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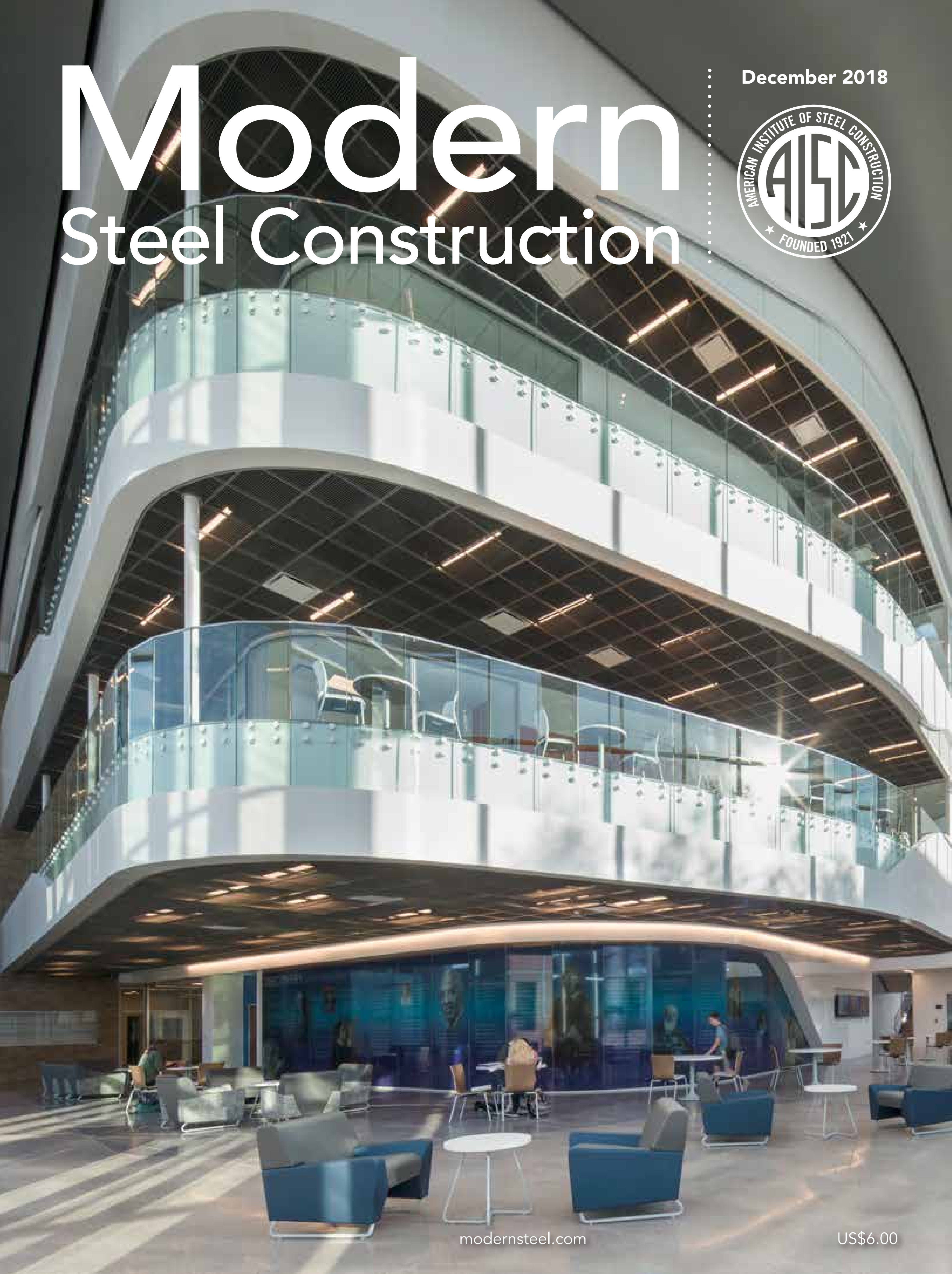

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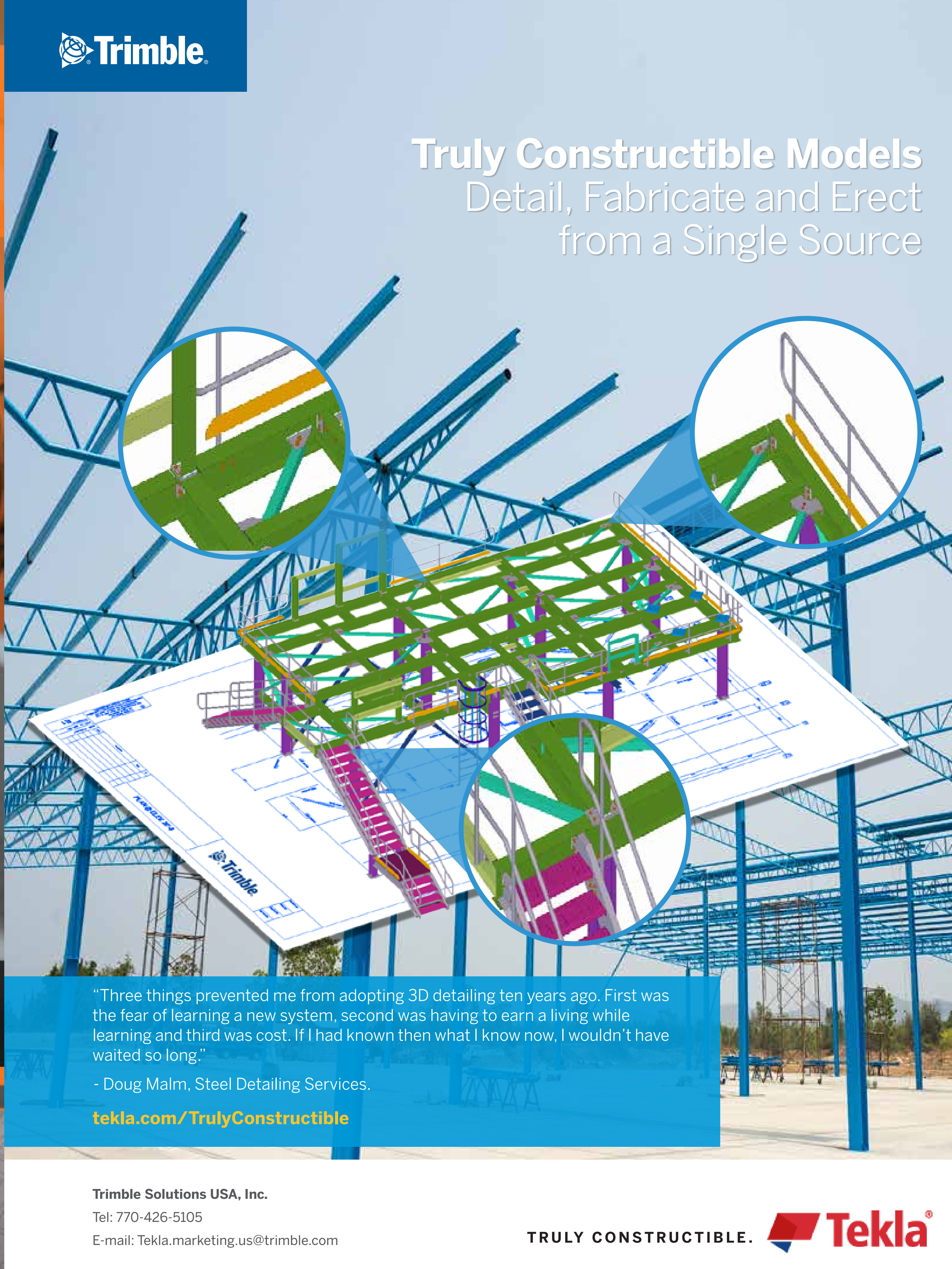
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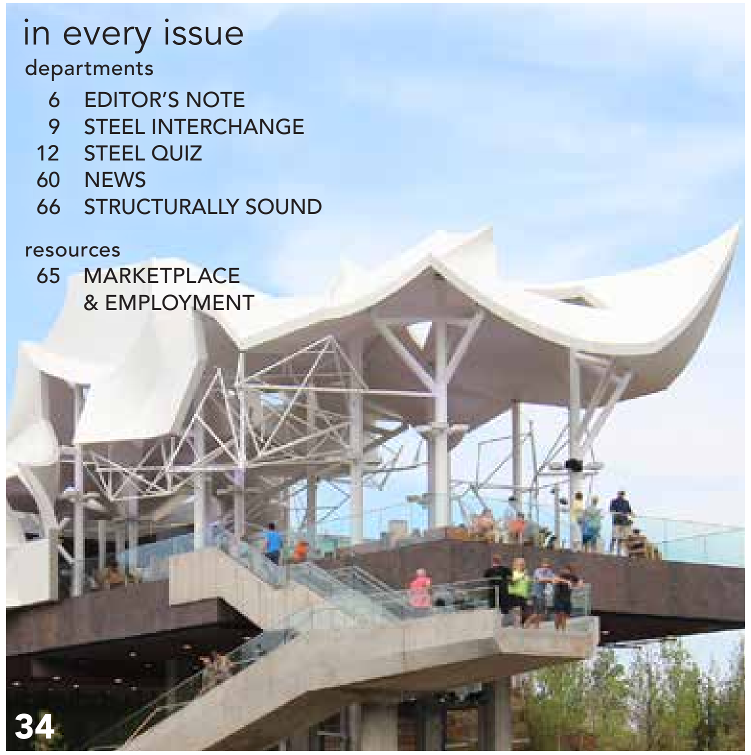

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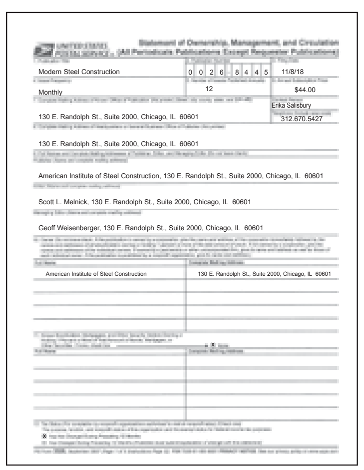

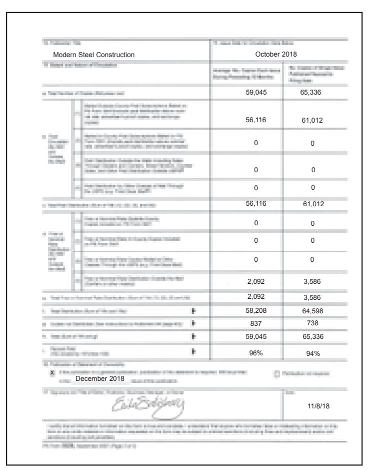

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ON THE COVER:
A two-story "pod" structure appears to float inside Abilene Christian University's new science building, p. 28. (Photo: Michelle Litvin Studio)

MODERN STEEL CONSTRUCTION (Volume 58, Number 12) ISSN (print) 0026-8445: ISSN (online) 1945-0737. Published monthly by the American Institute of Steel Construction (AISC), 130 E Randolph Street, Suite 2000, Chicago, IL 60601. Subscriptions: Within the U.S.—single issues $6.00; 1 year, $44. Outside the U.S. (Canada and Mexico)—single issues $9.00; 1 year $88. Periodicals postage paid at Chicago, IL and at additional mailing offices. Postmaster: Please send address changes to MODERN STEEL CONSTRUCTION, 130 E Randolph Street, Suite 2000, Chicago, IL 60601.

editor's note

Nearly three decades ago, Gus Bergsma visited AISC's offices and promised to show us the future of steel design. And to our surprise, he held up his end of the bargain.

He sat in our conference room and in less than an hour, developed the frame for a three-story office building. It was the first time any of us at AISC had seen RAM Steel. The product allowed structural engineers to substantially reduce design time and also gave them the freedom to experiment with variations to optimize the gravity load-resisting elements in a building frame.

Recently, we had another visitor to our office, and I immediately thought back to Gus' demonstration from the early 1990s. Henry Lederman, chief strategy officer with Qnect, showed us their connection software. Much like the early days of RAM Steel, the software promises substantial cost savings, though in this case when used to optimize connection design. But the real advantage is the time it slashes from a project. What might take a fabricator and detailer weeks to develop can now be completed in hours (or for smaller projects, such as the one Gus showed us years earlier, seconds).

Qnect estimates a savings of $30 to $50 per ton, including optimizing connections, resulting in a 20% to 50% reduction in bolts. But more importantly, it speeds the process—including the time needed for rework when member sizes or loads change. And the software isn't vaporware or some pipe dream. It's already been successfully used on projects.

How fast does the program work? According to Henry, Qnect developed connections for a 1,600-ton office building in California in less than an hour (the example he showed us in our office was about a 300-ton project, which took less than a minute).

Speed is the next big thing in the steel industry. We're already seeing impressive results with the SpeedCore system (visit **www.aisc.org/speedcore** and watch the truly amazing video). We're also seeing a growth in robotics usage in fabrication shops (visit **www.aisc.org/roboticwelding** to see a video I shot on a visit last spring to Prospect Steel in Little Rock, Ark.). And we're seeing many other innovative systems that promise faster, less expensive design and construction (check out our latest brochure at **www.aisc.org/why-steel/innovative-systems**).

All of these ideas will be on display at the 2019 NASCC: The Steel Conference (April 3-5 in St. Louis). We'll be offering more than 150 technical sessions and more than 200 exhibitors showcasing the latest in steel design and construction. It's your chance to see the future.

Scott Melnick

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steel interchange

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**.

Unless specifically stated, all AISC publications mentioned in the questions and/or answers reference the current edition and can be found at ***www.aisc.org/specifications****.*

Welding in the K-Area

Is it correct to say that welding in the curved transition between the flange and web of a wide-flange section is not welding in the k-area? Is welding in the k-area prohibited?

The answer to your first question is yes. The Commentary to the *AISC Specification for Structural Steel Buildings* (ANSI/AISC 360) states: "The k-area is defined as the region of the web that extends from the tangent point of the web and the flange-web fillet (AISC k dimension) a distance 1½ in. (38 mm) into the web beyond the k dimension."

The answer to your second question is no. The *Specification* does not prohibit welding in this location, and there are times where welding in this area is unavoidable. The issue with the k-area is that when a wide flange is rotary straightened at the mill, the k-area of the web undergoes cold working and loses some ductility as a result. When you place residual stresses in the area (resulting from weld cooling and restraint) there is a possibility that a crack can form. This crack only occurs during fabrication and, as stated in an advisory statement from 1997, "the number of examples reported has been limited and these have occurred during construction or laboratory tests, with no evidence of difficulties with steel members in service." This is why a simple visual inspection requirement after welding is sufficient. The footnote in Table N5.4-3 states: "When welding of doubler plates, continuity plates or stiffeners has been performed in the k-area, visually inspect the web k-area for cracks within 3 in. (75 mm) of the weld."

The 1997 advisory statement can be found here: **www.aisc.org/manualadvisory**

Jonathan Tavarez, PE

Staggered Bolts

What is the origin of the factor, $s^2/4g$, in Section B4.3b of the *Specification*, and why is the length not simply taken as the geometric distance between the centers of the holes?

The term, $s^2/4g$, goes back a long way. It was developed by V.H. Cochrane and was presented in *Engineering New Record* in 1922. The formula is a simplification of a theoretical approach he proposed in 1908. The concern was that the stress along the hypotenuse was a combination of shear and tension, so using this as the tension area might be unsafe since the shear strength is less than the tensile strength. Several alternatives have been proposed over the years. But despite the competitors, the formulation has held on for nearly one hundred years, and seeing that the *Specification* will not be updated again until 2022, it will very likely see its centennial in use.

Larry S. Muir, PE

Anchors in Base Plates

I seem to remember that AISC requires at least four anchor rods in base plates, but I cannot seem to find this requirement in the *Specification*. Is this no longer a requirement?

This is still a requirement, but to my knowledge it was never a requirement in the AISC *Specification*. It is an OSHA requirement. Some of the OSHA requirements are summarized in Part 2 of the AISC *Steel Construction Manual*, including:

1. All column base plates must be designed and fabricated with a minimum of four anchor rods. (This is required by OSHA 1926.755(a)(1).)
2. Posts (which weigh less than 300 lb essentially vertical and axially loaded) are distinguished from columns and excluded from the four-anchor-rod requirement

You can find the OSHA requirements at **www.osha.gov** (search for standard 1926 Subpart R).

Carlo Lini, PE

Who Provides Backing?

Who is responsible for supplying ceramic backing for field welding?

Ceramic backing is non-steel backing and is furnished by the erector per the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303).

Section 7.8.3 in the *Code* states: "When the erection of the structural steel is not performed by the fabricator, the fabricator shall furnish the following field connection material… (c) Steel backing and run-off tabs that are required for field welding."

Section 7.8.4 states: "The erector shall furnish all welding electrodes, fit-up bolts and drift pins used for the erection of the structural steel. Non-steel backing, if used, shall be furnished by the erector."

Carlo Lini, PE

Larry Muir is director of technical assistance, **Carlo Lini** is a senior staff engineer and **Jonathan Tavarez** is a staff engineer in the Steel Solutions Center, all with AISC.

STEEL SOLUTIONS CENTER

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

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

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.

Nondestructive Testing Performed by the Fabricator

It is my understanding that AISC certified fabricators must demonstrate the ability to perform nondestructive testing (NDT) including UT and MT. This means that they are required to perform NDT for structural steel that they fabricate. Please confirm my understanding.

Your understanding is not correct.

1. AISC certified building fabricators are not required to demonstrate the ability to perform NDT.

AISC provides certification to several different categories. Only AISC certified bridge fabricators are required to have NDT personnel on staff or available under contract. This is required per Section 4.5.4.1 of the *Certification Standard for Steel Fabrication and Erection, and Manufacturing of Metal Components* (AISC 207-16) which you can download for free at **www.aisc.org/certification**.

