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Modern STEEL CONSTRUCTION | December 2016

in every issue

columns

features

ON THE COVER: The Whitney Museum, an artistic structure built to house art, in Manhattan's Meatpacking District, p. 26. (Photo: Nic Lehoux)

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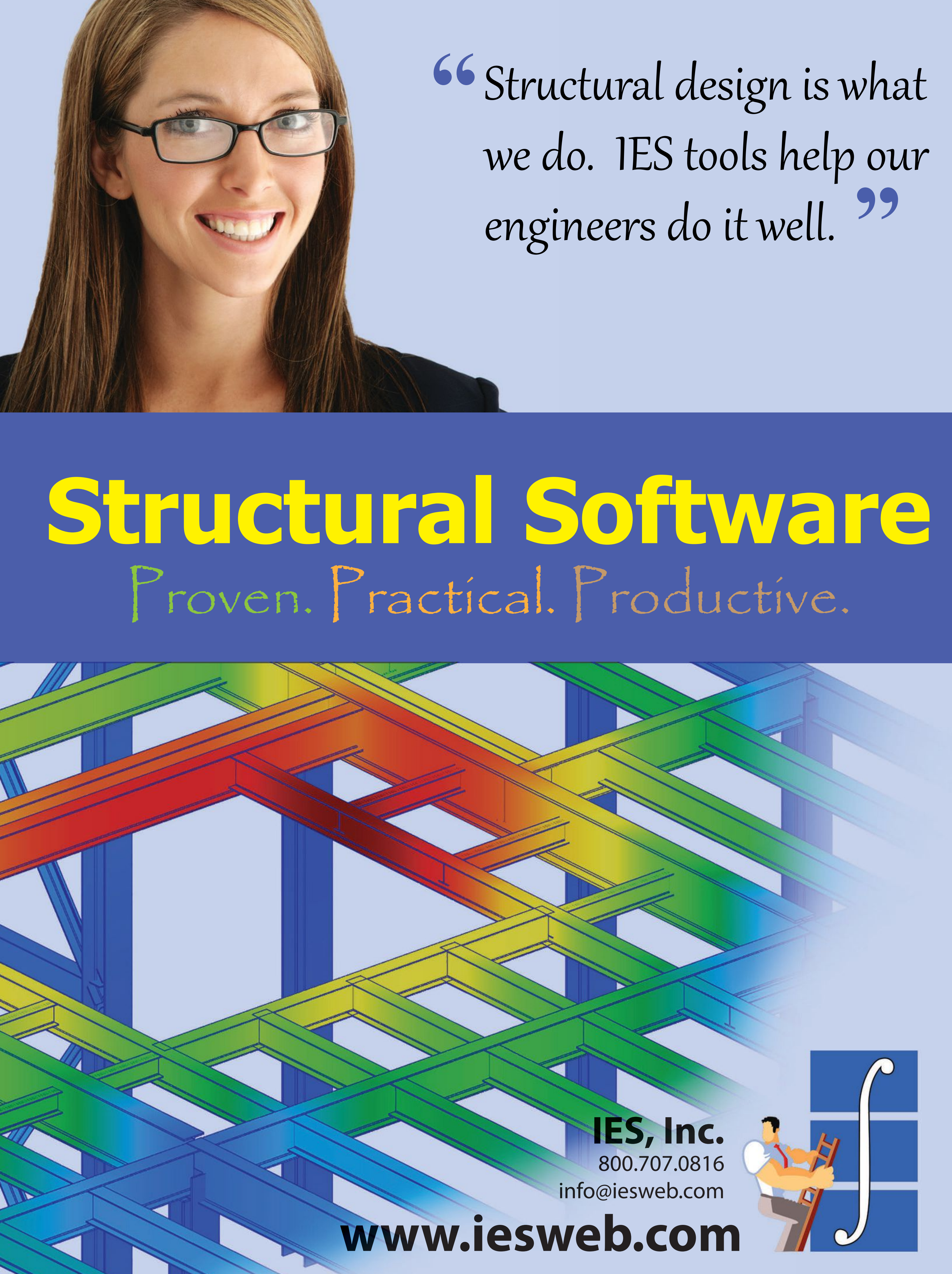
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editor's note

A STEEL FABRICATOR CALLED THE OTHER DAY WITH A PRETTY COMMON PROBLEM. He had just hired a new employee, fresh out of school, and he wanted to familiarize him with the structural steel industry. Did AISC have anything to help?

As it turns out, we have a lot; it's just not always obvious where to find it. As with many questions, the place to start looking is AISC's website, **www.aisc.org**. Under the education tab, we offer access to a series of teaching aids. These PowerPoint presentations and videos are chiefly intended to help engineering, architectural and construction management students, but they're really great for anyone who wants to know more about steel design and construction.

You can watch a video showing the creation of a steel building—from concept to detailing to fabrication to erection. And you can view a presentation on steel and sustainability or videos specifically about detailing, erection and production. There are dozens of resources that can give a new employee a firm foundation to begin exploring the structural steel design and construction industry.

Another great learning opportunity is viewing presentations from NASCC: The Steel Conference. We've recorded most presentations (since 2008) and made them available at no charge to AISC members. You can view hundreds of presentations at **www.aisc.org/proceedings**.

Of course, nothing beats attending The Steel Conference in person. It's a fantastic place to learn more and interact with others in the industry. The next conference is scheduled for March 22–24 in San Antonio, and we're expecting more than 4,500 attendees, including structural engineers, fabricators, erectors, detailers, educators and architects. The sessions focus on both technical and business topics, and networking is a huge draw. Registration opens December 12 (make sure to register early, as fees increase $10 each week) and you can view the advance program at **www.aisc.org/nascc**.

I hope to see you in San Antonio!

Scott Melnick

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

steel interchange

Chevron Brace with Both Braces in Compression

I am designing the gusset for a chevron brace connection with both braces in compression. The Whitmore sections of the individual braces overlap. How should this condition be treated?

The condition with both braces in compression is addressed in the Example 5.9 of AISC Design Guide 29: *Vertical Bracing Connections—Analysis and Design* (a free download for members at **www.aisc.org/dg**), though the Whitmore sections in the example do not overlap. It should be noted that a few different approaches are proposed for checking the stability of the gusset. Each is only a model considered to be reasonable by the authors. In your case, you must determine a reasonable model based on your own engineering judgment.

I imagine there could be many approaches one could take. You could simply ignore the portion of the Whitmore section that overlaps. You could perform some type of stress interaction check. You could run a fine-element analysis. Personally, I would likely be okay with the overlap in many instances for a few reasons. First, when we check the Whitmore section, we assume an even stress distribution along the Whitmore section area which is established using the 30° angle. This was found to give a good prediction of the peak stresses measured from aluminum joint testing performed by Whitmore [Whitmore, R.E. (1952), "Experimental Investigation of Stresses in Gusset Plates," Bulletin No. 16, Civil Engineering, The University of Tennessee Engineering Experiment Station, Knoxville, TN.]. Stress trajectories were plotted from the test data, and they vary greatly along the Whitmore section. The stresses were lower near the ends of the Whitmore section where the overlap occurs in your situation, although connection configurations could impact the stress distributions. Also, with the braces both being in compression, I imagine the stress level will be quite a bit lower than the yield strength of the plate.

Carlo Lini, PE

NDT and Special Inspection Waivers

Please confirm that when third party special inspections are waived by the authority having jurisdiction over the project, the NDT requirements in Chapter N of the *Specification* are also waived.

This is not correct. Section N7 clarifies the intent, stating: "Quality assurance (QA) inspections, except nondestructive testing (NDT), may be waived when the work is performed in a fabricating shop or by an erector approved by the authority having jurisdiction (AHJ) to perform the work without QA." NDT must be performed even when the QA inspections are waived.

Larry S. Muir, PE

Channels Warped During Galvanizing

Several channels we are using on a current project have warped significantly during galvanizing. It has been suggested that the channels may have been a poor choice for these members. Is there are validity to this suggestion?

Yes. ASTM A384: *Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies* recommends the use of symmetrical shapes and singles out channels as a member type that typically requires straightening after galvanizing. The April 2004 article "Galvanizing Tips" (available at **www.modernsteel.com**) reinforces this point and provides other useful tips related to galvanizing.

In addition, the American Galvanizers' Association suggests a collaborative effort should be used to achieve the best results: "The design of parts to be hot-dip galvanized is the responsibility of the design engineer and the architect; however, when there is a part that has an asymmetric design the galvanizer should let his customer know the part is very likely to distort during the galvanizing process."

Larry S. Muir, PE

Removal of Shim Stacks

For base plates that are shimmed and grouted, does AISC consider it necessary to remove the shim plates and pack grout in the voids left by the shims?

No, AISC standards do not require removal of the shim stacks. Leaving the shims in place under the base plate is common practice.

Ideally, column bases should be grouted as soon as possible in construction when the axial load to the column is only a small fraction of what the total anticipated final load could be. Done properly, the base plates should be grouted before any concrete is cast for the elevated floors when the only load delivered to shim stacks is the weight of the bare steel frame and some construction live loads. As additional load is added to the column, the grout will then distribute the load to the foundation.

Axial compressive forces from the column can be assumed to be evenly distributed as bearing forces on the shims and non-shrink grout. Even if the shims were to start out taking the majority of the load, the assembly will deform in a self-limiting manner through localized yielding of the steel as the force-distribution model assumed in sizing the base plate is attained.

Susan Burmeister, PE

A More Efficient Approach to Uplift

I have designed a 30-ft-long W14×22 roof beam to resist gravity loads. However, when we check the beam for wind uplift, bottom flange bracing is required at the mid-span. The W14×22 seems like a reasonable size for this application, and I have seen it called out on other similar projects without bottom flange bracing. Is there a method that might permit me to omit the bracing?

Based on the scenario you have described, bracing of the bottom flange might be needed. I have personally used bottom-flange bracing on numerous projects where the wind uplift pressures exceed the roof dead loads. In my experience, this is not an uncommon practice.

However, you may be able to calculate enough extra capacity for your beam if you take a closer look at the value of C_b used in your analysis. The Commentary to Section F1 of the AISC *Specification* provides some additional formulas that can be used to calculate C_b for a roof beam subject to uplift loads, as shown in Figure C-F1.5. This may increase the available strength enough to eliminate the need for bottom flange bracing. It is certainly worth investigating, especially for repetitive beam conditions.

Susan Burmeister, PE

Cambering Plate Girders and Heavy Beams

Can very large and very long beams, such as a 56-ft-long W40×593, be cambered? Likewise, can a 56-ft-long, 50-in.-deep plate girder be cambered?

Many fabrication shops have the capability to camber typical floor beams using a cold-bending operation (cold cambering). If the machine capacity is exceeded, heat can be applied to the member to reduce the yield stress. Because many bender-roller companies have specialized, high-capacity equipment, it is often more economical for the fabricator to sublet the cambering of large beams. However, it is doubtful that a 56-ft-long W40×593 could be cambered by cold-bending or heat-assisted bending.

Another potential option is heat curving, which is a bending process that relies only on the application of heat in specific patterns to induce curvature. This method is used primarily used by fabricators for cambering and curving to very large radii and for repairing damaged members. You should contact a fabricator to get their advice on this method.

Generally, plate girders cannot be efficiently cold-bent about the strong axis due to the high depth-to-thickness ratio of the web. In most cases, cold bending would cause local web buckling during the bending operation. The welding of the section also would be a challenge, since curving means plastic deformation and shear in the welds probably much greater than the design anticipated for loads in service. It's likely too that plate girders would usually exceed the capacity of the available cambering machine. Fortunately, there is another way. Plate girders are often cambered by cutting the web to the desired curvature, and then welding the flanges in place. This may be the best option.

Bo Dowswell, PE, PhD

Demand-Critical Welds on Seismic Projects

Must all welds on a seismic project meet AWS D1.8, making them all demand-critical welds?

No. Your question indicates quite a bit of confusion about the requirements and the terms used in AISC 341: *Seismic Provisions for Structural Steel Buildings*. I will try to clarify the requirements for you.

First, seismic effects must be considered for all projects. By seismic project, I assume you mean a project that must meet the *Seismic Provisions*.

The *Seismic Provisions* make several references to AWS D1.8. Each of these applies only to welds within the seismic force resisting system (SFRS). For example, Section A3.4a states: "All welds used in members and connections in the SFRS shall be made with filler metals meeting the requirements specified in clause 6.3 of *Structural Welding Code—Seismic Supplement* (AWS D1.8/D1.8M)." Welds outside the SFRS need not satisfy AWS D1.8.

Additionally, welds required to satisfy AWS D1.8 are not necessarily demand-critical welds. Demand-critical welds are a subset of the welds addressed in AWS D1.8. This is can be seen in the User Note that accompanies Section A3.4a, which states: "AWS D1.8/D1.8M subclauses 6.3.5, 6.3.6, 6.3.7 and 6.3.8 apply only to demand-critical welds."

It should be noted that per Section A4, the engineer is responsible for identifying the welds subject to requirements beyond those in AWS D1.1 through "Designation of the SFRS," "Identification of the members and connections that are part of the SFRS" and providing the "Locations of demand critical welds."

Larry S. Muir, PE

The complete collection of Steel Interchange questions and answers is available online. Find questions and answers related to just about any topic by using our full-text search capability. Visit Steel Interchange online at **www.modernsteel.com**.

Larry Muir is director of technical assistance and Carlo Lini is staff engineer—technical assistance, both with AISC. Susan Burmeister and Bo Dowswell are consultants to AISC.

Steel Interchange is a forum to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine.

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

If you have a question or problem that your fellow readers might help you solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact Steel Interchange via AISC's Steel Solutions Center:

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steel quiz

Steel Quiz made its first appearance in the November 1995 issue of *Modern Steel Construction*. This month's Steel Quiz takes a look at some of the best questions from 2000.

1 Why is back-gouging required at complete-joint-penetration groove welds?

2 What is the oldest arc welding process?

3 What is the additional required procedure for hot-dip galvanized surfaces to be used in slip-critical connections?

4 What is a "torsionally pinned end" condition?

5 What is the definition of a "HAZ?"

6 Is there a difference between the terms filler metal and weld metal?

7 Is steel in older existing structures weldable?

8 What does the term "Christmas Treeing" mean?
a. Putting a Christmas tree on the topping-out piece
b. Lifting more than one piece on a load line at one time
c. Erecting the structure in a stepped back fashion

9 Name at least two elements that are commonly found in structural steel alloys.

10 What is the difference between form deck and composite deck?

TURN TO PAGE 14 FOR ANSWERS

Everyone is welcome to submit questions and answers for Steel Quiz.

Steel SolutionsCenter

If you are interested in submitting one question or an entire quiz, contact AISC's Steel Solutions Center at 866.ASK.AISC or at **solutions@aisc.org**.

steel quiz | ANSWERS

1 Back-gouging is required to ensure complete fusion and complete joint penetration upon subsequent welding. Back-gouging is not required when a backing bar is used.

2 Bare wire arc welding is the oldest arc welding process.

3 To provide sufficient slip resistance, hot-dip galvanized surfaces should be roughened. Wire brushing (but not power wire brushing, which tends to polish the surface) is usually used for this purpose.

4 A torsionally pinned end is an end that is permitted to warp but is not permitted to rotate.

5 According to AISC Design Guide 21: *Welded Connections—A Primer for Engineers*, the heat-affected zone, or HAZ, is "the narrow region next to the weld metal, the part of the base metal that is heated by welding to a temperature lower than that required to melt the steel. While the chemistry in this region is unchanged, the mechanical properties of the material may be significantly affected, depending on the composition of the steel and the cooling rate experienced by the HAZ."

6 Yes, though it's a somewhat esoteric one. Filler metal is the product sold by the manufacturer used to make a weld. Weld metal is what's in place after the filler metal has been melted to form the joint.

7 Possibly. If the chemical properties of the steel to be welded are known, either by valid mill certification or by laboratory sample testing, its weldability can be judged by computing the carbon equivalent value. A more obvious approach would be to examine the existing structure for evidence of original welding. Alternatively, an on-site investigation could be performed to address weld ductility and base-metal hardening. Other factors should also be considered, such as past history of the structure, the nature of the loads, weather conditions and whether the members to receive welds are loaded.

8 **b.** Erectors lift more than one piece at a time to avoid having to return to the main steel storage place, often on another floor, for every piece.

9 Carbon, nickel, manganese, molybdenum and chromium are a few.

10 Form deck is only used as form work for a concrete slab. Composite deck is designed to act compositely with the concrete slab; it is a structural element.

