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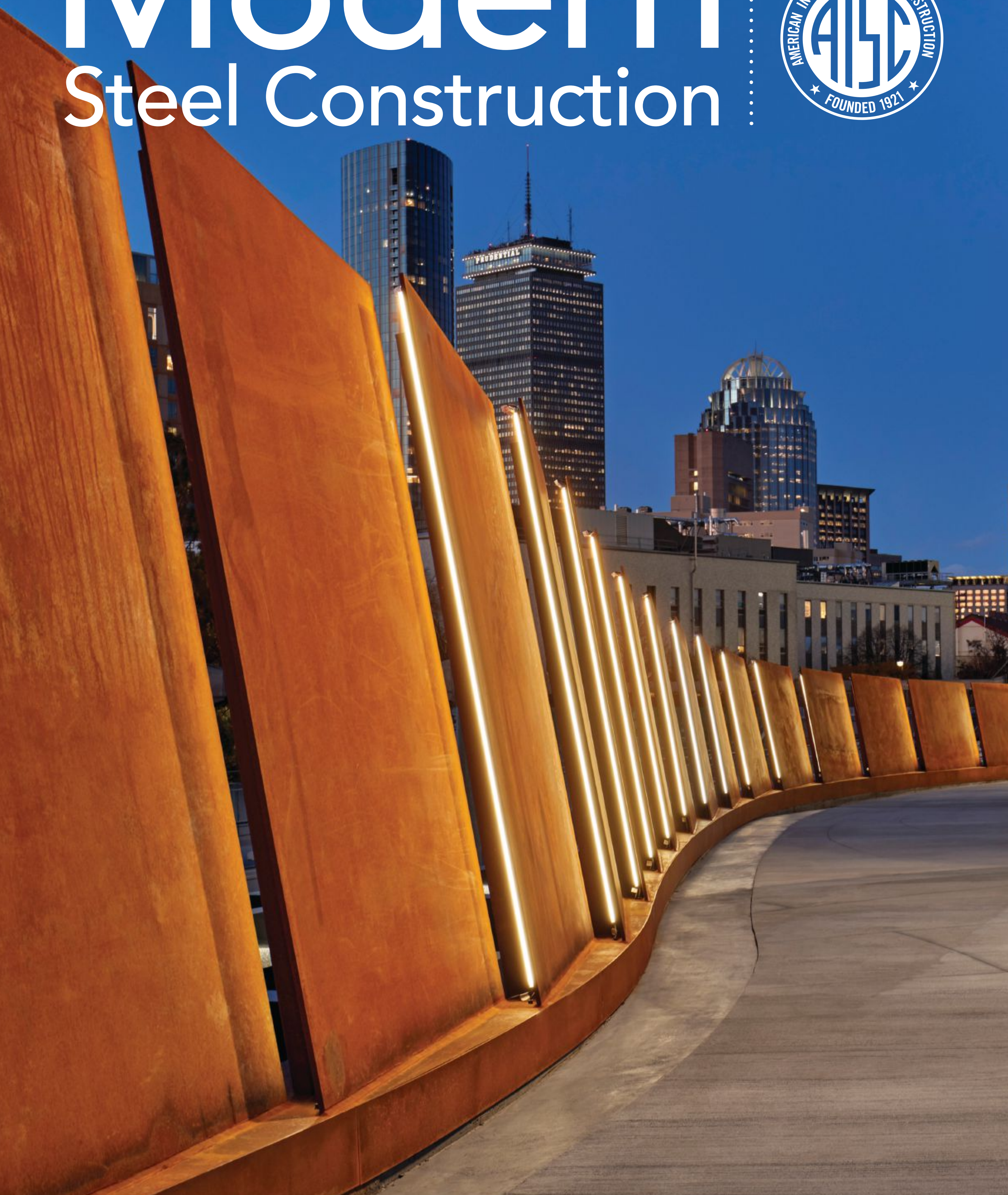


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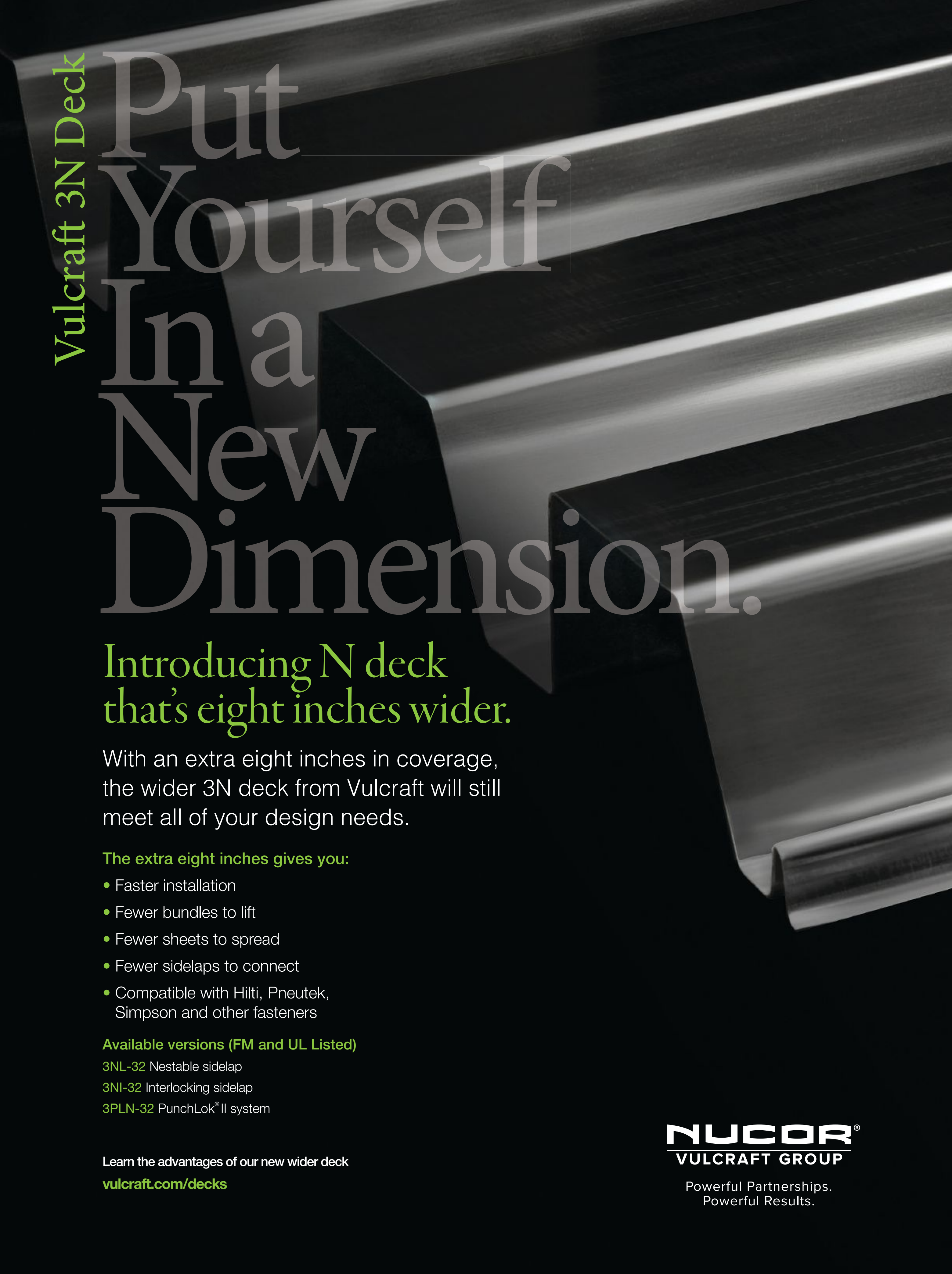

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Modern Steel Construction

February 2020

in every issue

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ON THE COVER: The long and winding bridge that leads to a Northeastern University building's door, p. 24. (Photo: Payette/Robert Benson)

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editor's note

If you had young kids in 1998, you'll remember how popular the movie *Mulan* was. Even McDonald's jumped on the bandwagon and went so far as to introduce a special Szechuan sauce with their chicken nuggets. Almost two decades later, McDonald's briefly reintroduced the special sauce—not because of *Mulan*, but because of a throwaway line in a wildly hilarious cartoon series *Rick and Morty* (a must-see for me and my boys!).

I love watching ideas go viral. For example, after each NASCC: The Steel Conference, we survey attendees to get feedback on sessions and speakers. But for the keynote speaker, the way I really judge success is to count the number of times I hear parts of the presentation referenced by other speakers and by attendees in random conversations. In other words, I count the buzz.

By that standard, AISC's initiative to develop ways to reduce the time it takes to design, fabricate, and build steel buildings and bridges is quickly becoming a success.

We recently hosted the fine folks at Simpson Strong-Tie at our office. While they're best known for their steel connections for wood products, they're also heavily invested in steel construction and have recently introduced a Yield-Link Connection for Steel Construction. This fully bolted connection is similar to RBS designs and most notably allows moment frames to be designed without bracing. It has also recently been accepted into AISC 358-16. The impressive aspect of the system is if it is damaged in a seismic event, it can be readily and easily replaced.

While it's always interesting to hear about new systems, what really excited me about Simpson Strong-Tie's presentation was that they directly referenced AISC's Need for Speed initiative. When they first started talking about this new system last year, they emphasized its potential for fabrication and erection cost savings. But they've now pivoted to talking about how it not only saves money, but it also saves time.

Of course, Simpson Strong-Tie isn't the only company we've seen talking about speed lately. From engineering software to welding machines, we're starting to see people pivot towards how we can continue increasing steel's competitiveness by reducing the time of design and construction. And I fully expect speed to be the dominant theme in the exhibit hall at this year's Steel Conference (April 22–24 in Atlanta; visit **aisc.org/nascc** for more information).

And if you have any great ideas about speed, I'd love to hear them!

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

steel interchange

All referenced AISC publications, unless noted otherwise, refer to the current version and are available at ***aisc.org/publications****.* Modern Steel Construction *articles can be found in the Archives section at* ***www.modernsteel.com****, and AISC Design Guides are available at* ***aisc.org/dg****.*

Moment Connection Load Paths into HSS Columns

I am designing a wide-flange-beam-to-HSS-column moment connection using cut-out flange plates similar to the detail shown in Figure 12-17 of the 15th Edition AISC *Steel Construction Manual*. The HSS face wall (transverse to the flange force) has an available strength equal to 50% of the required strength due to the flange force. Is it possible to transfer 50% of the flange force through the HSS face and the remaining 50% through the flange plate directly into the HSS side walls? Or should the entire flange force be transferred through the flange plate into the HSS side walls only?

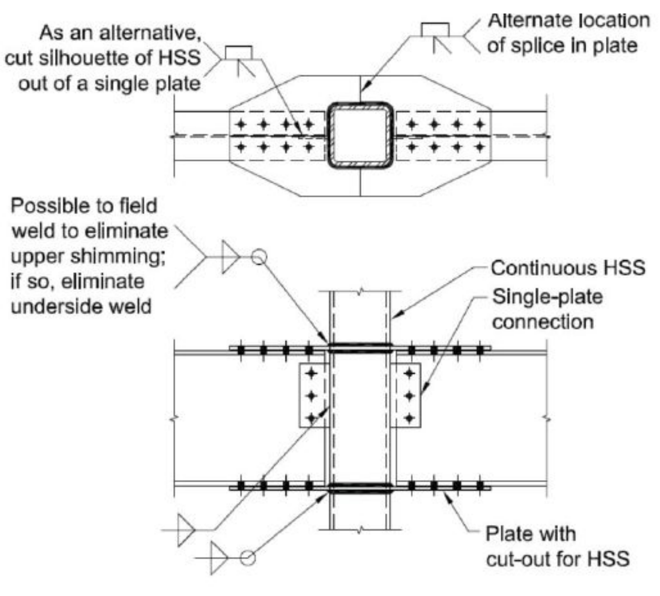


Fig. 12-17. Exterior plate moment connection.

It generally is not possible to justify the sort of ductility that would be required to support the use of the 50/50 model you describe. Using the following procedure is the best way to proceed when designing a cut-out plate moment connection to an HSS column.

The stiffness of the side walls relative to the load you describe will be considerably larger than the stiffness of the HSS face. This stiffness means most of the load will initially go to the side walls. Assuming sufficient ductility, anything the side wall connections cannot take will be transferred through the connection to the HSS face (as long as the overall column member strength is sufficient to transfer the load). However, the typical approach to designing this type of connection would be to transfer all of the load directly into the side walls through the flange plates. As indicated by Duane Miller in "Welding Wisdom: Part One" in the August 2015 issue, "A good welded connection has a clear and direct load path."

Larry Muir, PE

Pretension and End-Plate Moment Connections

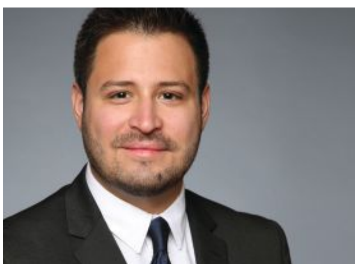
ASTM F3125 Grade A325 bolts in end-plate moment connections are subject to tension loads due to the moment. Must these bolts be pretensioned?

No, but there are some caveats. Section J3.1(a) of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) states: "Bolts are permitted to be installed to the snug-tight condition when used in: (2) Tension or combined shear and tension applications, for Group A bolts only, where loosening or fatigue due to vibration or load fluctuations are not design considerations." Therefore, the *Specification* permits snug-tightened Grade A325 bolts (which are listed in the *Specification* as Group A bolts) to be loaded in tension. Note that a Grade A490 bolt (Group B bolt) loaded in tension would need to be pretensioned as required by the *Specification*.

Note that Section J3.1 only specifically addresses bolts loaded in tension. You were asking about a specific application, Grade A325 bolts in an end-plate moment connection. The section on extended end-plate fully restrained moment connections in the 15th Edition AISC *Steel Construction Manual* states: "The procedures in AISC Design Guide 4 [*Extended End-Plate Moment Connections Seismic and Wind Applications*] are for pretensioned bolts and "thick plates" and result in connections with the smallest possible bolt diameter. For these connections, prying forces are zero. The procedures in AISC Design Guide 16 [*Flush and Extended Multiple-Row Moment End-Plate Connections*] allow for both "thick plate" and "thin plate" designs. A thin plate design results in the smallest possible end-plate thickness and the maximum bolt prying force. These connections can be designed using either pretensioned or snug-tight bolts, if Group A bolts are used. Group B bolts must be pretensioned."

AISC's *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* (AISC 358-16) addresses prequalified end-plate moment connections in Chapter 6 and requires bolts to be pretensioned.

Jonathan Tavarez, PE



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Calculating Column Shear

In the 3rd Edition AISC *Seismic Design Manual*, Example E4.3.6 (Page 4-112), $V_c = \Sigma(M^*_{pb})/(h_b + h_t)$. I have a hard time visualizing the meaning of V_c, but after reading different sources, it seems to make sense if, in the denominator, I replace what is shown in the *Seismic Design Manual* with ($h_b/2 + h_t/2$). In other words, it seems to me that V_c should be half the value shown in the example. Is this correct?

You are correct that the values used in the equation (84 in. and 75 in.) are half the story height. As such, the symbols used ($h_b + h_t$) could be misleading, and showing the division by two ($h_b/2 + h_t/2$) would be clearer. As you see on page 4-111 of the *Seismic Manual*, h_t and h_b are calculated based on an assumed point of inflection at one half of the story height already. Reducing this vertical dimension further would shift the assumed point of inflection closer to the beam to column connection (away from the column mid-height location) and would increase V_c, thus reducing the required panel-zone strength R_u. Increasing the vertical dimension would have the opposite effect, decreasing V_c and increasing R_u.

For a multistory building, it is typical to perform these calculations using the assumption that the column inflection point is at mid-height of the column (if there is no hinge built into the system). The greater the vertical distance between assumed inflection points, the lower the value of V_c, and the greater the net demand on the column (that is, the larger the column needs to be). The engineer can apply some judgment, but it is strongly recommended to not use less than one-half of the story height. The use of the full-story height will be "conservative" in that it will overestimate demands on the column.

Rafael Sabelli, SE

Normal-Looking Connections

The current framing plan on a project shows a W27 beam that frames into one side of a W18 truss chord. The maximum shear load can be accommodated, but the connection itself just doesn't look right. Should I consider upsizing the truss chord member?

While connecting a W27 beam to a W18 chord member is not ideal, it also does not strike me as unreasonable either, assuming you can design a connection that is sufficient to transfer the required strength. Part 10 of the 15th Edition AISC *Steel Construction Manual* provides the following guidance:

"It is recommended that the minimum length of simple shear framed connections be one-half the T-dimension of the beam to be supported. This provides for beam end stability during erection. When a beam is otherwise restrained against rotation about its longitudinal axis, such as is the case for a composite beam, the torsional end restraint is not critical."

The T/2 recommendation, while not a requirement, would likely serve as a good starting point when determining if modifications to the member sizes or connection details are needed.

I will also point out that the manual tables can be used to help identify unusual conditions that warrant further consideration. For example, Table 10-1 on page 10-16 in Part 10 of the *Manual* indicates that a five-row connection would be applicable for W18 shapes up to W30 shapes. This means that a five-bolt-row connection will fit within a W18 shape while also satisfying the recommended T/2 criteria for up to and including W30s.

Carlo Lini, PE

steel quiz

This month's Steel Quiz is comprised of reader submissions in response to our Halloween-themed online quiz (see the October 28 Steel in the News item at **modernsteel.com/news**). Thank you to all who sent in questions!

1 **True or False:** Shear studs on collector beams can be used for composite flexural action in conjunction with lateral loading without considering the interaction of the two loads.

2 What is the term for a section that is capable of developing a fully plastic stress distribution and possessing a rotational capacity of approximately three before the onset of local buckling?
a. Stiffened element
b. Compact section
c. Slender section
d. Unstiffened element

3 **True or False:** All exposed structural steel members that are in close proximity (with a viewing distance of under 20 ft.) must be categorized as architecturally exposed structural steel (AESS).

4 If you wanted to minimize the magnetization of stainless steel, which of the following would be helpful?
a. Minimizing welding
b. Using ferrite-free welding rod
c. Using Type 304N or Type 316N instead of regular Type 304 or Type 316 steel
d. Subsequent annealing

5 What GMAW welding process is not prequalified per AWS D1.1?

6 What is the recommended minimum weld shelf for a $^3/_{16}$-in. fillet weld?

7 What are the five types of NDT (nondestructive testing) for welds?

8 What are the two main groups of limit states?

TURN TO PAGE 14 FOR THE ANSWERS

steel quiz ANSWERS

1 **True.** The Commentary for Section I7 of the AISC *Specification for Structural Steel Buildings* (AISC 360, **aisc.org/specifications**) explains that it is not required to superimpose the horizontal shear due to lateral forces with the horizontal shear due to flexure for the determination of steel anchor requirements. Figure C-I7.1 demonstrates that lateral loads decrease the net shear in steel anchors within certain zones of the beam. *Submitted by Sririam Sankaranarayanan.*

2 **b.** Compact section. This definition is provided in the *Specification* glossary. Limiting width-to-thickness ratios for compact/non-compact sections can be found in Table B4.1b. *Submitted by Jeremy Rollins, CLC Engineering.*

3 **False.** Only members that are specifically designated as AISC AESS in the contract documents need to be categorized as AESS Category 1, 2, 3, 4, or C. (For more on AESS, including requirements for each category, see "Maximum Exposure" in the November 2017 issue, available at **www.modernsteel.com**.) A member designated as AESS placed at a viewing distance of less than 20 ft would be classified as AESS Category 3. *Submitted by Bryan Gilliland, Sure Steel, Inc.*

4 **d.** Susequent annealing. AISC Design Guide 27: *Structural Stainless Steel* (**aisc.org/dg**) states, in Section 2.4: "Heavy cold working, particularly of the lean alloyed austenitic steels, can also increase magnetic permeability; subsequent annealing would restore the non-magnetic properties. For nonmagnetic applications, it is recommended that further advice be obtained from a steel producer." *Submitted by Richard de Campo, Poss Architecture + Planning.*

5 GMAW short-circuit transfer is one mode of transfer welding, but it is not permitted by AWS D1.1 for use with a prequalified WPS unless the WPS is qualified by test and the welder is qualified to use this mode. AISC Design Guide 21: *Welded Connections—A Primer for Engineers* (**aisc.org/dg**) cautions, in Section 2.1.3: "One mode is short-circuit transfer, a low-energy mode of transfer that may lead to the weld defect of incomplete fusion. This is a serious defect that behaves much like a crack. Because the same electrode, equipment, shielding gas and other factors can be used for both short-circuit transfer and other modes of transfer, it is important to understand the conditions under which short-circuit transfer may occur." *Submitted by Noelle Kent, Mcohen and Songs.*

6 **$7/16$ in.** AISC Design Guide 21 recommends, in Section 4.2.8, that a shelf dimension minimum of ¼ in. larger than the fillet weld leg size be used to prevent undesirable melting of the edge. *Submitted by Noelle Kent.*

7 The five types of NDT are: **visual testing, penetrant testing, magnetic-particle testing, ultrasonic testing, and radiographic testing.** More information on these testing types can be found in Chapter 10 of AISC Design Guide 21. *Submitted by Noelle Kent.*

8 **Ultimate and serviceability limit states.** Note that Section B3 of the *Specification* states: "Design shall be such that no applicable strength or serviceability limit state shall be exceeded when the structure is subjected to all applicable load combinations." *Submitted by Morgan Miller, Oklahoma Department of Transportation.*

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

steelwise

DESIGNING FOR DISSIPATION

BY AARON MALATESTA, PE, BOB SCHNEIDER, AND CRAIG WINTERS

Advice on designing buildings for seismic energy dissipation using fluid viscous dampers and ASCE 7 alternative procedures.

