation of the AASHTO LRFD BDS provisions.

Eventually, the intent is to migrate the technical content of the guide to an interactive web-based design aide. This is the most exciting aspect of this effort: communicating the Determination of Applicability and Discussion in an engaging manner suitable to the newest generation of bridge engineers.

Want to learn more about *Navigating Routine Steel Girder Bridge Design*? Tune in to the related WSBS session! And keep an eye out for the guide's release, which is expected to take place soon. ■

This article is a preview of the session "Steel Bridges Can be Easy with NSBA's Guide to Navigating Routine Steel Bridge Design," which is being presented via the 2021 World Steel Bridge Symposium, part of the online NASCC: The Steel Conference. For more information and to register, visit ***aisc.org/nascc****.*

new products

Welcome to *Modern Steel's* New Products page! Every month, we feature a handful of product, tool, machine, service, and software offerings for the steel design and construction industry. This month's offerings focus on material layout in fab shops, welding simulation, and voice-activated construction spreadsheets.

AGT LayoutMaster

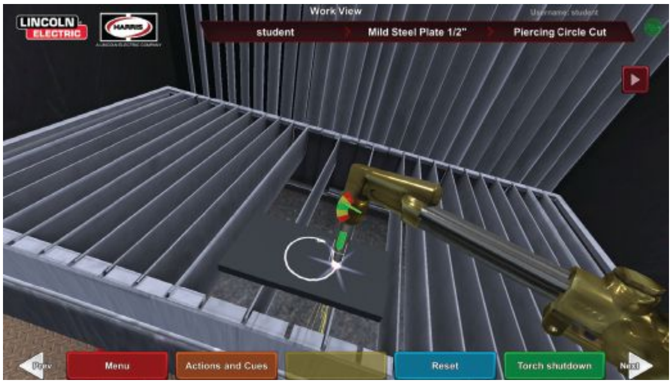
With no measuring or marking required, one operator using the LayoutMaster can be as effective as up to five fitters. With full-color projection and highly customizable layers, you can train any operator to become your best fitter in a matter of hours. The machine features more than 30 different features that can be laser-projected on a beam or other accessories—part 3D contours, holes, hole centers, welding information, part numbers, and much more.

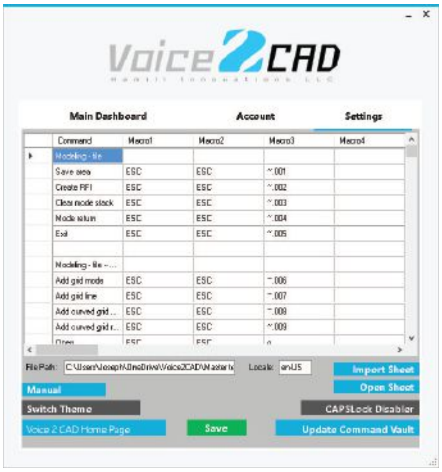
For more information, visit **www.agtrobotics.com/layoutmaster**.

Lincoln Electric VRTEX 360 OxyFuel Cutting Feature

Lincoln Electric's VRTEX 360 OxyFuel Cutting feature brings welding and cutting together for education by enabling users to practice torch cutting safely and virtually. From setting up the torch to executing the cut, each task is designed to simulate real-world cutting applications. Exclusive to Lincoln Electric, the feature is available on VRTEX 360 and VRTEX Transport models. The VRTEX 360 provides a best-in-class, advanced-level virtual reality welding simulation training experience for educational or industrial environments. It can be used for fundamental welding training, skill enhancement, diagnostic testing, and instructor preparation. Virtual reality arc welding trainers provide a powerful, cutting-edge solution for cultivating welding talent quickly and resourcefully. Together with the MIG, stick, and GTAW devices, they simulate the look, feel, and action of actual guns and torches.

For more information, visit **www.lincolnelectric.com**.





Voice2CAD

Voice2CAD is a speech-recognition tool designed specifically for drafting professionals. It harnesses the power of Microsoft's Windows 10 built-in speech engine to voice activate all dimensions, software commands, and material types, or open any website, file, folder, or program simply by saying the command. What makes this software unique is the ability to store and organize the commands in a pre-built, software-specific Excel sheet that allows users to create and edit commands or combine multiple commands into macros to automatically run tedious processes. By incorporating it into your process, you can eliminate thousands of manual keyboard strokes and mouse movements every day.