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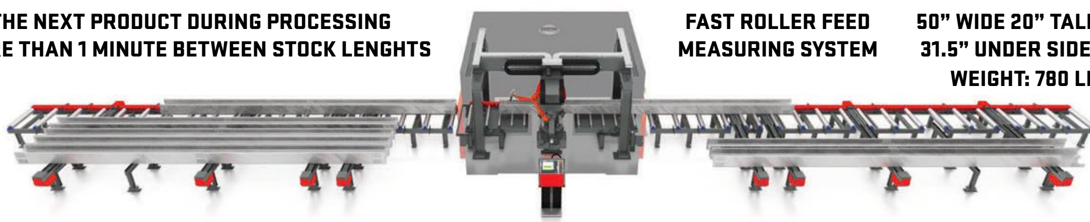

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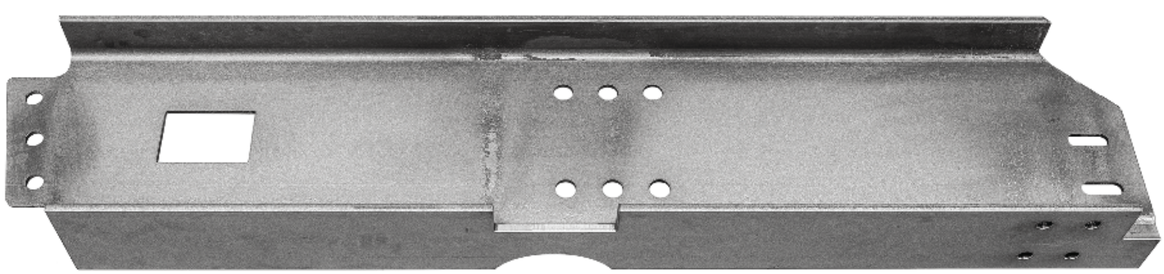

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Dear Roger,

On behalf of W&W/AFCO Steel I want to thank you for your leadership, devotion to excellence and the skill and experience that you have brought to the institute and to our industry as president of AISC.

You have advanced us with a proficiency that will serve us well into the future. Your friends at W&W/AFCO Steel wish all the best to you and Nancy, your family and your future endeavors.

Rick Cooper,
CEO

www.wwsteel.com

National September 11 Memorial Museum Pavilion
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New HSS standards and changes to slender elements, shear strength, angles, connections, advanced analysis and fire design are just a few of the updates in the 2016 AISC *Specification*.

specwise

WHAT'S NEW IN THE SPEC?

BY SAM BAER AND MATTHEW TROEMNER

AISC IS SET to release the 2016 edition of the *Specification for Structural Steel Buildings* (ANSI/AISC 360-16) in the near future.

Changes from the 2010 edition reflect the Committee on Specifications' desire to implement only essential changes that reflect new research, provide for more efficient designs or broaden its scope. Many of these changes were technical in nature, though edits were also made that focused on improving usability, transparency and editorial content.

The following is a brief overview of the most significant changes, some of which have the potential to substantially affect design procedures. A complete list of differences between the 2010 and 2016 AISC *Specification* will soon be available as a free download at **www.aisc.org/manualresources**.

HSS Standards

ASTM A1085 and ASTM A1065 have been added to the 2016 *Specification* as approved hollow structural section (HSS) material standards. ASTM A1085 is a newly developed material standard that has more stringent requirements than other already approved HSS standards (such as ASTM A500), including a mass tolerance and a stricter wall thickness tolerance. As a result of these requirements, the design wall thickness can be taken as the full nominal wall thickness.

ASTM A1065 is an HSS standard based on the use of already approved ASTM plate material standards. Due to the similarly reduced tolerances of these existing plate standards, design wall thickness for A1065 can also be taken as the full nominal wall thickness. It is important to note, however, that the 2016 *Specification* still requires that the design thickness of other HSS materials, including the more common ASTM A500, be taken as 0.93 times the nominal wall thickness.

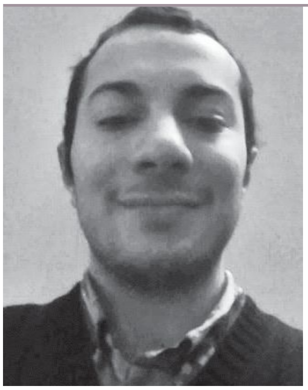
Additionally, ASTM A1085 and A1065 specify a minimum yield stress of 50 ksi regardless of shape. Further information on the benefits and impact of A1085 is detailed in the September 2013 article "Hollow Product, Solid Benefit," available at **www.modernsteel.com**.

Slender Elements in Compression

The method for determining compressive strength of members with slender elements has been revised in the 2016 *Specification*. Since 1969, the *Specification* used an approach centered on a reduction factor, Q, which modified the column critical stress. For slender unstiffened elements, Q was given by equations that included the width-to-thickness ratio of the element and was a constant for a particular shape, regardless of the load on the column; these Q values were tabulated in the *Manual*. For stiffened elements, Q was based on the ratio of a reduced effective area to the gross area of the member and was a function of the magnitude of the column stress.

While the 2010 *Specification* used a reduced effective area approach for stiffened elements, this methodology has now been refined and expanded to include both stiffened and unstiffened elements. The new provisions determine the reduced effective area and use that along with the unmodified column critical stress to determine compressive strength. As in the past, classification of members as slender element members, as determined in Table B4.1a, is based on the assumption that the column stress has reached the yield stress, F_y. Thus, members that were considered slender in prior editions of the *Specification* continue with that same designation. However, because the magnitude of the stress on the column influences the local buckling of the member elements (for all but round HSS), members that have been designated as slender element members may not actually experience a reduction in strength due to that slender element. For round HSS, the effective area is based on the diameter-to-thickness ratio and the yield stress of the material.

The changes in determining compressive strength for mem-



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The provisions for double angles and tees in flexure have been reorganized for clarity.

ASTM A1085 and ASTM A1065 have been added to the 2016 *Specification* as approved HSS material standards.

bers with slender elements have significantly altered the nominal compressive strength of select steel shapes (the difference for one such case is shown in Figure 1). Further information on the impact of this change and other affected shapes can be found in the third-quarter 2016 *Engineering Journal* article "Notes on the AISC 360-16 Provisions for Slender Compression Elements in Compression Members."

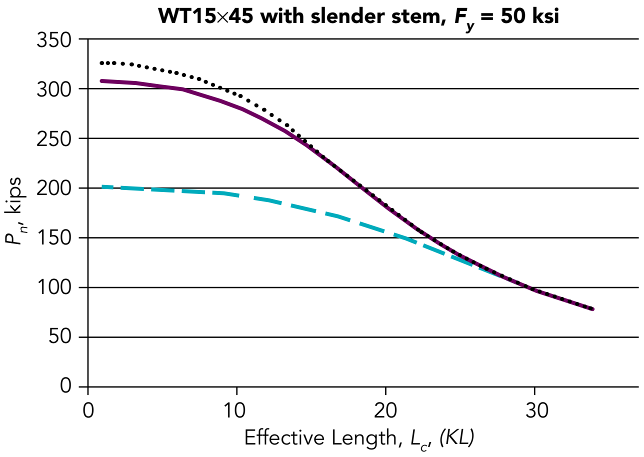


Figure 1. Comparison of available compressive strength to effective length from the 2010 to the 2016 *Specification*.

Shear Strength for I-Shaped Members and Channels

Chapter G of the 2016 *Specification* includes two significant changes in the provisions for I-shaped members and channels. The provisions for determining shear strength without consideration of tension field action have been revised to allow for inclusion of some post-buckling strength. This leads to an increase in available shear strength for certain built-up girders. In addition, the web plate shear buckling coefficient has been increased from 5 to 5.34 to better reflect its theoretical derivation. Since all W-shapes have webs that will be controlled for shear by the limit state of yielding, these changes will not impact the shear strength of these members.

For tension field action, several of the restrictions found in the 2010 *Specification* have been relaxed—designers may see some increased shear strength for interior panels of beams with stiffener spacing less than or equal to the height of the beam web in cases that previously could not have taken advantage of tension field action.

With the increase in available shear strength, the requirements for stiffeners have been increased. If the increase in available shear strength is to be used, larger transverse stiffeners than were required by the 2010 *Specification* may be necessary.

Angles, Double Angles and Tees in Flexure

The provisions for double angles and tees in flexure have been reorganized so that the distinction between their provisions is clearer. In addition, the lateral-torsional buckling provisions for stems and legs in tension are given separately from the provisions for stems and legs in compression. Flange local buckling provisions for tees have remained unchanged but for double angles it is now clear that strength should be determined as that of two single angles. Stem local buckling of tees was added to the 2010 *Specification* for the first time and these provisions have been revised in 2016 to more correctly reflect the strength for this limit state. As with flange local buckling, stem local buckling of double angles is to be assessed as for two single angles.

The 2016 *Specification* contains revised provisions for the lateral-torsional buckling limit state of single angles that are simply a reorganization of the previous editions equations. The nominal moment strength is a function of the elastic lateral-torsional buckling moment, formerly defined as M_e and now as M_{cr}, which is given for bending about the major principal axis of all single angles or the special case of bending about the geometric axis of equal leg angles.

Connections

The requirement for length of longitudinal fillet welds when used alone in end connections of tension members has been revised. The requirement from Section J2.2b—that weld length be at least equal to the distance between the parallel welds—has been replaced by a revised approach for calculation of the shear lag factor in Section D3 for longitudinal welds in end connections of tension members. Thus, shorter welds, as well as different length parallel welds, are permitted, but the resulting shear lag factor will be small and the strength of the member will be

▲ Welding requirements have seen some changes in the new spec.

reduced accordingly. In addition, the specific situational limitations for fillet weld terminations, stopped short or extended, have been removed and replaced with a performance-based requirement that the termination does not result in a notch subject to applied tension loads. The weld also must not prevent deformation required to provide assumed design conditions.

Two new ASTM bolt standards originally approved in 2014, that address bolts with a minimum tensile strength of 200 ksi, have been approved for use in the 2016 *Specification*. These bolts have been incorporated into the *Specification* via the designation Group C bolts and cover ASTM F3043 and F3111 material. To date, these are only available as proprietary products, but ASTM encourages other producers to propose alternatives. Another change implemented by ASTM that impacts the *Specification* is the development of a summary bolt standard, F3125 which includes the former A325, A490 and similar standards as grades. For Group A bolts of diameters greater than 1 in., the specified minimum bolt tensile strength had previously been 105 ksi and is now the same as for smaller bolt diameters: 120 ksi. This increase results in a higher available slip resistance for larger Group A bolts.

The requirement of pretensioned bolted connections in multistory structures over 125 ft for column splices and connections of beams and girders bracing columns has been removed, since it was arbitrary and could not be supported by any technical rationale. Additionally, for bolts of diameter 1 in. and greater, the maximum nominal diameter of standard size holes and the maximum nominal width of short-slots and long-slots has been increased by 1⁄16 in. The increase in maximum allowable hole size provides for greater ease of erection when connections make use of large-diameter bolts.

Chapter K in the *Specification* was changed from “Design of HSS and Box Member Connections” to “Additional Requirements for HSS and Box Section Connections” to reflect a change in approach that uses the requirements of Chapter

▲ The new version of the specification includes a handful of significant updates to bolted connections.

J when applicable to HSS connections and only uses Chapter K for specific requirements pertinent to HSS and box-section connections. This resulted in the Chapter K tables being revised to reflect a reduction in the types of connections covered in that chapter, with the other cases treated according to the more fundamental approaches provided in Chapter J.

Analysis and Fire Conditions

Appendix 1 permits the use of analysis methods that are more sophisticated than those normally used in design. Section 1.2 has been added to Appendix 1 in the 2016 *Specification* to permit elastic analysis that includes direct modeling of system and member imperfections. The advantage of this analysis approach is in the determination of compressive strength using only the member cross-section strength without the need to consider member length effects.

For fire design, the 2016 version of Appendix 4: Structural Design for Fire Conditions includes two additions. A new table relating bolt temperature to available strength is provided, and a simplified method is presented for calculating the nominal flexural strength of a composite beam using the bottom flange temperature. This new method incorporates the use of a tabulated retention factor dependent on the bottom flange temperature and the nominal flexural strength of the composite beam at ambient temperature, calculated according to the provisions of Chapter I.

These are just some of the changes to the *Specification* and should not be thought of as the only ones that might impact a particular project. A complete review is highly recommended so that one is familiar with the new version when building codes that incorporate it are adopted. For additional information on the major differences between the 2010 and 2016 *Specification*, take a look at the 2016 NASCC: The Steel Conference presentation "An Overview: The 2016 AISC Specification for Structural Steel Building," available at **www.aisc.org/2016nascconline**. ■

business issues

ACHIEVING SUCCESS ONE MISTAKE AT A TIME

BY MICHAEL HOWELL, SE, PE

The best engineers are the ones that make mistakes—and learn from them.

I USED TO BELIEVE that good engineers never made mistakes.

I have since learned that good engineers have just learned to never make the same mistakes twice. This has become apparent to me in the decade or so I've been doing this (yes, I am an engineer). I know some would look at my experience and say, "That's a long time," while others would suggest that I've only just started this journey. But one thing that's certain is that I've made a lot of decisions during my stint as an engineer. Most were good ones, but I've had some bad ones in there too. Each one has taught me something, but the bad ones seem to do it in a way I am less likely to forget. One of those "bad" lessons has stuck with me since my first week on the job.

Right into the Deep End

My story begins right after I graduated from college in 2005. I went to the University of Pittsburgh and was blessed to receive a job offer from American Bridge Company. On my first day, I was told I would be relocating to Washington, D.C., to work on the Woodrow Wilson Bridge project—the ten-lane, $200 million bascule portion of the much larger $2.5 billion beltway project. After spending a few days at the home office familiarizing myself with the project, buying my first pair of real work boots and packing my clothes and an old TV in the back of a truck, I was off to our nation's capital for my first taste of "real work."

It is every kid's fantasy (who likes construction) to be on a site like the one I was greeted with as I walked toward the project trailer that first morning. The cranes were tall, the steel was big and the equipment was loud. The sound of rolling machinery and the pounding of the ironworkers' "beaters" clanking against the steel was the perfect soundtrack to the landscape. The words "awestruck" and "overwhelmed" don't begin to capture everything I was feeling as I craned my neck to take it all in.

Michael Howell (mhowell@alleghenydesign.com) is director of sports and recreation with Allegheny Design Services.

The only thing that could have elevated my spirits more that first day was the news I heard from one of the project managers. The Discovery Channel would be visiting the project that very same week to film the show *Extreme Engineering*. If being on a construction site like this one was every kid's fantasy, then being on a show like *Extreme Engineering* was certainly every engineer's!

The episode would be centered on what was being referred to as the "heavy lift." Essentially, the heavy lift comprised the center portion of half of the outer loop (about three lanes of traffic). The assembly being lifted was a monstrous 100-ft-long × 50-ft-wide mixture of steel floor beams, stringers and cross-bracing all supported inside the nearly 15-ft-tall custom plate girders that served as the main load bearing elements for the span. At just shy of 500 tons, there was no denying that this was a serious operation well deserving of the nearly yearlong preparation that went into developing a plan to lift and fabricate it.

The plan for the lift entailed picking the piece at its four corners using strand jacks. The assembly would need to be lifted off of its resting place from a barge below and set into place within a fraction of an inch. An engineer and several ironworkers would man each of the corner strand jacks. It was the ironworker's job to work the jack while the engineer would measure each stroke and report it back to the chief engineer for analysis. The goal was to lift the assembly nearly level because too much tilt in any direction might have caused the jacks to seize. And since the jacks could only move in one direction, having one seize midway through the operation could spell disaster.

I remember that everyone arrived early that morning, most of us long before the sun had even started to creep over the horizon. Electricity seemed to be coursing through the air as we fastened our harnesses and grabbed our hardhats. In small groups, hushed conversations over steaming cups of coffee tended towards the fact that there was no "Plan B" should this fail. The only feasible method to get this piece into place was the operation we were about to undertake. We didn't have a crane on-site that could lift it; the only barge big enough to support it would need to depart the site shortly after we started, and the channel had to be open for national security reasons by that afternoon.

It would not be dramatic to say that this was a high-pressure moment for everyone involved. The size, manpower and physical constraints of the lift were enough to put everyone on edge. The presence of a TV crew and the many VIPs from both DOTs (who were also there to observe the first time both shores would be linked on the new structure) only added to it. For a fresh-faced, green engineer in his first week in the real world, it was rather intimidating. My hands were shaking so badly that I was having trouble climbing the ladder to the platform.

For all that was riding on this, the lift started with little fanfare. Just a command across the radio to take up the slack, and then we were off. In 18-in. increments, the 500-ton monolith of steel began to rise from the waters of the Potomac River. For the next eight hours, it would be up to each engineer to make sure everything was going according to plan from our tiny perch above each corner.

Growing Concern

Almost immediately though, we had a problem. The measurements on the jack I was monitoring were slightly off from the other three—not by much, just fractions of an inch. But after a few hours and countless lifts, those minor discrepancies were beginning to add up to the point we were starting to get concerned. As the piece inched closer and closer, the chance that it may not fit into its spot was becoming a very real, and very frightening, possibility.

The problem grew to the point that the legendary ironworker superintendent, Ugo Del Costello (known as "Hokey"), began to take an interest and approached my platform to see what was happening. Hokey was a salty, iron-jawed, no nonsense guy that often reminded me of Sam Elliot's character (Sgt. Major Plumley) from the movie *We Were Soldiers*. By the time I would leave the project a year-and-a-half later, I had so much respect for Hokey though that I would have probably climbed the bridge balanced on my fingertips rather than risk disappointing him. But at the time, he scared the living daylights out of me.

Hokey looked over my shoulder and in a moment had identified the problem. The next minute brought forth a string of mostly incoherent, but nonetheless colorful, adjectives about what exactly he felt they taught us "college kids." During this tirade, I was able to pick out the phrase that would forever stick with me: "He's holding the tape backwards." What he was referring to, and what I would soon learn, was that the "engineer stick rulers" we were using to record our measurements actually had two sides. The front side showed 1⁄16-in. increments while the backside 1⁄10-in. increments for surveying. While the other engineers were reading the front side, I was reading the back side and calling my measurements out as though they were quarters of an inch. When your tolerance is a fraction of an inch and you are taking measurements over and over again, even this seemingly small difference can add up to a real problem.