Aaron Malatesta (**aaronmalatesta@taylordevices.com**) is Western U.S. director of structural engineering services, and **Bob Schneider** (**bobschneider@taylordevices.com**) and **Craig Winters** (**craigwinters@taylordevices.com**) are industrial/seismic products sales managers, all with Taylor Devices.

EARTHQUAKES DON'T HAPPEN in outer space. But technology to resist them did.

Originally developed for NASA in the 1960s, fluid viscous dampers have successfully transitioned to the structural engineering community for use in protecting buildings, bridges, and other structures worldwide.

Also referred to as seismic dampers, fluid viscous dampers are hydraulic devices that, when stroked, dissipate the energy placed on a structure by seismic events, wind buffering, or thermal motion. The concept is simple: Viscous dampers convert the kinetic energy of the structural movement into heat and then dissipate that energy into the air, thereby obeying the laws of physics through the conservation of energy. They can increase structural damping levels to as much as 50% of critical, resulting in a dramatic reduction in stress and deflection.

Designing steel special moment frames with supplemental systems incorporating fluid viscous dampers can also be simple. Although nonlinear response history analysis (NLRHA) is the preferred procedure for seismic design and analysis, a more simplistic procedure is available to structural engineers. All that is required to implement the procedures is a practical understanding of seismic design principles and response spectrum analysis—as well as technologies such as fluid viscous dampers.

The alternate procedures are provided in Chapter 18 of ASCE 7-16 and are acceptable for use in seismic analysis and design under certain conditions. These procedures were developed and published in 2001 by the Multidisciplinary Center for Earthquake Engineering Research (MCEER) in Technical Report 00-0010 – *Development and Evaluation of Simplified Procedures for Analysis and Design of Buildings with Passive Energy Dissipation Systems*. They were later adopted by ASCE 7-05 and have remained as an acceptable design procedure.

Of course, it's best to consider a fundamental concept used in common seismic design practice before introducing the principles of the alternate procedures. The seismic response spectrum is critical to the design of seismic force-resisting systems

for building structures. We use it to estimate the dynamic response of building structures under seismic excitation. Early on, it observed and calculated that for most structures, the structural movement is greater than the ground motion; this increase of the structural movement over that ground motion is commonly referred to as dynamic amplification. The extent of dynamic amplification varies depending on the dynamic properties of the structure and the characteristics of the initial earthquake ground motion encountered.

It's important to note the significant effect damping has on the magnitude of seismic response spectra. Figure 1 is an example ASCE 7 response spectrum with varying levels of damping and indicates that a structure's spectral response acceleration is significantly reduced when higher levels of damping are considered.

Dynamic amplification occurs because a mass has kinetic energy. Damping resists kinetic energy, and an optimal solution for seismic protection of a structure will include damping. Most steel structures are designed with "fuses" that yield during a seismic event, and their hysteretic behavior provides damping to the structure. With steel special moment frames, these "fuses" occur at each end of the moment frame beams where special detailing is provided to allow plastic strains in the gross beam section without brittle fracture.

There is another way to protect structures during a seismic event and prevent extensive damage to the special moment frame beams. Supplemental damping can be provided through the application of velocity-dependent devices that are used solely for resisting the kinetic energy of the building caused by seismic excitation. A typical configuration of the steel special moment frame and the damping system (DS) is shown in Figure 2. The DS is defined as the damping devices and all other components required to connect damping devices to the other elements of the structure. These devices remain damage-free during a maximum credible earthquake.

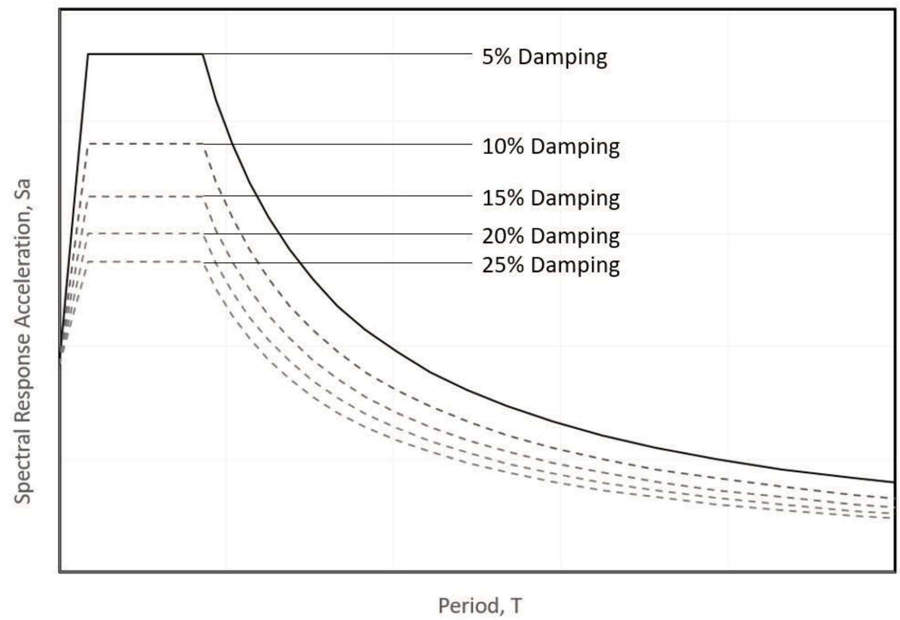


Fig. 1. Example ASCE 7 response spectrum with varying levels of damping.

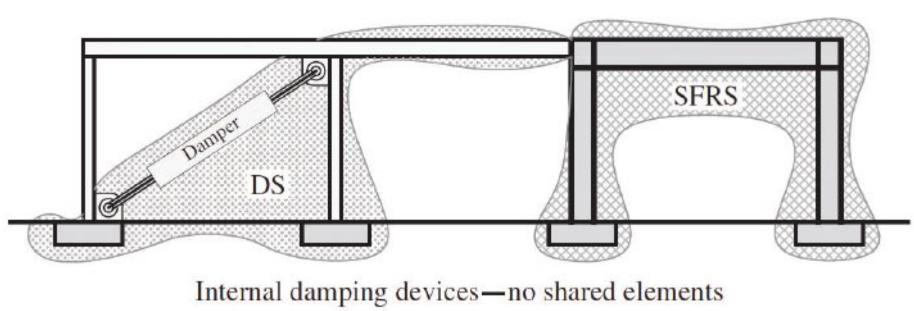


Fig. 2. Steel special moment frame with supplemental damping system.

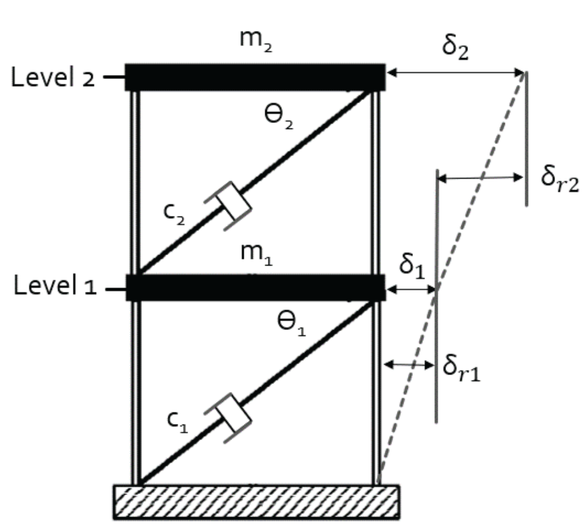


Fig. 3. Structural model diagram with *m*th mode of vibration.

With an understanding of seismic response spectra and the application of the damping system, we can move toward implementing the alternate procedures. Here, we will address a novel but fundamental concept for how to calculate the viscous damping ratio. All that is required is an assumed damping configuration and a modal analysis of the steel special moment frame. Each modal shape will have a different viscous damping ratio and can be described as shown below.

The viscous damping ratio of each mode of vibration, β_{Vm}, is defined by the following equations (the first is ASCE 7-16 Eqn. 18.7-50 and the second is ASCE 7-16 Eqn. 18.7-51):

$$\beta_{Vm} = \frac{\sum_j W_{mj}}{4\pi W_m}$$

$$W_m = \frac{1}{2}\sum_j F_{im}\delta_{im}$$

where:

W_{mj} = work done by jth damping device in one complete cycle of dynamic response corresponding to the mth mode of vibration of the structure in the direction of interest at modal displacements, δ_{im}.

W_m = maximum strain energy in the mth mode of vibration of the structure in the direction of interest at modal displacements, δ_{im}.

F_{im} = mth mode inertial force at level i.

δ_{im} = deflection of level i in the mth mode of vibration at the center of rigidity of the structure in the direction under consideration.

Using these equations, the damping coefficient, C, of the damping devices can be modified to achieve a target damping ratio based on the desired performance objective.

This simplistic manner in which supplemental damping can be considered for seismic design and analysis makes working with velocity-dependent devices simple. Once the desired viscous damping has been determined, you can calculate a modified response spectrum for each mode shape based on the added viscous damping in accordance with typical response spectrum procedures (take a look at Chapter 18 of ASCE 7 and the MCEER publication for a more detailed description of the alternate procedures).

Fluid viscous dampers have been used to protect thousands of steel structures around the world and can be an optimal solution for seismic protection of building structures. Understanding

how to best implement them can go a long way in improving the performance of your next project with increased seismic requirements. ■

Want to learn more about fluid viscous dampers? Check out the presentation "Design of Building Structures with Fluid Viscous Dampers for Seismic Energy Dissipation Using ASCE 7 Alternative Procedures" at the 2020 NASCC: The Steel Conference, taking place April 22–24 in Atlanta. For more information and to register, visit ***aisc.org/nascc****.*

field notes

BEATING THE DRUM

INTERVIEW BY
GEOFF WEISENBERGER

Structural engineer (and drummer) Bill Bast has designed projects for the base of Chicago's tallest building twice, including a recent major renovation.

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

WELCOME TO THE FIRST INSTALLMENT of *Modern Steel Construction*'s new monthly Field Notes podcast series, where we interview industry personnel with interesting stories to tell.

This month's subject is **William "Bill" D. Bast, SE, PE**, who heads the Forensics and Renewal practices at Thornton Tomasetti's Chicago office. With over 30 years of structural engineering practice, some of Bill's projects include relocating the U-505 submarine for the Museum of Science and Industry, the ongoing renovation of Wrigley Field, exterior façade repairs to Chicago's Metra headquarters and Water Tower place, and two renovation projects at Chicago's tallest building, Willis Tower; the first took place in the 1980s, when it was known as Sears Tower, as the second is currently finishing up. He also plays the drums. Below are some excerpts from our interview.

How did you decide to become a structural engineer?

My dad was a structural engineer for the local power utility, and I enjoyed hearing his stories about what he did and thought that he had a great work-life balance. And I was good in math and science, so I leaned toward engineering when I was looking at colleges. I graduated from Lehigh with a bachelor's degree in civil engineering and became a team manager for Procter and Gamble's paper products division, making Pampers diapers in northeastern Pennsylvania. It's definitely removed [from structural engineering]. They paid very well and it was very good management training from me, and a lot of what I learned 40 years ago in that job, I apply today to what I do here at Thornton Tomasetti.

How are the forensics and renewable practices disciplines related?

I always think of structural engineering the way I learned it at Lehigh as a spectrum, with forensics on one end of the spectrum and design on the other end of the spectrum and research and education all mixed up, and that one informs the other. So when you're designing and something bad happens, the codes change and you become a better designer, having seen problems in the field in the forensic way of things. And the design also informs the forensics—understanding how a structure should behave or should respond and compare it to what exactly did happen.

One of your recent projects is a renovation/addition to Willis Tower. And one of your mentors, John Zils, was a key designer of the building when it was originally under construction.

Yes, Fazlur Kahn was chief structural engineer at SOM, and John was a project engineer under him on the Sears Tower job, which as completed in 1973. One of the early jobs I worked on in my career at SOM was the Sears Tower revitalization project, a $25 million job where we put a new barrel vault entrance on the west side of the building and a winter garden type of structure inside of that, and John was also involved with that renovation. That was in 1985 and now 30-some years later, we're [Thornton Tomasetti] tearing that entrance off the building as well as the other entrances and building a four-story podium out to the curb line to create a new retail experience at Willis. I'm old enough now that my original designs are getting torn down!

Can you share anything you've learned from John?

One thing I can recall John stressing was the importance of smaller projects and the fact that not every job is the Sears Tower. What is it about a project that makes it exciting? He used to say there's always something there that is unique or special, and it's your job to find it. Another bit of wisdom he shared is that you don't have to be the expert on the project at the start, but you'd better be the expert at the end of it.

I understand that you are a drummer. How did you become a drummer?

Actually, I auditioned for [drums] in fifth grade. This was the school band, and I had to listen to the instructor tap out a rhythm and then try to replicate it, and he said, "You have an aptitude for drums." And so I went on to play in concert band and then marching band in junior high and early high school, and then I stopped for about 25 years or so. And then I got interested again when I was going to a contemporary Christian church and they had a full rock band up on the stage with a drum kit. I'd never played a drum kit, but I decided to buy one and teach myself how to play it. And about six months later, I was asked to play. That was about 12 years ago, and I've been doing that ever since.

Bast (left) with one of his mentors, Johns Zils, at the upper reaches of Chicago's Willis Tower. The two worked together on a renovation project in the 1980s, when it was still called the Sears Tower.

Besides the church band, do you have any other drumming outlets or have you done other gigs?

Actually, a few years ago, we formed a band here at Thornton Tomasetti. We named it Lev Zetlin (to sound like Led Zeppelin) as that's the name of the founder of our firm [Lev Zetlin and Associates, which Thornton Tomasetti purchased in 1975]. We've played a couple of gigs, and I was actually paid for one. We played in some dive bar in Logan Square, and I think I got 12 bucks for the night! ■

*You can listen to the full podcast at **www.modernsteel.com**. And if you want to learn more about the Willis Tower renovation project, check out the session "A New Base for Willis Tower," for which Bast is one of the presenters, at the 2020 NASCC: The Steel Conference, taking place April 22–24 in Atlanta. For more information and to register, visit **aisc.org/nascc**.*

business issues

BUILDING THE FELLOWSHIP

BY DAN COUGHLIN

The Actions of Leadership, Part Two: Putting together the right team for your organization's quest.

Since 1998, **Dan Coughlin** has equipped business leaders to consistently deliver excellence in management, leadership, and teamwork. Visit his Business Performance Idea Center at **www.thecoughlincompany.com**.

LEADERS DON'T ACHIEVE ANYTHING.

Whenever I read that an NFL or NBA head coach won a championship, I just smile. No NFL or NBA coach could actually play in a game during the season. They would get run over out there on the field or on the court. The *players* won the championship game.

The head coach *influenced* the other coaches and the players in order to produce a performance that won the championship.

I think of Martin Luther King, Jr., Mohandas Gandhi, and Mother Teresa as three of the all-time great leaders in history. They influenced literally millions of people to sit-in, stand up, march, boycott, pour soup, and wake up millions of other people to try to solve massive societal problems. Those people who were influenced by them changed history.

Leaders Build the Fellowship of the Quest

When I was 12 years old, I read J.R.R. Tolkien's *The Lord of the Rings*. Now 44 years later, I just finished rereading *The Fellowship of the Ring*, the first book in the series. Even if you haven't read them (or seen the movies) you may already know that this is the story of a group of people who worked together on a long and dangerous quest to destroy an all-powerful and dangerous ring in order to keep it out of the hands of the enemy. Frodo Baggins by himself could not travel across the country, deal with goblins and orcs and other such monsters, and destroy the ring. He needed a fellowship.

Mother Teresa needed other people to set up soup kitchens around the world to feed the poor.

King and Gandhi needed other people to protest in a nonviolent way in order to change the world.

You need a fellowship in order to fulfill the meaningful purpose and achieve the important goals of your quest. You will not do it by yourself. Let me repeat that. *You will not* do it by yourself.

Nurture Relationships

I'm not saying you should go party with your employees. Let me take that a step further and encourage you to *not* party with your employees. Those folks need time to party together—separate from you. And if you simply *have* to party with them, at least leave early. You do not, as their manager, want to be the last person standing—or even worse, falling over.

What I *am* encouraging you to do is to nurture relationships. Get to know each of your employees on an individual basis. And then get to know them on a group basis. Understand what they are thinking and feeling, and then respond appropriately. Understand the nuances of the individuals and the nuances that are created by the group. That is empathy, and empathy is critically important.

business issues

What's the secret to nurturing relationships with the people in your fellowship? Time. Time is the secret. Invest time with people. Listen to them. Turn off your cell phone, and *really* listen to them. Work to know them and understand them. Talk about what is important to them. And then talk about the quest, the purpose of the group, the goals the group is trying to achieve, and the journey it will take to get there.

> Time is the secret.
> Invest time with people.
> Listen to them.
> Turn off your cell phone,
> and *really* listen to them

Relationships. Focus. Effort. Communication. Sacrifice.

These are not new concepts. They compose the age-old journey that all leaders go on. It is *not* you by yourself. It is you in fellowship with other committed people to fulfill a purpose. You don't *achieve* anything. You *influence* people to work toward the fulfillment of that purpose and the realization of the fellowship's goals.

