Modern Steel Construction

July 2021

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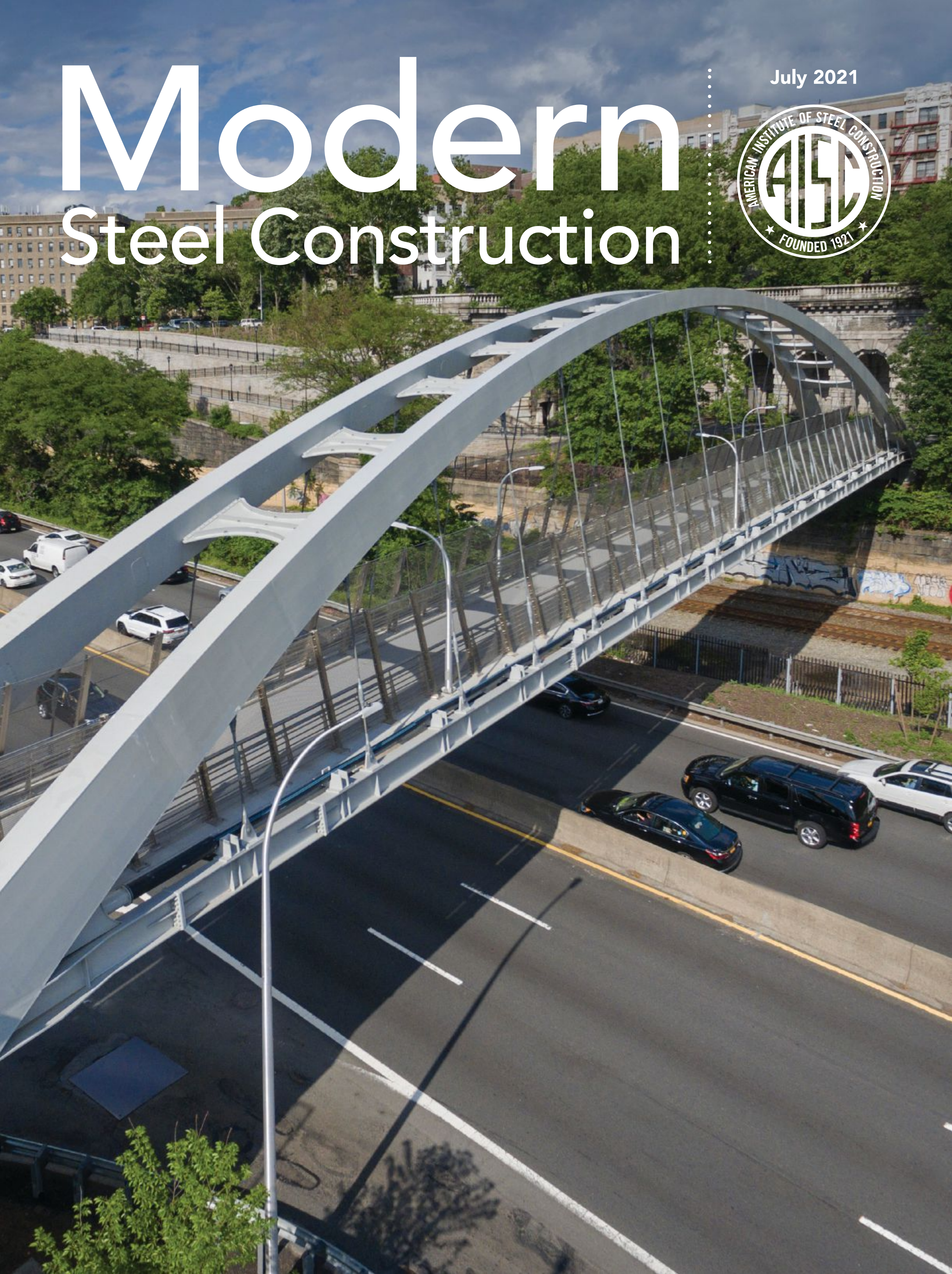


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Modern Steel Construction

July 2021

in every issue

features

columns

ON THE COVER: The Denny Farrell Pedestrian Bridge provides safe and stylish access over traffic and trains to Manhattan's Riverside Park, p. 26. (Photo: © John Baer - Building Images Photography)

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editor's note

While the internet has made it incredibly easy to access information, it has also made it increasingly difficult to evaluate the credibility of information.

This problem has weighed heavily on my mind lately, especially after a very reputable magazine published an article related to the safety of steel bridges. The article, unfortunately, was based on the misapplication of research. To its credit, the publisher withdrew the article and published another, correcting the misinformation in the original article. Unfortunately, the same author has since gone to a predatory journal (that is, a journal that will publish any article for which the author is willing to pay a fee to be published) and published another paper with even more egregious errors.

I'm not sure there's anything that can be done other than to warn people to view all information critically. However, there are some simple questions you can readily ask when presented with questionable information:

- Where is the paper published? AISC features two publications, a magazine (the very one you're reading right now, as a matter of fact) and a journal (*Engineering Journal*). Our magazine shies away from publishing original research; that's the province of our journal.
- If it's published in a journal, is the journal peer-reviewed? When we publish a paper in *Engineering Journal*, it undergoes a strenuous review from recognized experts in the specific area addressed in the paper.
- Did the author pay to have their paper published?
- How long has the journal been available?
- Does the journal have a valid ISSN (International Standard Serial Number)?

You can also do a quick internet search of the publisher. For example, you can visit **https://beallslist.net/** to view a fairly comprehensive (and disturbingly long) list of publishers suspected of publishing predatory journals. (If you use this resource, be sure to double-check the name of the publisher you're looking for. It's not unusual for these predatory publishers to use names that sound like other legitimate publishers.)

Duke University also offers the following advice:

- Consider how many articles the journal has published. Are they similar in scope and topic?
- If an author fee is charged, is it reasonable?
- What company owns and produces the journal? Are they reputable within the industry?
- Are the papers peer-reviewed?
- Who is on the editorial board and staff?

Lastly, check whether the publisher has a legitimate address, phone number, and website. The stakes are too high to simply accept false news. Please be vigilant—and don't hesitate to ask recognized experts and professional associations to weigh in on any claims that seem questionable.

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

steel interchange

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

Beams with Warped Webs

The cambering process for a 70-ft W33 roof beam has resulted in a slight warping of the web at midspan. Could you provide some guidance on evaluating the strength of a member with this type of imperfection?

This type of web deformation can occur because of the compression stresses caused by the concentrated load from the cambering machine as well as the flexural compression stresses in the web during the cambering operation. Any potential effect on the beam strength is dependent on the magnitude and geometry of the deformation. Except in extreme cases, these imperfections are unlikely to cause a reduction in strength when the deformed area is subjected to only static (non-fatigue) tensile stress.

When the deformed area is subjected to compression stress, the out-of-flatness imperfection can be checked using the limit discussed in AISC Design Guide 33: *Curved Member Design* (Section 4.3.3). If the out-of-flatness imperfection exceeds 0.264 times the web thickness, Section 5.5.1 of the guide can be used to determine any strength reduction.

In addition, AISC Design Guide 36: *Design Considerations for Camber* covers some of the pros, cons, and pitfalls associated with specifying camber.

Bo Dowswell, PE, PhD

Bridge Girder Depth and Transportation

Is there a suggested shipping limit on the vertical depth of a bridge girder?

Per Section C1.5.3 of the AASHTO/NSBA Collaboration G12.1-2020: *Guidelines to Design for Constructability and Fabrication* (**aisc.org/gdocs**): "Economy is achieved using girders that can be shipped web vertical by truck, which is limited by the overhead clearances on the shipping route. Girders that are under 9 ft deep can generally be shipped vertically on a truck."

Devin Altman, PE

Fillet vs. CJP Welds

At what point is a complete-joint-penetration (CJP) weld more cost-effective than a multi-pass fillet weld?

There is no definitive answer to this question, as different fabricators have different thresholds. Some shops draw the line at ¾-in. or 1-in. fillet welds, while others prefer using fillet welds larger than 1 in. over having to use a CJP groove weld.

My suggestion is that if you want the best bid and project cost, then you should either consult the fabricator or provide both options on the contract documents so that the fabricator can choose the option they feel is most economical.

Why is this such a complex and subjective decision? There are a lot of implications, and there can be questions related to the workflow, such as:

- How difficult will it be to coordinate with nondestructive testing (NDT) inspection when required?
- Is the equipment used to bevel the joints available, or is it tied up with other work?
- Is it possible to position the piece such that one type of weld becomes more favorable?

It is not an easy decision to make even on a case-by-case basis, and it's even more challenging at a company-practice level. This is likely why there is so much variation.

Larry Muir, PE

Visible Coating Defect

AISC's *Certification Standard for Shop Application of Complex Protective Coating Systems* (AISC 420-10/SSPC-QP 3) states that 100% inspection for visible coating defects is required. What is a visible defect in painting?

The standard defines *visible coating defects* as: "imperfections that may be detected without any magnification. These include but are not limited to runs, sags, lifting, chipping, cracking, spalling, flaking, mud cracking, pin holing, and checking."

Section 13 of the standard refers to Section 15, which states in part that the piece with a defect can be "used as-is (after more detailed analysis or acceptance by the firm's engineering or management, provided contract requirements are met) or treated as an 'owner-approved nonconforming product'" presumably if the owner approves the use with the visual coating defect.

Larry Muir, PE

Devin Altman (altman@aisc.org) is a bridge steel specialist, and **Margaret Matthew** (matthew@aisc.org) is a senior engineer and editor of *Engineering Journal*, both with AISC. **Bo Dowswell**, principal with ARC International, LLC, and **Larry Muir** are both consultants to AISC.

Double-Nut and Bolt Loosening

Can two nuts be used to prevent bolt loosening?

Using double-nuts to prevent bolt loosening is not addressed in the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360), and it is not a common practice in our industry. *Specification* Section J3.1 states: "Bolts in the following connections shall be pretensioned… (2) Connections subjected to vibratory loads where bolt loosening is a consideration." In my experience, it is generally accepted that pretensioning is the best way to prevent the loosening of structural steel connections.

The use of double-nuts is incompatible with slip-critical and pretensioned bolted joints. I am not aware of any evidence that the required pretension will be achieved or maintained if it is somehow achieved in a double-nutted connection. Improper pretension could lead to premature fatigue failures or joint slip. Depending on the application, either could potentially lead to catastrophic failure.

Section 8.2 of the *RCSC Specification for Structural Joints Using High-Strength Bolts* provides accepted installation methods for pretensioned joints and slip-critical joints. Again, these methods are incompatible with the procedures necessary to ensure the intended performance of double-nut connections. Even when installed in a manner that prevents complete loosening of the joint, it does not achieve or maintain the level of preload assumed in the AISC *Specification*. I would encourage you to do considerable research before employing such methods.

Larry Muir, PE

SpeedCore Design Guide Availability

Do you know when AISC's SpeedCore design guide will be available?

We expect the design guide to be available during the fourth quarter of 2021.

Margaret Matthew, PE

Single-Plate Connections to HSS

Are through-plates always required for hollow structural section (HSS) columns with slender walls, even though punching shear is satisfied?

Part 10 of the 15th Edition AISC *Steel Construction Manual* states:

> "As long as the HSS wall is not classified as a slender element, the local distortion caused by the single-plate connection will be insignificant in reducing the column strength of the HSS (Sherman, 1996)."
>
> It also states:
>
> "Through-plate connections should be used when the HSS wall is classified as a slender element… or does not satisfy the punching shear limit state."

Note that these statements are made in the *Manual*, not the *Specification*, and therefore represent guidance, not requirements.

Through-plates are not required for slender HSS columns. Single-plate shear connections can be used to the face of slender HSS columns if the potentially significant reduction in the HSS column strength due to "the local distortion caused by the single-plate connection" is accounted for in the design of the column. To my knowledge, there is no document that provides a method to account for the potentially significant reduction in the column strength of the HSS due to "the local distortion caused by the single-plate connection." The absence of such methods is likely why the *Manual* makes the above suggestion about through-plate connections being used when the HSS wall is classified as a slender element. However, if you are confident you can account for this effect, then you are free to do so. Most engineers I know would probably try to avoid the condition.

Larry Muir, PE

steel quiz

This month's Steel Quiz focuses on bridges. The answers to these questions can be found in the recently published NSBA *Guide to Navigating Routine Steel Bridge Design* (available at **aisc.org/bridges**) as well as on a page on AISC's website featuring "A Century of American Steel Bridges" (**aisc.org/timeline**).

1 **True or False:** Wind loads experienced during construction and in the final condition are one of the sources of flange lateral bending.

2 **True or False:** The NSBA *Guide to Navigating Routine Steel Bridge Design* is only applicable to what is defined as a "routine steel I-girder bridge."

3 Which was the first cast-iron bridge in America?
a. Roebling Suspension Bridge in Cincinnati
b. Dunlap's Creek Bridge in Brownsville, Pa.
c. Wheeling Suspension Bridge in Wheeling, W.V.
d. Macombs Dam Bridge in New York

4 **True or False:** In bolted splice connections for flexural members, the web splice is designed for the larger of the factored shear resistance of the web on either side of the splice.

5 **True or False:** For bridge projects designed to the AASHTO *LRFD Bridge Design Specification* and with ASTM A709 material specified, no other material specification can be used.

6 **True or False:** The Smithfield Street Bridge in Pittsburgh was the first bridge to use a lenticular truss design.

7 **True or False:** Table 3.4.1-1 in the AASHTO *LRFD Bridge Design Specification* applies a load factor of 1.30 to the live load force effects under the Service II load combination.

TURN TO PAGE 14 FOR THE ANSWERS


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steel quiz ANSWERS

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**.

1 **True.** Article 6.10.1.6 provides two sources for flange lateral bending stresses. Wind loads is one, and the other is torsion due to deck overhang loads acting on the discretely braced flanges of the bare steel exterior girders in regions of positive flexure during concrete deck construction.

2 **False.** The guide states that value may still be gained from designers even if the bridge in question does not fall under this definition. In such cases, a senior bridge engineer with steel bridge design experience should be consulted when determining if and how to apply the recommendations provided in the guide.

3 **b.** Dunlap's Creek Bridge is the oldest metal bridge still in use in the U.S. and was the first cast-iron bridge in the country.

4 **False.** AASHTO *LRFD Bridge Design Specification* Article 6.13.6.1.3a states that bolted flange and web splice connections are designed at a minimum for 100% of the individual design resistance of the flange and web. Thus, the web splice is designed for the smaller factored shear resistance of the web on either side of the splice. However, per Article 6.13.6.1.3c, should the moment resistance provided by the flange splices be insufficient to resist the factored moment at the strength limit state at the point of the splice, then the web splice plates and their connections are to be designed for a web force taken equal to the vector sum of the smallest factored shear resistance and a horizontal force located at the mid-depth of the web that provides the necessary moment resistance in conjunction with the flange splices.

5 **False.** ASTM A709 standard states: "When the requirements of Table 11 or 12 or the supplementary requirements of this specification are specified, they exceed the requirements of Specifications A36/A36M, A572/A572M, A992/A992M, A588/A588M, A1010/A1010M (UNS S41003), and A913/A913M." An additional option could be to allow for A992 material but also require the material to meet the ASTM A709 Table 11 or 12 toughness test requirements.

6 **True.** The first bridge to use a lenticular steel truss design was indeed the Smithfield Street Bridge, which opened in 1883 and crosses the Monongahela River in downtown Pittsburgh. It was designated as a National Historic Landmark in 1976.

7 **True.** Section 6.5.2 in the guide references this application when discussing the service limit state checks required for flexural members in routine steel I-girder bridges.

steelwise

ELEVATED EXPECTATIONS

BY ALANA FOSSA

Clearing up misconceptions and implementing best practices when it comes to hot-dip galvanized structural steel.

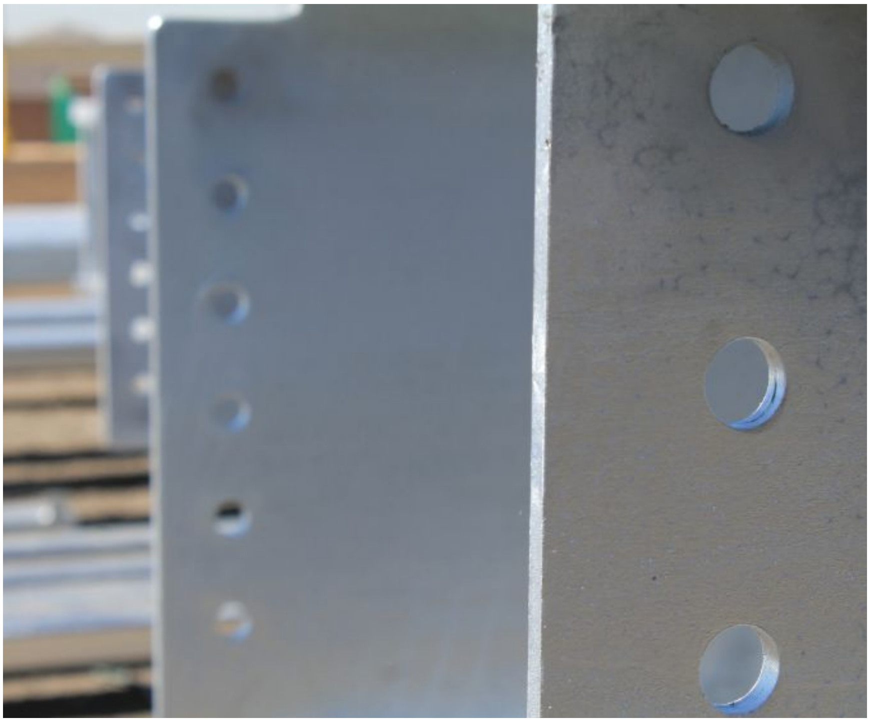
Alana Fossa (**afossa@galvanizeit.org**) is the senior corrosion engineer for the American Galvanizers Association (AGA) and the Vice Chair of ASTM Subcommittee A05.13, which authors and edits specifications on hot-dip galvanizing of steel.

A SMOOTH STEEL AESTHETIC AND rugged galvanized coatings are not mutually exclusive.

While after-fabrication batch hot-dip galvanizing (HDG) provides steel with a durable zinc coating and long-lasting protection from atmospheric corrosion, it did not originate as an architectural finish. Despite this, HDG is increasingly being used to achieve a contemporary or industrial aesthetic for a multitude of exposed steel projects, a trend that has brought heightened attention to its finish appearance.

The American Galvanizers Association (AGA) conducted a recent survey of more than 1,500 architects, engineers, steel detailers, and other specifiers and found that the vast majority of complaints about HDG can be traced back to its finish or appearance—typically that the galvanized surface does not have an even color appearance.

The good news is that several measures can be taken to improve the appearance of the galvanizing and achieve consistent, smooth, and uniform coatings within the project budget. These measures do require additional communication between specifiers, fabricators, and galvanizers. Here, we'll discuss common misconceptions about the appearance of galvanized coatings as well as recommendations for effectively communicating HDG requirements on projects with elevated aesthetics.

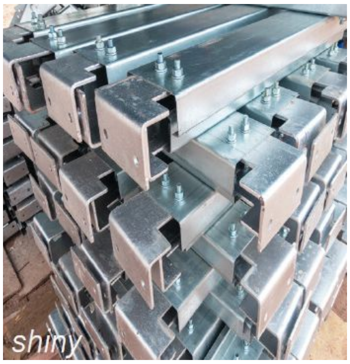


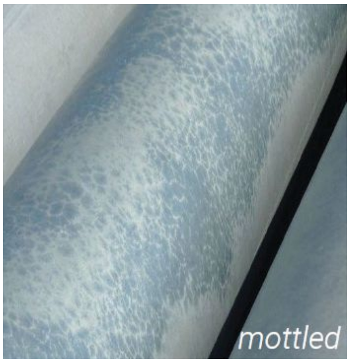
Initial Variations of HDG

While there is a common assumption that galvanized structural steel exhibits a shiny, smooth, or spangled finish akin to the galvanized sheet metal that is common in ductwork or corrugated panels, galvanizers and most structural steel fabricators know that galvanized steel elements rarely yield this type of appearance. Instead, it is common for a batch of galvanized steel to have a variety of initial appearances, including bright and shiny, matted, spangled, mottled, or a mixture of finishes. These differences are unrelated to galvanizing quality and can occur between individual pieces and even between sections of the same piece. The initial appearance of galvanized steel is difficult to predict and control for a variety of reasons, including steel chemical composition, stresses induced during steel processing, and cooling rates after galvanizing.

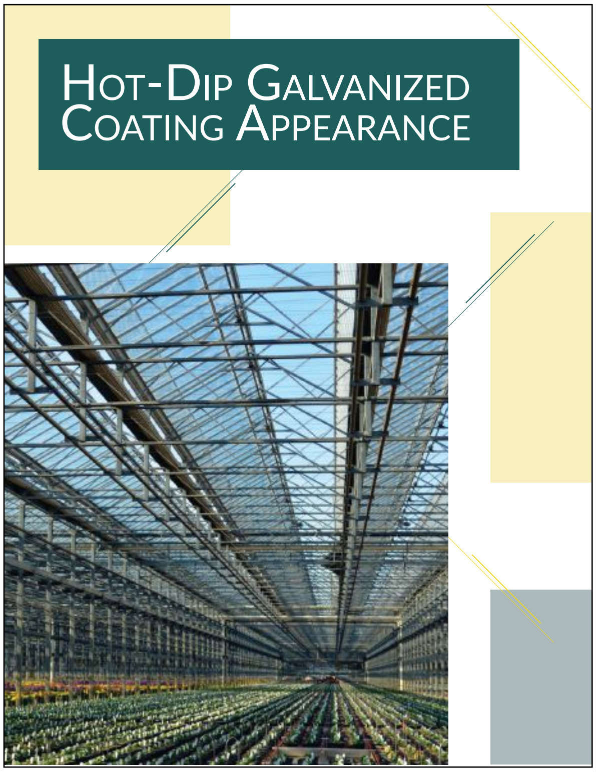
Natural Weathering

Many specifiers preferring a shiny finish on their galvanized steel do not realize the sheen is temporary. Regardless of the initial appearance, galvanized steel typically takes on a uniform matte gray appearance within six months to two years, depending on the exposure conditions. As the coating encounters natural wet/dry cycles in the environment, it develops a protective zinc patina of zinc carbonate, resulting in a soft, weathered, and more uniform gray appearance. Conversely, exposed galvanized steel elements installed in climate-controlled buildings are unlikely to experience natural weathering, and the initial appearance will remain unchanged.





above/right: Examples of possible initial appearances when specifying batch hot-dip galvanizing.



left: To explain the variety of appearances to be expected of newly galvanized steel, AGA offers a free publication, *Hot-Dip Galvanized Coating Appearance*, which contains pictorial examples, practical methods to achieve or avoid each appearance, and a description of how the appearance will look as it weathers over time.

