Modern Steel Construction

April 2021

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in every issue

features

columns

ON THE COVER: Seattle's former NBA venue gets a massive overhaul to become home to a new NHL team, p. 28.
(Photo: Elliott Veazey/CAA ICON)

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editor's note

NEED FOR SPEED

Can we cut the time it takes to design, fabricate, and erect a steel building by 50%? Frankly, I'm not sure it's really as hard as it sounds.

Nearly 18 months ago, AISC started talking about this goal, and we have eight fantastic projects underway to move the industry forward (see **aisc.org/needforspeed** for more information). However, those projects are just the tip of the iceberg. Fortunately, AISC is not alone in this effort. If you flip through the pages of this issue and just look at the ads, a remarkable theme emerges.

- Peddinghaus is touting its Peddi XDM-630 by talking about how a fabricator on a recent project cut fabrication time by 30%, eliminating two-to-three weeks on a 12-week schedule.
- Nucor Vulcraft is promoting its 32-in.-wide deck by explaining the extra 8 in. results in faster installation and fewer bundles to lift.
- Chicago Metal Rolled Products talks about keeping up with a recent project that had a 24/7 construction schedule by averaging a one-day turnaround on deliveries of more than 60 truckloads of steel.
- SDS2 features its latest upgrade, offering accelerated fabrication and construction by combining detailing, estimating, load planning, site planning, and model review into one package.
- CES (Cutting Edge Stair) talks about providing delegated design assistance to help speed projects.
- Automated Layout Technology from Lightning Rail can halve fabrication time for commercial handrails and stair stringers.
- Tekla PowerFab is designed to reduce the margin of error, which reduces bid time and speeds up projects.
- Voortman's automated processing is designed to reduce fabrication time.
- Ficep touts faster throughput to speed fabrication.
- Strut & Supply (Unistrut and Lindapter) features adjustable connections for rapid installation with no onsite welding.
- Bend-Tech touts their CNC plasma tube and pipe cutters to speed fabrication.
- Applied Bolting Technology's "squirters" provide a visual clue during installation to speed erection.
- LNA Solutions offers fastener assemblies to speed erection.
- CoreBrace features superior seismic performance while simplifying erection to cut time and save money.
- Lincoln Electric's PythonX system features advanced plasma cutting to reduce fabrication time.
- QuickFrames offers a simple, fast solution for rooftop framing systems to support mechanical equipment.

All of this is in just one issue of *Modern Steel Construction*—and those are just the ads. You can also read about speed in the article "Inside Job" on page 28, which highlights a project where the team was able to shave nearly four months off the schedule by accelerating the steel procurement and detailing processes. And in "Driving Innovation" on page 47, which discusses methods and technologies for making the steel design and construction processes more efficient and faster. And also in "Moving Bridges Forward" on page 54, which discusses, among other things, the topic of accelerated bridge construction (ABC).

Do you want to know more? Check out the more than 200 exhibitors at this month's NASCC: The Virtual Steel Conference (**aisc.org/nascc**). After looking at what the steel industry is already doing, you can decide for yourself whether we're well on our way to meeting our goal.

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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

This month's Steel Interchange questions and answers were provided by Chad Larson, president of LeJeune Bolt Company, and are based on a recent AISC webinar that highlighted changes introduced in the 2020 version of the RCSC Specification for Structural Joints Using High-Strength Bolts*. (See "Bolting Ahead" on page 44 for more on the updated specification.) Both the* RCSC Specification *and the AISC* Specification for Structural Steel Buildings *(ANSI/AISC 360) are available at* ***aisc.org/specifications****.*

Changes

Are the effects of changes from the 2014 to 2020 RCSC *Specification* captured in the latest AISC *Specification*?

No, the 2016 AISC *Specification* adopts requirements from the 2014 *RCSC Specification*. Section J3.1 of the AISC *Specification* states: "Use of high-strength bolts shall conform to the provisions of the *Specification for Structural Joints Using High-Strength Bolts*, hereafter referred to as the *RCSC Specification*, as approved by the Research Council on Structural Connections, except as otherwise provided in this *Specification*." Section A2 of the AISC *Specification* provides a list of specifications, codes, and standards referenced in the *Specification* and lists the 2014 *RCSC Specification*.

On occasion, the AISC *Specification* takes exception to requirements in the *RCSC Specification* as noted in Section J3.1. For example, a common exception in the 2016 AISC *Specification* is a difference in minimum bolt pretension values shown in Tables J3.1 of the AISC *Specification* and Table 8.1 in the 2014 *RCSC Specification*. As required per Section J3.1, the values in Table J3.1 would govern (unless noted otherwise in the contract documents). The Commentary to Section J3.1 of the *Specification* has a complete listing of the exceptions the AISC *Specification* takes to the RCSC requirements.

Use of the 2020 *RCSC Specification* with the 2016 AISC *Specification* falls outside the 2016 AISC *Specification* scope. It would have to be done with considerable judgment from the engineer of record (EOR) and with approval from the authority having jurisdiction.

Section A1 of the AISC *Specification* states: "Where conditions are not covered by this *Specification*, designs are permitted to be based on tests or analysis, subject to the approval of the authority having jurisdiction. Alternative methods of analysis and design are permitted, provided such alternative methods or criteria are acceptable to the authority having jurisdiction."

There is some overlap between the RCSC and AISC committee rosters, allowing coordination between the two standards to occur during the development process. Currently, revisions that were made to the *RCSC Specification* are being considered by the various AISC technical committees as work continues on the development of the 2022 AISC standards.

Thermal Breaks

How does one show bolt bending is okay and isn't a concern across thermal breaks or shims?

For the most current information, I would suggest an inquiry with the individual thermal break manufacturers and a review of any available research. The minimum stiffness of the break material would likely come into play. Commentary to Section 1.1 of the 2020 *RCSC Specification* has been added to provide additional guidance. It includes the following aspects of a thermal break joint for the EOR to consider:

- The stiffness and strength of the inserted layers and their influence on the intended performance of the joint
- The maximum bolt tension that the layers in the *grip* can withstand without losing integrity or performance
- The installation instructions to prevent overtightening of bolts
- The effects of the thickness of the added plies on the stiffness and strength of the *bolting assembly* and of the *connection* as a whole
- The resistance to exposure of the added plies, when applicable
- The type of forces that the joint is intended to transfer (e.g., shear, shear, and tension, compression, tension without fatigue)
- The long-term behavior of the inserted layers
- The electro-chemical interactions of the inserted layers with coatings on steel, if applicable

Type 1 Fasteners with Weathering Steel Girders

Typically, Type 3 fasteners are used with weathering steel girders. Do you have any thoughts on using Type 1 fasteners on weathering steel girders?

Use Type 3 fasteners for the best long-term performance when using corrosion-resistant materials. Weathering steels can add significant service life to structures in corrosion resistance, and using Type 1 fasteners puts additional reliance on the coating system and maintenance. It would be advisable for the small cost premium (and perhaps required by code) to use similar weathering materials. While it does not explicitly answer your question, Section 4 of the AASHTO/NSBA Collaboration G12.1 document offers some guidance and further information on bolts, providing a broader picture of what is available and typical for bridge applications (you can download it at **aisc.org/gdocs**). You should also consult AASHTO and state specifications as appropriate.

Chad Larson is president of LeJeune Bolt Company.

Adopting the *RCSC Specification*

When does the 2020 *RCSC Specification* go into effect? Is there a rollout period?

The specification was published on June 11, 2020, and the Research Council on Structural Connections has limited jurisdiction to enforce the adoption of its standards. Though some agencies regulate construction within specific sectors at the national (or state) level, building codes in the U.S. are typically adopted and enforced at the local level. There are many "authorities having jurisdiction" in the U.S., so when the 2020 *RCSC Specification* goes into effect will vary. Other specification bodies that need to review and approve the new practices for use in other codes or design practices may certainly make a determination on the applicability of changes.

For structural steel buildings designed to the AISC *Specification*, the 2022 version will reference the 2020 *RCSC Specification*. So at a minimum, you would need to meet the 2020 *RCSC Specification* requirements when required to design to the provisions in the 2022 AISC *Specification*.

If there is uncertainty about what standard is applicable, it is best to clear this up with an RFI or pre-contract conversation to avoid surprises.

Washer Limits within the Grip

Is there any limit on the number of washers that can be used either under the head or the nut?

No. The commentary provided for Section 2.7 of the 2020 *RCSC Specification* states: "If necessary, the next increment of bolt length can be specified along with ASTM F436 washers in sufficient quantity to both exclude the threads from the shear plane and ensure that the bolting assembly can be properly installed with adequate threads included in the grip."

The number of additional washers ultimately comes down to a workmanship issue in detailing or bolt placement. In some cases, additional washers may be needed to exclude threads from the shear planes based on the nominal shear strength used by the designer. In many cases, extra washers will not pose a problem, but the fact that a maximum number is not specified leads to some questions of what is acceptable workmanship. To avoid disputes when pretensioning is performed, some consideration should be given to preinstallation verification testing that closely replicates the installed condition.

Installation Methods

What are the changes to bolt pretensioning methods?

There are a few changes that users might need to know. Turn-of-nut method pretensioning allowed a -30°/+60° tolerance for installation in the prior edition. The minus tolerance has now been eliminated (see section 8.2.1 and Table 8.1). This change provides higher assurance that proper pretension is achieved.

Installation of bolts from the head side is now prohibited when performing calibrated wrench method pretensioning. The calibrated wrench method relies on torque for proper installation. There are cases where the bolt body may be in bearing with the steel within the grip, and the resulting friction may alter the torque-tension relationship. Nuts are often lubricated, and bolt heads are not. This can result in a significant change in resulting pretension (see section 8.2.2).

Combined method pretensioning has been added as one of the recognized installation methods. The combined method uses an *initial torque* to attain an *initial tension* in the bolting assembly, followed by the application of relative rotation between a bolt and nut (see Section 8.2.5).

STEEL SOLUTIONS CENTER

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

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

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

steel quiz

This special edition of the monthly Steel Quiz will test your knowledge on topics related to various sessions at the 2021 NASCC: The Virtual Steel Conference, taking place April 12–16 (for more information on the conference and clues for this quiz, visit **aisc.org/nascc**).

After reading this issue, answer the questions, then locate the answers in the word search puzzle. (Answers in the word search do not include spaces or hyphens—e.g., "wide-flange" would appear as wideflange.")

1 Two of the 2020 Prize Bridge National Award winners feature movables lift. (Hint: This one is named after a person. All of the 2020 winners are featured in the July 2020 issue, available at **www.modernsteel.com**.)

2 The [three words] of limit analysis is recognized as a fundamental principle of structural steel design for both the main structural frame and connections.

3 This substance is becoming widely legal for recreational use, which means discussions regarding the workplace must take place.

4 You can do this to iron, but it is also the name of one of AISC's distinguished awards.

5 Even with its recent steel-friendly facelift, it is often referenced by this original moniker by Windy City natives.

6 CASE recently published a document addressing the coordination and ____________ of structural construction documents.

7 AISC is sponsoring research aimed at optimizing the [three words] for selecting corrosion systems.

8 What kind of structures were added to the new AISC *Standard for Certification Programs* (AISC 207, **aisc.org/specifications**)? [two words]

9 Dan Coughlin will teach attendees how to influence others to ____ results.

10 AISC developed a useful guide that provides tips on how to preliminarily size beams and columns, as well as insights on architecturally exposed structural steel (AESS), sound isolation, and enclosure details. Who is this document focused on helping?

11 What can be considered the new frontier in structural design? [two words]

12 In addition to delegated design and informal involvement, what is a third relatively new design collaboration method? (Hint: All three are highlighted in a new document developed by AISC and the American Institute of Architects/AIA.) [two words]

13 Sometimes during _______ analysis, the exact real-world sequence of steps must be mimicked in the analytical model to understand deformations and member forces.

14 AISC 342 is planned to replace the ASCE 41 provisions for seismic evaluation and _____ of steel buildings.

15 What provides both the optimal material properties of steel and the creative freedom to shape components and direct the flow of forces in complex structures? [two words]

16 With low environmental impacts on a per-square-foot-of-construction basis, steel is the premier choice for environmentally conscious, _______ projects.

17 The SoFi Stadium structural design incorporates a _______ ring to help channel forces.

18 These kinds of structures provide operational flexibility to adapt a facility to a variety of conditions to either suit environmental conditions or event requirements.

19 What technology has evolved from being used for marketing purposes and in video games to viable application in design and construction? [two words]

20 Global pandemic willing, where will steel lovers convene this time next year?

TURN TO PAGE 14 FOR THE ANSWERS

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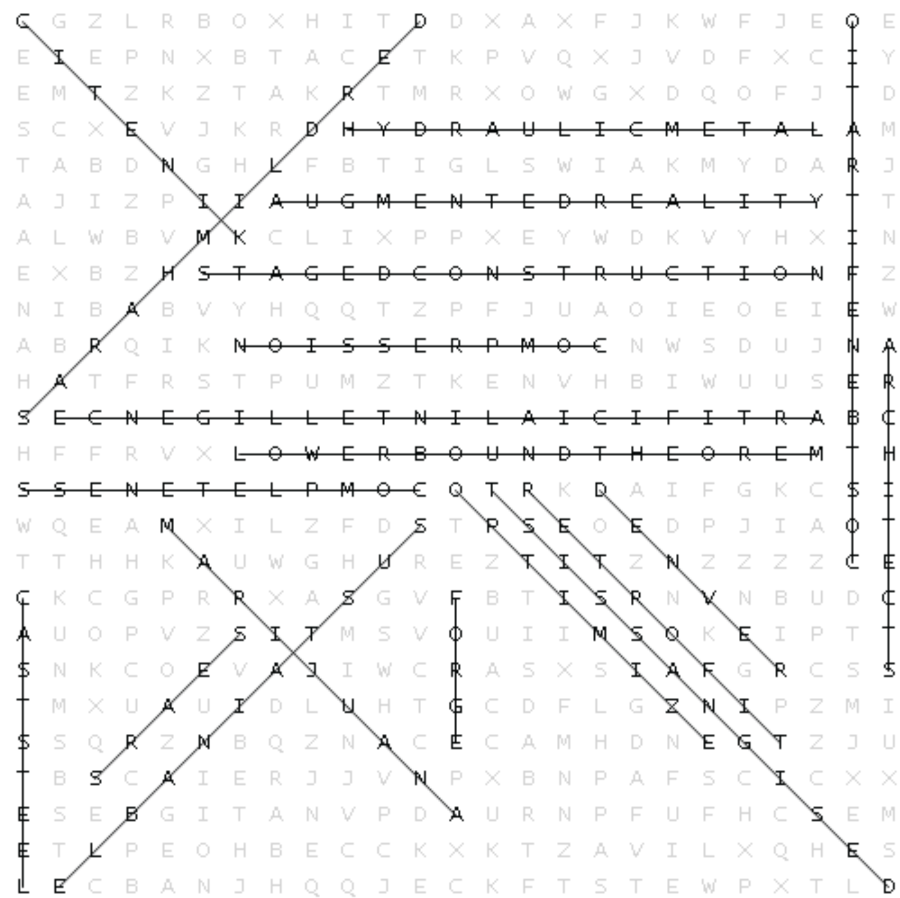

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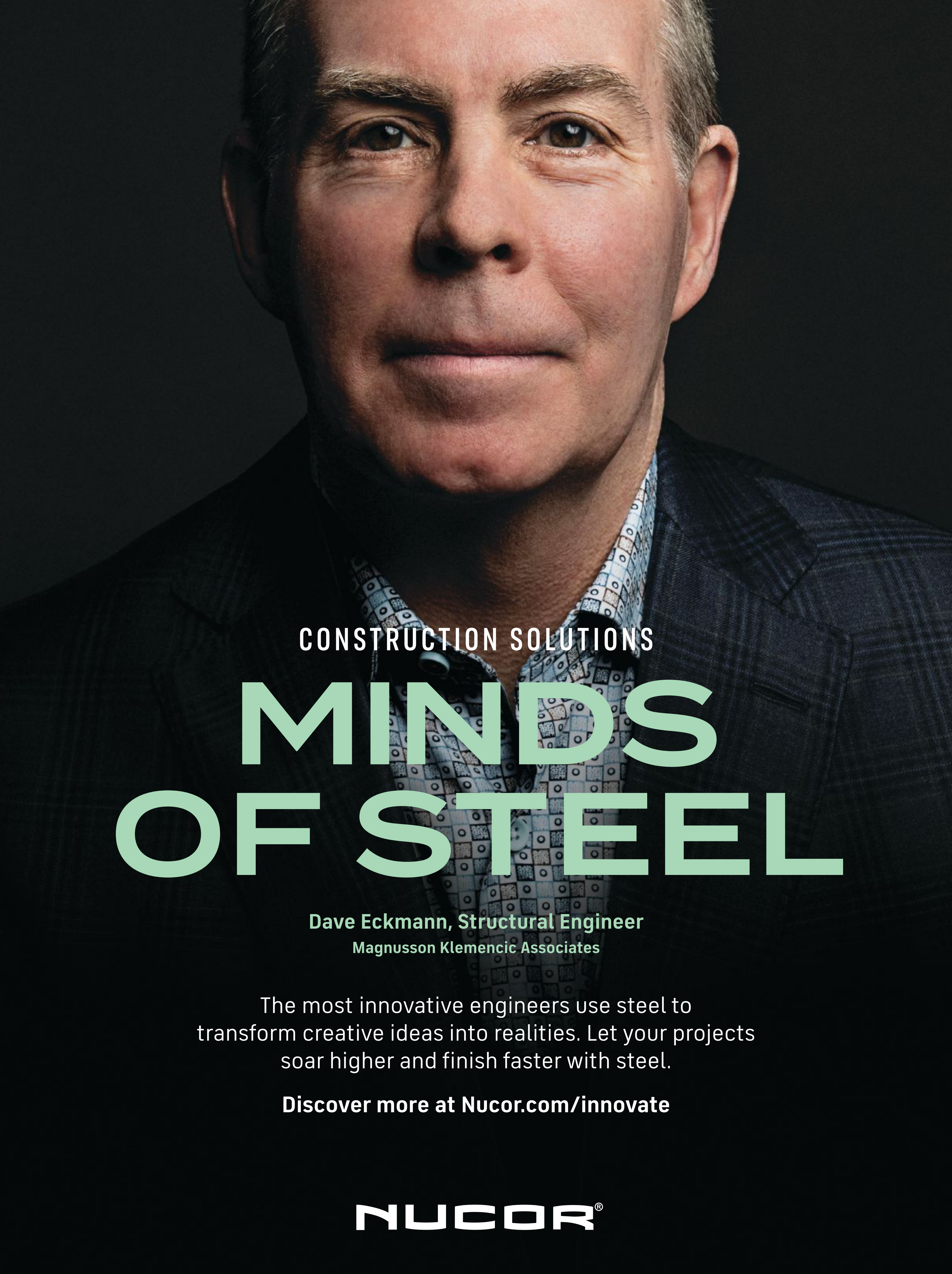
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A NEW CHAPTER FOR CERTIFICATION

BY MICHAEL A. WEST, PE, AND LARRY MARTOF

AISC's new *Standard for Certification Programs* includes a new structural approach, new terminology clarifications, and a new chapter on hydraulic metal structures.

Michael A. West (**michael.a.west@outlook.com**) is emeritus vice president of CSD Structural Engineers and a member of AISC's Committees on Manuals and Textbooks and the Code of Standard Practice and AISC's Specification Technical Committee TC 12 – Quality Control and Assurance. He is also the chairman of AISC's Certification Standards Committee.

Larry Martof (**martof@aisc.org**) is the director of QMC.

AISC'S CERTIFICATION PROGRAM is geared toward the evolution and improvement of fabrication shop and other structural steel-related operations—and as such, the program itself must continue to change as time, technology, materials, practices, customers, and industries evolve.

Of course, this includes the standard itself, and the AISC Certification Standards Committee (CSC) has recently revised and updated the previous document from the 2016 cycle, the *Certification Standard for Steel Fabrication and Erection, and Manufacturing of Metal Components* to become *Standard for Certification Programs* (AISC 207-20). The most significant revision to the 2020 version is the addition of a chapter on hydraulic metal structures.

Standard Unification

Let's take a brief look at how this addition came to be. The journey of AISC 207 began several years ago with the creation of the AISC *Certification Governing Requirements*. These requirements solidified how certification to one or several programs and endorsements was obtained, renewed, and denied, but the ongoing maintenance of five unique certification standards was becoming increasingly difficult for the AISC certification department. Inconsistencies were discovered in some of the common elements in each of the five different certification standards, which led to combining four of the standalone certification standards into the *Certification Standard for Steel Fabrication and Erection, and Manufacturing of Metal Components* (AISC 207-16), a unified standard; the complex coatings standard remains as a standalone document that fabricators use as an endorsement. This shift created a scenario in which only one Certification requirements document needed to be maintained and revised, with the *Governing Requirements* remaining as the method for dictating how the standard is applied for a company to become AISC certified.

While this effort was ongoing, the committee also recognized the growing need for a hydraulic steel structures certification program. This need was mainly being driven by the Army Corps of Engineers and other state and federal agencies that design and install structures to control water, such as locks, sluice gates, fish ladders, water treatment facilities, and other hydraulic structures. To address this growing demand, AISC's certification group borrowed from its bridge program requirements to define a certification program for hydraulic steel structures using the *Governing Requirements*—a solution that served as a temporary measure to address hydraulic structures until a full certification program could be developed for them.

Standard Approach

The new *Standard for Certification Programs* is structured on a set of general requirements in Chapter 1, which is implemented for all programs. Separate chapters of supplemental requirements are used to tailor and enhance the general requirements to a specific program, and this structuring makes it easier to add other chapters as the need arises.

Following the release of AISC 207-16, a task group was formed to define the requirements that would become Chapter 6 and consisted of representatives from the Army Corps of Engineers, structural steel fabricators, industry experts, AISC's certification department, and Quality Management Company (QMC) auditors. The group drafted a comprehensive set of hydraulic structure fabricator supplemental requirements for two categories: a standard and an advanced hydraulic structure fabricator. Both sets of requirements include and rely on the general requirements of Chapter 1 and use the supplemental requirements in Chapter 6, 6.A (Advanced), and 6.F (Fracture Control). Standard hydraulic metal structures do not require sophisticated measures, such as specialized equipment or techniques for geometric control, machining, welding, and handling. Common examples of standard hydraulic metal structures include sluice gates, knife gates, spillway gates, bulkheads and stop logs, needle beams, and lock culvert valves. Advanced hydraulic metal structures are those that do require sophisticated measures in fabrication and erection, particularly regarding size, curvature, plate thickness, distortion, machining, fabrication access, geometric tolerances, and constraint conditions. Common examples of advanced hydraulic metal structures include miter gates, vertical lift gates, roller gates, hoisting gates, bonneted gates, sector gates, and submersible Tainter gates (a type of radial arm floodgate used to control water flow in dams and locks). In a nutshell, the *Standard for Certification Programs* uses Chapter 6, with 6.F being available as an endorsement, while the advanced program includes the requirements of Chapter 6, 6.A, and 6.F.

