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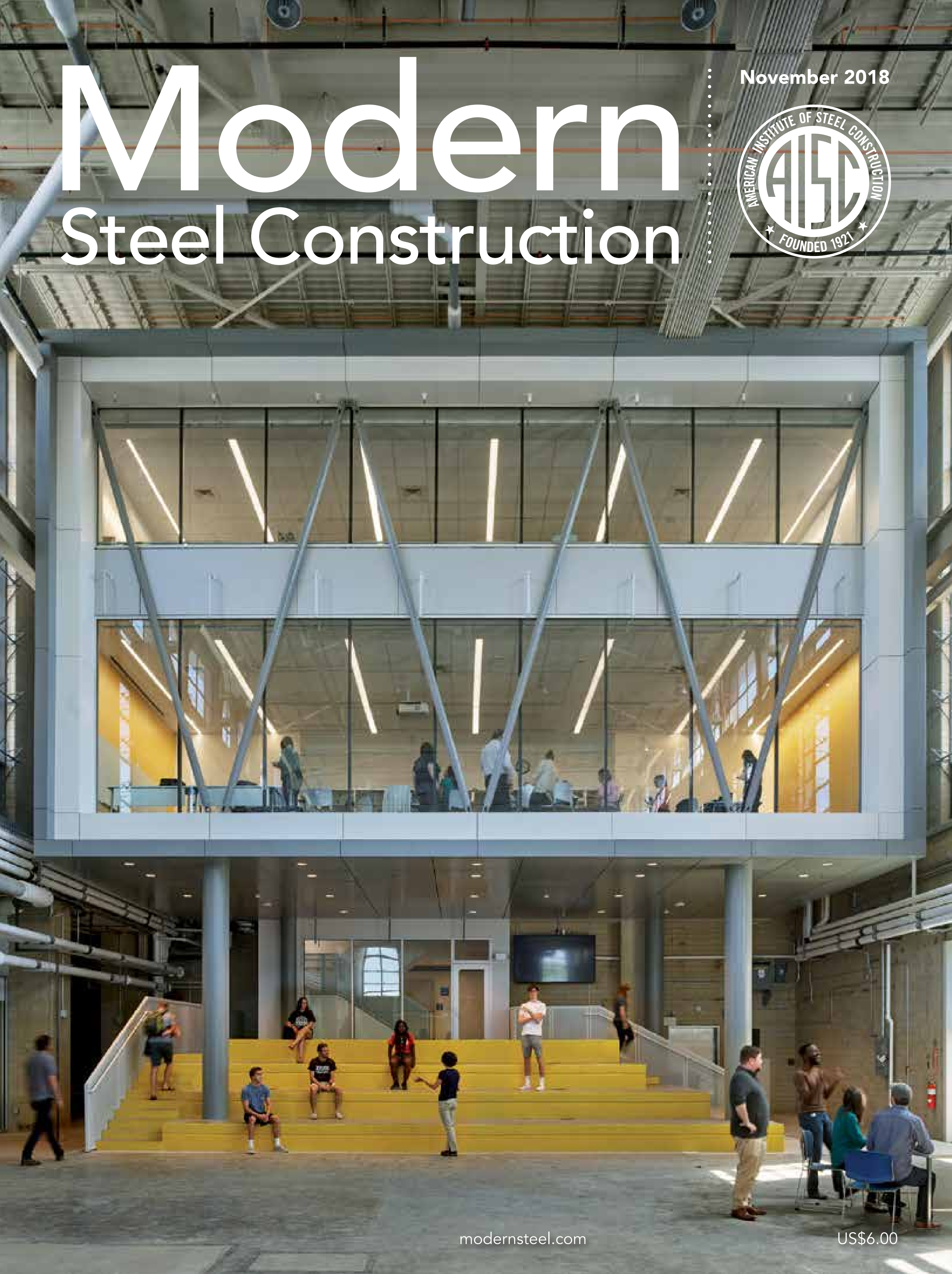

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November 2018

in every issue

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features

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ON THE COVER:
A box within a box serves as one new collaborative student space overlooking another in a repurposed Lehigh University building, p. 26.
(Photo: Todd Mason/Halkin Mason Photography)

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editor's note

Where were you on September 28? (To jog your memory, it was SteelDay, AISC's and the steel industry's celebration of the domestically fabricated structural steel industry.)

I had the privilege to attend Paramount Roll and Forming's fantastic open house in Santa Fe Springs, Calif., where the company's president, Ken Moscrip, spent the day showing his nearly 100 guests around and explaining the bending and rolling process (not to mention enjoying some fantastic tacos for lunch).

By the way, if you missed out on SteelDay this time around or are already planning to attend an event next year, SteelDay 2019 is scheduled for Friday, September 27. Mark your calendar!

There are two things I particularly love about SteelDay. The first is the opportunity to see something new. While I had visited other benders, this was the first time I had seen anyone doing heat-induction bending. The incredibly tight radii that can result—without any visible distortion—was simply amazing.

But just as enjoyable is the chance to chat with people involved in the design and construction of steel buildings and bridges. Too often, especially at larger events, I'm too busy to just sit and shoot the breeze. But it's the casual conversations that sometimes teach you the most.

So what did I learn during a few hours of chatting with some designers, a couple of fabricators, a few detailers and, of course, Ken?

To start with, even though we were all talking bending steel, no one seemed to know AISC had recently issued a new Design Guide (number 33, *Curved Member Design*, available at **www.aisc.org/dg**). In talking with folks during the tour, the most common question concerned what impact the bending operation has on the steel's material properties. And yes, the new Design Guide offers practical information on the fabrication and detailing of curved members as well as their behavior during the bending operation and in service. It also includes connection design information and addresses stability and serviceability concerns, as well as provides design examples.

I also learned that people aren't as familiar with AISC's Steel Solutions Center as I'd thought. AISC offers a free service to help designers and builders with any questions they have about steel design and specification. We have a team of engineers who answer nearly 200 technical inquiries each week. And if they can't answer the question, they seek out the leading experts (most of whom are affiliated with AISC through their involvement in our committees). As I mentioned, we provide this service free of charge; simply email **solutions@aisc.org** or call 866.ask.aisc (heck, even the phone call is free!).

Lastly, I discovered there's a thirst for more information on designing and building with steel. And while most people were aware of our obvious resources, such as NASCC: The Steel Conference, our ongoing webinar programs and this magazine, the plethora of material on our website (**www.aisc.org**) was widely unknown. For example, did you know we have nearly 1,800 free webinars posted in our education archives? Or that you can download AISC's series of free *Facts for Steel Buildings* books? Or access any paper ever published in *Engineering Journal*? We even offer free software for steel bridge design. I urge you to spend some time clicking around on the AISC website (as well as **www.modernsteel.com**). And drop me an email to let me know what you discover that we should also highlight for your peers.

Scott Melnick

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

steel interchange

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****.*

Cover of Design Guide 29

The picture on the cover of AISC's Design Guide 29: *Vertical Bracing Connections—Analysis and Design* conflicts with the advice given in Chapter 3 of the guide. Chapter 3 cautions against the use of plates alone at the brace-to-gusset connection and states: "Small wide-flange braces with this orientation are typically connected to the gussets by WTs or double angles back-to-back on the near and far side of the gusset. Alternatively, single angles on each side of the brace could be employed. If the brace is subjected to compression as well as tension, plates should not be used in place of the WTs or angles." It also states: "Plates can be used to attach the web, and 'claw' angles can be used to attach the flanges. The outstanding angle legs provide for stability."

I have encountered engineers who design brace-to-gusset connections employing plates assuming an effective length factor, *K*, of 0.5 and an unbraced length from the last row of bolts (closest to the work point) to the beam or column flange. This seems like a potentially dangerous practice.

Why are splice plates shown in the cover photo of Design Guide 29?

The short answer is that splice plates are not shown in the cover photo of Design Guide 29.

The splice is actually made using channels on both sides of the gusset and the plate knifed into the HSS. The flanges of the channels provide more out-of-plane strength and stiffness than a plate, though not as much as the WTs or double angles recommended in the guide. I_y for a 1-in.×18-in. plate is 1.5 in.^{4}. I_y for back-to-back MC18×42.7 is 47.6 in.^{4}. This is a significant increase in strength and stiffness. Even with the channels, there is still a small gap between the channels and the HSS. The ends of the gap can likely be considered clamped (fixed) and the gap is quite short. This, combined with relatively compact gusset plates, might make the overall stability of the condition less of a concern than it would be for a chain of lapped plates. However, engineering judgment must be applied to every condition encountered. It is also possible that a stiffener exists at the back side of the plate knifed into the HSS.

Though we do not mention the use of plates alone (other than to generally discourage their use) in Design Guide 29, AISC Design Guide 24: *Hollow Structural Section Connections* does address the design of similar conditions and recommends: K = 1.2, an assumed length equal to the entire length between the end of the brace and the face of the supports, use of geometric properties of the thinner element and consideration of eccentricity where it exists. These seem to be pretty good recommendations and are considerably more conservative than what you report seeing in practice.

As the saying goes, "You shouldn't judge a book by its cover." Engineers also should not look at a condition and judge it based solely on the way it looks. We sometimes get sketches and photos of connections and members with questions like "Is this crazy or what?" "Does this look wrong?" or "Is this okay?" I cannot simply look at any condition and decide whether it is okay or not. Each condition must be judged against its intended function, not some arbitrary measure of what looks "okay." I will admit that I tend not to like brace-to-gusset connections that employ only plates. To me, it looks like someone pushing on a chain. However, with proper consideration and judgment, these conditions can be safely designed, and I have used them. The fact that some figure or photograph in the *Steel Construction Manual* or an AISC Design Guide does or does not look like a condition in the real world should not be the deciding factor in its suitability.

Larry S. Muir, PE

Second-order Effects and Column Design

Are second-order effects to be considered in design for all columns or just columns that are part of a frame?

Second-order effects are increases in the moments and forces on columns that are part of the lateral frame due to lateral deformations caused by the first-order loads. The leaning columns (those that are not part of the lateral frame) add to those increases in the lateral frame because they go along for the ride.

Section C1 of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) provides general stability requirements and states: "Stability shall be provided for the structure as a whole and for each of its elements. The effects of all of the following on the stability of the structure and its elements shall be considered:... (b) second-order effects (including *P*-Δ and *P*-δ effects);..." The Commentary provides further guidance. It states: "Columns in gravity framing systems

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can be designed as pin-ended columns with $K = 1.0$, However, the destabilizing effects (P-Δ effects) of the gravity loads on all such columns, and the load transfer from these columns to the lateral force-resisting system, must be accounted for in the design of the lateral force-resisting system."

The second-order effects associated with all columns must be considered in design. However, the structure will "redistribute the story P-Δ effects to the lateral force-resisting elements in that story in proportion to their stiffnesses." The Commentary goes on to state: "In a building that contains columns that contribute little or nothing to the sway stiffness of the story, such columns are referred to as leaning or gravity-only columns. These columns can be designed using $K = 1.0$, but the lateral force-resisting elements in the story must be designed to support the destabilizing P-Δ effects developed from the loads on these leaning columns. The redistribution of P-Δ effects among columns must be considered in the determination of K and F_e for all the columns in the story for the design of moment frames. The proper K-factor for calculation of P_c in moment frames, accounting for these effects, is denoted in the following by the symbol K2." Note that the *Manual Design Examples* (a free download at **www.aisc.org**) illustrates the design of leaning columns.

Jonathan Tavarez

I have specified ASTM A992 steel for a structural steel frame. The bidders have asked if the connection plates and angles will be A572 Grade 50 steel. Is A572 Grade 50 an acceptable substitution for A992? Are there cost impacts to my requiring A992 for everything?