2. Fabricators are not required to perform NDT—unless this is required by the contract.

Section N6 of the *Specification* states: "NDT of welds completed in an approved fabricator's shop is permitted to be performed by that fabricator when approved by the AHJ. When the fabricator performs the NDT, the QA agency shall review the fabricator's NDT reports." Section A1 states: "The phrases 'is permitted' and 'are permitted' in these Provisions identify provisions that comply with the *Specification*, but are not mandatory." Therefore, the fabricator can but is not required to, perform NDT.

A User Note in Chapter J of the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341) states: "All requirements of *Specification* Chapter N also apply unless specifically modified by these Provisions." Section J1 of the *Seismic Provisions* states: "Nondestructive testing (NDT) shall be performed by the agency or firm responsible for Quality Assurance, except as permitted in accordance with *Specification* Section N6."

In my experience, many building fabricators do not possess the personnel or the equipment to perform NDT. The request to permit a fabricator to perform NDT, in lieu of an outside agency, often originates with the fabricator—not the owner's representatives. Some fabricators who employ NDT personnel see logistical advantages to being able to perform NDT in-house and also may offer this as an additional service to their customers.

The fact that NDT must be performed (is required) is a matter addressed in the *Specification*. Who is permitted to perform NDT is also a matter addressed in the *Specification*. Who will actually perform the NDT is a contractual issue. The *Specification* does not address contractual issues. Contractual issues are addressed in the *Code*.

Section 8.1.1 states: "The fabricator shall maintain a quality control program to ensure that the work is performed in accordance with the requirements in this *Code* and the contract documents. The fabricator shall have the option to use the AISC Quality Certification Program to establish and administer the quality control program."

Section 8.1.3 states: "When the owner requires more extensive quality control procedures, or independent inspection by qualified personnel, or requires that the fabricator must be certified under the AISC Quality Certification Program and/or requires that the erector must be certified under the AISC Erector Certification Program, this shall be clearly stated in the contract documents, including a definition of the scope of such inspection.

Performance of NDT by the fabricator is a more extensive quality control procedure that must be clearly stated in the contract documents if it is to be required for the project.

Larry S. Muir, PE

steel quiz

This month's Steel Quiz is all about the 15th edition AISC *Steel Construction Manual* (www.aisc.org/manual). Many thanks to Lutfur R. Khandaker, PE, and Raunac A. Khandaker of KBK Structural Design, LLC, who contributed this month's questions and answers!

1 **True or False:** Although the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) permits other materials for use as anchor rods, ASTM F1554 is the preferred specification.

2 **True or False:** Among three grades of ASTM F1554 materials, Grade 36 is weldable and Grade 105 cannot be welded.

3 **True or False:** Per the AISC *Manual*, the main hot-rolled structural shapes are: W-, M-, S-, HP-, C-, MC- and L-.

4 **True or False:** The AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303) does not include open-web steel joists in its definition of structural steel.

5 **True or False:** Per the *Manual*, steel castings are specified as ASTM A27 Grade 65-35 or ASTM A216 Grade 80-35.

6 **True or False:** Per the *Manual*, crane rails are furnished to ASTM A759, ASTM A1 and/or manufacturer's specifications and tolerances.

7 **True or False:** The mill tolerances are given as follows: For structural shapes and plates (ASTM A6), For HSS shapes (ASTM A500 or other applicable ASTM specification for HSS) and for Pipe (ASTM A53).

8 **True or False:** Fabrication tolerances are generally provided in AISC *Specification* Section M2 and *Code* Section 6.4.

9 **True or False:** Erection tolerances are generally provided in *Specification* Section M4 and *Code* Section 7.13.

10 **True or False:** In building structures, corrosion protection is not required for steel that will be enclosed by a building finish, coated with a contact-type fireproofing or in contact with concrete.

11 **True or False:** *Specification* Appendix 5 can be can be used for the evaluation of existing structures.

TURN TO PAGE 14 FOR THE ANSWERS

1 **True.** Although other materials can be used, ASTM F1554 is the preferred specification, since all anchor rod production requirements are together in this single specification (refer to page 2-22 of the *Manual*).

2 **True.** Grade 36 rods are weldable, Grade 55 rods are weldable only when they are made per Supplementary Requirement S1 and project specifications indicate this requirement. As a heat-treated material, Grade 105 rods cannot be welded (refer to page 2-22 of the *Manual*).

3 **True.** Three types of structural tees are also covered in the Manual. WT-, MT- and ST-shapes are typically split (sheared or thermal-cut) from W-, M- and S- shapes, respectively (refer to pages 1-3, 1-4 and 1-5 of the *Manual*).

4 **True.** Steel joists are designed and fabricated per the requirements of specifications published by the Steel Joist Institute (refer to pages 2-23, 16.3-6, 16.3-7 and 16.3-8 of the *Manual*).

5 **True.** Steel castings are specified as ASTM A27 Grade 65-35 or ASTM A216 Grade 80-35, and steel forgings are specified as ASTM A668 (refer to page 2-23 of the *Manual*).

6 **True.** Crane rails are furnished to ASTM A759, ASTM A1 and/or manufacturer's specifications and tolerances. Also, most manufacturers chamfer the top and sides of the crane-rail head at the ends unless specified otherwise to reduce chipping of the running surface. It is better to consult with the individual manufacturer before ordering (refer to page 2-24 of the *Manual*).

7 **True.** Refer to page 2-31.

8 **True.** Additional requirements that govern fabrication are as follows:
- Compression joint fit-up, per *Specification* Section M4.4
- Roughness limits for finished surfaces, per *Code* Section 6.2.2
- Straightness of projecting elements of connection materials, per *Code* Section 6.3.1
- Finishing requirements at locations of removal of run-off tabs and similar devices, per *Code* Section 6.3.2.

(refer to page 2-31 of the *Manual*)

9 **True.** The tolerances specified therein are predicated upon the proper installation of the following items by the owner's designated representative as specified in the *Code* (refer to page 2-31 of the *Manual*):
- Building lines and benchmarks, per *Code* Section 7.4
- Anchorage devices, per *Code* Section 7.5
- Bearing devices, per *Code* Section 7.6
- Grout per *Code* Section 7.7

10 **True.** When enclosed, the steel is trapped in a controlled environment and the products required for corrosion are quickly exhausted. The surface condition of unpainted steel framing of longstanding buildings that have been demolished has been found to be unchanged from the time of its erection, except at isolated spots where leakage may have occurred. Even in the presence of leakage, the shop coat is of minor influence as indicated in *Specification* Commentary Section M3. A similar situation exists when steel is fireproofed or in contact with concrete. Accordingly, shop primer or paint is not required unless specified in the contract documents (refer to page 2-36 of the *Manual*).

11 **True.** Appendix 5 covers Evaluation of Existing Structures. Note that *Specification* Section B7 provides the charging language for Appendix 5 on the evaluation of existing structures (refer to page 2-36 of the *Manual*).

STEEL SOLUTIONS CENTER

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

steelwise

UNLISTED MATERIALS – PART 3

BY LARRY S. MUIR, PE, AND THOMAS J. SCHLAFLY

In this third and final article in our series, we continue the discussion about unlisted materials, this time focusing in on considerations beyond those listed in the Commentary to the AISC Specification.

Larry Muir (**muir@aisc.org**) is director of technical assistance and **Tom Schlafly** (**schlafly@aisc.org**) is chief of engineering staff, both with AISC.

IN ADDITION TO the considerations listed in the Commentary to the *Specification for Structural Steel Buildings* (ANSI/AISC 360, available as a free download at **www.aisc.org/specifications**) there are other factors that might also be considered when contemplating the use of unlisted materials. We'll discuss them here.

Equivalency

Engineers and contractors often use the term *equivalent* when discussing unlisted materials. The party proposing the substitution will often claim that the proposed material is equivalent to a listed material, or the engineer will ask about the equivalency of two different materials. This sort of thinking misses at least half the issue.

In some instances, it may be possible to specify a more general material in such a way that it becomes equivalent to some other more specific material. In such cases, the material could likely be dual- (or multi-) certified rather than being treated as a substitution. Setting aside this possibility, it is unlikely that two specifications will be wholly equivalent. There will be differences. This means that equivalency must be judged not just considering the material side but also the application side. The two materials are not identical, but can they function in an effectively identical manner in a given application? Both the proposed material and the proposed application must be considered together.

In other instances, a single material can satisfy multiple ASTM specifications. Such materials are sometimes supplied as dual- or multi-certified materials, and multiple ASTM specifications will be listed. The most common condition seen in building construction is some combination of A36 with ASTM specifications for approved steels with a yield strength of 50 ksi. This is possible because ASTM A36 does not provide a limit on the maximum yield strength. For most building applications, the greater strength is not a concern. In some cases, such as in the AISC *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341, **www.aisc.org/specifications**), the material over-strength is explicitly accounted for (i.e., in the values for R_y and R_t).

There are, however, applications for which greater yield strength could be detrimental to the design intent. These applications generally fall outside the scope of the *Specification*. In such cases, the specifier must either specify a limit on maximum yield strength or adjust the design to accommodate readily available materials. It should be noted that obtaining ASTM A36 material with a yield strength near 36 ksi can be exceedingly difficult.

Seismic Considerations

The *Seismic Provisions* treats material selection differently than the *Specification*. Section A3.1 states: "The structural steel used in the SFRS described in Chapters E, F, G and H shall meet one of the following ASTM Specifications…" and provides a list of permitted materials. The permitted materials have been selected to be consistent with tested seismic systems and to reflect desirable seismic performance characteristics (e.g., ductility or limited maximum yield strength) consistent with the requirements of the *Seismic Provisions*.

Even if other materials were not explicitly prohibited, their use in the seismic force-resisting system (SFRS) could be difficult due to lack of expected material strengths

established to be consistent with the *Seismic Provisions*. The lack of values for R_y and R_t effectively excludes the use of unlisted materials for yielding elements and makes correct implementation of some provisions virtually impossible.

Steel Castings and Forgings

Section A3.2 addresses requirements for castings and forgings and states: "Steel castings and forgings shall conform to an ASTM standard intended for structural applications and shall provide strength, ductility, weldability and toughness adequate for the purpose." The use of standards not produced by ASTM or not intended for structural applications is prohibited under the *Specification*.

Consumables for Welding

Section A3.5 addresses requirements related to welding consumables and states: "Filler metals and fluxes shall conform to one of the following specifications of the American Welding Society…" A list of permitted filler metals is provided. The use of other filler metals is prohibited. Note that other codes may permit the use of other filler metals.

Headed Stud Anchors

Section A3.2 addresses requirements for headed stud anchors and states: "Steel headed stud anchors shall conform to the requirements of the *Structural Welding Code—Steel* (AWS D1.1/D1.1M)." The design of composite beams using steel headed stud anchors is semi-empirical. Therefore, the configuration and installation of the anchors must conform to the testing that has been performed.

Alternative-Design Fasteners

The *RCSC Specification for Structural Joints Using High-Strength Bolts* provides requirements for the use of alternative-design fasteners. The requirements provided in the *RCSC Specification* should be viewed as minimum requirements. The use, installation and inspection of alternative-design fasteners are subject to evaluation by the engineer of record (EOR).

Substitution Materials

The reason for the proposed substitution of material should be considered when evaluating an unlisted material. Sometimes, substitutions are proposed because the specified material is not available or will not be available in time to meet the project schedule. In such cases, the goal should be to find a product that is as similar as possible to the preferred material. Evaluating the material could be a simple as comparing the two specifications, identifying differences and then taking steps to either bring the substituted product into better alignment with the original product or ensure that the difference will not be detrimental to the design. This latter option may involve design changes. Of course, the best way to avoid these situations is to specify the preferred materials listed in Part 2 of the AISC *Steel Construction Manual* (**www.aisc.org/manual**) and to discuss availability with fabricators likely to bid the project.

One reason material substitutions are requested is that the approved materials may not be made where the material is needed. The substitution effectively increases the number of producers and potentially the quality of their practices and equipment. Where producers are well known and their products are in frequent use in similar structures, routine quality assurance practices are sufficient. However, where producers are not well

known, extra precautions such as tensile tests and chemical composition tests by independent laboratories of a sample of the product may be justified. It is the engineer who must both specify the tests to be conducted and evaluate the results.

There are, of course, other reasons an engineer may want to consider a material substitution. It may be that some material is especially well suited to the design of the project. For example, ASTM A992 and ASTM A1085 both existed as ASTM specifications prior to being approved under the *Specification*, and some engineers may have wanted to take advantage of some of the improvements inherent in these specifications. There are also specialty fasteners that permit bolting from one side only that, while not approved for use under the *Specification*, are relatively common in hollow structural section (HSS) connections.

However, the motivation for a proposed substitution can sometimes be more controversial and the evaluation more complex. The AISC Steel Solutions Center has received a number of inquiries involving conditions where either EORs or contractors have proposed to substitute ASTM A354 Grade BD bolts for ASTM F3125 Grade A490 bolts. ASTM A354 is a listed product in both Sections A3.3.(a) and A3.3.(b). ASTM A354 Grade BD is also included in Group B in Section J3.1. The *Specification* states: "When bolt requirements cannot be provided within the *RCSC Specification* limitations because of requirements for lengths exceeding 12 diameters or diameters exceeding 1½ in. (38 mm), bolts or threaded rods conforming to Group A or Group B materials are permitted to be used in accordance with the provisions for threaded parts in Table J3.2." This is the typical reason that A354 bolts are specified—because F3125 bolts of the required diameter or length are simply not manufactured.

That said, there have been instances of A354 Grade BD being substituted for F3125 Grade A490 bolts to get around the explicit prohibition against galvanizing A490 bolts. What is missed in this process is the fact that A354 Grade BD could be viewed as a more general version of F3125 Grade A490. By properly addressing all of the relevant parameters, it would be possible to specify a bolt that satisfies both A354 Grade BD and F3125 Grade A490. If this is done and nothing more, then it would seem that the prohibition against galvanizing should apply regardless of whether

one chooses to label the bolt A354 Grade BD or F3125 Grade A490. There are additional steps that can be taken that might lessen concerns about hydrogen embrittlement. If an engineer chooses to substitute A354 Grade BD for F3125 Grade A490 to provide a bolt that is galvanized, the engineer is responsible for evaluating the potential impact of the decision and deciding what additional steps should be taken when specifying the bolt.

When cost is the primary driver for a substitution, additional caution may be warranted on the part of the engineer. Safety and the performance of the structure should be the primary consideration during the evaluation of the proposed substitution. Even when all parties share the goal of having a successful project, it should also be kept in mind that the various parties involved may have different perspectives, spheres of knowledge and motivations.

Intended Use

When evaluating proposed substitutions, it can often be useful to look into the common or intended uses for the proposed materials. Engineers may be more comfortable and the evaluation simpler when the proposed material is commonly used for structural applications. The deliberation may be considerably more complicated and time-consuming when steel commonly used to manufacture automobile crankshafts is proposed to be used to fabricate anchor rods, or steel commonly used in refrigerator bodies is proposed to be used in the fabrication of single-plate shear connections. These substitutions may or may not be suitable, but they certainly seem less intuitive.

All the Stuff You Usually Get for Free

The materials approved for use with the *Specification* are approved because they are commonly used in the construction of structural steel buildings, and in many cases have been developed and manufactured with structural steel buildings in mind. It is important to understand that the specification associated with the proposed material may be more general than the originally specified material or the approved materials. When you specify an approved material, parameters are likely specified that make the material especially useful as structural components in a building.

When a substitution is made, it may be necessary to impose additional project-specific requirements beyond what is included in the standard specification. For example, ASTM A500 includes tolerances on outside dimensions, wall thickness, straightness, squareness, twist and other parameters. When a similar HSS is specified to be fabricated from plate, the specifier should carefully consider which of these parameters, if any, need to be controlled, and take measures to do so. In some instances, tolerances from other standards like AWS D1.1 may be applicable, but it should be kept in mind that these tolerances are often tied to the intended use—i.e., whether it is a column or a beam, which may not always be obvious in the contract documents.

Though not necessarily involving a substitution, specifying bolts and threaded parts provides a good example of an issue that can arise. If a bolt or anchor rod is specified as F3125 or F1554, most of the required parameters are already included in the specification and need not be deliberated and provided by the specifier. However, as the specifications become more general, more of these parameters must be defined by the specifier. One of the advantages A354 has over F3125 is that A354 permits a wider range of fasteners to be produced. However, this flexibility means that the specifier has to consider and provide more information. Going a step further, anchor rods are sometimes specified using even more general specifications like A36. This can be done, but it must be recognized that A36 contains no provisions that directly address fasteners, so all of the fastener-related parameters theoretically must be defined by the specifier. In practice, the contractors or suppliers often decide what will be provided when the contract documents are not clear, and use of the products is confirmed through the approval process. This process, though not ideal, often proved sufficient.

When considering the use of unlisted material, the specification should be carefully examined to ensure that all pertinent properties are addressed. Very general specifications should be avoided or supplemented with project-specific requirements.

A Team Effort

The use of unlisted materials can impact multiple members of the project team, sometimes in unexpected ways. These effects must be considered.

As described above, evaluating unlisted materials is not always simple. Significant engineering time and effort may need to be dedicated to evaluating the proposed material. In some instances, experts may have to be brought in, as structural engineers often do not possess specialized knowledge of metallurgy or welding that may be required in the evaluation. The project budget and schedule must accommodate these factors. If it is decided that additional requirements must be enforced, then the affected parties must work together to determine what is necessary, what is possible and what is practical.

If toughness is a design consideration but the toughness of the proposed material is uncertain, the engineer may want to impose minimum toughness requirements and impose toughness testing—but this will be to no avail if the material specified simply cannot meet the specified requirements.