Glossary Consistency

While the new document includes the requirements of Chapter 6 for hydraulic steel structures, no additional new requirements were added for other chapters. However, the revised standard does add clarity through new Glossary terms, more commentary, and improved alignment of sections and subsections. Revised Glossary terms reflect the updated terms expected in the 2022 AISC *Code of*

William Alden via Wikipedia

above: An example of a Tainter gate on the Ohio River.

below: AISC's new *Standard for Certification Programs* is focused on improving processes at fabrication shops and other structural steel-related operations.

Chapter by Chapter

Heres' a quick look at the chapter list for the new AISC *Standard for Certification Programs*:

- Chapter 1: General Requirements used for all certification programs
- Chapter 2: Building Fabricator Requirements
- Chapter 3: Metal Component Manufacturer Requirements
- Chapter 4: Bridge Fabricator Requirements
- Chapter 5: Erector Requirements
- Chapter 6: Hydraulic Metal Structures Fabricator Requirements

Standard Practice for Steel Buildings and Bridges (ANSI/AISC 303) and the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) and provide consistency in terminology across all AISC standards and documents. It is worth noting that the term "quality assurance" (QA) has been given a unique meaning in the new *Standard for Certification Programs* that differs from how it is used in Chapter N of the AISC *Specification* and instead conforms with its use in implementing quality management systems. Other terminology changes—such as updating "shop drawings" to "fabrication documents"—have been made throughout to better suit how information is conveyed to the shop. This information takes on many forms as technology continues to transition how we work, and the old large paper prints of drawings are being replaced with 3D models, tablets, automation, robotics, and eventually even virtual manufacturing.

Additional revisions were also made to better explain the concepts and practices of calibration, corrective action, nonconformance, inspection types, and welding controls. Words like "product" and "service" have been replaced by "work," which can be applied to anything one does. Other revisions were made to do a better job of clarifying requirements. For example, the revised provisions in Section 1.10.2: Selection of Subcontractors and Suppliers clarify that, as applicable, subcontractors and suppliers must be certified when this is a contract requirement. If a situation arises in which "a certified entity is not able to subcontract with another certified entity" (see the commentary to Section 1.10.2), then there must be an established procedure that defines how the certified entity is to go about obtaining permission to employ a subcontractor or supplier that is noncertified.

AISC's new *Standard for Certification Programs* represents the evolution of the certification process in the form of a major new addition and reflects consistency in terminology across all AISC publications. The addition of Chapter 6 will require current participants in the Hydraulic Certification Program to decide whether the standard or advanced hydraulic certification suits their business needs, and all certification participants will find the revised standard easier to understand and implement. And finally, the document's revised title reflects its current use while also allowing for the simple addition and integration of additional chapters as the steel industry turns to the next page. The standard, along with the other AISC publications mentioned, is available for free download at **aisc.org/specifications**. ■

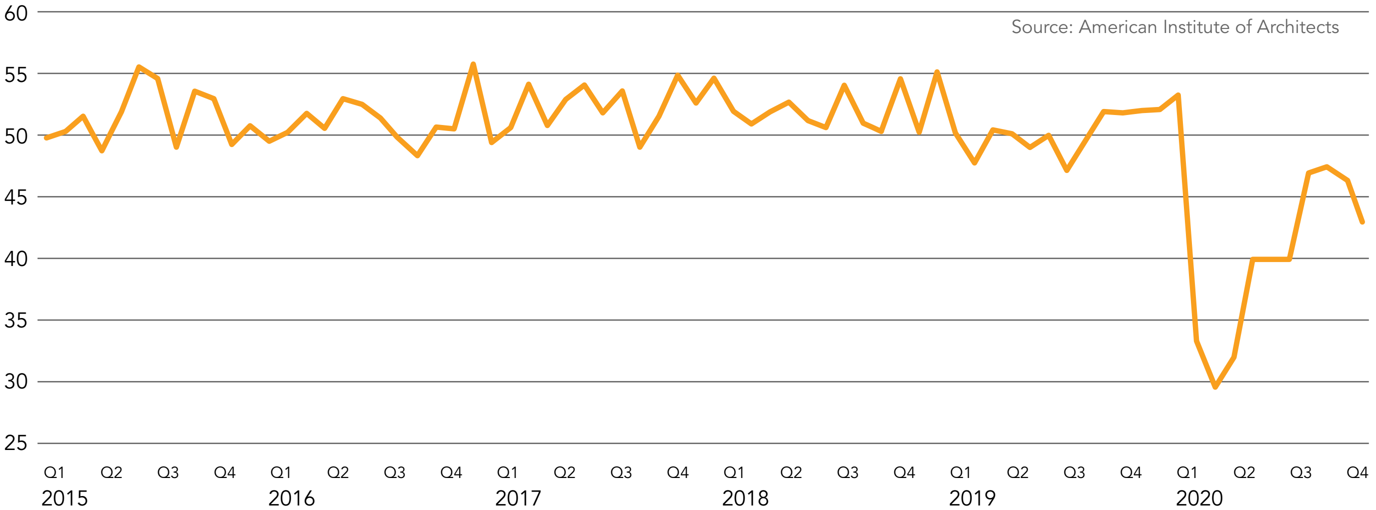
The Certification Standards Committee would like to thank outgoing vice-chair Jack Klimp, who remained on the committee until the completion of this current edition, for his many years of committed service to the committee.

Data Driven is a new page that highlights market trends, economic forecasts, or other relevant numbers that affect steel design and construction. This month's data focuses on AIA's Architecture Billings Index and the U.S. GDP's impact on construction spending.

data driven

Architecture Billings Index

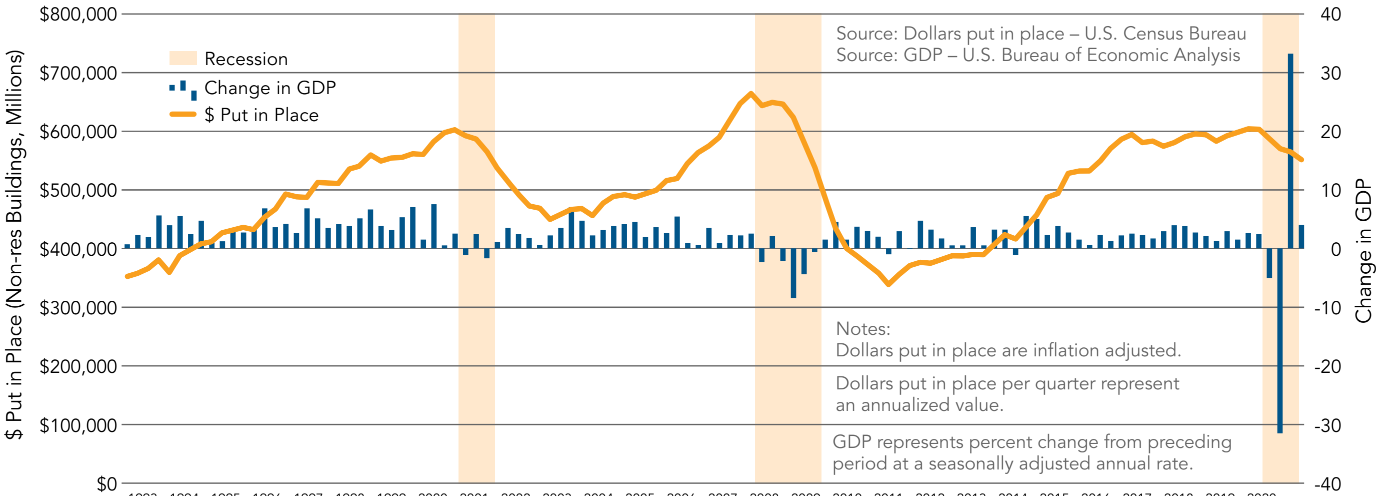
The Architecture Billings Index (ABI) is a diffusion index derived from the monthly Work-on-the-Boards survey conducted by the AIA Economics and Market Research Group. The ABI serves as a leading economic indicator that leads nonresidential construction activity by approximately nine to twelve months. The survey panel asks participants whether their billings increased, decreased, or stayed the same in the month that just ended. According to the proportion of respondents choosing each option, a score is generated, which represents an index value for each month. An index score of 50 represents no change in firm billings from the previous month, a score above 50 indicates an increase in firm billings from the previous month, and a score below 50 indicates a decline in firm billings from the previous month.



Impact of GDP on Construction Spending

Construction spending is often correlated with changes in U.S. GDP. Historically, construction spending lags changes in GDP by about 18 to 24 months, and a change from positive to several quarters of negative GDP usually indicates a downward trend in construction spending for 18 to 24 months. Subsequently, a change from negative to positive GDP historically indicates construction spending will begin to increase in 18 to 24 months. Additionally, the size and number of quarters of positive or negative GDP have historically indicated the volume increase or decrease in future construction spending. ■

*Visit **aisc.org/economics** for more information.*



Armed with sound advice from her father, Nyckey Heath has forged a rewarding path to become a project manager with one of the country's top steel erectors.

field notes

A SERIES OF FORTUNATE EVENTS

INTERVIEW BY
GEOFF WEISENBERGER

NYCKEY HEATH, PE, a project manager with Bosworth Steel Erectors (an AISC member), credits her military service, her can-do attitude (inherited from her father), and her inquisitive nature to her success in the construction industry. In this month's Field Notes podcast, she discusses how her impulse to join one U.S. military branch led to her joining another, how she narrowly avoided becoming a doctor, how working for a fabricator taught her how to be a more effective engineer, and how she acquired the best hard hat she's ever worn.

You currently live in Waxahachie, Texas, and work in Dallas. Are you a Texas native?

I was born in Houston and when I was an infant, my mother moved us to Arkansas, and I actually grew up all over that state. I was in foster care since I was four-years-old, and I was luckily adopted by an amazing dad when I was 15.

Nyckey is a presenter for two 2021 NASCC: The Virtual Steel Conference sessions: "How Is Your Steel Deck Attached?" and "Practical Guidance for Erection Engineering from a Steel Erector." The conference takes place online April 12-16. For information on these sessions, the conference as a whole, and how to register, visit **aisc.org/nascc**.

Speaking of your youth, what was your first answer to the question, "What do you want to be when you grow up?" Did it have anything to do with construction?

I wanted to be a famous country music singer.

Ah! That's a good answer. Did you sing or did you just like the idea of it?

I *thought* I could sing, but when I hear myself, I think I'm actually tone-deaf. And of course, my dad told me I sang great, but that I think that's what you're supposed to tell your child.

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*.

So what put you on the path to your current role?

Growing up in foster care and in poverty, I realized that if I didn't do something different with my life, I was going to end up in a bad place, and there was this defining moment where I looked around and told myself that I can't do this anymore, I've got to make a change. It was 2:30 in the afternoon on October 31, 2000. I looked at my sister and I said, "Take me to the Air Force recruiting office right now," and we drove all over town and couldn't find the Air Force recruiting office. But there was a strip mall that had Army, Navy, and Marines offices, so we went there instead. I walked past the Navy office and said, "Hmm, I don't really like those uniforms," and kept walking. I saw the Army guy with his feet up on his desk and kept walking, then I walked into the Marines office, and the guy stood at attention and asked, "Can I help you, ma'am?" And I said, "No, sir!" turned around, walked out, and went back over to the Army guy. He asked, "Hello, how are you doing?" and I said, "This is the right place for me." I ended up joining the Army for four years.

Again, I needed to change my entire path and I also needed a way to pay for college or get some sort of technical degree. I was on active duty for four years. It was a great experience. I got my EMT and then I went to radiology school. And when I got out of the military, I was going to go pre-med, but I learned very quickly that was not for me. I passed out when I saw a lot of blood. It was very sobering. I actually passed out three times before I realized that medicine wasn't the right path.

Luckily, a friend of my dad's who worked in the construction industry asked me if I'd ever thought about getting a job in construction. I hadn't, but I started out as a secretary at a construction company and very quickly realized that I didn't just want to answer the phones, so I asked the engineers if I could help them with anything. I started assisting them with estimates, and the next thing I knew, one of the engineers asked if I'd ever thought about being an engineer. And I said, "No, what do you do?"

I decided that was the path for me, so I started looking for schools that were friendly to veterans and where my GI Bill money could help out the most. I was released from Fort Sill in Oklahoma and was considered a state resident, so I could get in-state tuition and I went to Oklahoma State University and got my bachelor's degree in civil engineering. Then I went to Norwich University and got my master's degree in civil engineering, with a structural path.

Can you tell me a bit about your career following school?

I started at an engineering firm in Tulsa via an internship, and they eventually hired me. I worked for them for several years doing design work on multiple types of projects—small structures, large structures, cell phone towers. The sister company to the engineering company did fabrication and erection work, and I basically swapped positions with one of their engineers because I knew there was so much more to learn. I wanted to know how things were actually built. And so I just kind of jumped in, and during my first design project, someone came in from the shop floor and asked me, "Have you ever even seen a one-inch bolt?" And I said, "No, sir." He took me out to the shop, and after spending some time out there, learning from him, I realized, oh my gosh, I'm overdesigning everything.

The amount of knowledge that we gain being in the field is so tremendous, and I didn't realize it until I was forced to step back and actually see it. Fabricators can help engineers design things so that they're fabricated at a lower cost. Erectors can help them design things to be erected smoother, simpler, easier, and faster, which results in less money required from the owner. This mindset helps our entire industry.

Anyway, following that job, I worked for a steel erector and fabricator in Tulsa for a while. And then I met Vince Bosworth, the president of Bosworth Steel Erectors, and I knew that if I could get a position with them, it would take me to a different level in terms of my knowledge and skills. I'd taken some classes with several of his employees and had met Vince at one of them. He actually got up and got coffee for everybody, and I just thought wow, this is an executive and he's so down to earth, and working for him seemed like such a good fit. So when he eventually offered me a job, it was a no-brainer.

What's some of the most memorable advice you've received, either in the military or through work or life in general?

My dad is an attorney, and I was just fascinated by him in high school. I didn't know anything about college, and I remember sitting in the kitchen with him during my senior year in high school, and I asked, "Can I go to college? What's an associate's degree? What's a bachelor's degree? What's a master's degree?" He explained everything to me, and I asked, "Isn't college really expensive? Is it something I can even do?" And he replied, "Nyckey, if other people can do it, so can you." And that advice just hit me so hard, and it stuck with me. I remember being in college and thinking, "I can't do this. It's too hard." But then I remembered that advice. It was the same when I first considered giving a presentation at NASCC. And now every time I struggle with something, I remember that advice. And I've given that same advice to other people. It took me out of what I would consider a poverty situation and away from a path that was not going to go well.

Can you tell me about one of your more memorable work experiences?

I was once in Hawaii for several months, working on a naval base project. We worked seven days a week, so I didn't really get a lot of time outside in the tourist areas. But I did spend a lot of time with locals. We worked with union ironworkers, and they would bring us meals from their cookouts and they were just really nice people. I learned a lot on that project and at the end of the job, a bunch of them were huddled around a box, and I asked what was going on. They told me they weren't sure where the box came from, and I told them maybe they should open it, and they said, "No, you open it." And I did, and inside was one of their ironworker hard hats with a bunch of their local stickers on it. They told me, "We really like you because you know what you're doing, and we want you to feel like part of the team. We wanted to get you something to thank you for all your help out here." It was a great gift. ■

To hear more about Nyckey's recent foray into gardening, her son, her go-to dinner meal, the NASCC sessions she'll be presenting, her experience weathering the recent cold snap in Texas, and her thoughts on the Dallas Cowboys, visit ***modernsteel.com/podcasts*** *and listen to our entire conversation.*

business issues

YOU THERE?

BY ANNE SCARLETT

Tips for grabbing and keeping attention during virtual meetings.

Anne Scarlett is president of Scarlett Consulting, a Chicago-based company specializing in AEC-specific strategic marketing plans, marketing audits, and coaching. She is also on the adjunct faculty at Columbia College of Chicago and DePaul University. She can be contacted via her website, **www.annescarlett.com**.

DURING THESE UNUSUAL PANDEMIC TIMES, there's one thing that has remained constant: meetings. *Virtual* meetings.

Long after we return to normal, it's predicted that virtual meetings will continue to be a frequent mode for connecting—whether for internal meetings, external conferences, or anywhere in between. And your ability to lead effective meetings in the virtual space will be yet another boost to your leadership repertoire.

But let's face it. Whether in person or online, facilitating intriguing and productive meetings has always been a challenge, and virtual meetings pose additional considerations in order to attain the best results. As a college professor, I've had the "pleasure" of keeping mid-sized groups of 20 or so motivated and engaged during our online synchronous sessions. Not an easy task, but it is doable.

And here in the AEC industry, we've all had to figure out how to best connect and *engage* with our prospects, existing clients, internal colleagues, and external team partners. And whether your meeting purpose is centered around training, selling, relationship-building, project management, client progress, etc., we are all still learning the best approaches.

As a colleague recently pointed out, "When it comes to virtual meetings, good content trumps all." No hook, method, gimmick, or ploy will successfully engage your audience when the content itself is lackluster. Assuming your content is indeed top-notch—and that you've prioritized weeding out any extraneous information—let's now take a page from the higher-ed playbook for methods on engaging our participants in the professional realm.

Purpose

Regardless of the purpose, these tips apply to all virtual meetings.

Build community. Breakout rooms are arguably one of the most powerful tools on virtual platforms. Using them is a perfect method for giving everyone direct contact with others. People need the opportunity to be heard. Smaller groups—even two or three people—are often ideal. Try creating a rotation where groups are reformed two or three times. During breakouts, the facilitator should move between rooms to observe and assist.

Offer freedom of choice. One powerful breakout room feature is the ability for attendees to select their own rooms. Similar to the "open space technology" method—where participants have been invited in order to focus on a specific, important task or purpose—pre-assign topics to each room and then allow freeform movement between. This is a dynamic, participant-driven way to organize your meeting.

Foster collaboration and creativity. Another invaluable tool: any platform with real-time document sharing features, such as Google Docs (Slides/Sheets) or Office 365. What makes this fun is that breakout groups can focus on specific aspects of a pre-existing document shell. Everyone can watch as the document morphs into something co-prepared by all the groups. To solidify the effort, bring everyone back into the main room to present findings and outcomes.

Emulate the in-person experience. While facilitating a virtual discussion is challenging, it's not impossible. With under 15 participants, you can try unmuting everyone. Even so, most platforms allow only one speaker at a time, so using the old-fashioned hand-raise cue can still be helpful. Scribing on a virtual whiteboard helps to capture the comments for all to see.

Setup

Preparation is as important as purpose. Consider the following.

Prepare attendees in advance. Manage expectations by sharing a results-oriented agenda in advance of the meeting. Preparation will demonstrate your respect for their time. To boost their overall contributions, arm participants with any materials to review in advance. Finally, ask for comments on the agenda *in advance* of the meeting, and then reference those comments (along with the person's name) during the meeting. Above all, you're aiming to send the message of "Please engage—don't hide—during our meeting."

Master the technology. When all of us were suddenly thrown into working from home in March 2020, participants were patient with one another. We expected technical glitches. A year later, we should be able to reduce or eliminate time-wasting glitches. It's worth it to become familiar with—and push the boundaries of—your software of choice. (At this point, I'm on a first-name basis with Pierre from Zoom tech support!) If stakes are high, consider conducting a practice run of your meeting, even recruiting faux participants. Explore using dual screens. And finally, sign in to your meeting with a different device. The latter is very helpful so that you can see what the audience sees at all times.

Co-opt "helpers" by delegating roles. Depending upon the type of meeting, many people enjoy having a pre-assigned responsibility. They can monitor the chat box for questions and comments, serve as a time-keeper, etc. Even better, you can assign agenda topics for others to lead. This encourages accountability and involvement. To ensure that they are truly prepared and not scrambling at the last minute, ask them to submit their piece prior to the session for you to assemble.

Establish the mood with a splash page. When participants enter your meeting, they should see a visual slide that includes information about the meeting, to-do items to get settled, and/or something fun for a shared laugh (memes are crowd-pleasers). To add flair, playing music in advance of the meeting is another way to create a mood—ambitious, energetic, relaxing, etc. If possible, ask attendees for requests or playlists in advance to create subtle involvement.

Keep them on their Toes

Holding attendees' attention during the meeting takes more than great preparation. The effort to keep the group engaged is an ongoing task.

Create the unexpected with real stuff. Providing something tangible is a fun way to shake things up. For example, all professors in my department received packages in the mail, noted with "Bring this to our next faculty meeting, unopened!" Together, we unwrapped new gadgets: multiport USB adapters. Handy! An acquaintance from the tech giant Salesforce shared that all participants received hoodies to wear during their all-office virtual conference. A friend in business consulting mentioned receiving a care package of goodies in advance of the virtual holiday party. A principal researcher shipped a regional bottle of wine to his entire international team to enjoy simultaneously during a virtual celebration. These small gestures lighten up the mood and foster a sense of camaraderie.

Foster the human-to-human connection. Add quickie icebreakers, such as collecting rapid-fire responses by voice, chat box, or shared whiteboard. Prompts could include "this or that" choices or sharing quick personal specifics such as a go-to place for thinking, the book you currently have on your nightstand, your "happy place," your favorite ice cream flavor, your favorite travel destination so far, or your next planned trip; the list goes on. At the end of the session, invite people to stay after for casual conversations, just like what you'd do after an in-person meeting.

Present with charisma. Here is another area where practicing will serve you well. By recording a meeting rehearsal, you'll be able to adjust your body and paralanguage to be engaging yet not overwhelming. One example: In virtual meetings, gestures need to be slower and used in moderation. Additionally, facial expressions carry more weight on video. Are you satisfied with your expressions? Do they match your message and intent? If you are seated and/or reading from notes during a virtual meeting, then your paralanguage (vocal variety) may suddenly exude a lower energy level than you intend. Maybe you will identify useless movements. As an example, through my own recordings, I quickly discovered that I move my head in a distracting manner on video calls. All it took was a simple reminder note and some practice. Voila! The strange head movement disappeared! (For additional video best practices, see my May 2020 Business Issues article "Smile! You're on Camera" in the Archives section at **www.modernsteel.com**.)

Show your face! If you are on Zoom, you now have the option of using a PowerPoint slide deck as background. A small picture of your face appears in front of the slide deck, and you can resize and relocate as needed. This keeps participants more connected to you rather than switching their attention back and forth between your video and your content. Alternatively, if you are screen sharing in the traditional manner, make sure that you periodically stop sharing your screen so that your face returns to full-screen mode.

Mention participants by name throughout. Maybe you're calling on them directly for input or sharing. ("Andres resolved a sticky situation with our client last week. Andres, can you summarize the context and outcome?") Or perhaps you're illustrating a point by using their name. ("As an example, James could complete his part before handing it over to Misha's team. Eliot would review before submitting to the client.") Using names encourages undivided attention.