Stay tuned for the finale of the Actions of Leadership series, coming next month. ■

Dan will present multiple sessions at the 2020 NASCC: The Steel Conference, taking place April 22–24 in Atlanta. To check out the advance program for the conference, which includes a schedule and descriptions of all sessions, visit ***aisc.org/nascc****.*

Bridging the Gap between Designer and Builder

BY GEOFF WEISENBERGER

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

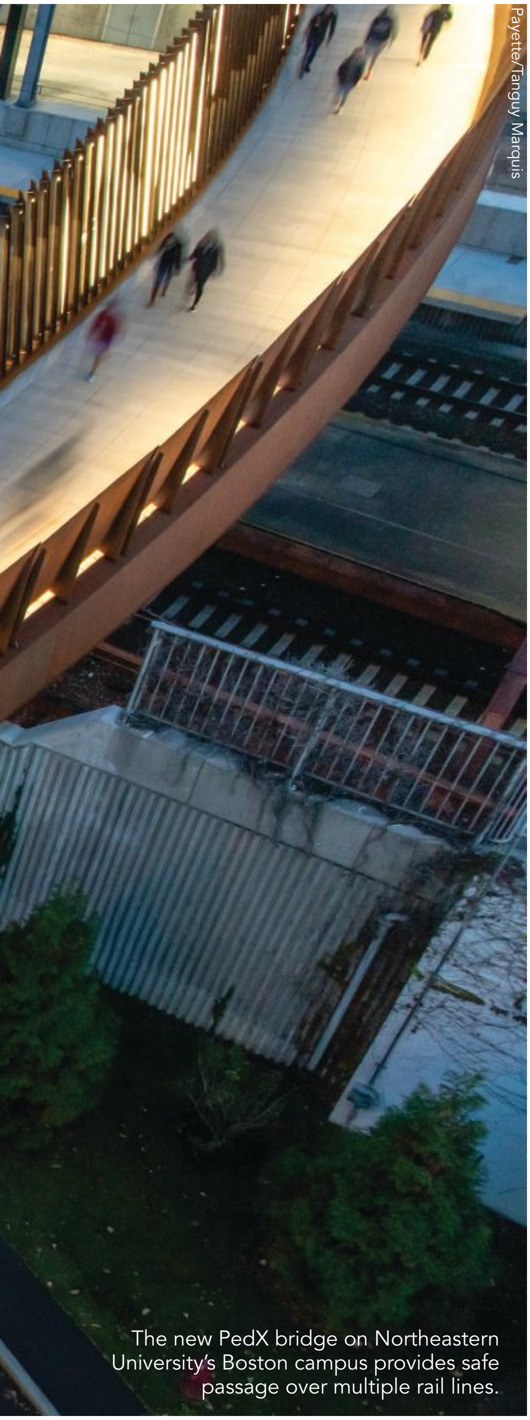
A NEW PEDESTRIAN BRIDGE on Northeastern University's campus crosses a valley of sorts in Boston.

The Northeastern University Pedestrian Crossing (PedX), which opened this past June, spans across five Massachusetts Bay Transportation Authority (MBTA)/Amtrak rail lines to connect the main campus with the expanding Interdisciplinary Science and Engineering Complex (ISEC) to the south of the tracks.

Serving more than just the University community, the bridge provides a safe, much-needed public connection between the Fenway and Roxbury neighborhoods and links the adjacent MBTA platform, bus station, pedestrian routes, and parking structures. Pedestrians previously had to walk through a parking garage to the east or through an MBTA station to the west to get across the tracks.

This ambitious steel-framed pedestrian bridge at a key transportation node for the city is a symbol of Northeastern's ongoing mission to strengthen communities by bringing

A collaborative mindset and an architect-as-prime delivery approach culminate in a stunning university pedestrian bridge that connects not only disparate campus areas but also communities.



Payette/Tanguy Marquis

The new PedX bridge on Northeastern University's Boston campus provides safe passage over multiple rail lines.

Weathering steel panels protect the train tracks and adjacent power lines from pedestrians and vice versa.

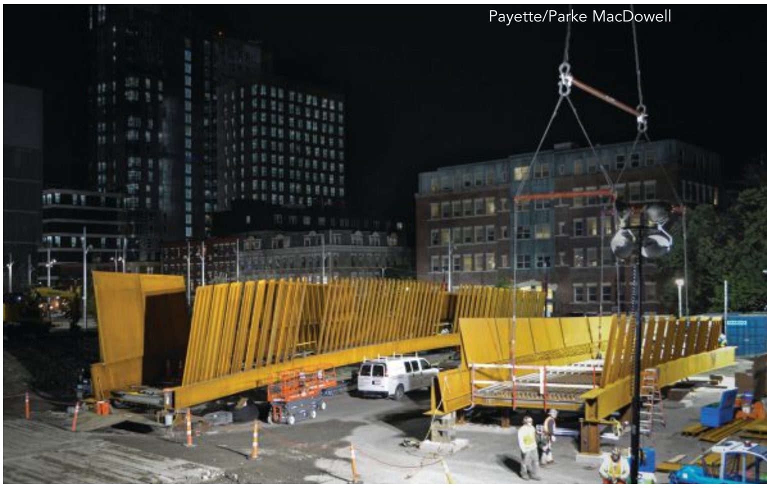
Payette/Warren Jagger

them together. The university desired an expressive architectural experience—to the point where architect Payette held the prime contract for the project—that not only provides access over the rail lines but also creates exciting new public spaces. The bridge's sense of movement and flow is informed by the design language of the precinct, which is evident in the organic forms and rich curved surfaces of the neighboring ISEC and the forthcoming EXP research building, which will break ground this year.

The bridge has a dramatic form that uses weathering steel plates (⅝ in. thick) to protect the train tracks and power lines from pedestrians and vice versa. The specialty steel's inherent corrosion resistance avoids the need for rail agency shutdowns for periodic repainting, and also imbues a reddish-brown patina to the structure that nicely complements the surrounding infrastructure and the new ISEC. Instead of employing the conventional "curl-over" guardrail fencing typical on bridges that cross railways, the new bridge's steel panels—33 on the west side and 106 on the east side—angle outward and grow in height to attain the necessary protection over the catenary wires.

At its northern terminus, the bridge lands delicately between existing buildings, and its solid parapet flares open and dissolves into a perforated pattern that invites pedestrians south across the main span. Traveling over the rail corridor, the bridge arcs and grows taller, its parapet panels rotating to expose slender glass panes with views to the ISEC and Boston skyline. The panels also lean outwards to enhance a sense of openness while adhering to


Payette/Parke MacDowell


Payette/Parke MacDowell

As there was only a two-and-a-half-hour window when the construction team could disrupt the Amtrak/MBTA tracks, the erection weekend needed to run seamlessly so that there were no disruptions to passenger safety. The erection crane was assembled on-site and was delivered in 39 truckloads.


Payette/Tanguy Marquis

the strict protection requirements established by the rail operators. The taller western parapet gently rises to a height of 18 ft towards the bridge's south abutment, creating a dramatic entry marker. All of the parapets are fabricated to AISC Architecturally Exposed Structural Steel (AESS) Category 3: Feature Elements in Close View requirements (for more details on the various AESS categories, see "Maximum Exposure" in the November 2017 issue at **www.modernsteel.com**). For the rest of the steel superstructure, all steel markings were specified to be on the "hidden face" of the elements, all erection brackets were removed, and all welds visible from the inside of the bridge were ground smooth.

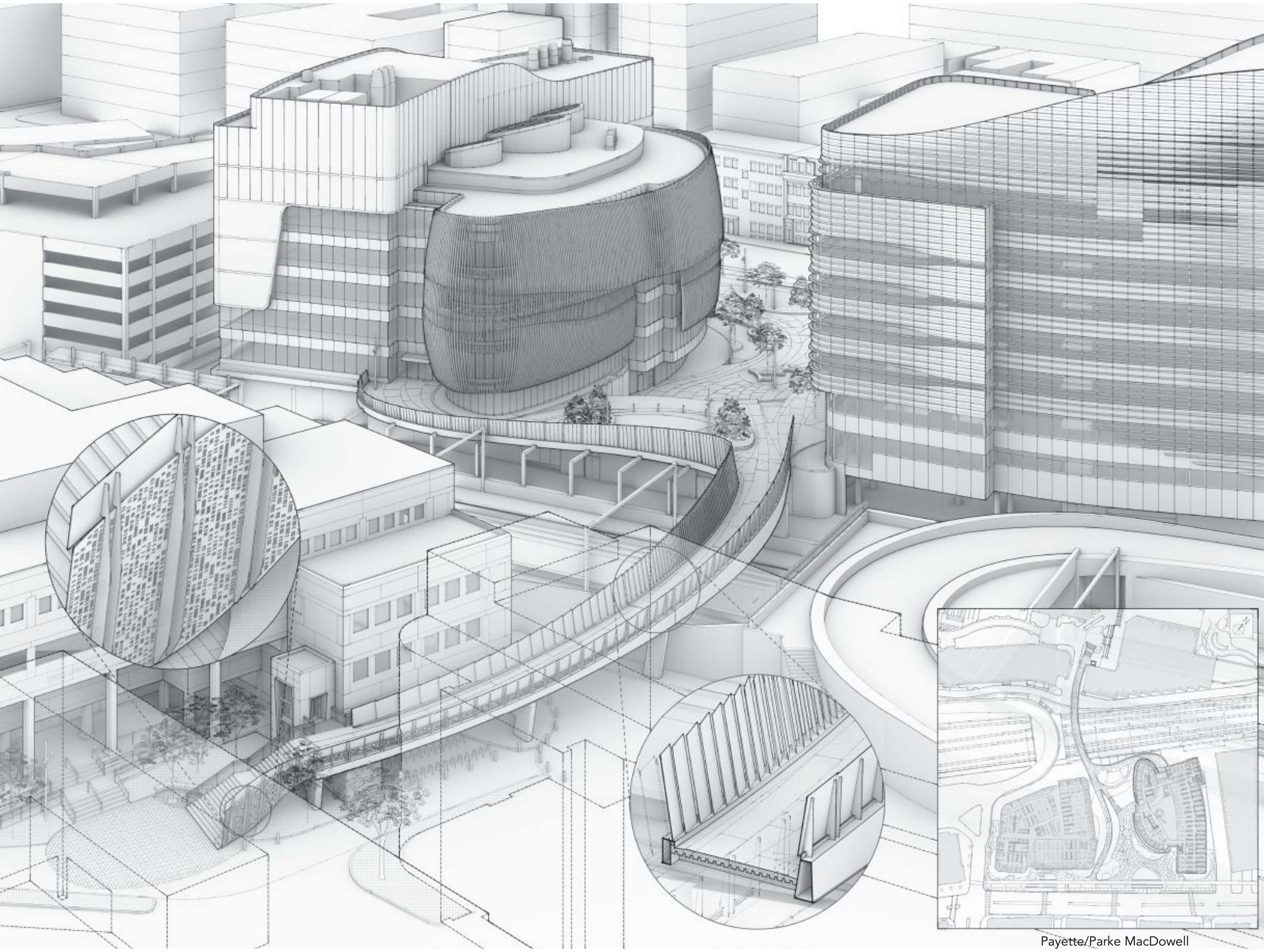
In addition, the bridge is ADA accessible and open to the general public 24-7. On the north side of the bridge (the main Northeastern campus), the bridge is approached by a set of stairs or an elevator. Across the railway corridor to the south, the bridge opens to a sloping, landscaped walkway that descends to Columbus Avenue and also flairs outward to approach the ISEC and its future sister building to the west.

Vital Statistics

Parke MacDowell, project architect with Payette, answered some general questions about the bridge.

How long and how wide is the bridge?

MacDowell: The 16-ft-wide bridge runs 320 ft from the north campus to the south campus across the rail corridor. Once the bridge lands on the south side of the tracks, it sweeps another 180 ft to the east over a service drive and terminates at the entry of the ISEC.



The bridge is a major piece of a local pedestrian network connecting the Fenway and Roxbury neighborhoods and links the adjacent MBTA platform, bus station, pedestrian routes, and parking structures. To get across the MBTA and Amtrak tracks, pedestrians previously had to walk through a parking garage to the east or an MBTA station to the west.

How tall are the bridge guards?

MacDowell: The bridge parapets vary in height from 4 ft to 18 ft, and the height of each parapet is informed by local codes (*the Massachusetts State Building Code* as well as MassDOT, Amtrak, and MBTA standards) and the required protections between pedestrians and the MBTA and commuter railway infrastructure below. Simply put, the design team unfolded the conventional "curl-over" pedestrian bridge guards and canted them outwards. Though inward curved guards are typical, the rail agencies accepted this alternative approach with outward-leaning guards but required an increased height.

How about the superstructure?

MacDowell: The bridge is defined by an asymmetrical steel superstructure below a concrete slab over corrugated steel decking. The main-span concrete was executed as a single continuous pour, and the saw-cut pattern in the concrete deck carries the landscape aesthetic from the ISEC plaza to the north campus. The primary load of the span is carried by the larger, west box girder, which allows the east girder to shrink to the level of the deck so the east parapets can flare open to reveal views to the Columbus Avenue campus and the Boston skyline. Despite their visual prominence, the parapets are not part of the primary structural system. And like the parapets, the primary bridge structure and guards are all made of weathering steel. The box-girder superstructure and panels total 270 tons of steel in all.

The shallow east girder is a rectangular box, 32 in. deep by 12 in. wide, with plate thickness ranging from ½ in. to 1⅜ in. The west girder, with plate thickness ranging from ½ in. to 1 in., varies in depth from 24 in. to 72 in. to roughly follow the bending moment diagram and integrate with bridge aesthetic and rail parapet requirements; the geometry is defined such that width of the girder increases with varying depth to ensure any double curvature in the plate is negligible.

What are the differences between the east and west sides of the bridge?

MacDowell: Both the east parapet and the west parapet cant outwards 10° from vertical, and the shingled panels of the east parapet feature infill glazing: 1-in.-thick, laminated, low-E glass with a hydrophilic "self-cleaning" coating. The west parapet includes the primary structural girder and shingled guard panels above a strip of cove lighting. On the north side of the bridge, the inside web of the west girder extends beyond the girder box, growing larger and more perforated as it approaches the north campus stair.

What parts of the bridge were prefabricated?

MacDowell: Working over railway tracks is expensive and challenging logistically, so erection must be done swiftly and safely. The team's approach was to fabricate as much as possible in the shop, assemble the remaining elements in the lay-down yard adjacent to the site, and then drop the primary spans in place overnight. Structural assemblies were fabricated at King Fabrication's shop in Houston and shipped to Boston for on-site assembly and installation.

*For more on the installation process, including a time-lapse video, visit the Project Extras section at **www.modernsteel.com**.*

Team Effort

Other members of the bridge's project team weighed in as well.

MacDowell

Pramberger

Potapova

Tuzzolo

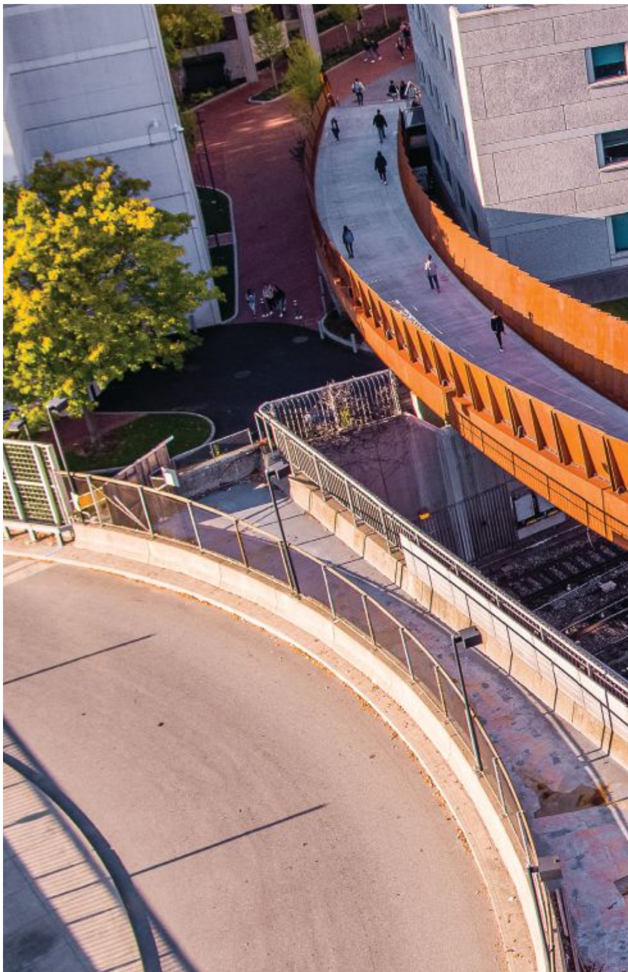
Susi

Rossitto

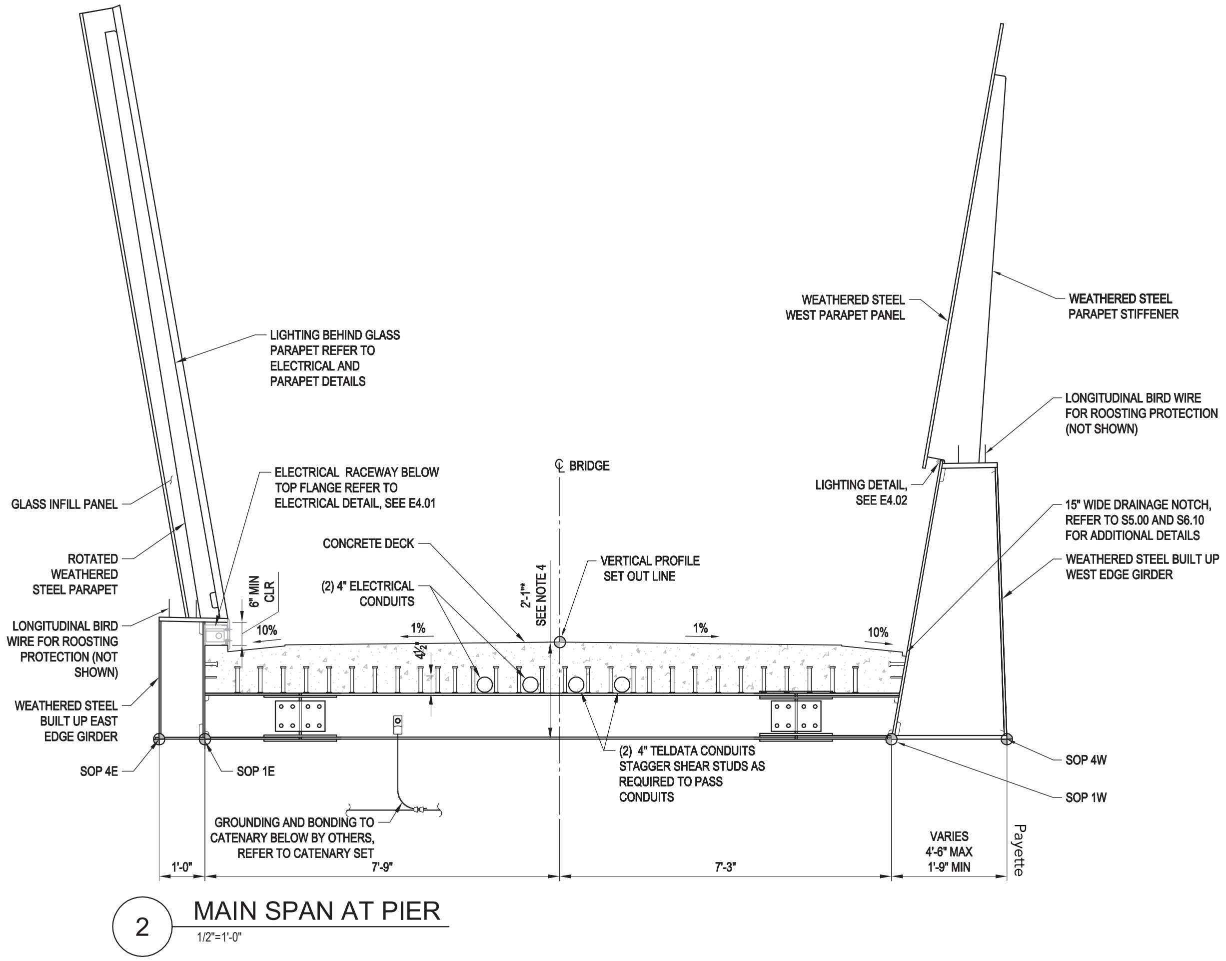
What were the greatest challenges for this project, and how were they addressed?

Andrew Pramberger, Project Manager, Skanska: The project had a very aggressive timetable that required the main span bridge steel fabrication to begin before the shop drawings for the bridge parapets, north stair, and ISEC deck/parapets were complete. As such, we were never able to preassemble the full bridge in the shop. The project team relied heavily on the concept of incrementalism. We identified the key fit-up points and built templates and jigs to replicate components no longer in the shop. We also relied heavily on King Fabrication's 3D model to coordinate between the packages. By breaking the job up as we did, we were able to allow King more time to prepare high-quality shop drawings of the later packages, rather than trying to get all shop drawings completed at once. We also incorporated lessons learned from earlier packages into later shop drawings so the same issues did not continue to surface during the review process.

above: Constructing a physical model helped the team visualize the intricate project as it weaves between buildings and over train tracks.



Payette/Parke MacDowell



below: From above, the visual effect of the bridge is a canyon traversing another canyon.

above: A cross-section drawing of the main span at a pier location.