Once we figured out my error, the rest of the lift proceeded without incident. The piece landed exactly where we predicted it would, the ironworkers finished bolting it in place and everyone shared a collective sigh of relief as we climbed down from our platforms. In the end, the show captured beautifully the intensity of the whole operation and even included a cameo shot of yours truly holding the now famous stick ruler up to the jack (although it must have been filmed *after* I corrected myself because I'm clearly holding it in the right way in the clip).

Lessons Learned

I have thought about this day a lot though over the course of my career. Occasionally, I remember being on the Discovery Channel and even sometimes I think about Hokey. But what has struck with me through every project since then are the two lessons I learned that morning.

First, education is a beautiful thing. I have always loved learning (so much so that I even married a teacher). As engineers, I think we take a lot of pride in our education. I always believed that education would provide me with the answers I needed for the challenges I would face in the real world. But I wouldn't have learned in a 100 years of education what I needed to know that day. Yes, we need education to do our jobs. But we also need to step outside of what we can read and study to learn by observing our surroundings. For a structural engineer like myself, that means seeing my designs not just through the lens of statics, physics or geometry but also as something that must get built by real people using real tools and methods. Oftentimes, we need to open our eyes and realize that all of answers we have learned in our education are useless unless we first ask the right question.

Second, details matter. I couldn't appreciate it then, being so new, but I have an idea now of just how big of a process that lift (and that whole project) was. I think of the thousands of decisions that had to be made right in the months and years leading up to this effort by the hundreds of people involved in it before me. And yet, the tiniest decision—which side of the tape the lowest engineer on the project should read—could have undone them all. Since then, I take pride in my ability to pick up on the details. The "what" is great, but if you don't also know the "how, why, where, when and who" that go along with it, then you don't really understand the problem. In every project since, I've strived to find the details that have eluded me on the last one, always pursuing that perfect project with every *i* dotted and *t* crossed. Because details matter in our business.

For a long time, I didn't tell this story. Maybe I didn't want to believe it was OK for an engineer to make a mistake. After all, we are paid to give solutions. But what I've learned since is that good engineers aren't immune to making mistakes; they are just smart enough to own them and do their best to never make the same ones again.

Architecture as ART

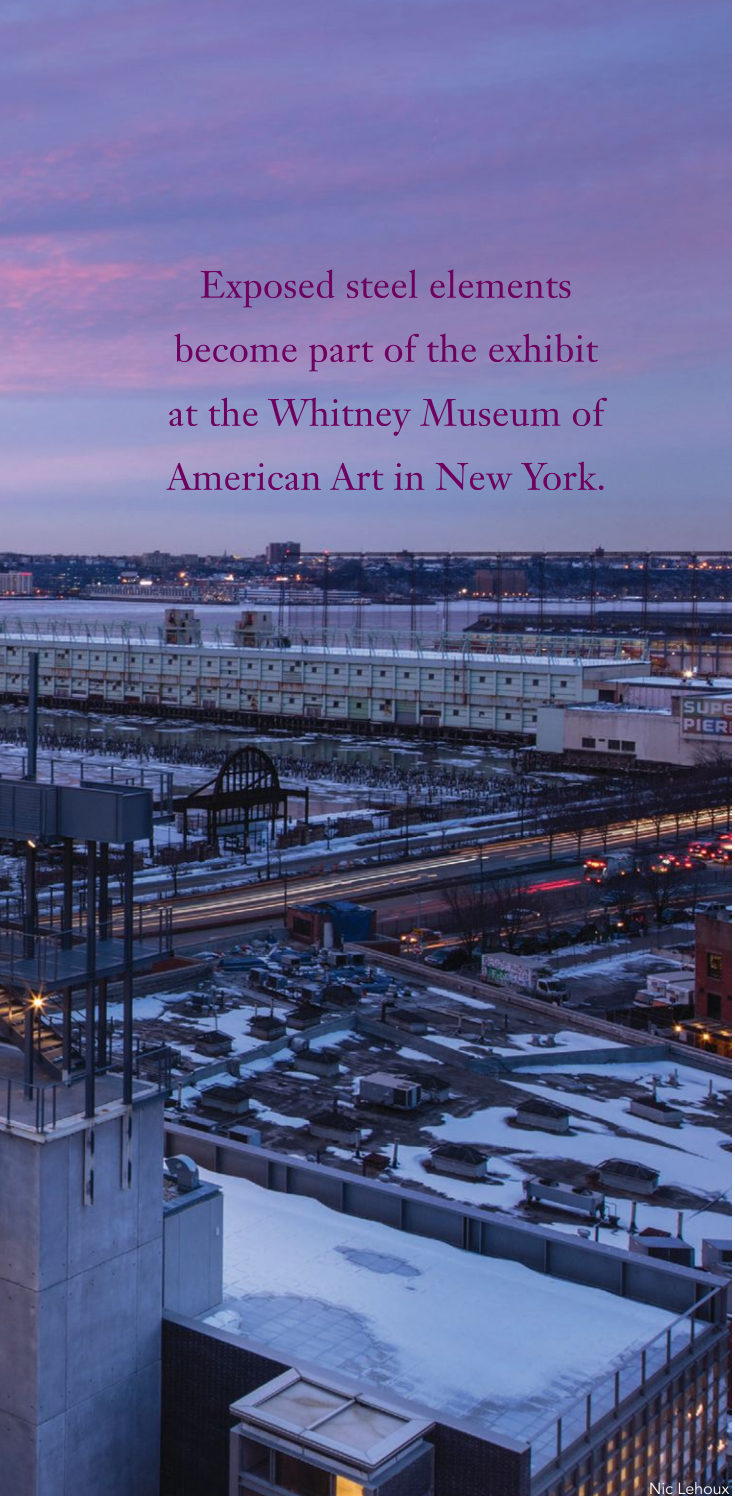
BY SHINJINEE PATHAK, PE, AND VICTORIA G. PONCE DE LEON, PE

Shinjinee Pathak (pathak@silman.com) is a senior engineer and **Victoria G. Ponce de Leon** (poncedeleon@silman.com) is an associate, both with Silman.

THE WHITNEY MUSEUM OF AMERICAN ART has had quite the journey.

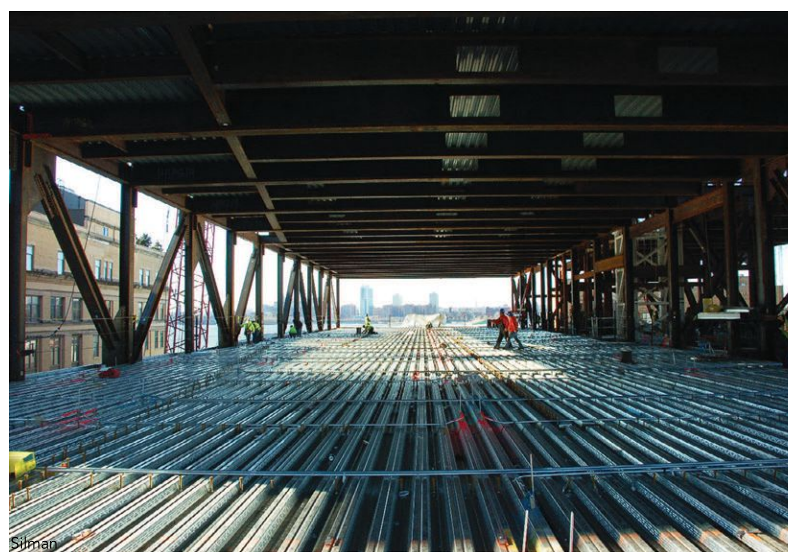
Founded in 1931 by socialite and art patron Gertrude Vanderbilt Whitney, the museum has been located in several spaces in Manhattan. In 1966, the museum moved to its Marcel Breuer-designed home on the Upper East Side with a collection numbering some 2,000 pieces—which has grown to 22,000 pieces today. To better showcase these thousands of modern and contemporary works, as well as to provide ad-

Exposed steel elements become part of the exhibit at the Whitney Museum of American Art in New York.



Nic Lehoux

Silman



Silman

◄ ▲ ▼ The superstructure of the museum uses steel framing with concrete-on-metal-deck slabs to achieve the design's requirement for long spans and open spaces. W14 sections were used for the majority of the columns and braces, with the largest section being a W14×500.

ditional programming space, the museum commissioned a new building located in Manhattan's dynamic Meatpacking District, nestled between the High Line and Hudson River.

The nine-story, asymmetrical building, designed by Renzo Piano Building Workshop (RPBW) features tiers of terraces and glazed walkways that step down to the High Line. Cantilevering dramatically over a public plaza, its set-back entrance opens into a nearly 10,000-sq.-ft lobby. A theater, office, support spaces and expansive new galleries—one of which, an 18,000-sq.-ft column-free space, is the largest open-plan museum gallery in New York City—are located on the floors above. At the top floor, the "studio" gallery and a café are naturally lit by a saw-tooth skylight system. The new building provides over 50,000-sq.-ft of indoor gallery space and nearly 13,000-sq.-ft of outdoor gallery space for the museum.

The structural design for the new Whitney building was developed by Robert Silman Associates (Silman) to provide flexible, open-plan galleries for the museum and to achieve the architectural vision of a simultaneously imposing and inviting urban structure. The typical challenges of coordination were even greater for the design of the Whitney, where high-end architecture meets high-profile artwork. To satisfy the needs of the institution, wants of the architects, demands of the mechanical and electrical systems and limitations of the construction site, Silman was heavily involved in coordination and in some cases, aesthetics.

The superstructure of the museum uses steel framing with concrete-on-metal-deck slabs to achieve the design's requirement for long spans and open spaces. The south half of the building houses the four main galleries on the fifth through


Nic Lehoux

eighth floors, each with a larger floor plan area than the one above. The open plan layouts programmed by RPBW provide flexibility for movable partition walls and displaying large art installations. The gallery floors were also designed for loads of 50 psf to 100 psf in addition to the minimum 100-psf code-required occupancy live loading to accommodate heavier art installations atop the floor framing or art loads hanging below the floor framing. Three of four outdoor terraces are extensions of the interior gallery spaces, necessitating increased load allowances for supporting art displayed in these areas.

Anchor points on the terraces and north facade of the Whitney are designed to provide flexibility for hanging or bearing large art installations. Silman collaborated directly with the museum to strategically locate the anchor points and design them for an acceptable capacity. Since its opening, the Whitney has retained Silman as the structural engineer for reviewing the structural feasibility and impacts of exhibits and installations.

Seismic System

Although New York is not thought of as a high-seismic area, the building's location on poor soil and its irregular geometry resulted in a seismic-controlled lateral design. The building was assigned to Seismic Design Category D based on the code in effect at the time. However, by performing a dynamic response spectrum analysis, Silman took advantage of an allowance by the *New York City Building Code* to design the building under Seismic Design Category C. In addition to a modal analysis, Silman performed a lateral pushover analysis to confirm that the trusses, which act as lateral elements in addition to supporting gravity loads, were stiff enough to not yield during a seismic event.

A central spine along the architectural core of the building effectively separates the north and south diaphragms. The locations of the lateral frames on the south side of the building were limited by the large open galleries on the south side of the core. These limitations on the frame locations introduced load path discontinuities as well as transfer elements (beams and trusses) at nearly every floor. The geometry of the building's lateral system also created torsional irregularities, diaphragm discontinuity, a weak story, a soft story and both in-plane and out-of-plane offsets in the lateral system, such that most lateral elements were designed for over-strength, thus requiring several very large structural members. W14 sections were used for the majority of the columns and braces, with the largest section being a W14×500.

Clever Cantilevers

Large cantilevers serve as both structural elements and architectural features of the building. The five upper stories cantilever in two directions over the lower four floors. The 25-ft-long to 80-ft-long cantilevers are achieved with a full-story truss that spans along the south side of the fifth-floor gallery. The south truss is supported from north-south spanning two story trusses, with top chord framing of 46-in.-deep built-up plate girders. These north-south spanning trusses are left exposed in the office spaces on the fourth and third floors.

At the front of the building the north-south trusses are supported by slender, architecturally exposed structural steel (AESS) round columns. These vary in height from 15 ft to 55 ft and are 15 in. in diameter, with the exception of the tallest column,

Handling Mechanical

The mechanical, electrical and plumbing (MEP) systems for an art museum are by necessity extensive and, as a result, can be very heavy. Silman coordinated with the architect and MEP engineers to keep main ducts aligned and sized the steel beams to allow for large web penetrations spaced evenly in the main galleries where structural framing is exposed in the ceilings. The double-height basement space houses the majority of the mechanical units and piping, much of which was laid out during the construction phase of the project. To avoid overstressing the slab on metal deck flooring system, anchor points and loading for all hanging MEP equipment were individually reviewed for structural impact and coordinated between Silman and the contractor.

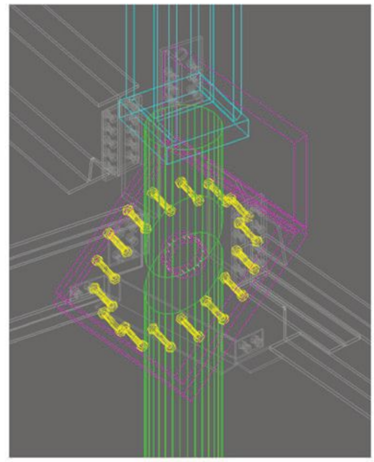
◄ The new building provides over 50,000-sq.-ft of indoor gallery space and nearly 13,000-sq.-ft of outdoor gallery space for the museum.

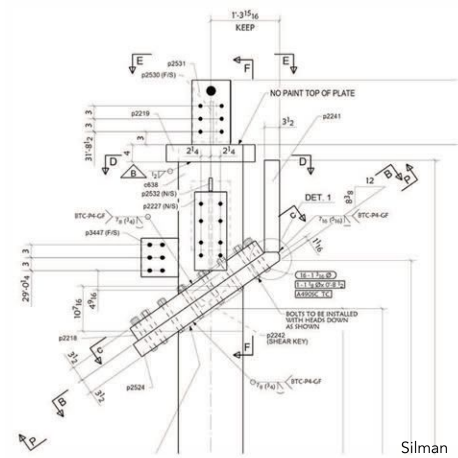
which is 22 in. in diameter. To maintain the small diameter relative to their height, the majority of the columns were designed as exposed round hollow structural sections (HSS), while the more heavily loaded HSS columns—such as the 55-ft-long, 22-in.-diameter column at the building's southeast corner—were filled with high-strength concrete and vertical rebar for increased strength and stiffness. (Some of the 20-in. and 22-in. round columns used on the project are actually solid steel, not HSS.)

These columns and their top and bottom connections are exposed within the lobby space, so their appearance was vital to RPBW's design; the lobby columns alone account for approximately 150 tons of steel. The slope and skew of the building facade extends to the column splice plates, creating complex three-dimensional connections that transition between the interior and exterior spaces. Silman used Rhinoceros' 3D modeler to understand the geometry for detailing the plates, bolts and thermal breaks, and worked closely with the steel detailer as well as the steel fabricator, Banker Steel, to understand any constructability concerns.

The facade of the Whitney Museum consists of three different systems: precast, steel panels and glass. Steel panels (manufactured by Gartner)—3/8 in. thick, 3 ft., 4 in. wide and up to 60 ft long—clads much of the exterior of the building. These panels are hung from the top and braced back laterally at each floor. The beams supporting the panels for gravity at the top were designed for the full weight of the panel, and the lateral connections provided redundancy to support the weight of the panels in the unlikely event that an upper connection fails.

A glass wall supported by a cable system wraps around the first-floor lobby and restaurant. Following the sloping profile of the lobby ceiling, the cable wall ranges in height from 24 ft to 45 ft, with tension points ranging from 20 kips to 85 kips. In the initial coordination of the glass cable wall and structural support, performed in cooperation with curtain wall consultant Heintges and Associates, Silman provided load path assumptions, deflection expectations and stiffness values of the primary building structure. In return, Heintges provided tension forces in





Silman

A connection detail for one of the complex exterior column assemblies.

the cables and the resulting loads imposed on the structure above and below. After several iterations to fine-tune the cable wall system and supporting structure, the connections were designed to allow for field adjustments to the pre-stressing of the cables.

Stunning Stair

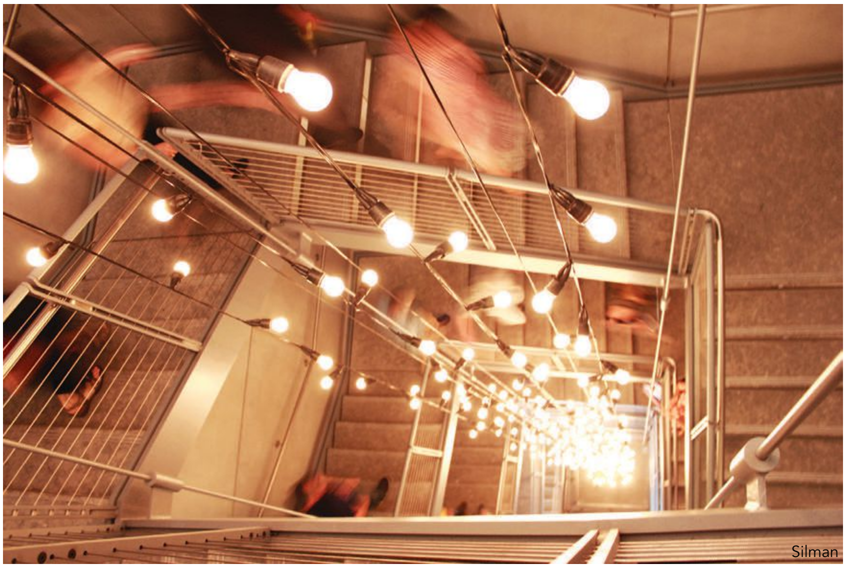
The interior feature stair, which spirals up from the lobby to the fifth-floor gallery, is possibly one of the most photographed spaces within the museum, partially due to the ethereal art installation (by Felix Gonzalez-Torres) cascading down its central open core. Throughout the design process, Silman

Close Call

In October 2012, the project received a bit of a wake-up call. With the building foundations substantially completed and the superstructure construction ramping up, Superstorm Sandy hit New York and flooded the Whitney site.