Chunk content. Anything that provides a "shift" will help maintain attention. This can be a shift in speaker, activity, or topic. In academia, my own rule of thumb is 15 minutes maximum before shifting in some manner. However, most would advise halving that to seven minutes. Whatever you do, make sure to reduce the actual amount of overall content by transferring some of it to offline (asynchronous) consumption.

Promote equity among contributors. In face-to-face meetings, sometimes the loudest person dominates the room. No more. One of the happy accidents of virtual meetings? They've "flattened" the organization, enabling easier access from the ranks to senior leadership. People feel increased permission to express themselves. For example, a large, multi-office architectural engineering firm can encourage participants to have ongoing conversations in the chat or use software such as Miro or WebEx to visually build upon—or react to—the content that is presented in the meeting. These things can be monitored and summarized so that the senior leadership can directly respond in real-time. So rather than simply broadcasting top-down information, the meeting becomes a true exchange and adds value to the overall experience.

To create equity in smaller meetings, the host can go low-tech. For example, as a host, you can have a hard copy list of attendees and mark a dot next to each person whenever they contribute. With a quick glance, you can make sure to loop quiet participants into the mix.

Squelch multi-tasking. As mentioned, if your content is compelling, you're more likely to keep their attention. Even so, I can personally admit that I've still multi-tasked with the camera off during high-quality learning sessions simply because I could. If I had been called upon to actively engage, you better believe I would have been more attentive. Just like in face-to-face meetings, setting some housekeeping parameters is perfectly reasonable. This includes requesting cameras on and other devices off.

Include polls (provided they would not be viewed as "gimmicks"). Intermittent polls are not just used for engaging participants. They also capture valuable information collected in a post-session report. Design your polls to include the option of expanding upon responses within the chat box. Just like in webinar design, a reasonable rule of thumb is launching a solid poll every 30 to 90 minutes. As an additional method for involvement, you could invite participants to prepare a poll question in advance.

Adjust the "parking lot" method. Just like in face-to-face meetings, a parking lot (collecting off-course topics on a flip chart for future attention) remains useful in virtual meetings. Let participants know ahead of time about the feature and simply create the parking lot within the chat or whiteboard.

Re-energize. Try to end your meeting ten minutes before the hour so that attendees have a break if they have to run to another meeting. Consider creating meeting-free timeframes within your organization where you respect the blackout periods. Encourage participants with special talents (acting/theater/meditation/etc.) to prepare optional two- to three-minute experiences to serve as a re-energizing break.

Zoom fatigue is real. Our mental health is at stake here. Make your meetings something to anticipate and engage with enthusiasm and not just another time suck in front of a screen. And please share your own tips and lessons learned with me, as we all remain students in this new-ish virtual world. ■

Inside Job

BY DARREN HARTMAN, PE,
MATTHEW FARBER SE, PE,
AND SHAWN LEARY, PE

SEATTLE'S KEYARENA began life as a World's Fair Pavilion and is now nearing completion of its transformation into a world-class sporting and entertainment venue.

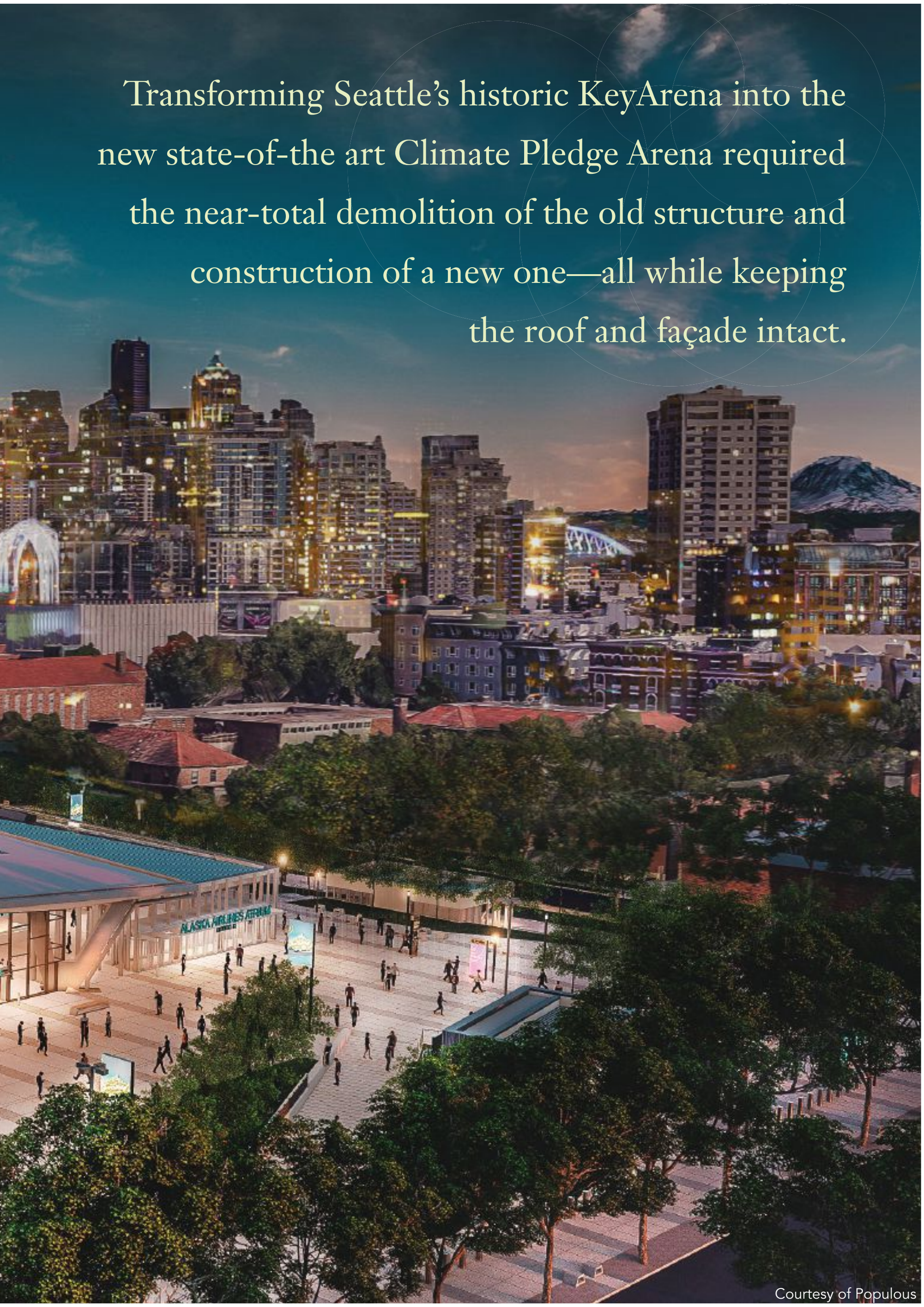
The historic venue, which started out as the Washington State Coliseum for the 1962 Seattle World's Fair and was the longtime home of the Seattle SuperSonics, will soon be home to the NHL's newest franchise, the Seattle Kraken. Slated for completion in late 2021, the $930-million renovation and expansion will result in Climate Pledge Arena, a new 800,000-sq.-ft below-grade venue that will hold more than 17,000 fans for hockey, basketball, concerts, and other events, along with a new parking garage. What makes this project unique, however, was that it preserves the 1960s-era building's iconic 22,000-ton steel-framed roof structure and the exterior curtain wall.

The project presented several complex challenges for architect Populous and structural and construction engineer Thornton Tomasetti. Most notable among these was determining how to demolish the existing structure and excavate 680,000 cubic yards of soil to make space for a new below-grade arena, all while temporarily supporting the 400-ft by 400-ft roof structure above it. Further complicating matters, the arena is located in a high-seismic zone, just two miles from a fault line—and on top of that, opening the facility in time for the 2021–2022 NHL season necessitated a very aggressive schedule.

Preserving an Icon

In fall 2017, KeyArena was classified by the Seattle Landmarks Preservation Board as a local landmark. This distinction required the Paul Thiry-designed roof, curtain wall, and exterior concrete

Transforming Seattle's historic KeyArena into the new state-of-the art Climate Pledge Arena required the near-total demolition of the old structure and construction of a new one—all while keeping the roof and façade intact.



Courtesy of Populous

At 800,000 sq. ft, the new Climate Pledge Arena is twice the size of the former KeyArena.

elements to be preserved as part of the Oak View Group's renovation of the arena. Consequently, supporting the existing roof while work occurred below drove nearly all facets of the project's design and construction.

The original roof was supported vertically by 20 concrete Y-columns on shallow foundations spaced approximately 60 ft around its perimeter. The lateral loads were resisted by a tripod of sloping concrete legs at the center of each side. The tripods, working as pylons, consisted of two chevron legs parallel with the perimeter concrete ring beam and one buttress leg in line with the roof's steel arch truss.

Temporary Roof Support

Since the foundations below the Y- and chevron columns would be undermined by the excavation for the new event level, a temporary roof support (TRS) system would need to support the vast majority of the roof's gravity load as well as resist wind and seismic lateral forces during construction. The 3,700-ton temporary steel framing for the

Darren Hartman (**dhartman@thorntontomasetti.com**) is a senior principal and **Matthew Farber** (**mfarber@thorntontomasetti.com**) and **Shawn Leary** (**sleary@thorntontomasetti.com**) are associate principals, all with Thornton Tomasetti.

NEED FOR SPEED

AISC's Need for Speed initiative recognizes technologies and practices that make steel projects come together faster. Check out **aisc.org/needforspeed** for more.


Elliott Veazey of CAA ICON

left: A view of the project from the south end of the site, showing the existing roof fully supported by temporary shoring structure. A steel "kickstand" was used to transfer thrust from the existing south pylon to a new perimeter foundation wall.

below: The new below-grade venue will hold more than 17,000 fans for hockey, basketball, concerts, and other events.

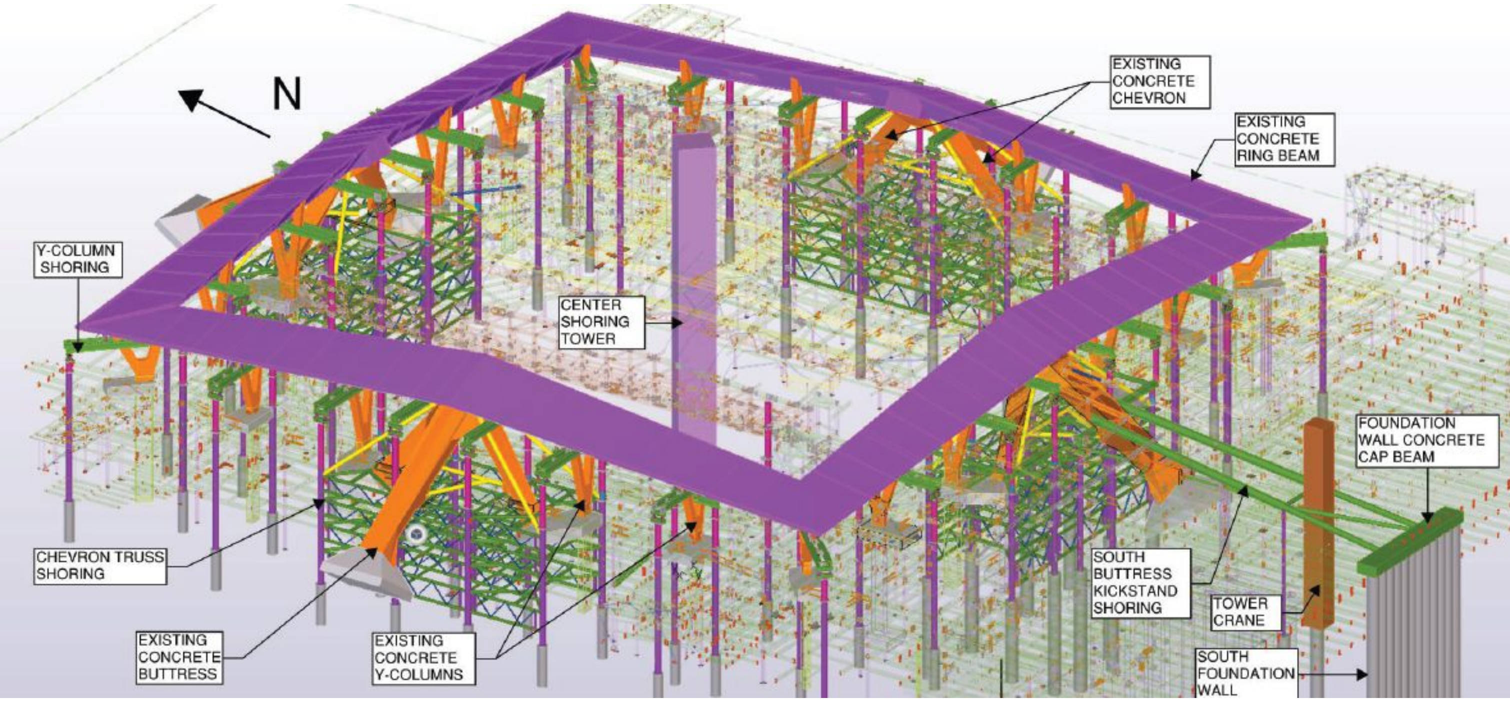
Courtesy of Populous

TRS was fabricated and installed by LeJeune Steel and Danny's Construction, the same team that would construct the new arena.

Supporting the gravity loads was accomplished by installing a shoring frame at each Y-column. A pair of W36 beams sandwiched the Y columns with a bearing pad placed under the concrete roof structure. At each end of the beams, a 36-in.-diameter shoring pipe was socketed into the earth from the existing ground level to the new arena floor level, some 85 ft below. The weight of the existing roof was transferred to the pipe shores via jacks and shims at the ends of the W36 sandwich beams prior to undermining the existing footings. This pre-loading resulted in nearly zero movement of the rigid roof upon load transfer.

On the north, east, and west sides of the building, the buttress footing was untouched by the excavation, except for the removal of the support below the chevron footings. The new parking garage at the south side, however, required the removal and temporary support of the buttress footing. Since the buttresses resist both thrust from the steel roof arch truss and wind and seismic forces, the approximately 3,300-kip force was resisted by a "kickstand" using a cone-shaped steel plate sleeve around the concrete buttress leg and large-diameter pipe struts flying above the garage construction. This assembly transferred the load to the new foundation wall at the south property line 160 ft away, and trussed moment frames temporarily replaced the chevrons at all four sides to resist vertical and lateral forces.

Evaluation, design, and construction planning for the temporary lateral force-resisting system required extensive collaboration from the entire project team. The system configuration and its capacity/stiffness continually changed as excavation progressed, and as areas of excavation proceeded in alternate quadrants, the bracing trusses were installed as soon as soil removal allowed. Work



Courtesy Danny's Construction

above and left: Temporary roof shoring and excavation.

below: W36 beams supporting existing Y-columns.


Courtesy Danny's Construction

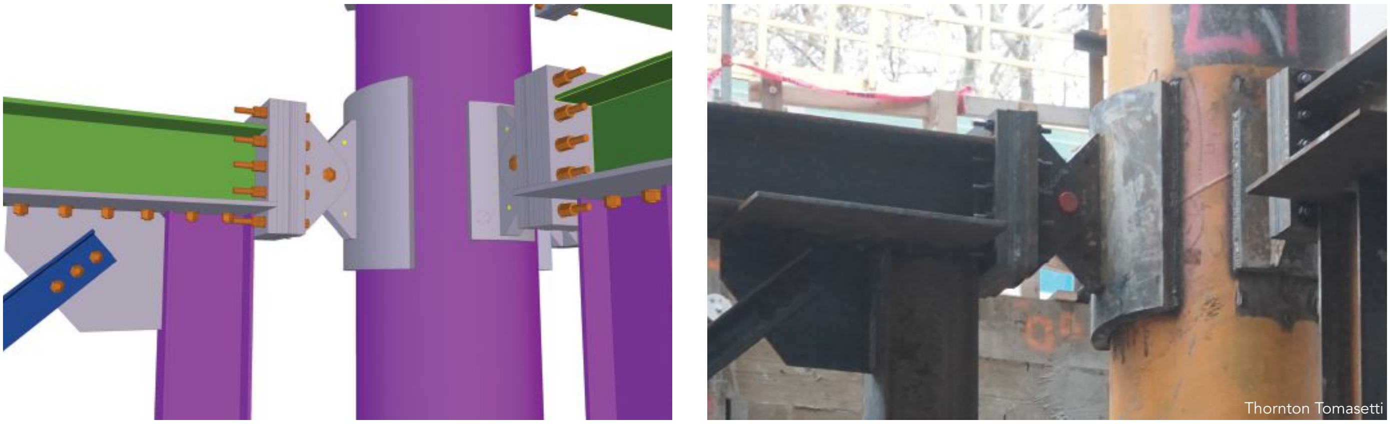
sessions with construction manager Mortenson and the steel, excavation, and foundation teams resulted in a series of colored maps defining the critical stages of analysis and design coordinated with construction activities. The steel team developed prefabricated drop-in steel truss panels with pinned connections designed with up to 8 in. of tolerance to accommodate the inherent tolerances of the 36-in.-diameter pipe shores.

The lateral force from the roof was delivered into the trussed frame system by massive 16-ton, 20-ft-long steel wedges installed at the triangular intersection of the roof and chevron leg. These wedges transferred the force in compression only, as the transfer in tension would have required an impractical number of post-installed anchors that would damage the surface of the structure. The decision to use steel pins and wedges to connect the trussed frames was the result of several hours of brainstorming between Thornton Tomasetti, Mortenson, Danny's Construction, and LeJeune.

"When all the parties get into a room and start melding the conceptual design with the work in the field, it can steer the final design toward the best solution possible," said Eric Fielder, a senior structural engineer with Danny's Construction. "Specifically, with the brace frame system, there was an emphasis on speed of installation and adjustability to accommodate the large caisson tolerances. This solution saved considerable time in that it didn't hold up excavation."

Ship in a Bottle

Designing and constructing a new steel-framed arena below the temporarily supported roof and around the temporary shoring was much like building a ship in a bottle. The arena, which will be the world's first net-zero-carbon-certified venue, consists of a new event



A Tekla model (left) and as-built (right) connection of the drop-in steel truss panels to the pipe shores. This connection accommodated the tolerance of the pipe shore locations and plumbness that resulted from installing the pipe shores from the existing ground level.

level 15 ft below the existing undersized event floor elevation, four complete arena levels at and below the surrounding grade, and two levels above the surrounding grade. All levels extend to or beyond the perimeter of the existing roof. The typical floor construction consists of steel beams with concrete slab on metal deck. Seating for the new bowl was framed with precast concrete stadia units supported by steel rakers.

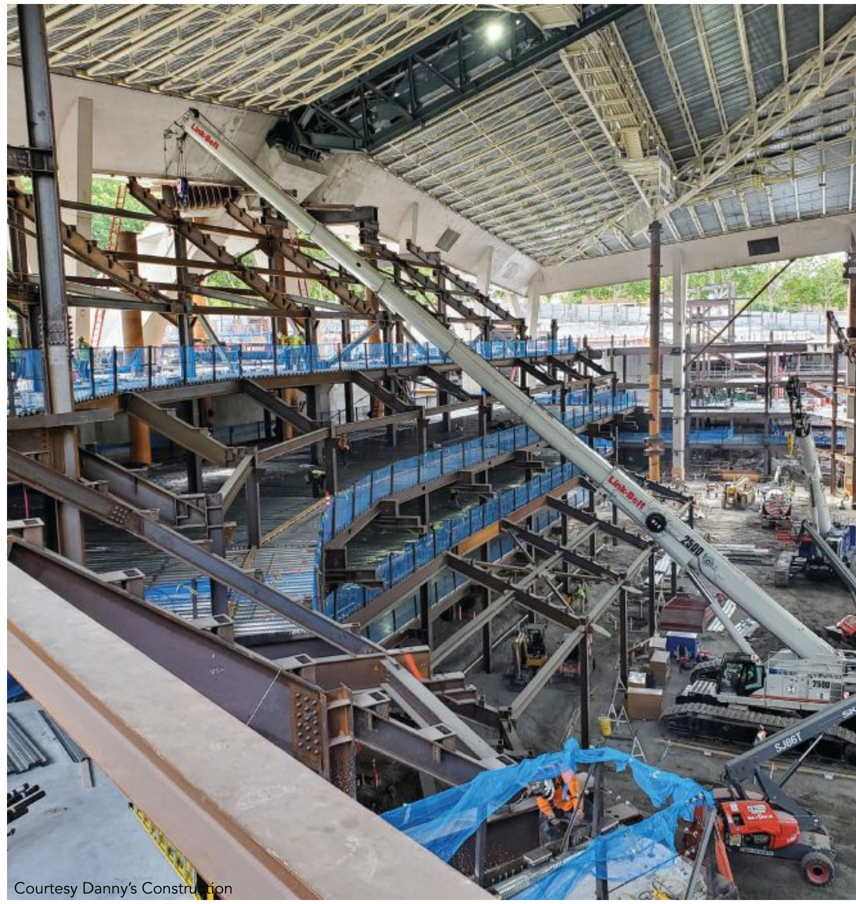
On the west side of the arena, a new press-level bridge floating above the seating bowl is supported by two trusses, a front Vierendeel truss and a back warren truss, spanning 275 ft between the new steel-framed elevator cores. The elevator core towers also support the existing corner roof trusses to facilitate the removal of existing corner columns. Slide bearings were provided between the new elevator core steel and the existing roof structure to seismically isolate the roof from the new bowl structure below. To minimize weight on these long-span floor trusses, a sandwich panel system (SPS) was used on the floor.

In addition to seismic retrofits to the roof, other measures included strengthening the steel roof trusses and their connections to bring them up to current code requirements, and supporting the additional loading of the new structure. The roof will now be able to support two 30-ton video boards along with hoisting equipment, a new catwalk, and a rigging grid with 100 tons of rigging capacity to accommodate modern touring and award shows.

Earthquake-Resistant Design

The 20 Y- and eight chevron columns that support the existing roof were extended

Steel framing for the seating bowl.



Courtesy Danny's Construction

down to the event level and once again support the gravity load of the nearly 60-year-old roof. These extended columns support local gravity loads from the new arena floor while being isolated from seismic forces. The chevron legs plus three original and one modified buttress deliver the roof's lateral load to the new upper concourse level framing.