If a large quantity of bent plate is required but the material specified proves to be susceptible to cracking when formed using typical shop practices, who is responsible for the costs associated with retooling, retraining and re-fabrication?

If the proposed material has a straightness tolerance significantly larger than that of the approved materials but the project specification requires a tighter straightness tolerance, how is this to be achieved? Will the mill supply straighter members than is typical? If so, how will this be done and will there be any detrimental effects to other material properties? Will the members be straightened by the fabricator and if so how—via heat straightening or cold straightening? If the material is damaged using typical shop straightening processes, who is responsible for the repair or replacement of the material?

These are the sorts of issues that may have to be addressed by the project team. The team should be prepared to address them, preferably in a proactive manner. It is often much more difficult and expensive to fix a problem than to prevent the problem from occurring in the first place.

Comparisons to Other Codes

As stated near the beginning of this article, the *Specification* is commonly referenced by other codes and used at the discretion of engineers for applications outside its stated scope. It is important to understand, however, that there are limitations to its applicability. Comparing the AISC provisions to those of other codes and information provided in guides and texts can sometimes provide the engineer with additional insight.

For example, some engineers simply apply provisions of the *Specification* to the design of stainless steel. In some instance, this may produce acceptable results, but stainless steel and structural steel as addressed in the *Specification* are different materials that sometimes require different considerations to be made. AISC Design Guide 27: *Structural Stainless Steel* (**www.aisc.org/dg**), though not a formal specification, provides design guidance that is more appropriate for stainless steel. Since the guide includes nearly provision-by-provision comparisons, modifications and discussions related to the design of stainless and structural steel, it provides useful and unique insight into the process of evaluating the different materials that might at first glance appear to be pretty similar or even equivalent.

One interesting recommendation involves making net section checks using the yield strength, F_y, rather than the tensile strength, F_u, used in the *Specification*. This is done, as explained in the guide, because stainless steel is twice as ductile as carbon steel and the *Specification* procedures could lead to larger-than-expected (and possibly unacceptable) deformations if applied to stainless steel. This is a case where a generally desirable property, increased ductility, could produce deleterious effects when combined with design provisions intended for use with a limited range of materials. An alternative to basing the net section strength on the yield strength might be to explicitly account for the increased deformation. Relative to stability, Section C1 of the *Specification* already requires consideration of "flexural, shear and axial member deformations, and all other component and connection deformations that contribute to the displacements of the structure." In practice, there are many sources that are considered, but their effects are neglected based on engineering judgment. When unlisted materials are specified, common design (and construction) practices may have to be reevaluated.

Comparing the *Specification* and the *North American Specification for the Design of Cold-Formed Steel Structural Members* is another exercise that can provide insight to engineers relative to design considerations that may have to be made when evaluating or designing unlisted materials. Both documents address members made from steel. However, there are many differences between the provisions due to the different materials and applications addressed.

Specifications also vary based on the application. Though the same materials are commonly used to construct both buildings and bridges, there are different specifications used for the two applications.

The possibility that a code exists that better addresses the design of the unlisted material should also be considered.

Approved by Others

There are other organizations that approve the use of steel materials and products. Though such approval may or may not indicate that the approving organization feels that the material can be implemented using the *Specification*, the approval cannot be taken to indicate that the material is approved by the *Specification*. Only the listed materials have been approved by the AISC Committee on Specifications.

Final Thoughts

Unlisted materials have been successfully used in structural steel buildings to provide safe and economical solutions to conditions that are outside the scope of the *Specification*. However, the use of unlisted materials should not be taken lightly by either the EOR or the contractor. In some instances, it might be possible to apply provisions of the *Specification* and/or the *Code* to the unlisted material, though some modification of either the provision itself or its implementation may be necessary. If this path is taken, it is done at the discretion of the specifier. ■

Parts 1 and 2 of this series appeared as SteelWise articles in the October and November 2018 issues, which you can view at ***www.modernsteel.com****. And to contact the AISC Steel Solutions center, visit* ***www.aisc.org/solutions****.*

EFFECTIVE MEETINGS

BY ANNE SCARLETT

A few tips on maximizing meeting outcomes, both as a leader and as an attendee.

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

WHY ARE MEETINGS often the butt of work-related jokes? Why do we sigh with disdain when our calendar is loaded with meetings?

Quite simply, many meetings are poorly run, resulting in little or no specific outcomes and action items. Conversely, an effective meeting—with clients, prospects, subcontractors, industry peers or colleagues—is actually considered a marketing and business development plus. When clients participate in a productive meeting led by their consulting engineer or architect, it bodes well for the overall client-service provider experience.

But not all meetings are created equal. They vary in terms of content requirements, environments (in person, by phone, via video, in office/out of office) and intentions. Meeting types in the AEC industry can include:

1. Short-term planning for project teams
2. Long-term planning, such as a senior leadership retreat
3. Creative brainstorming, including design sessions with the client
4. Information transfer (data dump), such as a training seminar
5. Motivational messaging, such as an all-office meeting where senior leadership shares company direction with the staff.

So how can you, as a meeting leader or attendee, walk away from the meeting feeling like it was time well spent? Time is our most valuable asset, and meetings do not always respect—or capitalize on—our time and contributions. Take it upon yourself to make a change!

> Remember that as a meeting attendee, you will be measured by the quality, not the quantity, of your contributions.

As a Meeting Leader

Here are some things to consider when you are the one leading things:

Remember that "facilitation" is the optimal word. Create an environment where others can participate, observe and have some takeaways. Facilitate others' ability to contribute. Even if the particular meeting is primarily intended as a one-way download of information from senior management to staff, you still need to create a situation to encourage active listening by attendees.

Invite the right people. Consider your meeting objectives and expected outcomes. Carefully choose those who will be the best contributors to the mix, like a recipe. Often, there will be individuals that—because of their status or position—either "should" attend or "want to" attend. Yet in your judgment, you may determine that those people will neither add to the meeting nor benefit from attending the meeting in an observatory role. In those cases, it's important to identify your hesitation to include them, and then have a quick and candid talk with them about those hesitations. Perhaps there is a misunderstanding. Perhaps it requires gently letting the person know that it is not personal, but that at this time it makes the most sense not to include them. Whatever you do, be specific, discreet and respectful.

Send out an agenda and expectations in advance. Keep your agenda tight. Assign initials next to components where you expect others to take charge. In addition to the agenda itself, make sure to include a brief bulleted summary of expected outcomes for the meeting. It may be as simple as: "We will conclude with clarity on our individual responsibilities for this week's project." Or "We will produce a minimum of three schemes for the schematic design." Or perhaps "We will bring the client to a point of decision on a particular sticking point." Or even "We will decide how to reallocate internal resources for cross-training purposes."

Where it makes sense, consider using a consent agenda. When the lion's share of a meeting structure involves passive reporting—as opposed to discussing, resolving and strategizing—then why not save time by using a consent agenda? This is a single agenda item covering a number of routine issues that require familiarity or approval but not necessarily in-person discussion. If a team member feels that discussion is warranted, any item may be removed from the consent agenda by simply requesting that it be removed. The removed item is then placed elsewhere on the active meeting agenda. The entire consent agenda is then acknowledged and validated by the team prior to moving on to strategic matters. While this method is most commonly used by nonprofit boards to save time, there is most certainly a place for consent agendas within a for-profit organization as well!

Establish a no-phone zone. This can be tricky, particularly when dealing with stubborn attendees who may be senior to you. But even one person scanning a cell phone can throw off the rest of the group and the leader. It's distracting at best and downright perturbing and discouraging at worst. Options to handle it include: establishing the meeting as a phone-free zone on the agenda invitation, asking people to check phones at the door and providing scheduled breaks for everyone to check their devices.

Use a "parking lot." To remain acutely focused on the meeting's intent, have a flip chart or white board handy. This will serve as the parking lot. Any time a worthy issue arises beyond the meeting context or intention, it moves to the parking lot. At the end of the meeting, the parking lot should be categorized by urgent and non-urgent items. "Next steps" should be assigned to the attendees for those that are deemed more urgent/important—exploring a new idea, researching answers to a particular problem or initiating an activity. Sometimes, parking lot items are bigger than they first appear, so they may need to spin off into separate meetings.

Other times, attendees ultimately realize that the parking lot item is of a very low priority, and they decide to table it indefinitely. The ultimate point is that all contributions are captured and attended to, one way or another.

Start on time. Start meetings on time even if there is only one other person in the room. As others drift in, simply continue moving along. If you'd like to be polite, you can stop for a brief moment, welcome them and let them know where you are in the agenda. Do not backtrack or repeat what you have already said. Sometimes, an integral meeting contributor (and decision-maker) will be late. Consider making a game-time decision by reorganizing elements to see what you can accomplish without him/her. When that person finally arrives, summarize what has already been discussed, then weave that back into the original agenda. End the meeting by reiterating the importance of timeliness for the sake of the team. Attendees will see that you are committed to an on-time start, and they will surely arrive promptly in the future.

End on time. Have an established meeting timeframe. Well-planned meetings should not run long. The only exception is a creative and/or brainstorming meeting, where juices are flowing abundantly. In those cases, you may want to respectfully ask for additional time from your attendees.

Get feedback. Allow a few minutes at the end the meeting to ask for feedback. You may even want to have people rate the meeting privately or right there on the spot (perhaps on a scale of 1 to 5). Off-line, feel free to ask the attendees for additional input or requests. You won't be able to satisfy everyone, but at least you will have heard them. If the group shares common goals and has the firm's best interests in mind, then they should all wholeheartedly strive to make the meetings productive.

Don't be satisfied with the "usual." Sometimes we get caught in a rut of attending the same meetings week after week, month after month. Maybe those meetings have lost their useful life; many do have expiration dates, after all. For example, one of my former firms held merger integration meetings for one year longer than necessary. Another firm I consulted for used an old and tired agenda for their project manager meetings that was no longer productive. At least once a year, perhaps during your strategic planning sessions, analyze the effectiveness of your firm's meetings. At a minimum, review all the "standing" meetings that are held both internally, as well as externally with clients and consultants as part of your overall work process. Which ones should stay? Which ones should go or be revitalized?

simply adding to the length of the meeting. If you truly agree with something, simply say, "I agree." And mean it.

Arrive early (especially for an external meeting). Never be the person that walks in late! Use your pre-meeting time to gather your own thoughts, review notes, etc. Furthermore, take the opportunity to connect with other attendees on a more casual basis before the meeting commences. This is where relationships can grow and strengthen!

Remain engaged (and look the part). Unless you are expecting a burning, time-sensitive client call, don't be a jerk. Keep the device silenced and out of sight, and do your part to remain present with the group.

> Unless you are expecting a burning, time-sensitive client call, don't be a jerk. Keep devices silenced and out of sight.

As an Attendee

Even if you are attending rather than leading, you share responsibility for the meeting's success. Do not be complacent and complain. Instead, recognize that you, as an attendee, can demonstrate positive behavior while motivating others to do the same.

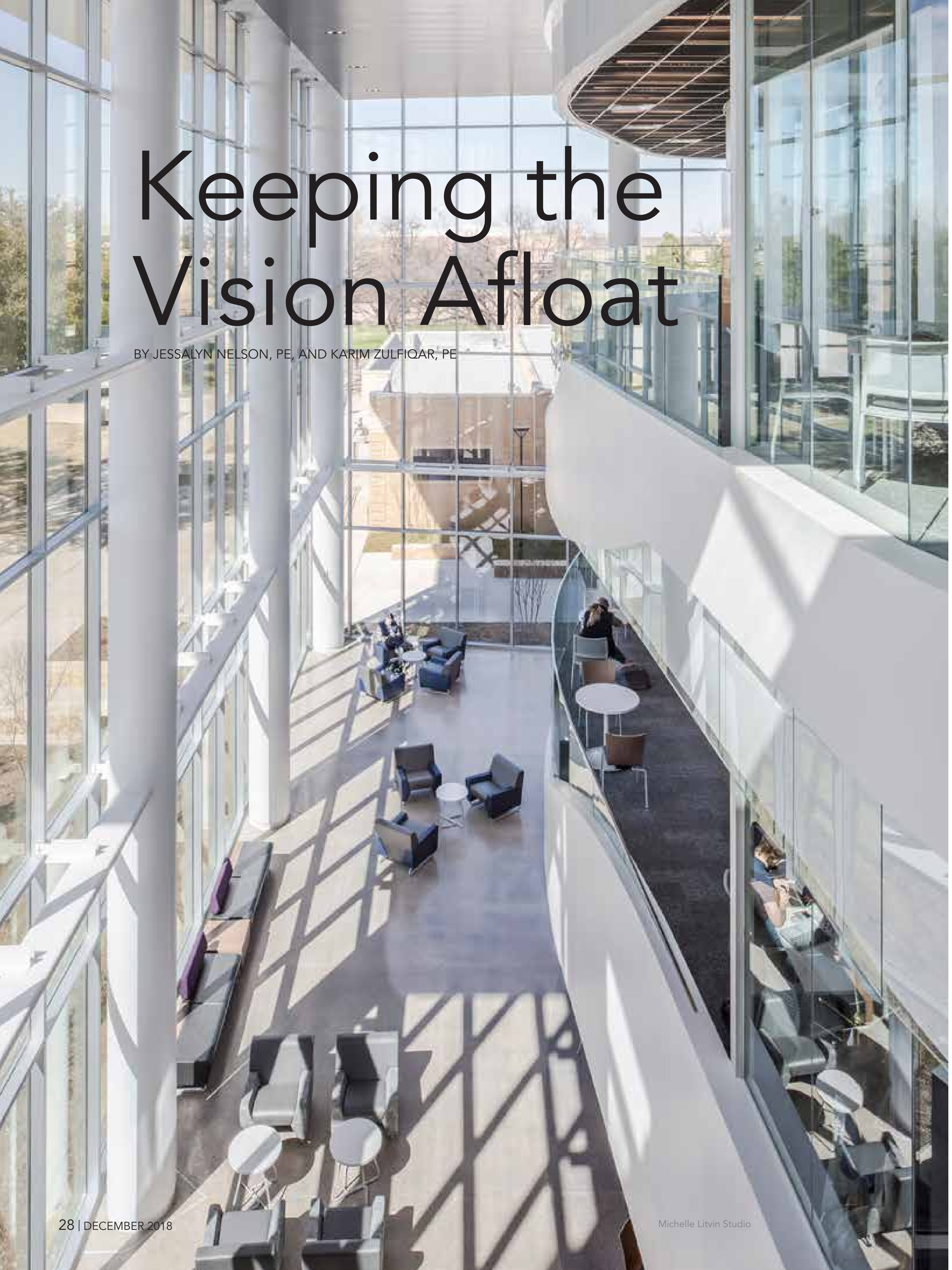
Come prepared. Read the agenda in advance. Have some thoughts/ideas/questions in writing. Collect any information that you need to prior to the meeting, and have it organized and on hand (no running back to your desk).

Make quality statements. You will be measured by the quality, not the quantity, of your contributions. Digressions run the gamut from the senior partner that wants to tell yet another story to the mid-level manager to repeating what others have already said to the chatty business developer that enjoys hearing himself speak to feel important. Don't add to this problem. There is no need to restate what others have already said unless you add something that will make a difference. People who repeat and restate are

Give your feedback. If you have ideas on how to improve a particular meeting type, don't be shy. In your most diplomatic way, present your ideas to the meeting leader off-line. First, express appreciation for their current efforts. Preface your suggestions by stating they are just for consideration, and offer to help in any way you can. Make sure you support your claims—i.e., share another context/story in which a particular meeting technique worked well.

Meetings are a broad—and often controversial—topic in terms of their real value. While some rebel companies have ousted meetings altogether, the majority of firms in the AEC world continue to rely upon meetings to service clients and move the company forward. They play a significant role in our professional lives. Let's make them the best they can be! ■

What is your experience with meetings? Which meeting ideas and tactics have worked well for you? We'd love your feedback! Send your thoughts to ***melnick@aisc.org***.