For more information, visit **www.voice2cad**.

AWARDS

AISC to Honor Leading Steel Professionals with Individual Awards in 2021

Twelve leaders across the structural steel design, construction, and academic communities will be honored with AISC awards this year. Whether it's for an innovative design, an insightful technical paper, or a lifetime of outstanding service, an AISC award bestows prestige and well-deserved recognition upon its recipient.

This year's Lifetime Achievement Award winners are:

- Scot Becker, Deputy Administrator–Regions, Division of Transportation System Development, Wisconsin Department of Transportation
- Jerome F. Hajjar, PE, PhD, Professor, Northeastern University
- John D. Hooper, SE, PE, Senior Principal and Director of Earthquake Engineering, Magnusson Klemencic Associates
- Dale Ison, Executive Vice President of Technical Services, Tampa Tank, Inc./ Florida Structural Steel

This year's Special Achievement Award recipients are:

- Jamie F. Farris, PE, Bridge Division Deputy Director, TxDOT
- Dennis Noernberg, Bridge Detailing Manager, W&W/AFCO Steel
- Jeffrey A. Packer, PEng, PhD, Bahen/Tanenbaum Professor of Civil Engineering, University of Toronto
- Rafael Sabelli, SE, Director of Seismic Design, Walter P Moore
- Gary W. Wisch, PE, Vice President of Engineering, DeLong's, Inc.

This year's Early Career Faculty Award recipients are:

- Mark D. Denavit, PE, PhD, Assistant Professor, University of Tennessee, Knoxville
- Erica Fischer, PE, PhD, Assistant Professor, Oregon State University
- Kara Peterman, PhD, Assistant Professor, College of Engineering, Department of Civil and Environmental Engineering, University of Massachusetts Amherst

To learn more about AISC's award programs, visit **aisc.org/awards.**

HSS

Steel Tube Institute Releases Updated HSS Technical Guide

The Hollow Structural Sections Committee of the Steel Tube Institute (STI) has introduced an updated technical guide, *Methods to Check Dimensional Tolerances on Hollow Structural Sections*, to assist fabricators and service centers. Available at **www.steeltubeinstitute.org**, the educational resource discusses in detail and illustrates the latest methods to correctly measure tolerances of hollow structural sections (HSS).

The guide assists professionals in verifying compliance with American Society for Testing and Materials (ASTM) specifications. While it is written for the A500 specification, it may be used for verifying tolerances for A1085, A847, A1065, and other similar tubular specifications. The resource outlines instructions for checking tolerances for outside dimensions, wall thickness, length and straightness, squareness of sides, radius of corners, and twist of the member.

"Since measurement techniques are not included in the A500 specification, we want to clearly show how tolerances should be measured for HSS to negate the possibility of any discrepancies between our producers and their customers," said Joseph Anderson, executive director of STI.

PUBLIC REVIEW

2022 AISC *Spec* Available for Public Review

A draft of the 2022 edition of the AISC *Specification for Structural Steel Buildings* (AISC 360) will be available for public review from February 5 until March 5, 2021. The draft and review form can be downloaded from the AISC website at **aisc.org/publicreview** during this time frame. This is the second public review period for this specification, which is expected to be completed and available in late 2022. A hard copy of the review draft is available (for a $35 charge) by calling 312.670.5411. Please submit comments using the form provided online or to Cynthia J. Duncan, AISC's director of engineering (**duncan@aisc.org**), by March 5 for consideration.

POLITICS

Former U.S. Senator Evan Bayh Publishes Op-Ed on Biden, Steel, and SpeedCore

RealClearPolitics, a widely read publication in D.C. and New York, recently published an op-ed by former U.S. Senator Evan Bayh. Bayh's piece, "Biden's Plan to Build Back Better With American Steel," focuses on how the Biden administration will prioritize rebuilding America and creating new jobs. He emphasized American-made steel and new technologies like SpeedCore will help achieve these goals.