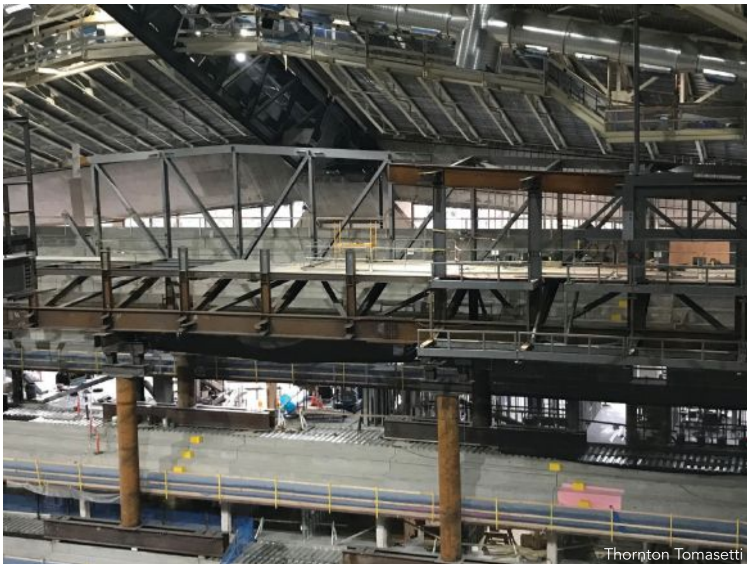
Buckling-restrained braces (BRBs) were used in the elevator cores to resist lateral loads from the press-level bridge and transferred down to the main concourse diaphragms. And for occupant comfort, two tuned mass dampers, located near the center of the long-span trusses, are used to control vibrations of the long-span floor system. Thornton Tomasetti also employed a demanding computational nonlinear response history analysis on the existing structure, including the incorporation of soil-structure interaction effects into the ground motions and the use of BRBs to control the demands at the new rigging grid. As a result, it was able to eliminate the need to retrofit the existing concrete roof elements and was also able to significantly reduce the number of steel roof members that would require retrofitting due to seismic loading.

above: Existing Y-columns are extended down to the bottom of excavation to support the existing roof and new arena structure.

left: The 8-ft-thick shear wall tying into the existing south pylon.

Saving Time and Cost

Complex projects like Climate Pledge Arena necessitate an integrated approach to solving challenges. All stakeholders, including owner, architect, engineer, construction manager, and steel contractor, provided timely input and feedback to produce innovative, practical, and constructable solutions. Thornton Tomasetti also implemented its Advanced Project Delivery (APD) services, which helped achieve considerable schedule and cost efficiencies. Using APD, Thornton Tomasetti engineers and the steel detailers are integrated into the design process to provide early fabrication, erection, and detailing input while developing a coordinated structural steel model. This early model provides the construction team with more complete and detailed information that can be relied on much earlier than traditional delivery methods. The model is then shared with the steel fabricator, and it becomes the base from which they can execute their final shop drawings as well as drives their CNC equipment during fabrication. The firm's construction engineering and structural design teams worked in parallel with LeJeune to provide a fully coordinated and connected Tekla model for the 8,700 tons of permanent steel for the arena and parking garage while producing full shop drawings for the 3,700 tons of TRS structural steel. This helped reduce the cost, schedule, and execution risk related to the complicated steel framing, connections, and tight confines of building under the roof around the TRS. With APD, the team was able to accelerate the steel procurement and detailing processes, enabling fabrication to begin much earlier and shaving approximately four months



The press level bridge truss supported on temporary columns during erection.

off the schedule while virtually eliminating RFIs, late coordination, and typical field issues.

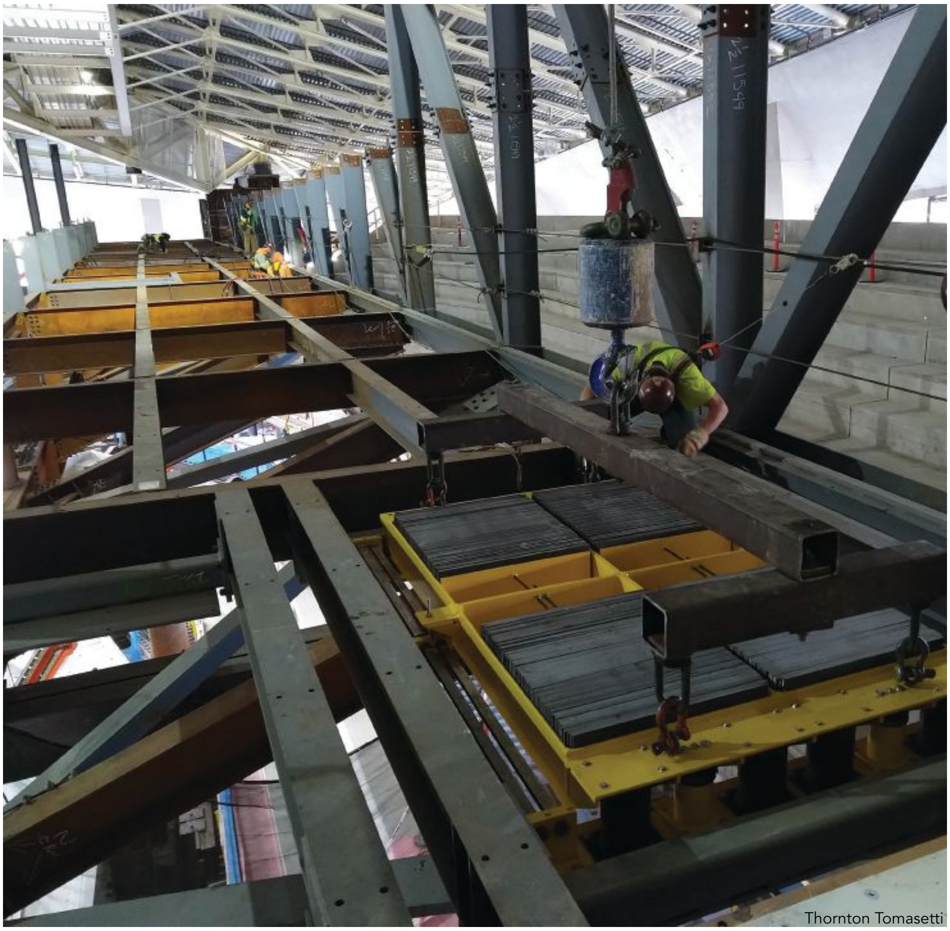
A Strong Team

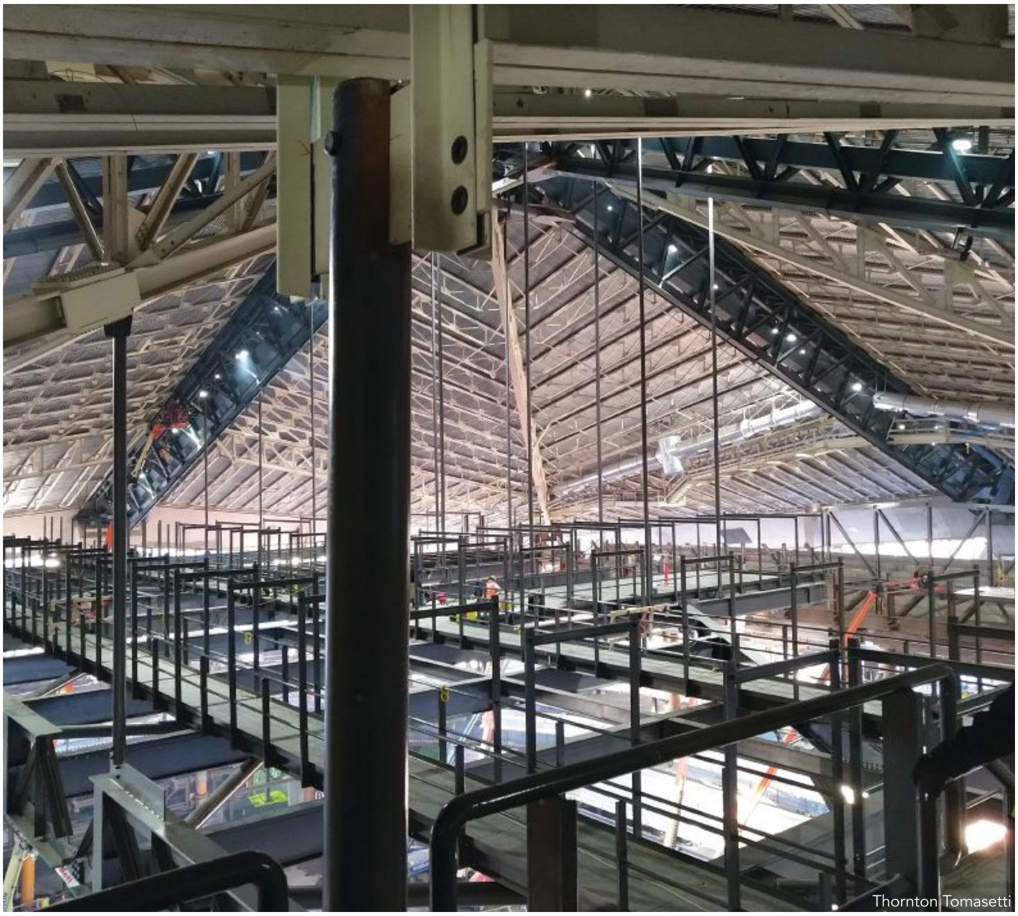
In sports, you need a strong team and an effective strategy to be the best. The same can be said for sports venue design. The efficiency of a single-source structural engineering firm collaborating with experienced and familiar fabricators and construction management was instrumental to the overall success of the Climate Pledge Arena project.

At the outset, Greg Knutson, field operations manager with Mortenson, laid out the "rules of the road" for addressing the project's many complexities. "When we come upon a challenge, it doesn't matter whose challenge it is; we will solve it together," he said. When the Seattle Kraken take to their new home ice later this year, the entire project team can take satisfaction in a job well done while cheering them on. ■

right: Installing the tuned mass dampers.

below: A new catwalk and rigging grid supported from the existing roof.


Thornton Tomasetti


Thornton Tomasetti

Owner
Oak View Group

Owner's Representative
CAA Icon

Architect
Populous

Structural Engineer
Thornton Tomasetti

Construction Manager
Mortenson

Steel Team

Fabricators
LeJeune Steel Company (AISC Certified Fabricator), Minneapolis
Corebrace, LLC/SME Steel Contractors, Inc. (AISC Certified Fabricator), West Jordan, Utah (BRBs)

Erector
Danny's Construction Company, Inc. (AISC Associate, AISC Certified Erector), Shakopee, Minn.

Detailer
LTC, Inc. (AISC Detailer), Onalaska, Wis.

A healthcare facility in western Michigan writes a new prescription for an efficient, enhanced, engaging experience.

Flipping the Script

BY ANDREA REYNOLDS, SE, PE, AND TIM TRACEY, AIA

LIKE MANY OLDER MEDICAL CAMPUSES, Spectrum Health Lakeland Medical Center in St. Joseph, Mich., is made up of multiple buildings that have been added over time, resulting in a fragmented structure and confusing navigation.

But Spectrum's leadership is changing this narrative. After initially planning a complex but small-scale operating room expansion and modernization, the leadership team—inspired by the facility's mission to improve health, inspire hope, and save lives—instead began working with engineers and architects at SmithGroup to completely re-envision the medical campus' future. With a theme of reinvention through reinvestment, the redesign included a long-range redevelopment plan, an MEP systems master plan for the entire campus, and a Phase I design encompassing a new 260,000-sq.-ft clinical pavilion and the renovation of 90,000 sq. ft of space.

The new steel-framed pavilion is a five-story building with the lower (basement) level located below grade and the first level located partially above grade. To improve site navigation, a new "main street" concourse anchors the pavilion, linking a new atrium with the main entrance of the existing facility. This multi-height concourse, which varies from one to three stories along its length, gives patients and visitors a direct line of sight into every clinical area.

The pavilion houses a comprehensive imaging suite, an advanced surgical platform, a short-stay unit, a heart center, and a new intensive care unit. A new three-story, light-filled atrium serves as the primary public space for the entire campus and includes an expansive farm-to-table café, a health concierge, and a conference center for staff and community education. And a three-story healing garden brings the outside in and offers connections to nature and a respite for patients and families year-round.

To create column-free spaces on the pavilion's lower level, SmithGroup's structural engineers designed the second and third floors to be hung from trusses above that transfer the load to adjacent columns, yielding the desired open floor plan to accommodate a 300-seat conference center.

One item that was necessary to accommodate the new patient tower and serve the campus for the next 40 years was to add parking. As such, an additional steel-framed level of parking was added to the existing three-story parking tower, and a roof was added over the top so that the entire parking garage could be used year-round, even during the harsh winters in the western Michigan snow belt.

"Every decision made on this project has been with our patients, team members, and community in mind and how we can provide them with the best overall experience possible," said Spectrum Health Lakeland's president and CEO, Loren Hamel. "Our hope

above, left, and below: The Phase I design for Spectrum Health Lakeland Medical Center in St. Joseph, Mich., encompasses a new 260,000-sq.-ft clinical pavilion and 90,000 sq. ft of renovated space.

is that through modernizations and the latest technology, we will be able to save more lives, restore health to more patients, and provide the quality health care our community needs so that they can remain close to home."

Material Selection

Both concrete and steel were considered to frame the new pavilion, renovations to the existing hospital, and the parking garage expansion. Ultimately, structural steel was selected for all three areas since it best aligned with the project schedule (and winter building conditions), locally available material and trades, economics, and its ability to accommodate the design opportunities and architectural vision.

Structural steel columns supporting composite steel beams and girders provided a straightforward framing system for much of the new pavilion. The floor framing and slabs, comprised of composite deck with normal-weight concrete fill, were designed to meet vibration criteria in addition to the required loading scenarios. (The team used AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity*—**aisc.org/dg**—to address vibration criteria, which was as stringent as 4,000 micro-in./sec. for the operating rooms.) Steel braced frames provided the solution for lateral resistance and were carefully placed to align and blend in with the various interior spaces.

Where steel proved to be most beneficial was economically creating the large column-free spaces that were desired on the lower level. SmithGroup's design incorporated 60-ft- and 80-ft-long, floor-height steel trusses to create the open conference space without having an impact on floor-to-floor or overall building heights. The steel framing scheme also addressed some of the more intricate areas, such as the interstitial space above the

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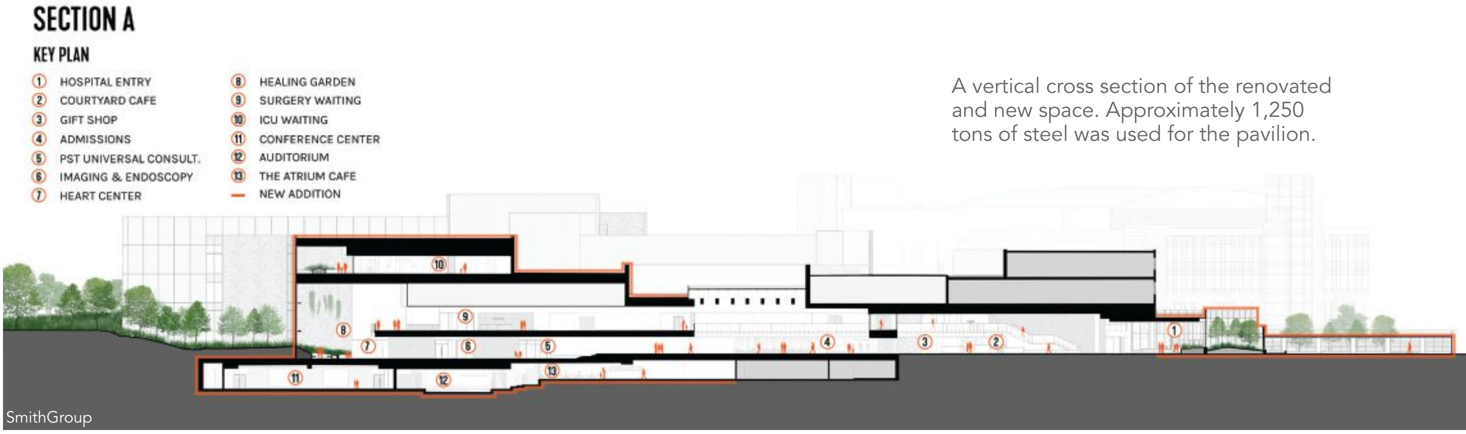


SmithGroup

A vertical cross section of the renovated and new space. Approximately 1,250 tons of steel was used for the pavilion.

laboratory/surgery spaces and the large-volume open atrium space.

The adjacent existing hospital was primarily framed with structural steel, and using steel for the renovations proved to be efficient in re-supporting existing slabs, roofs, and framing where new openings for skylights and MEP were being added; framing the entrance expansion at the emergency department; and re-supporting the existing framing where large portions of the second floor were being demolished to create the main street concourse.

Structural steel was also used for the vertical expansion of the parking garage. The existing garage is a traditional precast concrete parking structure, and the initial expansion concept was to simply add two new levels of precast framing above the existing level. However, it quickly became apparent that the weight of two additional levels of concrete would have a negative effect on the existing structural framing and foundations. To maximize the amount of additional parking that could be gained while minimizing the financial impact and extent of reinforcing, additional options were explored. These included adding one level of precast framing, adding two levels of steel-framed parking, adding one level of steel-framed parking with a steel-framed roof, and adding just a steel-framed roof. Ultimately, the reduced weight impact of adding one steel-framed parking level and a steel-framed roof provided the best balance of additional covered parking, structural impact, and economics. For the roof, light-gauge steel joists were implemented to achieve the 60-ft spans and further minimize steel tonnage and reduce costs. For corrosion protection, all structural steel for the parking garage addition was hot-dip galvanized. The new level is clad with precast to give the same appearance from the exterior, so the vertical expansion looks like it's always been there.

SmithGroup

SmithGroup

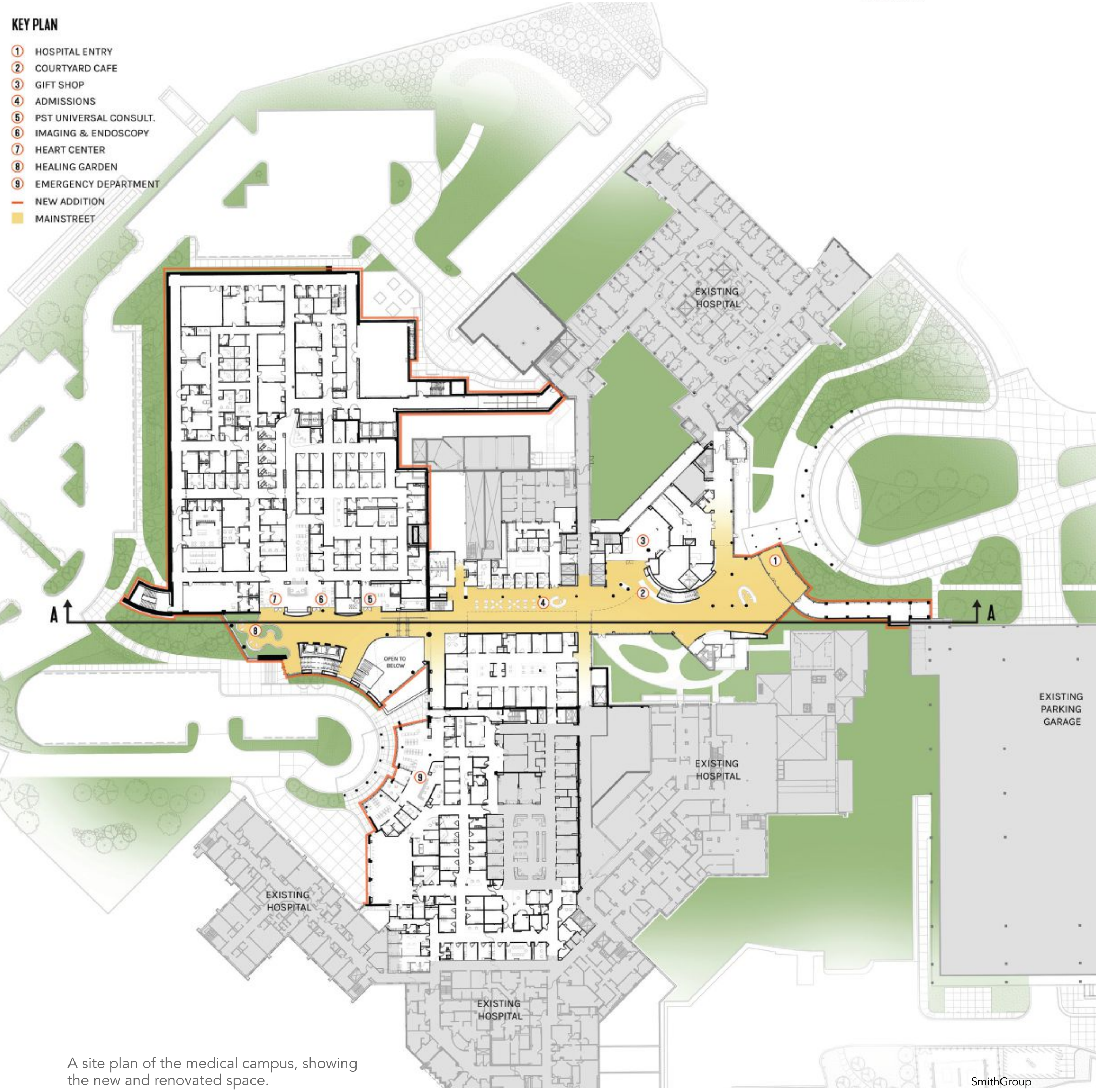
above and right: Adding one steel-framed parking level and a steel-framed roof provided the best balance of additional covered parking, structural impact, and economics.

Column-free Conference Center

For the pavilion, the biggest structural challenge—or rather opportunity—was to realize the owner's dream of creating an expansive new conference space. While the existing hospital did contain a conference space, the presence of columns in the space made it challenging to use or even re-plan. Thus, a new, more functional conference space was a high priority in the new portion of the hospital. For access, space planning, and functionality, placing this room on the lower level was also important. Naturally, constructing a new four-story building above this space required some creativity, and a handful of priorities were established to best achieve the design intent.

The first priority was, again, to make the conference center column-free. The original concept considered creating a 140-ft by 83-ft column-free space. Recognizing that this scenario would prove inefficient from a cost perspective and also be difficult to achieve given spacing constraints, the design team instead created two column-free zones: one that could accommodate as many as 300 people in one space or be divided into six separate rooms, and a second area that would include a small, tiered auditorium. A line of columns was placed between the two areas to reduce the truss spans to 80 ft and 60 ft on either side.

The second priority was to align the elevations of the floors for the new pavilion with the floor levels of the existing building, which are relatively low, particularly at the lower level. Simply providing long-span framing directly above the conference space was challenging as the floor height could not accommodate the framing depth



A site plan of the medical campus, showing the new and renovated space.

SmithGroup

required to maintain the load and vibration performance necessary on the first floor above. And removing the first floor above the conference space or dropping the lower level were both ruled out. Thus, the concept of providing floor-height trusses was born as this would lower the required steel tonnage and easily accommodate the floor vibration requirements.