Wet Storage Stain

Wet storage stain (often erroneously called "white rust") is an accumulation of white powdery corrosion products on newly galvanized surfaces when articles are closely packed, deprived of freely moving air, and exposed to moisture. Many specifiers and inspectors are under the impression that wet storage stain represents a coating quality issue that must be cleaned, but in most cases it is an aesthetic issue remedied at no cost by allowing the coating to weather naturally.

For projects where time is of the essence or where wet storage stain must be avoided or removed for critical aesthetics upon initial installation, designers should specify and plan for additional time, materials, and labor to provide adequate airflow during transportation and storage (e.g., using spacers or sheltering) and to perform cleaning. These are considered project-specific requirements to be clearly communicated to any party handling or storing galvanized steel.

Altering Zinc Color

The natural metallic gray finish of a galvanized surface is not always the desired look for a project. Many will look to a duplex system, such as painting or powder coating, on top of the zinc to achieve a specific color. However, alternative methods exist to alter the galvanizing hue without paint or powder. These methods include proprietary metal treatments applied via immersion or spray application to provide a range of translucent colors or even rustic, brown, or black finishes.

Improving the Finish

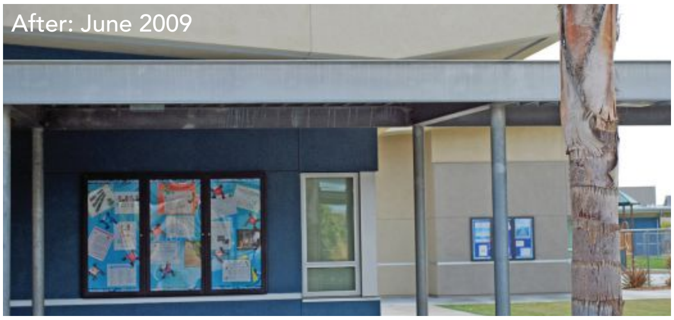
The primary specification for batch HDG in North America, ASTM A123: *Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*, does not place strict requirements on the aesthetic properties of the coating like other protective coating systems. Most galvanized products do not require heightened aesthetics, and unattractive aesthetic surface conditions are allowed if they do not affect the corrosion resistance or intended use of the product.

These relaxed aesthetics requirements in ASTM A123 sometimes make it difficult to achieve a finish appropriate for architecturally exposed structural steel (AESS) or other showcase elements without a defined list of additional requirements on the finish. This has led to a common misconception that it

above: An instructional video series produced by AGA earlier this year follows steel samples throughout fabrication and galvanizing to demonstrate controllable and uncontrollable aspects of design, fabrication, steel chemistry, the galvanizing process, cooling rates, and post-galvanizing use, all of which influence the initial appearance of the galvanizing. Visit **galvanizeit.org/appearance** to view the videos.

below: When this canopied walkway at Mark Twain Elementary was installed in Riverside, Calif., in 2006, the initial coating appearance varied from bright and shiny to matte gray on the same beam. The structure was revisited nearly three years later to examine the appearance and performance. The beams are now uniformly matte gray with little to no visible difference in appearance.


Before: October 2006


After: June 2009


Before: October 2006


After: June 2009

is difficult or impossible to galvanize showcase elements or articles to be coated after galvanizing. While the nature of the galvanizing process places some practical limitations on overall uniformity and smoothness achievable for items such as welds and seams, an architectural finish is absolutely possible when additional requirements beyond ASTM A123 are specified before and after galvanizing.

One issue that may be of concern is the presence dross protrusions, which are natural and distinct particles of zinc-iron intermetallic alloy that can become entrapped in the coating upon withdrawal from the galvanizing bath. Large parts that reach near the bottom 3 to 12 in. of the galvanizing bath are more likely to develop coatings containing dross. Appearing as bumps or pimples, small dross protrusions do not affect the corrosion protection but can be smoothed after galvanizing as an additional requirement beyond A123 for showcase elements.

That being said, the metallurgical reaction that forms the coating has many variables and natural byproducts, such as dross, that are impossible to control tightly. Even if every best practice for design, fabrication, and galvanizing is followed, galvanized steel elements that will be painted, powder-coated, or specified for an enhanced architectural finish will still be a need to be smoothed after galvanizing. The good news is that many common surface conditions can be reasonably ground, sanded, or filed to achieve the desired aesthetics. ASTM A385: *Practice for Providing High-Quality Zinc Coatings (Hot-Dip)* contains fabrication tips to help reduce surface conditions that require smoothing.

Galvanizing and AESS

At this time, there is not an established standard defining best practices for design, fabrication, and galvanizing to maximize the appearance and minimize the costs when galvanizing AESS. However, AISC's AESS Custom (C) category is an effective tool for defining requirements above and beyond ASTM A123, based on the viewing distance and type or function of the exposed steel. For example, a specifier might select from a few or many of the below requirements to achieve the desired aesthetic:

- HDG dross smoothed to projections $<\frac{1}{16}$ in.
- HDG runs smoothed to projections $<\frac{1}{16}$ in.
- HDG roughness smoothed to projections $<\frac{1}{16}$ in.
- HDG handling marks smoothed to projections $<\frac{1}{16}$ in.
- Progressive dip galvanizing avoided
- HDG zinc splatter removed
- HDG skimmings removed
- Grind thermally cut edges, including cut edge faces, $\frac{1}{16}$ in. into parent material to prevent edge flaking
- Oversized venting/drainage holes for HDG
- Drilled vent/drain holes only
- Plug and smooth round vent/drain holes
- Specify welding electrodes with less than 0.25% Si
- Wet storage stain prevention procedures
- Soft/padded slings, lifting devices, and rests

Because the list of additional requirements will vary depending on the specified AESS category, AGA published a *Specifier's Guide for Hot-Dip Galvanized AESS* in May to help specifiers communicate the requirements that are likely to achieve a realistic and practical equivalent using the AESS C category as a starting point. The guide includes galvanized samples that demonstrate realistic representations of each AESS category (see "Maximum Exposure" in the November 2017 issue, available in the Archives section at **www.modernsteel.com**, for a description of the various AESS categories). You can view the guide at **galvanizeit.org/aess**.

By addressing misconceptions of and setting realistic expectations for HDG, and communicating aesthetic requirements early in the process, attractive galvanized steel projects can come together efficiently—all while taking advantage of HDG's primary goal: corrosion protection. ■

above: The top photo shows two guardrail sections galvanized on the same day in the same batch. One panel was stacked and exposed to moisture without freely flowing air and developed wet storage stain. The other panel was stored covered and exposed to freely flowing air. Both sections were attached to the posts of concrete barrier on the dame day. The bottom photo depicts the same guardrail sections 14 weeks later after weathering in the environment. Both guardrail sections appear uniform in appearance, and the corrosion protection provided by each section is identical.

right: AGA recently published the *Specifier's Guide on Hot-Dip Galvanized AESS* to expand upon existing AISC AESS guidance and define practical exemptions and additional requirements necessary to achieving an equivalent matrix for the various AESS categories. Visit **galvanizeit.org/aess** to view the guide.

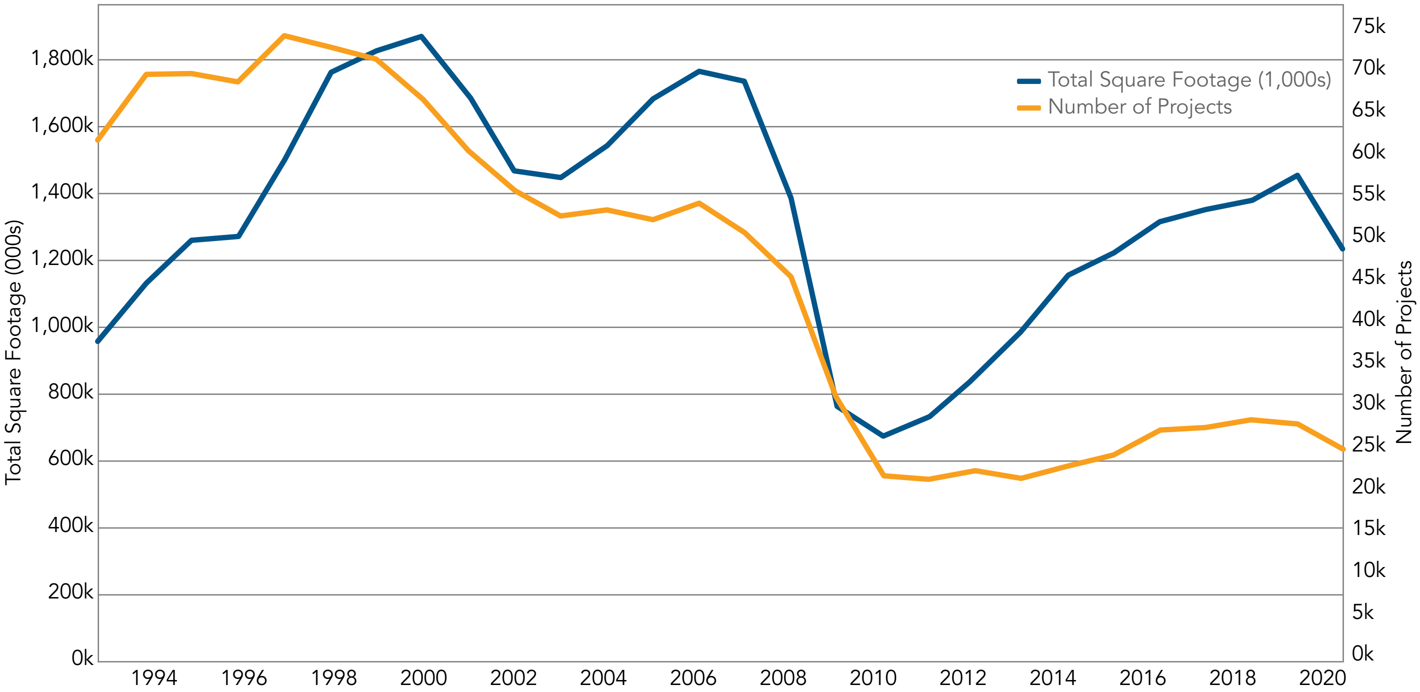
data
driven

BUILDING BIGGER

BY JOE DARDIS

Data Driven highlights market trends, economic forecasts, or other relevant numbers that affect steel design and construction. This month's edition focuses on changes in the types of buildings being constructed.

Total Square Footage and Number of Projects



Joe Dardis (**dardis@aisc.org**) is AISC's senior structural steel specialist for the Chicago market.

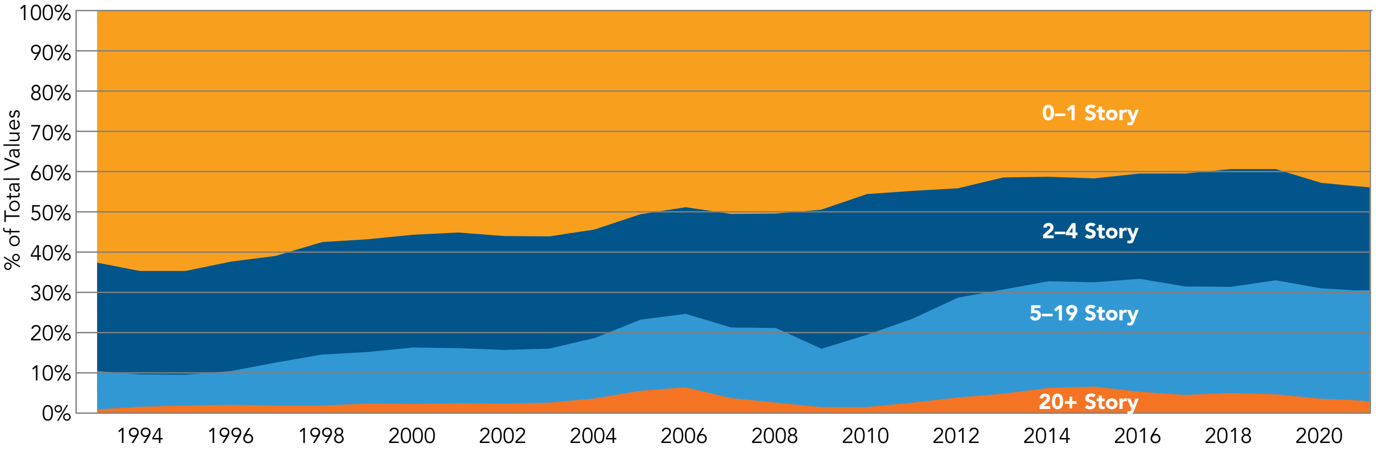
AISC HAS COLLECTED DATA ON building projects for several decades—and needless to say, we now have a *lot* of data.

There are thousands of different ways to slice and dice this information to make meaningful interpretations about what is happening in the built environment today and what might happen in the future. What seems to stand out most clearly, however, is a definitive trend towards larger building projects since the Great Recession of 2008.

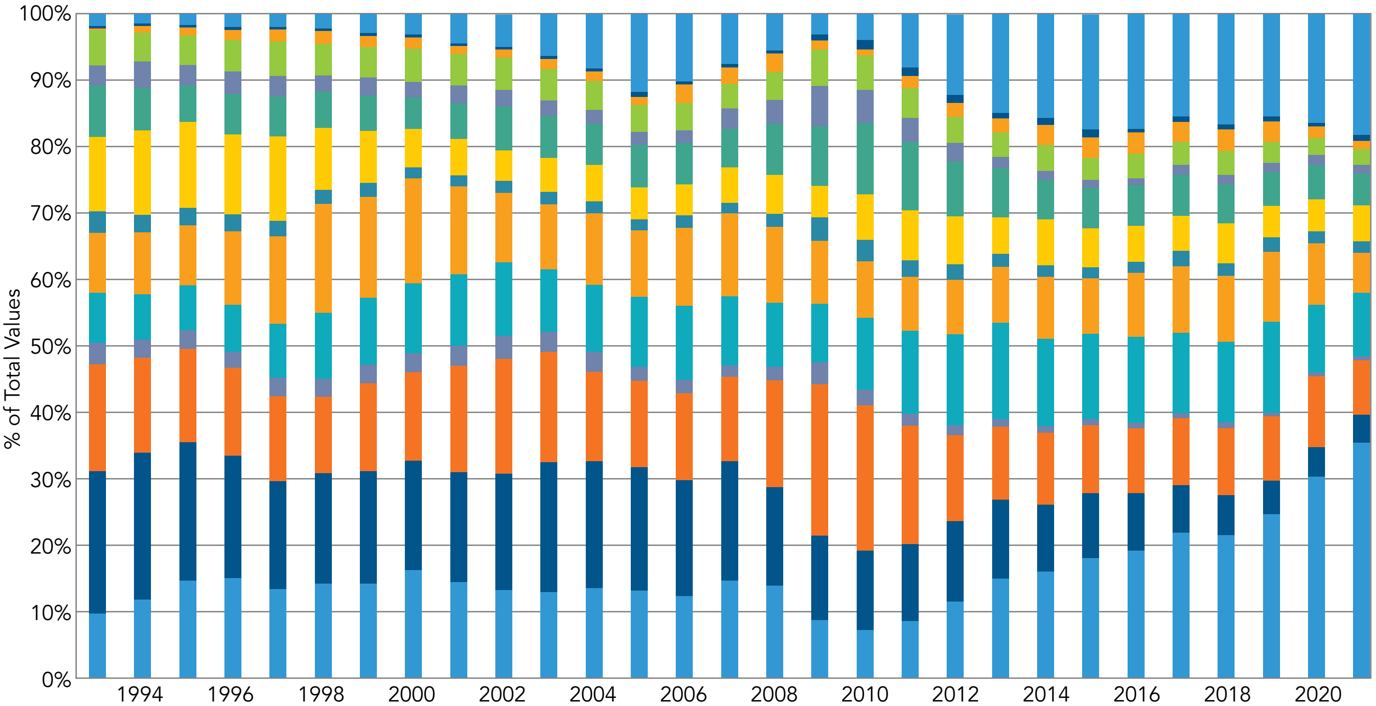
This trend can be most visibly seen by observing the project counts and total square footage by year, shown in the "Total Square Footage and Number of Projects" chart above. When considering all nonresidential and residential projects greater than four stories, the total number of project starts in the U.S. has remained relatively flat over the last 12 years while total project square footage has increased dramatically, according to Dodge Data and Analytics.

Does this mean projects are growing taller? Or are footprints getting larger? It's actually a little bit of both. The chart "Story Heights over Time" on the next page shows that buildings are indeed getting taller, with the main contribution coming from the growing mid-rise (five to 19 stories) sector. In 1993, mid-rise projects only accounted for roughly 10% of the square footage of all building projects, and now they account for almost 28%. The increase in mid-rise construction corresponds to an almost identical decrease in single-story buildings.

Story Heights over Time



Market Mix of Project Types



So why are footprints getting bigger? One word: warehouses. The "Market Mix of Project Types" chart above illustrates how project types have changed over time. Prior to the Great Recession, warehouses accounted for about 15% of the overall building market annually. But the rise in e-commerce and fundamental changes to the way we shop have spurred tremendous growth in the warehouse category, which currently accounts for 35% of the overall construction market. Subsequently, retail project types (stores and restaurants) have been steadily declining for these same reasons. The retail sector is also likely the culprit of the decline of the single-story building market.

Interested in learning more? AISC full members can visit **aisc.org/industrystats** and create their own customized market reports. Not an AISC full member? Contact your local structural steel specialist, and they will be happy to chat with you about the building trends in your market. ■

- Apartments
- Dormitories
- Hotels and Motels
- Amusement, Social, and Recreational Buildings
- Govt. Service Buildings
- Hospitals and Other Health Treatment
- Manufacturing Plants, Warehouses, Labs
- Misc. Non-residential Buildings
- Office and Bank Buildings
- Parking Garages and Automobile Services
- Religious Buildings
- Schools, Libraries, and Labs (non-mfg)
- Stores and Restaurants
- Warehouses (excluding mfg-owned)

field notes

FORGING A CONNECTION

INTERVIEW BY
GEOFF WEISENBERGER

Hunter Ruthrauff's Forge Prize-winning design was generated by his personal connection to San Diego's Balboa Park and addresses the need for a public connection across one of its canyons.

Field Notes is *Modern Steel Construction's* **podcast series**, where we interview people from all corners of the structural steel industry with interesting stories to tell. Listen in at **modernsteel.com/podcasts**.

HUNTER RUTHRAUFF has leveraged his knowledge of architecture, 3D printing, and bridge design into a successful career with T.Y. Lin International's Architectural Visualization Group (AVG).

He is also the winner of this year's AISC Forge Prize.

In this month's Field Notes interview podcast, he talks about how his passion for architecture spawned a passion for aesthetically significant bridges and how that passion spawned a pet project of sorts that became his prize-winning design, a 3D-printed steel pedestrian bridge that spans Florida Canyon in San Diego's Balboa Park.

It looks sunny there in San Diego. It's actually sunny here in Chicago today, but I feel like it's always sunny where you are. Are you from San Diego?

I'm a transplant, like a lot of us in San Diego. I grew up in Southern California but in L.A. County, specifically in the town of La Mirada. I lived there all the way through my undergraduate degree until I moved to Seattle for graduate school, then eventually came down to San Diego. I also spent a year in Denmark in college.

Got it. So where did you go for your undergraduate and graduate degrees?

I stayed local for undergrad and went to Cal Poly Pomona, which was a half-hour from my house—I lived at home for undergrad—then I went up to the University of Washington in Seattle and was there for a year and a half. I got my bachelor of architecture from Cal Poly Pomona and my master of science in architecture, digital fabrication, and parametric design in Seattle.

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

Excellent. Tell me about Denmark. Did you know Danish? Did you *learn* Danish?

Everybody there speaks English. I lived with a Dane who's a good friend now, and he would always tell me that it's so much easier to describe things in English because there were so many more words. It was my first experience in Europe, the architecture was tremendous, and I was there for a full year with my girlfriend, who is now my wife.

Were there any buildings you encountered when you were younger that made a lightbulb go off in your head and drove you into architecture?

I was always interested in buildings, you know, thinking, "What's under this layer? There's got to be something in between here," that kind of thing. I was definitely that kid in elementary school, middle school, and high school that was always sketching feverishly—typically it was abstract-form symbols and a lot of animals, so that was part of my portfolio to get me into undergrad. I got into Cal Poly and, unlike a lot of my colleagues, I didn't know anyone that was in the building profession, like engineers or contractors. When I arrived, I had no idea what an elevation plan was. So I was kind of on the fence my first year, but there was a professor that showed me Calatrava's Seville bridge and also "the eye of Valencia" (L'Hemisfèric). And that was that moment of, "Oh my God, structures can be so much more than what I see around me! I've got to get into bridges somehow."

That's great to hear. Can you give a brief history from your time in school and your early career to where you are now?

My first office job was as an undergraduate, where I worked for an industrial architecture firm that specialized in manufacturing buildings. So maybe that was the reason I was I was initially on the fence about becoming an architect. But most of my work from undergraduate through graduate school was residential and commercial, working for small two- to three-person firms. When I graduated from the University of Washington in Seattle, I followed my then-girlfriend/now-wife to San Diego and had a really good friend who was working for an architecture firm that did all kinds of civic and residential work, but they also specialized in bridges, which is kind of unique for a firm. At the time, they were working on the Sixth Street Bridge in Los Angeles, so I got into a working relationship with the bridge designers and eventually jumped ship.

Do you have a particularly memorable bridge project?