You should discuss the cost impact of various decisions with the fabricators.
ASTM A992 specifically addresses "rolled structural shapes." ASTM A572 addresses, "shapes, plates, sheet piling and bars." ASTM A6, which is referenced from both A992 and A572, defines plates and shapes. Based on the ASTM specification, A992 plate does not exist. Table 2-5 of the *Manual* indicates that ASTM A36 and ASTM A572 Grade 50 are both preferred materials for plate.

The *Manual* states: "The designation of preferred material specifications is based on consultations with fabricators to identify materials that are commonly used in steel construction and reflects such factors as ready availability, ease of ordering and delivery and pricing. AISC recommends the use of preferred materials in structural steel designs, but the final decision is up to the designer based on project conditions. Other applicable material specifications are as shown in grey shading. The availability of grades other than the preferred material specification should be confirmed prior to their specification."

Angles present a different situation. Angles are shapes and therefore can be made to satisfy ASTM A992. Table 2-4 of the *Manual* lists A36 as the preferred material specification for angles. 50-ksi material is becoming more common in U.S. fabrication. The article "Are You Properly Specifying Materials?" (**www.modernsteel.com**) states: "The preferred material specification for these shapes is in transition. ASTM A36 (F_y = 36 ksi, F_u = 58 ksi) is now only slightly more common than 50-ksi grades like ASTM A529 Grade 50, ASTM A572 Grade 50, or ASTM A992; each of these 50-ksi grades has F_y = 50 ksi and F_u = 65 ksi for these shapes."

There are several grades that are applicable for 50-ksi angles and plates. The common ones are covered in the article mentioned above, and your fabricator can let you know which one is suitable for your project.

Jonathan Tavarez

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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**.

steel quiz

This month's Steel Quiz is based on guidance and equations provided on eccentrically loaded weld groups in Part 8 of the 15th Edition AISC *Steel Construction Manual.*

The question and answers for this month's Steel Quiz were contributed by Hamza Sekkak, a PhD student at the Illinois Institute of Technology. Thank you, Hamza!

Refer to Figure 1. Given that weld size, *a*, is 5/16 in. and F_{EXX} is 70 ksi, solve for weld available strength, ϕR_n, using:

1 Table 8-4

2 Instantaneous center of rotation method

3 Elastic method

4 Plastic method

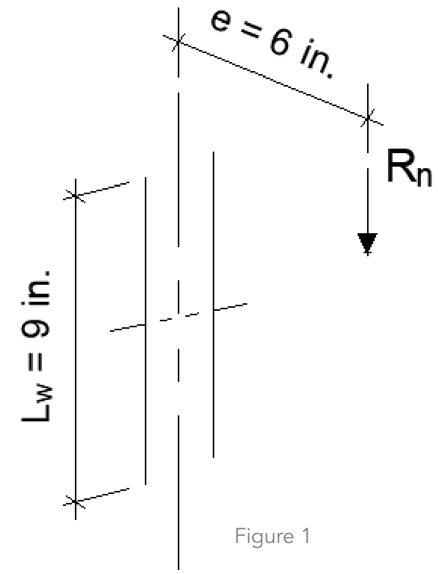

Figure 1

TURN TO PAGE 14 FOR THE ANSWERS

1 **Using Table 8-4.** $k = 0$, because the force applied is out-of-plane with regard to the cross-sectional plane of the plate. From Table 8-4:

$$C = 1.84$$

$$\phi R_n = \phi C C_1 D l = (0.75)(1.84)(1.0)(5)(9) = 62.1 \text{ kips}$$

2 **Using the instantaneous center of rotation method.** Break half of the weld length into equal segments (see Figure 2).

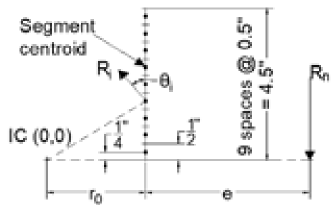

Figure 2

Select a trial location for the instantaneous center of rotation, r_0. Compute coordinates of the centroids of the segments and their angles. Compute the deformations Δ_{mi} and Δ_{ui} using the following equations:

$$\Delta_{mi} = 0.209(\theta_i + 2)^{-0.32} w$$

$$\Delta_{ui} = 1.087(\theta_i + 6)^{-0.65} w \le 0.17w$$

where θ_i is the segment angle in degrees and w is the weld size in in.

Compute Δ_i as follows:

$$\Delta_i = r_i \frac{\Delta_{ucr}}{r_{cri}} = r_i (0.0046)$$

Compute R_n, the resistance of each segment:

$$R_i = 0.60 F_{EXX} t_e l_w \left(1.0 + 0.50 \sin^{1.5} \theta_i\right) \left[\frac{\Delta_i}{\Delta_{mi}} \left(1.9 - 0.9 \frac{\Delta_i}{\Delta_{mi}}\right) \right]^{0.3}$$

Vertical Segments	Length l_w (in.)	X (in.)	Y (in.)	r_i (in.)	R_i (kip)	$(R_i)_x$ (kip)	$(R_i)_y$ (kip)	$R_i r_i$ (kip-in.)
1	0.5	0.82	4.25	4.329	6.87	6.75	1.31	29.75
2	0.5	0.82	3.75	3.839	6.89	6.72	1.48	26.44
3	0.5	0.82	3.25	3.353	6.82	6.61	1.68	22.86
4	0.5	0.82	2.75	2.871	6.66	6.38	1.91	19.13
5	0.5	0.82	2.25	2.396	6.41	6.02	2.20	15.35
6	0.5	0.82	1.75	1.934	6.02	5.44	2.56	11.64
7	0.5	0.82	1.25	1.497	5.44	4.54	2.99	8.14
8	0.5	0.82	0.75	1.114	4.56	3.07	3.38	5.09
9	0.5	0.82	0.25	0.861	3.34	0.97	3.20	2.88
					Σ =	46.51	20.71	141.27

Check rotational and force equilibrium until both values become the same ($r_0 = 0.824$ in.).

Rotational equilibrium:

$$R_n = \frac{2\left(\sum R_i r_i\right)}{e + r_0} = \frac{2\,(141.3)}{6.824} = 41.4 \text{ kips}$$

Force equilibrium:

$$R_n = 2\sum (R_i)_y = 41.4 \text{ kips}$$

Finally:

$$\phi R_n = (0.75)(2 \text{ weld lines}) \times 41.4 \text{ kips} = 62.1 \text{ kips}$$

3 **Using the elastic method.**

The moment of inertia of the weld is:

$$I_x = 2\left(\frac{9^3}{12}\right) = 121.50 \text{ in.}^3$$

Solve for the welding strength from the following:

$$\sqrt{\left(\frac{R_n}{2l}\right)^2 + \left(\frac{R_n ec}{I_p}\right)^2} = \left(0.707 \times \frac{5}{16} \text{in.}\right) 0.6(70 \text{ ksi})$$

$$R_n = 40.5 \text{ kips} \rightarrow \phi R_n = 30.4 \text{ kips}$$

4 **Using the plastic method.**

For one weld:

$$f_w = \sqrt{f_v^2 + (f_a + f_b)^2}$$

$$f_v = \frac{R_n}{l},\ f_a = 0,\ f_b = \frac{4M}{l^2} = \frac{4R_n e}{l^2}$$

$$f_w = \left(\frac{5}{16} \text{ in.}\right)(0.707)(0.6)(70 \text{ ksi})$$

For two welds:

$$R_n = 58.7 \text{ kips} \rightarrow \phi R_n = 44.0 \text{ kips}$$

Notes: The Steel Quiz submitted by Hamza Sekkak did not account for the directional strength increase when applying the plastic method. Section J2.4.(b) of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) states: "For fillet welds, the available strength is permitted to be determined accounting for a directional strength increase of ($1.0 + 0.50\sin^{1.5}\theta$) if strain compatibility of the various weld elements is considered." Though not explicitly addressed in the use of the plastic method, strain compatibility will likely not be a problem for the condition shown. This is a matter of engineering judgment. If the directional strength increase is to be included, it can be done as follows:

$$\theta = \operatorname{atan}\left(\frac{f_b}{f_v}\right) = \operatorname{atan}\left(\frac{4e}{l}\right) = \operatorname{atan}\left(\frac{4(6)}{9}\right) = 69.4°$$

$$\left[1.0 + 0.50 \sin^{1.5}(69.4°)\right] = 1.4$$

Accounting for the directional strength increase $\phi R_n = 63.9$ kips, this is within 3% of the strength predicted by the instantaneous center of rotation method, which explicitly considers strain compatibility of the various weld elements.

—*Larry Muir, PE, AISC Director of Technical Assistance*

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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 2

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

In this second of three articles, we continue the discussion of evaluating unlisted materials based on a list of factors provided in the Commentary to Section A3 of 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.

STEELS APPROVED FOR use with the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360, www.aisc.org/specifications) are typically required to be "killed."

When this is not explicitly stated in a given ASTM specification, there are likely reasons that the killed steel has been used to manufacture the product. Most materials used in the U.S. are continuously cast, a process that is efficient but demanding on the producer. The requirements a producer must meet to successfully produce steel provide such benefits as better through thickness properties and soundness. Ingot cast material is still permitted and can be killed, semi-killed, rimmed or capped. (For definitions of these terms, please see the "Steel Terms" sidebar on page 18.) All material listed in Section A3 of the *Specification* meets these requirements.

Tolerances

The effect of dimensional tolerances that are different from those provided in the approved ASTM specifications must be carefully considered. Section M2.6 of the AISC *Specification* requires the dimensional tolerances to be in accordance with Chapter 6 of the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303, www.aisc.org/specifications). Section 6.4.2 of the *Code* in turn references the "applicable ASTM standards" for straightness tolerances. If there is no applicable ASTM standard (or other source of a straightness tolerance such as the dimensional tolerances of welded steel members provided in AWS D1.1) then the tolerance must be defined in the contract documents. Tolerances introduced after the contract has been awarded represent a revision to the contract as addressed in Section 9.3 of the *Code*.

Tolerances can affect many aspects of a project. The most obvious effect will be on the plumbness, elevation and alignment of the structure. Experience has shown that the erection tolerances in Section 7 of the *Code* can be met using typical fabrication and erection practices when the mill tolerances in the appropriate ASTM specification and the fabrication tolerances defined in the various documents referenced from the AISC *Specification* are satisfied. Similar experience does not exist for the full range of materials that might be available in the marketplace. The specifier is ultimately responsible for ensuring that the accumulation of the mill and fabrication tolerances do not cause the erection tolerances to be exceeded, as indicated in Section 7.12 of the *Code*. If the tolerances for the substituted material are larger than those permitted in the ASTM specifications, then the fabrication tolerances may have to be tightened, the erection tolerances relaxed or both.

In addition to the effect that material tolerances may have on other tolerances, they also may affect the methods used to design the structure. Many of the design methods used in the *Specification* are implicitly or explicitly tied to the tolerances contained in the ASTM specifications approved for use with the AISC *Specification*.

For example, Section C2.2 of the *Specification* requires consideration of initial system imperfections in the position of points of intersection of members. There is no requirement to consider the initial out-of-straightness of the member. This is because the initial out-of-straightness is already considered in the design equa-

tions. The User Note in Section C2.2 states: "Consideration of initial out-of-straightness of individual members (member imperfections) is not required in the structural analysis when using the provisions of this section; it is accounted for in the compression member design provisions of Chapter E and need not be considered explicitly in the analysis as long as it is within the limits specified in the *Code of Standard Practice*." When the out-of-straightness is outside the limits specified in the *Code*, a more advanced analysis that includes modeling of member imperfections should be performed.