The third priority was to maintain a regular 30-ft by 30-ft bay spacing for the framing supporting the upper levels to align with the lower levels and keep the first and second floors visually open to the greatest extent possible. The bay spacing governed the truss configuration, aligning truss panel points with column placement. While the design intent and space planning for the first and second floor complicated the idea of floor-height trusses in terms of placement, the planning for the catheter labs and surgery spaces on the third floor provided the ideal location for the trusses in the demising walls. The trusses were located with the bottom chord supporting the third floor and the top chord supporting the fourth floor. The first and second floors were then suspended from trusses with hangers located on the regular bay spacing. The roof over the fourth floor is supported by posts above the truss that also align with the regular column spacing.

While achieving the column-free conference center was one of the project's most significant challenges, it became one of the most rewarding aspects since the team was able to create a more useful and usable space for the hospital without disrupting the various other programming areas.

A New Experience

The main street concept for the concourse that links the new pavilion with the existing hospital has brought a whole new experience to the medical center, introducing a large atrium in the new pavilion and new skylights and floor openings within the existing building. In the initial plan, a large portion of the second floor was to be removed to open up the main street, two existing columns from the first floor to the third floor would have been removed while keeping the hospital in service above, and additional framing would have been provided above the roof to hang the third- and fourth-floor portions of the existing columns that were to remain above the third floor. But due to budgetary and programmatic reasons, the owner ultimately elected to only remove floor framing from the second floor and leave the existing columns in place.

The lateral system for the new pavilion was conceptually simple, but the geometry of the building made the analysis complex. This complex geometry included discontinuous columns above the conference area and open areas and discontinuous slabs in the dining, lobby, and healing garden spaces in the main street area. In addition, approximately one-third of the third floor consists of interstitial space with no floor diaphragm, the northern portion of the third floor contained a mechanical room (and the floor was offset at a higher elevation to create more ceiling space for future operating rooms below), and there was no floor in the northern portion of the building to create the vertical height needed within the mechanical room. The architectural preference was to use moment frames. However, the structural and construction team pushed for braced frames to reduce steel tonnage and connection costs. The design team chose to locate the braced frames in areas that did not affect space planning and would transfer the lateral loads from the discontinuous diaphragms, through the building, and to the foundations.

Structural steel columns supporting composite steel beams and girders provided a straightforward framing system for much of the new pavilion. Steel braced frames provided the solution for lateral resistance and were carefully placed to align and blend in with the various interior spaces.

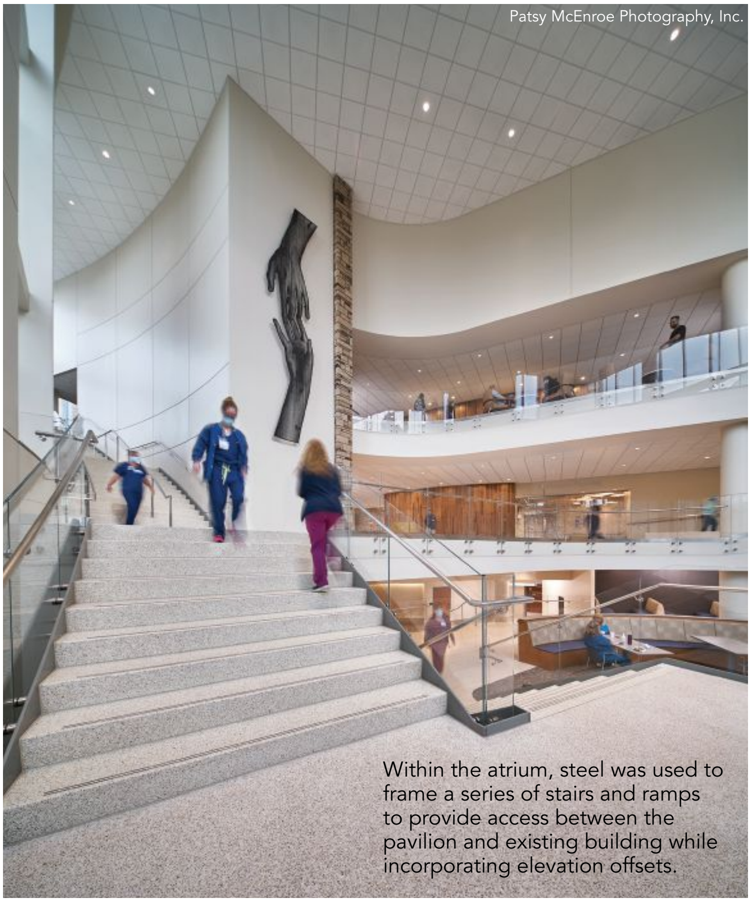
Thankfully, due to additional soil investigation, the site class was determined to be C, which resulted in a Seismic Design Category A classification versus a C classification, resulting in wind governing the overall lateral design. But due to the new pavilion being built directly adjacent to the existing one and with as many as two stories of the new pavilion being located below grade, there was a hefty unbalanced soil load to contend with. As such, the floor diaphragms below grade were tied to the floor diaphragms within the existing building to counteract the sliding and overturning from the unbalanced soil.

Steel framing was also used to form the curved southern façade along the atrium, which helps soften the approach to the adjacent emergency department. The façade consists of alternating portions of curtain wall and precast concrete, and steel columns are spaced to laterally support the precast yet disappear in the wall enclosure to give the appearance that the precast is self-supporting. Exposed horizontal steel framing was introduced to laterally support the curtainwall and reduce the size of the mullions, and was carefully placed to obscure the connections to the columns so that the need for architecturally exposed structural steel (AESS) finish requirements and intumescent coating were limited to the members only and not the connections. Within the atrium, steel was also used to frame a series of stairs and ramps to provide access between the pavilion and the existing building while incorporating elevation offsets.

Integrated Approach

The project team entered an integrated project delivery (IPD) agreement in which the various members began collaborating on the design, scheduling, and construction early in the project. Bi-weekly "big room" meetings were conducted to gather the entire team together, and as systems were selected, trade partners were brought into the meetings to collaborate with the project team. This collaboration between the client, design team, and construction manager assessed potential structural systems and materials balancing design intent, code requirements, schedule, costs, and constructability.

Once the decision was made to use structural steel, Steel Supply and Engineering was selected as the steel fabricator and worked side by side with the design team and construction manager to establish the project schedule and work through design and detailing decisions. Much of the 3D structural analysis was performed with RAM Structural Systems and RISA 3D, Autodesk Revit was used to document the structural drawings, and SDS/2 was used to detail the steel. Armed with the various models, the project team would review and update the framing in real time, reserving contract documents and shop drawings more for permitting and record purposes. As the project moved into construction, the partnering continued as the project team worked through the various challenges and opportunities.



Patsy McEnroe Photography, Inc.

Within the atrium, steel was used to frame a series of stairs and ramps to provide access between the pavilion and existing building while incorporating elevation offsets.

Input from Steel Supply and Engineering was crucial in the development of the framing concepts and locations for the trusses and the hanging framing. Evaluating costs and constructability early in the design process informed the best approach, and the IPD method ensured success. As the parking garage expansion was introduced into the project, input from both the precast and the steel team was used to assess potential options for the vertical expansion—again, with steel coming out (literally) on top.

Thanks to making the most of structural opportunities, this addition and renovation project—which was accomplished while the existing facility remained operational—has redefined the experience for Spectrum Health Lakeland patients, visitors, and staff and aligned the facility perfectly for potential future expansion. ■

Owner
Spectrum Health Lakeland, St. Joseph, Mich.

General Contractor
Turner Construction Company, Detroit

Architect and Structural Engineer
SmithGroup, Chicago and Detroit

Steel Team

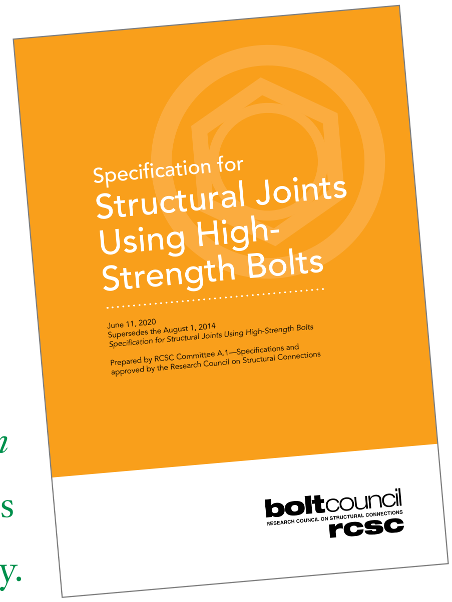
Fabricator
Steel Supply and Engineering (AISC Certified Fabricator), Grand Rapids, Mich.

Detailer
Universal Detailing, Inc. (AISC Detailer), Lansing, Mich.

Bender-Roller
Chicago Metal Rolled Products (AISC Associate), Chicago

Bolting Ahead

BY LARRY KRUTH, PE



The latest version of the *RCSC Specification* marks one of the most significant revisions to the document in its 70-year history.

Larry Kruth (**kruth@aisc.org**) is AISC's vice president of engineering and research and is also chair of the RCSC Specification Committee.

TECHNOLOGY DRIVES CHANGES in structural steel design, fabrication, and erection.

And while the word "technology" might invoke images of high-tech machinery and software, it also applies to one of the oldest and most quintessential icons of steel construction: bolts.

First published in 1951, the *RCSC Specification for Structural Joints Using High-Strength Bolts* has been regularly updated to reflect bolting innovations as they come into being and evolve. The latest version of the specification was published last year by the Research Council on Structural Connections, marking one of the substantial revisions since its inception. Here are a dozen of the most significant changes from the last version, which was published in 2014.

1 Bolted connections in structural steel have always prohibited non-steel elements in the connections. That remains true in the 2020 *Specification*, but there is now a discussion of thermal break joints in the Section 1 Commentary.

2 Changes in turn-of-nut and calibrated wrench installation methods may interest some users. Previously, the turn tolerance in the turn-of-nut method permitted a plus 60° and minus 30° workmanship tolerance from the specified angle of rotation. The specification now permits a plus 60° degrees and minus 0° workmanship tolerance on turns, as shown in Table 8.1. The other change is that the calibrated wrench method can now only be used where the nut is the turned element. This is a response to the recognition that friction on a turned head may result in reduced pretensions due to different friction on the bearing face or possibly the bolt body or threads binding in the hole.

Table 8.1
Nut Rotation from Snug-Tight Condition for Turn-of-Nut Method Pretensioning[a,b]

Bolt Length[c]	Disposition of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis, Other Sloped Not More Than 1:20[d]	Both Faces Sloped Not More Than 1:20 from Normal to Bolt Axis[d]
Not more than $4d_b$	⅓ turn	½ turn	⅔ turn
More than $4d_b$ but not more than $8d_b$	½ turn	⅔ turn	⅚ turn
More than $8d_b$ but not more than $12d_b$	⅔ turn	⅚ turn	1 turn

a Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For all required nut rotations, the tolerance is plus 60 degrees (⅙ turn) and minus 0 degrees.
b Applicable only to joints in which all material within the *grip* is steel.
c When the bolt length exceeds $12d_b$, the required nut rotation shall be determined by actual testing in a suitable *bolt tension measurement device*; see *turn-of-nut* Commentary.
d Beveled washer not used.

3 The new ASTM F3148, 144-ksi bolt has been added to the specification. This new bolt may look like a tension control (TC) bolt, but it is installed differently. Contrary to TC bolts, the splined end remains on the bolt throughout the installation; it does not snap off. This makes the nut end of the assembly longer, but it eliminates the need to dispose of severed splines or touch up the ends of coated bolts. F3148 is of a higher strength than Grade A325/F1852 bolts and can be mechanically galvanized. These bolts are installed to a pretensioned condition using the newly added combined method, which is described in Section 8.2.5.

4 The combined method is a pretensioning technique that relies upon an installation wrench that has been calibrated to provide the initial torque to attain the required initial tension, followed by the application of the relative rotation between a bolt and nut. Note that these bolts are close enough to the A490 level of tensile strength that they are pretensioned to the same level and achieve the same slip resistance as Grade A490/F2280 bolts.

5 The ASTM bolt specifications are now cited using the current standard designation. F3125 with the appropriate grades (Grades A325, A490, F1852, and F2280) is now listed in the *RCSC Specification*. (The 2014 edition was published before ASTM F3125 was published, so that version contained the older designations.) In the 2016 edition of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360), rather than use the long names for the bolts, such as F3125 Grade 325, bolts were designated as various Groups. Group A bolts were A325 strength level and Group B bolts were A490 strength level. In the new *RCSC Specification*, the "Group" names now reflect the bolt unit strengths in ksi. For A325 strength levels, the bolts are Group 120; for A490 strength levels, the bolts are Group 150; and for F3148, the bolts are Group 144.

Table 5.2
Minimum Bolt Pretension, Pretensioned and Slip-Critical Joints

Nominal Bolt Diameter, d_b, in.	Specified Minimum Bolt Pretension, T_m, kips	
	Group 120	Group 144 and Group 150
½	12	15
⅝	19	24
¾	28	35
⅞	39	49
1	51	64
1⅛	64	80
1¼	81	102
1⅜	97	121
1½	118	148

6 Table 5.2: Minimum Bolt Pretension, Pretensioned, and Slip-Critical Joints has been relocated from Section 8 Installation to more accurately reflect that this is used first and primarily in the design of slip critical connections. For 1⅛-in.-diameter and larger Group 120 bolts, the minimum pretension values have increased to reflect that these bolts are now made to a minimum tensile strength of 120 ksi rather than 105 ksi as required in the old ASTM A325 standard.

7 Hot-dip galvanized faying surfaces are no longer required to be hand wire-brushed for slip-critical connections. Previous research indicated that galvanized surfaces could have low slip resistance that could be increased by roughening. Prior versions of the *RCSC Specification* included a requirement to hand wire-brush galvanized surfaces in slip-critical joints. More recent research has shown roughening does not help, and council members speculate that obsolete post-galvanizing treatments are the source of the difference. For this reason, hand wire-brushing of hot-dip galvanized faying surfaces is now prohibited. Therefore, it is important to know what edition of the specification is required in the design documents.

8 Structural bolts are manufactured to the dimensional requirements of ASME B18.2.6. This dimensional standard includes tolerances that can be inconsistent with RCSC hole size requirements. This conflict has become more prevalent recently as equipment has been developed, permitting the installation of large diameter bolts more frequently. There have been cases where larger-diameter bolts have a swell or fin under the head, preventing them from fitting completely into a hole that is only 1⁄16 in. larger than the bolt diameter. For this reason, standard holes for all bolts 1 in. in diameter and larger are now permitted to be ⅛ in. larger than the bolt diameter. This change is supported by many past research projects dating back as early as 1960 that showed no adverse effects on the bolt shear or member bearing strength on using these larger holes.

Table 2.5
Bolt Lengths Required to Be Fully Threaded in Accordance with ASME B18.2.6

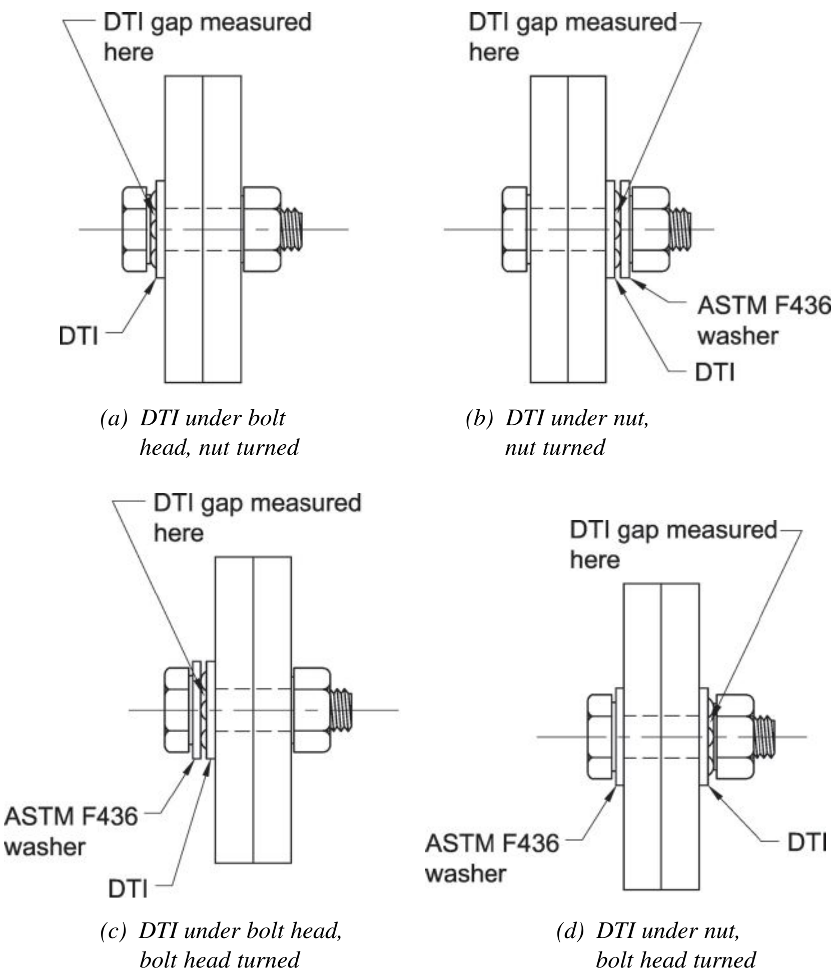
Nominal Bolt Diameter, d_b, in.	Bolt Length, L, in.
½	1¼
⅝	$L \le 1½$
¾	$L \le 1¾$
⅞	$L \le 2$
1	$L \le 2¼$
1⅛ & 1¼	$L \le 2¾$
1⅜ & 1½	$L \le 3¼$

9 A new Table 2.5: Bolt Lengths Required to Be Fully Threaded in Accordance with ASME B18.2.6 has been added. Structural bolts are commonly cold-formed with rolled threads. This manufacturing process requires a transition area between the bolt body and the rolled threads. This transition area is smaller than the shank of the bolt. If the shear plane falls in this area and the design calls for threads excluded from the shear plane, there may be a reduced capacity. Previous RCSC commentary noted that this strength reduction might be negligible, but a more conservative approach is taken in the 2020 revision, requiring shear planes in the transition to be considered threads included.

This is due to the fact that ASME B18.2.6 does not require a maximum for the threaded length nor a set dimension for the unthreaded shank of the bolts. Table 2.5 was added to the specification to alert the user that the bolt should be considered as fully threaded for bearing bolt installation conditions for each diameter listed if the bolt length matches the length listed in the table. Bolts of the diameter and length indicated in Table 2.5 shall

Commentary:
Direct tension indicators are recognized in this Specification as a *bolt tension measurement device*. *Direct tension indicators* are washer-shaped devices incorporating small arch-like protrusions on the bearing surface that are designed to deform in a controlled manner when subjected to compressive load.

During installation, care must be taken to ensure that the *direct tension indicator* protrusions are oriented to bear against the hardened bearing surface of the bolt head or nut or against a hardened flat washer if used under the turned element, whether that turned element is the nut or the bolt. Proper use and orientation is illustrated in Figure C-8.1.



Note: See Section 6 for general requirements for the use of washers.

Figure C-8.1. Proper use and orientation of ASTM F959 direct tension indicators.

Table 2.6
Permitted Coatings for Bolts, Nuts and Washers

Specification	Bolt	Nut	Washer
ASTM F1136	Grade 3	Grade 5	Grade 3
ASTM F2833	Grade 1		
ASTM F3019	Grade 4		

not be designed using the "X" condition, with threads excluded from the shear plane. These bolts can only be used in the "N" condition, with threads included in the shear plane, and as slip-critical bolts. (For more information, see the December 2020 article "The Short Shank Redemption" in the Archives section at **www.modernsteel.com**.)

10 Section 7: Preinstallation Verification has been substantially revised and reorganized to more accurately reflect each step required to be performed for preinstallation verification testing. There are now distinct steps for the turn-of-nut method, calibrated wrench method, twist-off tension control bolt method, direct tension indicator method, and the new combined method for F3148 bolts. In addition, Table 7.1: Minimum Bolt Pretensions for Pre-Installation Verification has been revised to mirror the new pretension requirements listed in Table 5.2 for Group 120 Bolts of $1\frac{1}{8}$-in. in diameter and larger.

11 The 2014 *RCSC Specification* only permitted ASTM F1136 coatings for Grade A490 bolts. There are now three coating standards permitted for use for Group 150 bolts: ASTM F1136, F2833, and F3019. These coatings are available in various grades. Table 2.6 shows which coatings and grades are permitted on structural bolts, nuts, and washers. As these coatings were developed and tested, they were designated in individual ASTM standards. Recently, an "umbrella" ASTM standard, F3393, was developed and approved, but it was too late to be included in the 2020 *RCSC Specification*. This new umbrella standard should be considered by those specifying coated Group 150 bolting components.

12 As in previous versions of the *RCSC Specification*, the faying surfaces of slip-critical connections can be clean mill scale or coated with a "qualified" coating. Differences in the 2020 version include a new limit on the duration of the coating qualification and the addition of "degree of cure" as an essential variable. Coatings must now be retested every six years, and coated faying surfaces shall not be assembled into connections until the coating has fully cured.

These are just a few of the updates to the 2020 *RCSC Specification*. You can download a PDF of the document (as well as the latest version of the AISC *Specification*) for free at **aisc.org/specifications**. ■

How can the steel industry drive true innovation?

conference preview

DRIVING INNOVATION

BY W. STEVEN HOFMEISTER, SE, PE

WITH THE MATURATION of 3D building information modeling (BIM), cloud computing, automation, and model-based project delivery methods, the steel design and construction industry should be on the cusp of disruptive innovation. However, in all too many instances, it's been business as usual.

To provide a clearer picture of how the steel design and construction community can best leverage technology to create better and more efficient projects, I and my fellow presenters, Thomas Z. Scarangello, executive chairman of Thornton Tomasetti; Don Banker, CEO of Banker Steel; and Chet McPhatter, Banker's president, will discuss some of the challenges that large-scale, predominantly fast-track steel projects can face—and how these challenges can thwart true innovation. Without the adoption of new technologies and informed collaboration between all parties, a project team can't successfully implement innovation to the benefit of the overall project. For the industry to realize true innovation, all involved parties need to recognize and address the impediments to progress.

The good news is that the technology available to design and construction teams is continuing to evolve at an incredible pace. Progressive design firms are developing interoperability, automation, and artificial intelligence (AI)-driven design tools to support the rapid study, conceptual development, design, and delivery of projects, from simple to complex, and to do this with a compressed schedule while delivering enhanced detail. 3D detailing has been widely available for more than 20 years. Virtually every project is now detailed to drive CNC fabrication and robotic assembly as well as site-dimensional control equipment. Construction managers are implementing 3D and 4D virtual construction models that would ideally be built upon models created by designers and fabricators. These technologies can all be used to create "digital twin" models. And these models can be used throughout the entire life-cycle of the structure, allowing the owner to make more informed decisions.