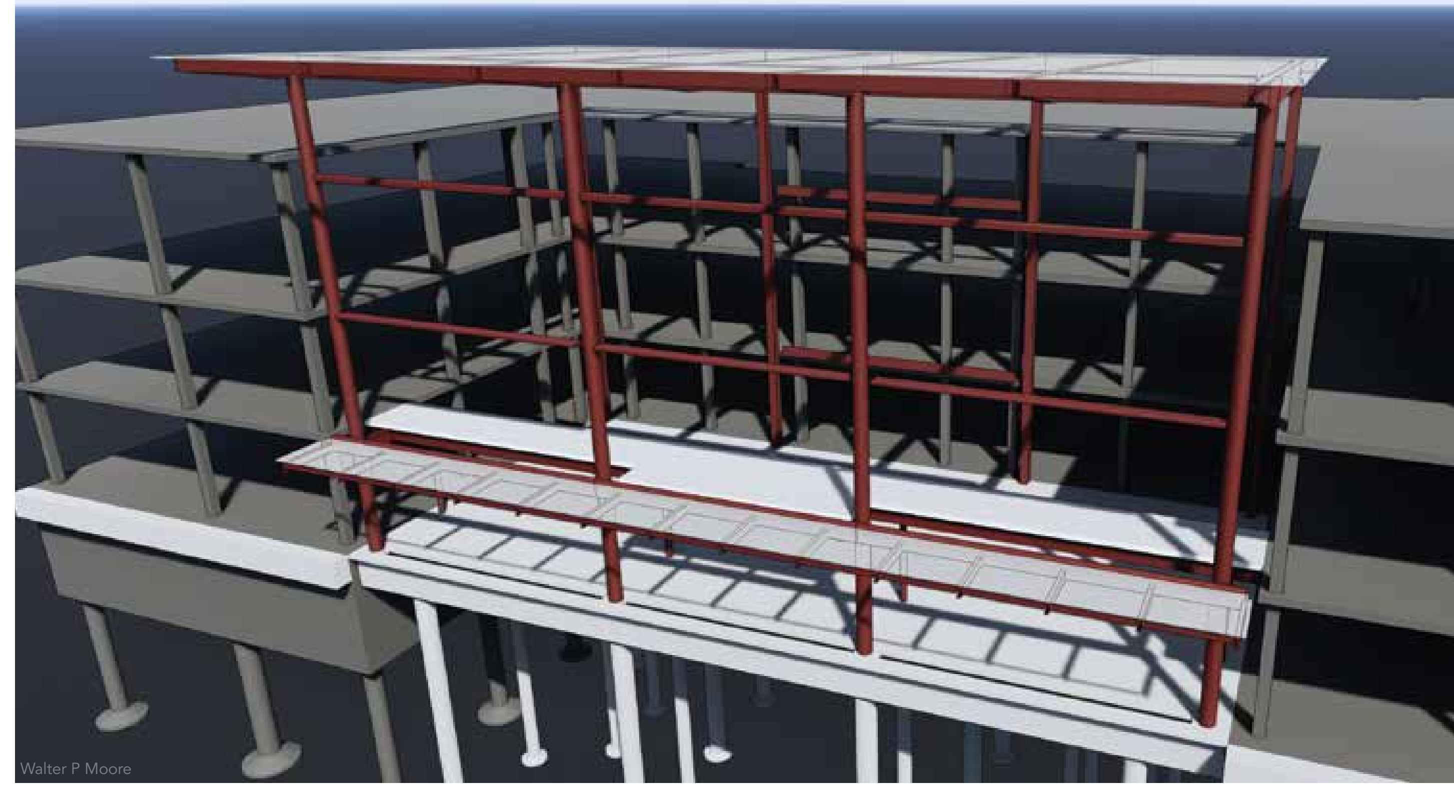


Keeping the Vision Afloat

BY JESSALYN NELSON, PE, AND KARIM ZULFIQAR, PE

Michelle Litvin Studio

A university science building incorporates hidden hangers and cantilevers to meld higher education with high design.



Walter P Moore

above: Framing for the column-free interior lobby space is highlighted in this model.

left: Abilene Christian University's new Halbert-Walling Research Center (HWRC) is part of a three-phase plan to upgrade the school's science facilities.

SEVERAL SCIENCE DISCIPLINES have a new steel-framed home at Abilene Christian University (ACU), all under one roof.

In developing a plan for a new science building on its Abilene, Texas, campus, the small private school envisioned a new and innovative space to house its biology, chemistry and biochemistry departments. The new 54,000-sq.-ft building, the Halbert-Walling Research Center (HWRC), is part of a three-phase plan to upgrade the science facilities on campus, which also includes façade and interior renovation work on the existing Onstead Science Center. Not only does it bring new laboratories, classrooms, lecture space and state-of-the-art equipment to the school, but it also adds a signature, modern edifice that stands out among the stately buildings that populate ACU's campus.

Pod Life

Architect Perkins+Will worked with ACU to develop a striking exterior and a column-free interior lobby space, and structural engineer Walter P Moore (WPM) designed a framing system to support this vision. The three-story building, which opened last year, incorporates a steel braced frame lateral system, with the roof and high roof—the latter a combination of transfer girders and long cantilevers separated from the regular roof by few feet—also framed with steel; 550 tons of structural steel was used in all. The project employed the integrated project delivery method, the first for steel fabricator Basden Steel, who was brought in early to provide expertise on material procurement, connection design and constructability.

Throughout the project, the use of steel enabled WPM to develop innovative solutions to support the expansive glass façade, thin roof profile and a prominent "floating" interior space. This latter, eye-catching feature, a two-story pod structure that appears to float above the first floor, includes auditorium and collaboration spaces as well as a corridor that wraps around the perimeter. A 6-ft-tall glass handrail runs along the corridor and pod edge, providing an airy, open walkway. While attractive, this element

Jessalyn Nelson is an associate and structural engineer and **Karim Zulfiqar** is a principal and senior project manager, both with Walter P Moore's Houston office.

The building's two-story pod structure appears to float above the first floor and includes auditorium and collaboration spaces as well as a corridor that wraps around the perimeter.

limited the use of hangers around most of the space, which necessitated a combination of hidden hangers and cantilevers. To develop this hidden support system, WPM performed analyses using Grasshopper visual programming within the Rhino 3D modeling package, including parametric modeling to optimize and balance hanger and cantilever support points, seeking to emphasize the floating appearance. This approach allowed for column-free space on Level 1 with almost 30 ft of uninterrupted overhang.

Another structural challenge with the pod was that various student spaces within the assembly were susceptible to vibrations. As such, WPM incorporated vibration studies in the design and analysis, following AISC Design Guide 11: *Vibrations of Steel-Framed Structural Systems Due to Human Activity* (**www.aisc.org/dg**) criteria for office spaces and limiting peak acceleration to 0.5% gravity. This enabled the team to size the steel beams appropriately to mitigate the impacts of expected excitations while still maintaining

The caltilevered roof framing elements were painted as protection against potential water intrusion, as they are not within the building envelope. They were also supported via temporary kickers during construction.

Cantilevered framing for the roof.

The tall glass façade is uninterrupted by columns and topped by a thin-profile cantilevered high roof.

Steel bracing at the main roof and high roof.

Framing for the pod assembly, which hangs from the ceiling in the atrium space.

the thin profile desired by the architect and owner.

To further enhance the lightness of the structure, Perkins+Will designed the glass handrail around the perimeter of the pod to be uninterrupted by metal supports. The solution was to produce "button" supports along the base of the glass within the depth of the structure to achieve the desired effect. The buttons appear inconspicuous within the depth of the primary structure but were engineered to support the above glass on their own.

Uninterrupted Façade

While the floating pod is a striking feature within the building, the tall glass façade—uninterrupted by columns and topped with a thin-profile cantilevered steel-supported high roof—makes an equally strong visual statement on the outside and acts as a new, modern focal point for ACU's campus. The façade pairs amiably with the newly renovated Onstead Science Center, which also features a glass façade and sits adjacent to the HWRC. To support the façade, WPM coordinated with Perkins+Will to design and detail curtain wall back-up steel, which incorporated hidden connections and embed plates, as well as exposed connections ground smooth to accomplish the streamlined look. The architectural expectations of the thin roof were met through careful configuration of the overhead transfer girders supporting the hangers via additional cantilevers within the tight soffit space.

The success of the HWRC project hinged upon close cooperation within a team that worked together on solutions from preliminary design stages through construction, keeping in mind the shared goal of reaching the aesthetic and performance expectations. Recognizing these end goals and striving to integrate solutions throughout the design process was crucial, as was viewing the process holistically. And the result is a new research center that serves as a campus icon not only for its aesthetic appeal, but also for the competitive educational advantages it brings to ACU's students and faculty. ■

The HWRC incorporates 550 tons of structural steel in all.

Owner
Abilene Christian University, Abilene, Texas

General Contractor
Hoar Construction, Austin

Architect
Perkins+Will, Houston and Dallas

Structural Engineer
Walter P Moore, Houston

Steel Fabricator, Erector and Detailer
Basden Steel, Burleson, Texas (AISC Certified Fabricator)

Land Granted

BY FALGUN SURANI, PE

Complex steel forms, both hidden and exposed, support signature elements of two dynamic buildings in a new urban green space.

The ONEOK Boathouse is one of two unique steel structures in Tulsa's new Gathering Place park.

SEA

SEA

The stone-clad, three-part fireplace provides an attractive focal point inside and outside of the Williams Lodge and is supported by an intricate steel frame.

SEA

Falgun Surani (**fsurani@seassociates.com**) is an associate and project manager with Structural Engineering Associates, Inc., in Kansas City.

THE GATHERING PLACE in Tulsa, Okla., is more than just that.

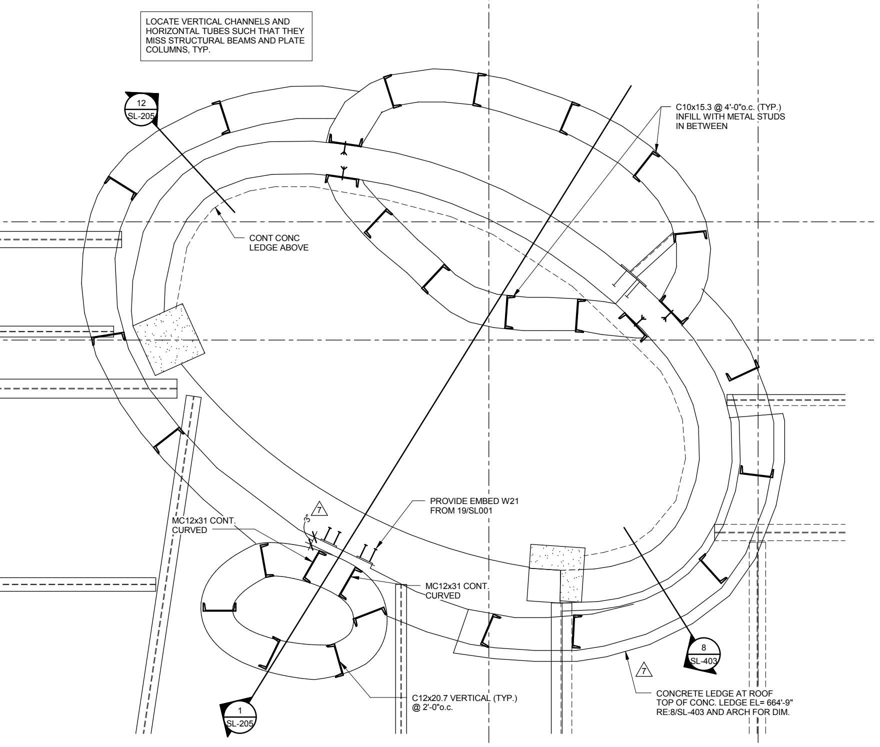
Designed to transform Tulsa's downtown waterfront along the Arkansas River into a dynamic, interactive environment, the $465 million, 66-acre green space is the largest private gift to a public park in U.S. history.

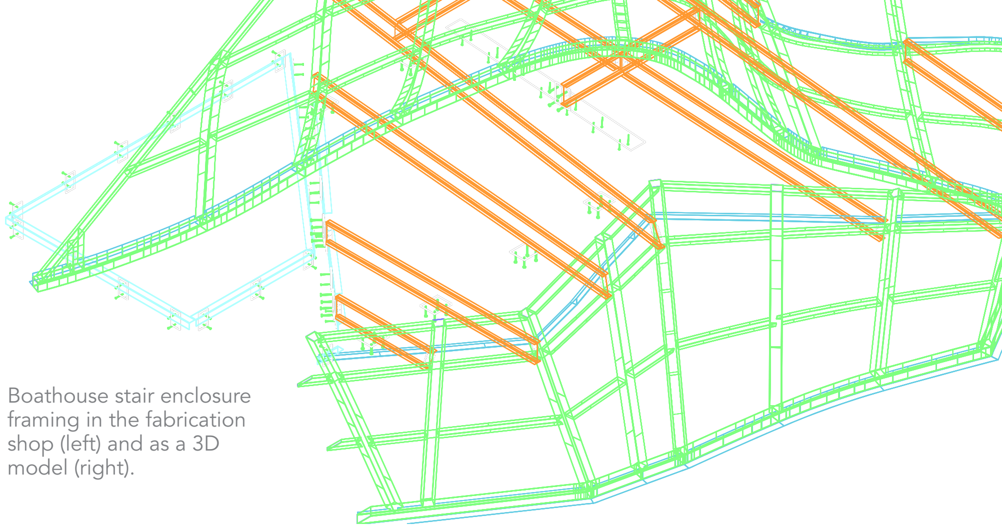
In addition to the vast open space, the park contains two dynamic steel-framed buildings (incorporating a total of 460 tons of structural steel) that anchor its services and activities, each structure embracing the powerful park landscape via a combination of traditional modernist strategies incorporating the rich, natural material palate of Oklahoma.

Williams Lodge

The first is Williams Lodge, which offers restrooms, a cafe, a two-story fireplace, indoor lounge spaces and educational activity rooms. Primarily made of stone floors, wood ceilings and full-height windows, the underlying design theme for the lodge was to provide an enclosed space that appears to be part of the landscape and also provides shelter during inclement weather. While the team chose steel as the framing material, the design goal of providing unobstructed views of the park ruled out larger hollow structural section (HSS) or wide-flange columns at the perimeter. Instead, closely spaced solid vertical steel plates (2½ in. by 8 in.) were implemented as columns to support the steel floor and roof beams—and also perform double-duty as window mullions. Nearly half of the plate columns are two stories tall, about 40 ft high. With concerns about losing plumbness during fabrication, shipping and erection, AISC member Unique Metal Fabrication proposed splicing the plate columns at floor level. However, the exposed nature of these columns as window mullions demanded a clean finish, rendering the splice unacceptable to the design team. Instead, the plate columns were erected first and temporary braces were provided during construction. Plate plumbness was repeatedly checked during construction, and the steel

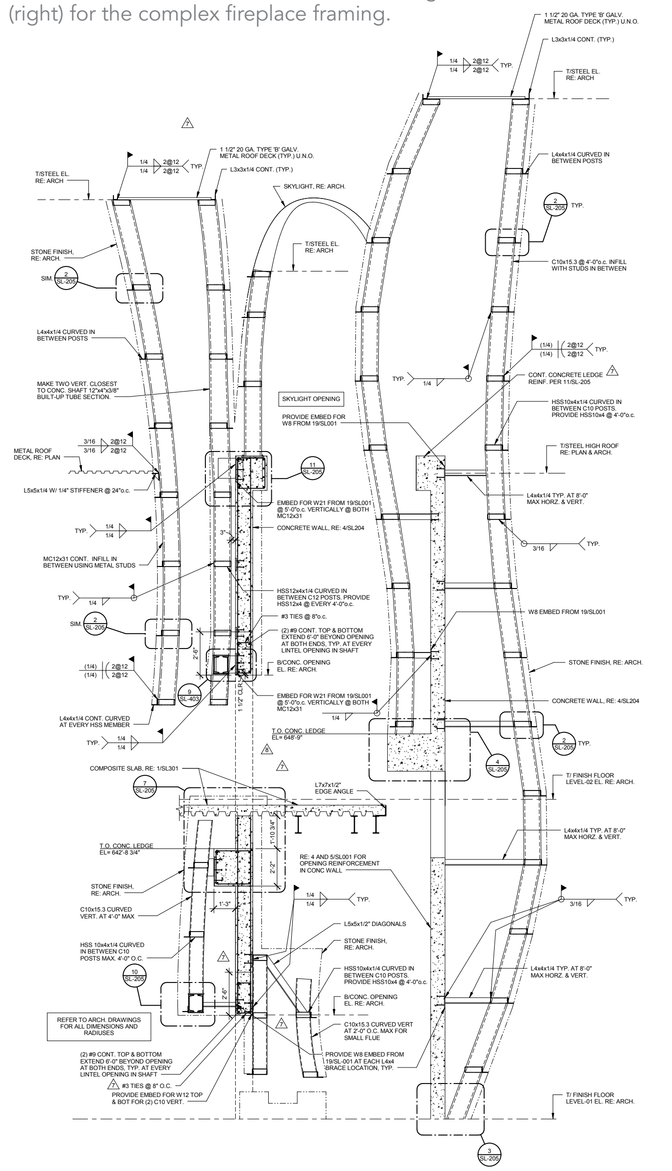
Unique Metal





Boathouse stair enclosure framing in the fabrication shop (left) and as a 3D model (right).

Details (above and below) and actual framing (right) for the complex fireplace framing.



floor and roof beams framing into the plate columns and glass windows were fabricated per final field dimensions.

The centerpiece of the lodge is a massive, two-story stone fireplace that's large enough for a group of people to walk in and around. The intricate shape of this structure meant that the skin would have to be supported by a curved steel structure since cast-in-place concrete forming was not feasible. A uniform oval concrete shaft was used as a shear wall as well as the core structure supporting the two-way steel grid that contains curved wide-flange members as verticals and curved HSS members as horizontals, both spaced roughly 4 ft on center. A SAP 2000 3D model was created to analyze and design this complex steel structure for out-of-plane wind loads as well as weight and moment coming from shelf angles supporting the stone façade eccentrically.

The chimney of the fireplace splits into three limbs that climb through the building. The first serves as the flue for the fireplace at level 1, the second supports the skylight in the center of the fireplace and the third serves as the flue for the fireplace at level 2, and also hangs from the face of the oval concrete shaft. It was nearly impossible to produce construction drawings for this steel structure, which had varying radii in every direction. Therefore, a 3D Rhino center line model was used as construction documentation, incorporating 2D details and sections with the structural drawings. Unique Metal extruded this 3D center line model to make a Tekla 3D model, which was then used to produce shop drawings. The traditional way of curving steel was not feasible since the steel grid structure changed shapes with non-uniform radiuses throughout its height and width. Additionally, shipping and erection of the roughly 60-ft-tall by 30-ft-wide steel structure wasn't possible. Unique Metal and general contractor Crossland proposed creating roughly 12-ft-tall ring grids that could be fabricated and shipped in quarter segments to be field welded to make the final shape of the structure. Each vertical and horizontal member was made by cutting ¼-in. or ⅜-in. plates to its radiused shape from the 3D Tekla model and then welding it in the shop to achieve the correct structural shape. All shapes made with plates were stich-welded alternatively on both sides to avoid any local distortion or warping effect from the welding heat.