With the installation of the first-floor framing was nearly complete, it was clear that simply reinforcing the floor structure and glass cable wall for a higher flood elevation would not be sufficient; the building would require a robust system of barriers, gates and flood doors to protect it and the artwork inside from future flood events. Silman helped design the attachments of this system, collaborating with Cooper Robertson Partners (CRP) and RPBW to architecturally integrate these attachment points into the building's design.

The interior feature stair spirals up from the lobby to the fifth-floor gallery.



Silman

collaborated with RPBW to provide a stair that was aesthetically pleasing, designed for the strength requirements of the local building code and dynamically satisfactory from a user-comfort perspective. The stair stringers are solid 2.75-in.-thick by-9-in.-thick routed plate profiles supported at two points on each side by steel plates that knife through the 6-in. precast panel architectural walls on three sides of the stair. The stair is also supported around its central core by 0.75-in.-diameter rods hung from steel beams between the fifth and sixth floors. Two of the four rods are connected to the first-floor structure by a custom spring clevis, and the rods are coupled at each floor by a custom connection (both the clevis and connection were designed by TriPyramid). The stone stair treads are designed to act compositely with the steel plate below the tread that spans down the center from stringer to stringer.

Due to the architectural requirements of the building design, the structural design team had to be adaptable and creative in the design of the structural system and, in many cases, take the lead on coordination to acquire and incorporate information from all parties. The team worked tirelessly to coordinate between the design consultants and construction personnel and find solutions to all of the challenges, all while keeping the goals of the museum as the top priority. The result is a building where structure is on display, enhancing both the architectural design and the art within. ■

Silman

HSS X-bracing.

Owner
Whitney Museum of American Art, New York

General Contractor
Turner Construction, New York

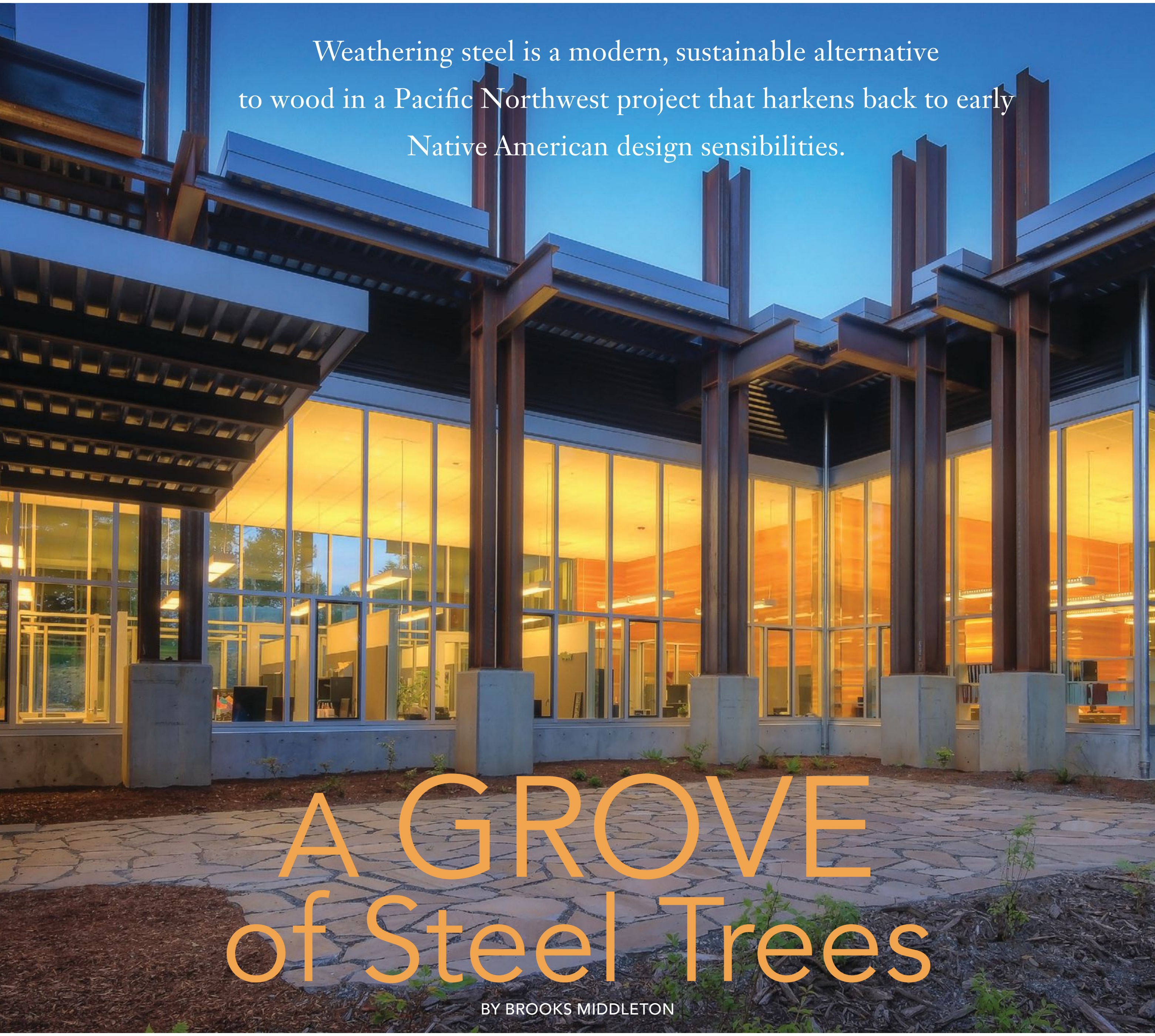
Architect
Renzo Piano Building Workshop, Genoa, Italy

Structural Engineer
Silman, New York

Steel Fabricator
Banker Steel, Lynchburgh, Va.

The steel-supported exterior stair and observation deck.

Silman



Weathering steel is a modern, sustainable alternative to wood in a Pacific Northwest project that harkens back to early Native American design sensibilities.

A GROVE of Steel Trees

BY BROOKS MIDDLETON

WHILE SOME BUILDINGS strive to gain notice, others, like the Stillaguamish Natural Resources Department Offices and Water Quality Lab building, would rather blend in.

Located in a forested area on a bluff above the flood-prone Stillaguamish River in Arlington, Wash. (about 50 miles north of Seattle) the building replaces several outdated structures that housed the Stillaguamish Tribe of Indians' Natural Resources Department (NRD) in the floodplain below. The 13,000-sq.-ft, one-story building and paved areas are sited in an existing clearing to minimize removal of the surrounding trees, and the natural setting enhances the work environment of the NRD employees.

Creating a sustainable, culturally sensitive structure was the driving mantra of the NRD's Building Committee. The project includes many green attributes, such as storm-water treatment via bio-retention rain gardens, permeable walkway paving, ground-source heat pumps, radiant-floor heating and extensive daylighting. And its architectural and structural design embraces sustainable practices and goals.

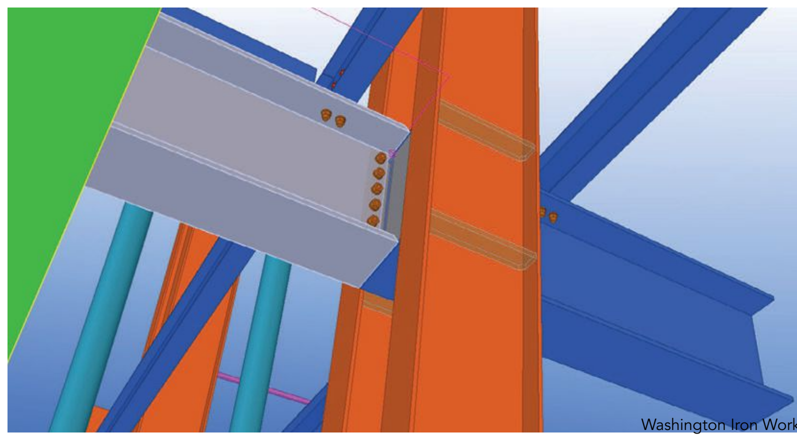
While researching early Northwest Coast Native American design style, which included reviewing countless historical building photos, the design team identified several common themes. The most prominent of these was the use of heavy wooden post-and-beam construction, resulting in straightforward structural design


Jacob Knapp C9 Photography


Brooks Middleton

▲ Double-columns were used to emphasize the "knifed" structural connections of the roof beams.

▼ A Tekla rendering of the roof edge assembly.


Washington Iron Works

◄ ▼ The double-columns extend 10 ft beyond the roof line and intersect with the roof beams, which in turn project beyond the facade, to create the impression of a modernist log cabin.


Brooks Middleton

and simple material palettes. However, the use of exposed heavy timber was not appealing for this project, due both to the loss of trees and the short life span of exposed wood in built structures. The solution was to use weathering structural steel (200 tons) whose patina gives a nod to the large timber frames of the historical structures both in terms of mass and color. The perimeter framing columns are exposed on the exterior of the building and extend 10 ft above the roof line. The roof support beam assemblies also project beyond the facade—sometimes serving to cantilever the roof and sometimes simply cantilevering into open air.

The steel structural members were connected in a manner that brings attention to the intersections of the wide-flange beams and

Brooks Middleton (**brooks@brooksmiddletonarchitect.com**) is the owner and principal architect of design firm Brooks Middleton, Architect.

Jacob Knapp C9 Photography

The 13,000-sq.-ft building boasts column-free interior spaces.

columns. The 1-in.-thick base plates, using 1-in.-diameter anchor bolts with heavy nuts, are intentionally positioned in a repetitive manner around the building near eye level. The eye then naturally ascends the columns to observe the beauty and simplicity of the exposed-column-to beam connections. Exposed secondary and tertiary roof beams and the final layer of metal decking are all visible from below.

Once the framing plan was established, the interior and exterior walls were located to meet the program functions of the building. The concept of adaptable space was typical for large community buildings of early Northwest Coast Native American groups, where family units set up interior walls as needed to create their own spaces within the larger building. The interior column-free design allowed nearly all interior and exterior walls to be glazed, thereby providing the occupants a connection with one another as well as the surrounding natural environment.

By designing the steel framing using moment connections, the exposed beams and columns are actually the gravity and lateral load-bearing elements of the building. The vertical framing incorporates double-columns, which, again, were chosen to emphasize the "through" nature of the structural connections. Instead of roof beams butting into columns, the members run past and through each other, requiring two columns to achieve a balanced structure. These intersections were fairly complex. The double-column and exterior beam extensions were fabricated in the shop as a column tree assembly, and the main member running inside the building was added on-site, such that the roof beam appears as a single piece extending outside the envelope between the columns, but is actually three pieces. The assemblies are made up of two 27-ft-tall W18×50 columns, with an intermediate shop-welded W21×83 extending 5 ft, 6 in. from the center of the columns to form the roof edge. The fabricator/erector (Washington Iron Works) was careful not to paint itself into a corner with the welding sequence when it came to welding the double-columns to the beam extensions.

Jacob Knapp C9 Photography

The design allowed nearly all interior and exterior walls to be glazed, thereby providing the occupants a connection with one another as well as the surrounding natural environment.

Jacob Knapp C9 Photography

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Creating a sustainable, culturally sensitive structure was the driving mantra of the NRD's Building Committee.

Continuing the roof beam assemblies through the building envelope created another potential issue in the form of thermal bridging. There was concern that the temperature differential between the interior and exterior of the building, especially in the winter, could cause the beams to condense on the interior. As such, the team elected to cover the interior of the large penetrating beam assemblies (the portion a few feet in from the exterior wall) with spray-on rigid insulation and fireproofing. The building has made it through two winters with no condensation issues.

The seasonal changes that the facility have endured thus far have also allowed the exposed weathering steel to develop its patina, thus completing the natural, wood-like aesthetic. With its modern take on historic, natural architecture, the building will work in harmony with its surroundings for years to come, providing an appropriate and attractive work space for those who are tasked with managing the area's natural resources. ■

Owner
Stillaguamish Tribe of Indians, Arlington, Wash.

General Contractor
Quantum Construction, Inc., Anacortes, Wash.

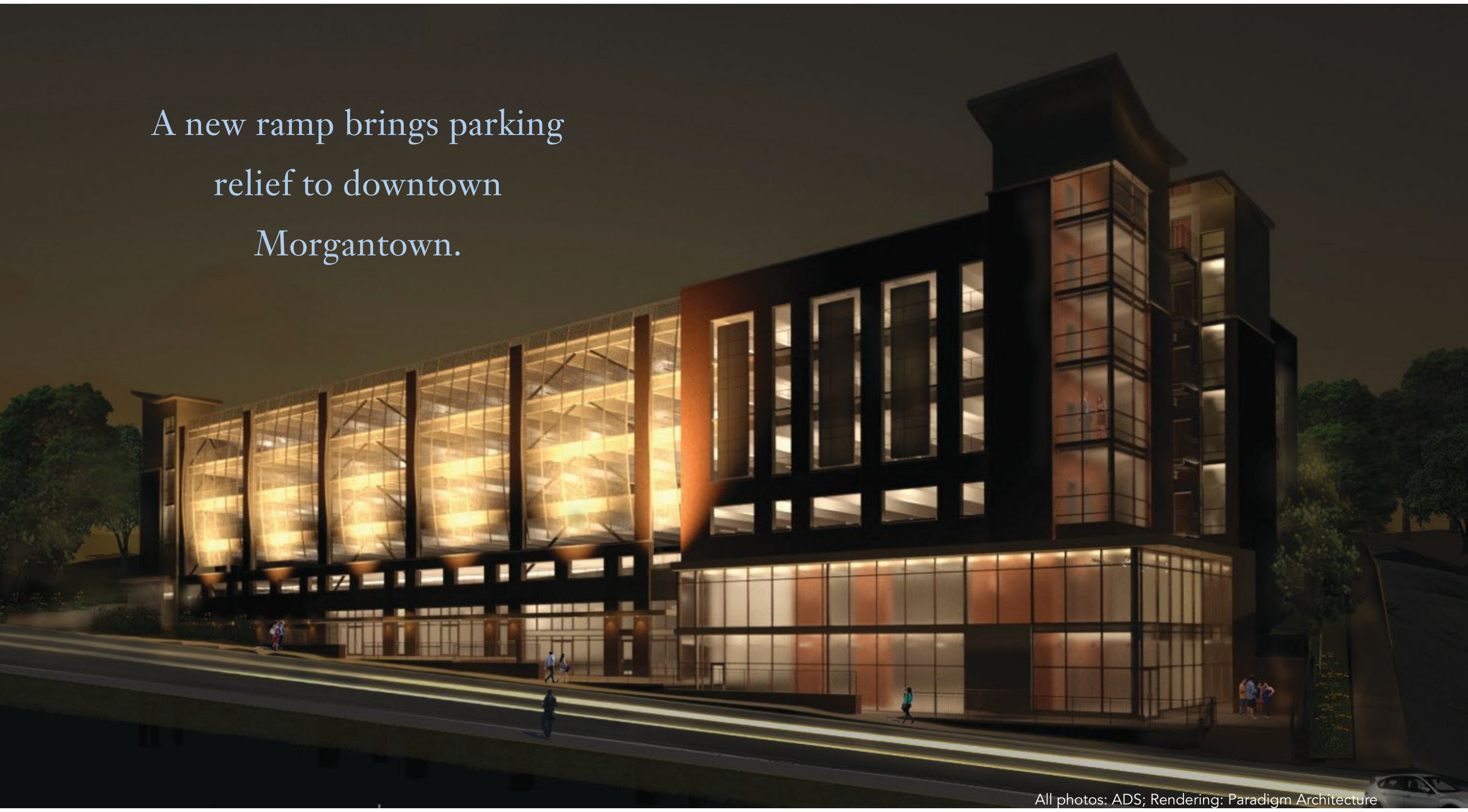
Architect
Brooks Middleton, Architect, Anacortes, Wash.

Structural Engineer
Andersen Bjornstad Kane Jacobs, Seattle

Steel Fabricator, Erector and Detailer
Washington Iron Works, Inc., Oak Harbor, Wash.

Preferred PARKING

BY JASON D. ROBINSON, PE



All photos: ADS; Rendering: Paradigm Architecture

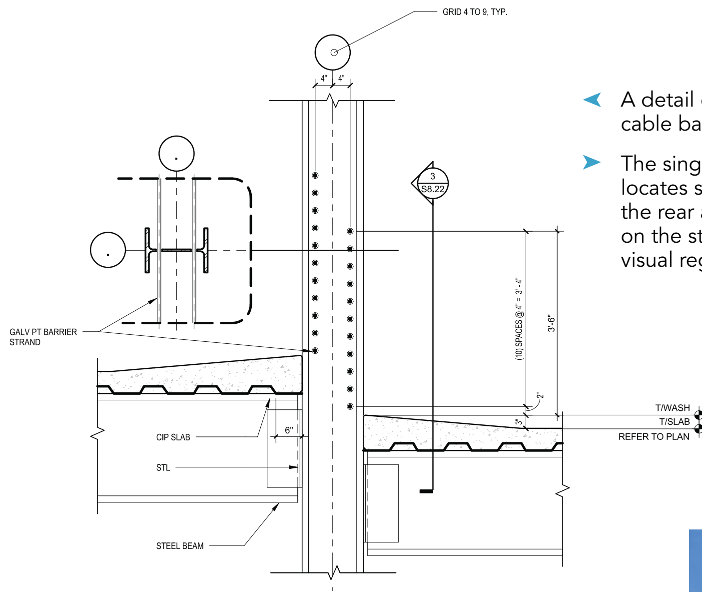
MORGANTOWN, W.V., excels at natural beauty and football, among other things.