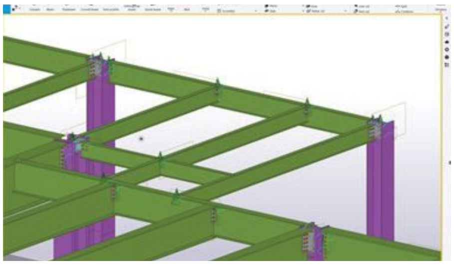
Many design firms have developed interoperability and automation tools and added steel detailing professionals to their rosters. This enables the delivery of real models ready for fabrication, thereby facilitating enhanced collaboration, improved project schedules, fewer conflicts, and better quality. Projects delivered on fast-track schedules with early steel fabricator involvement can incorporate enhanced construction means and methods in a design, subsequently improving cost, schedule, and quality.

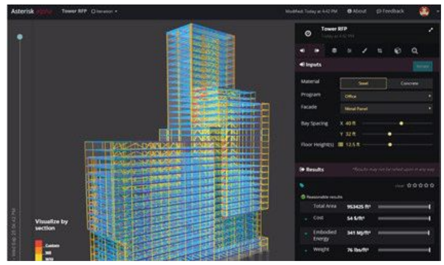
Oftentimes, the implementation of all of these innovative tools and the potential of a design-assist approach are not used to their full collaborative capacity due to the complex nature of modern contracting and project delivery methods. Too many design contracts and schedules are still built around a conventional design-bid-build delivery method, which can put more stress on the structural design and construction teams at the onset of a project. (For more on the design-assist approach, see the January 2021 article "Design-Assist: What It Is, Why It's Beneficial," available in the Archives section at **www.modernsteel.com**.)

Steven Hofmeister (**shofmeister@thorntontomasetti.com**) is a managing principal with Thornton Tomasetti.

NEED FOR SPEED

AISC's Need for Speed initiative recognizes technologies and practices that make steel projects come together faster. Check out **aisc.org/needforspeed** for more.





Owners frequently choose design teams based on their fees rather than qualifications and successful experience with the given project type and delivery method. This cost selection method also extends to the CM, which is often chosen before the design team. CMs, in turn, often select steel contractors from "bids" that are based upon schematic design (SD) or design development (DD)-level drawings without adequate allowances and contingencies to account for the final design. Note that AISC is attempting to positively influence this challenge by updating the *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303, **aisc.org/specifications**) to specifically address the needs of fast-track and other types of early procurement projects.

Thornton Tomasetti and Banker Steel are staunch supporters of the design-assist process and other progressive methods of teaming. But the expectations for these processes are often not well defined or communicated. In a design-assist project, all parties must behave differently than they would in a more traditional design-bid-build scenario. Designers must accept, or better yet, seek out, input from construction experts. Design-assist contractors must understand the design process and learn how to influence design at early stages. Their input can range from early non-binding cost and scheduling advice to technical consultation resulting in significant structural system improvements. Design-assist can even be extended to include the delegated design of major components of the structure. When this process is clearly communicated and managed, it almost always leads to a successful project outcome. When not properly implemented and managed, it can be commercially disastrous. Fortunately, AISC has collaborated with the American Institute of Architects (AIA) to develop guidelines for successful design-assist, and the Design-Build Institute of America (DBIA) continues to support design and construction collaboration as well.

Collaborative teams will always outperform those that are non-collaborative. We believe the owner has the greatest ability

to drive the collaboration throughout the course of the project, followed closely by the CM's influence. Conversely, owners also have the ability to pit the design and construction sides against each other by encouraging "behavior by contract," following contracts that are often one-sided and not tailored to the needs of the project.

If we want to talk about true innovation, why all the focus on contracts and other behaviors that are perceived to be largely out of our control? First of all, we are not willing to concede that we cannot influence contracts and behavior related to our projects. Secondly, and most germane to this discussion, we need to address the contractual and relationship challenges first to really be able to take full advantage of the innovation potential of technology. True innovation comes when you have the right tools and a culture of collaboration where all participants are singularly focused on a project's success. ■

This article is a preview of the session "How Can the Steel Industry Drive True Innovation?" which will be presented at the 2021 NASCC: The Steel Conference. The conference takes place online April 12-16. For more information and to register, visit ***aisc.org/nascc****.*

conference preview

KEEP ON MOVING

BY CHARLIE WOODS, PE, TEMPLE OVERMAN, PE, AND JOSE MARES, PE

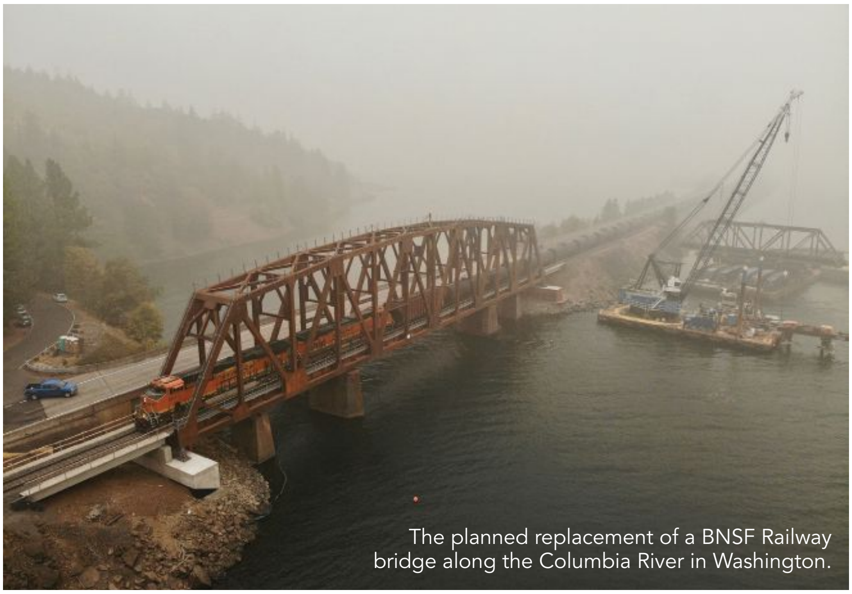
When a railroad bridge is taken out of commission, the most important consideration isn't what caused the outage but rather that bridge is replaced quickly.

Charlie Woods (**chwoods@hntb.com**) and **Temple Overman** (**toverman@hntb.com**) are both with project engineers with HNTB, and **Jose Mares** (**jose.mares@bnsf.com**) is director of bridge engineering with BNSF Railway.

RAILROAD BRIDGE OUTAGES can bring things to a grinding halt.

Of course, when they're known in advance, they can be accommodated and worked around. But when they result from a natural disaster, the impact is amplified.

In either case, replacement needs to happen as quickly as possible. This NASCC: The Steel Conference session discusses the rapid replacement of two steel railroad bridges: one that was planned and one that was a surprise.



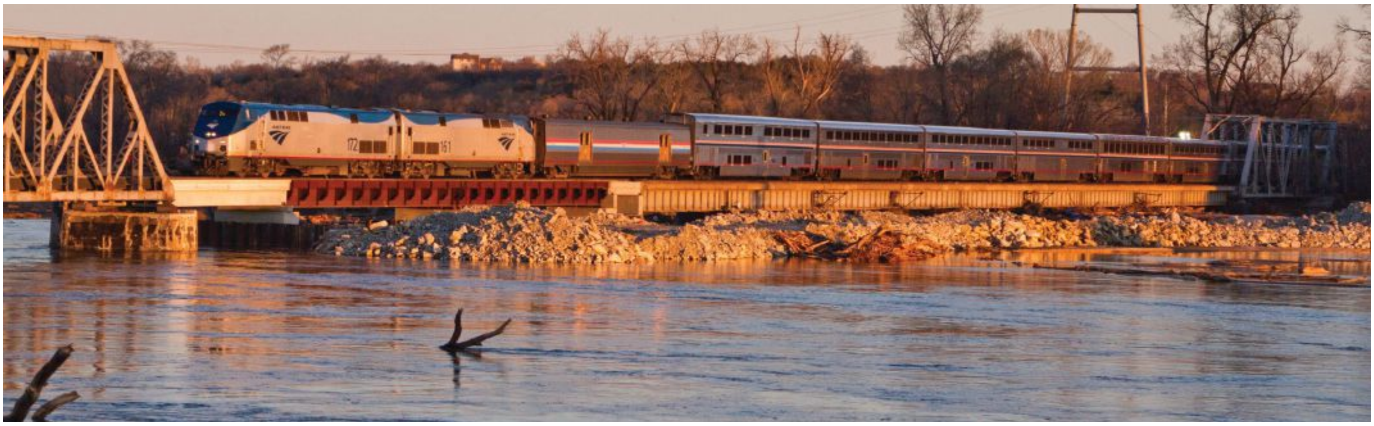
The planned replacement of a BNSF Railway bridge along the Columbia River in Washington.

Planned Outage

The first project was the design and construction of a replacement span for BNSF Railway's Bridge No. 66.40, located along the Columbia River near Cook, Wash. The online replacement of the existing 108-year-old pin-connected steel truss sandwiched between the Columbia River and the Lewis and Clark Highway/Route 14, and adjacent to a popular fishery at Drano Lake, presented extremely challenging site constraints, environmental permitting restrictions, and weather conditions. The design team was tasked with minimizing impacts to railroad operations at this significant, high-volume route for the BNSF. In addition, the design had to avoid impacts to both the foundation of the existing railroad bridge, which remained in service throughout construction, and to the foundations of the adjacent highway bridge.

We'll discuss how the design and construction plans were developed to mitigate and overcome each of these challenges—specifically, HNTB's work to address the contractor's challenges and develop appropriate solutions—as well as highlight the design alternatives HNTB proposed during construction to decrease the impacts on railroad operations.

Replacing a damaged BNSF Railway bridge over the Platte River near Omaha. The completed replacement is shown below.



Surprise Outage

Record flooding in 2019 caused major damage to infrastructure in the Midwest. A primary example is BNSF Bridge 0.95 near Omaha, which crosses the Platte River. Built in 1922, the 1,439-ft-long bridge is an important line on BNSF's Omaha subdivision. On March 13th, 2019, a bomb cyclone occurred in an area, which was already inundated with melting winter snow, and three days later the Platte River crested at its highest-ever recorded level. The flooded river carried large amounts of drift that dislodged spans in an adjacent upstream bridge, which then subsequently washed out three spans on Bridge 0.95, disrupting freight train and Amtrak traffic along the route. The affected spans consisted of a 94-ft-long through-plate girder and two 60-ft-long deck-plate girders supported on concrete piers and timber piles. BNSF led and coordinated recovery efforts, HNTB completed the design and provided construction inspection services, and Ames Construction completed around-the-clock construction to rebuild the bridge. The replacement foundations consisted of driven steel H-piles, which were welded to precast concrete pier caps. Sheet piling was used as a cofferdam around the new piers to facilitate welding the piles to the caps and was filled with concrete to serve as pier protection. The replacement superstructure consisted of two 75-ft-long steel deck plate girder spans that were available from BNSF's emergency stock, in addition to two precast concrete spans. By using steel elements in the substructure and superstructure, the team was able to reconstruct the 215-ft length of washed-out bridge in less than one month. ■

This article is a preview of the session "Railroad Bridges: Keep Those Trains Moving," which will be presented at the 2021 NASCC: The Steel Conference. The conference takes place online April 12-16. For more information and to register, visit ***aisc.org/nascc****.*

conference preview

LEGAL LINEUP

BY EDWARD SEGLIAS

This year's NASCC: The Steel Conference will feature a range of legal-related sessions, presented by law firm Cohen Seglias.

Edward Seglias (**eseglias@cohenseglias.com**) is an attorney with Cohen Seglias' Construction Department and is AISC's general counsel.

LEGAL MATTERS, WELL, MATTER.

Legal considerations are a crucial part of any construction project, and it's important to get a handle on them to protect yourself, your employees, and your customers. This year's NASCC: The Steel Conference will offer an illuminating educational experience geared toward informing attendees about a host of important technical and legal topics ranging from contract documents to navigating the new landscape of legalized recreational cannabis.

Here is a brief synopsis of five legal sessions that will be presented at this years' conference.

Marijuana and the Workplace: How to Prioritize Safety While Avoiding Liability. A growing number of states have legalized marijuana not only for medical purposes but also for recreational use. Far from a purely academic discussion filled with meaningless legal jargon, in this fast-paced presentation we will discuss real-life situations and provide nuts-and-bolts guidance. We will cover a variety of common issues, including pre-hire drug screening, post-accident and reasonable suspicion testing, zero-tolerance policies, progressive discipline, leaves of absence, and processing medical documentation. We will also explain the rules of the road for employers to maintain a safe working environment while avoiding liability for breach of privacy and disability discrimination claims.

This program is one hour long and will be presented by Jonathan Landesman, co-chair of Cohen Seglias' Labor and Employment Department.

Delay and Inefficiency Claims: Making Your Best Case. Delay and inefficiency claims do not immediately announce themselves. They have to be spotted, documented, and communicated to your contracting party, whether a general contractor or owner. So how are they properly documented and communicated?

In this program, we will discuss those measures that an erector or a fabricator must take to preserve and present information supporting delay and inefficiency claims in a timely and compelling manner. We will also teach attendees to be aware of contractual provisions that require notice of claims, content of claims, and other legal requirements that may affect the likelihood of success of the delay or inefficiency claims. Finally, we will explain the importance of documenting events, timelines, and costs to best position erectors and fabricators to recover delay and inefficiency damages.

This program is one hour long and will be presented by George Pallas, CEO of Cohen Seglias and a member of its Construction Department. George is also assistant general counsel to AISC.

Killer Contract Provisions and Managing Risk. Rarely are two contracts identical. But many contracts contain common provisions that have been interpreted by courts and therefore have developed a common meaning or understanding.

Learn which provisions in contracts shift the most risk to a fabricator and/or an erector, including payment risk, design risk, schedule loss, design changes, and material pricing. The session will focus on helping members understand the risks associated with certain provisions so that a bid properly considers or excludes risks as may be necessary. We will also discuss strategies to negotiate terms that account for things that are not within your control. Anytime you can improve your knowledge and understanding of key contract provisions, you will be better skilled to negotiate contracts prior to bid submission and after award.

This program is one hour long and will be presented by Jason Copley, chair of Cohen Seglias' Construction Department and assistant general counsel to AISC.

Understanding Commercial General Liability and Builders Risk Policies: What Covers What? Any competent fabricator or erector will understand its scope of work and contract obligations. But how well do they know the coverages that are provided in a commercial general liability policy or the coverages that are excluded? And builder's risk: What is that even for?

In this presentation, we will discuss the relationship between coverages provided under commercial general liability and builder's risk policies. We will also discuss the differences between these two policies and review real-world claim examples so that you can better protect your company when a claim or loss arises.

This program is one hour long and will be presented by Jonathan Cass, chair of Cohen Seglias' Insurance Coverage and Risk Management Group.

Design-Assist 2.0: Updates and Experiences. At last year's NASCC, we provided a general review of the design-assist concept and discussed the related contracting provisions, informal involvement, and delegated design. Since that program, the AIA and AISC have released a paper on design-assist, which further helps clarify the definition of design-assist, what it is, and what it is not: *Design Collaboration on Construction Projects Part I: Delegated Design, Design Assist, and Informal Involvement—what does it all mean?* (For more on design-assist and this paper, see the January 2021 article "Design-Assist: What It Is, Why It's Beneficial," available in the Archives section at **www.modernsteel.com**.)

In this years' program, we will review sections of the AIA-AISC paper to further explore the purposes and limitations of design-assist and also the various activities that can be incorporated into a design-assist program. This program will help better equip fabricators to cope with new and innovative program delivery formats that seek to accelerate both design and construction while at the same time minimizing claims and delays due to unexpected design issues or scope of work changes.

This presentation is one hour long and presented by me. ■

For more on these 2021 NASCC: The Steel Conference legal sessions—and to register for the conference—visit ***aisc.org/nascc****. The conference takes place online April 12-16.*

conference preview

MOVING BRIDGES FORWARD

BY ASHLEY P. THRALL, PhD, AND JASON PROVINES, PE

Corrosion-resistant steel bolts and built-up press-brake-formed tub girders are showing promise.

Ashley P. Thrall (athrall.nd.edu) is the Myron and Rosemary Noble Associate Professor of Structural Engineering in the Department of Civil and Environmental Engineering and Earth Sciences at the University of Notre Dame, and **Jason Provines** (jason.provines@vdot.virginia.gov) is a research scientist with the Virginia Transportation Research Council and the Virginia Department of Transportation. **Mirela D. Tumbeva**, University of Notre Dame; **Theodore P. Zoli** and **Thomas M. Bieneman**, HNTB Corporation; **Stephanie Wagner** and **Prince Baah**, Indiana Department of Transportation; and **Vin Bartucca**, National Steel Bridge Alliance, contributed to the PBTG portion of this article.

THE STEEL BRIDGE INDUSTRY strives to advance the state-of-the-art, and innovative methods and technologies can manifest in different ways.

Two innovations based on recent research are the subjects of a session at this year's World Steel Bridge Symposium (WSBS), part of NASCC: The Steel Conference. The first study, performed by the University of Notre Dame, HNTB Corporation, and the Indiana Department of Transportation (INDOT), focuses on built-up press-brake-formed tub girder (PBTG) bridges. The second, performed by the Virginia Department of Transportation (VDOT), focuses on corrosion-resistant steel bolts. Below is a brief look at both studies.

Fast Fabrication of Resilient Steel Bridges: Built-up PBTGs

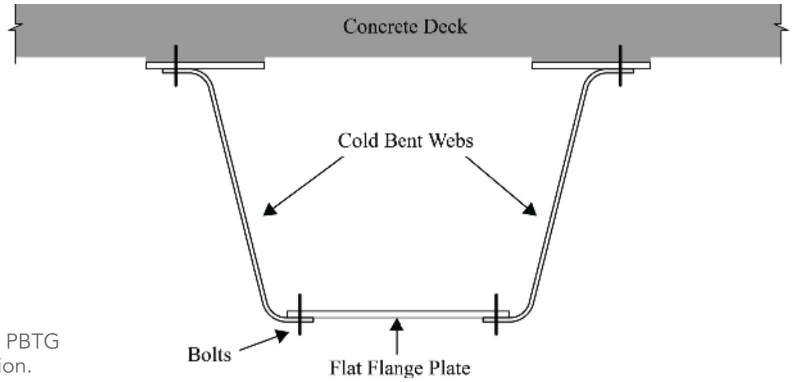
Accelerated bridge construction (ABC) concepts have evolved significantly over the past ten years, with a focus on minimizing traffic disruption through rapid erection techniques. One area that has received comparatively little research, with the potential for significant benefits, is the use of rapid fabrication techniques to significantly decrease the time it takes to fabricate steel girders. Traditionally, the fabrication process required unique shop drawings, potentially complex fabrication techniques, and customization, even for comparatively simple bridges. Ongoing research performed by the University of Notre Dame and HNTB Corporation is focused on developing design and fabrication strategies to dramatically reduce the time it takes for steel to be fabricated and shipped to the site. This research looks to take advantage of adjacent industries that are experienced in the steel supply chain but that do not traditionally fabricate bridges.

To address this knowledge gap, a new approach to accelerating the fabrication of resilient steel bridges has been introduced. This approach is a tub girder-type bridge comprised of two cold-bent webs bolted to flat flange plates with a composite concrete deck. Fabrication is fast and inexpensive as the webs are bent via a press brake, and flat flange plates only require that holes be drilled (i.e., no welding). Individual web and flange plates can be transported by truck, with the flange plates stacked and the cold-bent webs nested compactly, thus overcoming a primary barrier to the adoption of steel tub girders: that they are perceived as difficult to transport. On-site, the webs, flanges, and diaphragms would be rapidly bolted together (no field welding). In comparison to existing PBTGs fabricated from a single steel plate, this approach is a built-up section joined by bolts, thereby providing enhanced member-level redundancy as crack propagation can be arrested between components. Also, the depth is not limited by the constraint of being comprised of a single plate, and the flange can have increased thickness, leading to longer spans. This approach can become a kit-of-parts for a wide variety of span lengths and configurations.

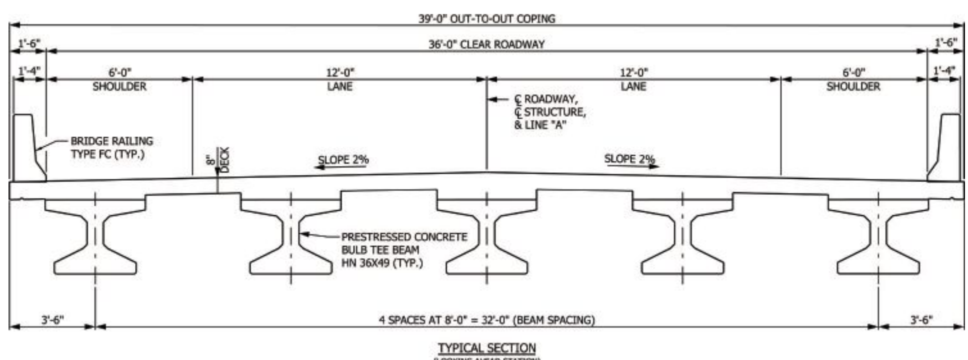
INDOT recognizes the value of innovation and also that the ability to rapidly fabricate and deploy tub girder bridges represents a new tool for resilient design, building on its ongoing interest in ABC. This research is investigating this approach through the design of two demonstration bridges to be constructed in Indiana in 2022, and also focuses on developing a kit-of-parts system that can be more broadly adopted. The research exemplifies the AISC's Need for Speed initiative, which includes a goal of delivering steel bridges 50% faster by 2025. This kit-of-parts approach highlights the steel industry's capability to innovate on all aspects of a project while reducing costs and fabrication and construction time. Critical to the success of this project, this research is being conducted through collaboration across industry and academia, including input from steel fabricators, designers, researchers, and INDOT.

The WSBS presentation will introduce this new approach for the fabrication of steel bridges and specifically focus on the design of a simple-span (97-ft span length) demonstration bridge. Prior to the start of this research project, preliminary design focused on a prestressed concrete girder alternative, but this has been updated to the proposed built-up PBTG cross section. Preliminary high-fidelity finite element models of the proposed design indicate low stresses in the section under combined dead and vehicular loads. The presentation will focus on design decisions for the built-up PBTG bridge, its benefits compared to the prestressed concrete girder alternative, and global and local behavior of the proposed system. This simple-span bridge and a second, two-span continuous bridge (105 ft and 86 ft, respectively), will be the first demonstration bridges for this approach.