In addition, the original design was to have the continuous wide-flange verticals supporting the HSS horizontals at every 4 ft, but this was not feasible due to shipping and erection limitations mentioned above. Instead, the horizontal HSS were made to run continuous, and vertical wide-flanges were made discontinuous at every intersection with horizontals. Since the 3D Tekla model was extruded from a center line Rhino model, this meant that all or a portion of the flanges of the wide-flange verticals would not receive a continuous weld on the HSS below due to the local twist in the overall shapes of the members. This issue was resolved by introducing a larger base plate at every vertical wide-flange top and bottom, and then these base plates were welded to the HSS horizontals at the top and bottom to achieve continuity. The design team of Mack Scogin Merrill Elam Architects and Structural Engineering Associates used a 3D model to coordinate the locations of several floor and roof beams that penetrated the steel grid structure of the fireplace and framed into the oval concrete shaft. Shelf angles supporting the stone façade at the fireplace was also made by welding two plates together to achieve the shape of the fireplace, and Fero brackets were used to connect shelf angles with the steel grid frame to provide the cavity for insulation.

The building also includes three stairways designed and fabricated using steel plate. The grand stair uses glass handrails and walls and was designed to cantilever between two floors, and the other two steel plate stairs use stone flooring. One of these is supported on a radiused channel stringer on one end, with the other end being supported on a concrete foundation wall where plate trades are notched around the plate-column base plates to avoid conflicts.

ONEOK Boathouse

The second building, the three-story ONEOK Boathouse, houses a restaurant on the pavilion outlook deck, offering views of the Arkansas river and downtown Tulsa, as well the Cabinet of Wonder, an educational and social gathering space. The centerpiece of the boathouse is a fiberglass canopy supported via HSS that serves as the roof for the uppermost pavilion level.

The steel stair enclosure covers the center floating stair serving all floors and is made with of HSS members placed in 4-ft by 4-ft grids. The enclosure is supported on composite steel beams on level 3, which in some cases cantilevers and also changes shape with varying radii in every direction. Like the support structure for the Williams Lodge fireplace, it was difficult to produce construction drawings for this structure. Hence, the same method of 3D modeling to produce shop drawings, as well as cutting and welding of plate, was used to achieve the desired built-up structural shapes. Metal studs are used as infill between the steel grid structure to support the stair enclosure's slate façade.

The level 2 mezzanine is made of composite steel beams, steel deck and glass walls, and hangs from the level 3 floor beams via four HSS hangers. The level 3 beams also support the entire roof structure for the restaurant, which includes another HSS hanger to support a floating stair landing.

Whether exposed to view in the boathouse canopy or hidden within the three-pronged fireplace in the lodge, complex steel framing elements are at the center of the Gathering Place's two signature structures. These structures in turn demonstrate how the built environment can mesh well with natural surroundings to enhance a riverfront experience in an urban setting. ■

Owner
City of Tulsa, Okla.

General Contractor
Crossland Construction Company

Architect
Mack Scogin Merrill Elam Architects

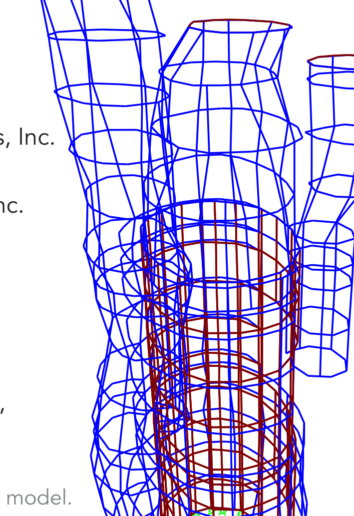
Park Designer
Michael Van Valkenburgh Associates, Inc.

Structural Engineer
Structural Engineering Associates, Inc.

Steel Team

Fabricator
Unique Metal Fabrication, Inc., Pittsburg, Kan.

Detailer
International Design Services, Inc., St. Louis



right: Fireplace framing model.

The centerpiece of the boathouse is a fiberglass canopy supported by HSS, that serves as the roof for the upper-most pavilion level.

The fireplace (above) and south stair (below) of the lodge.

Silica Safety

Silica dust, a common hazard in concrete and masonry construction, faces new regulations to curb worker exposure that may peripherally affect on-site steel construction.

BY KATHLEEN DOBSON

Kathleen Dobson (kdobson@alberici.com) is safety director with Alberici Constructors.

SINCE THE 1930s, the U.S. Department of Labor has been studying the relationship between silica dust and worker deaths. (Visit **tinyurl.com/silicasafety** to see a 1938 news reel of Frances Perkins, the first woman to head Occupational Safety and Health Administration—OSHA—introducing the hazards of silica.)

In 1971, OSHA put a standard in place for silica, limiting worker exposure to an average of 250 micrograms per cubic meter over eight hours. And now, after further research and discussion, an updated silica standard for construction has recently gone into effect, limiting respirable crystalline silica exposure to workers to an average of 50 micrograms per cubic meter of air over eight hours.

On September 23, 2017, 29 CFR 1926.1153, the respirable crystalline silica standard (**www.osha.gov**), became enforceable for employers in the construction industry. For construction contractors involved in activities that generate respirable crystalline silica dust, including blasting, grinding, cutting or otherwise working on materials such as concrete, brick and stone, it means a much stricter standard for respirable crystalline silica dust control.

What's important, and generally overlooked, is that contractors may be required to comply with the new standard if their workers are working *around* airborne crystalline silica produced by *other contractors*. For example, if an erector is working downwind from a contractor dry-cutting a concrete slab and is exposed to the dust cloud, the erector's employer is required to have a respirable crystalline silica program in place. As such, construction employers, including those working with steel, should evaluate the appropriateness of a silica safety program for their workers.

Employers who do not comply with the requirements of the new silica standard could receive financial penalties from OSHA. Serious or other-than-serious penalties could be up to $12,934 each—and repeat offenses or violations deemed by the agency to be willful in nature are subject to financial penalties of up to $129,336 each.

Employer Requirements

Employers will initially need to determine how much respirable crystalline silica dust workers are exposed to. If a viable sampling study indicates exposure levels below 25 micrograms, then the employer is not required to implement a silica program.

However, if the sampling study indicates exposure levels at or above 25 micrograms, then the employer is required to implement a written plan, provide medical surveillance and documentation and implement relevant engineering controls to effectively reduce the amount of respirable crystalline silica workers are exposed to. Most contractors anticipate that they will have many activities related to concrete work that will place the company in the level where they are required to have a comprehensive plan. Steel erectors will work around others or occasionally have tasks that expose them to silica. Steel fabrication facilities may have occasions where workers could be exposed.

OSHA's Table 1 (shown on the next page) also shows exposure control techniques for common construction tasks. If the table is followed regarding dust control techniques, respirators and a respirator program may not be required for silica exposures, and viable sampling studies will not be required.

FAQs

Here are answers to some frequently asked questions about silica:

Will everyone need a respirator? No. See if your tasks fall under Table 1 (there are 18 common construction activities) and determine how long each task will take. Most tasks in Table 1 require a respirator with an assigned protection factor (APF) of 10.

If I give a worker a filter mask (like an N-95 or N-100) will I be covered? Not necessarily. Filter masks are still respirators. Workers need to know how to wear them, when to exchange them and if they are properly fitting. There is no qualitative or quantitative fit test for this type of respirator, but there are instructions for testing seals (on the packaging) that a worker should follow every time they use one.

Also, OSHA considers any respirator use (including the filter masks) worn for silica exposure to be a part of our silica exposure plan. If a worker wears any type of respirator for 30 days (and OSHA considers a day's wear to be of any duration, whether it's 15 minutes or 8 hours) during a year, the worker must be medically evaluated once the 30-day threshold is met. This includes:

- A health history
- A physical exam (chest x-ray, pulmonary function test and TB skin test)

Costs will vary, but it is estimated that every worker undergoing a medical evaluation will be between $250 and $500, or more. Additional costs for fit-testing half-face respirators also need to be considered.

The workers wearing respirators must be tracked to maintain compliance with the standard.

At this time, we understand that the use of any respirator, including the dust masks, means our workers must be clean shaven; anything other than that is still to be determined.

What changes can be made to tools to reduce silica dust? Manufacturers who produce concrete tools have protective measures in place: filter systems, water systems, vacuum systems and so on. Many of the tools we currently use cannot be retrofitted and will not meet the standard requirements. Contact your company safety team for support and contact your manufacturer representative for training in the use of the new tools.

If tools incorporate wet methods, are other measures needed? Yes. You cannot assume that wetting down will be effective. If a manufacturer's tool has a wet method incorporated into the tool and it is used with water—and it reduces exposure to the permitted level—then that eliminates the need for other compliance testing and respirator use.

We don't have a full-time safety representative on our project. Who is the competent person? The project's competent person is:

- Someone who is on-site all the time
- Someone who knows the essential elements of the silica standard
- Someone who can enforce the rules with self-performed work and subcontractor's work
- Someone who can assure that personnel understand the standard if they are working around activities that produce respirable crystalline silica dust

If you aren't certain who to designate, make sure you contact the safety department for further direction.

Is this going to add costs to projects? Yes. Employers will be responsible for: training employees; assuring they have the correct tools (respirators, tools with integrated water systems and tools with integrated HEPA vacuum systems); and assuring that personnel who need medical evaluations are identified and receive the evaluations per the standard. Project leaders and estimators need to understand there will be additional costs.

If our subcontractors are performing concrete work that produces respirable crystalline silica, what do we need to do? Make certain they are following the standard and are not exposing your workers or any other subcontractor workers to respirable crystalline silica exposure. Failure to assure that subcontractors are complying may mean that OSHA will cite the general contractor for failing their controlling contractor responsibilities. Remember: Citations now begin at $12,934 per each maximum penalty violation.

In addition, OSHA's *Crystalline Silica Standard for Construction* and *Small Entity Compliance Guide for the Respirable Crystalline Silica Standard for Construction*, both available at **www.osha.gov**, are documents every shop and project should have and reference.

Understanding and following the requirements of this new silica standard will help you keep your employees safe and also help keep your company from becoming vulnerable to infraction-related fines. ■

OSHA's "Specified Exposure Control Methods" table is on the next page. ▸

Specified Exposure Control Methods When Working with Materials Containing Crystalline Silica

Equipment/task	Engineering and work practice control methods	Required respiratory protection and minimum assigned protection factor (APF)		
			≤ 4 hrs/ shift	>4 hrs/ shift
(i) Stationary masonry saws	Use saw equipped with integrated water delivery system that continuously feeds water to the blade Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions		None	None
(ii) Handheld power saws (any blade diameter)	Use saw equipped with integrated water delivery system that continuously feeds water to the blade Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions:	-When used outdoors -When used indoors or in an enclosed area	None APF 10	None APF 10
(iii) Handheld power saws for cutting fiber-cement board (with blade diameter of 8 inches or less)	For tasks performed outdoors only: Use saw equipped with commercially available dust collection system Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency		None	None
(iv) Walk-behind saws	Use saw equipped with integrated water delivery system that continuously feeds water to the blade Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions:	-When used outdoors -When used indoors or in an enclosed area	None APF 10	None APF 10
(v) Drivable saws	For tasks performed outdoors only: Use saw equipped with integrated water delivery system that continuously feeds water to the blade Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions		None	None
(vi) Rig-mounted core saws or drills	Use tool equipped with integrated water delivery system that supplies water to cutting surface Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions		None	None
(vii) Handheld and stand-mounted drills (including impact and rotary hammer drills)	Use drill equipped with commercially available shroud or cowling with dust collection system Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism Use a HEPA-filtered vacuum when cleaning holes		None	None
(viii) Dowel drilling rigs for concrete	For tasks performed outdoors only: Use shroud around drill bit with a dust collection system. Dust collector must have a filter with 99% or greater efficiency and a filter-cleaning mechanism		APF 10	APF 10
(ix) Vehicle-mounted drilling rigs for rock and concrete	Use dust collection system with close capture hood or shroud around drill bit with a low-flow water spray to wet the dust at the discharge point from the dust collector OR Operate from within an enclosed cab and use water for dust suppression on drill bit		None None	None None
(x) Jackhammers and handheld powered chipping tools	Use tool with water delivery system that supplies a continuous stream or spray of water at the point of impact: OR Use tool equipped with commercially available shroud and dust collection system Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions Dust collector must provide the air flow recommended by the tool manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism:	-When used outdoors -When used indoors or in an enclosed area -When used outdoors -When used indoors or in an enclosed area	None APF 10 None APF 10	None APF 10 None APF 10
(xi) Handheld grinders for mortar removal (i.e., tuckpointing)	Use grinder equipped with commercially available shroud and dust collection system Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions Dust collector must provide 25 cubic feet per minute (cfm) or greater of airflow per inch of wheel diameter and have a filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism		APF 10	APF 25
(xii) Handheld grinders for uses other than mortar removal	For tasks performed outdoors only: Use grinder equipped with integrated water delivery system that continuously feeds water to the grinding surface Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions OR Use grinder equipped with commercially available shroud and dust collection system Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions Dust collector must provide 25 cubic feet per minute (cfm) or greater of airflow per inch of wheel diameter and have a filter with 99% or greater efficiency and a cyclonic pre-separator or filter-cleaning mechanism:	 -When used outdoors -When used indoors or in an enclosed area	None None None	None None APF 10
(xiii) Walk-behind milling machines and floor grinders	Use machine equipped with integrated water delivery system that continuously feeds water to the cutting surface Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions OR Use machine equipped with dust collection system recommended by the manufacturer Operate and maintain tool in accordance with manufacturer's instructions to minimize dust emissions Dust collector must provide the air flow recommended by the manufacturer, or greater, and have a filter with 99% or greater efficiency and a filter-cleaning mechanism When used indoors or in an enclosed area, use a HEPA-filtered vacuum to remove loose dust in between passes		None None	None None
(xiv) Small drivable milling machines (less than half-lane)	Use a machine equipped with supplemental water sprays designed to suppress dust. Water must be combined with a surfactant Operate and maintain machine to minimize dust emissions		None	None
(xv) Large drivable milling machines (half-lane and larger)	For cuts of any depth on asphalt only: Use machine equipped with exhaust ventilation on drum enclosure and supplemental water sprays designed to suppress dust Operate and maintain machine to minimize dust emissions For cuts of four inches in depth or less on any substrate: Use machine equipped with exhaust ventilation on drum enclosure and supplemental water sprays designed to suppress dust Operate and maintain machine to minimize dust emissions OR Use a machine equipped with supplemental water spray designed to suppress dust. Water must be combined with a surfactant Operate and maintain machine to minimize dust emissions		None None None	None None None
(xvi) Crushing machines	Use equipment designed to deliver water spray or mist for dust suppression at crusher and other points where dust is generated (e.g., hoppers, conveyers, sieves/sizing or vibrating components, and discharge points) Operate and maintain machine in accordance with manufacturer's instructions to minimize dust emissions Use a ventilated booth that provides fresh, climate-controlled air to the operator, or a remote control station		None	None
(xvii) Heavy equipment and utility vehicles used to abrade or fracture silica-containing materials (e.g., hoe-ramming, rock ripping) or used during demolition activities involving silica-containing materials	Operate equipment from within an enclosed cab OR When employees outside of the cab are engaged in the task, apply water and/or dust suppressants as necessary to minimize dust emissions		None None	None None
(xviii) Heavy equipment and utility vehicles for tasks such as grading and excavating but not including: Demolishing, abrading, or fracturing silica-containing materials	Apply water and/or dust suppressants as necessary to minimize dust emissions OR When the equipment operator is the only employee engaged in the task, operate equipment from within an enclosed cab		None None	None None

Learning Experience

Photos: Cynthia DeMatteo Falconer

A collaborative approach and a team experienced in school construction made quick work of a steel-framed early childhood learning center.

The new Reginald Mayo School Early Childhood Learning School is the largest public preschool in Connecticut.

BY JAMES FALCONER, PE, PENG, CYNTHIA DEMATTEO FALCONER, TOM TORRENTI, PE, AND ROBERT GENNETT

James Falconer (jfalconer@jkfdesign.com) is owner and **Cynthia DeMatteo Falconer** (cfalconer@jkfdesign.com) is administrator, both with JKF and Associates, LLC, in New Haven, Conn.

TWO DECADES AGO, in an effort to modernize and improve its public school facilities, the city of New Haven launched its ongoing School Construction Program.

Since its initiation in 1998, the program has seen the renovation or construction of 46 schools totaling 4.2 million sq. ft and $1.6 billion. The latest project under the program is the Reginald Mayo School Early Childhood Learning School, which replaces the Helene Grant School (Grant was a school teacher who worked in the New Haven school system for half a century). The new facility is the largest public preschool in the state and the city's only early childhood learning school.

Framed with nearly 600 tons of structural steel, the main building for the new school consists of two wings with a maximum length of 190 ft—one featuring classrooms, a cafeteria and offices and another dedicated to administrative spaces—that stretch out at a 90° angle from one another from a hexagonal anchor section with a maximum side length of 133 ft. A new, smaller steel-framed administrative building, using approximately 50 tons of steel, was also part of the project.

The L-shaped plan of the main building is a series of block forms that represent the classrooms, with each block requiring long, column-free spans that facilitate open and flexible classroom spaces. The maximum span of the beams in the longitudinal direction is 38 ft, 10.5 in., which is longer than the typical beam span length for this type of building, and beams that support the stud brick façade were restricted to a maximum deflection of 0.3 in. in order to follow the provisions of local building code requirements for masonry walls. As a consequence, heavier-than-normal beams were used.

With a total area of 84,000 sq. ft and a height of 44.5 ft, the main structure consists of ordinary moment-resisting frames built up with 10-in. and 14-in. hollow structural section (HSS) columns (A500 Grade B) and wide-flange beams (ASTM A992) with sizes ranging from W21×201 to W12×40, all topped by a composite steel deck with concrete topping for the second floor and open-web steel joists with non-composite steel deck for the roof. The deck edges incorporate a $\frac{3}{8}$ in. plate to serve as a concrete pour stop as well as to provide horizontal support for the perimeter wall studs. In addition, kicker bracing was deployed along the edge beams to minimize cantilever slab deflection.