Yes, the Idaho Avenue Pedestrian Bridge in Santa Monica. It's a spiral alignment that kind of transforms from a ramp into a staircase. It's a very small bridge, but it has a really smooth set of V-piers adjacent to the staircase. It's definitely a complex-looking structure, and it taught me the importance of fabrication and understanding how you're going to make that form, and also how we've got a ways to go in advancing fabrication for these structures.

Speaking of complex and interesting bridges, can you talk a little bit about your winning Forge Prize design? I know it's designed for Balboa Park in San Diego, and I was just curious if you had a personal connection to the area.

Yes, I live in South Park, which is a perimeter neighborhood to the east of the park, and I frequently mountain bike in Florida Canyon. So I'm always over there and am cognizant that the east and west sides of the park are cut off from circulation by the canyon. It's a fantastic resource in the park, but it does present a geographic hurdle in connecting the different sides. In addition to that, over time there have been whispers and ideas of a bridge at that location. I figured that win or lose, I really wanted to take that bridge forward and eventually make it into something real. So that's where the idea for it started, and it's also really important for the continued development of Balboa Park for a bridge to be there.

I like the personal connection and practical application. Tell me a bit about the 3D printing aspect of the bridge.

A lot of the questions early on from the jury were about whether this bridge would be printed in place. The idea is that you'd set up a temporary facility in the Arizona Landfill on the east side of the park and set up printing robots that use wire-arc additive manufacturing technology. Essentially, it's a robotic head that's moving a wire-arc welder in the shape of a section, and then it grows each section vertically. And so the idea is that you bunch a few of these together to print the larger structures so that you're not taking forever to build a part. You build the part to one side and then crane it into place. Using balanced cantilever segmental construction techniques, you start building over this column and continue building outward until you get a cantilever, and then you can put in the keystone part that gives it stability. And the benefit of printing parts on-site, off to the side, is that you don't have to rely on the choke point of trucks and roads to get them from a facility to the site, and so you can theoretically print a much larger part and put it together in pieces, which means a shorter construction time.

Part of the Forge Prize program is the opportunity for entrants to work directly with a steel fabricator. What was that experience like, given that architects don't necessarily work directly with fabricators the way structural engineers do?

It was my first time working directly with a structural steel fabricator [STS Steel, an AISC member], and we really focused on the end diaphragms of these 3D-printed parts, as these components were actually plate steel, which the printer parts are positioned on top of. And we also focused on the bolted connections for each end diaphragm and even the hatches that provide access into the parts. But I also worked with Gijs Van Der Velden, the CEO of MX3D, the steel 3D printer manufacturer, and we focused on what we could realistically do with the machine if this were an actual job—focusing on print axis, maximum slope, print times, cost, and also size—and he was instrumental in driving the overall shape. ■

*This article is excerpted from my conversation with Hunter. To hear more, including Hunter's work on M-Form (**www.m-form.com**), his experience with additive manufacturing, what his role in T.Y. Lin's AVG encompasses, and his thoughts on San Diego (and its microbrewery scene), check out the July Field Notes podcast at **modernsteel.com/podcasts**. And to read more about his winning Forge Prize design, see "Printing a Winning Bridge" in the June 2021 issue, available in the Archives section at **www.modernsteel.com**.*

business issues

PREDICTIVE-BASED SAFETY

BY TIM GATTIE

Using data and analytics to prevent incidents before they occur.

Tim Gattie (tgattie@smartvid.io) is the vice president of industry strategy for Smartvid.io.

IN RECENT YEARS, construction has become a much safer profession, both on job sites and in facilities like fabrication shops.

The average total recordable incident rate for construction declined 42% from 2007 to 2017, according to the U.S. Bureau of Labor Statistics. Despite this improvement, construction still accounted for just over one in five of all on-the-job deaths in the U.S. in 2017, indicating that we still have a long way to go before we reach that elusive goal of zero incidents.

The construction industry has a huge opportunity to further reduce recordable incidents and ensure that more of our colleagues and friends go home safely each day. Technologies such as analytics, machine learning, and artificial intelligence (AI) can do far more than simply tell us what happened in the past, which is what behavior-based safety (BBS) initiatives tend to do. But by incorporating these technologies and enabling a more proactive mindset, in the form of predictive-based safety (PBS), we can predict where the next accident is likely to occur and take action to prevent it. Some early adopters of this new safety methodology have seen their incident rates drop by more than 50% over a twelve-month period, and they continue to see improvement.

Predictive Primer

Predictive analytics is the application of statistical and numerical models and machine learning to evaluate patterns in data to make probabilistic predictions on future outcomes. Common applications for predictive analytics include loan approvals, TV show recommendations on your favorite streaming service, and targeted online advertisements. Predictive models strive to answer the question: "What will happen?" Predictive analytics is at the center of what differentiates PBS from other safety management philosophies.

Requirements for PBS

Data is at the core of PBS—lots of it. This data feeds a predictive model that makes "recommendations" on which projects are most likely to experience an incident. But rather than focus on which tools are used to collect the data, I'm much more concerned with the data collection methodology because no matter how good the tools are, if the data fed to the predictive model is bad, then the results won't be any better.

Construction organizations have been collecting safety data for decades, primarily to meet compliance requirements and to power traditional BBS programs. This includes data from safety observations and incidents, among other sources. Observations are generally made by trained safety professionals using a form or checklist.

PBS requires a more expansive approach. Specifically, to drive PBS, observations need to:

1. Be performed by a wider swath of the project team and include operations personnel
2. Engage craft workers and crews in frequent safety conversations
3. Collect both negative *and* positive observations
4. Enable advanced analytics of the observation data by risk scoring each observation

By enabling anyone on the job site or in the shop to make observations and encouraging them to engage with craft workers on safety, workers quickly begin to take ownership of the work area, their own safety, and the safety of their crewmates. Also, with more observers in the field, you'll gather far more data and can more easily achieve the critical mass of data required to make reliable predictions.

When making observations, look first for what's going right, and then discuss how to fix any issues. Engage with the craft teams, and let them know that observations won't be used to produce write-ups but rather to collect high-quality, accurate data to understand risk and prevent accidents. Finally, before observers move on to another task, they should ask crews whether there's anything they need to be safer and note any issues that they share.

Everyone making observations must understand that the purpose of the PBS program is to gain an unbiased evaluation of the organization's safety risk across each site. The observation program must encourage "truth in the data," and anything that could cause hesitancy on the part of the observer to report the truth should be eliminated. For example, let's say a worker observes a severe hazard on the job site. If management brings down the hammer on the project for having a severe hazard, neither the worker nor other project team members are likely to report severe safety risks in the future, which will ultimately make safety risk predictions less accurate. Rather, management should be more concerned with the project team's response to the severe hazard.

And don't ignore good safety practices! "Catching" people doing the right thing and rewarding them for it is a far more effective means of encouraging good safety. Use the carrot, not the stick.

It's also crucial to look at the format of the observations themselves. Observers need to make risk-scored observations that determine the severity and prevalence of risks that they see to produce more precise predictions and insights. Observations also need to be categorized for reporting and saved in an AI-ready format.

Predictive-based Safety in Practice

So how might this play out in practice? Let's say a construction company has five active job sites, and they've been conducting PBS safety observations for a couple of months. Looking at their safety dashboard, the project manager notes that their project has a very high risk of an incident within the next week. The manager drills down deeper into the data, and the model indicates that a few safety drivers are out of whack, including the rate of observations and the ratio of supervision on the project. They request some discretionary safety resources and engages the team to perform additional observations early in the week to mitigate the lack of observations identified by the model. Additionally, the manager works with the project superintendent to hire another supervisor to balance the project supervision ratio. Two weeks pass without incident, and the safety risk identified by the model declines. Accident: successfully prevented.

With a team that's trained to gather quality safety observations and use the outputs of a predictive model to reduce risk, you'll be well on your way to dramatically reducing your recordable incident rate. And that's a goal everyone can support. ■

Attractive and Accessible

BY MATTHEW J. MOORE, PE

IN A CITY OF VAST AND VARIED public spaces, Riverside Park holds its own.

A beloved New York landmark that hosts more than 2 million visitors annually, the park stretches four miles from 72nd to 158th Streets along the Hudson River.

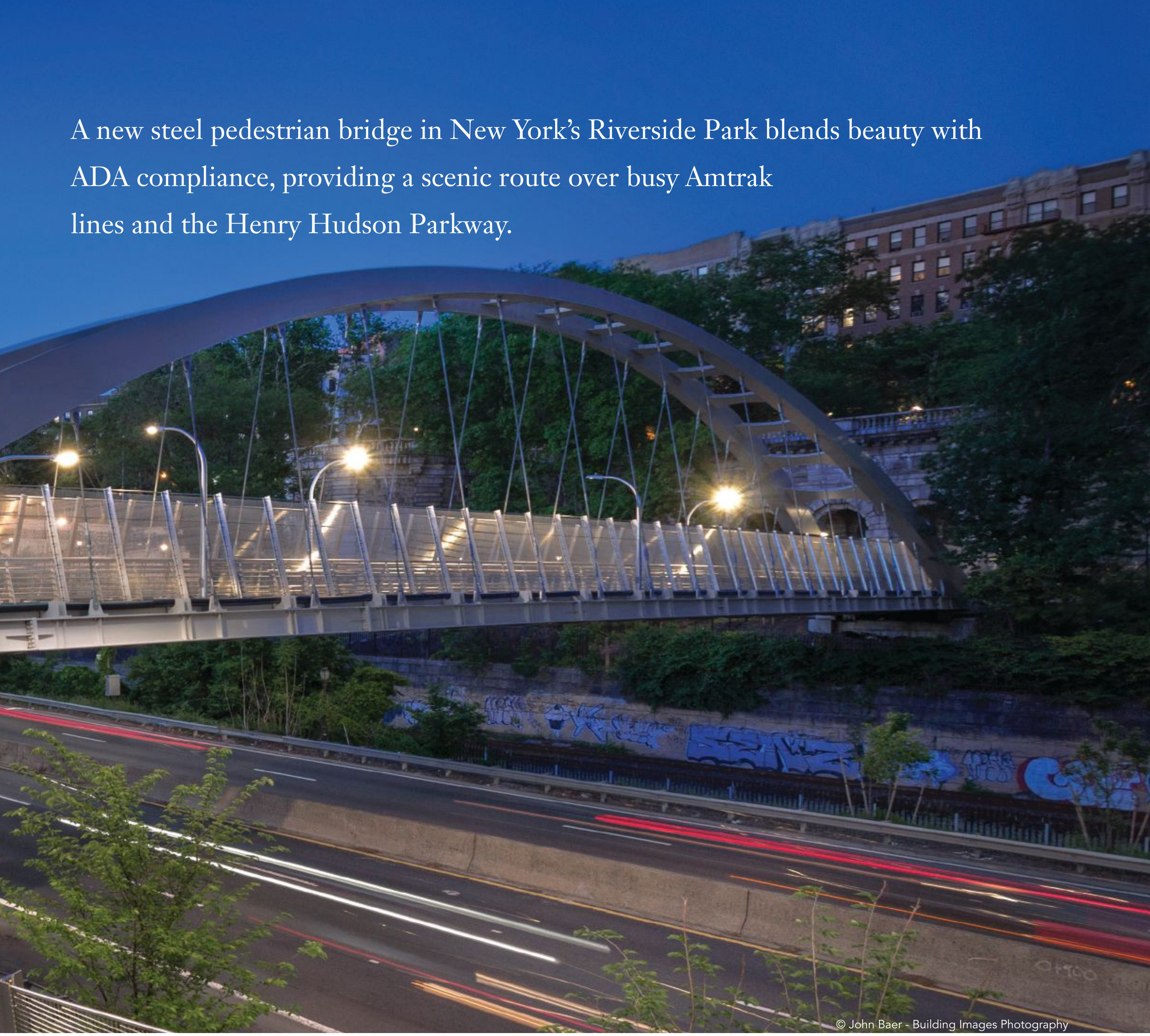
The spectacular waterfront park dates back to 1975 and was designed by Frederic Law Olmsted, the father of American landscape architecture. When the 151st Street pedestrian bridge over a prominent traffic artery fell into disrepair and eventually closed, visitors and Upper West Side residents lost their connection to this stunning green space. For several years, visitors had to hike up to 158th Street or down to 148th Street to access the park.

In conjunction with the New York State Department of Transportation (NYSDOT), structural engineer WSP (formerly Louis Berger) worked closely with a diverse group of stakeholders to conceive, design, and construct the new signature Americans with Disabilities Act (ADA)-compliant Assemblyman Herman "Denny" Farrell pedestrian bridge in the same location as the previous bridge. With ramps providing access from Riverside Drive over Amtrak rails and six lanes of the Henry Hudson Parkway, the park is now more easily accessible for people of all abilities to enjoy.

Keeping in mind NYSDOT's goals, an aesthetically pleasing, sustainable design for the new bridge was developed to mitigate future maintenance and site and environmental concerns. Concepts were proposed through visioning sessions, public information meetings, and presentations to stakeholders, including New York City Parks, the New York City Public Design Commission, and the New York City Department of Transportation (NYCDOT). Through collaborative discussions, a consensus developed behind a contemporary steel arch structure with classical undertones.

Achieving ADA compliance on both sides of the bridge was a challenge due to severe site space limitations. The project site is squeezed within the narrow corridor bounded by Riverside Drive and the Hudson River. Within this strip, from west to east, are: Riverside Park, Henry Hudson Parkway, Amtrak lines, and another narrow sliver of the park.

A new steel pedestrian bridge in New York's Riverside Park blends beauty with ADA compliance, providing a scenic route over busy Amtrak lines and the Henry Hudson Parkway.



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In its final design, an elegant steel tied-arch emerges from its stone-clad east approach towards the Hudson River, where it bears upon a concrete abutment that is shaped to visually continue the tapering arch shape down to grade. The west abutment provides for a cantilevered circular viewing platform of the Hudson River and iconic George Washington Bridge and is met by a steel stairway and ADA compliant ramp leading to Riverside Park. The ramp employs cantilevered arms extending from central piers utilizing a welded dowel configuration, eliminating the need for complicated bolted connections. In addition, the profile of the entire ramp (including the ADA landings) is concealed within the depth of the fascia girders, forming an aesthetically pleasing, linear facade—an approach that was driven by the NYC Public Design Commission's desire for a "graceful" appearance for the west ramp.

With over 60 ft of elevation difference from beginning to end, and 800 ft of pathways and ramps leading to the bridge on either side, the team worked carefully to design the proper grading, necessary utility modifications, and hardscape design. Cantilevered retaining walls supporting tiered switchback ramps were tucked into the steep, sloping embankment on the east side of the bridge, all clad with stone veneer to match the existing adjacent stone promenade. In addition, the new paved area was designed to reduce stormwater run-off and limit the urban heat island effect,

Matthew J. Moore (**matthew.moore@wsp.com**) is a structural engineer at WSP USA.


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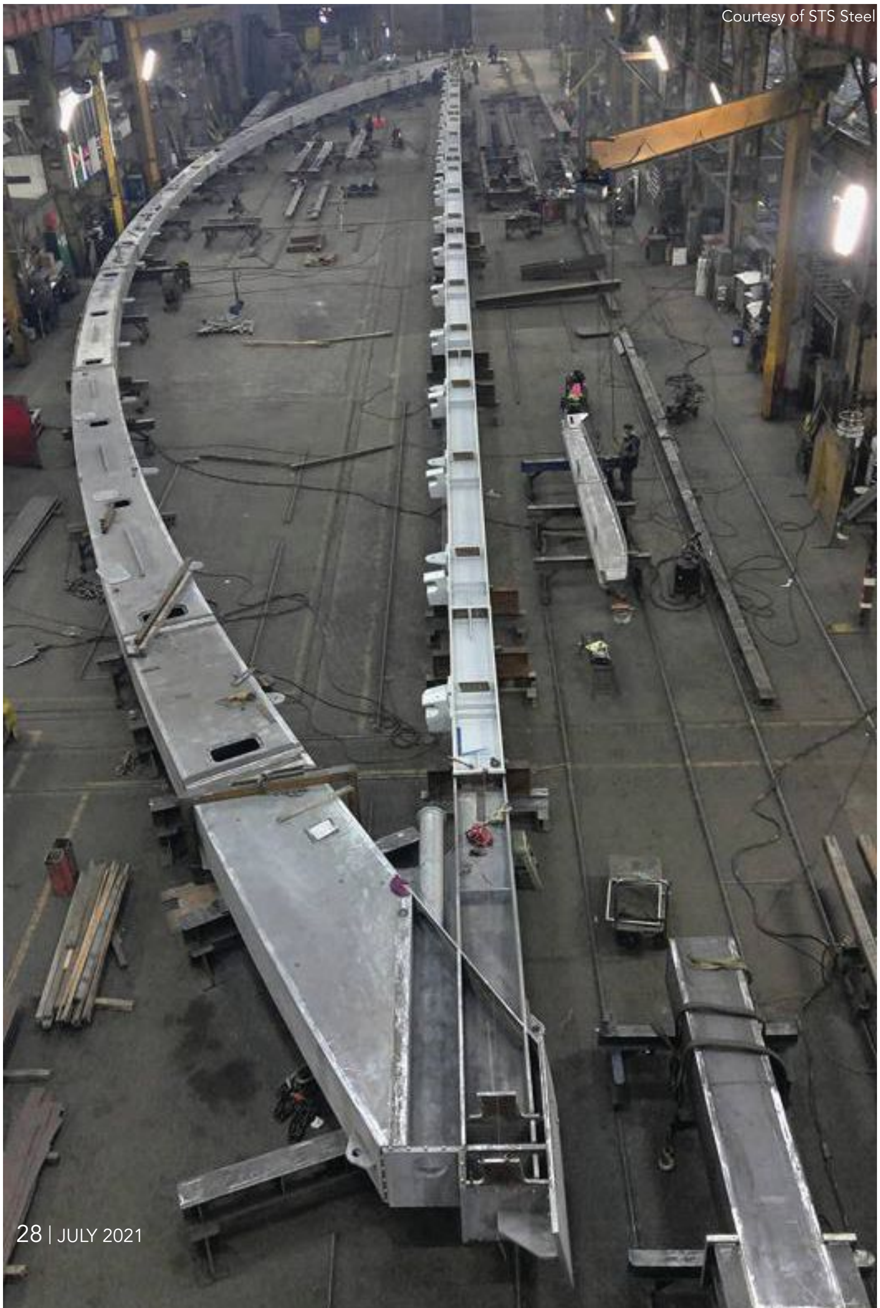

Courtesy of STS Steel

above: The new bridge stretches 270 ft over busy traffic lanes and train tracks.

left: A fully assembled arch in STS' fabrication shop in Schenectady, N.Y.

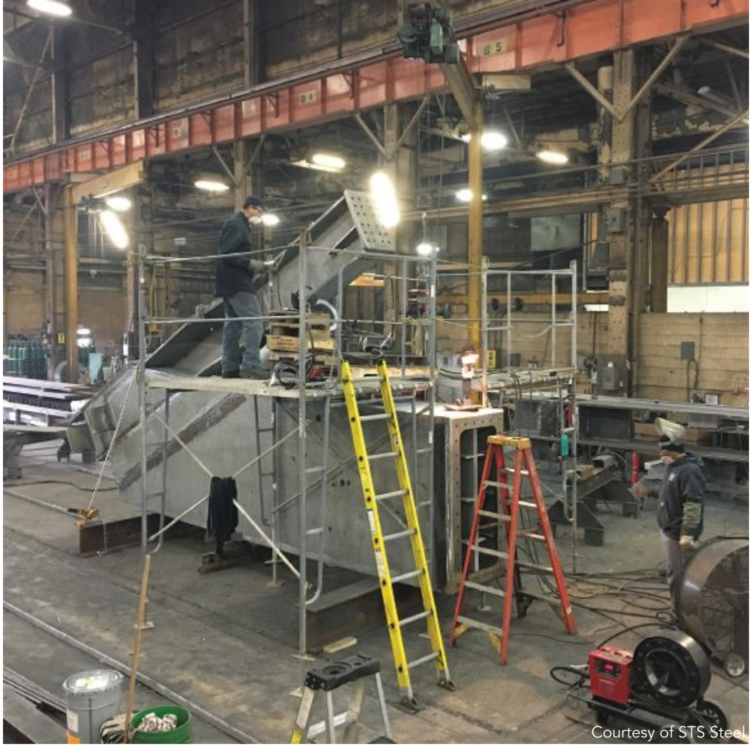
and native trees and plants were used for new vegetation to minimize disturbance to existing vegetation and soil.

Steel was selected as the most efficient material for the main arch structure and the west ramp's cantilevered piers and superstructure to meet the aesthetical goals, accommodate ADA compliance, and provide for the necessary vertical clearance over Amtrak and Henry Hudson Parkway. To address maintenance goals, the team turned to hot-dip galvanizing and a three-coat paint system (with the color chosen to match the nearby George Washington Bridge) to reduce repair needs during the life cycle of the structure.

By using a steel tied arch design, forces exerted on the abutments were greatly reduced, allowing the engineers to minimize abutment size within the tight site constraints. The concrete bridge deck is supported by a series of artistically designed steel floor beams suspended by hanger rods from the arch. These were created by cutting curved-web plates on a computer-controlled burning table, then welding the top flanges and shaped bottom flanges. These elements provided a light, strong, and attractive solution, with each of the 19 decorative floor beams weighing less than one ton. Shear studs welded to the top flange act compositely with the concrete deck.

Additional details of the main tied arch include post-tensioned cables running alongside the bridge deck and parallel to the bottom chord, with anchorages concealed within each of the arch knuckles. The cables are discreetly placed within saddles along the tie beam and provide redundancy for the bottom chord. Hold-down devices were fabricated from steel plate and anchored into the abutments adjacent to each of the four bearing assemblies. These devices are pin-connected to tongues extending down from the box-shaped end diaphragms to mitigate any possible uplift of the arch during extreme wind or seismic events, while also allowing for thermal expansion.

right and below: STS performed a full assembly of each arch, as well as the upper tie plates and the floor system with both bottom chords, to ensure accurate field alignment of all fabricated components before the components were transported via truck to Manhattan.