Home to West Virginia University and its acclaimed Mountaineer football team, the town of roughly 30,000 (twice that when WVU classes are in session) sits amongst the rolling hills of northern West Virginia along the banks of the Monongahela River.

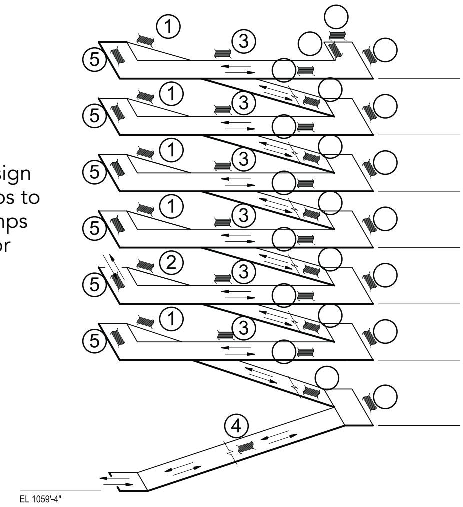
But one thing the town lacks is public parking, particularly in the downtown area. However, a recently completed parking garage is helping to meet parking needs. Built to service the University Place apartment development as well as provide public parking for retail stores in the area, the project is a public-private partnership between WVU and Downtown Campus Parking.

Completed in December 2015, the garage is six levels high, with 390 parking spaces and 12,000 sq. ft of retail space at the ground floor, and sports a red brick veneer with a metal screen cladding system for the parking areas. And it's framed in steel, an option selected by the contractor over common concrete alternatives for several reasons:

- Precast concrete would have been shipped in from out of state, resulting in a long lead time
- The contractor/erector, March Westin, is very proficient with conventional steel construction
- Contracting Engineering Consultants, the fabricator, is just a few miles from Morgantown, thus minimizing shipping distance
- Conventional steel framing was more architecturally flexible than precast, which was a major consideration for a parking garage in an historic downtown area



A detail of the cable barrier.



The single-helix design locates sloped ramps to the rear and flat ramps on the street side for visual regularity.

The base of the garage incorporates 12,000 sq. ft of retail space.

Chevron bracing comprises the lateral-force-resisting system.

The steep grade and tight site created challenging construction conditions.

Battling the Elements

The big question with any parking structure is how to minimize corrosion. A common misconception is that concrete parking structures do not have corrosion issues, when, in fact, they can start to corrode beneath the surface long before there are cosmetic concerns. The truth is that all parking structures require periodic maintenance, for both aesthetic and structural reasons.

For this steel-framed garage, corrosion protection came in the form of both galvanizing and a zinc-rich primer. All of the main beams columns and beams were coated with Carbozinc 11 FC. Braced frames, designed in a chevron pattern, made up the lateral-force-resisting system, and simple bolted connections were used for this system. The lateral system elements were hot-dip galvanized.

The protection requirements presented a challenge when it came to erection since March Westin didn't want the coating to become damaged, so the connections were designed in such a fashion that no field welding was necessary. A composite beam system was used, with shear connectors welded to the top flanges of the beams in the shop prior to painting.

Jason D. Robinson (jason@alleghenydesign.com) is a senior structural engineer with Allegheny Design Services.

▲ The garage uses 1,230 tons of structural steel in all.

▼ The metal screen system on the facade curves from top to bottom.

➤ Shear connectors were welded to the beams in the shop to protect the coating.

The deck system was composite—concrete slab on top and vented, galvanized deck beneath. The vents are meant to allow any water that might seep through the concrete slab to escape, thus preventing water build-up between the bottom of the concrete and the metal deck. The garage also incorporates a tension cable barrier for vehicles and pedestrians. All steel members for the barrier system were hot-dip galvanized as well, and all connections were either welded in the shop before galvanization or bolted in the field.

When it came to the metal screen system, attachment proved challenging due to the different deflections of the beams on each level depending on car movement and loading. Every upright had a slotted connection and the metal cladding was curved, which made for complicated layouts in the field. Also, every connection featured nylon bushings to allow for movement between the outriggers on the beams and the aluminum uprights. (This might not seem like much, but when everything has to line up perfectly on a curve and installation is happening with 80-ft hydraulic man-lifts, things can get difficult.)

Dense Downtown

Downtown Morgantown is relatively dense, not to mention on a fairly steep grade, leaving little wiggle room when it came to erecting the structure. Overhill Street, to the side of the garage, is at a 23° grade, and roof steel had to be set out of the elevator tower via a crane man-basket because there wasn't an area level enough for a regular man-basket to reach. The site was particular challenging in the winter, as the various cranes needed to be maneuvered around in icy conditions on the steep grade to install the various steel components.

The lack of lay-down room required a higher level of coordination when it came to steel deliveries. Individual trucks had to be loaded in order of erection so beams could be rigged for erection directly on the truck. The proximity of the trucks to the road was a safety concern because the beams would have to be lifted above the road before they could be swung into place. This was alleviated by stopping traffic every time a pick was made. Given the size of the members, each had to be picked individually. In addition, because the beams had the studs attached prior to erection (again, to protect the coating), this made it impossible for the iron workers walk the steel as it was being erected. As such, all field connections had to be made via man-lift instead of traditional methods.

Owner
West Virginia University and Downtown Campus Parking, LLC, Morgantown, W.V.

General Contractor
March Westin Company, Morgantown

Architect
Paradigm Architecture, Morgantown

Structural Engineer
Allegheny Design Services, Morgantown

Specialty Engineer (Cable Barrier System)
Carl Walker, Kalamazoo, Mich.

Steel Fabricator and Detailer
Contracting Engineering Consultants, AISC CERTIFIED FABRICATOR
Maidsville, W.V.

Thanks to this project, which used 1,230 tons of structural steel in all, the team discovered that a steel-framed parking garage was both faster to build than a concrete alternative and much more appealing from an architectural perspective. And as a result, downtown Morgantown now has an attractive new parking option. ■

▲ HSS braces resist lateral loads without creating large visual obstructions.

▼ The elevator lobby is bright and airy with tall windows, high ceilings and exposed structural elements.

RETHINKING Multifamily Residential

Braced staggered steel trusses provide a superior solution for a new residential tower in Connecticut.

BY NISSIM ELMANN, ALI MAHER, PE, AND NEIL WEXLER, PE, PhD

Marc J. Harary, City Architectural Photography

Nissim Elmann (nelmann@nwexler.com) is a project engineer, **Ali Maher** (amaher@nwexler.com) is a principal and **Neil Wexler** (nwexler@nwexler.com) is principal and founder, all with Wexler Associates in New York.

STAMFORD, CONN., IS ALL BUSINESS. Well, perhaps not entirely, but the city does boast the largest financial district in the New York City metropolitan area outside of New York itself and is home to multiple Fortune 500 and 1000 companies.

And a new residential tower will soon rub shoulders the city's more business-minded edifices. Located on Summer Street in downtown Stamford, Summer House comprises 16 stories of residences above a six-story parking garage that also houses a gym and retail stores. The L-shaped building is constructed to property lines, but because adjacent properties had retail tenants and are also owned by the same developer, the tower needed to extend 8 ft to 15 ft over these properties and be constructed without any interruption to the exisiting tenants.

The project was originally intended to be concrete. However, high costs associated with the material, difficult site logistics, a complex program with multiple tenant types and a challenging foundation scenario led the owners to explore other framing alternatives. Structural steel was recommended by contractor Erland Construction, and a mixed-type structure—with steel beams and columns and precast plank floors—was further proposed by the steel fabricator, Ocean Steel.

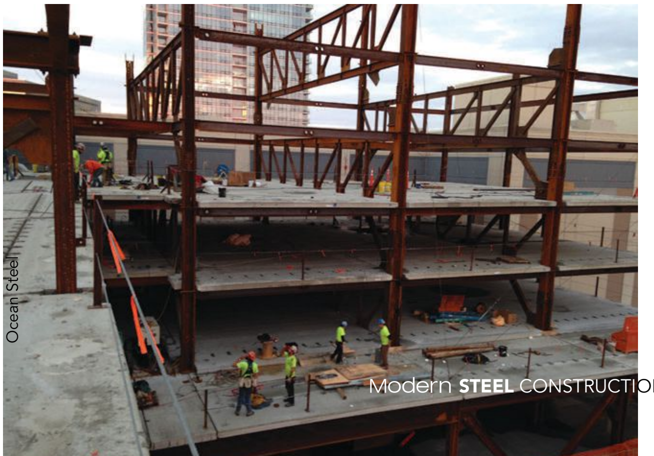
Wexler Associates was chosen as the structural engineer, thanks to its experience designing towers on small and tight urban sites with difficult logistics and constructability challenges, with the expectation that its new steel design would deliver a building within the original budget. Wexler redesigned the tower in stages. At each stage, budgets were prepared to verify that expenses did not exceed targets. By the time schematic design drawings were complete, the estimates verified that costs met expectations. The redesign took approximately eight weeks and construction proceeded on time according to the original schedule.

The L-shaped Summer House project is constructed to property lines and extends 8 ft to 15 ft over adjacent properties owned by the same developer.

Marc J. Harary, City Architectural Photography

Marc J. Harary, City Architectural Photography

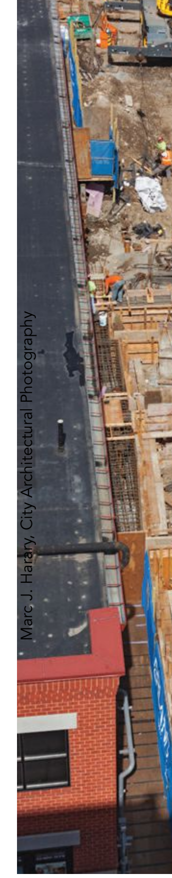
The project's framing system was switched from concrete to steel, and the redesign took approximately eight weeks—with construction proceeding on time according to the initial schedule.



Ocean Steel


Marc J. Harary, City Architectural Photography


Marc J. Harary, City Architectural Photography

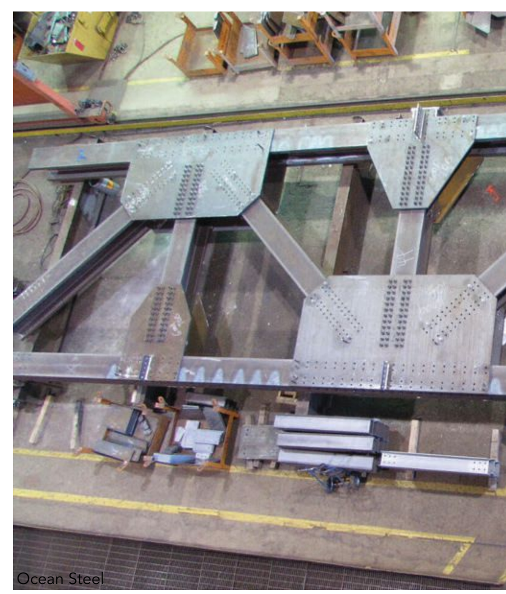

Marc J. Harary, City Architectural Photography

Views of the 16-story tower during construction.

Because building tenants required uninterrupted access to the streets, storage area for materials was nonexistent outside of the building footprint

The residential levels use a system of braced staggered trusses supporting plank floors. This modified version of a typical staggered truss reduces diaphragm demands and also provides structural redundancies with little increase in weight and cost.


Ocean Steel

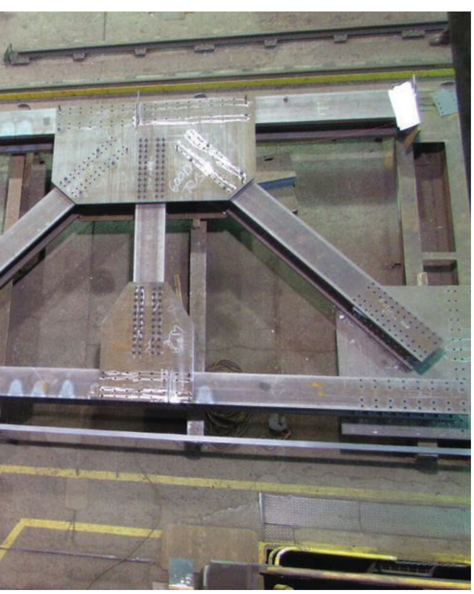

Ocean Steel

Hanging Out

From the start, the challenging site conditions could have had a significant cost impact. The tower was designed to cantilever over adjacent occupied buildings, and access for erection was limited to a narrow corridor. Because building tenants required uninterrupted access to the streets, storage area for materials was nonexistent outside of the building footprint, cranes and hoists needed to be embedded into and through the superstructure and access to adjacent buildings and rear yards could not be used for staging.

The team built a deep foundation, with caissons drilled 30 ft down into rock, and underpinned adjacent properties and grade beams 10 ft to 12 ft down. Long-span steel framing with composite deck was used for the garage levels, and a staggered truss system with plank floors was designed for the residential floors. A transfer level integrated the tower and the garage. Retail was easily incorporated at the lower levels, and a health club, pool and other amenities were located on the fifth floor.

Above the garage, the residential levels use a system of braced staggered trusses supporting plank floors. Braced staggered trusses, a modification to a more typical staggered truss system, are a good solution for seismic zones because they reduce diaphragm demands and also provide structural redundancies with little increase in weight and cost. They also reduce column bending during construction, thus decreasing column sizes. Additional horizontal bracing, located between the trusses and within the depth of the floor construction, helped reduce the use of temporary rods and cables during erection, thus speeding up the process.



Marc J. Harary, City Architectural Photography

Located on Summer Street in downtown Stamford, the project comprises 16 stories of residences above a six-story parking garage that also houses a gym and retail stores.

In addition, the regular geometry provided by the staggered trusses reduced both structural material and structural labor. Because the trusses are shop-built, field erection is limited to the column splices, spandrel beams and miscellaneous incidental steel. Interestingly, erecting the six-story garage took longer than erecting the 16-story tower on top.

The efficient use of steel kept the framing system to the desired quantity of 13 lb of steel per sq. ft. Together with the resulting reduction in floor-to-floor distance and more efficient foundations, the savings over the original concrete option were substantial. And in a part of town where efficiency and smart business practices are no doubt appreciated, the building stands as a positive example of structural steel's efficiency. ■

Owner
Summer House, LLC, Stamford, Conn.

General Contractor
Erland Construction, Inc., Burlington, Mass.

Structural Engineers
Wexler Associates, New York

Architect
Lessard Design, Inc., New York

Steel Fabricator and Detailer
Ocean Steel Corporation, Conklin, N.Y.

International COOPERATION

BY SELÇUK AVCI

Concrete was ruled out in favor of steel for the Congo Kintele Congress Centre, as steel met the project's schedule, financial and sustainability goals.

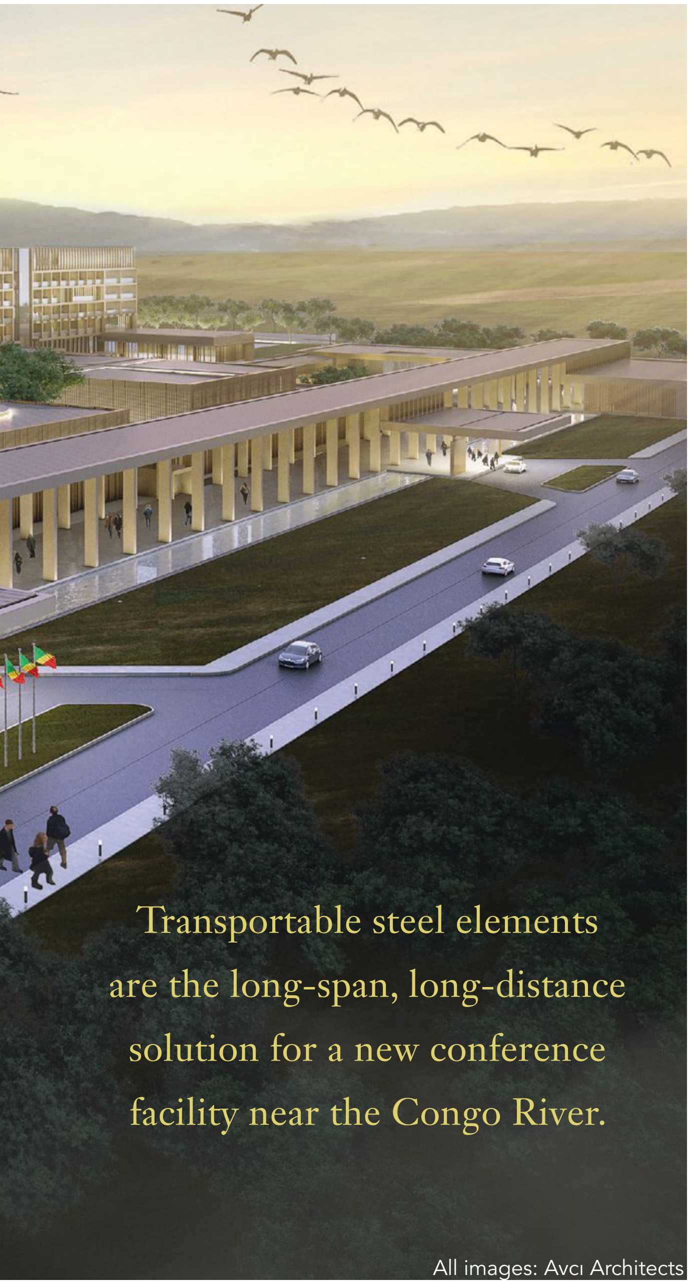
Selçuk Avcı is the founder and senior director of Avcı Architects.