Payette/Evan Patten

The bridge parapet installation was also a unique aspect. Each parapet was set at a unique angle to the bridge, so erector Atlantic Bridge's crews had to be diligent during erection. It was critical for the parapets to retain their individual geometry while blending to achieve the design team's intended collective gesture as pedestrians walked across the bridge. We also made the decision to install all main-span bridge parapets in the yard, before the span was erected. This decision greatly reduced the impact of materials falling onto the Amtrak and commuter rail operations below. It also introduced a degree of uncertainty as to the final deflection of the bridge span, when the span would be loaded with the concrete deck material. The potential deflection changes at that time might adversely affect the parapet alignment. We worked to mitigate this phenomenon through 3D finite element modeling of the main span and parapets to understand how the structure would move and what our risk would be. We also ballasted the bridge with timber mats and concrete barriers during preassembly to simulate the final deflection condition, to best fit the parapets.

Lana Potapova, Bridge Engineer, Arup: The 120-ft clear-spanning, 500-ft-long bridge emerged from site challenges, and the team embraced the project complexities. The desire to lower the bridge's grade line while maintaining railroad clearance, erect the bridge in a single weekend closure, and provide views toward the ISEC building, all while maintaining strict railroad parapet requirements, resulted in a stunning asymmetrical through-box girder solution. The east girder is maintained shallow to open the views while the west deepens gradually with the bending moment diagram over the main span to resist the bulk of the dead load.

One of the key architectural goals for the crossing is to provide a visual gateway to the new ISEC buildings. However, the bridge parapet height and limited perforation requirements over the railroad presented a challenge. The team worked with MBTA and Amtrak to introduce a resilient structural glass solution that requires no maintenance from the outside. This solution was the first approved use of structural glass over the MBTA tracks.

The steel girders are boxes to provide torsional stiffness to the highly asymmetrical bridge geometry. These are traditionally the most difficult to fabricate, but careful attention to sequencing plate assembly and geometry definition helped facilitate fabrication.

Greg Tuzzolo, Landscape Architect, Stimson: The geometric complexity of the project required a high degree of coordination, both during the design process and the construction phase. Across the site, the form of the bridge and landscape are constantly

Northeastern University desired an expressive architectural experience—to the point where architect Payette held the prime contract for the project—that not only provides access over the rail lines but also creates exciting new public spaces.

changing. This dynamic character required careful attention to the relationships between the walking surface, bridge panels, landscape features, and the existing campus fabric on both sides of the bridge.

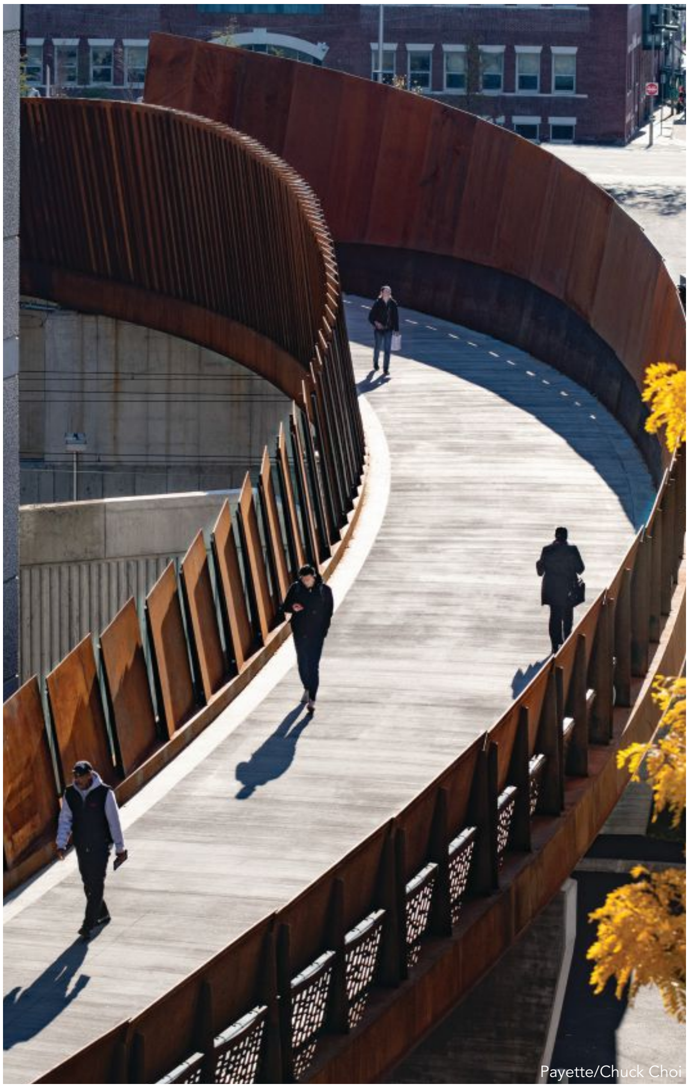
This challenge pushed the design team towards an integrated 3D model to capture all of these elements in a comprehensive format. Payette translated that 3D model into a virtual reality (VR) simulation that allowed the team to walk through the bridge as a dynamic experience rather than simply reviewing perspective drawings from set locations. This process gave us tremendous reassurance in the design as we moved quickly ahead into construction documents. The integrated model was critical from a technical perspective as well, and ultimately served as the basis for the detailed design of the concrete walking surface of the bridge. One of the most challenging issues we faced was the restriction from capturing any storm water over the tracks, pushing us to design a runnel system that carries water from the right-of-way into a series of basins at each end of the bridge. The concrete bridge deck had to be installed in a single mass pour, with no room for error or field adjustment, requiring the design of the surface to be precise, while still maintaining construction tolerance to allow

Prime Role

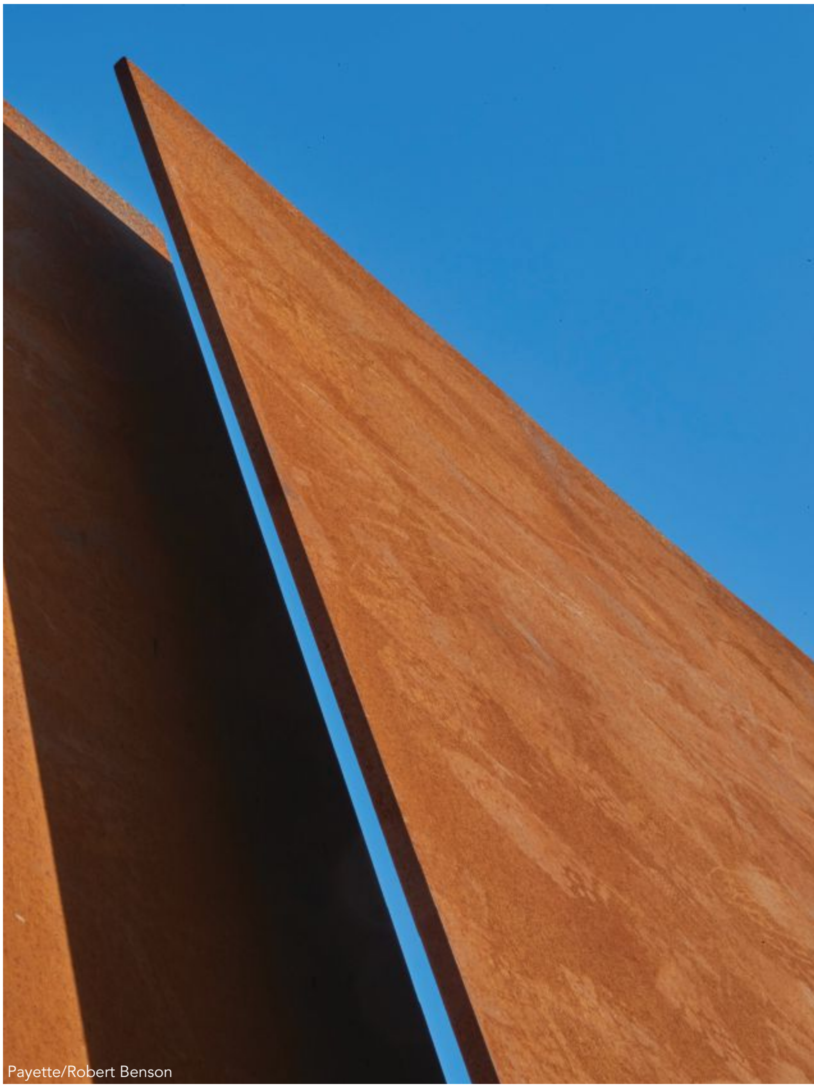
It is unusual for the architect to hold the prime design contract for a piece of infrastructure like a bridge, but Northeastern University sought Payette's leadership in crafting a cohesive vision for this project. Enabled by this contract structure, Payette saw an opportunity to tweak "business as usual" to improve the design process, streamline construction, and better meet user needs. Key to this approach was strategically collapsing the gap between designer and builder.

Payette, supported by Skanska and the subs, advocated the idea that the owner attains best value when there is a clear and direct relationship between designer and fabricator. This involves a fair amount of listening, empathy, and constructive discourse. Full-scale mock-ups executed not only by King but also by Payette in our in-house shop proved vital for interrogating design problems and for communicating solutions. We used digital and physical models to help all parties understand tricky project details and have a voice in their resolution. This strategy was an incredibly powerful way to facilitate decision-making and move the project forward.

—Parke MacDowell

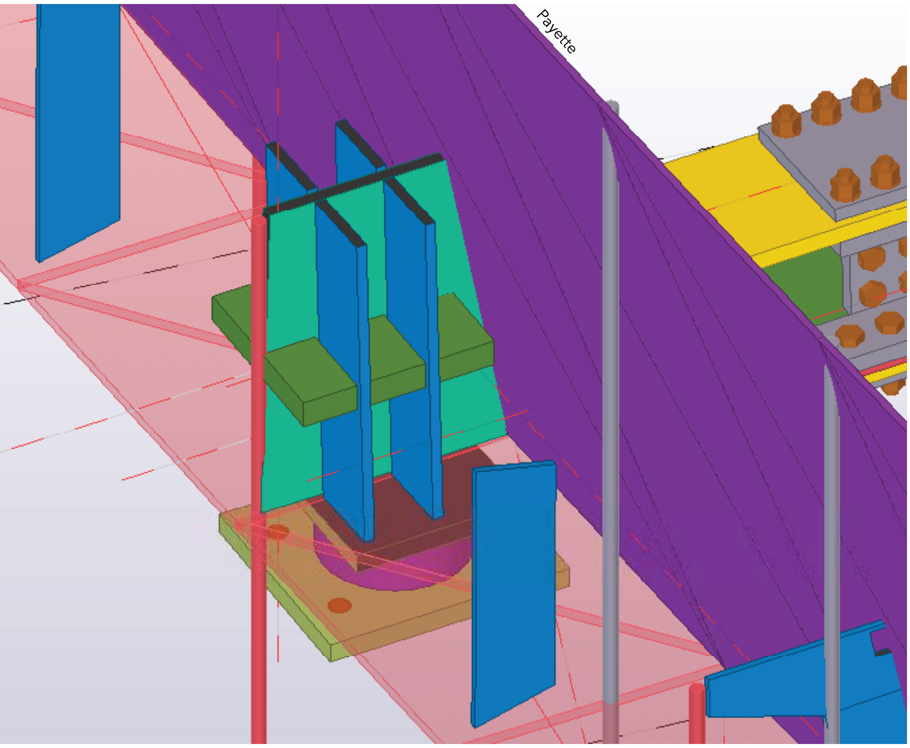


Payette/Chuck Choi



Payette/Robert Benson

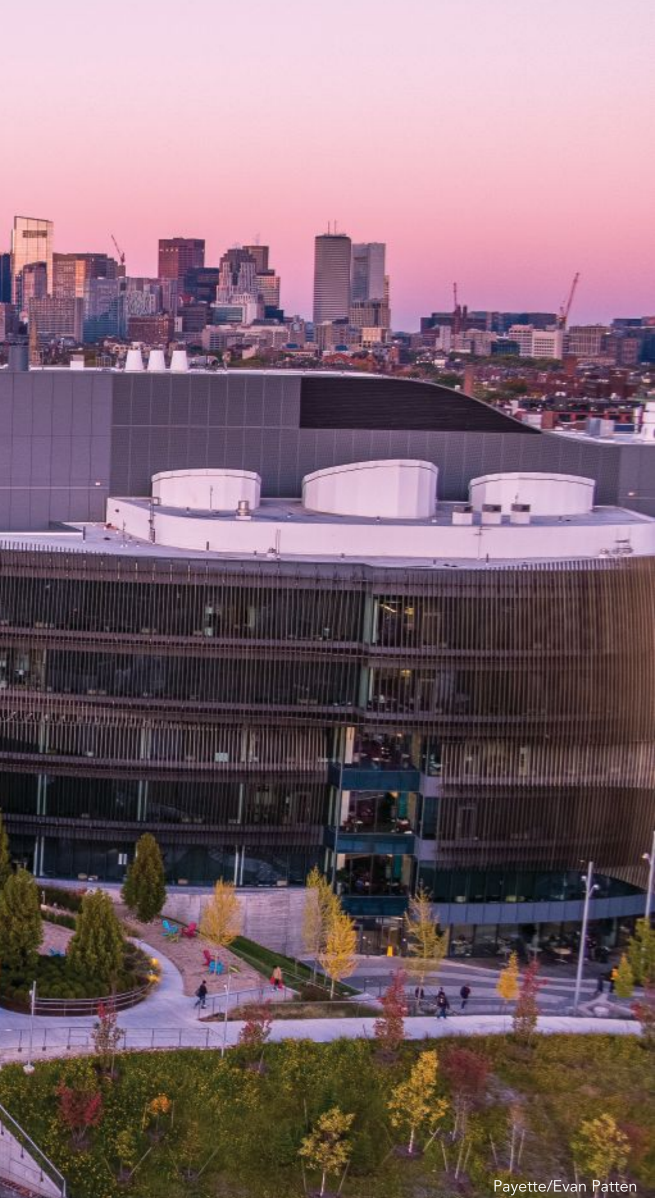
The steel panels of both the east and west parapets cant outwards 10° from vertical.



above: The wall panel system and box-girder superstructure were achieved with only 270 tons of structural steel.

left: The team held weekly steel calls to think through tricky connection details and fabrication sequences. For example, this Tekla model view shows the stiffeners within the primary girder at a bearing location (the top flange and exterior web of the box are turned-off for clarity). Due to access and sequencing challenges, this area was modified to incorporate a field-welded access panel so that King Fabrication could execute all of the specified welds.

right: Creating a wood mock-up of a parapet section in Payette's shop helped the team visualize the project before it was fabricated.



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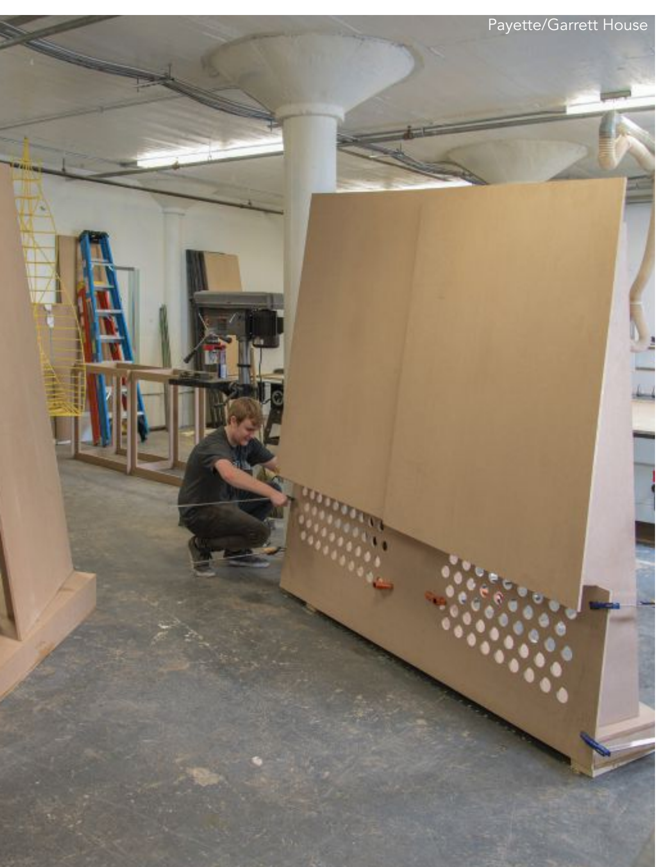

Payette/Garrett House

for ADA-accessible gradients throughout the warping surface. This challenge took several detailed iterations with all disciplines and close review by the contractor during the construction process, using as-built survey information.

Nate Susi, Project Manager, Atlantic Bridge and Engineering: The layout and installation of the east parapets was challenging. Each parapet was unique, and they were installed at variable spacing and rotation angles. Survey worked directly with the detailer to determine proper layout, and our ironworkers installed the panels and temporarily secured them. Payette then visually inspected the panels and made minor as-needed adjustments prior to permanent welding.

The other major challenge was executing the north stair parapet wall to achieve the aesthetic vision of Payette and Northeastern. This was tremendously difficult from a constructability standpoint. It took a great deal of coordination and flexibility on the part of the entire project team to determine the best solution.

Vince Rossitto, King Fabrication: For us, the greatest challenge was determining a means and methods of production to adhere to all relevant codes and specifications (AWS D1.5: Bridge Welding Code, fracture-critical requirements, AESS, MassDOT, etc.) combined with the complicated shapes and compartments. This leaves a small window to navigate through. At the end of the day, you still need to cut, form, and weld steel together as you would in any other project. In this case, you must vet multiple options to find a plan that you are comfortable will move the production forward with one hand tied behind your back.

What was the most interesting thing about this project?

Pramberger: To me, the most interesting part of the project was the preassembly and subsequent erection of the main span over the Amtrak Northeast Corridor rail line. We performed an exhaustive search to find the right crane to lift the 121-ton main span, ultimately settling on the Manitowoc MLC-650. It was exciting to see one of the largest cranes on the East Coast (all 39 trailers worth!) assembled on our small project site. I also enjoyed the coordination with the railroad as we worked through the erection plan. As we only had a two-and-a-half-hour window when we could foul the tracks, the erection weekend needed to run seamlessly so that there were no disruptions to passenger safety. Amtrak and MBTA were true partners in the process and went out of their way to support our work—making themselves available to answer any questions, meeting on site multiple times to review logistics, and suggesting ways to ensure success during the lift weekend.

Potapova: While bridge geometry is complex, it is also rationalized into distinct Euclidian components to facilitate detailing, fabrication, and erection. The through-girder design allowed for the erection of the main span bridge over a single weekend and also lowered bridge tie-in points, providing significant savings on the volume of the surrounding landforms. The fabricated steel girders are uniquely integrated into the overall architectural statement yet are detailed to facilitate fabrication, transportation into a busy urban center, and field assembly.

The design team worked collaboratively with a significant number of stakeholders to support the aggressive design and construction schedule, provided a design that ensured a smooth permitting process, and kept the cost of the bridge within the target budget.

The team provided a bridge that not only met the client milestone goals, but also was designed to be incredibly simple to maintain and operate. The steel details, concrete mix design over the main span, and design of electrical systems and glazing allow access and maintenance from the bridge deck, reducing the need to stall rail operations for maintenance.

Tuzzolo: The pedestrian crossing is the second of three major projects within the ISEC complex involving our firm. The work benefited from the extension of relationships on both the physical campus and the project team, allowing us to capitalize on lessons learned from the ISEC project, and take note for our future work at EXP. Ultimately, the most rewarding part of the job for me was learning from my collaborators and seeing the project come together as an incredible group effort.

Susi: The shapes of the girders and the welded splices to achieve the bridge's seamless look were unique, as was the perforated web extension. This is not your average bridge.

Rossitto: This one is easy: the perforations and the stair wall. We have tackled similar castellations, aesthetics and geometries before, but never simultaneously.

Where there any interesting lessons learned that would impact the way you might do business in the future? Was there anything that went particularly well that you might recommend to others?