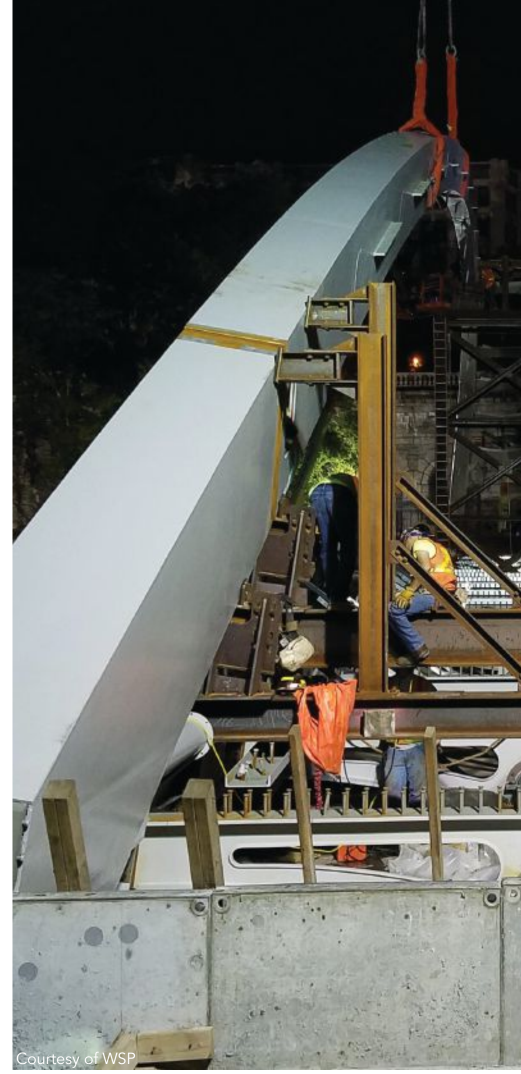

Courtesy of STS Steel

Courtesy of STS Steel

Courtesy of STS Steel


Courtesy of STS Steel

Erection took place on four separate evenings.


Courtesy of WSP

Each evening, the road below the bridge was closed for approximately six hours.

The west ramp substructure columns and cantilever arms are boxes fabricated from steel plate, with the arms inserted through an opening in the column and welded in place. The switchback ramp superstructure, and adjacent stairs are composed of wide-flange beams and a welded fascia plate to form a box-like section, mimicking the box shape of the main arch. By using steel, components could be fabricated off-site and sent as larger assemblies, minimizing erection time and taking advantage of limited lay-down space.

Quality of the fabrication was paramount. With internal connections between each arch segment, tight tolerances were imperative for these large pieces to properly align in the field. Without accurate connections, the placement and connection of the arches would have directly impacted the project schedule, structural integrity, as well as train and vehicle traffic. Dimensional and welding quality inspection was performed

Courtesy of WSP

The road opened in time for rush hour traffic after each closure.

throughout the fabrication process. Steel fabricator STS Steel performed a full assembly, in the horizontal position of each arch, as well as the upper bracing plates and the floor system with both bottom chords to ensure accurate field alignment of all fabricated components.

Due to the size of the structure, each arch was composed of four pieces: two large "knuckles" weighing approximately 16 tons each and two biaxial curved, tapered arch sections—one 137 ft long and weighing 40 tons and the other 92 ft long weighing approximately 26 tons. The four knuckles were shipped prior to the arch sections and set on the concrete abutments prior to delivering the arch sections. After their initial placement on temporary supports, the arches were tied together by bowtie-shaped bracing plates to provide yet another aesthetically pleasing detail. The arch sections were connected internally with heavy, milled endplates connected by bolts that are accessible through handholes. The external interface of these connections were then field-welded, ground smooth, and painted, leaving a smooth, seamless appearance. The entire bridge uses 445 tons of structural steel in all.

below: The entire ramp profile is concealed within the depth of the fascia girders, forming an aesthetically pleasing, straight-line structure.

right: The elegantly shaped floor beams were created by cutting curved-web plates on a computer-controlled burning table, then welding the top flanges and shaped bottom flanges.

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Courtesy of STS Steel

By using steel, bridge components could be fabricated off-site and sent as larger assemblies, minimizing erection time and taking advantage of limited laydown space.

The view of the arches from the bridge deck.

Coordination and delivery of the large structural steel arch elements required careful coordination with NYCDOT, the Department of Parks, Amtrak, and Con-Ed utilities. All elements were delivered by truck across the George Washington Bridge down Broadway and onto the Henry Hudson Parkway to the site. Erection took place on four separate evenings, approximately six hours each night, with the highway reopening to morning rush

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The bridge was painted to match the nearby George Washington Bridge.


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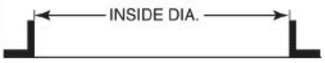
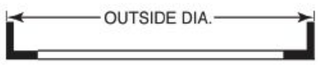
1 **Angle Leg Out**



10" x 10" x 1" Angle

2 **Angle Leg In**

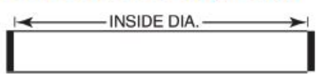


10" x 10" x 1" Angle

3 **Flat Bar The Hard Way**

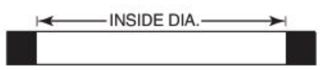
24" x 12" Flat

4 **Flat Bar The Easy Way**



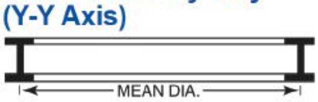
36" x 12" Flat

5 **Square Bar**



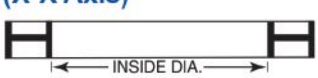
18" Square

6 **Beam The Easy Way (Y-Y Axis)**



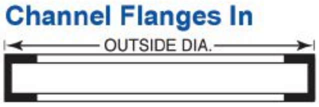
44" x 335#, 36" x 925#

7 **Beam The Hard Way (X-X Axis)**



44" x 285#

8 **Channel Flanges In**

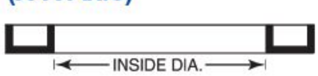


All Sizes

9 **Channel Flanges Out**

All Sizes

10 **Channel The Hard Way (X-X Axis)**



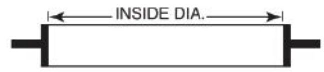
All Sizes

11 **Tee Stem In**

22" x 142 1/2# Tee

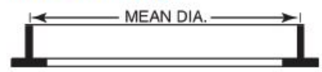
We bend ALL sizes up to:

12 **Tee Stem Out**



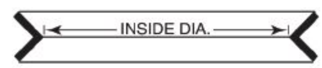
22" x 142 1/2# Tee

13 **Tee Stem Up**



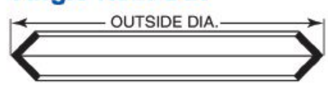
22" x 142 1/2# Tee

14 **Angle Heel In**



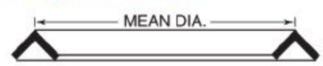
8" x 8" x 1" Angle

15 **Angle Heel Out**



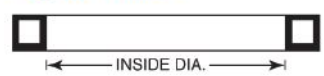
8" x 8" x 1" Angle

16 **Angle Heel Up**



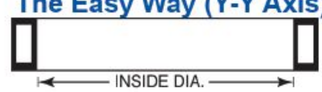
8" x 8"x1" Angle

17 **Square Tube**



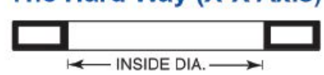
24" x 1/2" Tube

18 **Rectangular Tube The Easy Way (Y-Y Axis)**



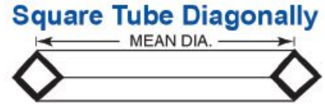
20" x 12" x 5/8" Tube

19 **Rectangular Tube The Hard Way (X-X Axis)**



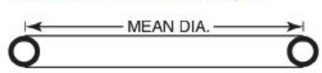
20" x 12" x 5/8" Tube

20 **Square Tube Diagonally**



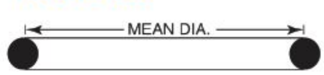
12" x 5/8" Square Tube

21 **Round Tube & Pipe**



24" Sched. 80 Pipe

22 **Round Bar**



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The new crossing usess 445 tons of structural steel in all.

hour traffic. On-site, arch segments were lifted more than 50 ft into place by a crane situated in the tight confines between the railroad right-of-way and the parkway.

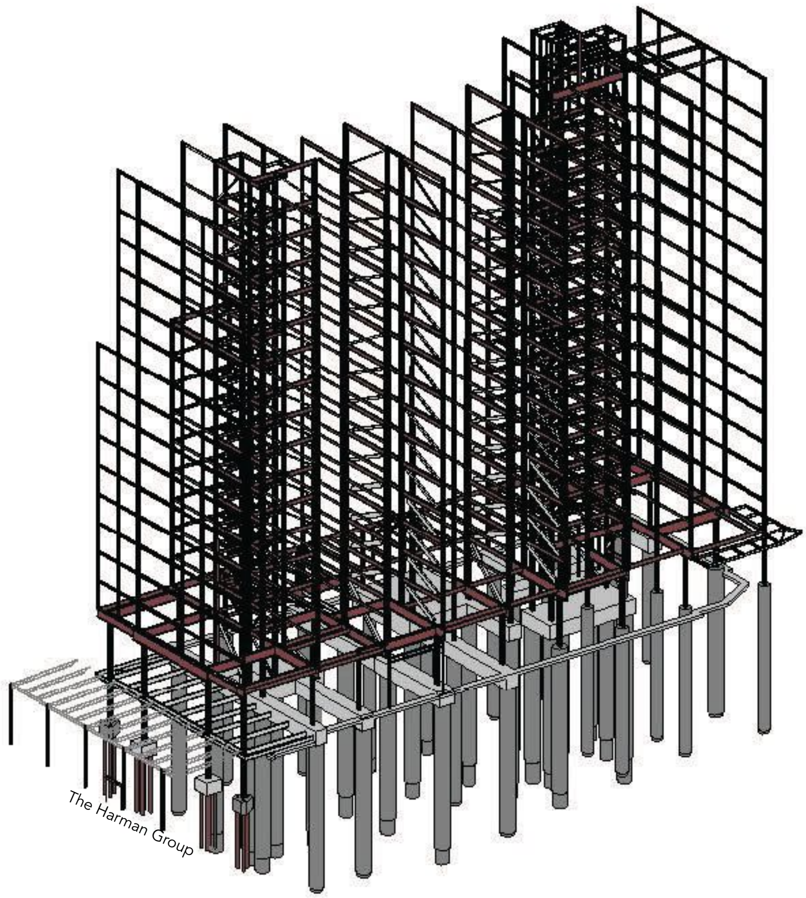
Today, residents and visitors of all abilities use the "Denny" Farrell pedestrian bridge to enjoy Riverside Park and views of both sides of the Hudson River and the river itself. ■

Owner
New York State Department of Transportation

General Contractor
E.E. Cruz and Company/Turner Construction, Whitestone, N.Y.

Structural Engineer
WSP USA, Purchase, N.Y.

Steel Fabricator
STS Steel AISC CERTIFIED FABRICATOR, Schenectady, N.Y.



Take Two

BY ALBERT J. MEYER, JR., PE

The second phase of a student housing development in Philadelphia turns to steel to sync up with the first phase.

Albert J. Meyer, Jr., is an associate and senior project engineer with The Harman Group.

LIKE THE MUSICAL SENSATION of the same name, Philadelphia's Hamilton project has a second act.

Situated on the Community College of Philadelphia's campus near the growing Museum District neighborhood, the student housing development consists of two phases. Phase I is a 10-story, 280,300-sq.-ft, 279-unit building, overbuilt on an existing 1940s-era cast-in-place concrete garage with cold-formed metal framing and precast, prestressed plank.

But the second act is much better. Phase II is a 16-story, 228,000-sq.-ft, 297-unit building framed with wide-flange steel and the Girder-Slab system. When combined, both phases encompass ground-floor retail, a community plaza and garden, fitness and gathering spaces, 576 residential units, and underground parking for 138 cars. It also includes a variety of amenities, such as a fitness center, game rooms, TV rooms, business centers, communal kitchens, and a rooftop deck with breathtaking views of downtown Philadelphia.

Design Considerations and Project Challenges

For Phase II, The Harman Group provided structural engineering services for the project in partnership with owner and developer Radnor Property Group, architect MY Architecture, and construction manager McDonald Building Company. The design team was presented with a series of challenges that stretched throughout the duration of the project. While no existing drawings were available, historical maps indicated that the site, while most recently a surface parking lot, was previously occupied by a Baldwin Locomotive Works facility (circa 1920) and prior to that, a drug and spice mill, stables, and a machine and scale shop, dating back to 1874. These previous structures and the proposed new construction both extended to the property line, increasing the chance

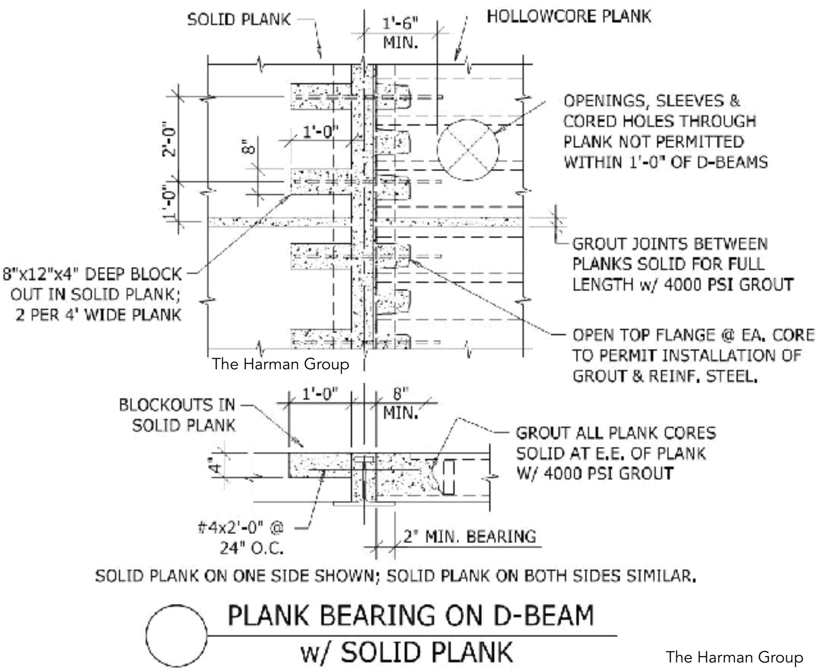
MY Architecture

An aerial rendering of The Hamilton (Phase 1 is on the left and Phase 2 is on the right).

of conflicts with existing buried foundations and walls. The team addressed this by insetting columns on the north and east faces from the ground to the second floor to avoid any potential existing walls and foundations from the site's multiple previous lives. On the south side, columns were inset to avoid a specific conflict. This was in the form of an existing tunnel wall, extending from the ground level to a sublevel. This tunnel provided an underground connection from a previous building on the Hamilton site under 15th Street to a building that the Philadelphia Inquirer occupied at the time.

For the second floor, the first residential level above the retail, public, and back-of-house spaces, the team designed a transfer level to accommodate the architectural programming; the floor height from the ground level to the second level is 20 ft. Building columns on the north, east, and south faces of the building were inset from the columns above at an average of 3 ft, and some interior columns were required to be transferred out above the second floor to accommodate ground-level spaces as well—e.g., a loading dock and retail spaces—using steel beams ranging from W36×135 to W40×593, for a total of 17 transfer girders.

Providing access to the lower parking levels for Phase I residents during the construction of Phase II also provided a challenge. Construction cut off access to the 15th Street entry, requiring a temporary steel-framed parking ramp that allowed access to the lower parking levels from the 16th Street entry. Architectural programming of Phase I previously removed the connection between the



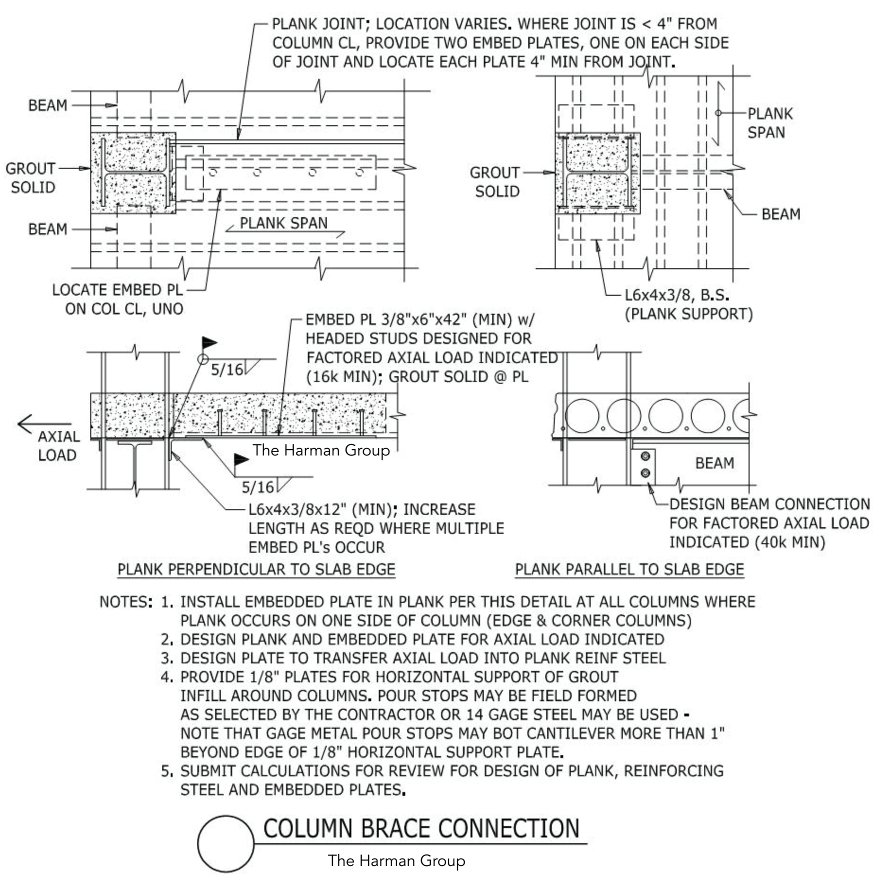
The Harman Group

above: A detail of both solid and hollow-core precast plank bearing on, and composite with, a D-BEAM.

below: A completed transfer girder in the fabrication shop.

McDonald Building Company

Construction progress through the sixth floor at the northeast corner.



A brace connection detail for exterior columns parallel to precast plank.

ground-level and below-grade parking. Design was also coordinated to allow construction of the project at the same time as the reconstruction of the 15th Street Bridge. This project was occurring simultaneously at the southeast corner of the project site, limiting construction access in this area.

An unexpected challenge was, of course, the COVID-19 pandemic. Project construction started in mid-January 2020, but the City of Philadelphia halted construction in mid-March. The project was shut down for seven weeks, delaying the tower crane erection and subsequent steel and plank erection. Luckily, construction resumed at the beginning of May, and the tower crane was erected, allowing steel erection to proceed. Steel erection began in late May and was completed two weeks ahead of the original project schedule completion date despite the seven-week shut-down.

Why Steel?

The design team, in early collaboration with McDonald Building during the preconstruction phase, quickly settled on a structural steel and precast concrete plank system. The system was economical, straightforward, and allowed the Phase II

Drive aisle framing at the south end of the building. The existing tunnel walls and floor remained after demolition of the tunnel roof. New steel building columns were threaded through openings cut into the existing tunnel floor and extend to new foundations at the floor level below.

A typical transfer girder at the second floor.

building to match floor-to-floor heights and the exposed ceiling and balcony profiles of the Phase I building. This system also required no formwork or temporary shoring during erection as would be required for a cast-in-place concrete building. The project site is in a fully developed urban area, and with the building footprint occupying the entire site, there was limited material storage area. Both structural steel and precast plank can typically be picked from delivery trucks on the street by crane, lifted into their final position, and bolted up without intermediate laydown, which would have required additional crane picks. The typical corridor beams were shop-attached to their supporting columns, which also helped minimize crane picks, limited field connections, and accelerated erection.

By using concentric and eccentric braced frames with width-limited hollow-structural section (HSS) braces, the team was able to achieve a structure that met an *H*/400 drift limit under wind loading. At 175 ft in height and 68 ft wide at its narrowest point, the building has an aspect ratio (height divided by the narrowest width at the base) of about 2.6:1. This is not considered slender; buildings are considered slender when the aspect ratio is generally greater than 7:1. However, spacing requirements limited braced frame lengths at the north and south ends of the buildings such that their aspect ratios ranged from 10:1 to 18:1. These frames required heavier column and brace sections that helped meet the *H*/400 drift limits set as part of the basis of design. In all, Phase II incorporates a total of 1,290 tons of structural steel.

Structural Systems

The structural system for the building consists of precast plank supported on steel beams for nearly the entire building at all levels. A low roof adjacent to the amenity courtyard at the second level is a steel-framed composite slab on metal deck system designed for a green roof, and a canopy at the main entrance of the building is steel-framed with a metal roof deck. The drive aisle at the south end of the building is a steel-framed composite-slab-on-metal deck system designed for a live load of 250 PSF, with the weight of a topping slab sloped to the drains. This drive lane provides access to the lower parking levels for residents and access for delivery and trash trucks to the loading dock of the complex. Steel in this area was hot-dip galvanized to help protect the steel from potential corrosion and deterioration, as the area below is partially above grade and the existing tunnel structure is unconditioned space.

The floor-to-floor height at the residential levels is typically 10 ft, with a finished ceiling height of 9 ft, 4 in., and the underside of the plank serves as the finished ceiling for most of the residential unit footprint. At these levels, W-shape beams were used around stair and elevator openings, at lateral frames, and exterior spandrel conditions where plank is supported on one side only. D-BEAM girders, the primary element of the Girder-Slab system, span between the columns. These girders act compositely with the plank and are effectively within the depth of the plank, providing a floor system depth nominally equal to the plank depth. In addition, the

McDonald Building Company

Placing of the final steel beam.

D-BEAM approach reduces floor structure depth, minimizes soffits where unit demising wall layout does not neatly follow steel support lines, and permits space in corridors for MEP systems without requiring beam web penetrations.

Unlike a typical composite-slab-on metal and dropped-W-shape beam system, this project did not use perimeter spandrel beams parallel to the plank. The precast plank is then used to brace the columns at these locations; a column brace detail was provided using a headed stud embed plate cast into the plank and anchored to the column using an angle that was shop attached to the column and field attached to the embed plate for a design force equal to 2% of the factored axial load in the column but not less than 16 kips minimum. This same detail was also used to drag diaphragm loads into the braced frames at each floor level.