THE NEWEST CONGREGATION FACILITY FOR the African Union was, rather fittingly, designed to exist in harmony with its surroundings.

Located in a newly developing Kintele area of the Republic of the Congo's capital city of Brazzaville, the steel-framed Congo Kintele Congress Centre has panoramic views of the Congo River to the south and a forested landscape to the north. The positioning of the buildings is largely dictated by the site's topography—a valley carved by the Congo River—and the buildings sit parallel to the contours of the valley.

Designed by Istanbul-based Avcı Architects and structural engineer Emir Mühendislik, with Summa as the general contractor, the facility was built to host summits of the African Union and includes the adjacent 200-room Kintele Resort Hotel.

The 1,500-seat congress hall, 300-person presidential hall, 1,000-seat banquet hall and public piazza are positioned in a linear sequence interrupted by courtyards, and all are linked by a 350-m (1,148-ft) sheltered colonnade, framed with encased steel, that links these elements. The hotel is



All images: Avcı Architects

The Piazza, retail space and restaurant.

The west entrance, congress hall and press hall.

The courtyard area, which encourages gathering between meetings.

positioned 5 m (16 ft) above this general public promenade, both to give it better views to the river and to create a separation of functions on the site. The colonnade also acts as a linear public space in and of itself, sheltering people from the rain that prevails for a significant portion of the year in this part of the world. The two ends of the colonnade act as public gates to the complex, which also includes a press hall, museum, shops and a restaurant.

Framing materials for the project were largely dictated by speed of construction, availability, ease of transport and financial requirements, thus concrete was ruled out in favor of steel. Funded by Turkey's Exim Bank, which required at least 70% of the project's construction value to be sourced from Turkey, the project had to be finished in 12 months.

Choosing steel so early in the process also expedited framing design decisions, fabrication and delivery, because constructability concerns had to be integrated as early as possible As such, final construction-level thinking had to be adopted at the outset of the project rather than following design. (Our experience in Turkey is that a project often jumps from conceptual design to permit drawings to bid documents with little time for assessing the impact of design decisions—decisions that create situations that must be resolved during construction. But in this case, again, constructability was considered from the start, resulting in very few surprises during construction.)

The project included multiple areas where long, column-free spans were required, another reason why steel proved to be the best solution. A key framing decision was to use space frames for larger spans in the banquet hall and the presidential meeting hall, which provided flexibility in installing mechanical and electrical systems. While this resulted in a deeper structure than we initially preferred, the steel components were smaller and lighter—and easier to ship from Turkey. The

Building spacing was dictated by the site's topography.

Structural steel being erected.

Erection of roofing assemblies.

The museum.

The presidential hall.

congress hall required a shallower system to maximize ceiling heights, so steel trusses crossed the shorter span of the hall.

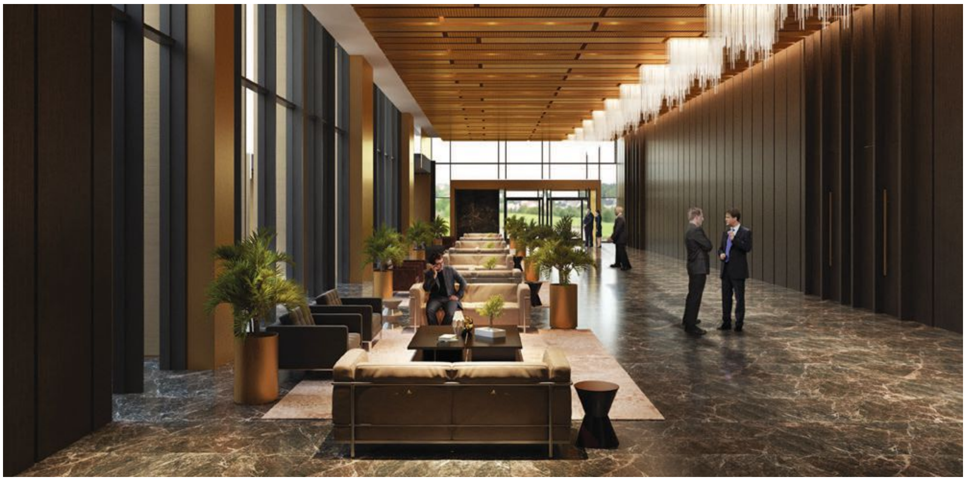
Steel construction also allowed the contractor to quickly erect a weathertight enclosure—again, in an exceedingly rainy region—so that interior work could begin while facade work continued. This was crucial, as the project had to be finished on time for several prebooked events.

Not only did this endeavor result in an attractive, important structure in a naturally beautiful environment, but it also gave us valuable experience with steel design—all in a fast-paced project located far from home. As the construction market becomes more global, we anticipate that investors will increasingly choose steel framing to take advantage of its economical, efficient and architecturally pleasing characteristics, all of

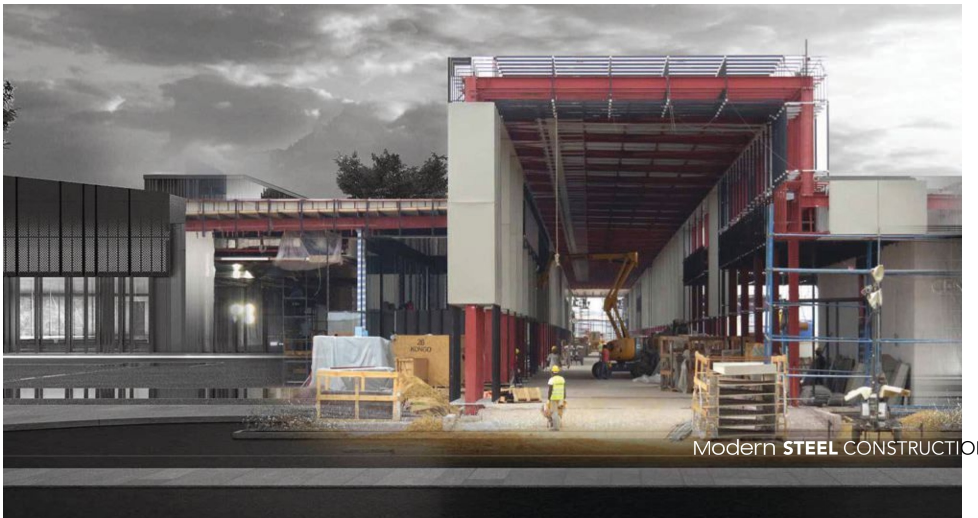
The congress hall will host meetings of the African Union.

The foyer of the presidential hall.

The hotel and pool.



Framing for the west entrance.



which are especially important for multifaceted, high-profile projects. And as architects, we look forward to creating more buildings that leverage these characteristics in our designs. ■

Implementing effective hearing-conservation training in structural steel fabrication starts with listening to your workers.

Have you HEARD?

BY DONALD J. GARVEY

OCCUPATIONAL NOISE-INDUCED HEARING LOSS (NIHL) has been a major concern ever since the beginning of the industrial revolution.

And it's still a major concern for the steel fabrication workforce and management; noise levels of typical equipment such as band saws can exceed 100 decibels. Exposure to noise has also been associated with increased blood pressure, muscle tension, sleeplessness and fatigue. These can combine to potentially cause workers to skip procedures, take shortcuts and create safety hazards other than hearing loss, not to mention contribute to an overall lower quality of life.

One of the key elements of protecting worker hearing is implementing a hearing conservation training program. The question is, how can employers best implement this training to maximize its effectiveness and encourage long-term healthy hearing-related behavior?

Tackling Training

Because exposure to noise can be unpredictable and intermittent, it is important that workers are able to recognize hazardous exposures and know how to protect themselves. This is particularly crucial for young people just entering the trades. Most NIHL occurs in the first 10 to 20 years of exposure; any subsequent loss is mostly due to aging. So it is critical that hearing loss prevention, including proper training, starts right at the beginning of the worker's career—before it is too late.

However, effective hearing conservation training and use of hearing protection devices (HPDs) is often nonexistent at the workplaces that need them most. When training does occur, it often just covers the basic information required by OSHA 29 CFR 1910.95, *Occupational Noise Exposure*:

- ➤ Effects of noise on hearing
- ➤ Advantages/disadvantage of HPDs
- ➤ Basic use and care of HPDs

While these topics are certainly important, training on them doesn't address the critical topic of motivating workers to change their behavior for the better (i.e., wearing HPDs). It is important to develop a framework that delivers the information in a way that acknowledges the workers' needs and concerns. Research in the construction industry indicates that a person's decision to take action is determined by the expected outcome of that decision and their evaluation of those outcomes. Several studies have identified five cognitive/perceptual factors that appear to influence HPD use. These include:

Donald Garvey (djgarvey@mmm.com) provides construction technical service in 3M's Personal Safety Division.

- ➤ Self-efficacy: confidence in one's ability to perform a task—in this case to properly wear HPDs. Even if the benefits outweigh the barriers, the person may not take action unless they believe they can successfully carry that action out
- ➤ Barriers: expected negative aspects of the behavior
- ➤ Benefits: expected positive effects of the behavior
- ➤ Control of health: a person's perception of his/her ability to maintain personal health
- ➤ Value of use: the perceived importance of the outcome of using HPDs

Studies indicate that self-efficacy strongly influences a person's response to exposure to noise and wearing HPDs. These studies indicate that training should devote a significant amount of time to hands-on activities and demonstrations to help develop a high level of skill mastery in properly donning HPDs. Training should be done one-on-one or in small groups to allow interaction between the worker and the trainer. In addition, the trainer should be familiar enough with the work site so they can relate actual on-site exposures during training.

When it comes to barriers, these can include:

- ➤ Wearing HPDs may be uncomfortable
- ➤ Wearing HPDs may make it harder to hear speech or warning signals
- ➤ Using earplugs is perceived as being too complicated
- ➤ Worker underestimation of the danger of their particular noise exposure

Barriers should be identified and addressed in ways that are specific to the audience. For example, workers may think the band saw noise is insignificant as it occurs only intermittently during the day. Training may include a discussion of noise levels produced by each saw used, approximate duration of daily use and comparisons to recommended exposure duration limits for the noise levels noted.

Other training useful techniques include:

1. Use the most appropriate delivery format. In studies that compared video and manufacturer's printed instructions, one-on-one training was found to be far more effective in increasing the *effectiveness* of donning HPDs. Subjects with no experience using HPDs received one of the above training methods and then donned the HPD. The subjects were then tested to determine achieved noise reduction using the HPD. The video and printed materials training showed similar performance in noise reduction achieved after putting the HPDs on. However, the individually trained subjects showed an average of 5 db to 8 dB increase in *achieved* attenuation versus the other two training method subjects. Similarly, small group training was compared to one-on-one training and to only reviewing manufacturer's written instructions. They found a similar increase in achieved attenuation over written instructions for both small group and one-on-one training. There was no significant difference between the small group and one-on-one options. It appears that small group training would be sufficient, with one-on-one training being the better option if a worker subsequently demonstrates a significant hearing threshold shift. Both studies indicate that the chosen training method can be a factor between achieving adequate and marginal protection.
2. "Gain frame" the behavior. This means emphasizing the gain to be realized by performing the desired action. In the case of hearing-prevention training, gain framing would communicate that wearing hearing protection *prevents* hearing loss, *maintains* health and allows the worker continue to *enjoy* the sounds of family and friends. Contrast that with "loss framing"—e.g., by not wearing hearing protection, you are likely to *lose* your hearing and you *won't be able* to hear your family and friends.
3. Make the training location-specific. Discuss noise levels of the equipment that the workers actually use.
4. Keep any handouts to a simple reading and comprehension level. Use pictures instead of text in printed materials. If pictures are used, they must show the *exact* HPD and procedure to be used.
5. Emphasize management support for effective hearing conservation training and the importance of preventing NIHL. Company leaders must be highly visible in wearing HPDs and personally encouraging workers to do the same.
6. Use noise indicators. Noise indicators are small devices workers wear on their clothing. They typically flash red when noise levels exceed a preset level such as 85 dBA. This notifies the wearer that they are in a high-noise area. One study, implementing both baseline training, reinforcement talks and noise indicators, showed a marked increase in use of HPDs compared to implementing training alone. The noise indicator provided real-time information on noise levels and also acted as a reminder to wear HPDs.
7. Test HDPs for proper fit. Hearing protection can now be fit-tested to help the user understand how to wear it properly and help select HPDs with the appropriate protection level and maximum comfort.

Noise exposure and hearing loss is not a new topic, but it is an ongoing issue. You can help increase effective HPD use by hearing your training programs from the workers' side of the classroom. Listening to what motivates workers and using the most effective ways to communicate valuable knowledge and skills can help you improve your hearing conservation training and ensure that your workers don't endanger their hearing while they're on the job. ■

A Fluid SOLUTION

BY PAUL NUTCHER

A new shop-applied thermal break coating gives owners an option for increasing the energy efficiency of their buildings.

THERMAL BRIDGING HAS ALWAYS EXISTED— but it hasn't always received much attention in the U.S.

But that has changed over the past few years—especially with the rise of the green building movement—and designers are increasingly addressing it.

The concept is fairly straightforward: Steel or other metal elements that penetrate a building's facade or bypass the insulated portions of the building envelope can conduct heat or cold into the building, driving up heating and cooling costs. This can also create interior condensation, especially around balconies.

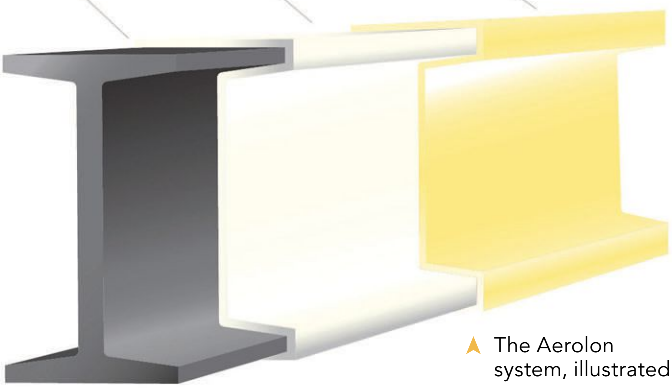
Several strategies—including non-conductive pads and shims or simply letting it occur and dealing with the cost—have been implemented, but a new approach has emerged in the form of fluid-applied thermal break coatings that can reduce or eliminate heat transfer. When applied in the shop or field for new or retrofit projects without impacting the structural design, these coatings can reduce the cost per connection for the fabricator while reducing the building's environmental impact through reduced energy consumption.

Pault Nutcher (pnutcher@greenappleconsult.com) is president of Green Apple Group, an advertising agency specializing in sustainability consulting and strategic, fully integrated marketing campaigns.

The coatings can provide thermal conductivity levels that are six to eight times more efficient than thermal break pads, as they change the surface temperature enough that moisture does not condense even without a physical break in the beam.

The Right Combination

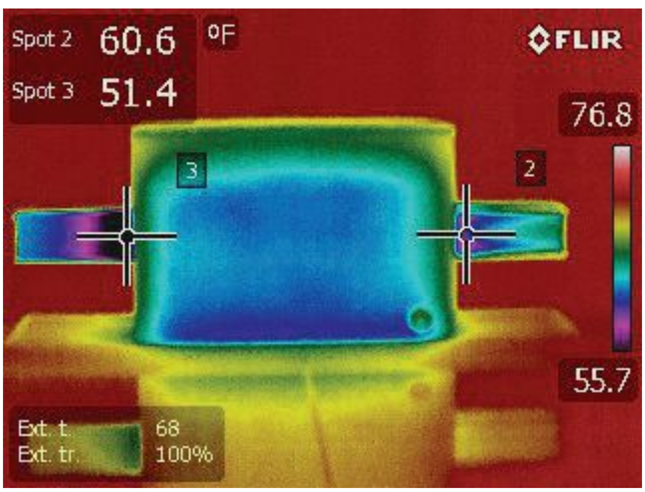
Typical insulation coatings are infused with fillers to produce a low-conductivity material that can be applied in its fluid form. The fillers can be ceramic or glass spheres, which can provide thermal conductivity in the 70 mW/mK to 100 mW/mK range. A new water-based acrylic coating from Tnemec Company, Inc.—Series 971 Aerolon—uses aerogel particles as the filler. Aerogels are solid, porous, low-density materials derived from a gel, with the liquid component being replaced with a gas. Thanks to the aerogel, Aerolon can provide thermal conductivity as low as 35 mW/mK.



The Aerolon system, illustrated.

▲ Coating on a beam that penetrates an exterior wall.

▼ An infrared image of varying temperatures in a coated assembly.



▲ Shop-application of the coating.

▼ Coated steel supporting a balcony.