It can be assumed that any limit state related to stability will be affected by tolerances outside the limits provided in the ASTM specifications that are approved for use under the AISC *Specification*. Stability-related limit states include (but may not be limited to) lateral-torsional buckling of flexural members, the limit states addressed in Chapter E and local buckling. The width-to-thickness ratios provided in Tables B4.1a and B4.1b may not be applicable to compression elements with tolerances outside the limits provided in the ASTM specifications that are approved for use under the *Specification*. The bracing requirements in Appendix 6 also may not be applicable. The engineer of record (EOR) must evaluate the applicability of the checks provided in the *Specification* and if necessary, develop alternative checks to account for the greater tolerances.

Steel Terms

Killed steel is steel that has been completely deoxidized by the addition of an agent before casting, so that there is practically no evolution of gas during solidification. Killed steels are characterized by a high degree of chemical homogeneity and freedom from gas porosity.

Semi-killed steel refers to a type of metal alloy compound of iron and carbon that has been partially deoxidized with minimal gas release during solidification.

Rimmed steel is a low-carbon steel that contains an amount of iron oxide such that continuous generation of carbon monoxide during solidification is not inhibited. Rimmed steel is virtually free from voids and is easily bendable and cleanable. Most rimmed steels contain less than 0.1% carbon.

Capped steel starts as rimmed steel but partway through the solidification, the ingot is capped. This can be done by literally covering the ingot mold or by adding a deoxidizing agent. The top of the ingot then forms into a solid layer of steel, but the rim of the rest of the ingot is thinner than in rimmed steel.

Another option might be to impose additional project-specific tolerances. Establishing project-specific tolerances can be complex and should ideally involve all affected parties. Very tight tolerances may lead to more efficient designs relative to member sizes but may be prohibitively expensive relative to mill production, fabrication and/or election.

Testing

The ASTM specifications approved for use with the *Specification* obviously contain limits on mechanical property and chemistry. They also contain requirements related to testing. When evaluating unlisted materials it can be just as important to understand how values associated with various properties were obtained as it is to know the values themselves. For example, how fast a tensile test is run or where the sample is taken within the section can have a significant impact on the reported yield stress.

Reporting

The ASTM specifications approved for use with the AISC *Specification* also contain requirements related to reporting. For example, ASTM A6 does not place a limit on boron, and boron is generally not added to approved steels. However, if boron is intentionally added, it must be reported. There are also reporting requirements related to heat treatment. Some of the approved specifications permit material substitutions but require that such substitutions be reported. The specifier of any unlisted materials should carefully consider what is and is not required to be reported.

Alloying Elements

Steel is iron with a small percentage of carbon, and the steel we use is all alloyed to some degree. The most common and prevalent alloying elements are manganese, silicon or aluminum, copper, columbium (also known as niobium) and vanadium. Chromium and nickel are added to weathering steels, and phosphorus and sulfur are also present. Many other elements can be present as well, particularly in scrap-based steels, but they are in small proportions that should not affect steel properties or usability in a detrimental fashion.

Some in the construction industry have expressed concerns about the presence of unusual alloying elements in structural steel. These concerns may be prompted by news reports and actions taken here and abroad. U.S. producers generally have no incentive to add alloying elements that are not required by the ASTM standards to their products. However, alloy steel is often treated differently than carbon steel or high-strength, low-alloy steel relative to customs and tax laws in some countries. This may incentivize producers to add elements to their products, which may be reported to qualify for such preferential commercial treatment but may not be reported to the purchaser or end user. Legal and technical definitions of alloy steel can vary. If there is a known incentive for a producer to add alloying elements to their products, then it may make sense to require testing for such elements. Note

that the mere presence of an alloying element does not necessarily indicate that any beneficial or detrimental effects on the steel have occurred. Further testing may be required to determine the effects. See the sidebar for more information.

Boron

In the last few years, other countries have reported that boron has been added to steel for commercial, not for metallurgical, reasons. Boron is added to steels by metallurgists for two reasons: making deep-drawing sheet and increasing hardenability for high strength after heat treating. Though only very small proportions of free boron are required to have the desired effect, boron reacts aggressively with oxygen and nitrogen dissolved in steel. Therefore, boron only produces the intended metallurgical effect if it is added to the molten metal in the right sequence with other elements to combine with the oxygen and nitrogen, or in large enough proportions that even after combining with the oxygen and nitrogen some free boron remains.

Since boron is not required in the steels we use and it is difficult to measure in the precision of interest, it is not measured or reported on material test reports of steel plates or shapes. ASTM A514 is an exception where many grades do require boron. ASTM A6 requires boron to be measured and reported only if it is intentionally added and states: "For steels that do not have intentional boron additions for hardenability, the boron content will not normally exceed 0.0008%."

The intended meaning can be difficult for steel users to determine. Steel with high hardenability is susceptible to weld cracking, but at the right level boron will help achieve the required strength. Boron is also present in some SAW and FCAW filler metals. (An independent testing lab that has tested multiple samples of steel plate in Canada reports boron composition as being between 0.01% and 0.02%.) An informal survey of major filler metal producers indicates that they have not become aware of weld cracking attributed to boron. If weld cracking that is not a result of other causes occurring, testing for boron would be a reasonable response. ■

The discussion on evaluating unlisted materials will conclude in Part 3 of this three-part series, which will appear in next month's issue. For Part 1, see the October 2018 issue at www.modernsteel.com.

Unfamiliar Producers or Suppliers

Though not directly related to the use of unlisted materials, engineers and fabricators may also have concerns about the use of material from producers that are not familiar to us. The AISC *Specification* does not treat steel any differently based on where it is produced or who produces it. Users of structural steel products (owners, general contractors, engineers, fabricators and authorities having jurisdiction) are free to introduce reasonable measures to protect the interest of designers/builders and their clients. Restrictions and additional requirements must be imposed contractually. If such measures are introduced after the contract has been agreed to, such measures would likely be considered a change to the contract.

HITTING NEW HEIGHTS

BY ELIZABETH MCCORMICK

Seven habits for taking your shop or firm to new heights.

Elizabeth McCormick is a speaker specializing in leadership, sales and safety presentations. She was recently named #4 on the list of Leadership Experts to Follow Online. A former U.S. Army Black Hawk pilot and author of *The P.I.L.O.T. Method: The 5 Elemental Truths to Leading Yourself in Life*, Elizabeth teaches instantly applicable strategies to boost your employees' confidence in their own leadership abilities. For more information, visit **www.yourinspirationalspeaker.com**.

"WINNING IS A habit. Unfortunately, so is losing."

So said legendary Green Bay Packers coach Vince Lombardi.

Your beliefs dictate your behavior, and your behaviors create habits that determine your destination. You're either going towards greatness or obscurity; there is no neutrality to your momentum. So, where are your habits taking you?

Leading your organization towards a specific destination or goal is like being a pilot of a passenger airplane: Wherever you go, your passengers/company goes. There isn't an auto-pilot setting if you expect to take your team to greater heights.

If you find yourself and your organization stuck, or you're ready to rev up your engine to soar higher, it may be time to engage your discipline and do the difficult things that other leaders may not do. Here are seven habits that can help you raise your organizational culture to a higher plane:

1. Have hopeful expectations. Whatever you look for is exactly what you will find. If you expect to find problems, you will. If you expect your team to discover creative solutions, exceed their potential and come together as a team and support you, your vision and your company goals, they will. A *positive* mindset is the first habit you need to cultivate to grow a *winning* mindset. Without it, you will fail to see what's possible.

Action plan: When faced with a new idea, prospect or proposal (especially in a meeting with your team) always communicate the positives first. Encourage and engage your team members to participate in developing new ideas. Cultivate innovation by asking them to spell out the pros and cons of their ideas. Then, when they're ready, empower them to run with it.

Just because you're busy doesn't mean you're productive.

2. Eliminate multitasking. Just because you're busy doesn't mean you're productive. When too much emphasis is put on multitasking, it could lead to miscommunication, mistakes, frustration and unmet goals. It's not about how much you can multitask but rather knowing which tasks can multiply your results.

Action plan: Remove all distractions and then choose one task that needs your attention, and work on it until it's done. This works for meetings too. Put your devices away and give your full attention to your team. Before you know it, they will follow your lead.

3. Practice intentional kindness. Many people have experienced random acts of kindness, but it's time to be more intentional in showing kindness to yourself and your team members. Become more aware of how you can encourage others, add value, meet the needs you see and extend grace whenever needed. As you do, you'll begin to see that mindset spread throughout your organization and beyond.

Action plan: Set up a charity of the month. Assign a 12-person committee, with each member taking ownership of one month. Some ideas include collecting winter coats and canned food, walking as a team in a fun run or 5K fundraiser, hosting a blood drive, adopting a highway or spending a day with Habitat for Humanity. Encourage involvement by participating full out.

4. Gear down. In today's world, it's tough to find time to think, yet thinking is one of the more critical elements of success. Studies show that intentional downtime improves productivity, energy and results. Don't fall for that top-speed mentality or you'll eventually run out of fuel. Schedule some time to gear down.

Action plan: Prioritize some non-negotiable time on your calendar just for you. Create a distraction-free space where you can clear your mind and unplug from everything. Start with just 10 minutes if that's all you have, but just start. You'll be amazed at the clarity and productivity you'll experience as a result.

5. Find the hidden opportunities. Being proactive is one of the hidden opportunities that leaders often miss. Instead of waiting to see what the day holds and reacting to that email, phone call or situation, a more strategic approach is to determine responses before calamity strikes.

Action plan: Along with your yearly planning meetings to fine-tune the company's vision and goals, be strategic about anticipating potential problems. Have an "anticipation meeting" with a goal of creating contingency plans, and ask each department to develop a "what if" list, along with solutions. This type of strategy allows you and your team to be more creative in your problem-solving abilities while in a calmer state than an emergency would allow.

6. Talk it out. Make it a habit to communicate openly with your team and allow them the opportunity to take part in the conversation. When communication is lost, your teamwork and productivity will suffer right along with your company's goals.

Action plan: No one likes to be kept in the dark. Be clear in meetings about expectations, goals and their command structure. You can also set a time where everyone knows your door is open to discuss topics that need to be dealt with one-on-one.

7. Share the load. Establish a habit of sharing the load. Delegating important tasks is another way you can honor and empower your team to take on new responsibilities that help to sharpen and show off their strengths.

Action plan: Encourage a company culture where employees at all levels have the chance to share their ideas, talk about what they do and possibly mentor new up-and-comers in your organization. When leaders at all levels take ownership of the company's vision and goals, there's no limit to what you and your organization can do.

When you choose winning habits by believing in the potential of your team, looking for the best in others, extending kindness and creating space for them to give back, share ideas and lead, you provide the jet fuel to ignite their creativity as you empower them to discover new levels of success. Don't be satisfied with the status quo. Make winning a habit so you and your team can soar to new heights. ■


EYP

Mountaintop Marvel

BY MARK KANONIK, PE

Lehigh's new renovated research facility demonstrates steel's adaptability while also giving students and faculty an attractive, open space for learning and interaction.


Todd Mason/Halkin Mason Photography

above: The completed C2 mixing box within the C2 high-bay.

left: Each high-bay wing is a single-story space about 80 ft by 240 ft.

BIG THINGS ARE happening on the mountaintop.

South Mountain, just outside of Bethlehem, Pa., is the lofty home of Lehigh University's Mountaintop Campus, a sprawling site that was once home to the research facility of Bethlehem Steel. Today, Lehigh University is reinventing the facility as a next-generation academic environment to support its Mountaintop Initiative, "a space in which students are given the freedom to pursue answers to open-ended questions while working in, and across, all disciplines," according to the Initiative's stated goals.