After selecting the ordinary moment system for the typical framing, the design team determined a minimum column size of HSS 10×10×$\frac{5}{8}$ everywhere except at the hexagonal center portion, where larger HSS14×14×$\frac{5}{8}$ columns were required. Moment connections were employed to achieve an unobstructed area of work, and using HSS columns helped facilitate multiple-direction connections at the same elevation in some areas. A number of HSS columns were strengthened, with help from RAM, to prevent local buckling where they connected to the beams. RAM indicates when to reinforce the wide-flange column webs for shear and additionally places top and bottom stiffeners at the beam-column connection points for wide-flange columns—though not in this case since the columns were hollow. Each frame, moment and shear element was analyzed, and the transfer forces to the column were determined to need reinforcement to avoid local buckling. The procedure involved cutting off columns, installing horizontal plates and welding the new assemblies to the original columns.

The center hexagonal building is used as a cafeteria and theater, and its complicated nexus was addressed via a couple of center main frames consisting of HSS trusses connected to the HSS columns and circled by ordinary moment-resisting frames. The center of the hexagon is crowned by a skylight that provides natural light to the cafeteria and is supported by two perimeter strengthened joists that were beefed up to take on the increased load. Because of the required sound isolation between the cafeteria and the classrooms, 8-in. reinforced concrete masonry units (CMUs) were implemented, and the heavy load imposed on the second floor is reflected in the size of the steel support beams, which are W21×166.

The building's exterior consists of steel studs finished with a brick façade, with relief joints distributed along the face of the building. The egress stairs needed to be isolated from the rest of the building in order to achieve a two-hour fire rating refuge as prescribed in the 2012 *International Building Code*. The typical approach is to use reinforced CMUs built as independent towers in the footprint of the building, but the towers interrupted the continuity of the steel frame, thus demanding additional members to circumvent them. As such, the conceptual design of the school did not consider the stair towers as part of the overall lateral-resisting system.

In one of the building's large openings, which involved a 25-ft span, steel hangers

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above: The administrative building uses roughly 50 tons of steel.

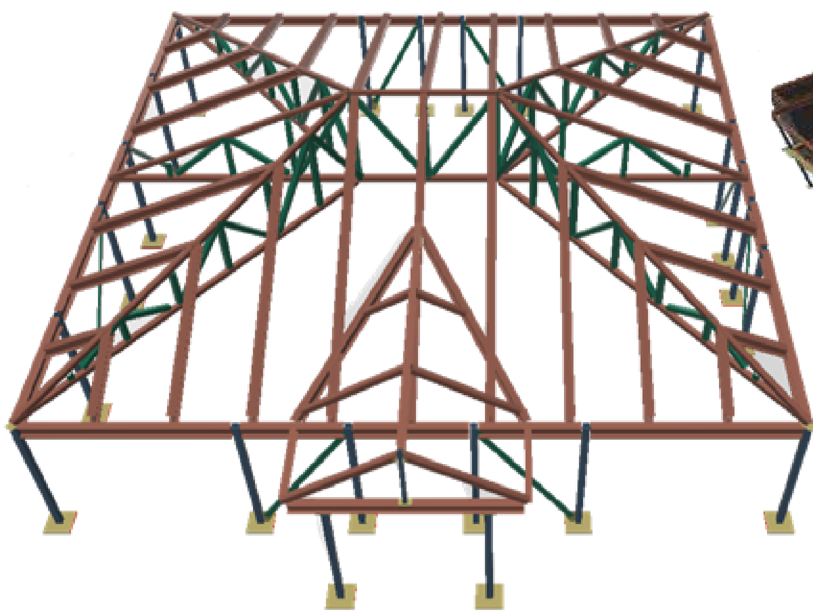
and kicker bracing were implemented in accordance with AISC Design Guide 22: *Façade Attachments to Steel-Framed Buildings* (**www.aisc.org/dg**). The bottoms of the hangers were back-connected to the roof beams via kickers to control rotation. The load in this particular case exceeded 500 lb per ft, with an eccentricity of 1 ft. Kickers around the perimeter of the building addressed deflections and were used in conjunction with the cantilever steel plate, which was modeled in Revit and placed on top of all the beams around the building, with the second-floor exterior wall resting on it. A decision between using a) thicker plate to take the load of the wall and concrete slab or b) thinner plate combined with kickers, had to be made, taking into consideration that a small deflection of the end of the cantilever slab might cause cracks in the façade bricks. The kicker option was eventually selected as it ended up being the most economical choice.

Charles Chamulak, vice president and shop superintendent with fabricator Schenectady Steel, expressed that the sheer number of plate connections was a challenge for the shop. "It was our first experience with such a large number of continuity plate moment connections," he said. "We had done them previously on various projects, but they were typically fillet welds from HSS to plate, whereas this project had a substantial number of full-penetration welds. It was definitely a challenging project as far as fabrication went."

But trial and error proved to be the solution, with Chamulak explaining that the straightness of the HSS column assemblies was maintained by repositioning them numerous times during welding to keep from introducing too much heat on any one side or elevation.

The framing for the smaller, administrative building consists of a combination of HSS sections and wide-flange beams, with

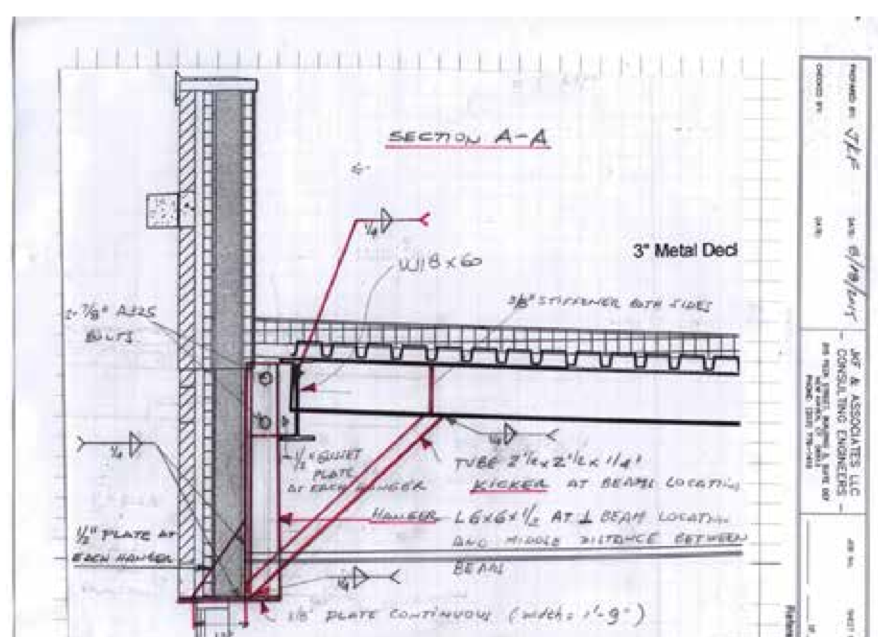
The main school building uses roughly 600 tons of structural steel framing.



left and right: Framing models of the administrative and main buildings.

below: The framing for the smaller, administrative building consists of a combination of HSS sections and wide-flange beams, with the main lateral force-resisting system made of bracing built up in the perimeter walls.

below: A sample connection drawing.



above: With a total area of 84,000 sq. ft and a height of 44.5 ft, the main structure employs an ordinary moment-resisting frame system.

below: Joist framing at the skylight.

For the framing of the main building, the design team determined a minimum column size of HSS 10×10×5⁄8 everywhere except at the hexagonal center, where larger HSS14×14×5⁄8 columns were required.

the main lateral force-resisting system being made of bracing built up in the perimeter walls. The main vertical force-resisting elements consist of a Warren truss connected to four hip trusses resting on the perimeter wall, which is made up of 6-in. HSS columns topped off by a 12-in.-deep wide-flange section, thus leaving an interior area uninterrupted by columns. The connections of the trusses and purlins to the vertical force-resisting elements were achieved with high-strength F3125 Grade A325 bolts that provided an adequate safety factor for stability during construction as well as for lateral distribution in the final service condition.

Construction for the entire project was accomplished in 20 months and with minimum change orders, which was facilitated in great part via the collaborative, model-based approach. In addition, several of the companies working on the project had already worked on multiple other area schools in the recent past, so strong communication between team members was realized from the very beginning. ■

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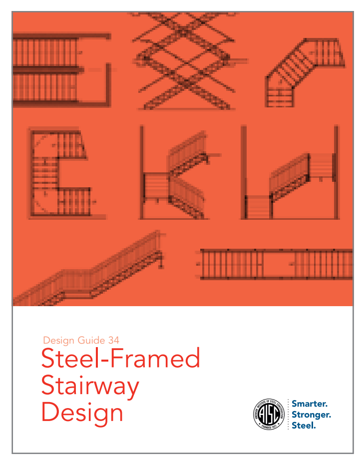
Stepping Up

BY ADAM FRIEDMAN, SE, PE

Knowing how to frame your structural steel around stairs—and the stairs themselves—will help take your multi-story projects to the next level.



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STAIRWAY DESIGN HAS been, shall we say, up and down over the years.

At one point, stairways, handrails and guards were fully designed and detailed in the design documents. In the recent past, their presence on design documents became minimal or they were simply delegated to the fabricator. Little oversight or review was required or necessary.

However, with recent changes to the design code, ASCE/SEI 7-16 *Minimum Design Load and Associated Criteria for Buildings and Other Structures*, and more rigorous review requirements from the design team and authority having jurisdiction (AHJ), the design, layout, fabrication and erection of steel stairways have become a complex and involved process.

In an effort to set clear expectations and provide practical design information for the steel industry, AISC has developed a new publication: AISC Design Guide 34: *Steel-Framed Stairway Design* (available at **www.aisc.org/dg**). This new resource provides guidance for the design and layout of steel elements for steel-framed stairways, guards, handrails and related components. Background information regarding stairways, code requirements and design methods is presented, and complete design examples are also included. A handful of sample figures from the new guide are included in this article.

Design Criteria

The guide begins with a basic overview of stair and rail types, classes and nomenclature as defined by the National Association of Architectural Metal Manufacturers (NAAMM) based on AMP 510-92 *Metal Stair Manual* and AMP 521-01 (R2012) *Pipe Railing Systems Manual*. Layout recommendations depicting 2015 *International Building Code* (IBC) and Occupational Safety and Health Administration (OSHA) style stairs are included, along with recommendations to determine appropriate core opening dimensions, and the guide can be used as an aid in determining code requirements related to typical stair and rail layouts. One of the more common issues with stair design is the lack of support provided for the stairs in the structural design; another is insufficient opening sizes provided for the stairway. Several recommendations are included to provide layouts that allow for proper connection fit-up and help avoid these common design issues.

A key recommendation of the design guide is to use the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360-16) and *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303-16) as reference documents for the design, detailing, fabrication and erection of steel-framed stairways (both are available at **www.aisc.org/specifications**). These criteria should be referenced as project requirements in the design documents, which will help ensure that all parties have the same set of criteria and expectations to meet.

Design loads are addressed per ASCE/SEI 7-16. Additional loading requirements, per current OSHA Standards 1910.25 *Stairways* and 1910.29 *Fall Protection Systems and Falling Object Protection-Criteria and Practices*, are also presented in the design guide.

Seismic Considerations

Specific guidance to determine seismic design forces and serviceability requirements per ASCE/SEI 7-16 is also included in the new design guide. In the 2016 edition of ASCE 7, major changes have been made related to seismic relative displacements, requiring that stair designs accommodate seismic movements within buildings without creating an undesirable load path or unacceptable performance. The

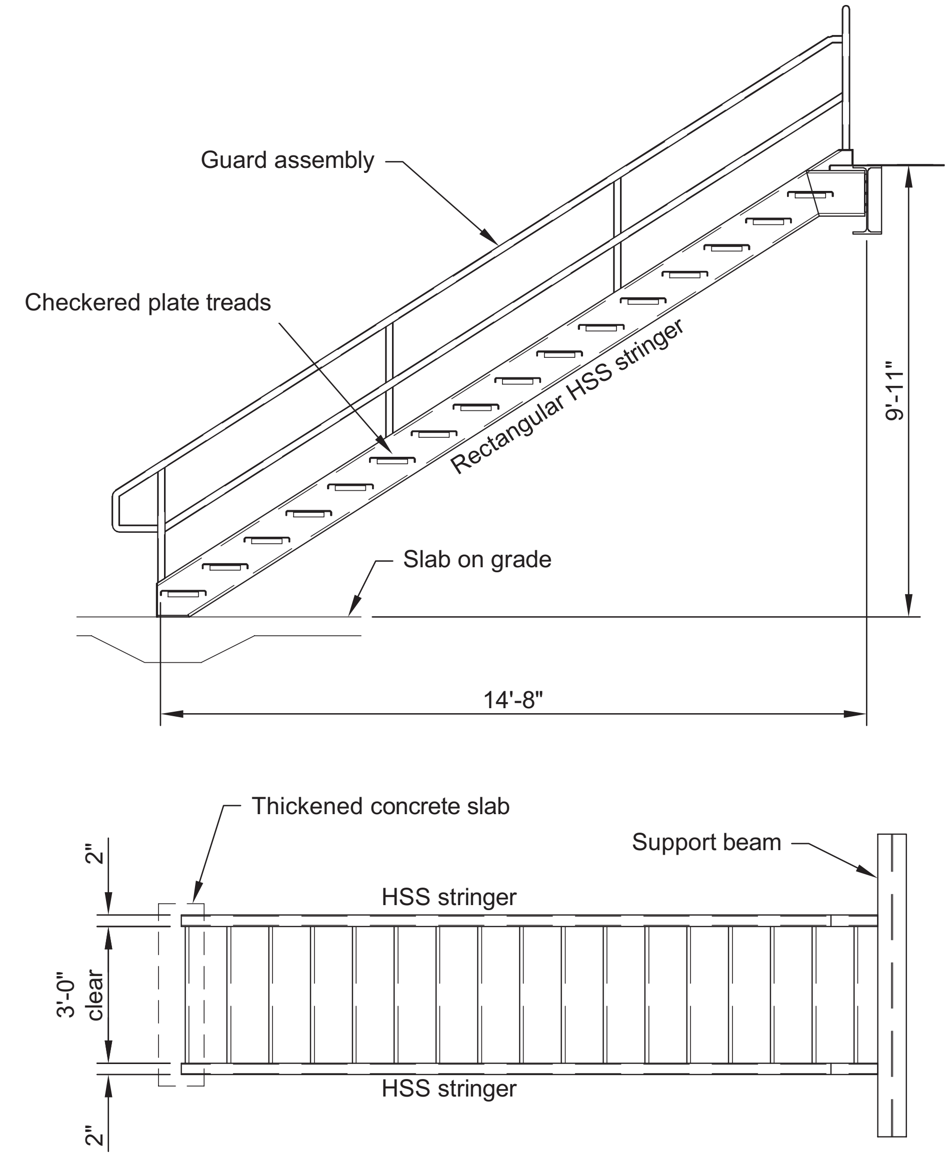


Fig. 10-9. Industrial stairway section and plan.

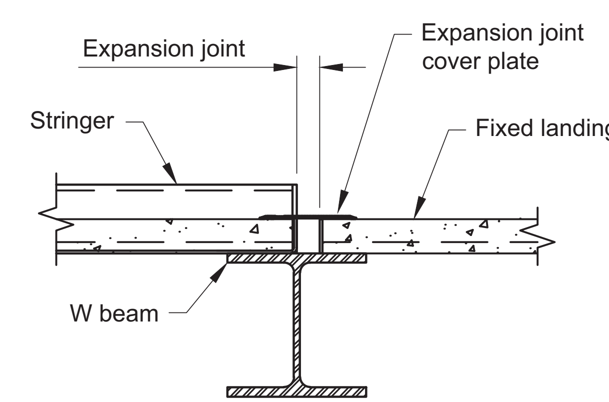


Fig. 6-20. Seismic displacement detail using expansion joint.

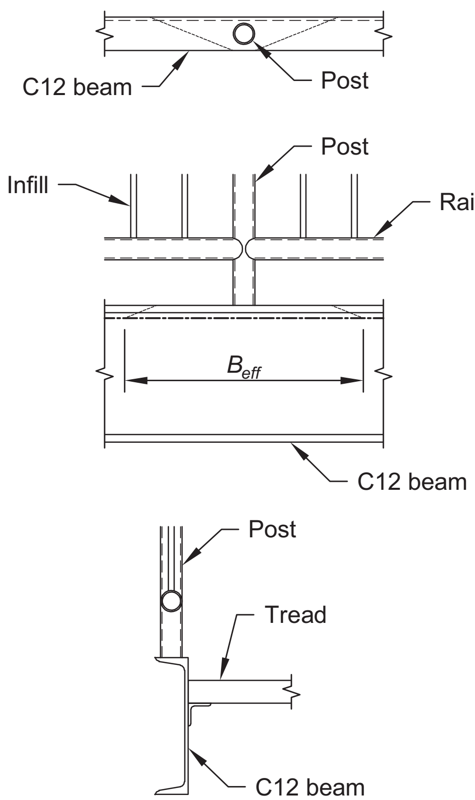


Fig. 10-8. Guard-post-to-channel-flange diagram.