Potapova: To achieve architectural quality, field welding and testing was required. Typically, welds are tested with radiography, which significantly impacts the occupation of the site and adjacent buildings due to X-ray waves. To avoid closing buildings on the active campus during testing, Arup engaged internal steel fabrication experts and approved phased array ultrasonic testing (PAUT). This alternative approach allowed Snell Library to remain open to students during final exams. Arup has since adopted the same technique on other projects.

Pramberger: This was a very complex, custom fabrication that had many design intricacies. We established weekly teleconference meetings to review the job status and focus on critical design, detailing, and fabrication issues. These weekly meetings were attended by the architect, engineer, fabricator, installer, general contractor, third-party inspector, owner's representative, and owner. By establishing a weekly dialogue, we could address issues as they arose rather than waiting for them to snowball into larger issues. This again was part of our focus on incrementalism. This process also allowed for the free flow of information between all parties and a true "team" work ethic. Sometimes the discussion would get very granular and allowed us to get at the heart of problems in order to understand and resolve them. I highly recommend this type of regular all-hands meeting to advance the design and fabrication process.

Skanska also procured the structural steel under a furnish-and-install contract in which King worked directly for Atlantic Bridge. Atlantic's project manager was involved in the process from the start of 3D modeling, so he knew the design rationale for certain details and he was able to offer constructability comments. By the time the steel arrived on-site, Atlantic was fully engaged in the process and knew how the structure was supposed to be erected, rather than first looking at the plans when the steel arrived on-site.

Rossitto: We were pleased the most with the perforations and the stairs simply because we had one chance to get it right (and quickly). On projects like this, you've got to have the right people on your team. Specifically, we needed highly skilled Tekla modelers to interface between the designers and the shop floor.

Tuzzolo: We were fortunate to have a construction job-site camera available to us during the project. I highly recommend this feature as it allowed us to have up-to-date awareness of job-site activities, construction progress, sequence, and when we needed to be on-site to review items. It saved us time and allowed us and others on the design team to remain in the loop on progress. In addition, I would definitely budget extensive time in construction administration for the next project with this level complexity.

Susi: A bridge with a shape this unique needs to be detailed and fabricated by a company like King with the in-house ability to model complex shapes, a state-of-the-art fab shop to facilitate those shapes, and the experience to put it all together.

As the erector, I have worked on jobs where I have no direct lines of communication with the engineers or architects; the collaborative nature of this project was key to its success.

The 16-ft-wide bridge runs 320 ft from the north campus to the south campus across a rail corridor. Once the bridge lands on the south side of the tracks, it sweeps another 180 ft to the east over a service drive and terminates at the entry of a Northeastern building.

Payette/Tanguy Marquis

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15. **Angle Heel Out** — OUTSIDE DIA. — 8" x 8" x 1" Angle
16. **Angle Heel Up** — MEAN DIA. — 8" x 8"x1" Angle
17. **Square Tube** — INSIDE DIA. — 24" x $\frac{1}{2}$" Tube
18. **Rectangular Tube The Easy Way (Y-Y Axis)** — INSIDE DIA. — 20" x 12" x $\frac{5}{8}$" Tube
19. **Rectangular Tube The Hard Way (X-X Axis)** — INSIDE DIA. — 20" x 12" x $\frac{5}{8}$" Tube
20. **Square Tube Diagonally** — MEAN DIA. — 12" x $\frac{5}{8}$" Square Tube
21. **Round Tube & Pipe** — MEAN DIA. — 24" Sched. 80 Pipe
22. **Round Bar** — MEAN DIA. — All Mill Produced Sizes

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The shingled panels of the east parapet feature infill glazing: 1-in.-thick, laminated, low-E glass with a hydrophilic "self-cleaning" coating.

Payette/Robert Benson

Expanding Authorship

Ultimately, the execution of this project was informed not only by the aspirations and client needs as understood by the architect, but also by the constraints and opportunities best known by the fabricator and erector. Supported by 3D digital models and CNC fabrication, this workflow proved a fruitful means of expanding design authorship while controlling risk and delivering value. ■

Owner
Northeastern University, Boston

Architect
Payette, Boston

General Contractor
Skanska USA Civil Northeast, Boston

Structural Engineer
Arup, New York and Boston

Landscape Architect
Stimson, Cambridge, Mass.

Steel Team

Fabricator
King Fabrication, Houston AISC CERTIFIED FABRICATOR

Erector
Atlantic Bridge & Engineering, Inc., Hampton, N.H. AISC CERTIFIED FABRICATOR & ERECTOR

Thanks to an innovative detailing and design process, a massive new steel-framed cruise terminal in Miami will let passengers set sail in style.

All photos courtesy of Anatomic Iron Steel Detailing

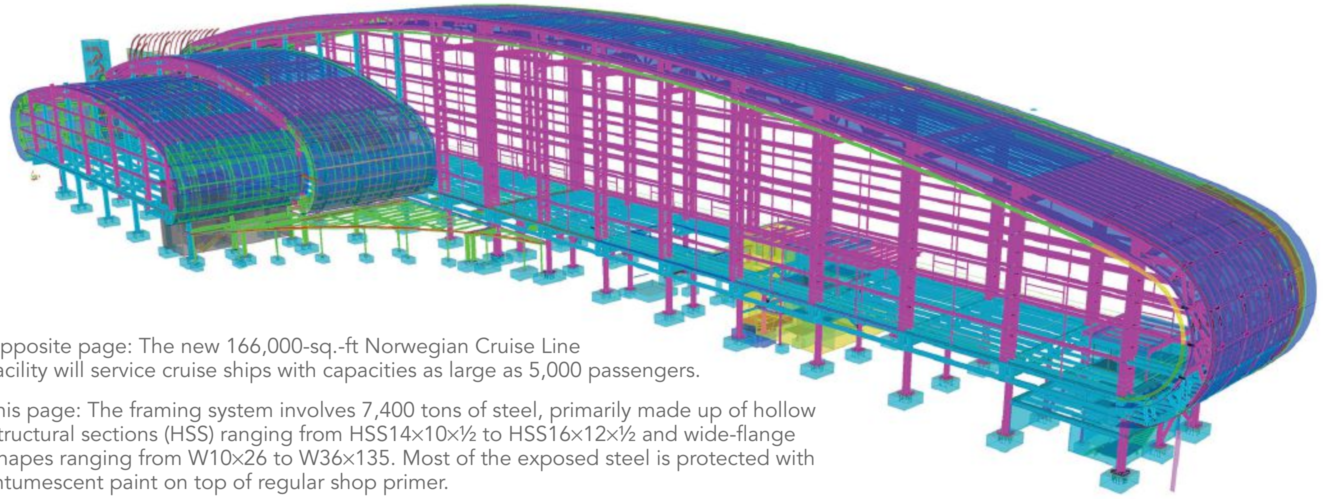
Steel Sendoff

BY CLIFF YOUNG AND TOUAN PLANTE

LANDLUBBERS WILL SOON be able to embark on high-seas adventures from a curvaceous new cruise line terminal in Miami.

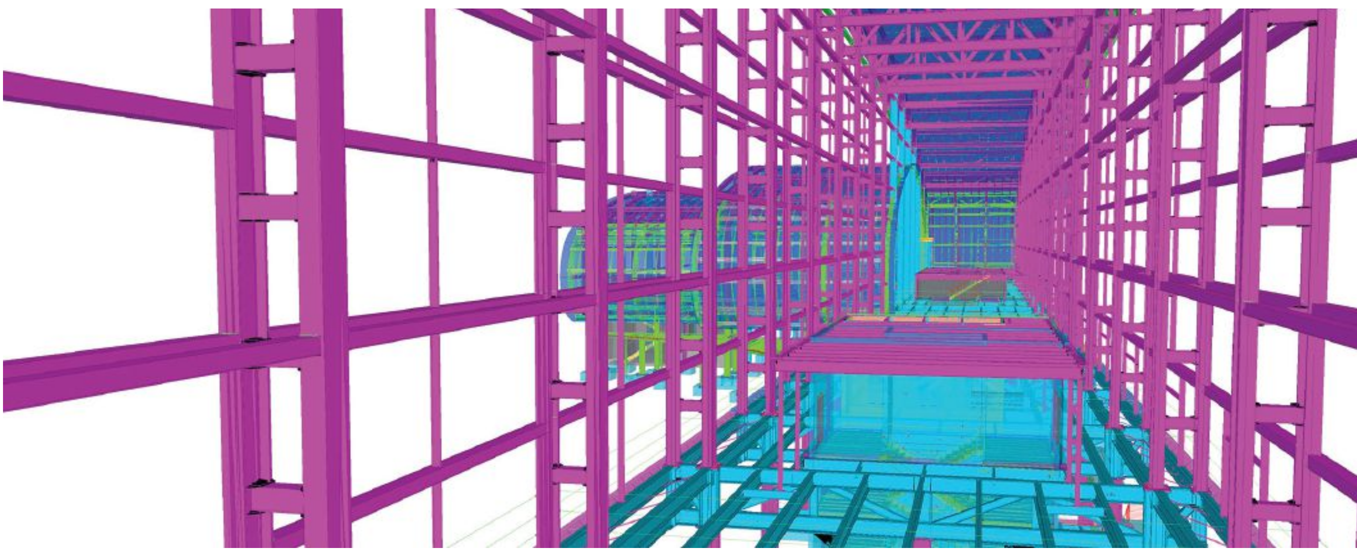
Currently under construction on Dodge Island between downtown Miami and Miami Beach, the 166,000-sq.-ft Norwegian Cruise Line facility will service cruise ships with capacities as large as 5,000 passengers. A joint venture of the Haskell Company and NV2A, the new cruise terminal's main building, adjacent to its current terminal, is composed of three unique domes, known as "pearls," positioned side-by-side and inspired by the shape of a nautilus. The curvaceous building is 128 ft tall at its peak and 800 ft long, comprising a total of 166,500 sq. ft. It's framed with 7,400 tons of steel, mostly made up of hollow structural sections (HSS) ranging from HSS14×10×½ to HSS16×12×½ and wide-flange shapes ranging from W10×26 to W36×135. (Haskell also served as the project's fabricator and transported the steel from its Jacksonville, Fla., facility to Miami via barge.)

"This is a very specialized steel project," says Mike Young, chairman of Anatomic. "The main building is very long and narrow, with massive rolled truss framing at both ends, each connecting seamlessly with the parabolic curved roof. Heavy mid-level trusses were incorporated into the design to accommodate the high loads generated by the building's dimensions and its location over the water."



opposite page: The new 166,000-sq.-ft Norwegian Cruise Line facility will service cruise ships with capacities as large as 5,000 passengers.

this page: The framing system involves 7,400 tons of steel, primarily made up of hollow structural sections (HSS) ranging from HSS14×10×½ to HSS16×12×½ and wide-flange shapes ranging from W10×26 to W36×135. Most of the exposed steel is protected with intumescent paint on top of regular shop primer.



Detailing During Design

Construction began in September 2018 and the building is expected to open this spring. To meet this accelerated schedule, steel detailer Anatomic Iron Steel Detailing used the design detailing process—a model-based process it has developed that allows the engineer, fabricator, and architect to exchange Tekla models continually—to accelerate the delivery of fabrication and erection drawings by completing the detailing concurrently with the steel design.

The basis of the system is that the detailer works directly for the structural engineer and begins detailing when the project is only 50% designed. RFIs about steel conflicts and design issues are sent directly to the engineer inside the model via weekly GoTo-Meetings, resulting in issues that would typically become RFIs later in a traditional project instead being resolved during the design stage. In addition, the engineer approves the detailing model itself rather than issued-for-approval (IFA) drawings as the last step when the final design drawings are completed. As such, when the steel fabricator is selected, the detailer only needs to generate the for-fabrication drawings according to that fabricator's standards and thereby avoids the detailing or drawing approval process. This means the for-fabrication drawings are supplied within a matter of weeks rather than months, and fabrication thus starts months earlier.

"The terminal had to be designed, detailed, and fabricated by Haskell all at the same time, which is precisely what our design detailing process is for," says Anatomic project manager Kerry Young. "Norwegian had already scheduled cruises and if the terminal were not to open on time, the cruise ships would have no place to dock. At the beginning of the project, we were supplying advance bills of material for Haskell and determining the roof geometry and detailing based only on concept drawings that weren't yet final IFC [issued-for-construction] design drawings. Later, while it was being erected, DDA and Martin/Martin [structural engineer and connection designer, respectively] were still designing, and we were following along with the final detailing scope and final fabrication drawings."

Cliff Young (cliff@anatomiciron.com) is CFO and vice president of Anatomic Iron Steel Detailing, and **Touan Plante** (touan.plante@haskell.com) is a senior project manager with the Haskell Company.

As lay-down area at the site was limited on a small island bustling with cruise-related traffic, up to three cranes at a time were used to erect the steel at various points during the schedule.

According to Kerry Young, this made it much easier to solve problems and communicate throughout the project, as a design team would typically need four to eight months to design and submit IFC drawings on a project of this scope, then the detailer would need at least another eight weeks to prepare the first submittal of drawings for approval. "Under the design detailing process on Norwegian, we squashed them all together," he notes. "Thereby, the design and detailing were completed all at the same time, saving at least five months of construction time."

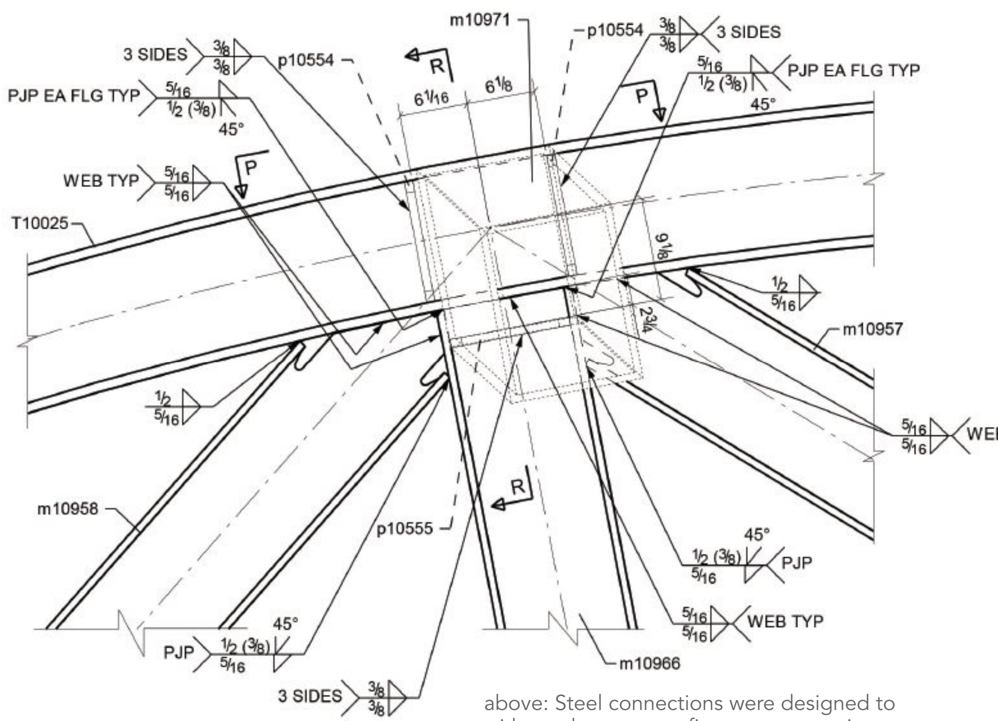
During the project, Anatomic further refined the process to help solve field issues that occur when designing and erecting a structure at the same time. Kerry Young anticipates that the design detailing process on design-build projects will be used more in the future. "If you have the detailer working directly with the design team, the direct line of communication gets easier," he says. "You can get a building standing a lot faster without dealing with RFI's which always slow the project down. We just work together as one company. We can help engineers uncover a lot of potential problems before the design drawings get to the rest of the construction team."

Keeping the Roof on

Wind loading was determined via wind tunnel testing and analysis by the wind consultant RWDI, and the terminal uses a 3D rigid frame structure to resist hurricane-force wind loads. Both the radiused end caps and the junctions between each of the three pearls provide regions of increased strength and stiffness that were used to realize efficiencies throughout the entire structure. The combination of multidirectional loading, participation in lateral resistance by many elements, and curved geometry created numerous highly atypical connections.

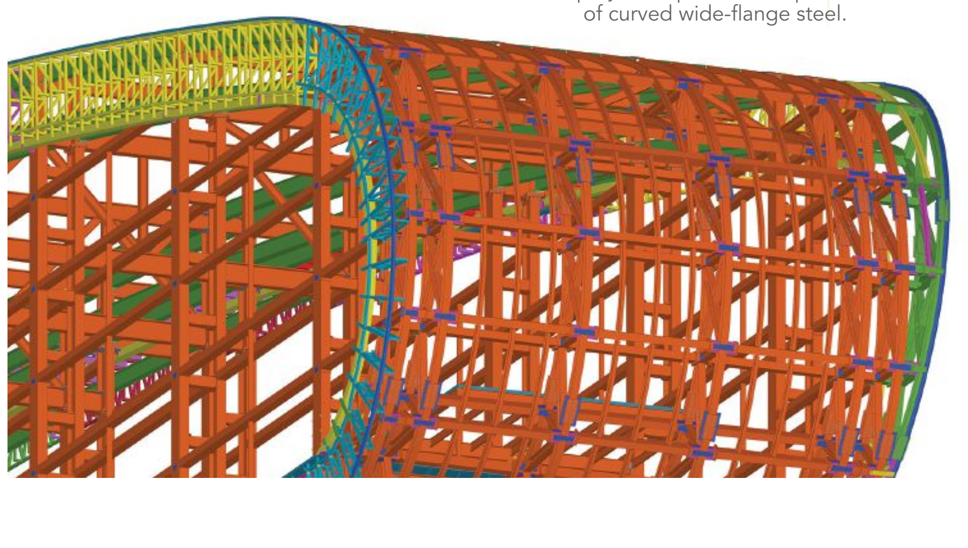
In addition, the pearls' volumes are relatively empty compared to a typical building. The main building has a single main floor plus a small VIP mezzanine 27 ft above. "The building as a whole is mostly air inside," explains Eric Sobel, an associate with Martin/Martin Engineers. "The wind load really dominates the behavior of the building."

For a large, airy glass- and architectural metal-clad building in Miami, where hurricanes and tropical storms are common, his main goal was simple.

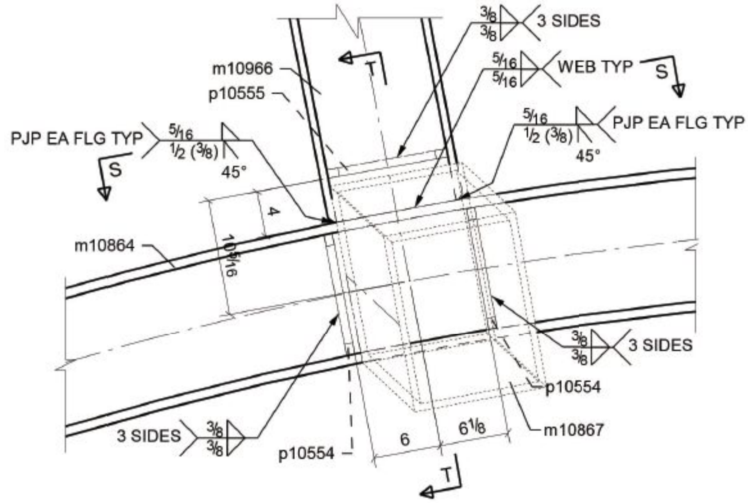


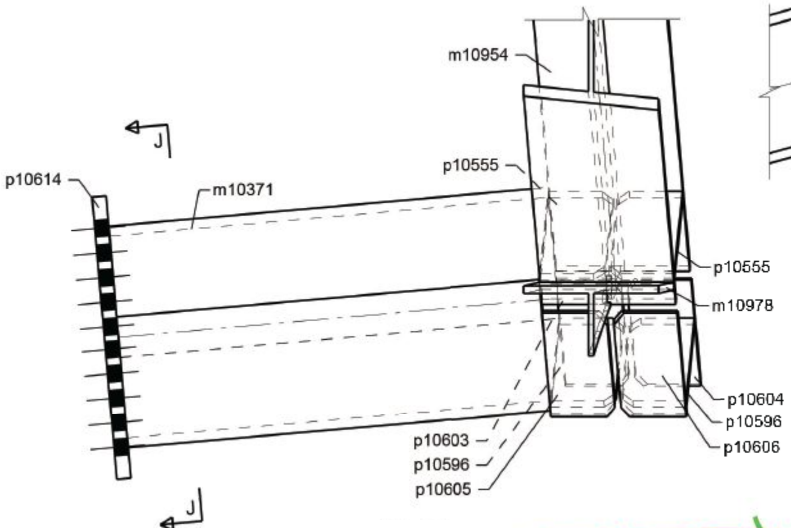
above: Steel connections were designed to withstand a category five storm, meaning sustained winds of 156 mph or greater.

below: The project required 1,500 pieces of curved wide-flange steel.