Rehabbing Building C

The first step in this reinvention involved the rehabilitation of Building C, a steel-framed structure that was built in multiple phases from the late 1950s to the mid-1970s. In plan, Building C is shaped like the letter E, with three high-bay wings connected to a horizontally-curved "spine." In its original usage, the high-bay wings housed light industrial spaces, and the spine housed offices, common areas and mechanical spaces. Each high-bay wing is a single-story space about 80 ft by 240 ft in plan, with a clear inside height of about 60 ft for overhead cranes. The spine is a three-story structure about 55 ft by 400 ft in plan. Interestingly, Building C is structurally separated into six buildings, with each of the three high-bay wings isolated from the spine, and the spine itself is separated into three sections.

Students have been using two of the three high-bays (and a small portion of the spine) for the past several years, turning the high-bays into open-air markets of ideas and collaborative spaces. Technically speaking, the City of Bethlehem considered usage of Building C to be temporary and subject to annual renewal. Lehigh wanted to per-

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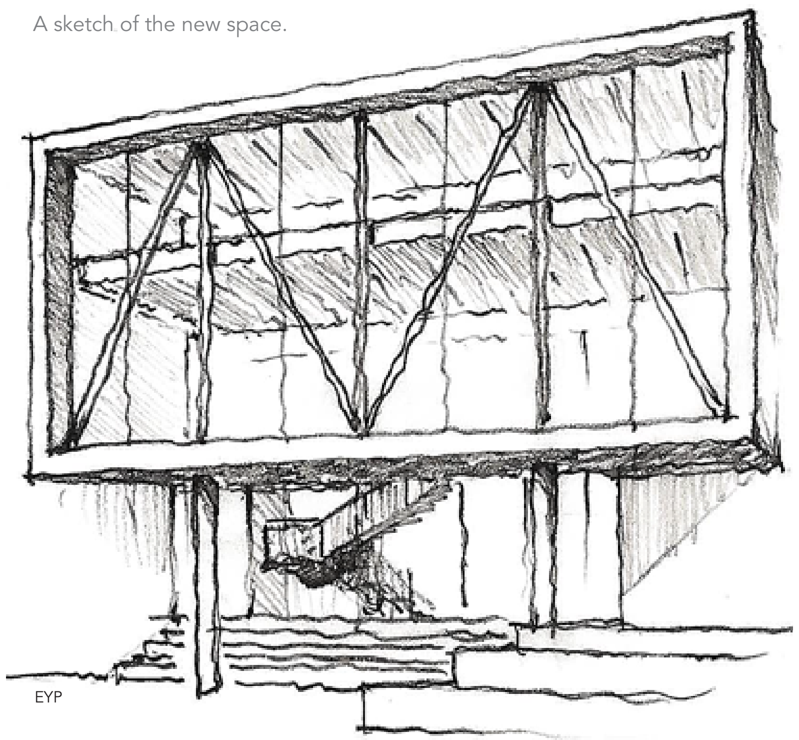
manently and prominently showcase these areas, so two-story additions dubbed "mixing boxes" were proposed as conference rooms within each high-bay. However, repurposing a nearly 60-year-old industrial building for use by students presented some challenges, particularly with respect to the *Bethlehem Building Code*, which is based on the 2009 *International Building Code*. The new programming would result in a change of occupancy of the high-bay wings from F-2 (low-hazard factory) to B (business), thus reclassifying the high-bay wings to a higher hazard category per Table 912.4 of the *IBC*. This triggered a seismic analysis of the high-bays per Section 907.3.1 of 2009 *IBC*, even though no modifications to the existing structural framing were proposed, since the mixing boxes would be structurally isolated from the high-bays and, therefore, self-supporting. It should be no surprise that the steel framing of the high-bays is generally quite robust, given that the facility was designed by and built for one of the largest structural steel producers in the world at the time.

No Seismic but Plenty of Snow

Thankfully, Bethlehem is in an area of relatively low seismicity, and the high-bays can withstand the expected seismic loads as long as the mixing boxes do not add additional seismic load. The roof framing consists of open-web bar joists, and consideration of drifted snow loads was not included in the design of the lower portions of the roof. Given that the methodology to quantify drifted snow loads didn't develop until decades after the building was designed and built, it was not unexpected that these low-roof areas were overstressed when considering drifted snow loads. The floor spaces under these low-roof areas were excluded from the project due to budget and programming constraints, but the design team felt that it was in Lehigh's best interest to reinforce the low roofs as part of this work so that it can confidently repurpose these spaces in the future. The use and occupancy of the spine did not change with the new programming, and the proposed work resulted in only a very limited structural alteration. Therefore, it was not necessary to evaluate the spine to the same level as the high-bay wings.

A sketch of the new space.



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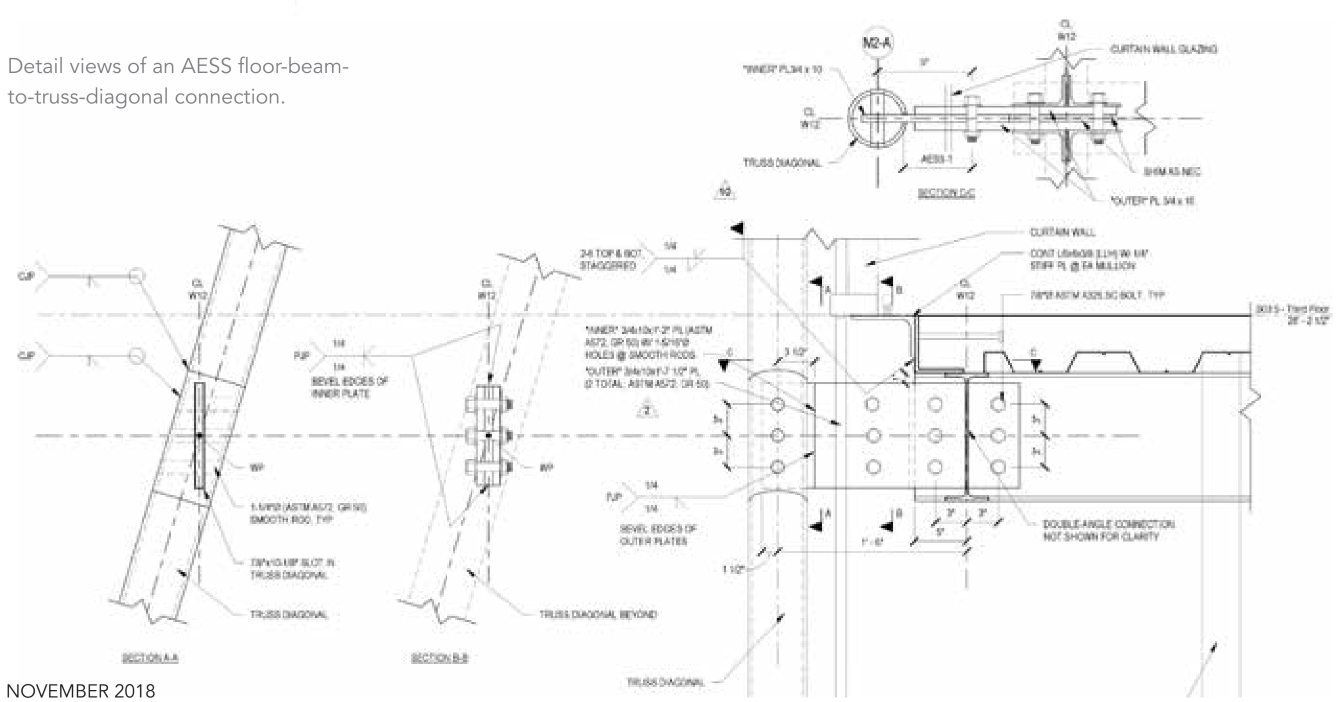
AESS connection of a floor beam to a truss diagonal.

Detail views of an AESS floor-beam-to-truss-diagonal connection.



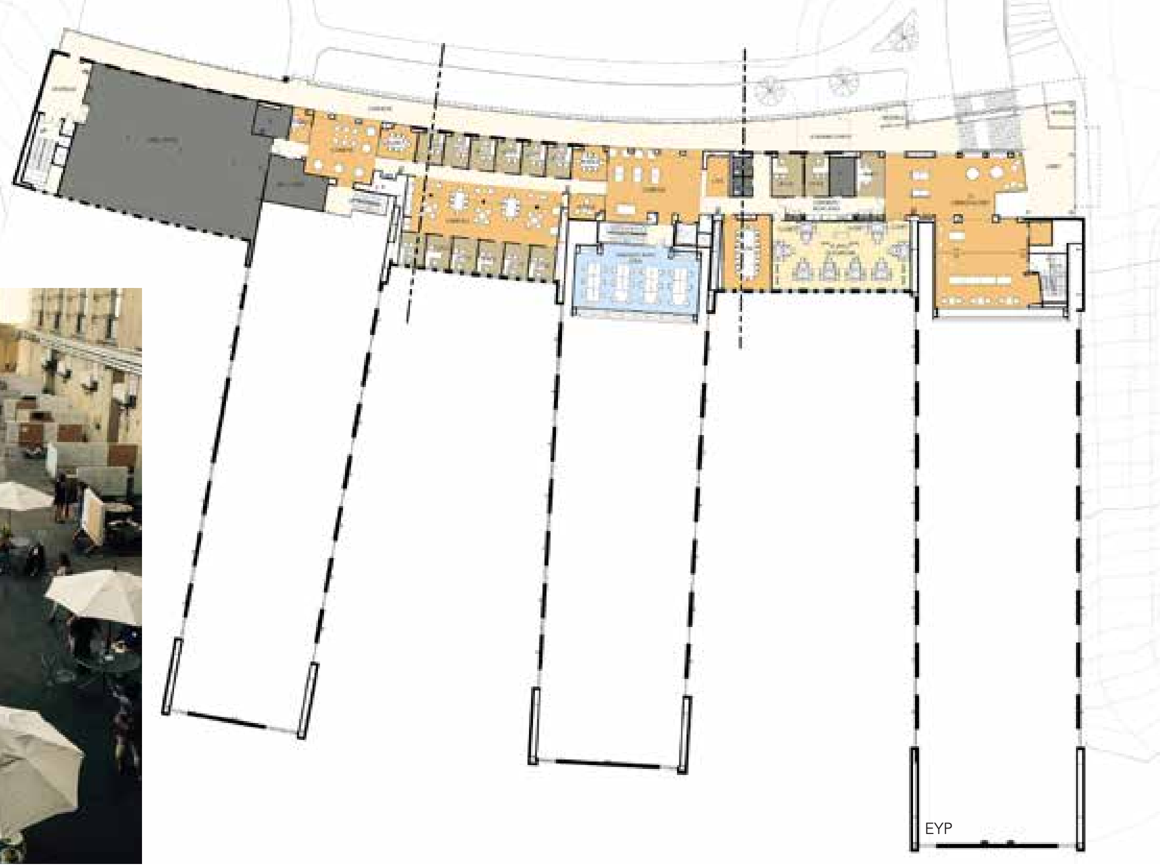
The mixing boxes within both the C2 and C3 high-bays are two-story conference areas that allow students, faculty and guests sweeping and uninterrupted views of the student spaces across the entirety of the high-bay floors. A mixing box was also proposed for the C1 high-bay, and within this area is an essential electrical room that could not be impacted, although the space above the electrical room is valuable and useable. A mixing box could cantilever over the electrical room, thus capturing the space above without impacting existing utilities within the electrical room. Ultimately, the mixing box in the C1 high-bay was eliminated, but the design of the mixing boxes in the other high-bays initially had to be suitable for the C1 high-bay as well.