"SpeedCore, a revolutionary composite steel wall core, is being used in new construction projects around the country," Bayh wrote. "In the U.S., the Rainier Square Tower, a striking 58-story mixed-use high-rise building in Seattle, was the first built using this new innovation in steel. The building took only ten months to erect, and SpeedCore shaved 43% off the construction time compared to traditional alternatives that include curing time for each concrete pour. The steel in SpeedCore can support up to four floors of decking by itself, making it possible to erect four floors in a week."

Bayh noted that direct investments in such innovations will save millions in construction costs, allow for earlier occupancy of new buildings, and facilitate structures being built with materials made in the U.S. He added that launching new construction projects will help Americans get back to work in the post-pandemic economy.

Read Bayh's full November 18, 2020 op-ed at **www.realclearpolitics.com** (search on "Bayh").

BRIDGES

Iowa-Bound I-74 Mississippi River Bridge now Open to Traffic

The Iowa and Illinois Departments of Transportation recently announced the opening of the I-74 Mississippi River Bridge to Iowa-bound traffic. Motorists drove down the newly opened route during their morning commutes starting this past November.

Once complete, the dual steel arch bridges will contain 35,000 tons of structural steel. Work will continue on Illinois-bound I-74 while both directions of traffic will share the Iowa-bound bridge in a two-way configuration. The fabricator for the project is Indiana-based Industrial Steel Construction, Inc., an AISC certified member fabricator. Follow the progress of the I-74 Mississippi River Bridge project at **i74riverbridge.com/newsroom/#73**.

Letters to the Editor

Make It Here

I loved reading the "Make It Here" Field Notes interview with Barry Zenkelman (December 2020, **www.modernsteel.com**). He seems like a great leader with a wonderful message. I truly hope American companies take his message to heart and implement the "make it here" philosophy. I will be sharing this with everyone I know. I hope it sinks in!

Brian Smith
President, Albina Co., Inc.

Absolutely terrific job on the Barry Zekelman interview and getting it down in print. I'm not a huge podcast listener, but this will get me to check it out. Zekelman's message and perspective need a huge audience from every walk of life and profession.

Kevin Davis
Traverse City, Mich.

People & Companies

Founded as one of the first integrated architecture and engineering firms, **Albert Kahn Associates, Inc.**, is celebrating its 125th anniversary. Headquartered in Detroit, Kahn has designed and engineered projects worldwide, from significant industrial and automotive facilities, research and testing spaces, university and educational buildings, hospitals and healthcare spaces, corporate office campuses, to urban waterfront and development projects, among many others. Visit **www.albertkahn.com** to explore an interactive map that allows users to create personalized tours of Kahn buildings in Detroit and around the globe.

Simpson Strong-Tie, an AISC member manufacturer of engineered structural connectors and building solutions, announced the appointment of **Mike Olosky** to **Simpson Manufacturing Co., Inc.'s** executive leadership team as COO. A senior executive with more than a decade of global management experience in Asia and Europe, Olosky was most recently president of **Henkel North America** and head of the company's Industrial and Electronics division.