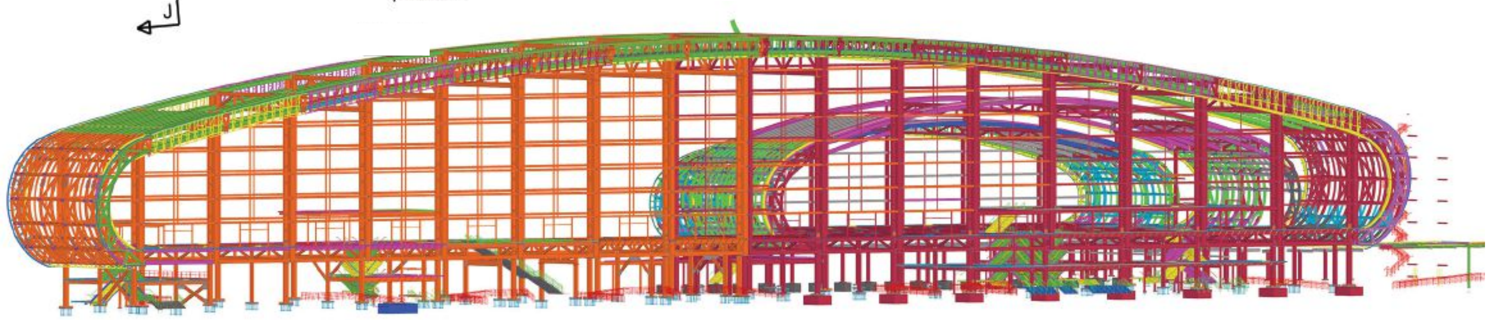
right and below:
Example connection details for some of the truss framing connections.





below: The main building has a single main floor plus a small VIP mezzanine 27 ft above. According to Eric Sobel with Martin/Martin Engineers, the building is mostly air inside and the wind dominates the structure's behavior.

TYP



"Make sure the roof wouldn't get torn off the building," he says. "Related to that, the wind exerts a force to the sides of the building. Keeping the building from cracking or falling over is another design consideration."

This required Martin/Martin to design connections that would withstand a category five storm, meaning sustained winds of 156 mph or greater.

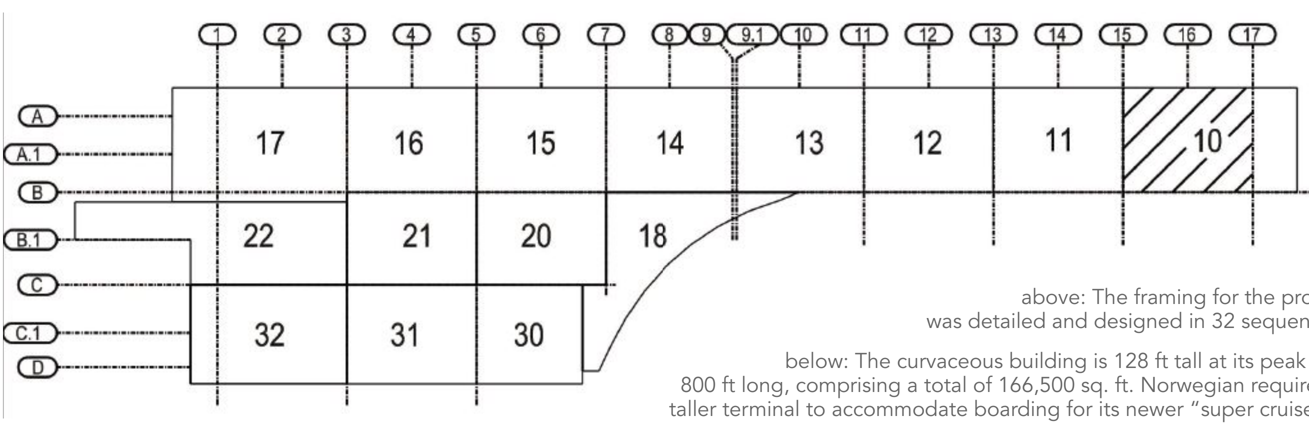
"The building has nice geometric lines to it," Sobel says. "The glass walls connect to the curve of the roof. There were a lot more details than if it was a box building or a building with fewer curves facing each other."

By Land and Sea

Given the sheer size of the building, transporting the massive columns and trusses was challenging. Some of the columns are over 50 tons each, and the roof trusses measure 20 ft by 85 ft at 55 tons each.

These roof trusses were fabricated at Haskell's plant up the Florida coast in Jacksonville, put on barges, and shipped down the Intracoastal Waterway to Miami—two trips with four trusses each. Due to seawall issues and the fact that no cranes were allowed between the project site and the water, the barges were unloaded on the cargo side of the port, almost directly across from the project site. From there, the steel assemblies were transported to a storage yard directly across the street from the site, then brought to the site individually when they were ready to be erected.

The project also incorporated 1,500 pieces of curved wide-flange steel, which required the services of multiple bender-roller companies, including Chicago Metal Rolled Products and



above: The framing for the project was detailed and designed in 32 sequences.

below: The curvaceous building is 128 ft tall at its peak and 800 ft long, comprising a total of 166,500 sq. ft. Norwegian required a taller terminal to accommodate boarding for its newer "super cruisers."

Whitefab. As lay-down area was limited on a small island bustling with cruise-related traffic, up to three cranes at a time were used to erect the steel at various points throughout the schedule.

Now topped out, the huge yet light structure is in the final stages of construction and is expected to open in time for the summer cruise season. The eye-catching design and floating appearance will provide the perfect introduction to seafaring travelers, as the vast openness of the building's volume reflects and provides views of the open water itself.

The design, fabrication, and erection of the building were a great challenge, but all the team members pulled together to deliver a successful project to the owner and an amazing terminal from which to set sail.

Owner
Norwegian Cruise Line, Miami

General Contractor
The Haskell Company and NV2A, a Joint Venture

Architect
Bermello Ajamil and Partners, Inc., Miami

Structural Engineer
DDA Engineers, P.A., Miami

Connection Designer
Martin/Martin Consulting Engineers, Lakewood, Colo.

Steel Team

Fabricator
The Haskell Company, Jacksonville, Fla. (AISC Certified Fabricator)

Erector
LPR Construction Co., Loveland, Colo. (AISC Associate)

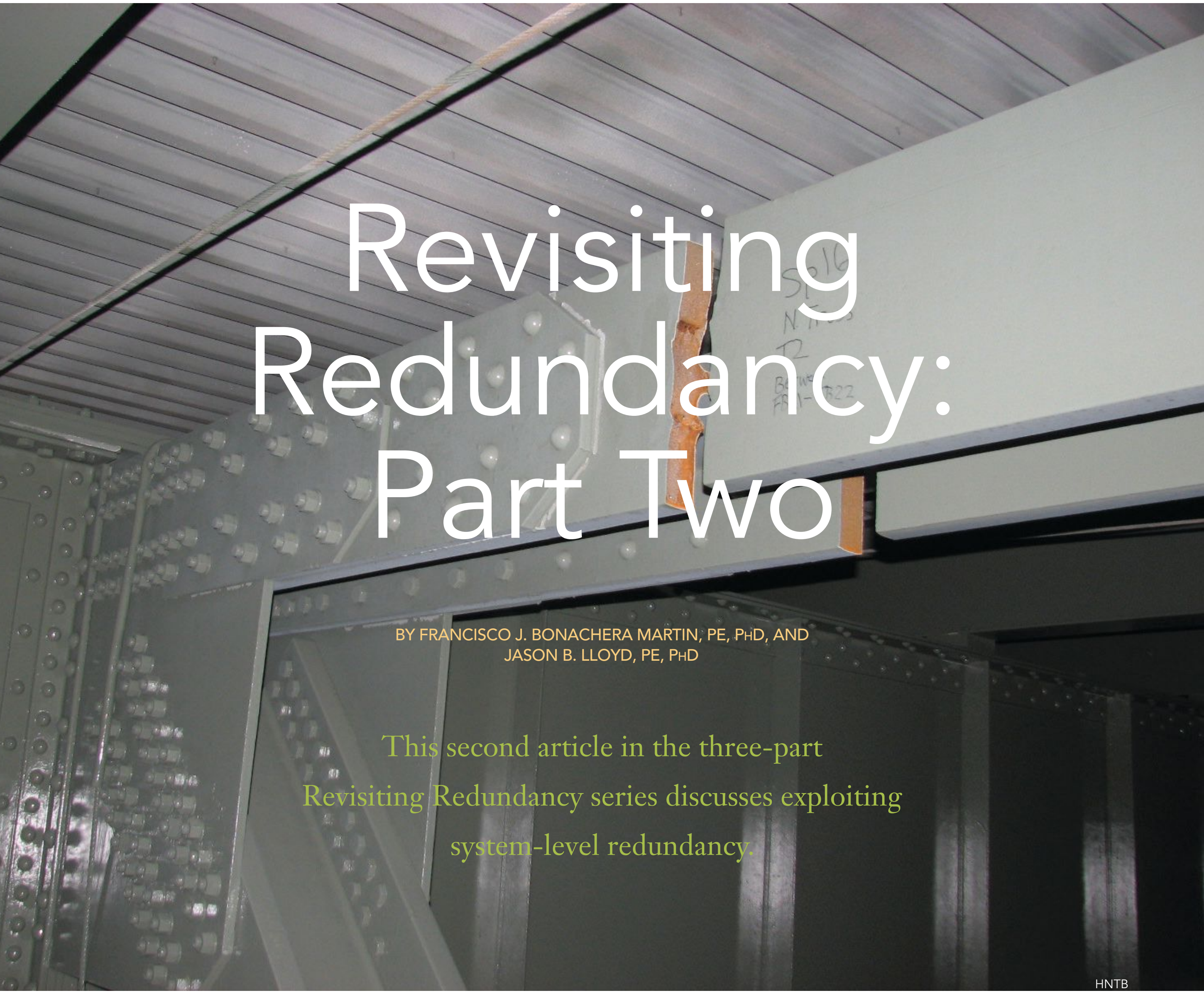
Detailer
Anatomic Iron Steel Detailing, North Vancouver, B.C. (AISC Detailer)

Bender-Rollers
Chicago Metal Rolled Products, Chicago (AISC Associate)
Whitefab, Birmingham, Ala. (AISC Associate)

above: A steel pedestrian bridge, delivered to the site in four segments, connects the new facility to an existing building.

right: Curved steel being shipped from bender-roller Chicago Metal Rolled Product's shop.

below: Support framing below one of the pearls.



HNTB

Revisiting Redundancy: Part Two

BY FRANCISCO J. BONACHERA MARTIN, PE, PHD, AND
JASON B. LLOYD, PE, PHD

This second article in the three-part Revisiting Redundancy series discusses exploiting system-level redundancy.

DO MOST STEEL BRIDGES have post-failure load-carrying potential?

The answer is a resounding yes.

While certain bridge collapses, such as the Silver Bridge and the Mianus River Bridge—both of which collapsed due to failures of truly non-redundant tension members—suggest the contrary, the reality is that there are far more cases where steel bridges were able to operate in the faulted condition. This applies even to bridges that have traditionally been considered to have no system-level redundancy. (And of course, damaged structures still need to be repaired and inspection should be performed on all members, regardless of criticality.)

One example of a bridge that withstood the failure of a fracture-critical member (FCM) is the Lafayette Bridge, a two-girder steel bridge in which a fracture rendered a girder unable to carry any significant portion of the load. This scenario would have led to collapse if the bridge was, in fact, nonredundant—but it wasn't and it didn't. Similar scenarios include the Hoan Bridge, the U.S. 422 Bridge over the Schuylkill River, the Green River Bridge, the Diefenbaker Bridge, the Delaware River Turnpike Bridge, and countless others.

Were these structures designed to operate in the faulted state? No. Was system performance in the faulted state considered in the design? Again, no. The reality is that all of these structures, despite being designed in different eras, shared the same overall design philosophy and principles in which post-failure capacity was not considered. In all these cases, system-level redundancy was unplanned, most likely the product of typical conservatism in design. But the fact that it was unintentional does not mean that it cannot be exploited.

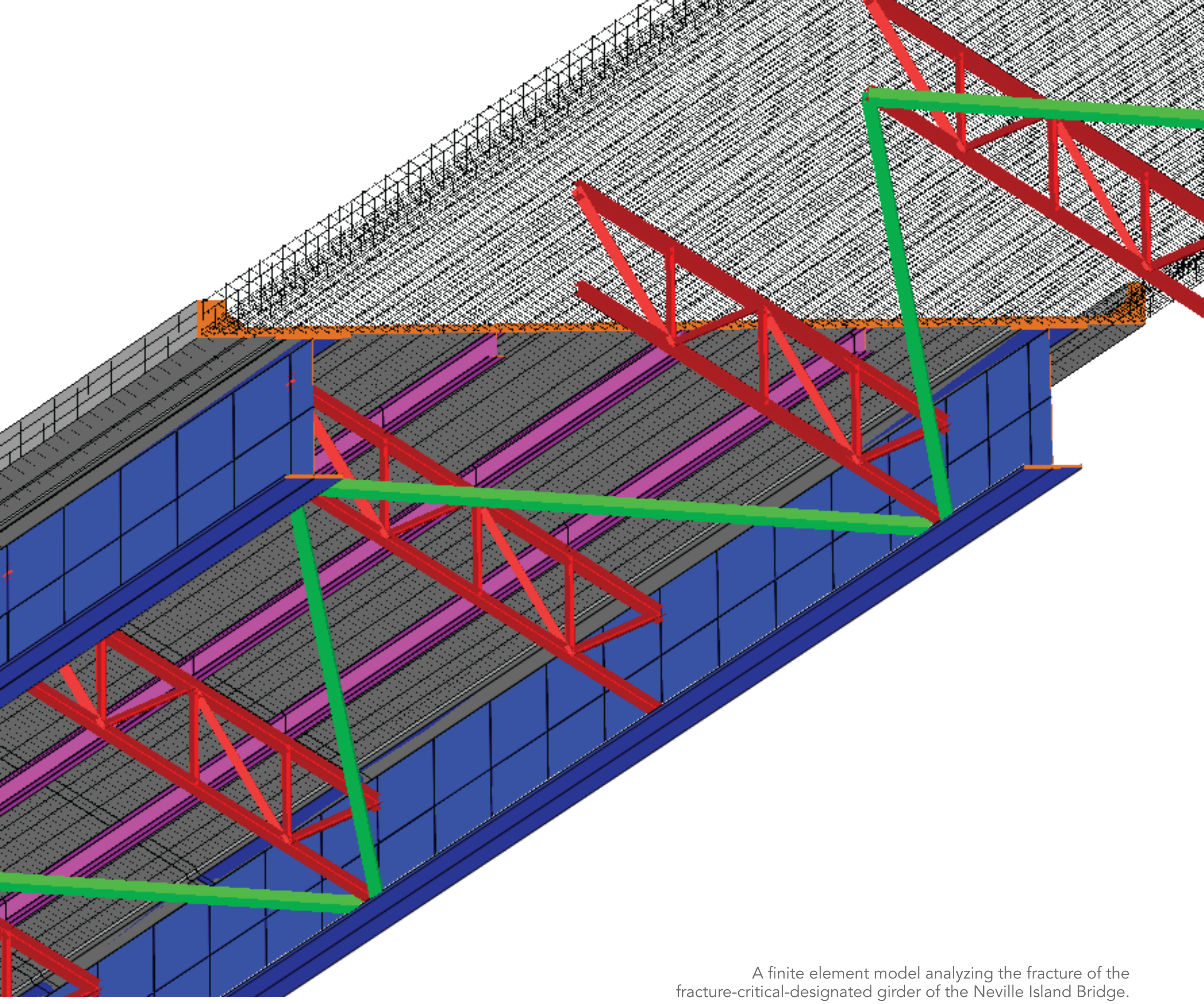
above and opposite page: A fracture of a fracture-critical-designated member on the Delaware River Turnpike Bridge, which continued to carry service loads until the fracture was discovered and repaired.

AASHTO's *Guide Specifications for Analysis and Identification of Fracture Critical Members and System Redundant Members* (referred to hereafter as the SRM Guide Spec) is a tool that allows engineers to take advantage of previously unexploited system-level redundancy, and owners to efficiently allocate resources to provide better infrastructural solutions to the public.

Released in 2018 and available at **www.aashto.org**, the SRM Guide Spec tackles a complex problem: characterizing the demand and capacity of a structure in which a primary steel tension member has failed. For a system to be considered redundant, two fundamental concepts regarding load were followed: First, the bridge cannot be expected to operate as reliably in the faulted condition as in the pristine condition. Second, the bridge must be able to survive the failure event and provide service in the faulted state.

The first fundamental concept is clear but leaves a question to be answered: What is an acceptable reliability level in the faulted state? To answer this question, let's take a look at the overall failure rate. Current load and resistance factor design (LRFD) bridge design provisions are based on allowing a nominal failure rate that applies to the structure in its pristine state. For the faulted state, the same nominal failure rate can be maintained by acknowledging that it is the product of the failure rate in the faulted state and the rate at which primary tension member failure occurs. In other words, by conservatively establishing how likely it is for a member designated as FCM to fail, a lower target failure rate can be calculated for the faulted state.

Francisco J. Bonachera Martin (**fj.bonacheramartin@mbakerintl.com**) is a technical specialist with Michael Baker International in Indianapolis, and **Jason B. Lloyd** (**lloyd@aisc.org**) is NSBA's West Region bridge steel specialist.



A finite element model analyzing the fracture of the fracture-critical-designated girder of the Neville Island Bridge.

So why not calculate the load that causes the member to fracture instead? If a primary steel tension member fractures, load isn't the only culprit. There are also the factors of temperature, material toughness, and quality of fabrication. On top of that, fracture—caused by, say, vehicle impact—isn't always the culprit when a primary steel tension member fails.

Once an acceptable target failure rate, or level of reliability, for the faulted state is calculated, it is applied to the development of two new load combinations: Redundancy I and Redundancy II. Redundancy I characterizes the loads experienced by the structure during the failure event, which is assumed to be sudden fracture of a primary steel tension member. This load combination is analogous to an extreme event load combination in which the event load includes the dynamic amplification of load due to the inertial effects of the member failure. Redundancy II basically warranties strength in the faulted condition against normal use until the member failure is detected. The need for both load combinations becomes clear when considering several failure cases. For example, in the case of the Neville Island Bridge, fracture of the fascia girder was discovered by a tug boat captain passing underneath the bridge! Meanwhile, the bridge continued carrying traffic and no significant deflections were observed. Based on this case, it is evident that if a member fails and a bridge has adequate capacity against the member failure, traffic will continue to load the bridge.

As previously mentioned, the SRM Guide Spec contains guidelines to calculate, via non-linear, detailed finite element models, the capacity of a steel bridge after the hypothetical failure of a primary tension member. (Typical analysis procedures are not capable of reliably capturing the mechanisms that lead to redundancy without being overly conservative, so finite element analysis is needed to simultaneously consider and evaluate various load paths.) In developing the SRM Guide Spec, much effort was devoted to benchmarking the computational analysis framework against available data from large-scale experimental studies and field data of structures in which a primary steel tension member failed.

The resulting provisions guide engineers through the entire modeling process. Here's how it works: A screening process is used to assess whether the structure is a candidate for the analysis, in order to avoid including structures for which the overall approach would not work—e.g., a suspension bridge—or characteristics that are not reliably implementable in a finite element model, such as pin and hanger assemblies. Then the finite element analysis methodology is explained, including software requirements, analytical procedures, failure scenarios to be modeled for different structure types, and application of loads for the Redundancy I and Redundancy II load combinations.