Floating Boxes

During the initial planning, a key requirement of the mixing boxes was that they could not interfere with the student spaces below, so the boxes appear to float above these spaces. A second yet equally important requirement was that the mixing boxes could not overpower the exposed industrial aesthetic of the high-bays. The original steel framing, particularly the columns, is exposed and integral to the original architectural design, so it was only natural that the mixing boxes would be framed of structural steel as well. A long cantilever over the electrical room might have been susceptible to vibrations from people walking throughout the conference rooms, and deep beams would be stiff enough to mitigate possible vibrations—but doing so would not satisfy the architectural design intent. Instead, a modified Warren truss was proposed to frame the mixing boxes.

While the truss originated as a structural response to the programming requirements, it quickly became a significant architectural feature. The diagonals are located "outside" of the mixing box to be clearly visible from the high-bay floor, all the while respecting the aesthetics of the high-bays, yet with a modern touch. A structure with a clean and logical flow of forces is always visually pleasing, and the diagonals and all exposed

Student spaces within the C2 high-bay.



The “E” shape of the building.

connections were fabricated to AISC AESS (architecturally exposed structural steel) Category 2 to create a minimalist look (see **www.aisc.org/aess** for more on the various categories). The window framing facing the high-bay runs the full height of the mixing box, so the truss is beyond the edge of the floor. The floor beams were detailed with an exposed knife-edge connection that bring the loads directly to the center line of the diagonals, eliminating eccentric loads and out-of-plane bending on the diagonals. Universal pin connectors (produced by Cast Connex) were used at each diagonal to further enhance the aesthetics of the truss.

Each mixing box is supported on 18-in.-diameter round hollow structural section (HSS) columns that were chosen over typical wide-flange columns because they have equal stiffness in both axes. The columns are founded on a 24-in.-thick mat foundation to limit the loads applied to the existing foundations. A beneficial consequence of a mat foundation was that the bases of the columns could be fixed rather than pinned, significantly reducing lateral drift and allowing somewhat more useable space per floor as the isolation joints could be smaller. When viewed from the floor of the high-bay spaces, the isolation joint around the mixing boxes is almost imperceptible.

Grand Entrance

Since Building C is the first building to be repurposed for the Mountaintop Initiative, it is fitting that the building has a grand entrance to welcome students and faculty. Located at the end of the spine near the C3 high-bay, the new entry also includes a conference room with an amazing view of the Lehigh Valley below. The existing columns in this area are very closely spaced and would detract from an open and inviting entrance, so a portion of the existing building was removed to permit a column-free space of roughly 40 ft by 25 ft in plan. Unlike the mixing boxes, the C3 entry is an exterior addition, meaning that it is subjected to wind loads as well as seismic loads. The structural layout of the addition is of sufficiently different lateral stiffness so as to necessitate isolating it from the rest of the building.

The entrance vestibule is bigger in plan than the conference room above, so some of the upper-level columns were transferred at the low roof to keep the entrance vestibule open and column-free. The low roof of the entrance vestibule is also more than 2 ft lower in elevation than the floor of the conference room, so all of the beams (including the transfer beams supporting the upper-level columns) were kinked to match both elevations. Similar to the mixing boxes, the C3 entry is founded on a 24-in.-thick mat foundation. It also includes a new corridor that connects to the entire 400-ft length of the spine. For most of the corridor, the new roof framing is hung from the existing framing above. Near the entry, the corridor flares away from Building C, and the roof framing could not be hung from the existing building. As such, the framing is supported on slender 3-in.-diameter pipe columns aligned with the window mullions positioned to be as inconspicuous as possible.

Winds of Change

Renovating and expanding an existing building is always challenging. Design methodologies and assumptions change over time, as do materials and methods of construction. Even the amount of information shown on the drawings changes, and most buildings more than a few decades old were not designed for seismic and/or drifted snow loads. We were fortunate to have most of the original construction documents, but many of the utilities within the high-bays changed over time, and some were replaced about a year before this work began. We could not relocate utilities that were installed only a year earlier, even if they impeded the proposed work. In hindsight, we should have contracted for a 3D laser survey of the inside of the high-bays; utilities would have been exactly located in each high-bay, and a few fit-up issues that were encountered during construction could have been avoided—something to consider for similar, future projects. In addition, erecting steel within an existing building is never easy, as the erector discovered when it took a full eight hours and two cranes to install the first column. That was a very steep learning curve, but after this, the rest of the steel erection went much more quickly.

The original building is approximately 120,000 gross sq. ft in area, and just over half of that area was renovated as part of this work. The two mixing boxes and the C3 entry added roughly 15,000 sq. ft of space framed with approximately 150 tons of new steel. From a structural perspective, Building C is now nine separate buildings under one roof, and together these nine buildings provide an exciting, attractive and adaptable space where Lehigh students are motivated to affect positive change in the world. ■

Owner
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Construction Manager
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Architect and Structural Engineer
EYP Architecture and Engineering, New York

Steel Fabricator and Erector
Levan Associates, Inc., Emmaus, Pa.

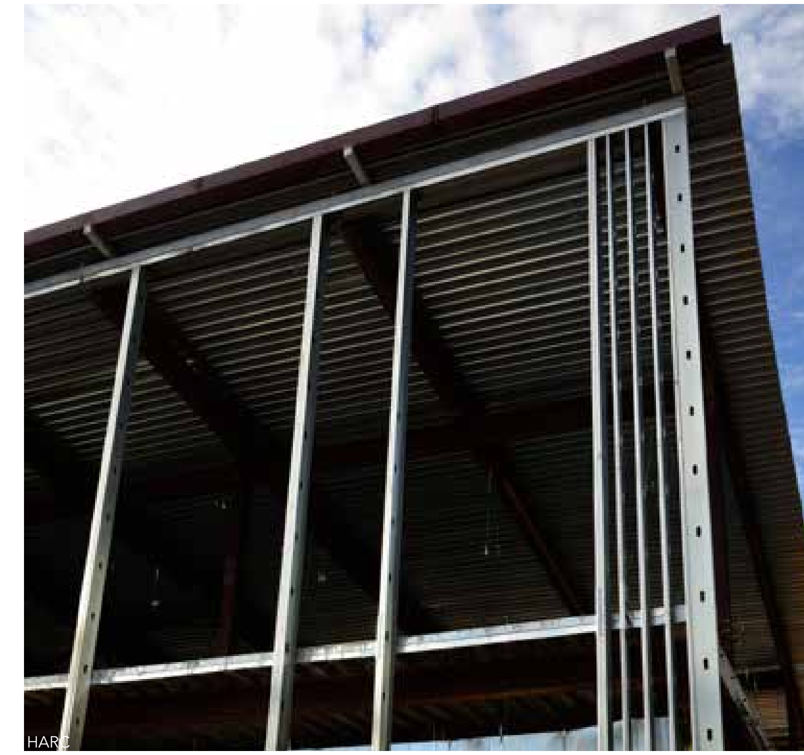
Occupants “inside the box” can look out into the high-bay space.

The project added 15,000 sq. ft of space to the existing 120,000-sq.-ft building.

Redefining Net Zero

BY DIRK KESTNER, PE, AND KILEIGH SHEA

A Houston research facility successfully implements a whole-building life-cycle assessment to reduce embodied emissions and push toward a "zero-carbon" building.



HARC is a not-for-profit research facility that provides analysis on energy, air and water issues in buildings.

Dirk Kestner (dkestner@walterpmoore.com) is a principal and **Kileigh Shea** (kshea@walterpmoore.com) is an associate, both with Walter P Moore's Austin office.

HOUSTON HAS UPPED its sustainability game with a new environmental research center.

The Houston Advanced Research Center (HARC) is a not-for-profit research facility that provides analysis on energy, air and water issues in buildings. Its mission is to contribute to a "sustainable future in which people thrive and nature flourishes." HARC collaborates with universities, private organizations, governmental agencies and community groups to develop solutions to environmental issues and affect policy related to sustainability.

HARC's original campus, built in the 1980s, no longer supported this mission. Furthermore, many of its offices did not have access to daylight and it did not provide an inspiring work environment. HARC sought to build a new headquarters that directly reflected its mission and serve as a living example for regionally appropriate sustainable design in the Gulf Coast region. It was also essential that the design respect the financial realities of a not-for-profit research institution. Gensler was selected as the prime architect and from the earliest stages of design, facilitated fully integrated planning sessions with the full ownership and design team, including structural engineer Walter P Moore.

These sessions illuminated HARC's project goals and focus not only on operational energy efficiency, but also on minimizing environmental impacts due to the materials used within the building. The team chose to pursue certification under the then current LEED 2009 rating system and set Platinum certification as its goal. While LEED 2009 did not include a whole-building life-cycle assessment (WBLCA) in the main body of the rating system, based on the owner's interest in reducing embodied impacts the team elected to pursue a LEED Pilot Credit that allowed for application of the LEED v4 WBLCA language in LEED 2009. HARC's new headquarters opened last year.

A New Design Tool

A WBLCA is a quantitative tool for measuring the environmental impacts of a project through the entire lifespan of the project—from design, material sourcing, construction, operations and maintenance to end of life. Though WBLCAs are relatively new to the buildings industry, consumer product manufacturers have used life-cycle assessments (LCAs) for some time to determine the environmental impacts of their products.

To perform an LCA, manufacturers study the processes from the time raw materials are extracted from the earth until the useful life of the product is complete and the material is recycled into a new product or is returned to the earth. Quantifying the energy input and emissions at each stage of the process, manufacturers can make quantitative analyses of a product's impact on the environment and determine where improvements can be made to minimize those impacts. For example, AISC has performed LCAs on various types of steel, including hot-rolled steel sections, plate steel and HSS that measure the impacts on the environment due to a specific volume of each material. The results of these LCAs are published in environmental product declarations (EPDs), which are short reports summarizing the environmental impacts in each material. Steel EPDs can be accessed at **www.aisc.org/epd**.

A WBLCA uses the same principles applied to consumer products, but at a whole-building level. WBLCA allows design teams to model all the materials in a building using specialized software—in this case, the Tally Environmental Impact Tool—and then compare multiple design scenarios based on their environmental impacts (there are currently several WBLCA software packages on the market, ranging in price and complexity). WBLCAs go beyond comparing steel buildings to concrete buildings; they allow designers to compare various types of steel, adjust concrete mix proportions and investigate various enclosure design options to make informed design decisions. Additionally, WBLCAs are now part of many sustainability rating systems, including LEED v4, which puts a much greater emphasis on quantitative comparisons of the impacts caused by building products.

As is typical for most projects, HARC's structural design team investigated different structural systems during the project's schematic phase. However, unlike typical projects, the team also used a WBLCA tool (Tally) to compare several structural systems and investigate which assemblies and subassemblies contributed the most to each environmental impact indicator, and used those results to drive the design.

Understanding the Environmental Impacts of Design

As part of the schematic design, and to establish a benchmark, the design team first considered what would constitute a "typical" structural system for this type of building located in this region. In suburban Houston, a building of this size—two stories and 20,000 sq. ft—is frequently constructed of site-cast concrete perimeter bearing walls and interior steel framing. Insulation is either placed on the inside of the concrete panel or within a "sandwich" panel, and the exterior is either left exposed or sometimes partially clad to achieve the desired exterior aesthetic. The plan dimensions of the building were set at 240 ft by 62 ft based on programming requirements and the desire to ensure that all spaces could effectively have access to natural light. For the bearing wall case, this resulted in a single row of columns down the middle of the building, with composite steel framing at the second level and steel bar joists at the roof. Belled drilled footings, bearing 15 ft below grade, were recommended in the geotechnical report, and the bearing wall scheme required three lines of drilled footings.