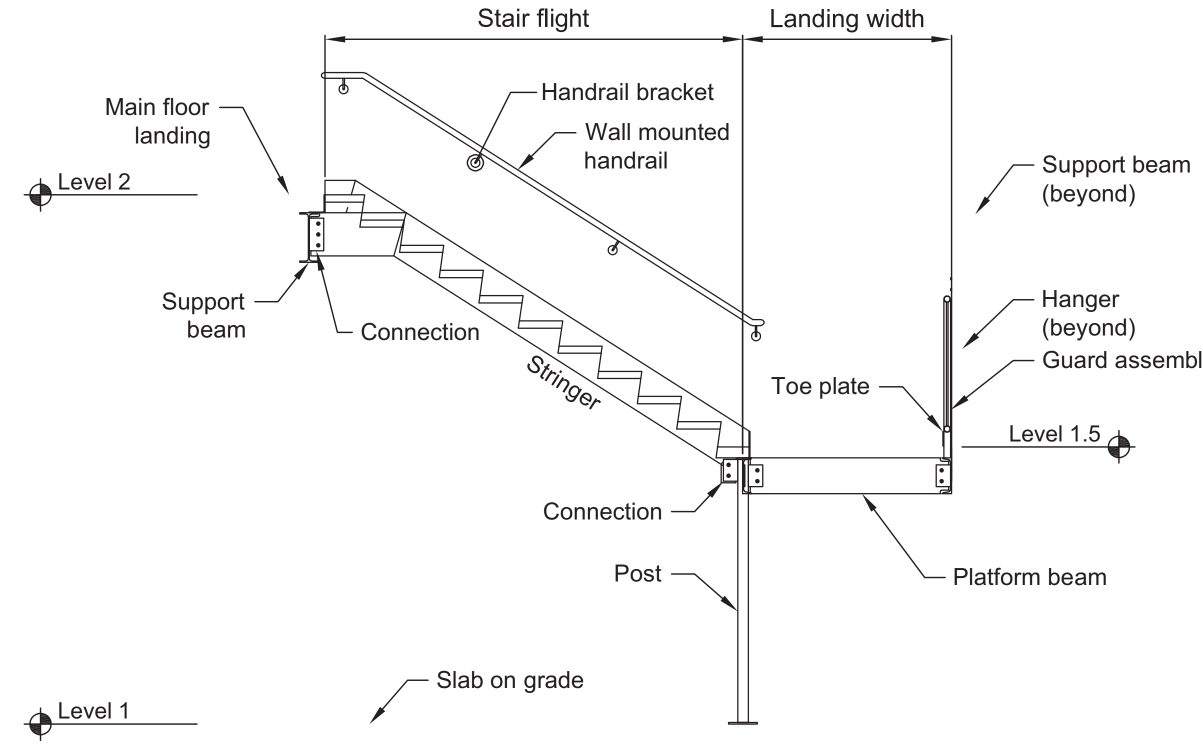


Fig. 2-12. Nomenclature—section views.

guide provides an overview of this criterion along with conceptual drift/sliding details. ASCE/SEI 7-16 also requires that stairs must be incorporated into the structural building model when the stair does not accommodate the seismic relative displacements using sliding or ductile connections. These code revisions will likely require changes to current stair design, layout, detailing and fabrication used in seismic regions.

Design Methodologies

Several recommendations and design methodologies are provided for typical stair elements. The application of loading on stringers and determination of forces can be solved using different methods. Various techniques and assumptions are explored to provide engineers with several options to verify design intent against real-world conditions. Determination of deflections at sloping beams (e.g., stair stringers) is covered as well to assist designers in accurately finding overall vertical deflection.

Recognizing that architectural requirements vary from project to project, the guide also discusses the aesthetic and engineering pros and cons of different member types. Figures and discussion are included for different aspects of the stair, guard and handrail elements, and each section provides conceptual details, recommendations and design resources.

Delegated Design

Because steel stairway design and layout is commonly delegated to others by the engineer of record, the design guide dedicates an entire chapter to this topic. The advantage with delegated design is that the team members with the expertise, experience and knowledge of steel stairways can provide the design and layout. Typically, delegated design will be completed by a specialty structural engineer to provide structural calculations and by the detailer/fabricator to provide the layout and fabricated stair. To accomplish this in an efficient and effective manner, the structural engineer of record and the architect of record need to provide critical information to the delegated design team. As such, the guide provides an overview of the critical information that should be provided within the design documents, as well as additional discussion regarding code compliance. The goal is to ensure that all project team members understand their scope of work and have clear expectations to meet project requirements.

Connections

Design and layout information regarding the members and connections of the guardrail and handrail elements are covered as well. Specific discussion is provided for the connection of a steel guard post to the top of an unstiffened channel flange. This detail is commonly used, and the guide provides recommendations to determine the capacity of the channel to resist the moment imposed by the guard post.

Using typical AISC connections can simplify the engineering process and make detailing and fabrication more straightforward and economical, and using similar connections for the main steel structure and on steel-framed stairways allows for greater repetition and efficiency. Considering this, the design guide provides figures of simple shear connections, hangers, moment connections, bracing and connections to non-steel members. References and guidance are also included to aid designers in finding the appropriate sections within the 15th edition AISC *Steel Construction Manual* (**www.aisc.org/manual**) as well as other available resources.

Additional guidance is provided related to lateral bracing and diaphragm design for stairs subjected to lateral loads. When considering seismic forces, it is critical that stair designers carefully determine the load path when implementing sliding or drift details.

Additional Considerations

Other topics covered in the design guide include construction tolerances, galvanizing, long spans, vibration and erectability. The intent is to make stair designers aware of these potential issues so that appropriate coordination is completed in advance of finalizing the design.

Several design examples are included, covering commercial and industrial stairs, with the industrial stair example stepping through the determination of seismic design forces. Various member design examples are included, following the design methodologies discussed throughout the guide, and specific connection checks for stair elements are also covered.

Overall, Design Guide 34 provides adequate information for structural engineers to design steel-framed stairways, as well as guidance on delegating this work to other engineers or stair designers. Combined with practical knowledge and sound engineering judgment, it can help optimize any steel stairway design. ■

Bon Appétit

BY GERALD C. WALLACE, III, AIA

Steel framing cooks up an appetizing new school that hopes to attract and retain the next generation of culinary professionals.

Matt Silk

The new International Culinary Institute of Myrtle Beach for Horry Georgetown Technical College.

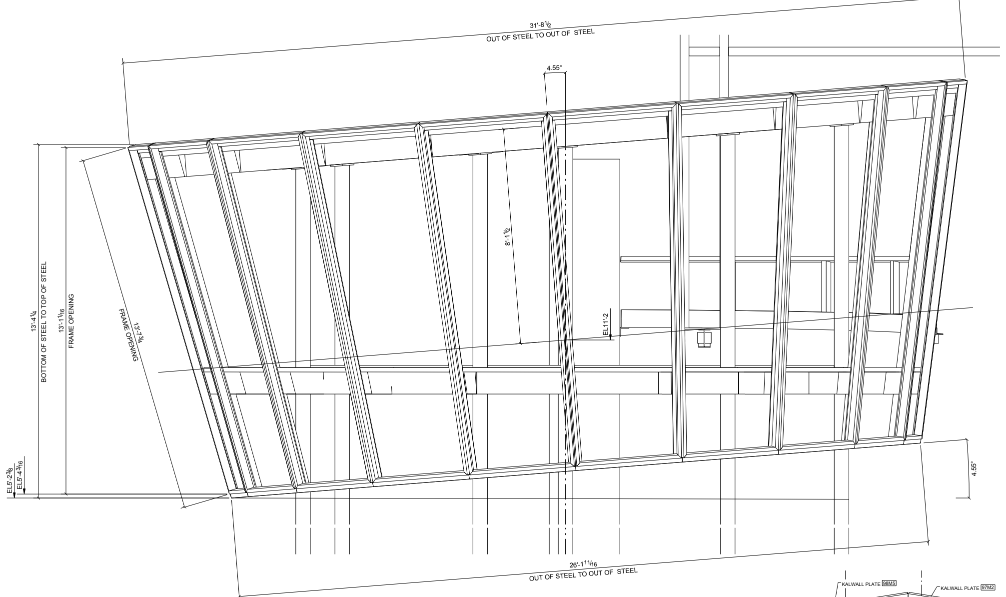
Gerald Wallace (gwallace@mozingowallace.com) is a senior partner with Mozingo + Wallace Architects, LLC, in Myrtle Beach, S.C.

THE FIRST GOAL of the new International Culinary Institute of Myrtle Beach for Horry Georgetown Technical College is fairly obvious: Teach the culinary arts.

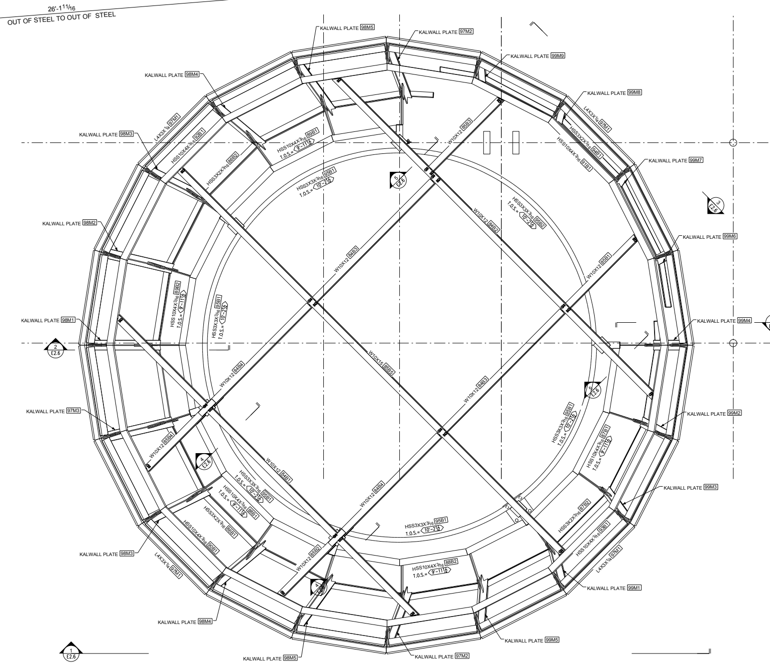
But just as important is the additional goal of retaining students through to graduation. While the school has long attracted plenty of enrollees, less than half of them stayed long enough to earn their full two-year degree. This wasn't because students weren't engaged or didn't perform well, but rather because they had the opportunity to "go pro" early, as most would gain some training, only to be drawn away due to the high demand for restaurant employees in the resort area surrounding the college. Horry Georgetown determined that it would take more than a quality education to keep students for the full two years and, as is common with other types of university and sports programs, looked to the building itself to increase retention via a unique appearance and an enhanced learning environment.

Steel was the natural choice for the main building frame due to several factors. Its strength was necessary to hold up the enormous amount of overhead equipment that services the building's six full commercial kitchens. It was also able to provide the long spans that facilitate a tremendous amount of glazing, allowing much of the interior to be bathed in natural light—which contributes to an improved learning environment.

Matt Silk



One of the building's architectural and structural hightlights is the conference room, which is topped by a skewed cylindrical skylight cap evoking a chef's toque.



Monteith

Matt Silk

Monteith

And perhaps most importantly—especially given the region's history with hurricanes—it provided strength to withstand extremely high wind loads.

Located on Horry Georgetown's campus approximately one mile inland from the Atlantic Ocean, the 30,000-sq.-ft building eschews the flat surfaces and square corners common in the adjacent, older buildings of the campus. Circular steel-framed spaces bookend the facility. At one corner of the building sits a round demonstration kitchen/lecture hall, with the other end anchored by a round conference room. The conference room is topped by a skewed cylindrical skylight cap evoking a chef's toque. Texture is added to the front by the use of tilted rain

Entrance framing, before and after coating was applied.

screen panels, and the overhanging roof is supported by double hollow structural sections (HSS) located outside of the building envelope, allowing for an uninterrupted clerestory that lights up the interior concourse.

This concourse acts as both collaboration and social space and seats up to 290 without interfering with circulation. A full-service restaurant, four teaching kitchens, administrative offices and a lecture hall are all adjacent to this public area. All of these spaces, excluding the lecture hall, have glazing panels fronting the concourse, spreading natural lighting from the clerestory into the teaching areas, and letting visitors view classroom activities.

From a steel fabrication standpoint, the project's biggest challenge manifested in the multiple and complicated pitches. Anticipating issues, the project's steel fabricator and erector, Elvis Welding Service, scheduled multiple meetings with the detailer, general contractor Monteith Construction, architect Mozingo +Wallace and structural engineer Kyzer and Timmerman to get a handle on the shop drawings and ensure that all team members were on the same page. Some of the framing for the cylindrical skylight cap—which is round, tilted and tapered outward from bottom to top as a truncated cone—involved two or three different pitches in a single fabricated piece, which created quite a headache in detailing, fabrication and final erection. The circular demonstration kitchen at the opposite end of the building was marginally easier for the steel team, since it at least was level from top to bottom. However, it contained a long curved window requiring a curved steel lintel, which in turn had to support a splayed series of vertical sunscreens on the window, using steel extensions for braces.

With the building now open, the college anticipates that the new steel-framed space will not only continue to attract future chefs and cooks, but also retain them for their full two-year terms. ■

The circular demonstration kitchen contains a long, curved window requiring a curved steel lintel, which in turn had to support a splayed series of vertical sunscreens on the window, using steel extensions for braces.

Matt Silk

Owner
Horry Georgetown Technical College, Myrtle Beach

General Contractor
Monteith Construction, Wilmington, N.C.

Architect
Mozingo + Wallace Architects, LLC, Myrtle Beach

Structural Engineer
Kyzer and Timmerman Structural Engineers, West Columbia, S.C.

Steel Team

Fabricator and Erector
Elvis Welding Service, Inc., Myrtle Beach

Bender-Roller
WhiteFab, Inc., Birmingham, Ala.

Matt Silk

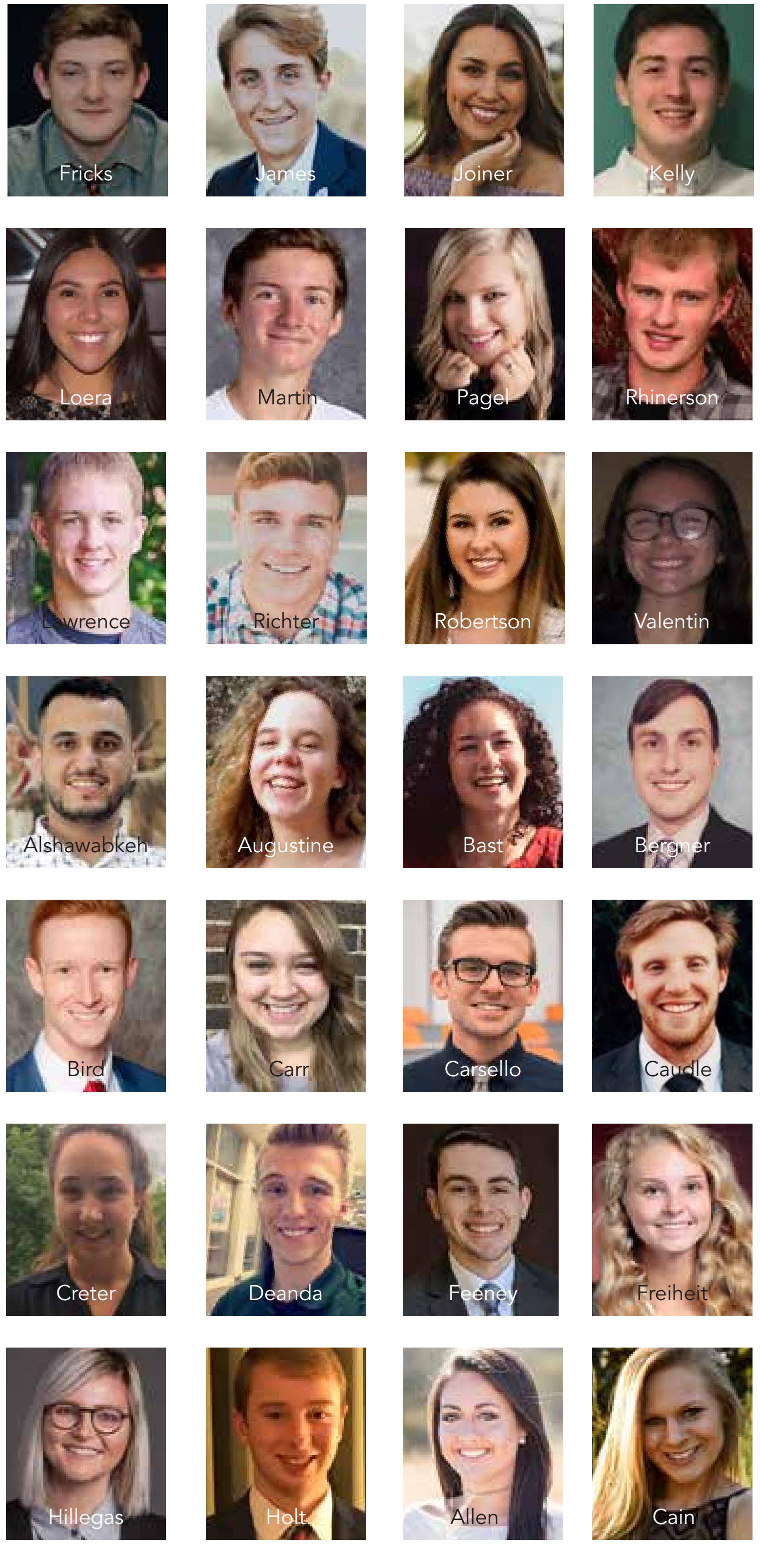
above: Steel framing facilitated long spans, resulting in a large amount of glazing that allows much of the interior to be bathed in natural light.

below: The interior of the circular conference room.

Matt Silk

EDUCATION

Annual AISC Scholarship Winners Announced



In 2018, AISC administered over $200,000 in financial aid to 58 deserving undergraduate and masters-level students for the 2018-19 academic year.