The guide includes all necessary information for conducting a detailed finite element analysis, including material models for concrete and steel, meshing requirements, application of boundary conditions, and interactions and constraint modeling, as well as detailed provisions to model shear stud behavior. Finally, the guide also includes failure criteria intended to prevent the need for integrating stress data from a finite element analysis with sectional forces and moments.

The SRM Guide Spec opens opportunities for bridge engineers to think outside the box and potentially optimize bridge designs in ways that have been avoided for decades due to a lack of understanding and codified guidance. Furthermore, it provides advantage to owners to more efficiently manage limited resources while maintaining reliability and safety of our infrastructure. ■

*Part One of this series appeared in the November 2019 issue (**www.modernsteel.com**) and discussed historical considerations of redundancy and FCMs. Part Three, which will appear in the April issue, will take a closer look at member-level redundancy.*

above: A close-up of a fracture-critical-designated girder on the U.S. 422 Bridge over Schuylkill River. The bridge continued to carry service loads in the failed condition before the fracture was discovered and repaired.

below: A close-up of a constraint-induced fracture on the former Pennsylvania Railroad two-girder bridge, which is now located at Purdue University's S-BRITE Center. (For more on S-BRITE, see "Wanted: Old Steel Bridges" in the October 2019 issue at **www.modernsteel.com.**)

Solar Steel

BY GEOFF WEISENBERGER

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

SOLAR POWER and steel fabrication are not phrases that are typically uttered in the same sentence.

But that may be changing, with a multiple-shop AISC member fabricator leading the way.

SteelFab, which has eight facilities in seven states, has installed rooftop solar arrays on five of them. The company had been approached by multiple solar companies over the years and decided to take the solar plunge in 2013, performing due diligence late that year and beginning installation a couple of years after that.

SteelFab started with its Charlotte plant, with installation beginning in the summer of 2015 and being completed the following spring. After evaluating the success of that shop, it rolled out the solar initiative to four additional plants in 2017. To date, the company has employed two solar array providers.

"Due to various state tax credit laws, some firms were interested in doing work in all the states we have plants in, while some were not," noted Glenn Sherrill, CEO of SteelFab. "We actually used Inman Solar for our Charlotte plant and Renewvia for our Virginia, Georgia, South Carolina, and Alabama plants."

Each shop has a different capacity, depending on local conditions. For example, SeelFab's Emporia, Va., facility installed 556kW of solar production via 92,000 sq. ft of rooftop space. None of the roof structures for the buildings implementing solar arrays needed to be reinforced.

"The smallest solar array is around 20,000 sq. ft and the largest we have in place is closer to 40,000 sq. ft," said Sherrill. "Due to position of the sun, the shape and condition of the roofs, we could not cover all of our plant roofs with the solar panels."

Tax incentives were a big part of the decision to go solar. With the Charlotte location, for example, the company receives federal tax credits along with North Carolina state tax credits over and beyond a capital expense deduction (all locations received federal tax credits while only the North Carolina location received state credits). In the case of Charlotte, the utility, Duke Power, is required to buy a certain amount of solar power every year, so some of the solar power the Charlotte facility's system generates goes to supporting shop operations while some is sold back to Duke Power. Duke does not indicate a clear credit on its

monthly power invoices for power, SteelFab tracks solar power usage internally, and Sherrill estimates that the facility achieves a savings of close to 10% over its pre-solar power bills. He also notes that the return on investment for a solar array can range between three to eight years, depending on the credits available.

According to Sherrill, the performance has been mostly in line with what the solar providers indicated, and the tax credits have performed as described. And it's not all about the money.

"At the end of the day, there is an argument to be made that we could have made more money for SteelFab investing in equipment and expansions in lieu of solar power," he explains. "However, we believed it was the right thing to do for the environment. Every little bit helps when it comes to reducing the carbon emissions footprint and stemming the repercussions of global warming."

And in addition to the financial and environmental benefits, Rob Burlington, president of SteelFab's Virginia Division, points out another advantage.

"One small side benefit is that our shop stays cooler," he says. "Most shops are not conditioned and have metal roofs. In the summer, this generates heat inside. The solar panels absorb this heat and we are noticing a positive difference in those hot summer months in the South." ■

Have you implemented solar power or other renewable energy sources at your facility, or are you considering it? Let us know by emailing ***weisenberger@aisc.org****.*

And for more on the sustainable aspects of domestically produced and fabricated structural steel, visit ***aisc.org/sustainability****.*

conference preview

EFFECTIVE EDUCATION

BY CHRISTIAN CROSBY, PE

To develop an effective training program for your organization, you must be intentional.

IN LAST YEAR'S MARCH ISSUE, I wrote an article called "Ongoing Involvement," which focused on improving fabrication quality through continuous communication with, engagement of, and training for shop and field personnel. (You can read it at **www.modernsteel.com**.)

After it was published, several of my colleagues contacted me to discuss my ideas on training. Most people I spoke with described the scope of their formal training program as an onboarding orientation for human resource policies and paperwork, a review of their safety policies and procedures, and a recap of their quality policies and goals. Several colleagues discussed their formal mentoring program, in which a new craft team member would work with a more experienced team member, but they felt that their programs lacked formal direction and clear expectations. They all agreed that while their current system is filling a need, they see an opportunity for improvement. As such, this article will focus on five key elements to developing an effective educational program for your organization:

- Conduct a business needs assessment
- Develop relevant, tailored curriculum
- Deliver educational content
- Address budgeting considerations
- Evaluate the program's efficacy

Business Needs Assessment

Identifying the specific skills needed in an organization is the first step in this process. While the other elements should be developed concurrently, the needs assessment should be completed independently of those elements. In addition, organizations should be assessing their needs not just at the start of developing an educational program but also on an ongoing basis. As an organization evolves, this ongoing assessment becomes a forward-looking tool for finding specific skill sets that are required to support the organization in its future endeavors. It is important that the individuals working on the needs assessment initiative bring with them a complete picture of the organization and not just an individual narrative. A diverse team is ideal for this effort.

Once the team is assembled, the members should attempt to answer questions like: What are the specific skill gaps in our organization? What specific job functions are we lacking team members for? Do we need more fitters? Do we need more *experienced* fitters? Is the quality of our welders in need of improvement? How should we address the recent spike in quality issues with our painted steel? How do we find someone to operate the new piece of equipment we are thinking about purchasing? Do we need stronger front-line supervision? Do we need to strengthen our project management team? How are we doing on finding the next generation of managers? What are our needs in the estimating department? While this list can seem daunting, the next step is to prioritize which gaps need to filled first.

Christian Crosby (**ccrosby@cianbro.com**) is operations manager for Cianbro Fabrication and Coating's Georgetown, Mass., plant.

AISC

As an example, let's say we're a fabrication shop that has recently completed its needs assessment and has determined that the top priority is hiring more fitters/layout personnel. As we discuss this need, we quickly recognize that there is a broad spectrum of layout and fitting skills. To address this, we might establish different levels based on skill sets and experience. For example: fitter level 1 applies to those who have the skills to lay out and fit simple beams (clips and copes) and simple columns (base and cap PLs, shear tabs, seat Ls, etc.); fitter level 2 includes the skills required for level 1 as well as the skills to lay out and fit complex beams (skewed connections, beveled ends, complex geometry), complex columns (stiffeners, continuity PLs, web doublers, beam-flange capture PLs, skewed compound connections, etc.), and simple shop assemblies (roof frames, simple trusses, straight rails); and fitter level 3 requires the level 1 and 2 skills as well as the skills to lay out and fit complex assemblies (stair stringers, rake rails, complex trusses, hoppers bins chutes, assemblies with complex geometry).

After we have completed the needs assessment and prioritized distinct skill levels, we can then start to develop the learning objectives for each level. These objectives are simply brief statements that describe what the trainee will be expected to learn by the end of the educational event. In other words, these are the goals of the training event, the specific takeaway from the experience. In addition, the learning objectives will become measurements in our evaluation at the end of the training program (more on this later).

Returning to our example of layout and fitting skill levels, the learning objective would be "Gain the ability to: read and understand structural steel fabrication drawings per the defined level (1, 2, or 3), lay out main material with correct marking for fitting materials, and fit the detail parts onto the main material in accordance with the requirements of the fabrication drawing."

Relevant, Tailored Curriculum

The next step to developing an effective training program is developing focused curriculum. For certain areas of fabrication, such as welding, there is adequate, quality educational material and equipment available that can be sourced from suppliers and community vocational schools. Similarly, manufacturers of fabrication equipment also offer educational opportunities for equipment operators. It is worth taking advantage of these training materials and even more worth it to tailor them to your specific internal processes. And in some cases—such as where it isn't prudent to send employees off-site for training—internally developing materials and curriculum can be more effective than outside sources to the degree that they are developed with the individual organization's means and methods, best practices, tooling, and equipment in mind.

Delivering Educational Content

While developing relevant, tailored curriculum, we need to keep in mind how the materials will be delivered. The best practice during development is to "package" the content to allow for multiple delivery methods. This will provide additional opportunities to use the content and meet the various learning needs of your team members and thus maximize the return on your invested time. There are many different methods to deliver educational content—both for specific skills and general purposes—including:

- On-the-job training/coaching
- Mentoring
- Job shadowing
- Formal classroom training, on-site and off-site
- Formal hands-on laboratory training, on-site and off-site
- Job swapping
- Online training
- Third-party training

In considering the delivery method, it's important to keep in mind the audience and their preferred leaning style. Some team members learn better with a hands-on approach as opposed to a more formal classroom, instructor-led approach. Which one is best? Talk to the involved team members to obtain feedback on their preferred learning style. In my experience, a blended method


Cianbro

(some formal classroom time and some hands-on time) seems to be a successful approach, but again the key is to find the right mix—enough classroom work to understand the principles but not put trainees to sleep and enough hands-on time to keep them interested and engaged.

Budgeting Considerations

Financial planning for educational events will vary widely between fabrication shops. For many shops, training is an ongoing and annually budgeted process. Others don't have this luxury, and an hour off the floor can mean a shipment not made and thus an invoice not sent. Consequently, you need to not only calculate the cost of training but also strategically schedule your training/educational events. You should develop your training budget as you develop your curriculum and plan the delivery methods, and then you can determine the optimum time to proceed with the training.

Calculating the cost of training—materials, equipment, development time, trainer time, trainee time, administration time, etc.—is the easy part. The more difficult part is calculating the return on your training investment. But you can start by calculating or at least estimating the reduction in rework, back charges, team member turnover, and recruitment costs, along with an increase in productivity, that the training will provide. In addition to these improvements, you should also consider that providing a good education for your team members will pay off in ways beyond an increase in productivity and improvements in quality. It will also pay off in terms of team member job satisfaction, which is a key ingredient for your organization's long-term success.

Evaluation

As one of my mentors always told me, "What gets measured gets improved." This especially holds true for training programs. You need to assess how effective your training is. You can do this by applying the Deming Cycle to your efforts: plan, do, check, act. You plan the training, execute it, evaluate how it went, and finally make changes based on your evaluations. In terms of what you are evaluating, this should be the trainee, the trainer, and the curriculum to determine if your goals were met—and if they weren't, what changes need to be made.

Evaluating the trainees—ideally as soon after their training as possible—can happen in the form of written tests and practical, hands-on assessments. In addition, you should periodically reassess their newly acquired skills on an ongoing basis. These additional evaluations will give credence to the effectiveness of your programs and answer the simple question "Did the trainee retain the presented material?"

You can also evaluate the trainer in the form of class surveys and direct feedback from the trainees; the latter can be a vital tool in assessing a trainer as long as the feedback is free of personal bias. And of course, you can and should take the time to observe the trainer in action. When it comes to the curriculum, evaluation can be obtained from both the trainees and the trainer in the form of direct feedback. Was it clear and easy to follow? Was it easy to teach? Did it make sense or did trainees feel that it didn't explain things thoroughly?

From these evaluations, you can now make meaningful changes to your educational programs. You can adjust the curriculum and content; you can make changes to the delivery; you can even "train the trainer" (or find a new trainer if necessary); you can adjust your budget and timing; and you can determine if the training was worth it—and if not, what needs to change to make it worth it. More than anything, you need to be *intentional* about evaluating your programs so that you have enough data to make the positive changes. Training will never be perfect, but it can always be improved. ■

Want to learn more about developing effective training? Attend the session "How to Set up an Effective Training Program" at the 2020 NASCC: The Steel Conference, taking place April 22–24 in Atlanta. For more information and to register, visit ***aisc.org/nascc****.*

conference preview

KEEP IT CLEAR

BY JOHN EDWARDS

A clear and simple guide to writing a clear and simple—and effective—quality procedure.

John Edwards (**edwards@qmcauditing.com**) is a QMC contract auditor.

THE BENEFITS of a well-organized, well-written, easy-to-read, well-implemented internal quality manual are quietly, almost invisibly remarkable.

Your quality manual is a reflection of the effectiveness of your company's executive management team and quality management system. It describes written instructions on how work assignments are to be performed and executed the same way every day. It is an invaluable training tool for steel fabricators and erectors, starting with new employee orientation and continuing on as part of ongoing quality training for all employees. The annual review and performance evaluation of each work procedure, during your internal audit, provides opportunities to improve the work process over time. The best companies thrive on hard work—work that is dependably, efficiently, and consistently performed. Your quality manual and procedures are your company's road map to that consistency—which in turn leads to profits.

The goal here is to provide a guide on writing clear, easy-to-read, easy-to-understand, and easy-to-follow quality procedures that will ensure that those who follow the documented instructions in the procedure can perform the same function or process consistently, day in and day out. In order for any quality manual writing, whether it involves a new manual or an update, to be effective, executive management must be fully engaged and supportive and approve the contents of their quality manual 100%. Anything less undermines the entire process and renders a company's quality management system (QMS) ineffective, a ship without a rudder.

Another note, based on my experience as a contract AISC/QMS auditor, is that I'd estimate that 15% to 25% of all in-house quality manuals are outdated, confusing, disorganized, cumbersome, and ignored by employees. If your manual is 4 in. of paper crammed into a 3-in. binder and was written over ten years ago, then you likely have an ineffective quality manual.

But it doesn't have to be that way. Here, we'll look for some dos and don'ts when it comes to writing or updating your quality manual. First, let's review three key definitions from the glossary in AISC's *Certification Standard for Steel Fabrication and Erection, and Manufacturing of Metal Components* (AISC 207-16, **aisc.org/specifications**).

Chapter 1, Section 1.4 – Definitions, states: As used in this Standard, the words *shall* or *will* denote a mandatory requirement. The word *should* denotes a guideline or recommendation. The words *may* or *can* denote an opportunity to make a choice. Your procedures must be fully compliant with all the *shalls* and *wills* in Chapter 1 and the *shalls* and *wills*, as applicable, in Chapters 2 through 5 of the *Standard*.

Quality Manual. A document stating the quality policy and describing the quality management system (QMS) of your company. These documented procedures are sometimes called: standard operating procedure (SOP), operating procedure (OP), quality procedure (QP), or simply detailing, welding, or inspection procedure, etc. Whatever the title, the objective is to have a work process performed consistently, time after time in accordance with its documented procedure.

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Documented Procedure: A procedure that is established, documented, implemented, and maintained. The documentation provides information about how to perform an activity or process consistently. Documentation shall contain:

a. Purpose of the procedure
b. Process definition that includes steps required for completion of the work
c. Assignment of responsibility for performance
d. Assignment of responsibility for review, revision, and/or approval of the procedure
e. Identification of records that are generated
f. For inspection activities, the frequency of observations or inspections and how those observations or inspections are documented

The Dos

With those definitions in mind, here are some things you should do when creating or updating your in-house quality manual.

- **Do** create a quality manual that, when completed, is no more than 2 in. thick. The best quality manuals for the structural steel construction industry range from 1 in. to 1.5 in.
- **Do** write documented procedures that address all the wills and shalls in the AISC *Certification Standard*.
- **Do** involve all concerned individuals involved in the work process. Issue a blank job function checklist to each manager/supervisor and applicable employee and have them list their work activities on how they will accomplish the tasks they are assigned.
- **Do** interview managers and employees and review their checklists with them so that you have a complete understanding of what they do and accomplish on a daily basis.
- **Do** be reader-friendly. After you write your manual, read it as though you are an employee who will be using it. If any part seems confusing, rewrite it.
- **Do** write to the skill level of those required to perform the work processes described. Write brief statements using the common language of your company's everyday work environment.
- **Do** write in short, precise statements that are easy to memorize if need be. If more detailed instruction is required, create a work instruction (WI) in addition to the basics in the procedure, and provide a link or reference to the WI.
- **Do** keep a job function checklist team involved in proofing the procedure until final approval is achieved.

Every department should have their related quality procedure posted and signed off on by the approving authority, department manager, and individual employees, and should also update it annually. There is nothing easier to ignore than an old yellowing document with curled corners, covered in dust, that looks like it hasn't been touched since the 1970s. At a minimum, each department head should have their quality procedure readily available and be able to provide objective evidence that the stated work process is being consistently performed.

The Don'ts

And here are a few things to avoid when writing your quality manual.

- **Don't** use terminology that only a PhD engineering student can understand.
- **Don't** use regional shop talk from somewhere else that your employees aren't familiar with.
- **Don't** write one more word than you have to, and don't go into excessive detail describing the work process. Again, if more detailed is required, create a WI to complement the procedure.
- **Don't** write rambling paragraphs of useless information (this should go without saying).
- **Don't** allow a documented work process to be ignored. A procedure that is not being executed correctly, or not being performed at all, is a management system nonconformance and is corrected through the corrective action process. In short, don't set your shop up for failure by writing a manual or procedures that no one will pay attention to!

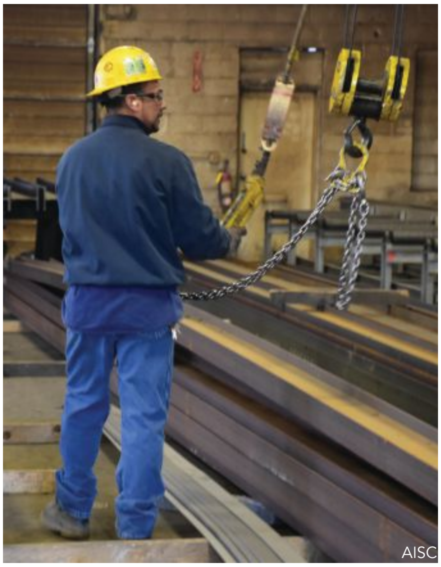
Basic Elements

In your quality manual, each procedure should include the following:

1. **Purpose.** A simple description of what the procedure is for—e.g., purchasing, detailing, welding, etc.
2. **Responsibilities.** Describe who, by title, is responsible for performing the task. For purchasing, this could be the purchasing manager, purchasing agent, project manager, or designer.
3. **Procedure.** List and describe the work activities to be performed—e.g., the purchasing manager will prepare and issue purchase orders based upon the bill of materials supplied by the project manager, and at a minimum the following purchasing data shall be listed in the purchase order…
4. **Records.** List the records required to perform the work by actual name and, if applicable, form name and form number—e.g., Purchase Order F10-01 or Bill of Materials F7-01.
5. **Revision history.** It is imperative that you have a method for controlling and describing revisions—e.g., a revision history could be included in a table at the front of the manual, a cover page for the specific procedure, or at the end of the procedure.

Your quality manual is a reflection of the effectiveness of your company's executive management team and quality management system. Make it as brief as possible while still being complete, user-friendly, easy-to-read, and not ignorable. Doing so will help ensure that everyone will appreciate, understand, follow, and consistently execute their required work assignments. ■

*Want to learn more about writing a high-quality quality manual? Attend John Edwards' session "How to Write Clear and Simple Quality Procedures that Are Easy to Understand and Effective" at the 2020 NASCC: The Steel Conference, taking place April 22–24 in Atlanta. For more information and to register, visit **aisc.org/nascc**.*



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Industry Quality

AISC has developed and promotes a certified Quality Management System (QMS) certification program whose stated purpose is to communicate to owners, the design community, the construction industry, and public officials that those who adhere to the requirements of the program (over 1,500 strong) have the personnel, organization, experience, documented procedures, body of knowledge, equipment, and commitment to produce fabricated steel to the high standard of quality required for structural steel buildings and other structures in accordance with contract requirements.