The preliminary WBLCA run of a single bay of the building indicated that a significant amount of the environmental impacts, particularly global warming potential (measured in tons of CO_2 and also known as a "carbon footprint"), were attributed to the concrete panels and foundations. Walter P Moore then developed an alternate steel-framed scheme with wide-flange girders spanning the 62-ft direction of the building and 24-ft composite steel beams spanning between the girders. This allowed the girders to be supported on two column lines with a 35-ft central span and two 13-ft, 6-in. cantilevers to the inside of the exterior walls. This framing system, while slightly increasing the steel tonnage, allowed for the perimeter wall to be non-load-bearing and framed from cold-formed steel studs that spanned continuously from the top of the perimeter grade beam to the underside of the roof. The continuity of the steel studs allowed for a more efficient stud design and eliminated joints in the building envelop at the second floor.

The perimeter wall supported exterior insulation and a rain screen enclosure that uses an exterior panel slightly offset from the insulation plane. This system allows warm air to vent vertically outside of the insulation plane. Together, the continuity of the envelope and the rain screen system were key components of the building's net-zero energy strategy.

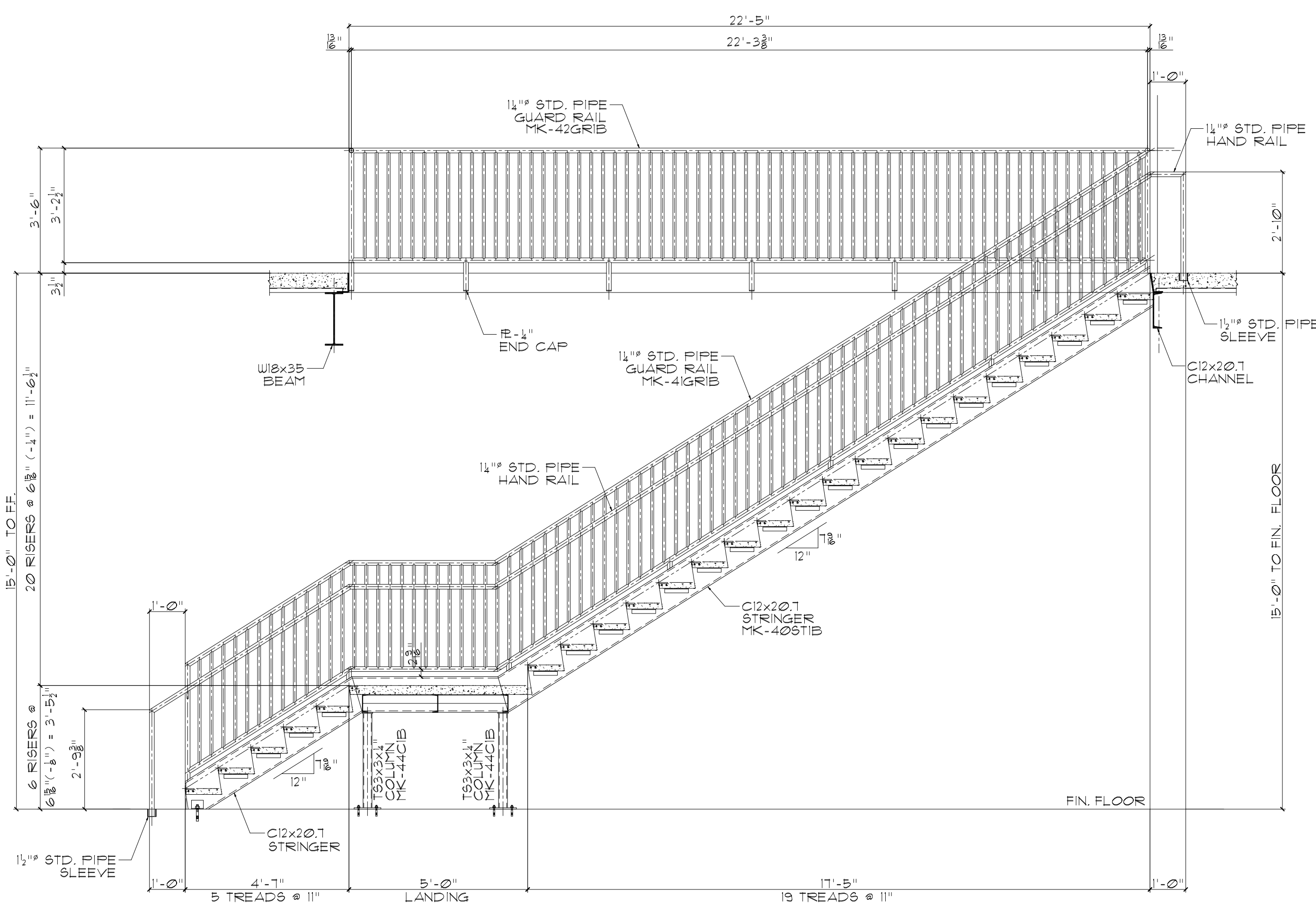
The steel system also permitted the removal of one line of drilled footings. Drilled footings were only required below the interior column lines and the non-load-bearing perimeter wall was able to be supported on a perimeter grade beam—a strategy that resulted in a significant reduction in the project's total concrete volume. However, the double-cantilever girder scheme resulted in a condition that could be susceptible to floor vibrations. This required Walter P Moore to perform a time-history vibration analysis on the double-cantilever to optimize the steel framing while not compromising occupant comfort.

Modifying the structural and enclosure system, and also refining the concrete mixes to use less cement, resulted in impact reductions in most categories and a 20% reduction in the carbon footprint without increasing the construction cost or schedule. Perhaps more significantly, these carbon savings occurred immediately unlike operational energy savings that build incrementally over the life of a building.

Approaching True Net-Zero

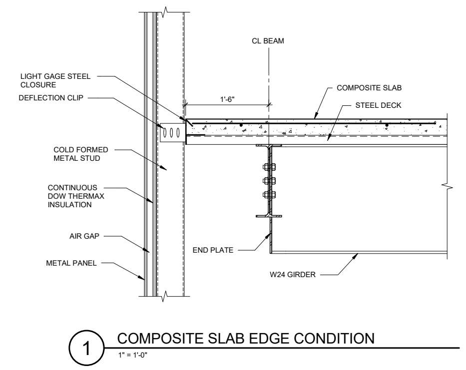
The use of a WBLCA to inform the structural and enclosure design of HARC's headquarters provided the team additional insight regarding material sourcing and structural system choices and allowed the full design team to better understand the

Wide-flange girders span the 62-ft direction of the building, and 24-ft composite steel beams span between the girders.



A detail of the main stairs and railings.

The LCA process.



A slab edge detail.

The steel-framed stairs, installed.

Baldinger

Baldinger

Baldinger

A whole-building life-cycle assessment was employed to optimize the structural framing system for HARC's new headquarters.

project's environmental impacts. It also provided lessons that can be employed by other teams wanting to use WBLCAs to minimize the impacts of their designs.

For this WBLCA, the structural system was the focus of the optimization, and Walter P Moore performed the WBLCA in parallel with their other analyses. This both allowed the WBLCA analysis and findings to immediately inform structural design choices and more importantly, the professional performing the WBLCA understood what modifications to the structural system were most realistic.

WBLCAs show that reducing embodied impacts is more complex than comparing two building materials and following through with standard design choices. System selection should be considered in combination with analyses of the largest contributors to each environmental impact for each system. Following selection of a system, other elements such as framing schemes, foundation systems and material-specific sourcing decisions should be made.

Finally, the WBLCA allowed the team to understand the full impact of the building and push as close to a zero-carbon building as possible. In fact, HARC recently received a grant to place additional photovoltaic panels on the roof, an added capacity that is projected to more than exceed the building's annual electrical demand. The surplus renewable energy will be fed back into the grid and allow the project to begin offsetting emissions associated with the building materials, bringing the zero-carbon goal closer than ever. ■

The HARC project is the focus of the session "Redefining 'Net Zero': Design + Operate + Educate" at the 2018 Greenbuild conference in Chicago, November 14-16. See ***www.greenbuildexpo.com*** *for information.*

Owner
Houston Advanced Research Center

General Contractor
Brookstone

Architect
Gensler

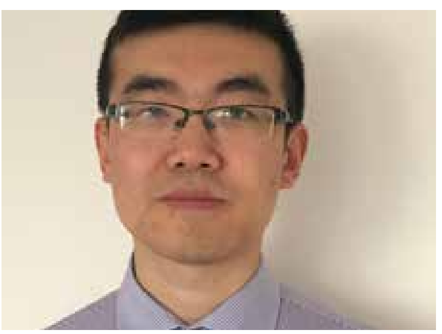
Structural Engineer
Walter P Moore

Steel Fabricator and Erector
Sanco Steel (dba) Southern Steel Fabricators and Erectors, La Blanca, Texas

Double Impact

BY KARA D. PETERMAN, PHD, LIZHONG WANG, MARK D. WEBSTER, PE, JAMES A. D'ALOISIO, PE, AND JEROME F. HAJJAR, PE, PHD

Two research projects at Northeastern University's STReSS lab shed some light on opportunities to make steel construction more sustainable.



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BUILDINGS ACCOUNT FOR NEARLY 40% of U.S. energy consumption and greenhouse gas emissions.

The materials required to construct a building all require energy to manufacture, fabricate, deliver and erect. Once it is operational and in use, the building itself is heated and cooled. And when it has reached the end of its lifespan, energy is required to disassemble and demolish the building.

When it comes to framing systems, structural engineers can take a leading role in developing new structural systems that are more sustainable. The good news for structural steel is that, in addition to other green attributes, it is largely produced from recycled materials. And work is currently underway in the form of systemic innovations that can take steel-framed buildings to the next level of sustainability.

Two projects at Northeastern University, in collaboration with Simpson Gumpertz and Heger (SGH) and other partners—both funded in part by AISC—are exploring improvements to common structural steel systems that can help reduce their environmental impacts.

Both projects take a closer look at the contributions of the structural system to the energy consumed in building construction and use. The first project explores strategies for adding thermal breaks to cladding details to reduce building heating and cooling demands while maintaining the structural efficacy of the details. The second project addresses a composite structural floor system developed to facilitate deconstruction, in which the structural systems are designed to be taken apart and reused in other structures. Both projects highlight testing conducted at Northeastern's Laboratory for Structural Testing of Resilient and Sustainable Systems (STReSS Laboratory) which was established in 2011.

Thermal Break Strategies

When a structural element spans the building envelope, it can act as a thermal bridge that allows energy to flow between the building's exterior and interior. Steel, for all its strength and ductility, is also thermally conductive. Conductive cladding details combined with large differences in interior and exterior temperatures are not only appropriate conditions for energy loss, but also condensation. A thermal break may be used to mitigate this thermal bridge.

Together with the Charles Pankow Foundation, the American Composites Manufacturing Association (ACMA) and the Pultrusion Industry Council (PIC), AISC partnered with a team from Northeastern University, SGH and Klepper, Hahn and Hyatt (KHH) to design and validate a suite of thermal break strategies. While many steel elements can become thermal bridges, this work focused on slab-supported shelf angles, roof posts (for supporting mechanical units and other rooftop structures) and canopy beams.

As an effective thermal break involves improved thermal performance in addition to adequate structural performance, stainless steel and fiber reinforced polymers (FRP) were natural candidates, both as shims inserted in the building envelope and as full or partial replacement of the structural member. Based on the expertise of the SGH and KHH engineers along with the project's Industrial Advisory Panel—which included representatives from AISC, ACMA, PIC and a number of companies—viable solutions were developed using these materials, then validated using 3D thermal modeling software to determine the effectiveness of the proposed breaks. Structurally promising solutions were then tested at full-scale as subsystems in the STReSS Laboratory. In addition to these subsystems—which included shelf angles, roof posts and canopy beams—double-lap-splice steel-bolted connections with FRP fills of varying thicknesses and flatwise creep testing of the FRP materials subjected to through-thickness compression was also conducted. Finite element modeling was used to substantiate the results from the experimental testing.