Use of Technology

The team used Bentley's RAM Structural System structural analysis software to model the primary structural system of the building at and above the foundation level, as well as Bentley's Integrated Structural Modeling (ISM) software to import the model in Autodesk's Revit 3D building information modeling (BIM) software to produce construction documents. By using ISM, the majority of the information in the structural analysis model was transferred directly and correctly into the 3D model. This expedited drawing development for the contract documents and allowed the design team to focus on developing project details and coordination earlier in the process. And of course, in addition to the structural team, MY Architecture and the MEP engineers also used BIM software, which greatly assisted in overall project coordination and clash detection and resolution.

With the occupancy of Phase II scheduled to begin in August, the Hamilton is set to be an essential, "must-see" addition to the neighborhood, meeting the needs of

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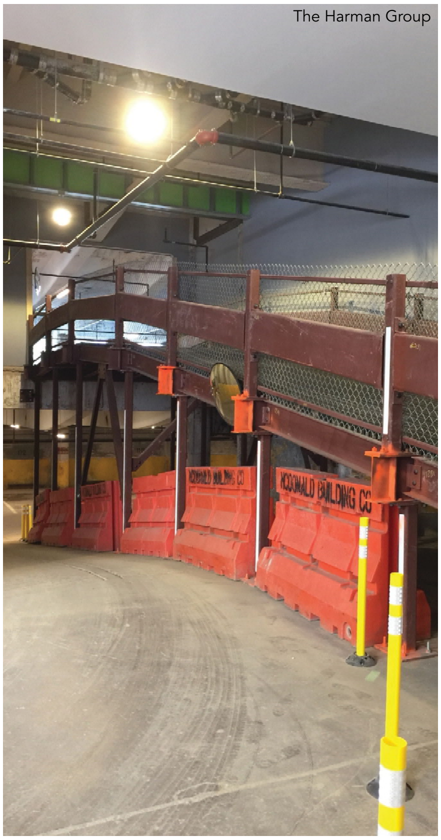
The nearly completed structure at the northeast corner (looking southwest) on the day of the topping out ceremony.



The Harman Group

The 15th Street entrance to the lower parking levels was inaccessible due to construction of Phase 2 and and the simultaneous reconstruction of the 15th Street bridge at the southeast corner of the site, so a temporary steel ramp was constructed to provide access to these parking levels from the 16th Street entrance.

graduate students and young professionals in the area and bringing this two-act structural performance to an exciting finale. ■

Owner and Developer
Radnor Property Group, Wayne, Pa.

General Contractor
McDonald Building Company, Norristown, Pa.

Architect
MY Architecture, Philadelphia

Associate Architect
WKL Architecture, Wilkes-Barre, Pa.

Structural Engineer
The Harman Group, King of Prussia, Pa.

Steel Team

Fabricator and Detailer
Crystal Steel Fabricators, Delmar, Del.

Erector
Independence Steel/ XLE Metals, Chester, Pa.

A Simple Solution for Simple-Span Bridges

BY ATOROD AZIZINAMINI, PE, PHD

A look at the second generation of the folded steel plate girder bridge system.

Atorod Azizinamini (**aazizina@fiu.edu**) is the Vasant H. Surti Professor of Civil Engineering; Director, Moss School of Construction, Infrastructure and Sustainability; Director, Accelerated Bridge Construction University Transportation Center (**www.abc-utc.fiu.edu**); and Director, Preeminent Institute for Resilient and Sustainable Coastal Infrastructure (InteRaCt) at Florida International University.

THE SECOND GENERATION of a simple-span bridge solution is now available.

Developed at the University of Nebraska-Lincoln (UNL) and Florida International University (FIU), the folded steel plate girder (FSPG) bridge system is fabricated from a single steel plate of uniform thickness bent along multiple lines using a hydraulic metal press brake, forming a trapezoidal-shaped section that is open at the bottom. The plate thickness of either ⅜ in. or ½ in. can accommodate a range of various span lengths by simply changing the location of the bends. Only the width of the top and bottom flanges and the depth of the web vary depending on span length. The preferred method for corrosion protection is the hot-dip galvanizing process, as the components are short enough for most galvanizing tanks without the need to double-dip them.

Why use it? The FSPG system eliminates the need for internal and external cross frames due to the large amount of lateral stiffness generated by the shape. The absence of cross frames in the system results in less costly details, and the need for welding is therefore significantly reduced. The lowest fatigue category is Category B, reducing any concern for fatigue cracking during service life. Another major advantage of the FSPG system is that the bottom of the girder is open, allowing for easy inspection of the inside of the girder. The FSPG approach is also ideal for accelerated bridge construction (ABC) applications and results in uniform spacing between girders.

Up until now, the maximum length of an FSPG bridge system was limited to 60 ft, but based on recent work, the second generation of the system has increased the maximum length to 105 ft and has added a third plate thickness (¾ in.). Overall, the FSPG system is an excellent solution for replacing the increasing number of simple-span bridges across the U.S. that are garnering a "poor" rating. And all FSPG bridges can be fabricated from just three plate thicknesses, allowing fabricators to quickly build folded girders with minimal stock requirements.

below and right: The first FSPG implementation is a 46-ft-long stream crossing in Uxbridge, Mass., which opened to traffic in November 2011.

above: An FSPG bridge being installed in Nebraska.

above: The first FSPG bridge installed in Pennsylvania employs a full-depth deck, integral abutment, and prefabricated railing.

below: Hot-dip galvanizing is the preferred method of corrosion protection for FSPGs.

Courtesy of MaiCo Industries, Inc., Ellsworth, Kan.

FSPG History

Let's take a quick look at the system's history. An extensive initial investigation, taking place over seven years at UNL, resulted in the FSPG system's development. This investigation included fatigue testing, ultimate load tests, shear tests, and development of complete design provisions that are fully in accordance with the AASHTO *LRFD Bridge Design Specification*.

The system has enjoyed success in the field for a decade. The system's first implementation was as a 46-ft-long stream crossing in Uxbridge, Mass., which opened to traffic in November 2011 and has displayed excellent performance since. The second FSPG bridge was constructed in Nebraska and opened to traffic in 2014. This bridge is 57 ft long and employs a prefabricated end turndown and full depth deck. To date, additional FSPG bridges have been built in Pennsylvania, Massachusetts, Michigan, Nebraska, and Montana. In 2017 and 2018, a contractor in Pennsylvania, as part of a major bridge initiative for the state, installed seven FSPG bridges, based mostly on the cost advantages when compared to alternate bridge systems.

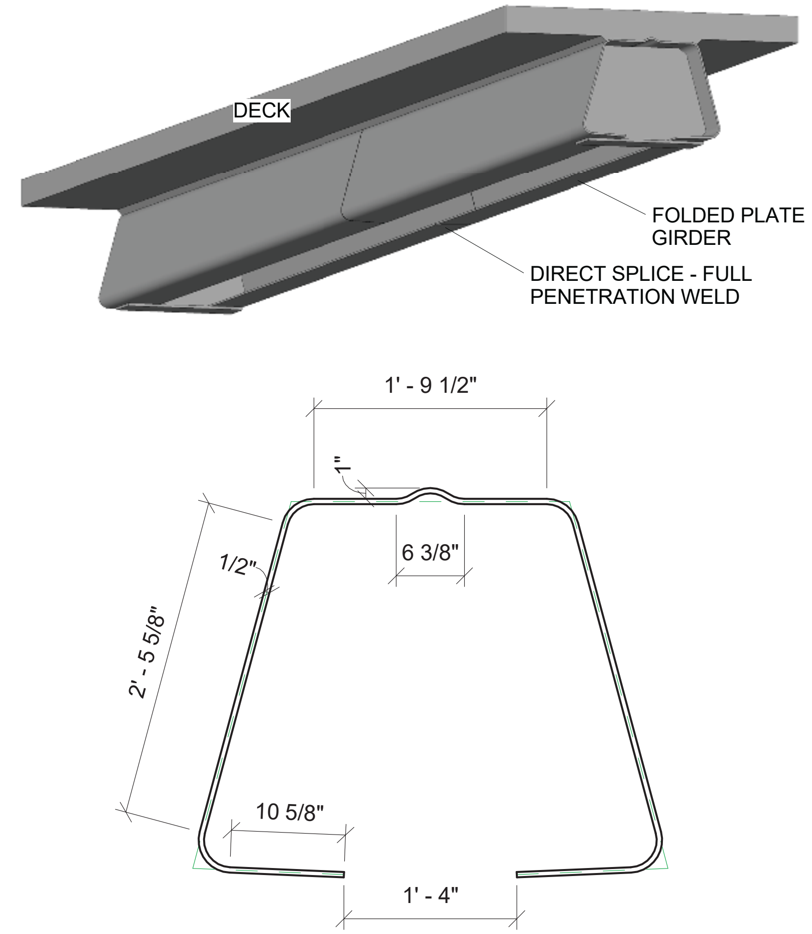


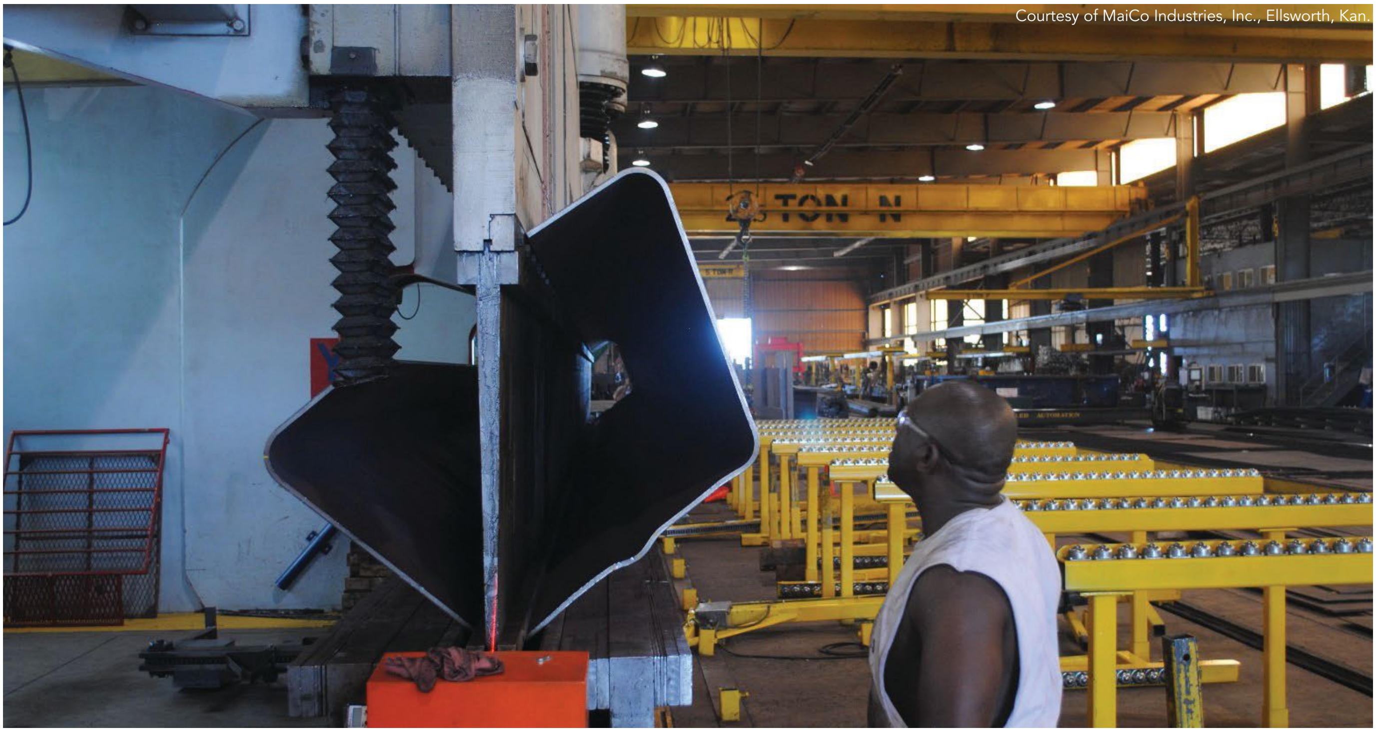
Fig 1. A cross section of a typical FSPG.

Extending the Reach

The first generation's maximum span length was 60 ft, which was the maximum press brake length available to manufacture the units. In response to feedback from owners and consultants—and thanks to the recent research at UNL and FIU—expanded design methodologies and fabrication details now allow for spans to reach 105 ft.

This extension of the FSPG system is achieved by connecting two segments via a full-penetration weld in the middle of the span. (It is also possible to connect three segments with splice points at one-third and two-thirds of the span length.) In addition to increasing the span length, new details allow fabrication of the FSPG using shorter segments. Fabricating shorter segments requires smaller press brake, thus opening the field to more fabricators. As an example, to produce an 80-ft-long FSPG, a fabricator will need to have a 40-ft-long press brake if two segments are used, or a 25-ft-long press brake if the span length is 75 ft (three segments).

The "Maximum Span Length" table shows the maximum spans that can be reached with different combinations while meeting all design provisions stated in the AASHTO *LRFD Bridge Design Specification*. As indicated, up to 90-ft-long spans would require a plate thickness of ½ in., and ¾-in. plate would be required for longer span lengths. The typical cross section for all cases is shown in Figure 1.



Courtesy of MaiCo Industries, Inc., Ellsworth, Kan.

Bending steel plate to create a girder for an FSPG bridge.

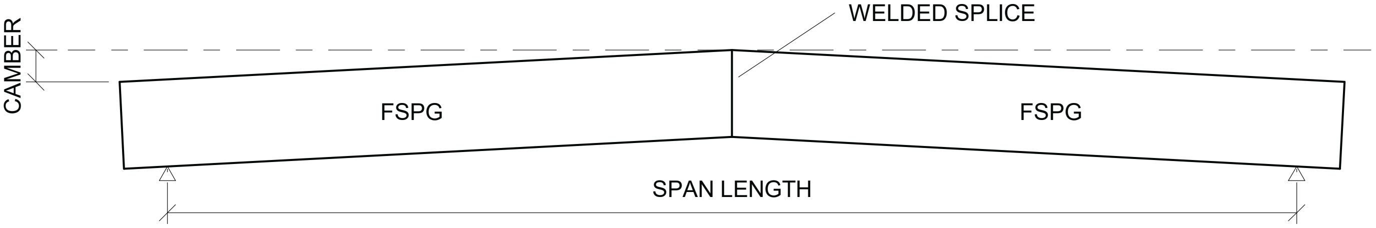


Fig. 2. An elevation drawing of an FSPG girder with camber.

Maximum Span Length

	Yield Strength	
Thickness	50 ksi	70 ksi
½ in.	80 ft	90 ft
¾ in.	95 ft	105 ft

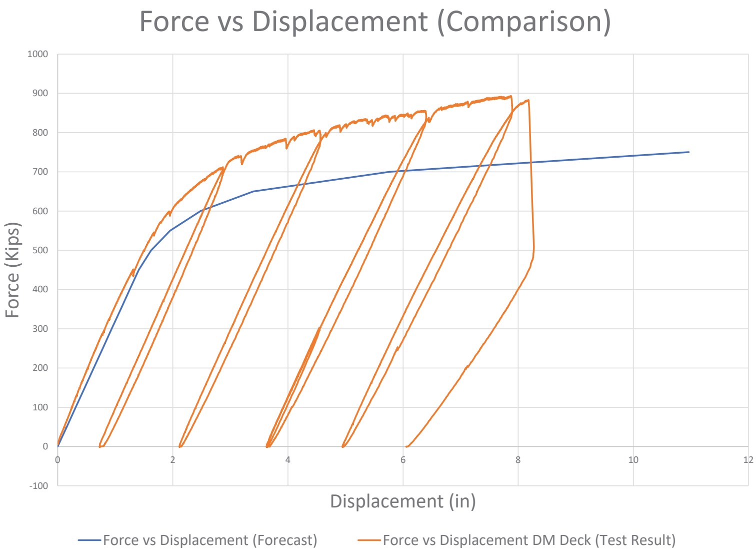
For short-span bridges under 60 ft, camber is typically not a consideration, and the correct profile can be achieved by varying the deck profile with the haunch. For spans longer than 60 ft, camber may be required to account for dead load deflection and achieve the required vertical profile. This camber can be introduced in the multi-segment girder by providing beveled cuts at the splice locations. The multi-linear profile is then smoothed by setting the haunch as required. Figure 2 shows an elevation of the girder with camber.

The solution for extending the maximum length of the FSPG bridge system to 105 ft was investigated at FIU using extensive experimental and numerical studies. The test specimen was composed of two equal-length (20-ft) segments such that the splice was deliberately subjected to maximum moment. In practice, multiple segments can be used, and the splice can be located away from midspan to reduce demand at the splice if needed. Although the specimen was not the full 105 ft, the primary goal of the physical testing was to evaluate the performance of the splice.

The specimen was first subjected to five million cycles of loading at a level sufficient to simulate 100 years of heavy truck loading. The system did not experience any reduction in stiffness throughout the duration of the test, and no visible damage to the steel girder was observed. Once the fatigue test was completed, the specimen was loaded to failure to determine the ultimate capacity. The loading setup and resulting load-deflection curve are shown in Figure 3. The FSPG's behavior during the ultimate load test exceeded the predicted capacity while displaying excellent ductility.

The FSPG system is an economical alternative for simple- and short-span bridge construction, especially using principles of ABC, which we see as the future of bridge engineering. The initial, 60-ft-maximum version has been used successfully over the last decade, and thanks to recent research extending the maximum length to 105 ft, this economical and durable bridge system can see expanded use as a solution for new bridges and those needing replacement. If you have any questions regarding the FSPG system, including potentially incorporating it into a bridge project, please reach out to me! ■

Fig. 3. Testing at FIU was performed to increase the maximum length of an FSPG bridge to 105 ft. The resulting load-deflection curve is shown below.



Taking on the need for speed in welding applications.

Accelerated Welding: Part Two

BY DUANE K. MILLER, PE, CURTIS L. DECKER, SE, PE, PhD, AND MICHAEL S. FLAGG

IN A TYPICAL WORKDAY, welders do far more than just weld.

They assemble tools and personal protective equipment (PPE) at the beginning of the shift, attend safety briefings, walk or climb to their workstation, set up their equipment, etc. While those activities are all necessary and important, none contributes directly to the goal of depositing quality weld metal.

Even when a welder is "actually welding," there are many welding-related activities that do not involve "arc-lit welding," Consider the time to clean a weld joint, preheat, remove slag and spatter, grind weld starts and stops, remove weld tabs, etc. Again, all these activities are necessary and important, but none involve depositing weld metal in a joint.

To address these non-welding activities, it has been traditional to use an "operating factor," which is normally determined by dividing the arc time by the total time. Operating factors are usually estimated—and are generally grossly overestimated. Actual operating factors are usually in the 5% to 15% range. This does not mean welders are doing nothing productive for 85% to 95% of the time; rather they may be involved with necessary activities, but those activities do not involve depositing weld metal.

Minimize Non-welding Activities

The previous article in this series ended at Concept 12 and a second broad category (you can read it in the June issue, which is available in the Archives section at **www.modernsteel.com**). This third broad category of minimizing non-welding activities focuses on increasing the speed of delivery of a project by minimizing welding-related activities that do not involve arc-on time. The opportunity to increase speed in this often-overlooked area is huge since these activities may consume tenfold more time than arc-on time.

Concept 13. Set up a system for welding gun maintenance. FCAW-G and GMAW (with solid or metal-cored electrodes) are the welding processes of choice for fabricators; both processes require the use of a gun and cable assembly that requires ongoing maintenance. Liners, gas diffusers, contact tips, and gas nozzles all need cleaning and/or replacement (see Figure 1).

When a welder experiences a welding gun-related problem, arc-time comes to a halt, as does throughput. The welder may not have the tools, the parts, or even the experience to quickly repair the gun. Even the replacement of a simple contact tip is expensive when lost productivity is considered.

This concept is simple: Assign an individual with making sure all welding guns are in good operating condition before the welding shift begins. Gun liners can be blown out with compressed air or replaced as needed. Nozzles can be reconditioned or replaced. When welding resumes the next day, everything will be in working order and will hopefully stay that way for the whole shift.

Concept 14. Easy control of welding equipment settings. Traditionally, there have been two ways of controlling welding parameters: from the wire feeder or from the power supply. If the power supply is, for example, 50 ft from the welder, considerable productivity can be lost as the welder makes output changes. Maybe the greater loss is when the welder chooses not to make necessary changes, due to the inconvenience of returning to the power supply to make the changes.

Today, welding equipment can store multiple welding procedure settings, and the welder can change the welding procedure settings by toggling the trigger of the gun to the desired set-

Fig. 1.

ting. This makes it possible for the welder to switch from one set of parameters to another without returning to the power source or even to the wire feeder. Not only is time saved, but optimal welding parameters can be easily implemented.

Concept 15. Consider smart welding positioners. The primary material-handling system in many fabrication shops consists of overhead cranes. It is not unusual to see multiple welders waiting for the crane to arrive to reposition their work. Welding positioners (see Figure 2) can be used to rotate subassemblies in a quicker and safer way.

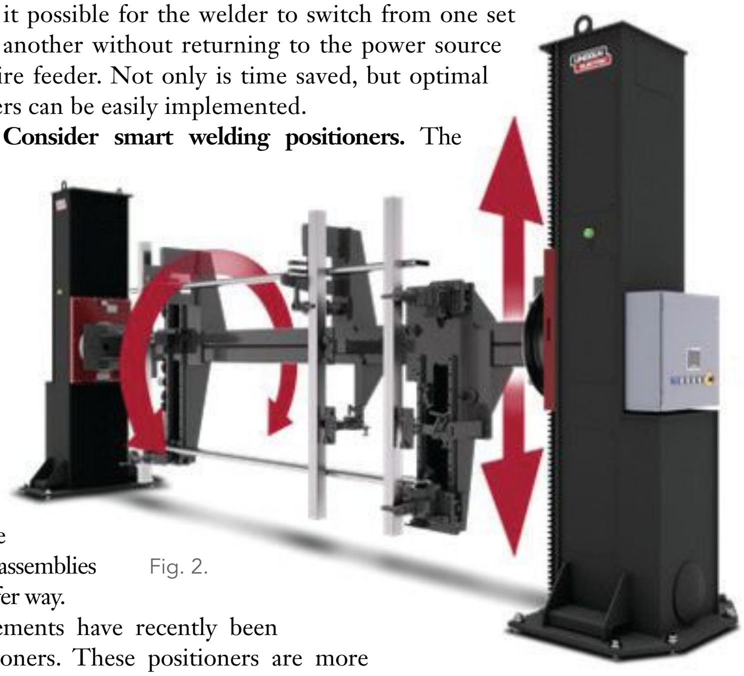


Fig. 2.