The heart of the certification program is the *Certification Standard for Steel Fabrication and Erection, and Manufacturing of Metal Components*. All program participants, regardless of size, must have their in-house quality manual and quality procedures in compliance with the general requirements of the *Certification Standard*, and proper documentation is critical. The words "The fabricator or manufacturer shall develop a documented procedure…" or "A documented procedure shall be developed for…" appears no less than 49 times throughout the standard—hence the importance of writing manuals and procedures that are clear and accessible.

conference preview

GO BIG

BY MIKE SENNEWAY

Considering going after a major project? Here's some advice on whether to take a shot—or not—and how to let the owner know that you're the right company for the job.

Mike Senneway (**mikes.mjsmanagement@gmail.com**) is president of MJS Management.

"WHAT IN THE WORLD were they thinking?"

As a long-time fabricator (now advising owners and developers on the mysteries of successful steel construction) I have heard that question sincerely asked from both sides of the contract. In fact, I'd say this statement occurs even more often on "major" projects.

As often as fabricators and builders form relationships, many often misunderstand their "partner" in the project. I am convinced that if fabricators improved their understanding of the owner's perspective, it would greatly improve their odds of closing work and experiencing more successful projects.

The Major Project Conundrum

In order to develop a successful strategy for landing major projects, let's first define what we mean by major. There are no official designations or characterizations of what constitutes a major project, but fabricators know them when they see them. After many years of pursuing these jobs, I would identify major project territory as:

- High-rise buildings involving climber cranes
- Any stadium or arena project
- Art centers, auditoriums, or convention centers
- Water-crossing bridges
- Projects requiring the feeding of more than two cranes
- Any project exceeding 10,000 tons

Once a major project is identified, the fabricator first needs to seriously consider whether the job fits within its strategic goals. Secondly, they must evaluate if the expected return on the project will be worth the cost of the chase. And major projects do carry several advantages:

- There are typically fewer competitors, so the margins are usually higher.
- The ratio of overhead to direct labor hours is lower. While the steps needed to execute any project are essentially the same, the advantage of a larger job is that once you have secured the work, the "up-front" overhead expenses drop away and, thus, the overall percentage of overhead to direct labor hours is reduced.
- Subletting opportunities. A big job allows a savvy fabricator to retain high-productivity tasks and sub out the work that they are less efficient at so as to enhance overall margins.
- Economies of scale—i.e., the more steel you buy, the better prices you get.

Of course, there are serious disadvantages to consider as well:

- They can be expensive to pursue. The time, travel, and materials involved can add up quickly.
- Time. Long bid cycles are the norm, which may preclude bidding other work.
- Higher risk, thanks to the complexity of the work, a higher level of sophistication among the major players (owner, developer, construction manager, and general contractor), more onerous and risk-absorbing contract provisions, and higher working capital requirements.

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And a quick note: While we're focusing on major projects, understand that many of the points we're covering are universal and can be applied to any project.

The Hunt

Once you've made the decision to go after a major project, be prepared to pursue it with a company-wide commitment to win the job. The investment in the chase is too high to approach things half-heartedly.

As always, preparation is the key. Get to know the players early on, and while introducing yourself and your company, be sure to *listen*. Your goal is to find out all you can about the project *beyond* the documents.

Identify the key drivers for the project. Be aware that there may be differing objectives among the various members of the construction team. For example, it is not uncommon for the owner's general contractor/construction manager to be working under a guaranteed maximum contract while the architect is envisioning a statement project worthy of making the cover of illustrious publications such as this one.

It is critical to learn if the project is to be schedule-driven or whether cost is the main objective. Will the owner be using the building themselves, leasing it out, or "flipping" it? The contractor may have conflicting projects that they are juggling key personnel among; are you are dealing with their starters or their second string for this project? Are there key tenant provisions that will need to be accommodated? Permitting restrictions? Any demolition on the site? More subtly, have any of the construction team members had a recent bad experience with any of the other bidders? Or you? If it's the latter case, that bad memory must be expunged *quickly*.

Position yourself and your firm as a resource for the construction team. The specific logistics and complexities of fabricating and building a major steel frame are often beyond the general expertise of the builders, and they will need help (whether they realize it or not). However—and this is important—guard against becoming an "Alexa" service for them. Contractors often succumb to eagerly sucking up any and all free advice proffered over many meetings, phone calls, and repeated rounds of bidding, all the while implying that they will "work the job out" with you, only to later announce that the "bank" or "the owner" is requiring them to go out to five bidders (or more).

On the other hand, those meetings and one-on-one involvement with the construction team can build a relationship that


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establishes trust and confidence with your firm and can lock up the job for you. But it's hard to determine which way things will go. All the more reason to get to know the people involved and develop personal relationships with them. Just make sure not to give away key points without a commitment. It is OK to explain that bidding this project costs a lot of money or is preventing you from pursuing other work and that you need assurances before you go further. And get those assurances from more than one person or make the assurances known to key members of the contracting firm. Some people will rationalize a "change of direction" to themselves but are less likely to do so if it exposes them as duplicitous to their peers.

What Owners Want

"Certainty" is an owner's number-one goal. They will test for this concept when evaluating all three of the major aspects of the project:

- Price
- Schedule
- Scope/quality

As we all have experienced, the challenge for the construction team is to thoroughly communicating the job requirements to the bidders. The design is seldom complete during bidding, unless you are bidding a bridge, and the spec is often incomplete or contains conflicting provisions. Just remember that no matter what your role is on a project, your partners want to do a good job and be part of a successful project, too. And never forget that they also have bosses.

As you can see, the bidding process provides many opportunities for misunderstandings to occur—but also opportunities to develop successful, lasting relationships and become part of building something major together. ■

Want to learn more about how to successfully bid on major projects? Attend the two-part session "Closing the Deal on Major Projects" at the 2020 NASCC: The Steel Conference, taking place April 22–24 in Atlanta. For more information and to register, visit ***aisc.org/nascc****.*

NASCC

AISC to Honor Leading Design, Construction, and Education Professionals at NASCC

AISC will honor 13 leaders across the structural steel design, construction, and academic communities with awards at the 2020 NASCC: The Steel Conference (April 22–24 in Atlanta). The awards presentation and opening keynote will take place on Wednesday, April 22, at 10:30 a.m. at the Georgia World Congress Center. AISC awards honor significant individuals who have made a difference in the success of the fabricated structural steel industry. Whether it's for an innovative design, an insightful technical paper, or a lifetime of outstanding service, an AISC award bestows prestige and well-deserved recognition upon its recipient.

The **Lifetime Achievement Award** honors individuals whose continued outstanding service has made a difference in the success of AISC, the structural steel industry, and the structural steel design, construction, and academic communities. This year's Lifetime Achievement Award winners are:

- Carol Drucker, SE, PE, PEng – Principal, Drucker Zajdel Structural Engineers, Inc.
- W. Samuel Easterling, PE, PhD – Dean of Engineering, Iowa State University
- Daniel G. Fisher, Sr. – Founding Partner, Girder-Slab Technologies, LLC
- Ronnie Medlock – Vice President, Technical Services, High Steel Structures, LLC
- Chia-Ming Uang, PhD – Professor, University Of California, San Diego
- John M. Yadlosky, PE – Senior Bridge Engineer, HDR, Inc.

The **Special Achievement Award** recognizes individuals who have demonstrated notable achievements in structural steel design, construction, research, or education. It honors those who have made a positive and substantial impact on the structural steel design and construction industry. This year's award recipients are:

- Michel Bruneau, PhD, PEng – SUNY Distinguished Professor, University at Buffalo
- Ron Klemencic, SE, PE, Hon. AIA– Chairman and CEO, Magnusson Klemencic Associates
- Rex I. Lewis – President, Puma Steel
- Amit H. Varma, PhD – Karl H. Kettelhut Professor of Civil Engineering, Purdue University

The **Early Career Faculty Award** provides recognition to faculty who demonstrate promise in the areas of structural steel research, teaching, and other contributions to the structural steel industry. This year's recipients are:

- Emily Baker, AIA – Assistant Professor of Architecture, University of Arkansas
- Negar Elhami-Khorasani, PhD – Assistant Professor, University at Buffalo
- Julie Fogarty, PE, PhD – Assistant Professor, California State University, Sacramento

For more information about The Steel Conference, visit **aisc.org/nascc**. To learn more about AISC's award programs, visit **aisc.org/awards.**

Last year's award-winners at NASCC: The Steel Conference in St. Louis. From left: David Zalesne, David Ratterman, Jon Magnusson, Ron Ziemian, Michel Bruneau, John Cross, Heather Gilmer, Francesco Russo, Johnn Judd, Matthew Yarnold, Charlie Carter, Matthew Hebdon, and Doug Rutledge.

People and Companies

- AISC member **Triple-S Steel Holdings, Inc.**, announced that, through its subsidiary, **Intsel Steel East, LLC**, it has acquired the assets of **Bushwick Metals**, a wholesale distributor of structural steel products. Bushwick Metals brings approximately 110 employees—in three locations in Connecticut, New Jersey, and Delaware—to Triple-S. As part of Intsel Steel East, the business will be led by **Rick Perlen**, the great-grandson of Bushwick's original founder.

- Structural engineering firm **Keast & Hood** has opened the exhibition **Structure & Purpose: The Legacy of Engineering at Keast & Hood** in Philadelphia. Curated by architectural historian **Izzy Kornblatt**, the exhibition posthumously explores the role of the firm's founding engineers, **Carl A. Baumert Jr.**, **Nicholas L. Gianopulos**, and **Thomas J. Leidigh**. Through an array of never-before-exhibited materials, the retrospective examines the scope and importance of their work via 16 of their major projects. Objects on display include original drawings by **Louis I. Kahn and Associates**, **Robert Venturi**, **Renzo Piano**, and **Romaldo Giurgola**; documents and drawings from the company's archives; models and material samples; and video interviews. Lending institutions include the **Architectural Archives of the University of Pennsylvania**, the **Renzo Piano Foundation**, and several others. The exhibition, which is free and open to the public, will be on view through March 31, 2020.

ENGINEERING JOURNAL

First Quarter 2020 *EJ* Now Available

The first quarter 2020 issue of AISC's *Engineering Journal* is now available. You can access the current issue as well as past issues at **aisc.org/ej**. Below is a summary of this issue, which includes articles on high-strength bolts, bolted joints, shear lag in hollow structural section (HSS) tension members, and constrained-axis torsional buckling.

Dimensional Tolerances and Length Determination of High-Strength Bolts
James A. Swanson, Gian Andrea Rassati, and Chad M. Larson

Structural engineers and detailers are often removed from the process of manufacturing bolts, and thus the tolerances and variances that go along with common manufacturing processes. While this does not represent a problem in most cases, being familiar with the manufacturing processes and tolerances associated with high-strength bolts can help prevent some problems from occurring before the design process even begins, particularly when shorter bolt lengths are needed. This lack of familiarity, in some circumstances, might lead to mistaken assumptions regarding the location of the shear plane relative to the threads of the bolt, which may lead to incorrect designs. While an engineer might presume that bolt strength would not control in such short grips, this paper will discuss the cases in which this can become an issue. This paper summarizes the major variances between nominal and actual dimensions, evaluates some of the consequences that those variances can have on design, presents solutions to those issues, and culminates with a proposed design procedure for proper length determination of high-strength bolts with several illustrative examples.

A Reliability Study of Joints with Bolts Designed with Threads Excluded but Installed with Threads Not Excluded
James A. Swanson, Gian Andrea Rassati, and Chad M. Larson

This paper presents a reliability and probability study focusing on connections using relatively short bolts that in a companion paper have been shown to have the potential to have been designed with threads excluded from the shear plane and then subsequently installed with the threads not excluded from the shear plane. After an introduction outlining the background of the shear strength and associated design of joints in various editions of the AISC *Specification*, the paper presents a structural reliability analysis as well as a probability study using Monte Carlo simulations, and then finally a discussion of additional considerations and mitigating factors associated with this potential problem. Calculated reliability coefficients and probabilities of failure are tabulated for joints using two diameter groups of 120-ksi bolts (from ⅝ in. to 1 in. and from 1⅛ in. to 1¼ in.) and for joints using 150-ksi bolts. The paper provides an evaluation of the reliability of joints with bolts that have been designed with the threads excluded from the shear plane but installed with the threads not excluded from the shear plane. Although it is recommended that future designs involving short bolts be based on the assumption that the threads are not excluded from the shear plane, this study provides a measure of the reliability of structures that have already been constructed with bolts designed assuming that the threads were excluded but installed with the threads not excluded.

Reexamination of Shear Lag in HSS Tension Members with Side Gusset Plate Connections
Akashdeep A. Bhat and Patrick J. Fortney

This paper presents an evaluation of the shear lag factor for HSS tension members connected with two side plate gussets with longitudinal welds as given in AISC *Specification* Table D3.1, Case 6b. The current AISC *Specification* for Case 6b does not permit weld lengths less than the perpendicular distance between the welds, and has the potential of producing negative shear lag factors. Similar issues previously existed for members given in Case 4 of Table D3.1. However, the AISC *Specification* has adopted a mathematical model proposed by Fortney and Thornton for Case 4 of Table D3.1. The work presented in this paper offers: (1) a mathematical model for calculating the shear lag factor for Case 6b derived by repurposing the model adopted by AISC for Case 4 of Table D3.1; (2) the results of a parametric study comparing the results of the new mathematical model to the results using the current AISC method, and; (3) discusses the protocols developed for use in finite element analysis to evaluate the effectiveness of the proposed mathematical model. The proposed new mathematical model will permit longitudinal weld lengths less than the perpendicular distance between the welds, and removes the possibility of calculating a negative shear lag factor, while better representing the redistribution of cross-sectional stress near the connection region.

Continuous Bracing Requirements for Constrained-Axis Torsional Buckling
Mark D. Denavit, William P. Jacobs V, and Todd A. Helwig

The design of floor and roof framing members is typically controlled by flexural demands; however, if a member serves as a chord or collector it can also be subjected to significant axial compression. Continuous restraint provided by the floor or roof diaphragm is commonly assumed in design to provide adequate bracing of connected wide-flange members against minor-axis flexural buckling; however, these members are still susceptible to major-axis flexural buckling and potentially to torsional buckling about a constrained axis located at the top flange. In addition to the lateral restraint, floor and roof decking systems can also provide continuous torsional restraint through their flexural stiffness and strength. This restraint can be used to increase the calculated constrained-axis torsional buckling strength or inhibit the mode altogether. In this paper, the specific case of a wide-flange steel beam-column with both lateral and torsional restraint located at the top flange is investigated and torsional bracing requirements are derived. The focus of the study is on continuous torsional bracing and its effect on the constrained-axis torsional buckling mode.

RESEARCH

Two AISC Research Projects Nearing Completion

Two AISC solely funded projects are entering into their final testing phases and could have a significant impact on future versions of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360, **aisc.org/specifications**). Here are updates on both:

Bolts, Welds and Combinations of Both
Mohamed Soliman,
Oklahoma State University

This project focuses on investigating the behavior of steel connections with bolts and welds sharing the load. The need to combine bolts and welds can occur if the design load changes, when there are unforeseen difficulties in the make-up or matching of bolt holes, or when retrofitting an existing structure. As is currently understood, a welded connection possesses a relatively small capacity for deformations when reaching maximum strength, and slip-critical bolted connections remain stiff during loading.

Therefore, the structural engineering community remains skeptical about these combination connections due to the uncertainty regarding the deformation capacity of both welded and bolted connections. The current research is an extensive experimental program involving more than 100 specimens and also uses complex analytical tools to help fully understand the behavior of combined bolt and weld connections. The overarching goals of the project are to provide design guidance for realistic configurations of connections employing bolts and welds in steel buildings and bridges as well as to provide the structural engineering community the necessary tools to design with and understand the behavior of bolted connections supplemented by welds. This project is in its second and final phase of testing. The first phase of testing focused on concentrically loaded specimens, while the second phase is focusing on eccentrically loaded specimens. So far, the results indicate that there may be more capacity in combined bolted and welded connections than what current AISC provisions calculate. These results are still being analyzed, and any final recommendations implementation into future versions of the AISC *Specification* will be subject to review and formal balloting procedures.

Investigation of Bearing and Tearout of Steel Bolted Connections
Mark Denavit, University of Tennessee

The goal of this research is to determine whether bolt tearout checks within the context of the current AISC *Specification* can be eliminated completely when edge distances comply with a minimum length. Per current AISC *Specification* requirements, the strength of a bolt group is computed from the strengths of individual fasteners with consideration of strain compatibility and, except for special cases, neither bolt shear rupture nor bearing strength will vary among the individual bolts in a group; only tearout will vary based on the clear distance. Where the direction of loading for individual bolts is difficult to determine, such as in eccentric connections, the above methodologies give rise to the "poison bolt" approach, where the overall connection strength is reduced, sometimes drastically, due to a single bolt.

The project is split into two phases, where the first focuses on examining existing test data into a database for analyzing and determining the parameters that should be tested in the second phase of the research. The research is currently entering into the testing phase, which will investigate both single bolt and multiple bolt specimens and includes connections that are eccentrically loaded. As noted, the testing matrix was selected carefully by conducting an extensive review of existing test data, assembling the results into a database, performing various parametric studies on the data, and through discussions with the industry oversight committee. The upcoming testing will help to add to the existing database of bolted connections and will also aid in determining if adjustments can be made to the AISC *Specification* to allow for a more straightforward in estimating bearing and tearout of bolted connections.

MEMBERSHIP

AISC Board Approves New Full and Associate Members

Full

Bickers Metal Products, Miamitown, Ohio
Kay & Kay Contracting, London, Ky.
Performance Solutions, LLC, Smyrna, Tenn.
Prestige Iron Work, Inc., Lancaster, S.C.
Revolution Industrial, Chandler, Ariz.
State Welding & Fabricating, Wallingford, Conn.
Variable Steel Unlimited, LLC, Atlanta

Associate

AISC DETAILER

Detailers
BW Detailing, LLC, Austin
EASTCAD Drafting Services, LLC, Mount Airy, Md.
Great Lakes Builders, Inc., Elk Grove Village, Ill.
Om Steel Solutions Pvt., Ltd., Mumbai, India
Quality Emphasis Steel Solutions, Thane, India

AISC ASSOCIATE

Erectors
Northwest Steelworks, LLC, Anchorage, Alaska
Prairie Steel Services, Inc., Champaign, Ill.

marketplace & employment

advertiser index

HISTORY LESSON

ONE PRUDENTIAL PLAZA, AISC's current home, turns 65 this year. And AISC itself turns—brace yourself (pun clearly intended)—100 next year.

The 601-ft-tall (912 ft to the tip of the antenna spire) building rises 41 stories and was the first high-rise built in Chicago following World War II.

At the recent Council on Tall Buildings and Urban Habitat's World Congress in Chicago, Sherwin Asrow, who performed the lateral force analysis for the building, shared some of his experiences with the building, which was designed in 1947 and opened in 1955. Perhaps ironically, the home of an organization known for its steel construction codes and standards was also the cause of a major steel-related change to the city's building code.

According to Asrow, during installation of the bracing system for the basement, the contractor didn't install the horizontal members properly, causing part of the vertical sheet pile bracing to move inward on the east side of the excavation. The hand-dug caissons had been installed down to rock at about 90 ft on this side, and the movement caused the upper portion of about 10 caissons to crack. Asrow worked with University of Illinois professor Ralph Peck (an expert in soil mechanics involved with installing Chicago's subway tunnels) to inspect the bracing system and evaluate a means for jacking back the bracing that had moved.

After the sheeting had been restored to vertical, the upper part of the affected caissons was removed and replaced, and reinforcing bars were embedded into each caisson below, extending to their tops. This experience resulted in a change to the *Chicago Building Code*, which added a requirement for all caissons thereafter to have full-height vertical steel reinforcing bars to prevent cracks from occurring.

For more about Asrow's thoughts and experiences on his work with One Prudential Plaza, see the related Steel in the News item at **www.modernsteel.com**.

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