The research demonstrated that FRP shims can be effective and structurally sound thermal breaks for shelf angles and roof posts, as well as for canopy beams subjected to light loads that were within the scope of this research. Figure 1 shows the setup for testing the strength of shelf angle assemblies connected to steel framing with different thermal break strategies. In the setup, the specimen is shown in green, and the loading beam representing gravity loading from cladding is shown in brown. Figure 2 shows a schematic of a roof post assembly, along with representative results through thermal modeling to show the potential impact of using thermal breaks. Compared to thermally unbroken connections, we estimated thermal transmittance reductions of up to 65% for roof posts, 30% for canopy beams and 92% for shelf angles. Creep can be managed by limiting the stress in the shims. Some of the connection configurations explored in this work, all of which used snug-tight bolts, are not compliant with the *RCSC Specification*. The project team is looking forward to expanding the work to include a greater range

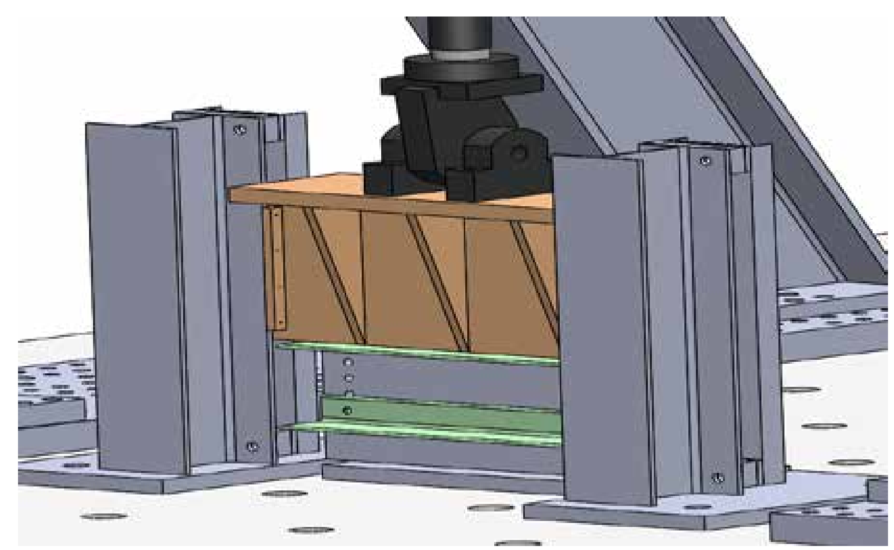
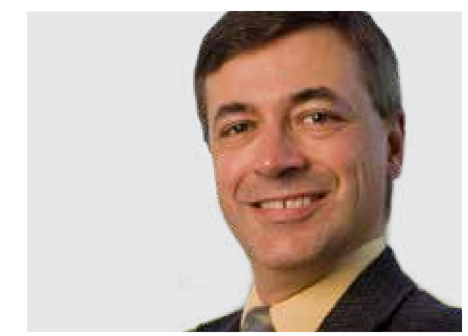


Figure 1. Test setup for shelf angle assemblies examined in the thermal breaks project.



James A. D'Aloisio (jad@khhpc.com) is a principal with Klepper, Hahn and Hyatt. **Jerome F. Hajjar** (jf.hajjar@northeastern.edu) is the CDM Smith Professor and Chair in the Department of Civil and Environmental Engineering and director of the Laboratory for Structural Testing of Resilient and Sustainable Systems (STReSS Laboratory) at Northeastern University.

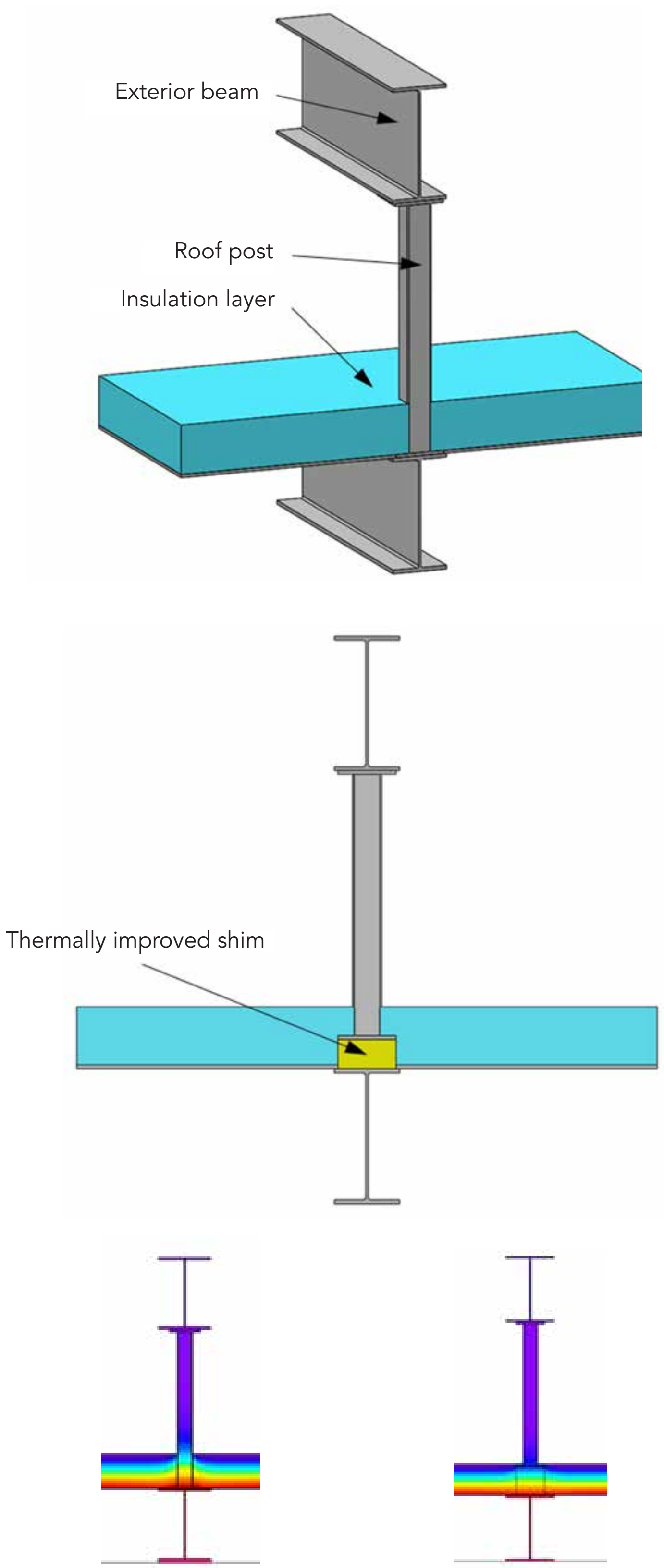


Figure 2. The top detail shows an initial design concept for a thermal break at a roof, the middle detail shows the design with an improved shim incorporated and the bottom image shows thermal imaging/efficacy of the assembly without (left) and with (right) the shim.

of structural design provisions, structural loads, mitigation techniques and involvement from industry.

A hallmark of this work was the continued and enthusiastic involvement of AISC, practicing engineers and representatives of the numerous funding agencies and participating companies. As the recommended mitigation strategies must ultimately be designed and implemented by engineers, guidance throughout the research process ensured that the results have been meaningful for structural steel design.

Design for Deconstruction

A deconstructable structural system provides a new paradigm for construction in which the structural system can be taken apart at the end of its useful life and its components reused in other structures, assuming there has been minimal to no damage to the system. Often, buildings are demolished not due to structural deficiency but rather because their styling or floor plan has fallen out of favor, or due to development trends in the building's neighborhood. Even if a building reaches its design service life and needs to be demolished, the steel and concrete components, which are protected from the environment within the envelope, are normally free of corrosion and deterioration and can thus potentially be reclaimed from the demolished building and reused in a new project—provided that the structural system can be readily deconstructed. To achieve this goal, a deconstructable structural system should embody key features that include: having modular components dry-assembled on site; independence of various systems; application of parallel instead of sequential assembly/disassembly; use of mechanical connectors; and related features.

A traditional composite steel-concrete floor system does not integrate future deconstruction into the design and construction process. For several decades, composite steel-concrete floor systems incorporating steel deck, shear studs and cast-in-place concrete slabs have been the most ubiquitous type of structural steel framing for commercial and institutional buildings. This cost-effective solution, however, is also a highly integrated design, which removes the possibility of deconstructing and reusing the structural system at the end of its service life. The steel beams and shear studs are generally extracted from the demolition debris and recycled, while the concrete slabs may be broken up and sent to landfills or crushed to make aggregate for fill or new concrete.

Our design for deconstruction (DFD) research project, funded by the National Science Foundation (NSF) and AISC, developed a deconstructable composite floor system to maintain the benefits offered by composite construction while enabling deconstruction and reuse of the structural components, thereby reducing demolition waste from old projects and raw material consumption in new projects (Figure 3). The system consists of precast concrete planks and steel beams joined with clamping connectors. The clamping connectors use friction at the steel-concrete interface to resist required shear flow and achieve composite action. Channels are cast into the concrete to provide flexibility for where the beam intersects the plank and to allow for different beam widths. Tongue-and-groove joints at the concrete plank edge ensure vertical load transfer between adjacent planks and offer a level and well-matched finished floor surface.

To transfer in-plane diaphragm forces, the precast concrete planks are staggered and connected using un-bonded threaded rods before being attached to the steel beams (Figure 4). Friction, developed by pretensioning the rods, provides the resistance against joint sliding due to diaphragm shear and joint opening due to diaphragm flexure.

By untightening the bolts and rods, the precast concrete planks and steel beams can be disassembled and reconfigured in future projects. This type of construction also facilitates adaptation for renovations. Preliminary plank dimensions are 20 ft by 2 ft by 6 in. This size is small enough to facilitate transportation and handling and promote reconfiguration in future structures, but large enough to have structural integrity and reduce labor for construction and deconstruction. Ideally, the planks would be stocked in different sizes and concrete strengths for ready use, comparable to how steel is currently stocked at service centers.

The experimental program of this project consisted of push-out tests and composite beam tests, all conducted at full scale. In the push-out tests (Figure 5) the clamping connectors were subjected to direct shear, and the characteristics of the clamping connectors were quantified, including load-slip curves, strength, stiffness and slip capacity. The push-out test results show that the peak strength of a clamp using a 24-mm bolt is close to that of a ¾-in. (19-mm) diameter shear stud, but the clamps possess much greater initial stiffness, ductility and slip capacity than a stud.