Unlike structural thermal breaks, insulated coatings do not require additional engineering and do not incur additional fabrication and installation costs beyond application. As such, the cost savings of fluid-applied thermal-break coatings compared to thermal-break pads appear to be significant, as reported by a survey of fabricators performed by coatings consultant the Righter Group, Inc. In one analysis, the installed costs for fluid-applied thermal breaks was roughly 25% of the installed costs for thermal-break pads.

Application

In order to use a fluid-applied coating, the steel must first be prepped and then primed with a high-performance coating. The degree of surface prep depends on several factors—existing steel condition, environment, surface temperature, primer chosen, etc.—but will generally meet the requirements of SSPC-SP 6 *Commercial Blast Cleaning*. If it is determined that blasting is not required, then SSPC-SP 3 *Power Tool Cleaning* is sufficient. The primers used most often will be epoxies or zinc-rich coatings, though using zinc-rich primers is not generally recommended when in-service temperatures exceed 120 °F.

The coating should cover 18 in. to 24 in. of the penetrating beams, starting at the interior side of the exterior wall, and should also be applied to the portions of the beams that pass through the wall. If it is not practical to apply the coating through the total wall thickness, then it should be applied as far inside the exterior face as possible.

As with any project, especially one where a new technology is being introduced, communication is key. And in the case of addressing the issue of thermal bridging, communication is especially crucial between the fabricator and structural engineer and the project team members charged with the energy efficiency performance and condensation control of the building. A fluid-applied, thermal insulating coating using aerogel particles can help address these issues by imparting exceptional insulation properties to a building's structural steel components—and in doing so, boost the framing system's profile in contributing to a greener, more economic and more efficient building. ■

For more on thermal bridging, see the AISC publication *Thermal Bridging Solutions: Minimizing Structural Steel's Impact on Building Envelope Energy Transfer,* the product of a joint AISC/SEI committee. Download it for free at **www.aisc.org/sustainability** under "Resources."

Standing TALL

This year's Steel Design Student Competition challenged students to design onward and upward, with a focus on tall buildings.

ELEVEN STUDENT DESIGN PROJECTS have been honored in the 16th annual Steel Design Student Competition for the 2015–2016 academic year. Administered by the Association of Collegiate Schools of Architecture and sponsored by AISC, the competition encourages architecture students from across North America to explore the use of steel in structural design. A total of $14,000 in cash prizes was awarded to the winning students and their faculty sponsors.

Students competed individually and in teams in two separate categories that required steel to be used as the primary structural material and with special emphasis placed on innovation in steel design. The Tall Buildings category challenged students to find alternative design approaches for tall buildings and create high-rise buildings inspired by the cultural, physical and environmental aspects of place while embracing new technologies. In the Open Category, students were given the flexibility to select a site and building program.

The jurors for the Tall Building category were: Antony Wood, Council on Tall Buildings & Urban Habitat; Jon Magnusson, Magnusson Klemencic; and Gail Borthwick, Gensler. The jurors for the Open Category were Doris Sung, University of Southern California; Lee-Su Huang, University of Florida; and Elizabeth O'Donnell, The Cooper Union.

Two hundred and forty projects from 745 students were entered in this year's competition, and 78 faculty members served as student advisers. In total, 44 universities from across North America took part. To learn more about the competition, as well as view more images of each project, visit **www.aisc.org/studentdesign**. Here are this year's winners.

WINNERS – Category I – Tall Buildings

"This winning submission is programmatically ambitious, but believable and extremely well resolved."

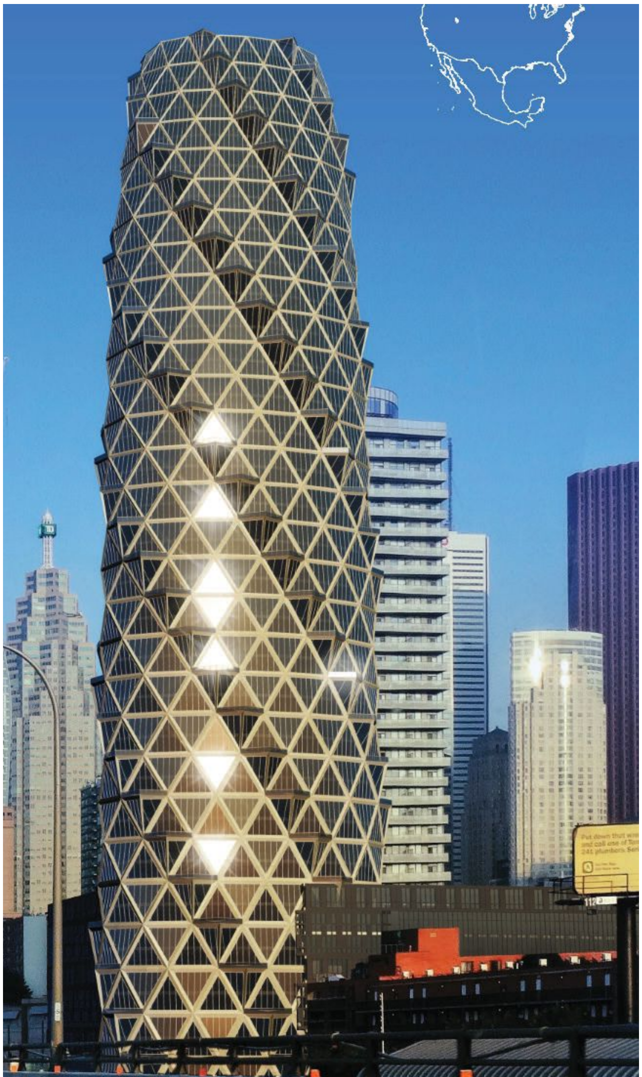
▲ **First Place: VERTICALI**
Student: Mario Ramos
Faculty Sponsor: Peter Stapleton Raab
School: Texas Tech University

VertiCali is a beacon of edible light, exposing is green contents to promote local food growth, healthy lifestyles and sustainable communities. It vegetates the urban core and connects downtown Los Angeles and East L.A. by creating a central food hub in the Arts District. Steel's strength allows outward undulation in the tower form to maximize solar exposure, and the trusses use a rigid frame system to isolate the lower structure from the surrounding ground while allowing an expressive and playful surface for the community gardens and elevated landscape over the rail lines that require a minimum clearance.

Second Place: DIAGROUP TOWER
Students: Scott Proudfoot, Mengdie Zhang, Sarah Donaldson and Gabriela Chorobik
Faculty Sponsor: Terri Meyer Boake
School: University of Waterloo

Diagroup Tower brings a diverse mixed-use program to Toronto's housing projects district, with the goal of upgrading former low-income housing into a denser and more diverse neighborhood. A courtyard typology was selected to mirror the rhythm of the existing townhouses' public and semi-public spaces while still increasing density, and the rotating tower form is a nod to the maelstrom of growth Toronto is currently experiencing. The project employs a whole-site thermal circulation system in which cool water begins its journey hundreds of feet below street level in geothermal exchange wells that tap into nearby Lake Ontario. The podium acts as a thermal reservoir, with a methane-fueled cogeneration plan augmenting winter heating.

"This persuasive project came directly off the drawing board and is ready to be built. This building could only be built with structural steel."



"This successful design put thought into how people actually inhabit the space along with how the exterior transfers to the inside."

Third Place: TESSELLATE
Student: Megan Stenftenagel
Faculty Sponsor: Robert J. Koester
School: Ball State University

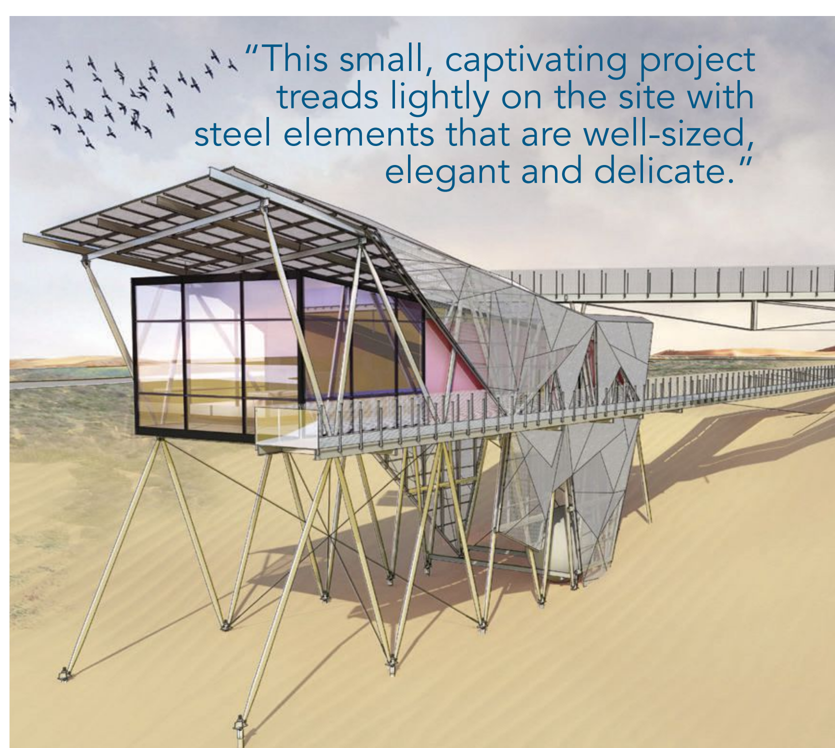
Vancouver's Cultural and Linguistic Living-Learning Community brings social groups together in interdependence to celebrate the city's diversity. The project challenges the separation of different social groups with the concept of a tessellation, in which each independent part, brought together in an artful composition, makes the whole more complete. The building can accommodate approximately 500 students from around the globe, and a central atrium opens the ground level for public interaction with an art gallery to showcase student work. Outside the atrium, an open plaza, covered seating and park area enable food truck vendors and artisans to gather, promoting visitors and residents to further explore the art of different cultural groups.

First Place: JUNCTURE
Students: John Berger, Sasha Francoeur
Faculty Sponsor: Robert Gillig
School: Boston Architectural College

This project activates underused waterfront airspace in Boston by extending a bridge across Commercial Street and into the North End. Through a series of steel acrobatics, three tectonically layered display spaces elevate themselves above the groundscape. As visitors rise up from the city via a steel pedestrian bridge, they are greeted with three layers of intervention: a column grid to reduce disturbance, a floated groundscape to activate the waterfront for the public and a diverse array of public display spaces clad in elegant steel systems composed of nuanced tectonic assemblies.

Second Place: THE NEST – Guadalupe Nipomo Dunes Wildlife Refuge Interpretive Center
Student: Edern Audrain
Faculty Sponsor: Jonathan Reich
School: California Polytechnic State University

The Guadalupe Nipomo Dunes Interpretive Center provides basic visitor information and facilities at the entrance to the dunes, as well as visitor access by means of a controlled walkway into the dunes that will not interfere with the seasonal sensitivities of the flora and fauna there. Intended to take advantage of the mild and very constant temperatures there, the building is equipped with triple-glazing and extra insulation and mainly serves to protect users from the wind and wind-driven sand. Steel was chosen for its efficient strength-to-weight ratio and its ability to minimize the on-site construction impact through carefully designed parts that can be installed piece by piece. Steel is also employed as the exterior cladding's sun/rain/sand screen and for the many building specialty elements (railings, fittings, etc.).



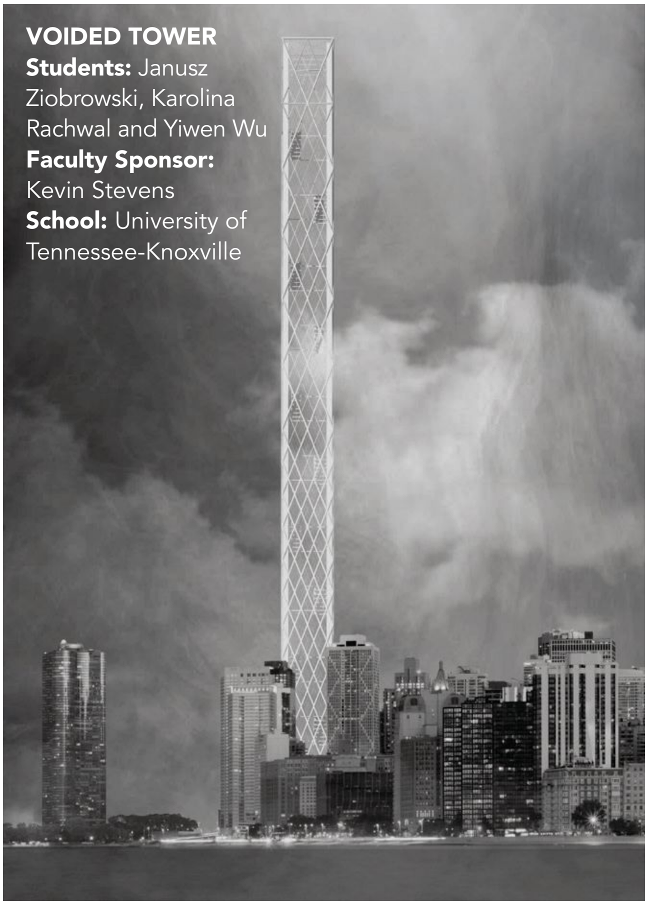
"This ambitious project's strength is in the articulation of a programmatic idea while using the delicate steel architecture design to stimulate the remediation of brownfields."

WINNERS – Category II – Open

- **Third Place: Productive | Accessible | Ecofriendly – BROWNFIELD REMEDIATION RESEARCH PARK**
  Student: Jesus J. Alfonso Pagan
  Faculty Sponsors: Luis Ayala-Rubio, Alberto Dueño Jordán, Jesús O. García Beauchamp, Carlos Quiñones-Maymí and Luis Alonso Conty
  School: Pontifical Universidad Catolica de Puerto Rico

The former PR#127 Industrial Park in Guayanilla and Peñuelas, Puerto Rico, hit its heyday the 1950s and 1960s but has since fallen into decay, with portions being dismantled and removed. As a symbol of the transformation from pollutant to purifier, the new facility for the Brownfield Remediation Research Park renders the silhouette of an inverted industrial archetype through long-span steel structures, all the while integrating itself into the industrial landscape through its high-tech aesthetic and the use of steel as the main structural material. This includes open-web girders that span from 80 ft to 120 ft, vertical and horizontal sunscreens, vertical trusses for curtain wall support and exterior steel grating elevated pathways that allow vegetation to grow below.

HONORABLE MENTIONS – Category I – Tall Buildings



VOIDED TOWER
Students: Janusz Ziobrowski, Karolina Rachwal and Yiwen Wu
Faculty Sponsor: Kevin Stevens
School: University of Tennessee-Knoxville

IM//PORT L.A. Tri-Commerce Epicenter for Los Angeles
Students: Michael Chin and Alexander Kim
Faculty Sponsor: Gerard Smulevich
School: Woodbury University

HONORABLE MENTIONS – Category II – Open

INNOVATION INITIATION within the Raymond Creative Enterprise Zone
Student: Bridget Geissler
Faculty Sponsor: Nat Madson
School: University of Minnesota

▲ **CREATURE**
Student: Xiaoyin Xie
Faculty Sponsor: Thomas Fowler
School: California Polytechnic State University

▼ **UNEARTH ARCHAEOLOGY RESEARCH CENTER**
Students: Trent Harrison and Andrew Lopez
Faculty Sponsor: Kevin J. Singh
School: Louisiana Tech University

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news

STEELDAY

Eighth Annual SteelDay Showcases Industry to Thousands

A webinar featuring a new documentary on one of America's greatest bridge designers drew more than 5,000 online viewers in celebration of the structural steel industry's eighth annual SteelDay on September 30. In addition, thousands of AEC professionals, students and others gained first-hand insight into the work, experience and accomplishments of the U.S. structural steel industry at dozens of networking and educational events at steel facilities and jobsites around the country, hosted by AISC and its members and partners. This year's national event also incorporated various online voting competitions.

"This year's SteelDay celebration continued the tradition of allowing design and construction professionals to gain insight into the structural steel supply chain and grow in appreciation of the expertise that the steel fabricator contributes to the successful completion of a project," said John Cross, AISC vice president.

The highlight of this year's SteelDay was a free on-demand screening of the new documentary film, *Bridging Urban America: The Story of Ralph Modjeski*, produced by sOlar eye communications. The movie illustrates the life story of Ralph Modjeski, the designer of some of the 20th century's most significant bridges, and his influence as an engineer, entrepreneur, artist and innovator. If you weren't able to watch it on SteelDay, purchasing information for the DVD is available on the film's website at **http://bridginguamericafilm.com**.

In the sixth annual SteelDay Sculpture Competition, AISC members crafted their own steel sculptures for a chance to be one of five finalists to have their creation put on display at the 2017 NASCC: The Steel Conference, March 22–24 in San Antonio, Texas. Nine sculptures were entered into the competition with their photos posted to **www.steelday.org/sculpturecompvoting**, where fans voted for their favorites. You can view all five finalists in the November Structurally Sound column "Final Five," available at **www.modernsteel.com**.

This year's SteelDay also celebrated 30 years of the AISC Steel Sculpture, a teaching sculpture made up of various steel members and connections that can be found on more than 170 college and university campuses across the U.S. Students entered photos of their campus' sculpture to be featured on AISC's Facebook page and voted on by fans during the week of SteelDay. The winners are: Christie Moore from Christian Brothers University; CJ Powell from Rochester Institute of Technology; Reggie Raney from Christian Brothers University; Lauren Santullo from The College of New Jersey; and Eric Bellville from the University of Central Florida. The winners are featured in the October 28 Steel in the News item at **www.modernsteel.com**.