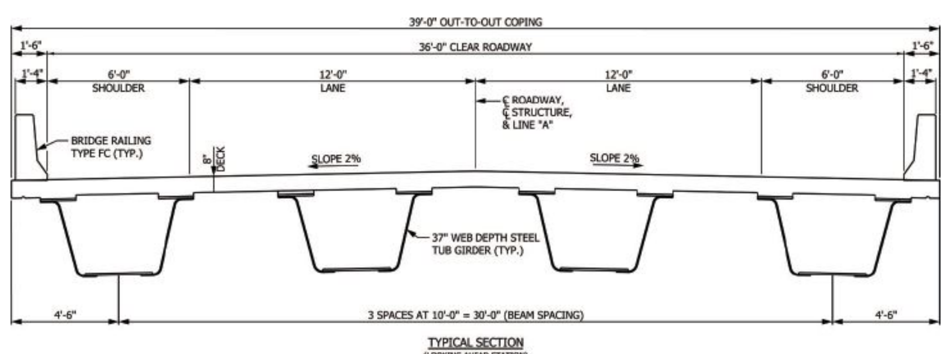
This work is supported by the Joint Transportation Research Program administered by INDOT and Purdue University. Contributions from Seth Schickel, Skyler Coombs, Angela Pearl, and Matthew Keusch of HNTB



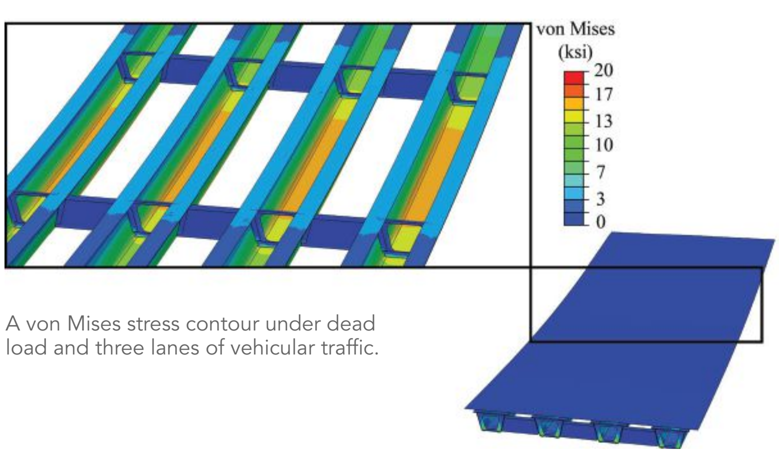
A built-up PBTG cross section.



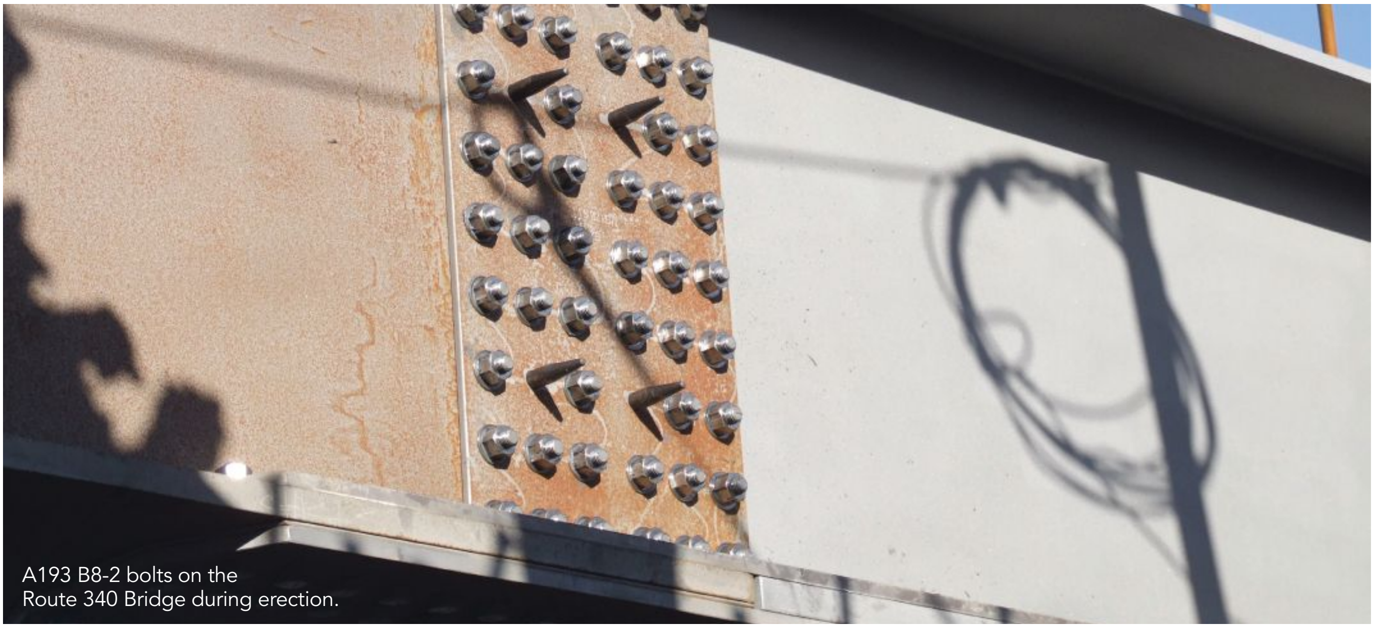
A preliminary prestressed concrete bridge design.



A proposed built-up PBTG cross section.



A von Mises stress contour under dead load and three lanes of vehicular traffic.


A193 B8-2 bolts on the Route 340 Bridge during erection.

Corporation are gratefully acknowledged. The authors are also grateful for the participation of the Study Advisory Committee, including Patrick Conner, Jennifer Hart, Jose Ortiz, Donald Shaw, and Randy Strain, as well as Infra-Metals/Delta Steel. Note that the contents of this paper reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policies of the sponsoring organizations.

Corrosion-Resistant Fasteners

Corrosion is a common cause of bridge deterioration that can lead to expensive maintenance actions. One method in which steel bridges can become more corrosion-resistant is by using ASTM A709 Grade 50CR steel. Formerly specified as ASTM A1010, Grade 50CR steel is a cost-effective stainless steel that can provide inherent corrosion resistance in aggressive environments.

Six Grade 50CR steel bridges in the United States have used various bolt types, including ASTM F3125 Grade A325 Type 3, Grade A325 galvanized, and ASTM A193 Grade B8 Class 2 (A 193 B8-2) bolts. A193 B8-2 bolts are austenitic stainless steel and are strain-hardened for improved mechanical properties. These desirable corrosion and mechanical properties led to the selection of A193 B8-2 bolts for use on the cross-frame connections for one of the Oregon Department of Transportation's (ODOT's) 50CR steel bridges and on the bolted splices used on VDOT's 50CR steel Route 340 Bridge.

Although the A193 B8-2 bolts performed adequately for the Route 340 Bridge, there were a few differences when compared to Grade A325 bolts. The ⅞-in.-diameter A193 B8-2 bolts were only able to achieve a 30-kip minimum bolt pretension, which is less than the 39-kip value for A325 bolts. This smaller clamping force required a modified tightening procedure to be developed and required an increase of approximately 40% more A193 B8-2 bolts in the bolted splices of the Route 340 Bridge compared to using Grade A325 bolts. Although ASTM A194 contains specifications for nuts to match the A193 B8-2 bolts, there are no equivalent washer specifications. Stainless steel bolts are also much more susceptible to galling, which is when two stainless steel parts essentially become cold-welded together. This is a concern for bolts because galling on threaded parts can cause an increase in torque while minimizing tension, both of which are problematic. Lubricants to minimize galling exist and are readily available for stainless steel fasteners, but their relative effectiveness is unknown. Due to the differences in minimum bolt pretension, a lack of installation procedure and washer specifications, and the unknown effectiveness of lubricants, there is a need to investigate other potential corrosion-resistant bolt options for use with 50CR steel.

The Virginia Transportation Research Council (VTRC) recently conducted a research project to evaluate three different types of corrosion-resistant steel fastener assemblies for use on 50CR steel bridges. The three corrosion-resistant steel bolt types included in the evaluation were A193 B8-2, Type 2205 duplex stainless steel, and bolts made from a martensitic chromium alloy (MCA) meeting the chemical requirements of ASTM A1035 CS. The evaluation of the corrosion-resistant steel fasteners included mechanical tests on individual elements of the fastener assembly, such as proof loading and wedge tests on bolts, proof tests on nuts, and hardness tests on the bolts, nuts, and washers, all conducted according to the ASTM F606 specifications. Five types of lubricants made for stainless steel fasteners were evaluated in terms of chemistry and their effectiveness in reducing galling. Fastener assemblies were also subject to torqued tension and relaxation tests to evaluate their assembly performance. Long-term corrosion tests samples of the bolts with 50CR steel were also placed at an exposure site to monitor over time. A cost analysis was also conducted to evaluate the cost of corrosion-resistant steel fastener assemblies relative to standard fastener assemblies.

The test results showed that corrosion-resistant fastener assemblies are a viable option for use with 50CR steel. Proof load tests showed that A193 B8-2 and 2205 bolts possess sufficient strength and ductility to meet the Grade A325 specifications, while the MCA bolts meet the requirements of the Grade A490 specifications.

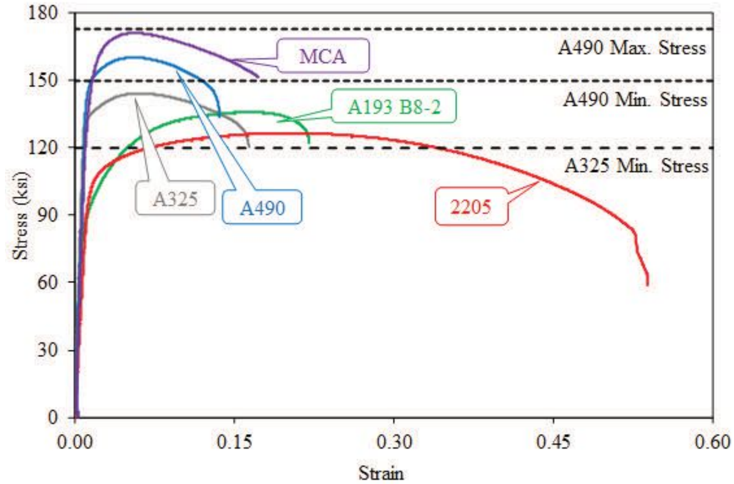
Specified minimum bolt pretension values and installation parameters, such as the nut rotation for turn-of-nut installation, were developed for these corrosion-resistant fastener assemblies. The study showed that A193 B8-2 and 2205 bolts can be pretensioned to 30 kips, while MCA bolts can be pretensioned to 49 kips. All corrosion-resistant nuts in this study met their required proof and cone proof load tests.

Testing confirmed that washer hardness is critical to a bolt's installation performance. The results of a test using the Rockwell C scale (HRC) indicated that the MCA washers were only slightly softer than required by the ASTM F436 washer hardness specifications. The 2205 bolts were approximately half as hard as the F436 specifications, and the 303 washers (used with A193 B8-2 bolts) were not hard enough to be accurately measured in the HRC scale. The soft 303 washers led to the poor performance of some A193 B8-2 bolts in the torqued tension tests. However, a comparison to previous research on A193 B8-2 bolts confirmed that harder 303 washers can lead to the successful performance of 93 B8-2 bolts.

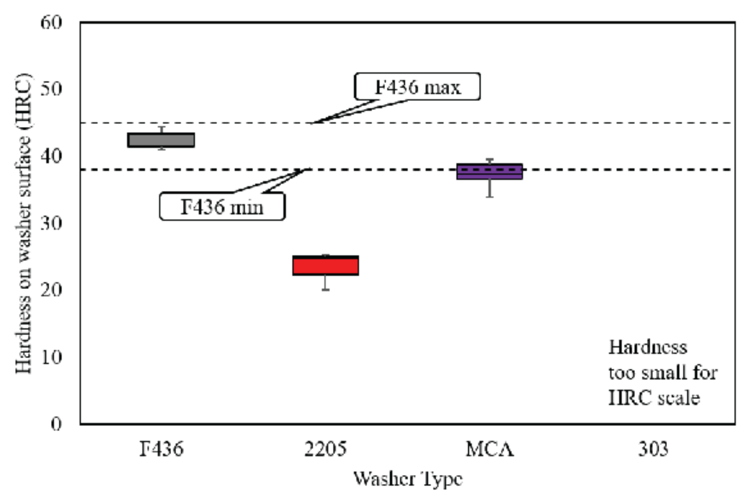
The effectiveness of the lubricants was evaluated by testing each fastener assembly type paired with the five different lubricants. Lubricant effectiveness was determined using the k-factor (or nut factor) determined during the linear portion of torqued tension testing of each fastener assembly and lubricant combination. Lubricant 1 was a standard lubricant used for carbon steel bolts, while Lubricants 2 through 5 were designed specifically for stainless steel fasteners. The results showed that while many lubricants are advertised as being effective with stainless steel fasteners, some are much more effective than others. Lubricant 5 was effective with each of the corrosion-resistant bolts and was especially effective at reducing galling with the MCA bolts.

The research showed that corrosion-resistant bolts lack dimensional standards, and their commercial and domestic availability needs to continue to be evaluated. A cost evaluation showed that A193 B8-2 and 2205 fastener assemblies can currently be expected to cost approximately eight to ten times more than galvanized Grade A325 fastener assemblies. VTRC and VDOT will continue to evaluate corrosion-resistant fasteners, specifically in terms of minimum hardness values for washers, dimensional standards, domestic and commercial availability, and galvanic corrosion potential when placed in contact with 50CR steel. ■

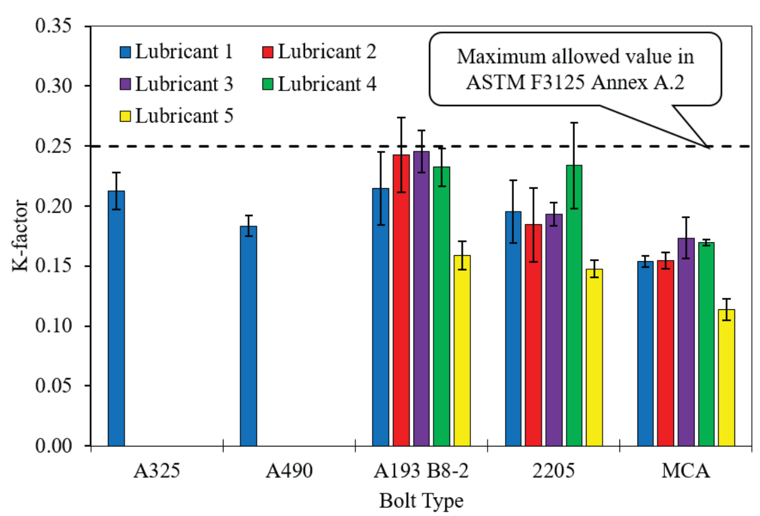
This article is a preview of the session "Innovative Steel Bridge Solutions," which will be presented at the 2021 NASCC: The Steel Conference. The conference takes place online April 12-16.



Proof test stress vs. strain comparison of bolts.



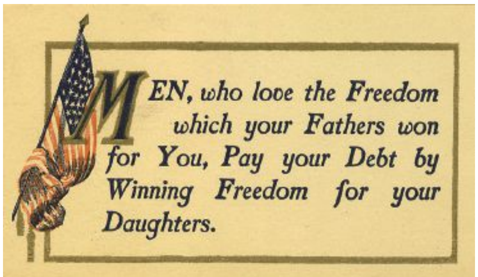
Box and whisker plot of surface hardness tests on washers.



Lubricant effectiveness results showing average k-factor for each bolt and lubricant combination. Error bars represent one standard deviation around the mean.

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

1847
Seneca Falls Convention launches women's suffrage movement.



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

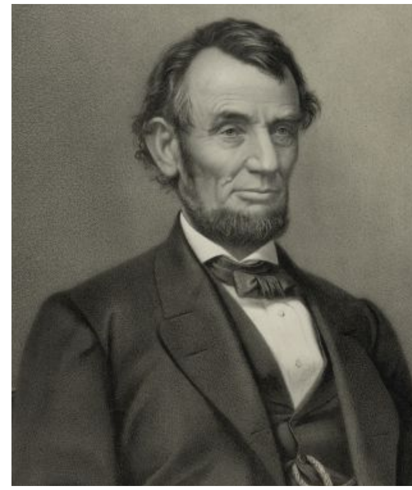
5,189 SUCH BRIDGES
were already open when the Nineteenth Amendment finally granted women the right to vote in 1920.

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

1863
President Abraham Lincoln delivers the Gettysburg address.



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

EVERY DAY IN THE U.S., AN AVERAGE OF 77 MILLION VEHICLES CROSS MORE THAN 25,000 STEEL BRIDGES BUILT BETWEEN 1838 AND 1938.

These are just a few of the stories these bridges could tell: dazzling innovation, events that changed the world, and quirky people being...well, quirky.

Visit **aisc.org/timeline** for more.

This month's offerings include a cutting machine that can accommodate massive steel elements, a new crane with a boom that can reach higher than two football field lengths, and work gloves that are even stronger than steel.

new products

Liebherr LR 1700-1.0

The new LR 1700-1.0 from Liebherr combines the benefits of the economical transport of 600-tonne (661-ton) class crawler cranes with the performance of 750-tonne (827-ton) class lattice boom cranes and features all the innovations of Liebherr's crawler crane developments from the last few years. The crane features a completely redesigned base machine, with a slightly wider track and longer crawler carrier, that delivers 10% to 15% more lifting capacity. The boom can be raised to a height of up to 198 meters (650 ft), comprising the main boom at 102 m (335 ft) and a luffing jib at 96 m (315 ft). These lattice sections enable the crane to be used in purely main boom mode with a length of up to 162 m (531 ft).

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

Bendmak BPM-D GANTRY

Bendmak's model BPM-D GANTRY Drilling and Oxy-Fuel/Plasma Cutting machine introduces full CNC-controlled hole drilling, marking, and cutting. The bridge is movable while the table is fixed, allowing for the heaviest workpieces to be accommodated. While the smallest model starts at 78 in. in width and 244 in. in length, the largest model can reach up to 16 ft in width and 120 ft in length. Gases produced by plasma and oxy cutting operations are collected from the fixed table, filtered, and delivered to the environment clean.

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

Brass Knuckle SmartCut BKCR303

Brass Knuckle SmartCut BKCR303 gloves succeed on three fronts by providing dexterity, grip, and ANSI cut level A2 protection. This triple threat is accomplished with a glass fiber and ultra-high-molecular-weight polyethylene (UHMWPE) shell—a composite yarn that has a strength-to-weight ratio eight to 15 times greater than steel—and polyurethane coating. The thinner, 13-gauge material delivers deftness without trading away its inherent cut-resistance. The non-sticky polyurethane coating on the palm and fingers features excellent grip, even against oils, fats, and greases, and can deliver enhanced puncture protection and abrasion resistance, all without adding bulk or reducing touch sensitivity. In addition, the glove's uncoated back and wrist improves ventilation. A seamless and stretchable full knit wrist provides a snug fit and prevents dirt, debris, and cold from getting inside the glove. Color-coded cuffs easily indicate glove size.

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

IN MEMORIAM

Leslie Robertson, Legendary Structural Engineer, Dies at 92

Leslie E. Robertson, whose career came to be defined by his work on the World Trade Center, died Thursday in San Mateo, Calif., following a diagnosis of blood cancer.

"Les had such a cordial influence on others, including for me personally," said Charles J. Carter, SE, PE, PhD, AISC's president. "I first met him as an undergraduate student when he agreed to meet for a morning to discuss his recently completed Bank of China building. He made the whole concept of the building lateral system clear to me (as a student!) in about 20 minutes with just a few sketches and a brilliantly simple physical experiment that proved he found a creative way to eliminate column bending."

"We've lost a giant whose work will continue to speak volumes for generations to come," Carter continued.

Robertson won AISC's J. Lloyd Kimbrough Award in 2001. The award, named for AISC's first president, honors engineers and architects who are universally recognized as the pre-eminent steel designers of their era. It is the highest honor AISC gives to designers; only three other people have received the Kimbrough Award since 2000.

Robertson was in his 30s when he and John Skilling took on the World Trade Center project, his first high-rise structure. He designed an innovative framing system that used closely spaced exterior steel columns and long-span steel floor trusses to create large, open column-free spaces.

On September 11, 2001, those towers withstood the impact of fully loaded, high-speed aircraft that were much larger than the Boeing 707 Robertson had considered during the design process. Thousands of people were able to escape before the towers collapsed, but Robertson was haunted by their fall. (The movie night at the 2019 NASCC: The Steel Conference featured the documentary "Leaning Out," which focused on not only Robertson's reaction to the World Trade Center attacks but on his remarkable career as a whole.)

Leslie Robertson received a 1971 Architectural Award of Excellence for his work on the United States Steel Building. Pictured left to right at the awards ceremony are: W.H. Mueser, a senior partner with Mueser, Rutledge, Wentworth and Johnson; G.M. Dorland, AISC's president; John H. Long, president of American Bridge Division; and Robertson, who was a partner with Skilling, Helle, Christiansen and Robertson.

PUBLIC REVIEW

Stainless Steel Code and *Specification* Available for Public Review

Two new AISC standards are available for public review until April 12: the AISC *Specification for Structural Stainless Steel Buildings* (AISC 370) and the AISC *Code of Standard Practice for Structural Stainless Steel Buildings* (AISC 313). Both standards are expected to be completed and available by the end of 2021.

The two publications and their review forms can be downloaded from the AISC website at **aisc.org/publicreview**. Please submit comments using the forms provided online or to Cynthia J. Duncan, AISC's director of engineering (**duncan@aisc.org**), by April 12 for consideration.

People & Companies

Bridge engineering firm **Modjeski and Masters** has appointed **Kevin Johns** to vice president and will retain his role as movable bridge business unit director. Johns joined the firm in 1998 and within the past five years has served as either project manager or task leader on 28 movable bridge projects. **Christopher Ahlskog** has been promoted to technical manager. Since joining the firm (also in 1998) he has specialized in structural analysis, load rating, and both the design of new bridges and the rehabilitation of existing bridges.

Magnusson Klemencic Associates (MKA) announced that **Kelsey Rose Price, PE**, has been named one of ***Building Design + Construction (BD+C)*** magazine's 40 Under 40 honorees for 2020. An Associate at MKA, Price is focused on promoting structural solutions that encourage sustainability, carbon-consciousness, and environmentally friendly approaches and played an important role in the development and launch of the Embodied Carbon in Construction Calculator (EC3), a free and open-access tool that helps identify lower embodied carbon building materials in an effort to reduce overall emissions during the design and construction of a project. For more on Price and the rest of the winners, visit **bdcnetwork.com/40under40-2020**.