The AISC David B. Ratterman Fast Start Scholarship program, which began in 2012, awarded a total of $46,000 in scholarships to 15 students this year. The program awards children of AISC full member company employees who will be freshmen and sophomores during the upcoming academic year. The students may attend two- or four-year programs and may choose any area of study.

In addition, the AISC Education Foundation, in partnership with several other structural steel industry associations, awarded $156,000 to 43 students. AISC recognizes that without our industry partners, many of these scholarships would not be possible, and we offer our sincerest thanks for their generous, continued support.

Congratulations to the following students for earning their well-deserved scholarships for the 2018-19 academic year:

David B. Ratterman Fast Start Scholarships:

$2,000 Award Recipients

- Ashley Allen, Jones County Junior College
- Kasside Cain, Kirkwood Community College
- Kayelen Joiner, Holmes Community College
- Kolby Lawrence, Kennebec Valley Community College
- Jonathan Martin, Kansas State Polytechnic
- Kyle Rhinerson, Ohio Technical College
- Joseph Richter, Bismarck State College

$4,000 Award Recipients

- YeChan Bang, Clemson University
- Max Fricks, Drury University
- Garrett James, Middle Tennessee State University
- Paul Kelly, Rochester Institute of Technology
- Renae Loera, University of La Verne
- Kaylee Pagel, Towson University
- Ashton Robertson, University of Southern Indiana
- Natalia Valentin, Universidad de Puerto Rico-Rio Piedras

AISC Scholarships for Juniors, Seniors and Masters-Level Students:

AISC Education Foundation

- Madeline Augustine, Northeastern University
- Karly Bast, Massachusetts Institute of Technology
- Nathaniel Bergner, University of Texas at Austin
- Christopher Bird, University of Louisville
- Lara Creter, Manhattan College
- Anthony Feeney, Lehigh University
- Sarah Freiheit, Cornell University
- Hannah Hillegas, Kansas State University
- Justin Holt, University of Kentucky
- Lauren Hudak, Colorado State University
- Joseph Jesse, University of Washington
- Ramzi Labbane, University of Minnesota Twin Cities
- Kai Ling Liang, Stanford University
- Matthew Moorhead, University of Houston
- Brian Seemann, Kansas State University
- Chase Suehiro, University of California, Berkeley
- Marc Toro, University of California, Berkeley
- Christopher Waite, Oklahoma State University
- Gabrielle Willis, The University of Alabama

AISC/Associated Steel Erectors of Chicago

- Yazan Alshawabkeh, University of Illinois at Chicago
- Linnea Carr, Western Illinois University Quad Cities
- Matthew Carsello, University of Illinois at Urbana-Champaign
- Samun Khalilian, University of Illinois at Urbana-Champaign
- Herbert Nuwagaba, University of Illinois at Chicago
- Nicholas Sabatini, University of Illinois at Urbana-Champaign
- Michael Walz, Purdue University

AISC/Great Lakes Fabricators and Erectors Association

- Chris Kuenzer, University of Michigan

AISC/Rocky Mountain Steel Construction Association

- Nathan Deanda, University of Colorado Boulder
- Lauren Hudak, Colorado State University

AISC/Southern Association of Steel Fabricators

- Christopher Bird, University of Louisville
- Seth Caudle, University of Tennessee at Chattanooga

AISC/Indiana Fabricators Association

- Nigel Hensley, Rose-Hulman Institute of Technology
- Bowen Plogmann, University of Notre Dame
- Alexandra Bridwell, Purdue University Fort Wayne
- Alex Baker, Valparaiso University

AISC/W&W Steel/Oklahoma State University *(program includes sophomores, juniors and seniors)*

Seniors

- Jose Reyna, Construction Management
- Kennedy Stephens, Architectural Engineering
- Lauren Breedlove, Civil Engineering

Juniors

- Evan George, Civil Engineering
- Jesse Mathews, Construction Management
- Gage Strom, Architectural Engineering

Sophomores

- Jacqueline Fuller, Civil Engineering
- Nathaniel Northcutt, Construction Management
- Payton Hill, Architectural Engineering

AISC/UIUC Architecture Scholarship

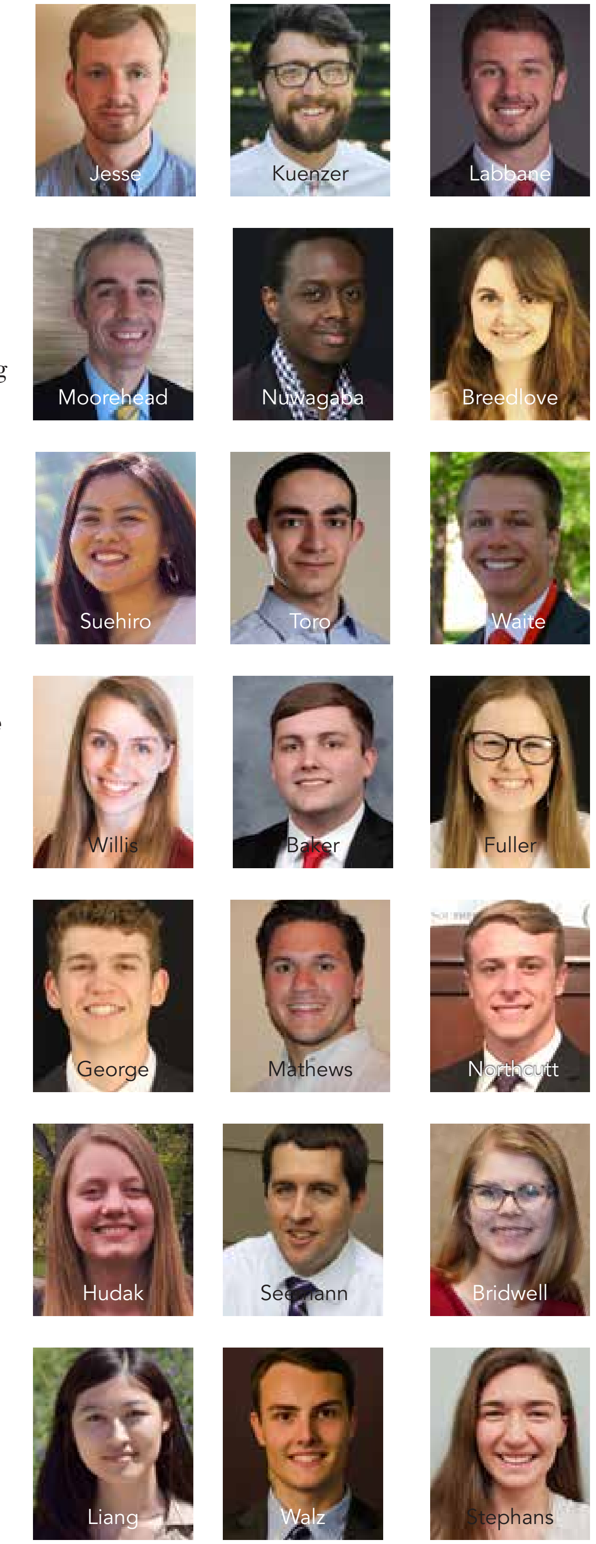
- Conor Schafer, University of Illinois at Urbana-Champaign

The David B. Ratterman Scholarship Jury consisted of the following individuals:

- Jack Klimp, Vice Chair, AISC Board of Directors
- Lawrence Cox, AISC Board Member
- Babette Freund, AISC Board Member
- Patrick Leonard, AISC Board Member
- Hugh McCaffery, AISC Board Member
- David B. Ratterman, AISC General Counsel

The AISC Scholarship jury consisted of the following individuals:

- Benjamin Baer, Baer Associates Engineers, Ltd.
- David Bibbs, Cannon Design
- Christopher Brown, Skidmore, Owings & Merrill, LLP
- Luke Johnson, AISC
- Colleen Malone, formerly of H.W. Lochner, Inc
- Steven Offringa, EXP



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EDUCATION

Annual AISC Scholarship Winners Announced (continued)

AISC also wishes to congratulate the winners of the Puma Steel 2017 SteelDay Welding Contest. Area high school juniors and seniors took part in the competition, and winners were awarded scholarships to attend Laramie County Community College (LCCC) during the 2018-19 academic year as part of the David B. Ratterman Fast Start Scholarship. The winners are as follows:

- Esteban Archuleta, Rawlins High School (1st place)
- Coby May, Rawlins High School
- Chance Rankin, Rawlins High School
- Keedin Denny, Cheyenne Central High School
- Dominik Swank, Cheyenne South High School
- Edgar Vega, Cheyenne South High School
- Dakota Blew, Cheyenne South High School
- Agustin Loya, Cheyenne South High School
- Conner Wilson, Cheyenne East High School
- Chayce Willet, Cheyenne East High School

Puma held the competition again this year on SteelDay, September 28, and top finishers were awarded approximately $13,000 in scholarships to LCCC. This year's participants are shown below.

STEELDAY

Documentary on Leslie E. Robertson Premieres in New York

The world premiere of the documentary film *Leaning Out*, the story of acclaimed structural engineer Leslie E. Robertson, took place during the 2018 Architecture and Design Film Festival in New York in October. AISC was a co-producer of the film and was represented at the event. An exclusive pre-screening of the film was also held as part of AISC's 2018 SteelDay.

Told by the guru of high-rise structural design himself and those closest to him, with voices of visionary architects and engineering experts, the film recounts Robertson's storied career pioneering tall landmark structures, including New York's World Trade Center, and highlights his unique perspective on innovative uses of steel and wind engineering.

The film was directed and produced by Basia and Leonard Mysznski and written by Basia Mysznski. Other contributors include: ArcelorMittal (an AISC member); the International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers (IW); the Ironworker Management Progressive Action Cooperative Trust (IMPACT); the Council of Tall Buildings and Urban Habitat; Nucor Yamato Steel (an AISC member); Zekelman Industries, the parent company of Atlas Tube (an AISC member); and the Steel Institute of New York. Louis F. Geschwindner, former AISC vice president of engineering and research, is interviewed in the film.

To learn more and watch the movie trailer, see the film's Facebook page at **www.facebook.com/leaningout**.

EDUCATION

2019 Steel Design Student Competition Program Now Accepting Entries

AISC and the Association of Collegiate Schools of Architecture (ACSA) are pleased to announce the 19th annual Steel Design Student Competition for the 2018-19 academic year. The competition encourages architecture students from across North America to explore the many functional and aesthetic uses for steel in design and construction. A total of $14,000 in cash prizes will be awarded to the winning students and their faculty sponsors.

The competition offers students the opportunity to compete in two separate categories. The intermodal transportation center category challenges students to design a facility that proposes a cohesive transit system including components such as international, regional and local train stations, bus terminals, ports, airports and spaceports in a major urban location. In the open category, students are given the flexibility to select a site and building program.

The competition is open to upper-level students (third year or above, including graduate students). All student entrants are required to work under the direction of a faculty sponsor. Registration is free and open to eligible entrants until April 3, 2019. For more information and to view this year's winners, visit **www.aisc.org/education**. The winners were also featured in our November issue, available at **www.modernsteel.com**.

news

PUBLICATIONS

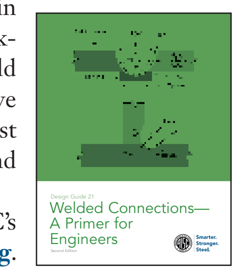
New Edition of Welded Connections Design Guide Now Available

The second edition of AISC Design Guide 21: *Welded Connections – A Primer for Engineers* (DG 21) is now available. This new edition of the guide, authored by structural welding guru Duane K. Miller, PE, ScD, The Lincoln Electric Co., provides an updated overview of all kinds of topics related to structural welding, including selection of weld types, weld design, metallurgy, weld repair, weld procedure specifications, quality, inspection, economy and safety.

"When the AISC Steel Solutions Center needs information about welding, we always turn to AISC Design Guide 21 first," said Larry Muir, PE, AISC's director of technical assistance, and co-author of AISC Design Guide 29: *Vertical Bracing Connections – Analysis and Design*. "We know the answers are there, and we're excited that the guide been updated and expanded. Anyone who saw Duane Miller's incredible presentation, 'Important Lessons I've Learned During the Past 40 Years,' at the 2018 NASCC: The Steel Conference (**www.aisc.org/miller2018**) will be especially interested to read through the 'Fourteen Principles of Connection Design' (Section 4.1.2) in the guide, where many of the lessons from his presentation are further illustrated and applied. I encourage engineers to return to this section often until the principles become second nature to them."

The second edition of the guide references provisions in the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360), the AISC Se*ismic Provisions for Structural Steel Buildings* (ANSI/AISC 341) and the *AWS Structural Welding Code – Steel* (AWS D1.1:2015) and contains new chapters on seismic considerations and fracture mechanics applied to welded connections, as well as an expanded chapter on fatigue. In addition, the popular first edition chapter on special welding applications has been divided and expanded to address more special applications, and a new chapter on problems and fixes addresses commonly encountered problems with practical advice to solve the problem.

Muir added, "At this point, if your design includes something related to welding that is not addressed in Design Guide 21, you should not be asking, 'Why is it not included?' You should be asking, 'Why are we doing this?' I have often stated that Design Guide 21 is the best design guide AISC has ever published, and now it is even better."



Design Guide 21, as well as all of AISC's design guides, is available at **www.aisc.org/dg**.

news

AWARDS

Ronald D. Ziemian Wins 2019 Higgins Award

The 2019 winner of the $15,000 AISC T.R. Higgins Award is Ronald D. Ziemian, a professor at Bucknell University, Lewisburg, Pa. Ziemian is recognized worldwide for his expertise in structural stability and his uncanny ability to take an incredibly complex topic and make it understandable to everyone from undergraduates to experienced structural engineers. Get an inside look at his life and career in the May 2016 Steel Profiles podcast episode at **www.aisc.org/podcasts**, in which he discusses the most important concept for engineers to understand about stability.

The Higgins Award, presented annually by AISC, recognizes an individual for their outstanding lectures and papers that have advanced the state-of-art of steel in construction. Ziemian will present his lecture "Structural Stability—Letting the Fundamentals Guide Your Judgement" at the upcoming NASCC: The Steel Conference on April 5 in St. Louis (registration for the conference opens January 2; visit **www.aisc.org/nascc** for more information). You can view his past conference sessions, including "More Opportunities with the Direct Analysis Method" and "Modules for Learning Structural Stability," in our Education Archives at **www.aisc.org/educationarchives**.

"Ron was primarily nominated for his stability paper, 'Formulation and Validation of Minimum Brace Stiffness for Systems of Compression Members,' which was published in the *Journal of Constructional Steel Research*, as well as his stability work, which was particularly notable in the discussions of the jury," said Larry Kruth, PE, AISC's vice president of engineering and research. "Ron's work has done much to advance the understanding of stability in the structural engineering profession, and it is our pleasure to present him with this year's award."

In addition to authoring papers on the design and analysis of steel and aluminum structures, Ziemian is co-author of the textbook *Matrix Structural Analysis*, the developer of the educational analysis software MASTAN2 and the editor for the 6th edition of the *Guide to Stability Design Criteria for Metal Structures*. He is also the co-editor-in-chief of Elsevier's *Journal of Constructional Steel Research*. He is a member of AISC's Committee on Specifications, currently chairs AISC's TC3 - Loads, Analysis and Stability and previously chaired AISC's Task Group on Inelastic Analysis and Design. He also serves on the AISI and Aluminum Association Specification Committees, is active with the Steel Joist Institute and is a former chair of the Structural Stability Research Council. Ziemian was awarded an AISC Special Achievement Award in 2006, the ASCE Shortridge Hardesty Award in 2013 and the ASCE Norman Medal in 1994 for his contributions to the profession related to the stability analysis and design of metal structures. He received his BSCE, MENG and PhD degrees from Cornell University.

For more about the T.R. Higgins Award and its past winners, please visit **www.aisc.org/higgins**.

correction

In the sidebar at the end of the October article "Design with a Twist," Trilogy Machinery, Inc., was inadvertently left off the list of AISC Bender-Roller Committee members.

advertiser index

marketplace & employment

GIVE ME PARK AVENUE

SO PROCLAIMED EVA GABOR (as Lisa Douglas) in the theme song to the iconic 1960s sitcom *Green Acres*.

And buildings like 425 Park Avenue may have even kept her husband, Eddie Albert (aka Oliver Wendell Douglas), from wanting to leave the city for farm living and fresh air. The 900-ft-tall, 47-story office tower, an incredibly complicated steel renovation project that will encompass some of the most expensive real estate in the city when completed, would have no doubt been a great home for his law practice.

Designed by Foster + Partners and WSP (and fabricated and erected by AISC members Owen Steel and A.J. McNulty and Company, respectively) the project expands upon an existing 30-story structure that was built in 1957. Seventeen levels of the original building were retained and incorporated into the new tower, a zoning strategy that allowed the owner to build a taller structure with an additional 90,000 sq. ft of space that wouldn't have been possible had the entire original structure been razed. The entire building is nearly 700,000 sq. ft.

Here are some facts about the steel framing:

- The framing for alternating floors was removed to create a three-story lobby and double-height levels up to the new seventh floor.
- Sloped "V" and tripod columns at the sloped-column floor (seventh) and Club Level (16th) incorporate a 7% twist to accommodate the façade. A.J. McNulty originally desired bolted wide-flange shapes for the feature sloped columns, but the façade required welded box columns instead. Both of these floors feature hanging mezzanines facilitated by intricate trusses.
- There are no columns at the corners, an impressive feat for double-height floors.
- Like most tower projects in New York, the building employs a hybrid spine with embedded steel columns to transfer loads and aid in constructability. The building is expected to top out around the end of the year.
- The building will use nearly 8,400 tons of structural steel, all fabricated at Owen's Columbia, S.C., and Wilmington, Del., facilities.