Photos from this year's SteelDay can be found on AISC's Facebook page (**www.facebook.com/AISCdotORG**) in the SteelDay 2016 photo album. If you'd like your SteelDay photos featured in the album, please email **socialmedia@aisc.org**. Next year's SteelDay is scheduled for September 15, 2017. For more information, please visit **www.steelday.org**.

One of this year's many SteelDay events was a presentation on the new Tappan Zee Bridge north of New York City. Members of the design team provided insight on the project to a crowd of nearly 80 at a venue overlooking the bridge itself.

People and Firms

Cliffs Natural Resources, Inc., and the **American Iron and Steel Institute (AISI)** have announced that **U.S. Representative Rick Nolan (D-MN)** was honored with the 2016 Congressional Steel Champion Award from AISI. The award recognizes Rep. Nolan for his dedication to and support of the American steel industry and its employees.

Lourenco Goncalves, Cliffs' chairman, president and CEO, and **Thomas J. Gibson**, AISI president and CEO, presented the award at a gathering of Cliffs' employees at Hibbing Taconite mine in Hibbing, Minn.

"What an honor to receive this Steel Champion award from the American Iron and Steel Institute," said Nolan. "We've been fighting hard in Washington to support and protect Minnesota's workers in the iron ore and steel industries. The progress we've made is due to numerous appeals to the White House, the Commerce Department and the International Trade Commission to bring the hammer down on illegal steel imports that devastated the Iron Range economy."

In presenting the award, Goncalves said, "Congressman Nolan was instrumental in focusing the attention of the White House on the steel import crisis. He has fought for aggressive enforcement of our trade laws to combat these illegal imports in order to protect mining jobs on the iron range and to preserve our all-important domestic steel industry."

IN MEMORIAM

Amrit Das, Author of STAAD, Dies

Amrit Das, founder of Research Engineers International, Inc. (REI) and the original author of STAAD, passed away late this summer in Kolkata, India, after a battle with brain cancer.

Das changed the way structural engineers looked at design problems. By introducing finite element analysis—a specialty typically reserved for mechanical engineers to solve complex problems—to structural engineers whose results could easily be transferred seamlessly to steel or concrete design, he revolutionized how structural engineers approached problems, which ultimately led to more efficient designs.

Das was the chairman, CEO and founder of REI and then netGuru, Inc. He graduated from Bengal Engineering College in 1966 with a degree in civil engineering, and after starting his career at Catalytic Engineers, an engineering consulting company in Philadelphia, he decided to pursue his dream of starting his own engineering firm. He founded REI in 1978 after developing STAAD in his spare time using a used Telex machine, a borrowed VAX-11 and some late nights at the Drexel University library, learning FORTRAN. After taking some sound advice from John Walker (his booth-mate at an AEC Systems show in Washington, D.C.), he decided to port STAAD to a PC, banking on the fact that personal computers would become as ubiquitous to an engineer as paper and pens.

Over the next few decades, STAAD became the world's leading general-purpose structural engineering software responsible for the underlying design of tens of thousands of structures, including stadiums, skyscrapers, industrial plants, towers, dams and iconic edifices like the Wimbledon Centre Court roof, Guangdong Olympic Stadium, NASA rocket launching pads and the reconstruction of the Grand Palais in Paris. In 1991, after moving the company to California, Das had ambitions of expanding REI's footprint outside of the structural software realm. At the time, it was unheard of for a small engineering company to go public, but Das' vision was to expand REI from being solely a vendor of structural engineering software to a being solutions provider to the AEC community at large. The California Chamber of Commerce recognized him as its Man of the Year in 1996, when REI was listed as a public company on the NASDAQ and went on to create software for the piping and civil engineering industries.

After losing his first wife, Purabi, to ovarian cancer in 1998, Amrit looked to give back to his roots by connecting Indian immigrants in the U.S. with their families in India. Realizing the immense commercial potential of the information technology industry, he created netGuru in order to diversify into the areas of e-commerce, digital media and IT products and services.

Perhaps Das' biggest professional accomplishment was selling STAAD to Bentley. "David Nation and Amrit negotiated the REI sale to Bentley back in 2005," noted Santanu Das, Amrit's son and a senior vice president with Bentley. "An extremely complex deal was effortlessly completed because of David and Amrit's persistence and business acumen. It is a shame that both would lose their battles to brain cancer within 24 hours of each other. I am sure they are out there somewhere looking for the next venture."

Widely known and respected in the information technology and AEC communities worldwide, Das is listed in the International Who's Who of Global Business Leaders, Who's Who of Outstanding Americans and Who's Who of Leading American Executives. On top of his various professional achievements, Das had a passion to succeed and innovate. He came to the United States without knowing a soul and went to school in the segregated South in the 1960s. With no prior knowledge about computers, he taught himself computer programming and then started writing commercial-level software in his spare time. He simply would not take "no" for an answer, striving to bring his ideas to life.

"People said he couldn't start a software business as a structural engineer with little computer knowledge, but he proved them wrong when he took STAAD to global heights and made it a household name," recalled Santanu. "When investors said diversifying outside of his expertise was unwise, he started (at the time) the largest online e-commerce site for India and bought three IT companies to boot. And when critics said he knew little about the media business, he created a successful animation company, ran concerts with various Bollywood artists and even made a feature film in memory of his first wife."

"Although he only lived to the age of 71, Amrit accomplished enough in his life to fill ten lifetimes. He took great pride and satisfaction that his first child, STAAD, found such a great home in Bentley. He knew it was a family business like his and recognized that family businesses would always take care of their own."

Das is survived by his second wife, Tamisra, and their three children.

AISC SEISMIC STANDARD

2016 AISC Prequalified Seismic Connection Standard Now Available

The 2016 version of the AISC standard *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* (ANSI/AISC 358-16) is now available for free download. This updated version of the standard has been expanded to cover nine connections: reduced beam section moment connections; bolted stiffened and unstiffened extended end-plate moment connections; bolted flange plate moment connections; welded unreinforced flange-welded web moment connections; Kaiser bolted bracket moment connections; ConXtech ConXL moment connections; SidePlate moment connections; Simpson Strong-Tie Strong Frame moment connections and double-tee moment connections. In addition to general requirements and limitations, each prequalified connection chapter includes a step-by-step design procedure.

The new standard has been approved by the AISC Connection Prequalification Review Panel (CPRP) and is ANSI-accredited. "With the release of AISC 358-16, there are now nine prequalified beam-to-column moment connections for Special and Intermediate Moment Frames," said Michael D. Engelhardt, chairman of the committee. "Work is already underway to prequalify additional connections and to extend the range of use for some of the existing prequalified connections, with the goal of providing designers with an ever growing range of options." ANSI/AISC 358 is an essential companion to the upcoming AISC *Seismic Provisions* (ANSI/AISC 341-16), which outlines the requirements for the prequalification of seismic moment connections in Chapter K.

You can download ANSI/AISC 358-16 for free at **www.aisc.org/aisc358**; all current AISC specifications and codes are available as free downloads at **www.aisc.org/specifications**. And you can read more about it in the November article "What's New with Prequalified Connections?" available at **www.modernsteel.com**.

HIGGINS AWARD

Helwig Wins 2017 T.R. Higgins Lectureship Award

Todd A. Helwig, PhD, professor of civil engineering at the University of Texas at Austin, is the 2017 recipient of AISC's T.R. Higgins Lectureship Award. Helwig is being honored for his paper "Stiffness Behavior of Cross Frames in Steel Bridge Systems" and other papers related to stability bracing, as well as his outstanding reputation as an engineer and lecturer. This annual award, which includes a $15,000 cash prize, will be presented to Helwig at the 2017 NASCC: The Steel Conference in San Antonio, Texas, March 22–24.

"The jury noted the significant and meaningful contributions of all of Todd's work in stability bracing, not just the paper on which his nomination was based," said Charlie Carter, AISC's incoming president. "It touches buildings, bridges, long-span trusses and many other types of structures that defy description by these categories. We look forward to a broadly applicable lecture at The Steel Conference."

Helwig is in his 23rd year of teaching and conducting research in the field of structural engineering and currently holds the J. Neils Thompson Teaching Fellowship in Civil Engineering at UT Austin; he joined the faculty in 2005 after teaching at the University of Houston for 11 years. His area of interest is the design and behavior of steel structures with an emphasis in structural stability and bracing.

He has codeveloped and taught a number of short courses on structural stability and bracing on behalf of AISC, the Structural Stability Research Council (SSRC) and the National Highway Institute. Since 1994, more than 5,000 engineers have attended the short courses that Helwig has co-developed and taught. In addition, he has conducted a wide range of research studies on the design and behavior of steel buildings and bridges. Results from past studies have led to design methodologies for bracing systems for steel box girders as well as new details for stability bracing systems for I-shaped sections. Helwig has also developed recommendations for cross-frame and diaphragm systems that rely on lean-on bracing to help reduce the number of fatigue sensitive braces on steel bridges.

Helwig's research has been recognized with several awards from ASCE, including the Collingwood Research Prize, the Moisseiff Award and the Shortridge Hardesty Award. In 2005, he was recognized by TxDOT with a top innovation award for his work related to lateral bracing of bridge girders by permanent metal deck forms. He also received an AISC Special Achievement Award in 2010 for his work on stability bracing systems in steel bridges. He has served on a number of technical committees for AISC, ASCE and SSRC and currently serves as Chair of SSRC.

Each year, the T.R. Higgins Award recognizes an outstanding lecturer and author whose technical paper or papers, published during the eligibility period, are considered an exceptional contribution to the engineering literature on fabricated structural steel. The nominations are judged by a distinguished panel of industry experts who reflect a blend of professional insight, industry experience and academic excellence. For more information about the award, please visit **www.aisc.org/TRHigginsAward**.

PROJECTS

3 World Trade Center Tops Out

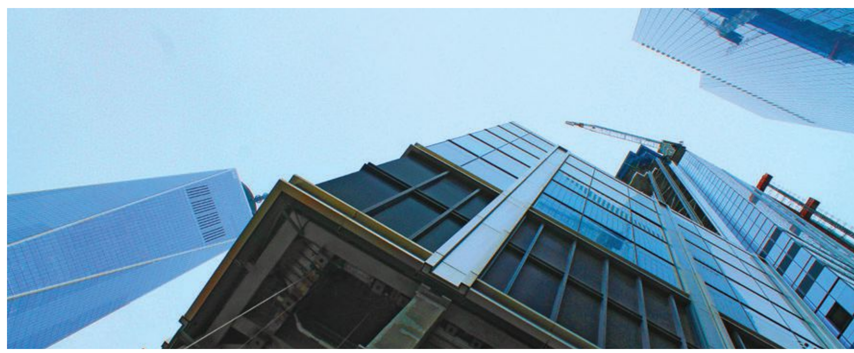
Structural steel for 3 World Trade Center topped out recently. At 1,079 ft and 80 floors, the 2.5-million-sq.-ft tower is envisioned to be the third-tallest skyscraper at the World Trade Center site and will be the fifth-tallest in New York upon completion in 2018.

The tower consists of a steel framing system around a reinforced concrete core. A defining feature of the building is its load-sharing system of K-shaped bracing, which helps articulate the building's east-west configuration. The tower's gravity system has few interior columns and no perimeter columns, giving tenants ample space and unobstructed views.

The building's three-story lobby will provide visitors a "big picture window" of the Memorial park outside and contain a retail complex with architecturally exposed structural steel (AESS). Upper floors will straddle those beneath in a podium building formation, lending the tower a distinct interlocking nature and facilitating the high occupancy of the office floors. Finally, the redeveloped Cortlandt and Dey Streets that interface with 3 WTC will improve the accessibility both of the retail spaces in the building and the WTC Transportation Hub. The building will seek to achieve the LEED Gold standard for energy efficiency.

Owen Steel Company (an AISC member and certified fabricator) fabricated 27,000 tons of structural steel for the tower's gravity system. NYC Constructors, a company of Banker Steel (an AISC member and certified fabricator) erected the structural steel for the project.

For more about the project, visit **www.wtc.com/about/buildings/3-world-trade-center**.



▲ 3 WTC (middle) in relation to 1 WTC (left) and 4 WTC (right), all steel-framed.

BRIDGES

World Innovation in Bridge Engineering Competition Call for Abstracts

Abstract submissions are being accepted through December 31 for the inaugural World Innovation in Bridge Engineering (WIBE) competition. Organized by BERD-FEUP (Bridge Engineering and Research Design and the Faculty of Engineering of the University of Porto), the competition will award $50,000 to the author(s) of the paper that demonstrates the greatest potential of innovation and contributes to the development of bridge engineering worldwide. The winner will be selected by a jury of international associations, including AISC/NSBA. The submission period for actual papers will be May 1 through July 31 of next year.

For more information, visit **https://paginas.fe.up.pt/~wibe**.

AISC CODE

2016 *Code of Standard Practice* Now Available

The 2016 AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-16) is now available as a free PDF download at **www.aisc.org/2016code**.

"The most fundamental change is that the Code is now an ANSI-approved consensus document," commented Charles J. Carter, AISC's incoming president. "The composition of the Committee that developed it has equal representation from industry, design professionals, and general interest members. This includes structural engineers, architects, a building official, a general contractor, fabricators, detailers, erectors, inspectors and an attorney."

"The *Code* defines the statement of custom and usage for fabricated structural steel," said Code Committee Chair Babette C. Freund, president of Universal Steel of North Carolina. "This is important to all; you don't have to reinvent the wheel every time you have a new project."

Also of note is that portions of the *Code* have been incorporated by reference into the *International Building Code*. The *IBC* references ANSI/AISC 360 (the AISC *Specification*) and ANSI/AISC 341 (the AISC *Seismic Provisions*), and these documents both reference parts of the *Code*. A complete list of these parts is provided at **www.aisc.org/303IBC**.

Beyond the basic change of making the *Code* a consensus document, modifications have also been made in the 2016 revision. Beyond the basic change of making the *Code* a consensus document, the following modifications have been made in the 2016 revision of the *Code*:

- The *Code* now addresses contracts that utilize drawings, models or drawings and models in combination.
- Section 1.4 addresses responsibility for identifying contract documents; subsequent sections have been renumbered.
- Section 1.10 has increased emphasis that the absence of a tolerance in this *Code* does not mean that tolerance is zero.
- Section 1.11 addresses marking requirements for protected zones in frames designed to meet the requirements of ANSI/AISC 341.
- In Section 3.1, two items are added to the list of required information: preset requirements for free ends of cantilevered members and the drawing information required in ANSI/AISC 341.
- Section 3.1 better addresses what is required for bidding when the owner's designated representative for design delegates the determination and design of member reinforcement at connections to the licensed engineer in responsible charge of the connection design.
- Section 3.2 addresses revisions, if they are necessary, when referenced contract documents are not available at the time of design, bidding, detailing or fabrication.
- Section 3.3 has added emphasis that the fabricator need not discover design discrepancies.
- Sections 3.7 and 4.2.2 address intellectual property rights of the owner's designated representative for design and the fabricator, respectively.
- Section 4.4 has been clarified to better reflect the role of the connection design criteria required in Section 3.1.1 when connection design work is delegated.
- Commentary to Section 4.5 addresses potential pitfalls when fabrication and erection documents are not furnished by the fabricator.
- In Section 6.1.1, the listed shop-standard material grades have changed for HP-shapes and hollow structural sections (HSS).
- In Section 6.4.2, the tolerance for curved members has been improved.
- In Section 7.5.1, tolerances for anchor-rod placement have been revised for consistency with the hole sizes provided the AISC *Steel Construction Manual* and the tolerances given in ACI 117.
- In Section 7.8.3, the number of extra bolts required to be supplied has been increased to account for bolt loss and pre-installation verification testing requirements; also, backing has been clarified as steel backing.
- In Section 7.8.4, non-steel backing is now addressed.
- In Section 7.13, the term "building line" has been changed to "building exterior."
- Commentary has been added in Section 7.13.1.2(e) to coordinate with the cantilevered member preset information added in Section 3.1.
- Section 9.1.5 addresses allowances, when used.
- Section 10 has been significantly revised with multiple categories for architecturally exposed structural steel (AESS) and different treatments required for each.

Since the first edition of the *Code* was published in 1924, AISC has constantly surveyed the structural steel design community and construction industry to determine standard trade practices. Since then, this *Code* has been updated periodically to reflect new and changing technology and industry practices. The *Code* is significant and important to the process of buying and selling fabricated structural steel. Its provisions are balanced, fair, and consensus-based, and provide for the vast majority of work in standard form.

structurally sound

RENOVATING WRIGLEY

WRIGLEY FIELD, HOME OF THE CHICAGO CUBS (winners of the 2016 World Series!) is currently undergoing a multi-year renovation and rehabilitation project. Some of the most complex work includes strengthening the existing grandstand structure to support future programming additions. Built in 1928, the upper grandstand and rear roof structures include trusses with riveted chords and web members attached to ⅜–in.-thick gusset plates. Proposed additions of an upper concourse and additional amenities induce significant load on the trusses, exceeding the capacity of the existing gusseted connections. To avoid obtrusive gusset plate extensions, Stantec Architects and structural engineer Thornton Tomasetti devised gusset clamp plates that are made to nest in the existing connections (above photo). Removing existing rivets allows the new plates to seat against the existing truss members. The existing rivet holes were reused for high strength A490 bolts. The configuration of the new connection effectively doubles the number of shear planes in the connection. The new plates—designed to support the full loads of the connection—are 1-in.-thick 60-ksi plate material.