Great advancements have recently been made with positioners. These positioners are more accurate, with greatly improved user interface, accurate and automatic movement/rotation, and ease of clamping that can significantly decrease the set-up time. The head stock and tail stock supports can be set up on a track system so that short or long members can be handled efficiently. One such system can be seen in action in a YouTube video at **tinyurl.com/lincsmartpos**.

Concept 16. Automate handling, position, and tacking of parts. The days of soapstones, tape measures, and manual handling and tacking of parts *should* be gone. Some fabrication shops have already introduced automated systems that can accomplish these tasks (see Figure 3 for an example, as well as this video on the Peddinghaus website: **tinyurl.com/peddassemb40**). Automated systems such as these solve time-consuming operations with a handling and parts-scanning robot that accurately and efficiently places the part to be welded in its position with a torch-mounted laser-measuring device. The automated machine can rotate the main member where parts are tack welded in place and final welds produced with amazing speed. Not only can time be saved, but accuracy, consistency, quality, safety, and labor costs can be enhanced with these systems.

Concept 17. Make good use of shadow boards. Shadow boards (see Figure 4) are often associated with 5S principles. The concept of 5S started in Japan, where the five key principles each started with the letter S. In the United States, these terms have been translated as sort, systematize, shine, standardize, and sustain. Shadow boards are

Fig. 3.

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a visual method of storing and organizing standardized tools so that they are easy to identify and readily available at specific workplaces. Each shadow board consists of outlines or "shadows" in the shape of individual tools to make it obvious where each item should be stored. Shadow boards should always be located near the place where the work is being performed. This ensures that the tools and equipment are close to where they are needed, which reduces wasted motion and saves time from having to track down needed tools.

The primary challenge associated with the effective use of shadow boards is one of discipline. It is essential that tools are returned when not needed. This concept is where *sustain* comes into play. Shops are filled with well-designed shadow boards that are devoid of any tools. The same shops are routinely cluttered with miscellaneous tools distributed throughout the facility in various stages of disrepair. The lost time associated with the hunt for the needed tool is hard to track but slows production nevertheless.

Concept 18. Eliminate grinding. Walk through a typical fabrication shop and you may see more sparks from grinding than from welding. In many cases, the grinding is to address welding-related problems. This concept is to eliminate conditions that create the need for grinding. Two examples will illustrate the idea.

First, consider the grinding associated with flame-cut edges. Maybe the residual dross on the backside of the joint is being ground away. It may be possible to adjust the cutting parameters to eliminate this dross. Perhaps the thermal cutting of the bevels for a groove weld has left gouges and irregular surfaces that need grinding before welding. Certainly, correcting for these conditions before welding is commendable, but improving the consistency of the beveling operation may eliminate the need for grinding altogether. A change in the cutting tip may eliminate the need for grinding.

Second, consider the grinding operations associated with post-welding operations: removal of spatter, grinding of weld toes to correct for overlap, and removal of excess weld reinforcement, for example. Fixing the causes for the weld imperfections will eliminate the need for time-consuming grinding opportunities.

Finding the opportunity to increase speed by eliminating grinding is simple. Look for a shower of grinding sparks (see Figure 5) and ask the simple question: Why is the grinding needed? Then, look for the upstream operation that makes grinding necessary and focus on improving that activity.

Minimize Weld Quality Problems

The lowest-cost weld is the one that is made only once. Alternately stated, the fastest welding operation is one that deposits quality welds the first time. Poor weld quality has a huge negative impact on throughput.

Consider the steps associated with the resolution of a weld quality problem. The original weld is made, inspected, and found to be suspect, and the delays in throughput begin. The first delay is associated with the determination of whether the weld discontinuity is acceptable or rejectable. The suspect weld may be subjected to re-inspection. Extra measurements may need to be taken, code requirements reviewed, and the nature of the loading may need to be investigated (compression or tension, for example). While this is underway, the steel remains in the shop and throughput is halted.

After determining that the weld is defective and needs to be repaired, the defective weld may need to be removed and a repair weld made. Then, the repair weld needs to be re-inspected. Routinely, the repair weld is subject to more scrutiny than the original weld, consuming more time. Estimates suggest that repairing a defective weld costs six to ten times more than the cost of an original quality weld. The impact on throughput is even greater.

The next series of concepts focus on enhancing the "first pass yield"—i.e., the number of quality units that are produced without the need for any rework. In the case of welding, the focus is on making a quality weld the first time.

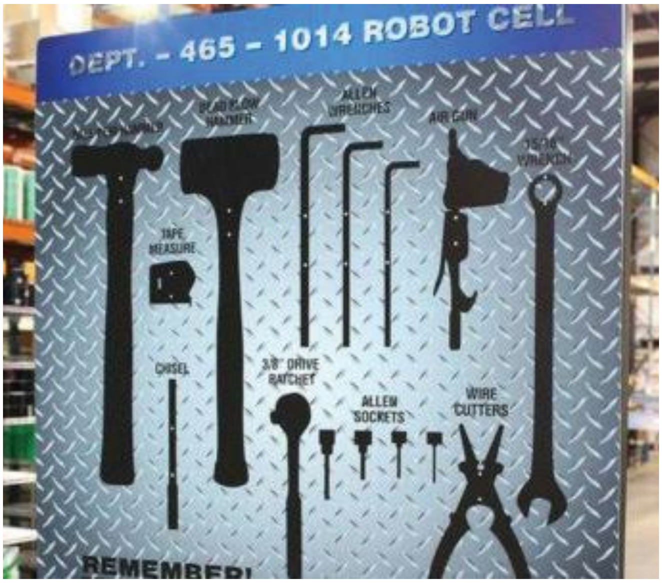

Fig. 4.

Fig. 5.

Concept 19. Focus pre-weld inspection on the joint to be welded. Weld inspection begins long before a welding arc is struck. In Chapter N of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360, **aisc.org/specifications**), Table N5.4-1 (Figure 6) provides a helpful list of inspection tasks that are to be performed prior to welding. The old adage "you can't make a silk purse out of a sow's ear" also applies to welding: "you can't make a good weld on a poorly prepared joint." Proper fit-up, joint cleanliness, and correctly beveled members are critical to good weld quality.

A concerted effort to make certain the joint is ready for welding will result in better weld quality, fewer repairs, and enhanced speed of production. The beveled edge in Figure 7 Part a will more likely result in a good weld than the beveled edge shown in Part b.

Concept 20. Follow the WPS. If this sounds similar to what has already been said in this article, it is. Concept 10 (Concepts 1 through 12 appeared in the previous article) focuses on following WPS requirements from a productivity perspective. Concept 20 is focused on following WPS requirements (Figure 8) from a quality perspective. If a WPS has been properly prepared (see Concepts 8 and 9), then adherence to the WPS will achieve the mutually compatible goals of good productivity and good quality.

We came across a recent weld quality problem involving using an improper electrode. The project involved A913 Gr 65 steel, which should have been welded with E80 electrode; E70 was used instead. The WPS listed the proper filler metal, but the wrong electrode was used in the field. The welder did not notice that the wrong electrode had been delivered to the job site, and the inspector only discovered the mistake after the welding was completed. The simple step of following the WPS, including the use of the proper electrode, would have circumvented this problem and the associated delays surrounding its resolution.

Concept 21. Use good in-process inspection. This concept is particularly important for multiple pass welds. The quality of the partially completed weld should be carefully inspected before an additional weld layer is deposited. Welds should be de-slagged and inspected. Any trapped slag needs to be removed. Welds with porosity should be ground. Narrow grooves between weld passes or the weld and base metal should be ground to a U-shaped configuration to ensure fusion by the next weld pass. For applications needing preheat and inter-pass temperature control, these temperatures should be checked. Any weld cracks should be removed before additional welding. Never trust a welder who claims, "I'll just burn it out with the next pass."

Table N5.4-2 of Chapter N provides a helpful checklist of inspection tasks to be performed during welding. Included in the table is a check to make sure that both the WPS and proper welding techniques are followed.

While good in-process inspection is time-consuming, it is more efficient to fix nonconforming conditions before additional welding is performed. Internal defects revealed by nondestructive testing will be much more time consuming to fix.

Concept 22. Provide prescription safety glasses, and periodic eye exams. AWS D1.1 requires welders to be qualified for the welding process and position in which welding is to be performed. Once qualified, the welder's qualification

TABLE N5.4-1
Inspection Tasks Prior to Welding

Inspection Tasks Prior to Welding	QC	QA
Welder qualification records and continuity records	P	O
WPS available	P	P
Manufacturer certifications for welding consumables available	P	P
Material identification (type/grade)	O	O
Welder identification system[a]	O	O
Fit-up of groove welds (including joint geometry) • Joint preparations • Dimensions (alignment, root opening, root face, bevel) • Cleanliness (condition of steel surfaces) • Tacking (tack weld quality and location) • Backing type and fit (if applicable)	O	O
Fit-up of CJP groove welds of HSS T-, Y- and K-joints without backing (including joint geometry) • Joint preparations • Dimensions (alignment, root opening, root face, bevel) • Cleanliness (condition of steel surfaces) • Tacking (tack weld quality and location)	P	O
Configuration and finish of access holes	O	O
Fit-up of fillet welds • Dimensions (alignment, gaps at root) • Cleanliness (condition of steel surfaces) • Tacking (tack weld quality and location)	O	O
Check welding equipment	O	–

[a] The fabricator or erector, as applicable, shall maintain a system by which a welder who has welded a joint or member can be identified. Stamps, if used, shall be the low-stress type.

Fig. 6.

a.

b.

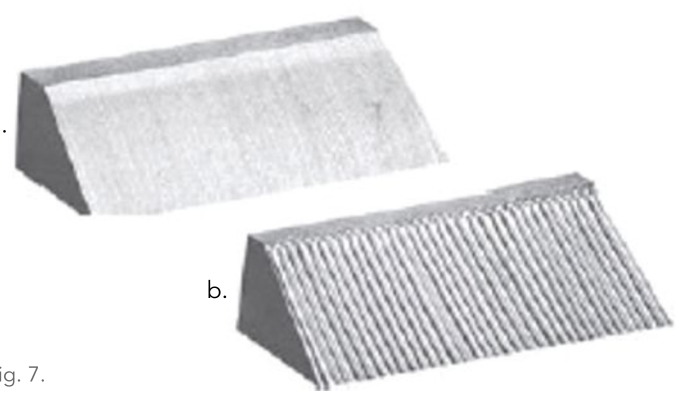

Fig. 7.

Fig. 8.

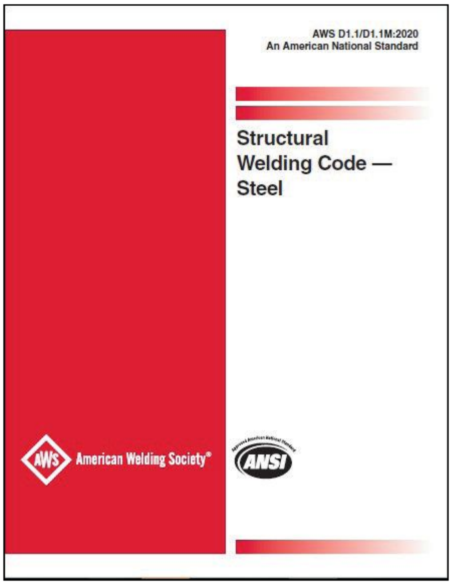

Fig. 9.

Fig. 10.

remains valid indefinitely, providing the welder uses the process on a frequency not to exceed every six months (see AWS D1.1:2020, Clause 8.4.3; Figure 9). There is, of course, nothing magical about six months, and welders do not forget how to weld after not welding for a half year.

What does change with time, however, is that eyesight often deteriorates as individuals age. The decline in capacity is slow and often unrecognized by the individual, be it a weld inspector or a welder. While D1.1 mandates eye examinations for inspectors every three years (see D1.1:2020, clause 8.1.4.6), no such examination is required for welders.

Manual and semiautomatic welding requires keen eye-hand coordination, and welders with impaired vision will have welding challenges. Ensuring welders have good corrected vision when using prescription safety glasses can enhance first pass yield weld quality and speed up throughput. Simple near-vision eye exams can be offered by the welder's employer to ensure prescriptions are still effective.

Concept 23. Make good use of the latitude offered by AWS D1.1 Clause 8.8. For most fabrication and erection, the weld acceptance criteria as contained in AWS D1.1 (Figure 9) is simply followed without question, as it should be. For unusual situations, however, AWS D1.1:2020, clause 8.8 offers flexibility that may be significant in terms of project throughput. This clause opens the door to a "fitness for service" analysis. AISC Design Guide 21: *Welded Connections--A Primer for Engineers* (**aisc.org/dg**) discusses this concept in more detail (see page 151 of the guide).

Consider the following application for Clause 8.8. A big "problem" has occurred, and many as-made welds do not meet the standard weld acceptance criteria of D1.1. Further, "everyone" knows that they are good enough for the application—i.e., the welds are suitable for the given application. With the approval of the engineer and sufficient technical support, Clause 8.8 permits the use of alternate weld acceptance criteria. This latitude can avoid costly and time-consuming delays, permitting acceptance of the as-built quality. Obviously, this approach should not be used casually; due caution is required whenever fitness of service analysis is used. Proper application of Clause 8.8 always requires the involvement of the engineer. The inspector is not empowered to use this option, and judicious use of this clause may keep a project moving along on schedule, eliminating the need for (specifically in this case) unnecessary weld repairs.

Concept 24. Never compromise on safety. Perhaps safety should not be grouped with the items associated with minimizing weld quality problems, but it is appropriate to finish this article with a focus on safety. Safety is always a priority, regardless of the impact on productivity. However, the two are not mutually exclusive. Especially with the emergence of automation, safety, production time, consistency, and quality can all be simultaneously improved.

Safety guidelines for welding-related activities are addressed in ANSI Z49.1 *Safety in Welding, Cutting, and Allied Processes*, available as a free download from AWS (**aws.org/standards/page/ansi-z491**). Every safety professional associated with welding operations should have a copy of the document and ensure that the practices are followed. Also available from AWS are 45 different Safety and Health Fact sheets (**aws.org/standards/page/safety-health-fact-sheets**). These shorter documents (typically two to four pages) are excellent sources for shop or erection site safety talks. Lincoln Electric also offers a variety of safety-related help on its website, including informative publications, posters, and videos (**tinyurl.com/lincelecsafeed**; also see Figure 10).

Following safe practices is not only the right thing to do, but in terms of productivity, it is the *smart* thing to do as well. A well-organized, uncluttered shop and job site contribute to both safety and productivity.

Speedy Steel

The 24 welding-related concepts described in this two-part article are practical and can be implemented today. Innovative welding equipment and consumable manufacturers and their welding distributor partners are willing to assist forward-thinking steel fabricators and erectors in turning these concepts into realities. N4S may not be your primary focus right now, but producing quality welds at a low cost and in a safe way will always be a challenge. Implementing a half-dozen of these concepts will materially improve welding operations for most fabricators and erectors. ■

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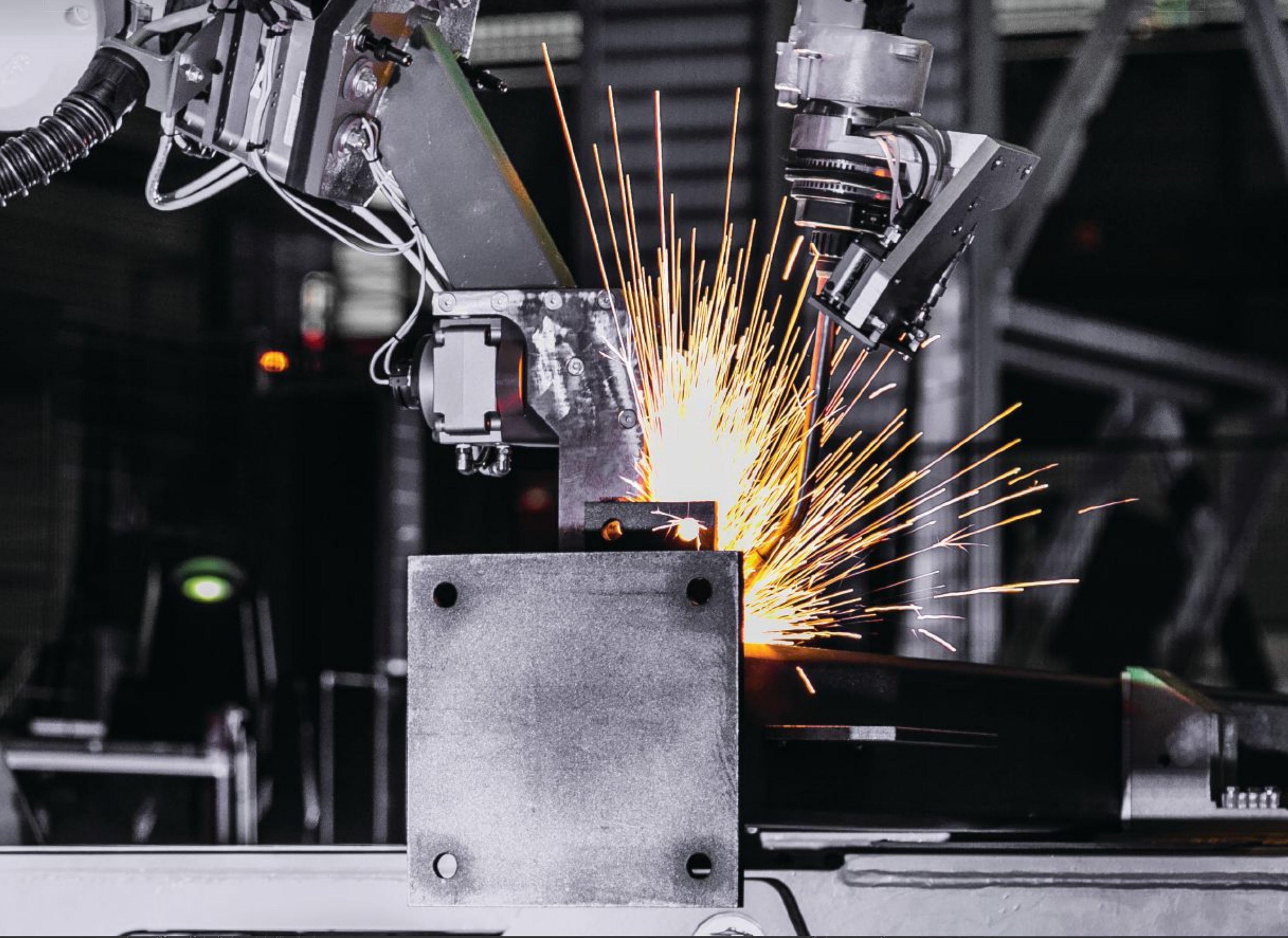

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UNDERSTANDING DRIVES **SOLUTIONS**

Century Club: Standard Iron

BY GEOFF WEISENBERGER

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

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

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

This month's century clubber is **Standard Iron Works** in Scranton, Pa., which opened before World War I and has been led by the same family since the very start.

Answers provided by Paul Dennebaum, president of Standard Iron Works:

How and when did your company start?

We have been a family business from the start, from my grandfather, John, to my father, Paul, to myself, also Paul, and now my three children. The company started in 1914 with three partners, and my grandfather was one of them. Several years later, my grandfather bought out the other two. Back then, it was a small building next to a railroad track in downtown Scranton, mostly doing railing and stair fabrication with an occasional beam or column for small buildings. There were no cranes in the building, so all the material was handled by hand or a chain hoist.

In the early 1950s, my grandfather bought a building that consisted of a warehouse with a cab-operated overhead crane and a steel-cutting saw. The main building had a central bay with a crane-way and two other bays for miscellaneous iron fabrication (stairs, railing, ladders, and angles for lintels). This building was later in the right of way of a planned four-lane highway bypass, so my father bought another building that was previously a railroad car repair shop. This is the building we are currently working in today. At the time, the facility had a warehouse with a ground-operated crane and a main building with a sizeable office for administrative duties and drafting. It also had two bays with overhead cranes and another for miscellaneous iron fabrication.

Over the years, we've expanded our customer coverage from northeastern Pennsylvania to the middle and eastern portions of the state, all of New Jersey, part of New York State, and occasionally to other nearby states.

CELEBRATING 100 YEARS 1921–2021 AMERICAN INSTITUTE OF STEEL CONSTRUCTION AISC FOUNDED 1921

I have two sons and one daughter, each working at and owning part of the business. They share all the responsibility except for the estimating, which I've always felt was the most important function. If there is no work on the books, there is no work for any of the employees. Another reason is that if the work is not priced right, the business cannot survive.

Your company has been able to weather challenges for more than a century. How has this helped you weather the current pandemic?

The business has weathered the pandemic without a hiccup. Our most recent projects have involved a hospital as well as a facility for a pharmaceutical company. Our office did have a few people come down with COVID-19, but they quarantined and were back to work after that.

AISC is 100 this year. How long has your company been involved with AISC and taken advantage of its resources?

We have always been an AISC-connected company since my grandfather and father were structural engineers, and we have used their resources often. We became an AISC certified fabricator back in 1996 and are proud to have the logo on our letterhead. ■

For more content related to AISC turning 100 this year, visit ***aisc.org/legacy***.

above: A new 40,000-sq.-ft passenger terminal buidling for the Williamsport (Pa.) Municipal Airport, a recent Standard Iron Works project.

below: Another recent Standard project, a 100,000-sq.-ft Geisinger office building in Danville, Pa.