MEMBERS

AISC Board Approves New Full and Associate Members

Full

Acadian Contractors, Inc., Abbeville, La.
Accelerated Construction and Metal, Modesto, Calif.
Advance Industrial Mfg., Inc., Grove City, Ohio
AF Steel Fabricators, Phoenix,
Alumiworks, Inc., Randleman, N.C.
Barone Steel Fabricators, Brooklyn, N.Y.
Covington Machine and Welding, Inc., Annapolis, Md.
Dakota Precision Fabricating, Inc., Forman, N.D.
Extreme Precision Indust. Contractors, Gillette, Wyo.
Gerlinger Steel and Supply, Woodland, Calif.
RHRBD Holdings, LLC, dba Hale Steel, Alexander, Ark.
Nick's Welding and Fabricating, Inc., Hixton, Wis.
Paradise Architectural Panels and Steel, Miami
Pegasus Steel, Goose Creek, S.C.
Perfect Group, LLC, Lumberton, Miss.
Premier Fabrication, LLC, Congerville, Ill.
Richards Welding and Metal Fab., LLC, Wendell, N.C.
Tippen Steel Services, Boyd, Texas
Triple S Welding Co., Lytle, Texas
Twin Brothers Marine, LLC, Louisa, La.
Victory Machine and Fab, LLC, Sidney, Ohio
RWT Corporation, dba Welding Works, Madison, Conn.
Wilson Iron Works, Crown Point, Ind.
Worth Steel, LLC, Pocatello, Idaho

Associate

Alliance Riggers and Constructors, Ltd., El Paso, Texas, *Erector*
Ayari Venture, Greensboro, N.C., *Detailer*
E2G Detailing Services, LLC, Woonsocket, R.I., *Detailer*
Fab Design Engineers, Bangalore, India, *Detailer*
JPW Engineering Services Pvt., Ltd. Nashik, India, *Detailer*
Mid-Atlantic Structural Detailing, Inc., Myersville, Md., *Detailer*
Misco Steel Erectors, Inc., West Terre Haute, Ind., *Erector*
PT Sambada Gatya Praya, Bogor, Indonesia, *Detailer*
Rogue Erectors, LLC, Leander, Texas, *Erector*

Welcome to Safety Matters, which highlights various safety-related issues. This month's topics are hazard communication and revisions to the National Fire Protection Association's NFPA 70E *Standard for Electrical Safety in the Workplace*. Also note that May 3–7 is the National Safety Stand-Down to Prevent Falls in Construction. Visit **osha.gov/stop-falls-stand-down** for more information.

In addition, visit **aisc.org/nascc** to see the list of safety-related sessions scheduled for NASCC: The Virtual Steel Conference, taking place online April 12-16.

Hazard Communication

The goal of OSHA's *Hazard Communication Standard (HCS)* is written as follows: "In order to ensure chemical safety in the workplace, information about the identities and hazards of the chemicals must be available and understandable to worker."

When it comes to duties, chemical manufacturers and importers must evaluate the hazards of the chemicals they produce or import and prepare labels and safety data sheets (SDSs) to convey the hazard information to their downstream customers. Suppliers (distributors) who sell hazardous products must provide *HCS*-compliant labels and SDSs to downstream customers.

Employers must prepare and implement a written hazard communication program, ensure that labels are on containers, maintain and provide access to SDSs for all hazardous chemicals in their workplace, and inform and train workers on the hazards of the chemicals in their work areas, including how to identify and control hazards and protect themselves.

In addition, workers must receive information and training provided by their employer on hazardous chemicals in their work area. *Hazard Communication: Small Entity Compliance Guide for Employers That Use Hazardous Chemicals* is a good source of information. You can download a PDF of the publication at OSHA's site, **www.osha.gov**.

A fundamental element of a hazard communication program is to ensure that containers, including workplace (secondary) containers, are labeled. So when your employee takes a chemical out of the large industrial-size container you bought it in and transfers it to a container that is more conveniently sized for use at the workstation, you need to make sure it is properly labeled. Labels for a hazardous chemical must contain: name, address, and telephone number; product identifier; signal word; hazard statements; precautionary statements; and pictograms. For additional detail regarding OSHA's labeling policy, see OSHA Instruction CPL 02-02-079, *Inspection Procedures for the Hazard Communications Standard (HCS 2012)*, dated July 9, 2015, Section X.F.3 for more (you can download the PDF from **www.osha.gov**). You can also find the various pictograms in this document.

NFPA 70E

The National Fire Protection Association has published the 2021 edition of NFPA 70E: *Standard for Electrical Safety in the Workplace*. While this standard is not an OSHA regulation, it can be enforced under the general duty clause, and it contains essential safety information for employers who have employees working with electricity. Anybody who wires a circuit benefits from this information. The 2021 edition of NFPA 70E features five key changes. You can read about them in the *Safety+Health* magazine article "NFPA 70E: Five Key Revisions for 2021" at **www.safetyandhealthmagazine.com**.

We are always on the lookout for ideas for safety-related articles and webinars that are of interest to AISC member companies. If you have safety-related questions or suggestions, we would love to hear them. Contact us at **schlafly@aisc.org**. And visit AISC's safety page at **aisc.org/safety** for various safety resources.

news & events

ENGINEERING JOURNAL

Second Quarter 2021 *EJ* Now Available

The second quarter issue of AISC's *Engineering Journal* is now available. (You can access this issue as well as past issues at **aisc.org/ej**.) Below is a summary of the latest issue, which includes articles on eccentric stiffeners, advanced elastic analysis, internal second-order stiffness, and nonorthogonal connections.

Determination of Capacities of Eccentric Stiffeners Part 1: Experimental Studies and Part 2: Analytical Studies

Javier Alvarez Rodilla and Keith Kowalkowski

Forty column specimens were experimentally tested and analytically investigated with an effort to evaluate the effective stiffener capacities of eccentric stiffeners when used within moment connections of beams connecting to column flanges. The column specimens were set horizontal, and a concentrated load was applied to the top flange, perpendicular from the longitudinal axis of the column specimen. Three test methods were performed described as; (a) single tension with load pulling away from the column specimen, (b) single compression with load applied towards the column specimen, and (c) double compression with load applied towards the column specimen and with a reaction plate directly opposite from the applied load. For column specimens tested without stiffeners and for compression tests, the maximum loads compared favorably to that predicted for web local crippling and were significantly higher than that predicted for web compression buckling (double compression tests) and web local yielding. For single tension tests, the maximum load always exceeded that predicted for the limit states of flange bending and web local yielding. Analytical models were then developed for the experimental column specimens presented in Part 1: Experimental Studies. These models were utilized to calibrate the finite element methodology and to develop consistent comparisons between the experimental and analytical results.

AISC Design by Advanced Elastic Analysis: An Investigation of Beam-Columns

Yunfei Wang and Ronald D. Ziemian

At the heart of the provisions for assessing structural stability within the AISC *Specification for Structural Steel Buildings* is the direct analysis method. The fundamental concept for this method is that the more behavior that is explicitly modeled within the analysis, the simpler it is to define the AISC *Specification* design requirements. In other words, the direct analysis method consists of calculating strength demands and available strengths according to a range of well-defined and fairly detailed analysis requirements. This paper begins with an overview of two logical extensions to AISC's direct analysis method, both of which are now provided in AISC *Specification* Appendix 1, Design by Advanced Analysis. In establishing these approaches, many systems were investigated in previous research, and it was noted that systems with beam-columns subject to minor-axis bending may deserve additional attention. This paper presents a detailed study that investigates such members, as well as members subject to major-axis bending.

Technical Note: Internal Secord-Order Stiffness: A Refined Approach to the R_m Coefficient to Account for the Influence of P-δ on P-Δ

Rafael Sabelli and Larry Griffis

One component of the B_2 amplifier method of addressing second-order effects is the R_M coefficient, which represents the influence of P-δ on P-Δ effects. This paper presents the background for R_M based on LeMessurier's paper "A Practical Method of Second-Order Analysis: Part 2-Rigid Frames" (1977) and makes explicit the simplifications entailed in the AISC *Specification* formulation for this coefficient. These simplifications, while providing for reliable strength design, can overestimate the P-δ effect for typical building applications, especially if applied to drift. A simple formula for R_M based on the work of LeMessurier permits a more precise estimate, which can be used as a component of both force and displacement amplifiers presented in this paper. This explicit approach to the R_M coefficient provides the basis for a clear presentation of the relationships first-order and second-order stiffness (both internal and external), including the distinct effects of P-δ and P-Δ stiffness reductions on equilibrium at the second-order displacement.

Steel Structures Research Update: Seismic Performance of Nonorthogonal Special Moment Frame Beam-to-Column Connections

Judy Liu

Ongoing research on the seismic behavior of nonorthogonal special moment frame beam-to-column connections is highlighted. Featured is a comprehensive experimental and computational study underway at the University of Arkansas and led by Dr. Gary Prinz, Associate Professor in Structural Engineering. The research team includes PhD students Hossein Kashefizadeh and Damaso Dominguez. Dr. Prinz's research interests include mechanics and simulation of ductile fracture, seismic design solutions for steel structures, and computer simulation of structures under dynamic loading. He received a National Science Foundation Faculty Early Career Development (CAREER) award to investigate a new micromechanics-based approach to ductile fracture simulation in additively manufactured steels for improved seismic structural fuse design. Dr. Prinz has also been awarded AISC's Milek Fellowship. The four-year Milek Fellowship is supporting this research on the seismic performance of skewed special moment frame (SMF) connections. The research team is part way through year three of the four-year study. Selected results from the computational parametric study are highlighted along with a preview of the experimental investigation.

FORGE PRIZE

Three Visionary Finalists Selected to Present their Ideas at Live Forge Prize Event

AISC has selected three finalists for The Forge Prize, which celebrates emerging architects who create visionary designs that embrace steel as the primary structural component while exploring ways to increase project speed. Each finalist worked with a steel fabricator before presenting their final concepts to the judges during a live YouTube event in late March. (See **www.forgeprize.com** for more information on the competition.)

"The Forge Prize competition gives younger architects a unique opportunity to develop new concepts and applications for one of the core materials of building design and construction—steel—in its many forms and manifestations," said 2021 Forge Prize judge Robert Cassidy, executive editor of *Building Design+Construction*.

The winner will receive a $10,000 grand prize and an invitation to present before an audience of the industry's best minds at NASCC: The Virtual Steel Conference on April 12, 2021. (See **aisc.org/nascc** for more information and to register.)

Hunter Ruthrauff of T.Y. Lin International Group in San Diego designed a 3D-printed steel pedestrian bridge that spans Balboa Park's Florida Canyon. Ruthrauff chose 3D-printed steel because it offers better tensile strength than 3D-printed concrete and lessens the complexity of the design process.

NASCC

Registration Still Open for NASCC: The Virtual Steel Conference, Taking Place April 12-16

Learn about the latest in the structural steel industry without leaving your living room! There's still time to register for NASCC: The Virtual Steel Conference 2021, which will take place online from April 12–16. Visit **aisc.org/nascc**.

Registration costs just $200 for AISC members ($400 for non-members). A discount is available when multiple attendees register from one firm: The first four members who register will pay $200 per person, and each member who registers after will pay $50 per person. Educator registration costs $25 per person, and student members and DOTs receive complimentary registration.

The Virtual Steel Conference is an educational and networking event offering more than 150 practical seminars on the latest design concepts, construction techniques, and cutting-edge research, as well as more than 200 virtual exhibitors showcasing products ranging from structural design software to machinery for cutting steel beams.

Attendees can earn up to 23 PDHs by attending the conference's many dynamic sessions on topics ranging from "Durability of Present-Day Corrosion Protection Systems" to "Retrofitting Existing Buildings with Steel Joists" to "Why Good Employees Say Goodbye: Employee Retention and Equity in the AEC Industry."

At present, AISC intends to hold the 2022 Steel Conference live and in-person in Denver, March 23 to 25, 2022.

AISC NEWS

AISC Turns 100!

AISC has reached a historic milestone; 2021 marks our 100th anniversary! To celebrate a century of steel, we're shining a spotlight on the legacy of our industry.

"AISC turns 100 this year," said Charlie Carter, AISC's president. "And while this is a great achievement, we're not content to simply look back at our achievements and the legacy we've created. Rather, we want to look ahead to the great legacy the steel industry and design community can continue to create for ourselves, our children, and future generations."

AISC has worked toward uniting and promoting the steel industry since the very beginning—even before its official foundation. On November 21, 1917, a group known as the War Service Committee was formed to help the fabrication industry meet the needs of America in the first World War. Four years later, a new association was formed: The National Steel Fabricators Association. One year later, the National Steel Fabricators Association was incorporated as the American Institute of Steel Construction.

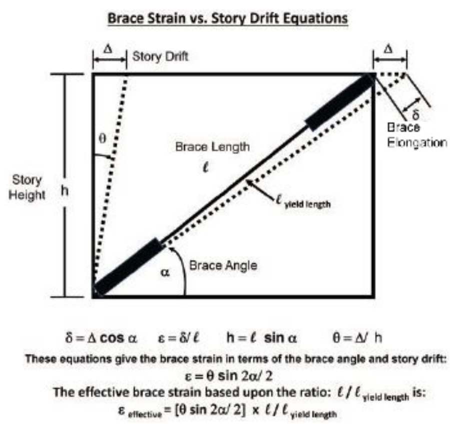
As we enter our second century, we look back fondly on all of the remarkable people, creative innovations, and soaring structures that made our first so special. For 2021, we have embarked on a multimedia project to celebrate that history. The retrospective will feature historical articles, interactive timelines, and more. Our first chapters, Foundations of AISC and Early History, are now available at **aisc.org/legacy**. You can also see *Modern Steel* content related to this milestone in the Centennial Content section at **www.modernsteel.com**.

Letter to the Editor

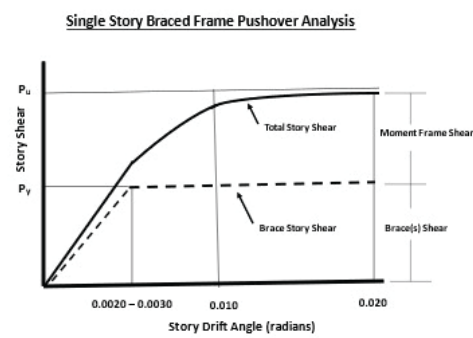
Lower Bounds

The July 2020 article "How Low Can You Go" by William A. Thornton, PE, PhD (available in the Archives section at **www.modernsteel.com**), shows a braced frame gusset plate connection design rationale based on the uniform force method (UFM). The UFM assumes that the beams and columns are elastic and are only axially loaded so that all the lateral resistance by the frame is made by the braces. However, after the braces yield, all the additional frame lateral resistance is made by moment frame action by the beams and columns of the frame. Therefore, a story drift angle limitation must be made so that only axial forces exist in the beams and columns consistent with UFM gusset connection design rationale.

Shown in the figure below is the derivation of the relationship between the effective brace strain and the story drift angle. For a Grade 50 brace with a yield strain of 0.001724, a 45° brace angle, and an effective length to length ratio of 0.70, the story drift angle at brace yield is 0.002463 radian. For other typical braced frame designs, the braces yield at story drift angles between 0.0020 and 0.0030 radian. This is the story drift angle limitation rationale for braced frames with gusset plate connections based on the UFM. It is consistent with the AISC 314-16 Commentary on SCBF and BRBF connections that address the issues of frame distortion (frame action) in their connection designs.



A "pushover" analysis of a single-bay braced frame is shown in the following figure that graphically shows the story shear distribution, as a function of the story drift angle, between the braces(s) and the moment frame formed by the beams and columns. Full-scale tests (e.g., Lopez, W.A., et al., "Structural Design and Experimental Verification of a Buckling-Restrained Braced Frame System," AISC *Engineering Journal*, Fourth Quarter, 2004, **aisc.org/ej**) have shown 50% or more of the story shear may be resisted by the moment frame for seismic design drift angles of 0.010 to 0.020 radians. To reduce the moment frame shear, semi-rigid beam-column connections have been proposed (refer to the AISC 314-16 Commentary on ductile connections for SCBFs and BRBFs).



Typical Story Shear Disribution in Braced Frames for a 0.020 radian story drift angle

Ralph M. Richard, PE, PhD
Professor Emeritus
University of Arizona

Response from Bill Thornton:

Your letter deals with distortional forces, which are not mentioned in my essay on the lower bound theorem (LBT). That is not to say they are not important but rather they are unnecessary for the discussion I presented.

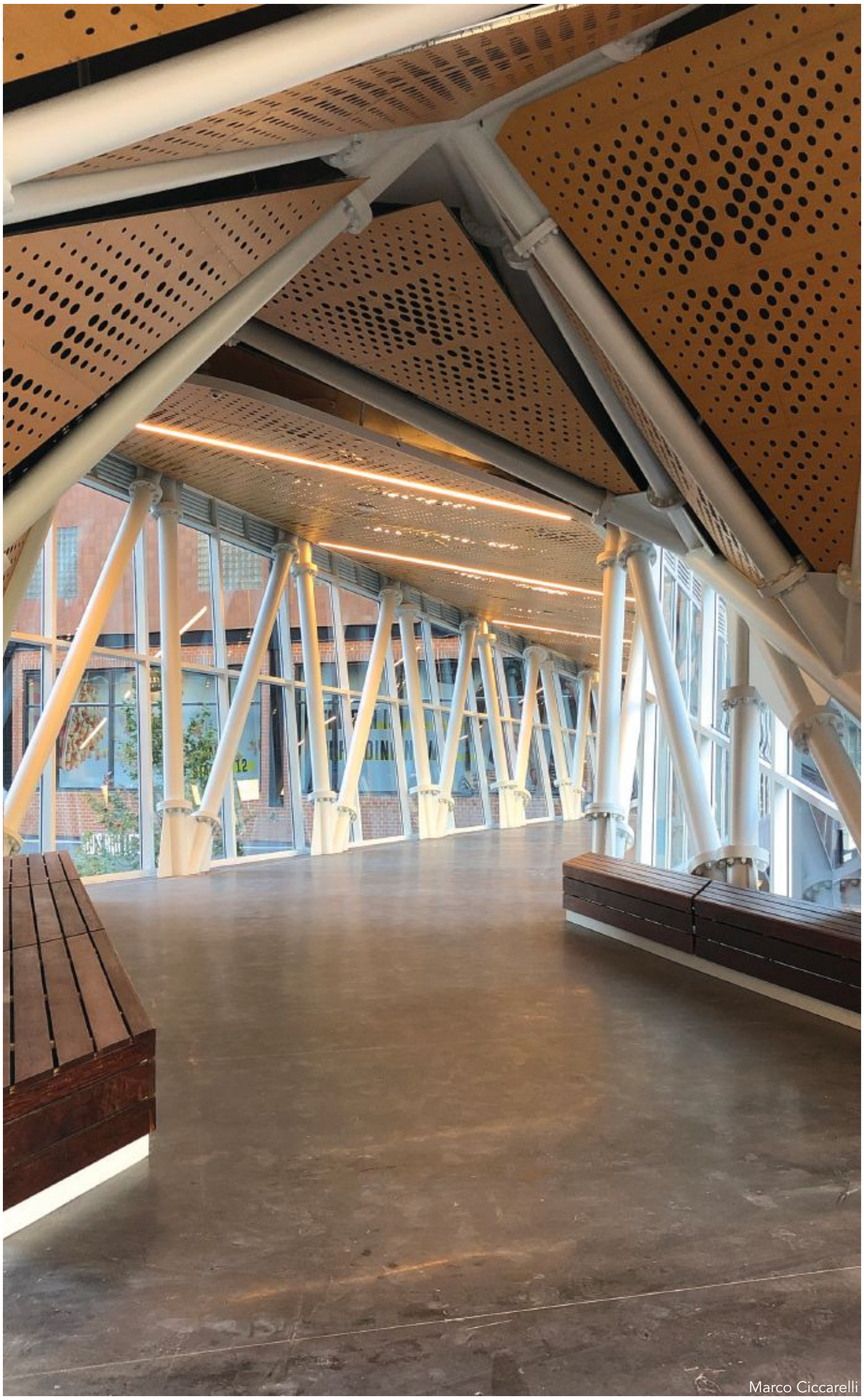
Distortional forces will exist in all bracing connections, even in non-seismic situations unless, as noted below, real physical pins are used for the beam to column connection. Distortional forces are discussed in Design Guide 29: *Vertical Bracing Connections—Analysis and Design* (**aisc.org/dg**) on pages 69 through 71, and Equation 4-12 on page 70 is derived using the same model shown in your first figure. It is not used elsewhere because the variation in the actual physical situations makes a general approach impossible.

For non-seismic design and low seismic design, distortional forces can be ignored, based on historical performance, even in bridges. In seismic design of SCBFs, they can't be ignored, as the paper you cited by Lopez et al. shows. The distortional forces can't be ignored, but they can be controlled and minimized. AISC 341 gives some ways of doing this. The beam to column connection can be one that allows rotation; see AISC 341-16 Fig. C-F2.16, or one that minimizes distortional forces; see AISC 341-16 Fig. C-F2.18. It is possible to eliminate distortional forces entirely by means of a real pin at the beam to column connection. This idea was used 150 years ago to render statically indeterminate bridges statically determinate and thus amenable to simple analysis.

Two of the 3rd Edition *Seismic Design Manual* examples, Example 5.3.9 and Example 5.3.11, use these ideas. They also use the UFM. A third example, Example 5.3.10, uses a moment connection between the beam and column and the Parallel Force Method (PFM) for the force distribution. In none of these examples is an explicit consideration of distortion forces given. They are implicitly considered by designing all parts of the connection for a brace load of $R_yF_yA_g$, as well as maximum brace buckling and post-buckling loads defined in AISC 341-16, rather than the actual bracing force from analysis.

The UFM satisfies the LBT. The LBT is a consistent approach used to design moment, bracing, and many other connection types. The LBT is used throughout the AISC design examples. To the best of my knowledge, the UFM and the LBT are consistent with the various frame analysis and design procedures used by designers using ASCE 7, AISC, and the *IBC*.

advertiser index


Marco Ciccarelli

ANGULAR APPROACH

THE BALLSTON QUARTER PEDESTRIAN WALKWAY angles its way across a busy thoroughfare in Arlington, Va.

The steel pedestrian bridge, designed by studioTECHNE | architects and structural engineer Peller + Associates, connects two buildings on either side of Wilson Boulevard, providing a direct connection to the nearby Ballston-MU Metro station. The eccentric structure of the walkway oscillates between the wall and roof, and the lines that comprise the structure and glass planes of the walkway engage pedestrians, establishing unique viewing corridors highlighted by triangular forms and allowing users to both observe and be observed as they move from private space to public realm.

The design called for exposing as much of the structure as possible, so round hollow structural sections/HSS (fabricated by AISC member Crystal Steel) were chosen for the superstructure—not just for their aesthetic value but also for their ability to resist the complex torsional, shear, and bending stresses, in addition to all gravity loads.

The bridge is a 2021 AISC IDEAS^2 winner. Want to learn more about it—and the rest of this year's winners? Check out next month's (May) issue at **www.modernsteel.com**. The winners will also be announced at NASCC: The Virtual Steel Conference, taking place online April 12-16. For information about the conference and to register, visit **aisc.org/nascc**.

150+ sessions

Registration NOW OPEN!

earn up to 23 PDHs

NASCC: THE *VIRTUAL* STEEL CONFERENCE

April 12–16, 2021