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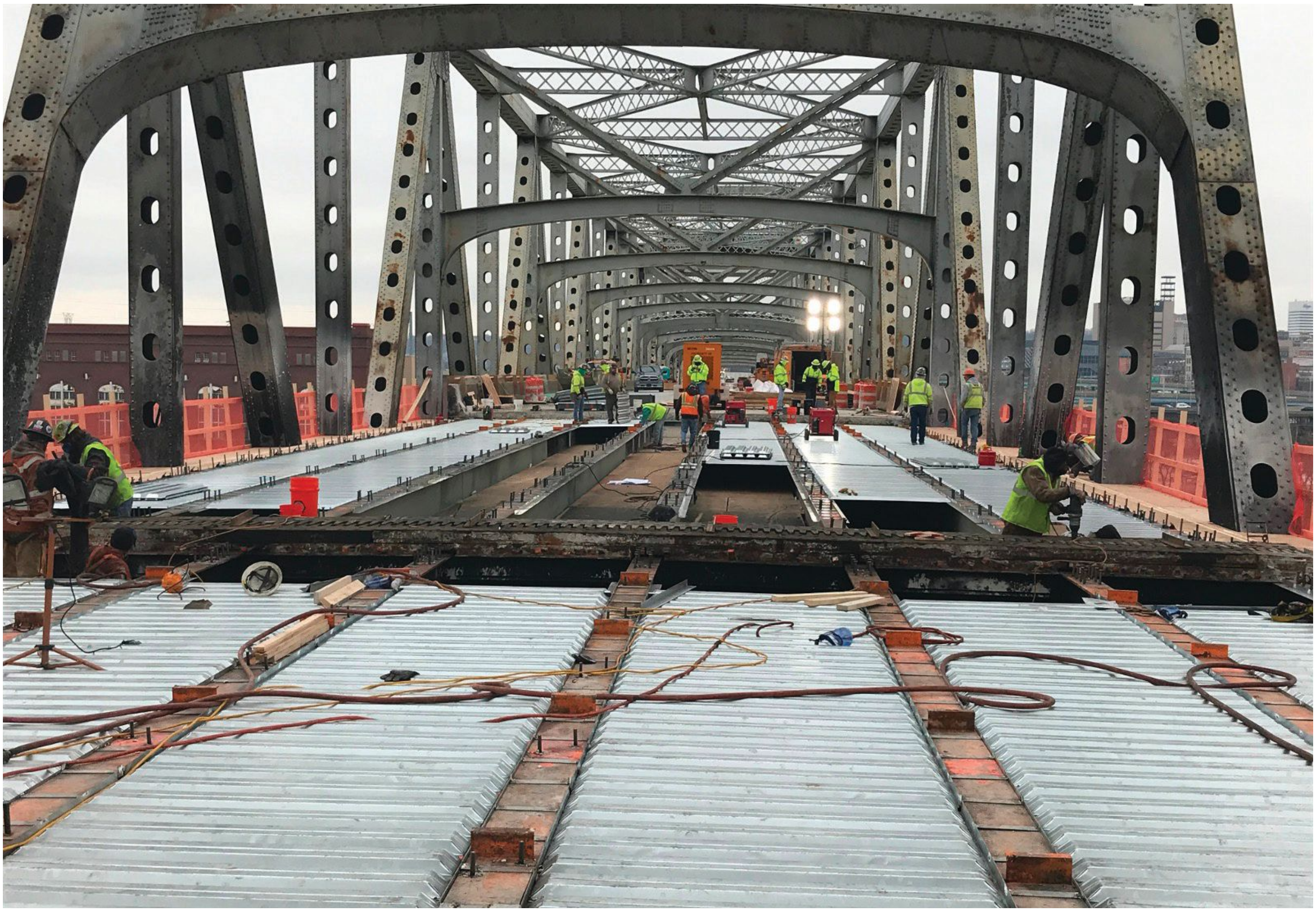

FIRE—AND RESCUE

NEED FOR SPEED

ON NOVEMBER 11, a fire resulting from a semi-truck crash damaged the upper and lower decks of the Brent Spence Bridge, a 1960s steel truss carrying Interstate 71 over the Ohio River between Covington, Ky., and Cincinnati.

But by late December, the bridge was open to traffic again. This impressive timeline was made possible by national and local experts coming together to inspect the structure, perform material testing, and develop and implement the repairs.

The upper concrete deck and two bays of steel stringers required complete replacement. By November 17, the bridge repair team, led by the Kentucky Transportation Cabinet (KYTC), procured 16 replacement wide-flange beams for the stringers and delivered them to Bottoms Engineering and Service, Inc., an AISC certified member fabricator. Bottoms completed work on the stringers and delivered them to the job site in two shipments on November 25 and 27. Two days after the second shipment, AISC certified steel erector Kokosing Construction Company completed the installation of the stringers.

Metal stay-in-place deck forms and steel reinforcing facilitated the placement of the concrete deck on the upper deck during the second week of December. Additional repairs to the roadway surface on the lower deck, as well as to the electrical and drainage systems, marked the completion of the job.

You can read more about the repair job at **brent-spence-bridge-kytc.hub.arcgis.com**. More detailed coverage of the project will appear in an upcoming issue of *Modern Steel Construction*. ■


BOOST
YOUR PRODUCTION
CAPACITY