Defensive legal strategies and contracts can help fabricators navigate unexpected and dramatic material price fluctuations.

When Steel Prices Spike

BY EDWARD SEGLIAS, ESQ, AND MATTHEW SKAROFF, ESQ

Edward Seglias (**eseglias@cohenseglias.com**) and **Matthew Skaroff** (**mskaroff@cohenseglias.com**) are both attorneys in the Construction Department at Cohen Seglias Pallas Greenhall and Furman PC, AISC's general counsel.

THERE HAS BEEN A LOT OF TALK about how steel prices—along with those of other materials—have risen dramatically, even reaching record highs, over the last few months.

But it is not the first time that has happened—even in recent history.

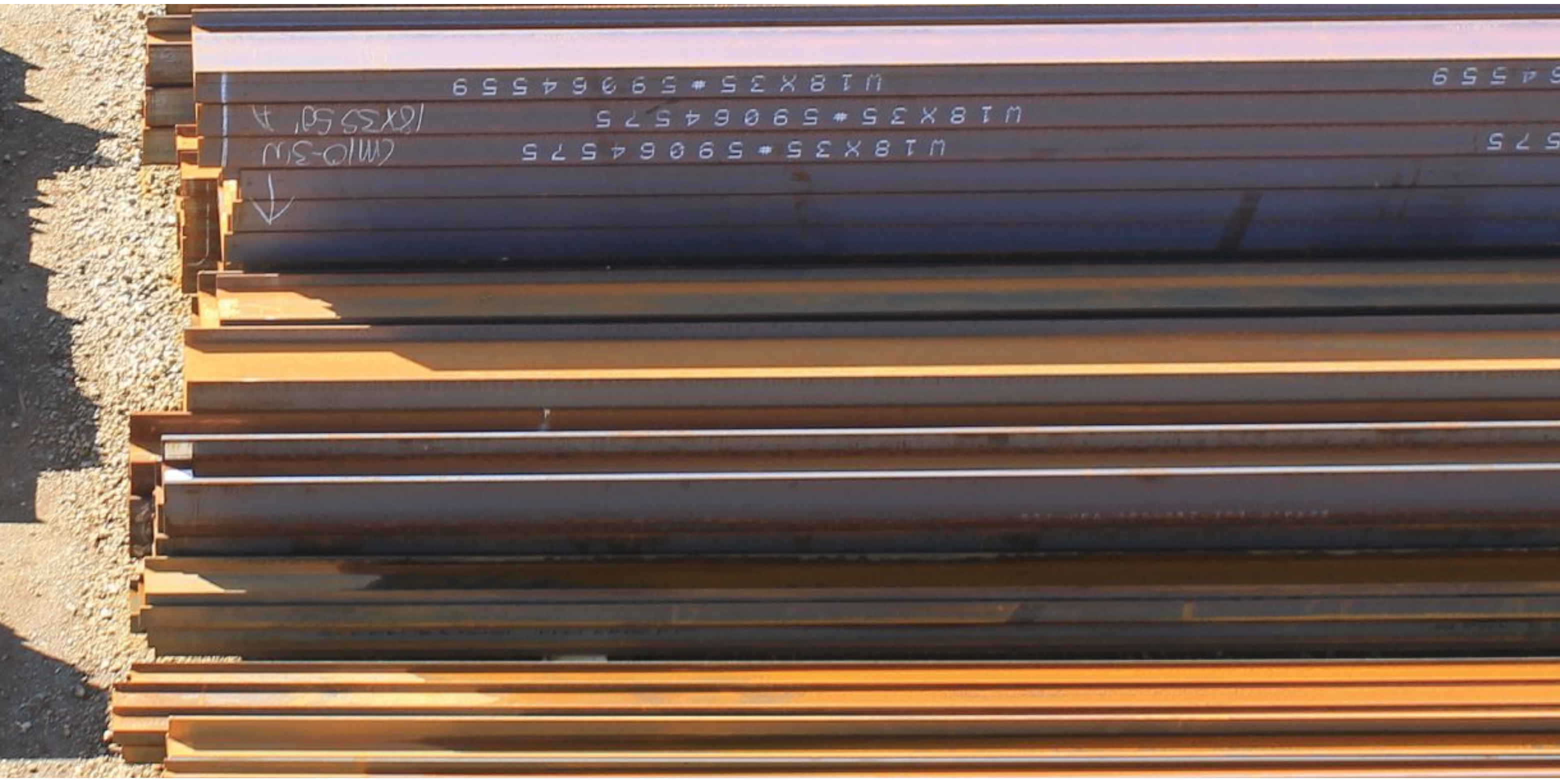
In 2017, steel prices significantly rose following new tariffs on foreign-made steel, with suppliers drastically reducing the time they would hold quotes. Similarly, 2004 saw at least a doubling in the spot price of almost every type of steel.

Unexpected and rapid rises in the price of steel create problems for many different businesses, but especially for structural steel fabricators. These types of pricing fluctuations can squeeze margins on jobs already under contract, when the steel has not been purchased and when material pricing has not been locked in. They create risk in taking on new work, as the predictability of pricing is now called into question. And while frustrating, this situation is not surprising as subcontractors typically bear the burden of price escalation. But despite these problems, properly written and administered contracts and the law may offer fabricators some relief.

Battling Rising Prices

On existing jobs impacted by rising prices, fabricators have a few pathways. If they were prudent in negotiating their contracts, then those contracts may contain price escalation clauses or other adjustment clauses. Often, such clauses are typically based on a triggering event, such as a certain percentage increase in the price of materials. Likewise, an allowance for material costs would provide for similar relief in the event of spiking prices. But these clauses require the negotiator to have the foresight to include them in the original contract, typically before a major price event such as what we have recently witnessed.

Other contract clauses may also offer options to address cost increases, though these are less likely to provide relief than are specific price escalation clauses. Many contracts include "force majeure" clauses that provide a fabricator with a remedy in the event of an unexpected occurrence, such as a natural disaster, unanticipated government action or inaction (e.g., tariffs), or labor issues. Force majeure language is highly variable from



contract to contract, and the particular phrasing could potentially connect enough to the situation behind a steel price increase to allow for contract price adjustment. But the possibility is remote given how such clauses generally are written and interpreted.

Separately, the language of change order provisions alone may be broad enough to justify additional payment to a fabricator. For example, older versions of AIA A201: *General Conditions of the Contract for Construction* contemplate contractors submitting claims for additional cost based on "reasonable grounds," which can be interpreted broadly to include unexpected material price increases. Language in contracts regarding changes and claims should be examined closely to see if any of these arguments can be made for adjustment.

Finally, the law itself provides a few doctrines that may help mitigate rapid price increases. Many jurisdictions recognize the concepts of "commercial impracticability" and "frustration of purpose," which generally set aside contract performance obligations based on an unexpected occurrence resulting in an "extreme and unreasonable expense" or rendering the performance purposeless. Though these doctrines are very difficult to prove in court, they may warrant consideration depending on how extreme the situation may be for a fabricator.

As you can tell, there are no certainties that you'll be able to recover unexpected price increases that were not previously anticipated during contract negotiations. But things are different now. The art of mitigating risk for new jobs lies in clear language and carefully selected contract clauses with both upstream and downstream parties.

Win-Win

As discussed previously, a price escalation clause or an allowance in a contract with a general contractor should help limit the risk of uncertain future prices. An allowance can also provide a win-win situation; coming in under the allowance price will represent savings to the general contractor, and coming in over will offer protection to the subcontract by providing a right to recover. To make such clauses more palatable for the other party, a fabricator may suggest capping any allowance or price escalation with a guaranteed maximum price, thereby dividing the risk between the parties.

Quotes and bids also need to be carefully coordinated. While bidding on new projects, fabricators should align the timing of fixed quotes from suppliers with the length of time that the fabricator itself holds its bids for a general contractor or construction manager. To the extent that there is a gap in timing, fabricators should strive to include language in their bid to provide for pricing adjustments, if possible.

It is essential that any quotes, bids, or proposals clearly spell out the price obligations, how long they will be held open, and in what scenarios they are subject to adjustment. If a supplier reneges on price or a party refuses to reimburse a fabricator for a price increase, then clear contract language can mean the difference between litigation and negotiated resolution.

The most recent steel price spike is not the first, and it won't be the last. Fabricators should plan accordingly and play defensively to ensure they are well protected and have the proper contract language in place the next time the market jumps. ■

Back to Building

BY JENNIFER TRAUT-TODARO

While pandemic-related delays and material shortages and price increases have added construction challenges, remember: We've seen this movie before. And steel's flexibility and relative scheduling predictability can help guide the story to a happy ending.

Jennifer Traut-Todaro (**trauttodaro@aisc.org**) is a senior staff engineer in AISC's Steel Solutions Center.

THE COVID-19 PANDEMIC has clearly taken its toll on the AEC industry, but the effects certainly haven't been distributed equally across the board.

While construction was considered an "essential service" in some municipalities and experienced little to no delays, in many other areas, clients were forced to wait through the dark days of the pandemic—and now they're ready to build those projects that were put on hold. However, the aftermath of the pandemic—or the late stages, depending on your point of view–is challenging us in new ways in the form of material delays and subsequent cost increases.

Materials, Delays, and Prices, Oh, My!

An American General Contractors (AGC) Coronavirus Survey from early March cited "shortage of construction materials, parts or equipment" as the leading cause of project delays. The industry is feeling delays all the way up the chain to the designers' offices, causing design teams to rethink their go-to material choices.

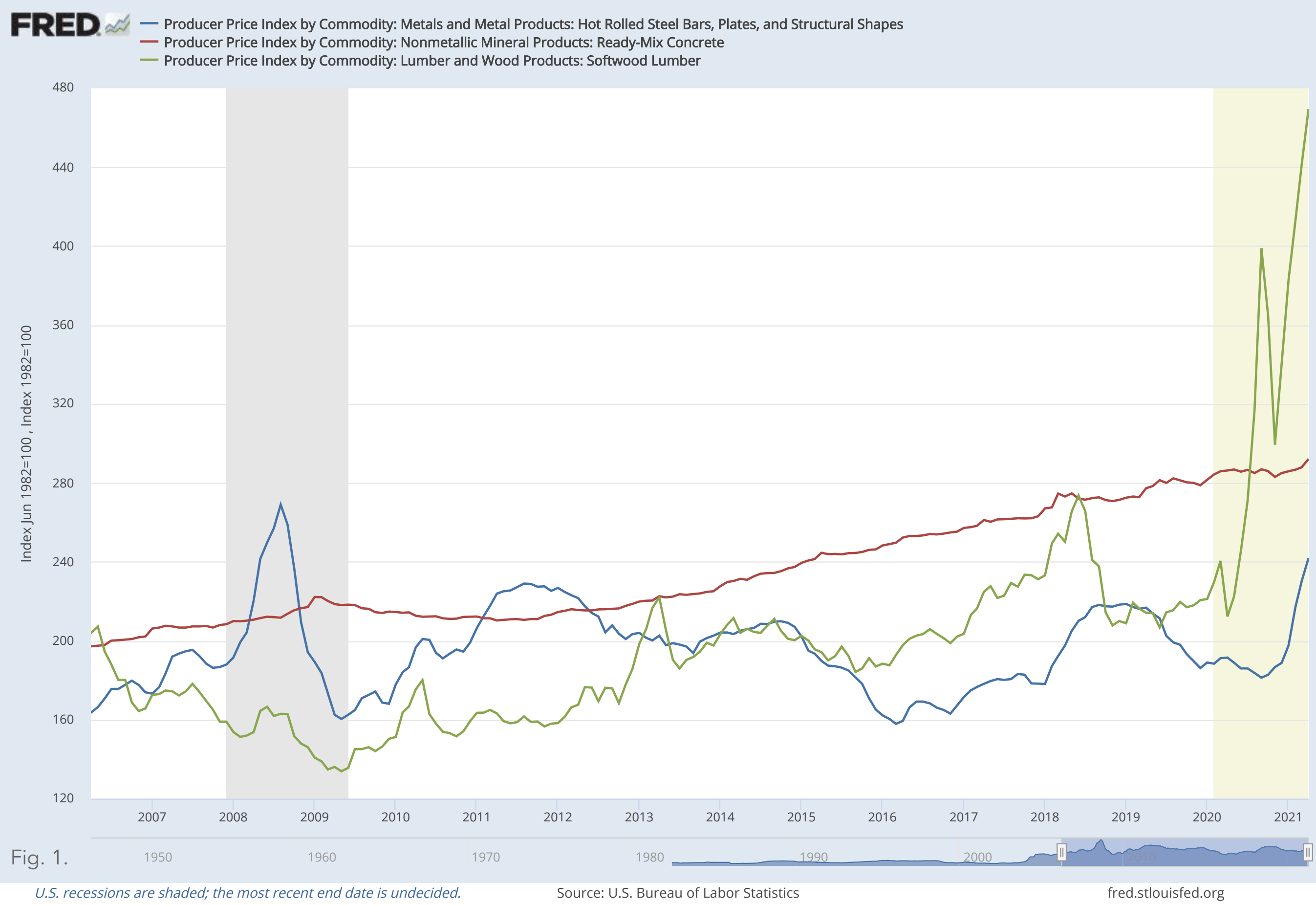
Of course, there are concerns that these delays, in addition to the price increases, could result in project cancellations even as the economy gains momentum. The good news is that, though material delays are happening across the board, structural steel schedules remain more predictable than others.

Let's take a look at some data. In recent months, the Bureau of Labor and Statistics reports an overall increase in the cost of materials commonly used in construction (see Figure 1). If there is one thing we know for certain, it is that concrete prices continue to increase with no signs of stopping. (It is worth noting that, in this chart, concrete is evaluated alone, without steel reinforcement as a construction composite.) Wood pricing resembles a dizzying rollercoaster in recent months, and be aware that hot-rolled steel (unfabricated) has seen a significant uptick in cost.

Much has been said and written about how the current situation is quite different from the Great Recession of 2008 or any other economic downturn (see the shaded area in Figure 1 for a look back at construction material pricing behavior during the downturn of 2008). Although the 2008 recession was caused by the financial crisis and 2020's was due to the pandemic, there does appear to be a resultant pattern of increased material costs.

It is also worth taking a closer look at steel and its supply chain. On average, structural steel in the U.S. is made of 93% reclaimed and recycled content. Scrap metal accounts for almost all of the base material for hot-rolled steel. Regardless, the fact that steel prices are currently up has created obvious problems for both concrete and steel construction projects (don't forget about rebar). One surprising outcome that has emerged from these supply chain issues is an opportunity to reduce current project schedules through design.

Figure 3 (page 58) shows U.S. raw steel production and capacity use data (provided by the American Iron and Steel Institute) since 2016. The data is very promising, showing the steel


FRED
Producer Price Index by Commodity: Metals and Metal Products: Hot Rolled Steel Bars, Plates, and Structural Shapes
Producer Price Index by Commodity: Nonmetallic Mineral Products: Ready-Mix Concrete
Producer Price Index by Commodity: Lumber and Wood Products: Softwood Lumber
Index Jun 1982=100 , Index 1982=100
480
440
400
360
320
280
240
200
160
120
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
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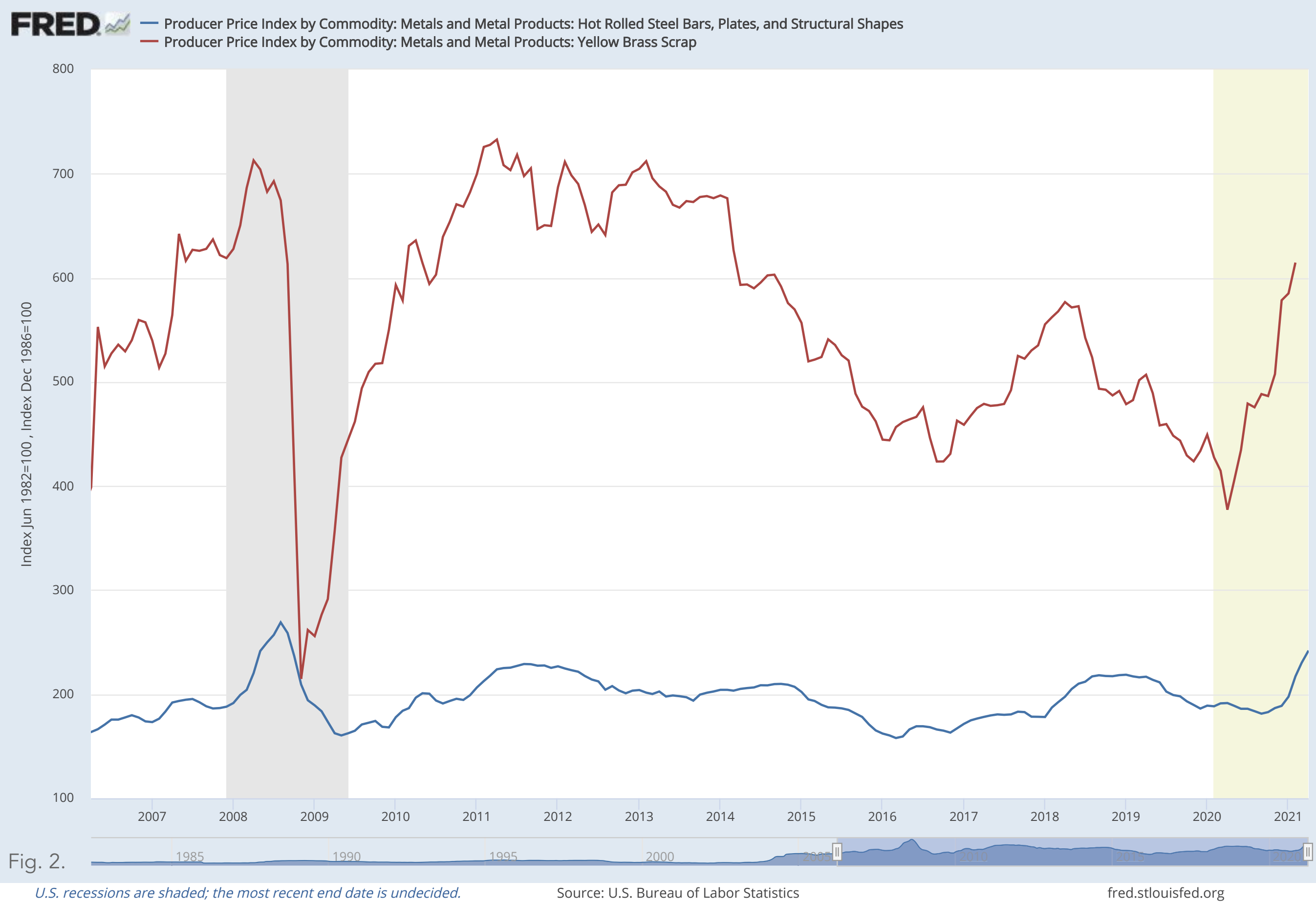
2019
2020
2021
1950
1960
1970
1980
1990
2000
U.S. recessions are shaded; the most recent end date is undecided.
Source: U.S. Bureau of Labor Statistics
fred.stlouisfed.org
Fig. 1.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Producer Price Index by Commodity: Metals and Metal Products: Hot Rolled Steel Bars, Plates, and Structural Shapes
Producer Price Index by Commodity: Metals and Metal Products: Yellow Brass Scrap
Index Jun 1982=100 , Index Dec 1986=100
800
700
600
500
400
300
200
100
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
1985
1990
1995
2000
U.S. recessions are shaded; the most recent end date is undecided.
Source: U.S. Bureau of Labor Statistics
fred.stlouisfed.org
Fig. 2.

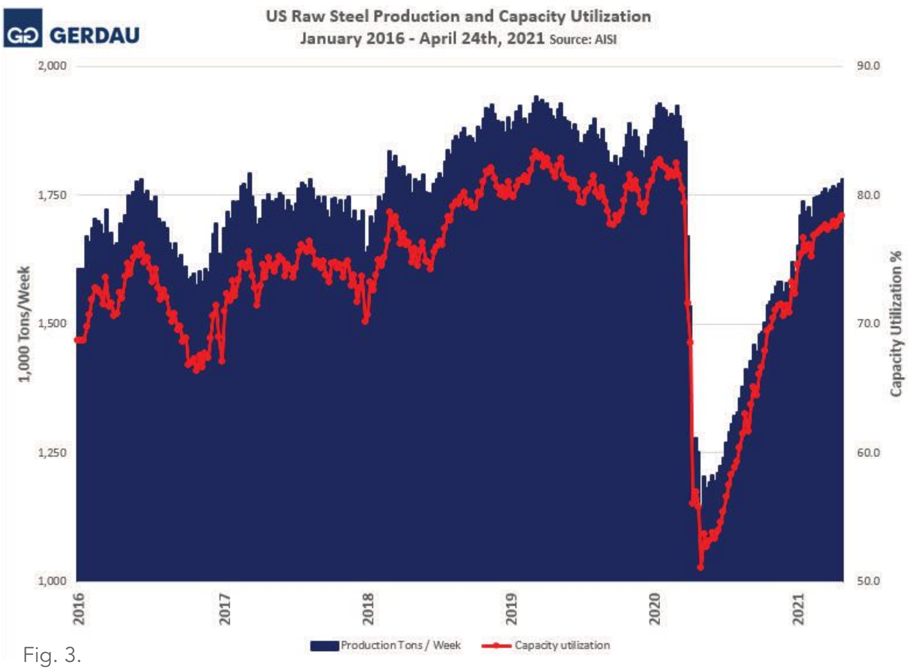


Fig. 3.

industry's ability to bounce back and meet current needs. What's even more promising is the capacity to scale production as demand increases. Many construction products were challenged by the pandemic, but this figure proves that the steel industry has the flexibility to catch up with demand. (If you are interested in diving deeper and tracking average pricing, **aisc.org/economics** is a great place to start.)

Design(ing) Alternatives

Current trends within AISC's Steel Solutions Center (SSC) highlight just how creative and adaptable the AEC community can be. For example, this spring we've seen a sharp increase in questions and requests regarding open-web steel joists. We've heard multiple partners cite eight-month lead times for joists over the traditional three months expected before the pandemic. The addition of a five-month wait with a higher price tag makes joists significantly less competitive.

Engineers are beginning to provide structural steel alternatives in their construction drawings where they might have typically used open-web joists, and general contractors are also asking for alternatives. And if a design makes it to a fabrication shop without that alternative, some fabricators are contacting the SSC for a conceptual solution (where SSC staff evaluate a project's requirements and develop a solution to meet them using structural steel, thus demonstrating the viability of a steel framing system for the project; see **aisc.org/solutions** for more details on this free service) and a rough structural steel take-off. Everyone is looking for ways, within their own scope, to help clients keep projects on track with a more palatable timeline.

If you have never worked with the SSC, you might be wondering what we can do to help. Simply put, we are able to quickly substitute steel wide-flange beams in place of open-web joists, design the alternate members, optimize the framing, and share a conceptual report and framing plan to help better define what the structural revision might look like (see Figure 4). From there, an AISC member fabricator can provide price and schedule information for their client. We want projects to stay on track just as much as you do, so this service is complimentary.

We can't control pricing or delivery dates, but we also can't ignore the value of our own effective project management. Our AISC member fabricators have always thrived on working with what they've got to get projects done for their clients—and they're even more effective when you engage them as early as possible on a project! Through transparent communication and clear expectations, we can get through this rough patch and build some amazing projects together.

Reach out to the Steel Solutions Center with your project challenges today (remember, it's free!) at **solutions@aisc.org**. We are excited to work with you! ■

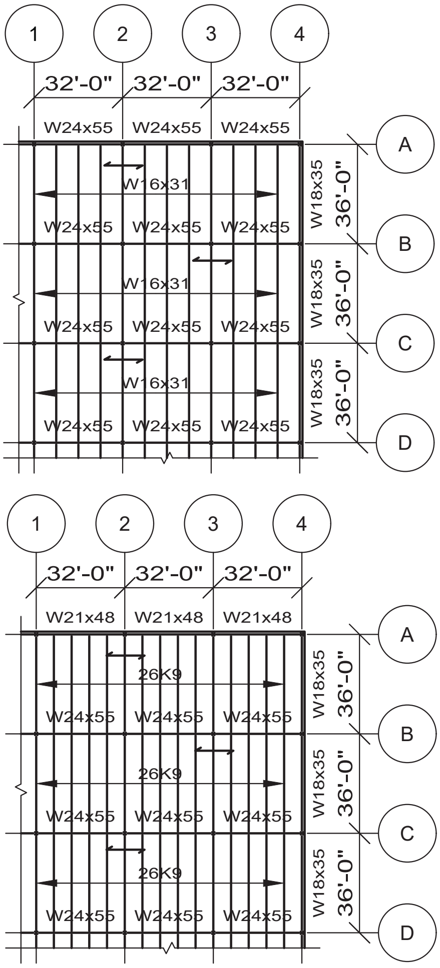


Fig.4.

new products

This month's New Products section features an updated angle grinder, the latest version of an engineering software package, and the addition of a fastening system to the latest *RCSC Specification* (which is available to AISC members at **aisc.org/specifications**).

FEIN CG 10-115 PDEV

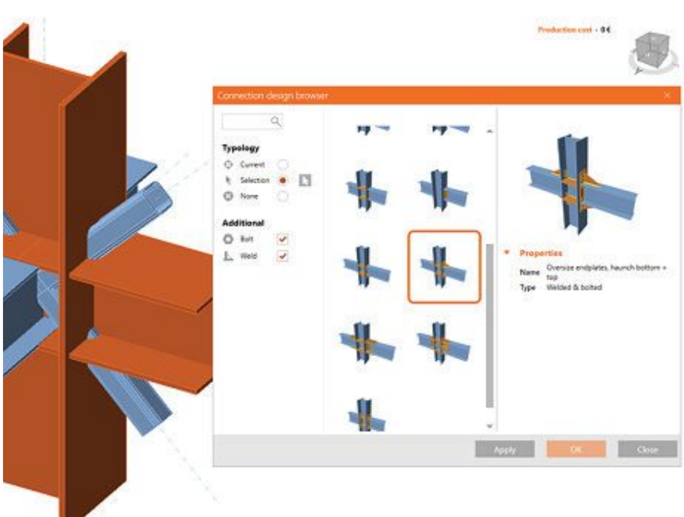
This updated high-performance 1,140-watt compact angle grinder features a paddle switch and dead-man function for complex deburring, grinding, and cutting work, including stainless steel. The grinder's variable speed (2,700 to 10,500 rpm) allows customers to use it in a wide variety of applications. Its design provides accessibility in tight spaces due to its compact solid-metal drive head that rotates in 90° increments. In addition, its unique dust-protection grill protects the motor from metallic dust and chips that typically damage other angle grinder motors.

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

IDEA StatiCa Version 21.0

IDEA StatiCa Version 21 aspires to further streamline the connection design process. The calculation core is now 30% faster. Bulk import from various CAD/FEA applications can process tens or hundreds of steel connections in one go. Code-compliance updates for LRFD and ASD for the 2010 and 2016 versions of the *Specification for Structural Steel Buildings* (ANSI/AISC 360, **aisc.org/specifications**) are now included, as are several new templates for seismic and other connections.

For more information, please visit **www.ideastatica.com**.



LeJeune TNA Fastening System Receives RCSC Approval

The Research Council on Structural Connections recently published the 2020 *RCSC Specification for Structural Joints Using High-Strength Bolts*, which includes a fifth installation method: the combined method, which uses torque for the snug-tightening process and then employs angle (degree of nut rotation) for final tensioning. And LeJeune's Torque + Angle Fastening System is the first system on the market to use the combined method. Now users can specify ASTM F3148 TNA bolts and this method on future projects with the confidence of industry approval.

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

MEMBER NEWS

First New Hampshire Regional Welding Competition Connects Students with Industry Professionals

Novel Iron Works, an AISC member and certified fabricator and erector, hosted New Hampshire's first-ever regional welding competition on Friday, May 7. This competition is the second to tie into the AISC Education Foundation's Rex I. Lewis Scholarship Program (Lewis himself, co-owner of AISC member and certified fabricator Puma Steel, started the first one five years ago in Wyoming).

Students from the Seacoast School of Technology in Exeter, the Regional Career Technical Center in Dover, and the Portsmouth Career Technical Education Center gathered at Novel Iron Works in Greenland, N.H. to compete for scholarship money. The team from Portsmouth won the top three places in the regional competition. First place winner Addison Kady walked away with a $1,000 scholarship to a Community College System of New Hampshire welding program of his choice, and the second and third place winners were each awarded a $500 scholarship.

"We have wonderful partnerships that have pulled together for the benefit of the students, the industry, and the state," Hollie Noveletsky, competition organizer and chief executive officer of Novel Iron Works, told *Seacoastonline*. "We are just hoping to recruit young people into welding careers and increase the state's pool of skilled welders."

The competition in Greenland, N.H., was one of two regional competitions. The other was co-sponsored by Capone Iron Corporation, an AISC member and AISC-certified fabricator, and held at White Mountain Community College in Berlin, N.H. Winners from both regional events will advance to the state competition, which SL Chasse Steel Fabricators, an AISC member certified fabricator, is hosting May 21 at Manchester Community College.

Find out more about the competition and see more photos at **www.seacoastonline.com**.

From left to right: Hollie Noveletsky, chief executive officer of Novel Iron Works; third place winner John Shortill; Portsmouth welding instructor Bill Schefer; second place winner Dan Mitchel; first place winner Addison Kady; and Sean Clancy of Great Bay Community College.

IN MEMORIAM

Former AISC Regional Engineer Robert Pyle Dies

Robert "Bob" Wallace Pyle, Jr., a longtime AISC regional engineer, passed away on April 30. He was 65.

Born in California in 1955, Pyle spent several decades in the construction industry and was a strong advocate for structural steel. In recent years, he had retired in Utah to spend time with his sons and grandson.

"Bob was the unique combination of an engineer with a fun-loving, outgoing, and gregarious personality," recalled Kimberley Robinson, director of design services at SunSteel. "He was involved in the SAC Steel Project to develop ductile steel moment connections after brittle failures were found after the Northridge Earthquake. He also assisted in the development of AISC Design Guide 14: *Staggered Truss Framing Systems*. Using his dynamic personality, he worked closely with steel contractors in implementing design-build and early-involvement strategies into their marketing models. Bob was a force in the steel construction community and the structural engineering community."

"Bob was truly a great person and bigger-than-life personality," said James "Jim" O. Malley, SE, group director and senior principal of Degenkolb Engineers. "He will be missed."

"Bob was a good man and a good friend while I was active in the profession," said Ron Reaveley, founder of Reaveley Engineering Associates in Salt Lake City.

"We are all so saddened to hear of Bob's passing," said Charles Carter, SE, PE, PhD, AISC's president. "He was a convivial face of AISC in his regional role representing the steel industry in the western and southwestern states for so many years. Nobody was a stronger advocate for steel fabricators and steel solutions."

Bob is survived by his sons, Nathan and Nicholas, and grandson Miles.

safety matters

Welcome to Safety Matters, which highlights various safety-related issues. The July edition was contributed by AISC Safety Committee member **Kathi Dobson** of **Alberici**.

This month, we want to share some upcoming events and remind everyone of regular, routine activities to keep workers safe.

Holiday Hazards

July 1, Canada Day, and July 4, U.S. Independence Day. These holidays often bring fireworks, barbecues, sunburns, hot weather, and water fun, but all can be dangerous. Fireworks can cause burns, blindness, and, well, fires, if used improperly. Barbecues can lead to food poisoning, and when you are with a number of people, that physical closeness you may enjoy can spread viruses. When on or in the water, whether swimming or boating, know the area you are in and be aware of water hazards. Wear life vests/jackets as appropriate and always have a buddy system. And remember that heat stress and sunburns can be an inadvertent consequence of all these fun activities. Sunscreen!

Dates to Note

- National Fireworks Safety Month, brought to us by Prevent Blindness America, **www.preventblindness.org**
- Vehicle Theft Prevention Month, sponsored by the National Highway Traffic Safety Association (NHTSA), **www.nhtsa.org**
- National Heatstroke Prevention Day, July 31, also sponsored by NHTSA, **www.oksafety.org**
- Safe and Sound Week, August 17–21, **osha.gov/safeandsoundweek**

Safe and Sound

"Safe and sound," by definition, can mean free from danger or harm, or unharmed and healthy. These definitions go back to the early 1300s when the phrase appeared in a medieval English poem called the *Cursor Mundi*.

For our purposes, Safe and Sound is an OSHA program that works as an occupational health and safety management system (OHSMS) process, and we recognize and celebrate it each year in August. OSHA says:

1. Safe workplaces are sound businesses.
2. Every workplace should have a safety and health program that includes management leadership, worker participation, and a systematic approach to finding and fixing hazards.
3. Wherever you are, take a step in the right direction.

Safe and Sound is not just a one-week effort; it should be something that any workplace can establish as part of their year-long goals. Using this concept of management leading the way, workers getting involved and engaged and everyone identifying and correcting problems, companies can build a simple but comprehensive OHSMS without a costly investment in programs such as ISO 45001.

Let OSHA know what you are doing to be Safe and Sound at Work. Email the organization via **osha.gov/safeandsound** or use #SafeAndSoundAtWork on social media.

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

People & Companies

Bridge design, inspection, and rehabilitation firm **Modjeski and Masters** recently announced the hiring of **Laura Rampersad, PE**, as regional director of the firm's new office opening in Grand Rapids, Michigan. In her role, Rampersad will be responsible for managing the company's operations in the state and surrounding region. With nearly 30 years of experience, Rampersad is the Communications Committee Chairperson for **Women's Transportation Seminar's Michigan Chapter**. She is also actively involved with the **Institute of Transportation Engineers** and the **American Council of Engineering Companies (ACEC) of Michigan**.

AISC producer member **Gerdau** recently announced the completion of installation, cold commissioning, and initial hot rolling trials in the recent rolling mill upgrade of its Petersburg, Va., structural steel mill. The $33 million project involved a variety of upgrades, including the installation of two additional rougher stands, and was designed to improve the mill's capacity and productivity while expanding the facility's product offerings.

ENGINEERING JOURNAL

Third Quarter *Engineering Journal* Now Available

The third quarter issue of AISC's *Engineering Journal* is now available. (You can access this issue as well as past issues at **aisc.org/ej**.) Below is a summary of this issue, which includes articles on shear lag factors for HSS, tearout strength for bolts, stability design using the drift method, and simplifying shear strength for concrete-filled steel tubes.

Analysis of the Shear Lag Factor for Slotted Rectangular HSS Members

Bo Dowswell

Rectangular HSS tension members are often connected by slotting two opposite walls and welding the slotted walls to a gusset plate. Due to nonuniform stress distribution in these connections, the tensile rupture strength of the member is dependent on a shear lag factor. The accuracy of the 2016 AISC *Specification* provisions for the tensile rupture strength of slotted HSS tension members was evaluated using existing data from five previous research projects. The results revealed that the current equations are excessively conservative. The accuracy can be improved by replacing the existing equation for the connection eccentricity with the equation proposed in this paper.

Tearout Strength of Concentrically Loaded Bolted Connections

Nicolo Franceschetti and Mark D. Denavit

The limit state of tearout can complicate the design of steel bolted connections since, in contrast to the limit states of bearing and bolt shear rupture, tearout strength can vary from bolt to bolt within a connection. Under the current AISC *Specification*, tearout strength is proportional to the clear distance, in the direction of force, between the edge of the hole and the edge of the adjacent hole or edge of the material. However, recent studies on concentrically loaded bolt groups have suggested that the use of clear distance may not accurately represent tearout strength and have proposed alternative lengths for use in strength equations. A reevaluation of the limit state of tearout in concentrically loaded bolt groups is presented in this work, including a thorough evaluation of the proposed alternative tearout lengths using a large database of previously published experimental work and new experiments with various edge distances and hole types. Equations with the alternative tearout lengths were found to be more accurate than those with clear distance, especially for small edge distances. Design recommendations implementing the alternative tearout lengths were developed. The results of this work increase understanding of the limit state of tearout and offer improved methods of evaluating this limit state in design.

Determination of Second-Order Effects and Design for Stability Using the Drift Limit

Rafael Sabelli, Larry Griffis, and Louis F. Geschwindner

Buildings for which second-order effects are significant are often governed by drift limits. Amplifier-based approximate second-order analysis, as presented in AISC *Specification* Appendix 8 (2016), typically utilizes factors based on first-order drift, for which a preliminary design and an analysis are required. This paper derives equations for the amplifier used in approximate second-order analysis, B2, based on the second-order drift. Upper-bound values of amplifiers based on the drift limit can thus be determined in advance of design, eliminating the need for iteration and simplifying the design process; these values are not excessively conservative for drift-governed designs.

Simplified Equations for Shear Strength of Composite Concrete-Filled Steel Tubes

Hadi Kenarangi, Michel Bruneau, Amit H. Varma, and Mubashshir Ahmad

Shear strength of filled composite members, namely circular or rectangular concrete-filled steel tubes (CFST), has been investigated in past research. Results established the relative contributions of the steel tube and concrete infill to the total shear strength and showed that the concrete contribution depends on the development of a compression strut in the concrete infill when shear-span values are low. While experimental results and numerical models are available in the literature, simple equations that empirically encompass this behavior are preferable for design purposes. This paper provides an overview of the technical approach that has been followed to propose such equations for consideration and possible implementation in future editions of design specifications. The shear strength obtained using the proposed equation is compared with the shear test database from the existing literature and found to be safe; it accurately captures the contribution of the steel tube to the total shear strength and conservatively approximates that of the concrete.

PUBLIC REVIEW

New AISC Standard, *Seismic Provisions for Evaluation and Retrofit of Existing Structural Steel Buildings* (AISC 342), Available for Public Review

A new AISC standard, *Seismic Provisions for Evaluation and Retrofit of Existing Structural Steel Buildings* (AISC 342), is available for public review from July 6 until August 2, 2021. The standard will provide provisions to be used with ASCE/SEI 41 for the seismic evaluation and retrofit of existing structural steel buildings.

The standard and its review form are available for download at **aisc.org/publicreview**. Hard copies are also available (for a $35 charge) by calling 312.670.5411. Please submit comments via the online form to Cynthia J. Duncan, AISC's director of engineering (**duncan@aisc.org**), by August 2, 2021, for consideration.

Letters to the Editor

Reopening the Box

I have the following comments on the statements made in the March 2021 article (**www.modernsteel.com**) "Thinking Inside the (Big) Box."

1. The statement that open-web steel joists (OWJs) lack reserve capacity is certainly true if the original EOR specified the joist to be designed for minimum code loads. This would be the same as for structural steel if it were designed for minimum code loads. The statement insinuates that joists do not have reserve strength. They are designed using the same safety factor as structural steel.
2. "The actual OWJ elements are manufacturer-provided items, and their final designs are not often kept with other structural base building drawings." Based on my experience, this is true not only for buildings constructed using joists, but all buildings.
3. The statement that "There are no guarantees OWJ-framed buildings have steel lateral systems. Rather, these structures are often supported by load-bearing exterior concrete masonry unit (CMU) walls." No structure has such a guarantee unless it is designed properly by the EOR and properly erected. This is not the fault of joist buildings.
4. "It is difficult to efficiently strengthen, cut, and reconfigure OWJs for new floor openings. New floor openings likely require peeling back all slab and OWJ framing to their nearest unaffected beam or girder and reframing full, new bays with wide-flange steel." Joists can be reinforced for new openings. Economics may dictate whether it is less expensive to use structural steel in the new framing or to reinforce the existing joists. Refer to the Steel Joist Institute's Technical Digest 12: *Evaluation and Modification of Open-Web Steel Joists and Joist Girders*.

James M. Fisher, PE, PhD
Emeritus Vice President,
CSD Structural Engineers
Consulting Engineer, Steel Joist Institute

Response from one of the article's authors, Travis Corigliano, SE, PE, Associate, Magnusson Klemencic Associates:

1. This statement refers to existing OWJ conditions where, for example, the design drawings indicate a Total Load = 250 PLF. In a retrofit condition, without full OWJ calculations or shop drawings, retrofit designers must assume the OWJ was fabricated for exactly 250 PLF with no reserve design load. If that OWJ were instead a wide-flange member, or a concrete member with known reinforcement, the retrofit engineer can use the known section properties across the length to back-calculate the member capacity, often finding reserve capacity. If joist members and welds are known across the full length of members, this would apply to joists as well.
2. Similar to response 1, if existing structural plans show a joist Total Load = 250 PLF, that does not provide information on actual member sizes or welds within the joist. The joist calculations and shop drawings, which would have that information, are not often found with base building drawings. If the joist supplier can be identified, they occasionally have record drawings.

   This is similar to a concrete building that does not include reinforcement drawings or shop drawings. In both instances, there is little a retrofit designer can do to justify increased loading on those elements without completed field observations and measurements.
3. This statement is claiming no fault in OWJ-framed buildings or the adequacy of their existing lateral system. Rather, it is observing many joist buildings found to be built integrally with load-bearing CMU exterior walls. It is the load-bearing exterior walls that present a challenge, as compared to a non-load-bearing exterior façade, if the redevelopment is trying to "open the box."
4. Agreed. Joists can be reinforced for new configurations. Each project should evaluate the time and material required for joist strengthening versus joist replacing on a case-by-case basis.

Approved or Authorized?

I read the May 2021 article "Vaccination Considerations" (**www.modernsteel.com**), and I thank you for the facts that were laid out in the article. However, I feel that you left out one important issue: the fact that the COVID vaccines are not "approved" by the FDA but rather are "authorized" by the FDA under the Emergency Use Authorization (EUA).

Can an employer legally mandate an employee to take an experimental therapy like the Covid vaccine if it only has an FDA EUA?

Abi Aghayere, PhD

Response from one of the article's authors, Hope Steidle Kildea, Cohen Seglias Pallas Greenhall and Furman PC: Thank you for your interest in our article on employer-mandated COVID vaccination policies. Your distinction between approved and authorized vaccines is well taken. However, I believe your concerns go to the morality and ethics of employer-mandated vaccination, not the legality. The Equal Employment Opportunity Commission (EEOC) has made it clear that employers can legally require their employees to get vaccinated against COVID, subject to the exemptions and limitations discussed in our article.

However, that is not to say that employers can generally require employees to submit to authorized but unapproved vaccines or experimental therapies. The EEOC's position on this matter is limited to the context of COVID vaccination and, presumably, reflects the EEOC's attempt to balance competing demands regarding employee rights, a public health crisis, and economic needs. The competing interests at stake here may explain the agency's unprecedented leniency when it comes to certain COVID-specific employment policies. Thus, the legality of employer-mandated COVID vaccination should not be viewed as an indication that the EEOC would permit a similar policy in normal circumstances.

To advertise, contact M.J. Mrvica Associates, Inc.: 856.768.9360 | **mjmrvica@mrvica.com**. Search employment ads online at **www.modernsteel.com**.

advertiser index

The Moscone Center's steel pedestrian bridges project in San Francisco was a 2021 IDEAS[2] Award winner. To read about it, as well as the rest of this year's winners, see the May 2021 issue in the Archives section at **www.modernsteel.com**.

Matthew Millman

BIGGER, BETTER IDEAS

AISC'S IDEAS[2] AWARD COMPETITION is breaking new ground.

The IDEAS[2] (Innovative Design in Engineering and Architecture with Structural Steel) Awards have long recognized outstanding projects that illustrate the exciting possibilities of structural steel. And for 2022, they're incorporating YouTube into the judging process.

Typically, a rotating jury of industry professionals reviews all submissions in one sitting, then picks the winners. This time around, an extra step has been introduced into the process. The teams behind three finalist projects in each category will present their projects to the judges via online streams throughout December. Not only will the YouTube format provide the finalists with an additional opportunity the wow the judges, but it will also enable them to share their projects with the world.

AISC will announce the winners at NASCC: The Steel Conference, taking place in Denver, March 23–25, 2022. The winners will also be featured in the May 2022 issue of *Modern Steel Construction*. In addition, winning teams will have the opportunity to present their projects to the AEC community during special webinars or live events throughout the year. If possible, AISC will conduct an on-site award presentation for each winning project during 2022.

Thinking about submitting a project? Visit **aisc.org/ideas2** for more information and to enter. Entries are due by **September 8, 2021**. ■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