We then tested four 30-ft-long deconstructable composite beams using W14×38 and W14×26 W-shapes and 6-in.-thick planks (Figures 6a and 6b). All the beams exhibited very ductile behavior even at a beam deflection of over 14 in., well past service load deflections. The beam test results confirmed the clamp strengths obtained from the push-out tests and demonstrated that AISC design provisions for conven-

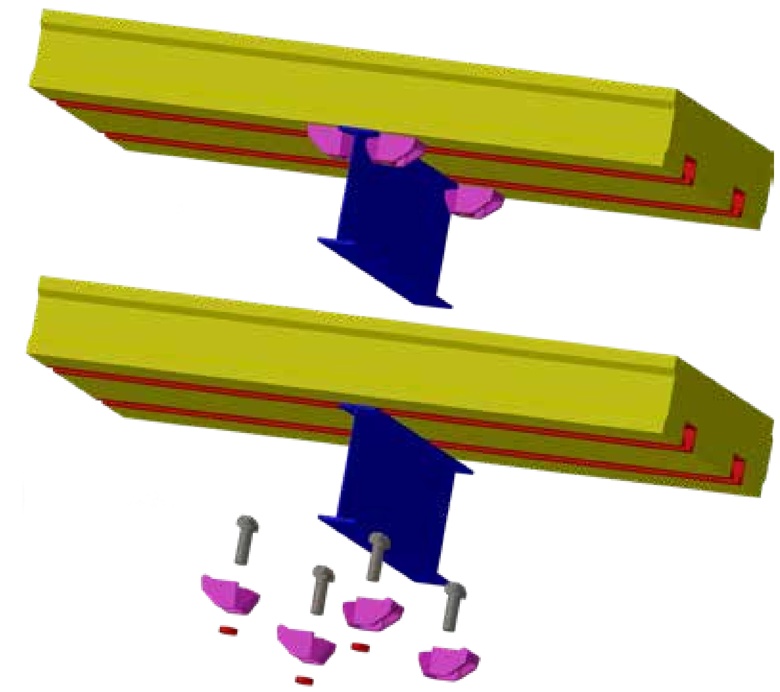


Figure 3. A deconstructable composite beam prototype, including concrete plank, steel beam, cast-in channels, tongue-in-groove joints, bolts and clamps.

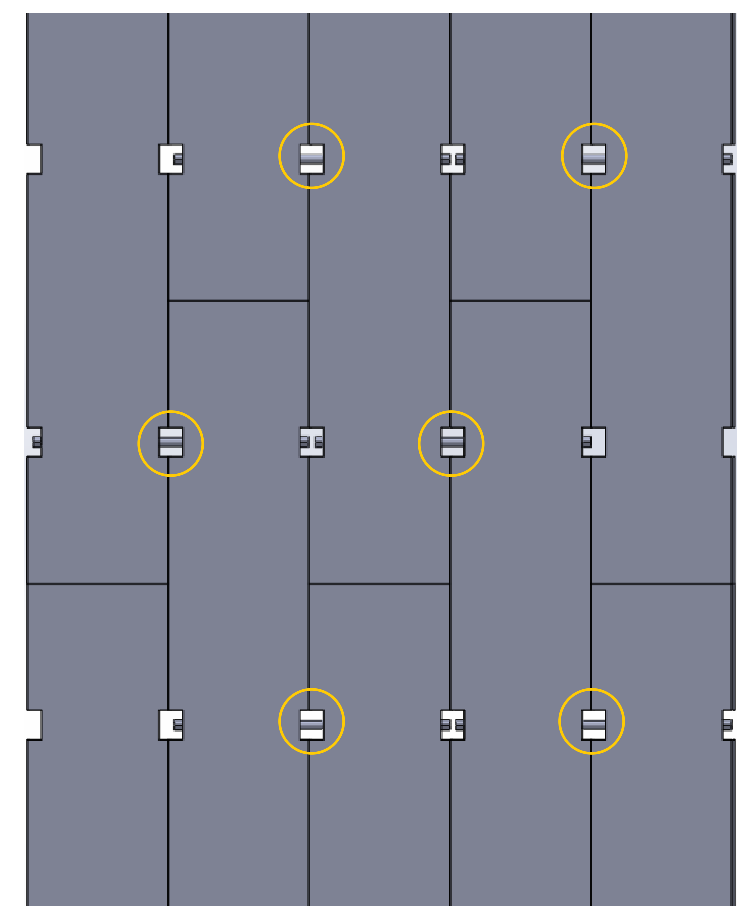


Figure 4. Precast concrete plank in-plane connections. Threaded rods are indicated with yellow circles.

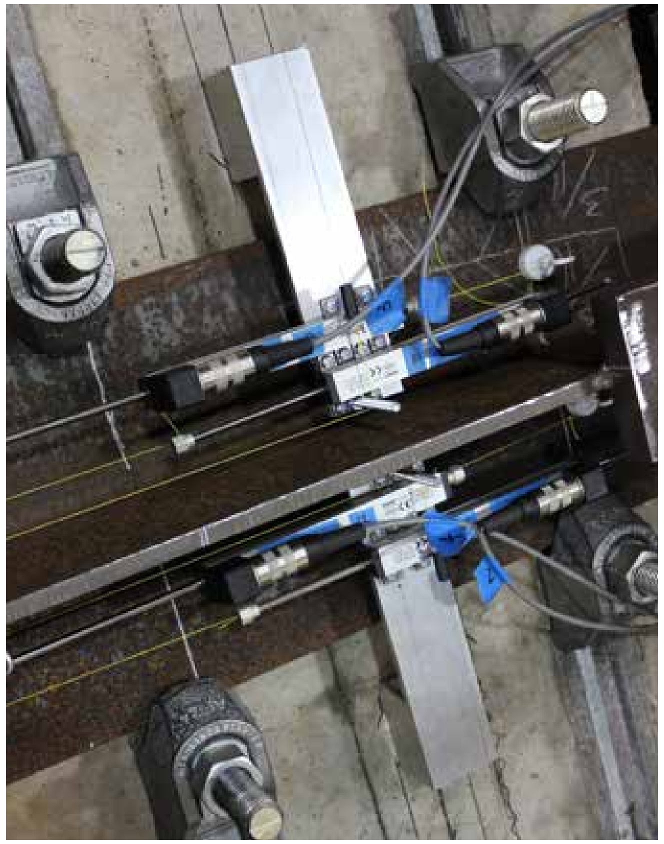


Figure 5. Push-out test specimen.

Figure 6a. Beam test specimen.

Figure 6b. Beam test specimen.

tional composite beams are applicable to the deconstructable composite beams. This research shows that using clamped connectors at the steel-concrete interface can effectively achieve composite action in sustainable composite beams, and these tests confirm a potentially transformative approach for nearly damage-free transfer of force in appropriate applications.

Design for deconstruction of buildings still requires additional work before being fully accepted, such as building code guidance on evaluating and designing with reused materials; coordination between material demand and supply, including time for deconstruction in project schedules; and consideration of possible costs or potential savings from this approach. However, this research highlights the viability of a key structural system to enable the reduction of energy required in construction.

This research highlights new strategies for reducing the environmental impacts of construction and creates clear opportunities for sustainable structural steel design. Researchers and practitioners should collaborate and embrace these new opportunities to ensure that research not only expands the frontiers of structural engineering but also produces pragmatic design outcomes. ■

Acknowledgments

This material is based upon work supported in part by the National Science Foundation under Grant Nos. CMMI-0654176 and CMMI-1200820, Charles Pankow Foundation, AISC, the American Composites Manufacturers Association, the ACMA-Pultrusion Industry Council, Simpson Gumpertz and Heger, Inc., Klepper Hahn and Hyatt and Northeastern University. In-kind support was provided by Armadillo NV, Bedford Reinforced Plastics, Benevento Companies, Capone Iron Corporation, Creative Pultrusions, Fabreeka, Fastenal, Halfen, Infra-Metals, Lehigh Cement Company, Lindapter, Meadow Burke, S&F Concrete, Souza Concrete and Strongwell. Any opinions, findings, and conclusions expressed in this material are those of the authors and do not necessarily reflect the views of the sponsors.

Building (for) the Future

BY LUKE JOHNSON, SE, PE

As the vocabulary for earth-friendly buildings increases and lots of buzzwords get thrown around, the most important thing to design for is the future.

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GREEN. EARTH-FRIENDLY. DURABLE. Sustainable. Resilient.

These words have all gained popularity in the building world over the past several years, and demand for projects that advertise themselves using any of them continues to grow across the United States.

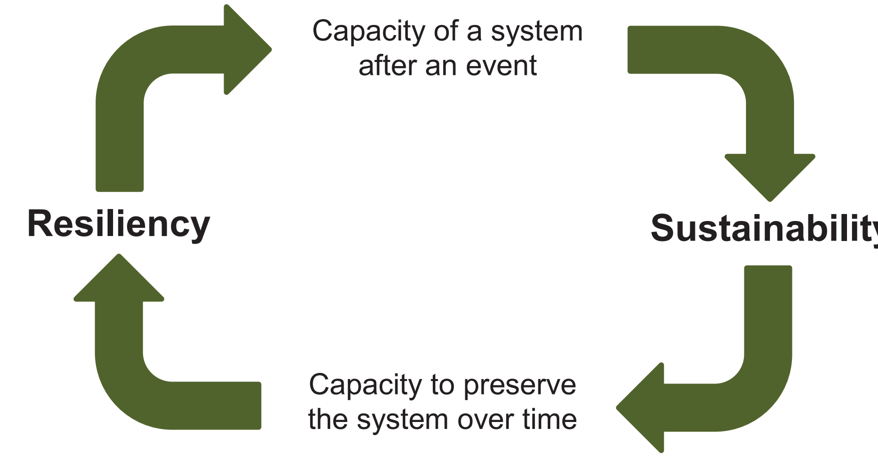
And for good reason. Sustainable and resilient buildings not only provide a better working and living environment for tenants and residents, but they are also better equipped to handle extreme events, both naturally occurring and man-made, increasing the possibility of returning the building back to full occupancy and use shortly after the event. For this reason, building owners and occupants continue to drive the need for structures built using sustainable materials and resilient designs.

As this movement continues to grow, more and more architects, engineers and contractors are realizing the benefits of selecting structural steel framing systems as a means of achieving both sustainable design and long-term building resilience. Therefore, it is important to understand what sustainability and resiliency—and related terms—mean when it comes to structural framing systems, and how these concepts can work hand-in-hand to provide better long-term framing options for buildings and their occupants.

Sustainability

A sustainable resource is defined as being harvested or used so that it is not depleted or permanently damaged. Building materials that are sustainable should consider the following characteristics: the recycled content within the material, the recyclability of the material, the recovery rate of the material and the material's ability to be reused. Domestically produced structural steel contains an average recycled content of 93%, as these structural shapes are created from steel scrap, making the steel industry the largest recycler of waste by mass in the United States.

And all structural steel is 100% recyclable at the end of its useful life—i.e., steel that was used in an automobile or household appliance can be recycled and used to create new structural steel shapes for use in a new building. While many materials may be recyclable, not all building materials are easy to recover at the end of their useful life and therefore may end up in a landfill instead of being recycled. On average, 81% of all domestic steel products and materials are recovered and recycled into new steel products, with 98% of structural steel being recovered at the end of its life.



The cycle of resiliency and sustainability.

Think of it this way: Recycling one ton of steel avoids the consumption of 2,500 lb of iron ore, 1,400 lb of coal and 120 lb of limestone. (Note that the vast majority of domestic structural steel is created using the electric arc furnace process, which creates new steel shapes out of recycled scrap.) While structural steel is very commonly recycled, it can also be reused and repurposed at the decommissioning of a building or facility. While only a small amount of recovered structural steel is re-fabricated and directly reused in new building projects, a significant amount of structural steel is reclaimed from the waste stream of deconstructed buildings for reuse in non-building applications such as pipe racks, shoring and scaffolding.

Resiliency (and Other "R" Words)

Next, let's discuss **resilience**, which is defined as the ability to recover from or adjust easily to misfortune or change. As the global climate continues to change, along with the ever-present danger of terrorist events, more and more attention is being paid to the resiliency of communities, buildings, structural framing systems and construction materials. A building material's resiliency can be measured by taking a closer look at the following four characteristics: robustness, resourcefulness, recovery and redundancy.

Robustness measures a building's ability to remain operational during and after an extreme event. This becomes most critical for essential facilities that contain services such as health care, power management, transportation and communications. A building's robustness is a direct result of the integrity of the structural framing system, as well as the strength of the framing material used. The strength, elasticity, durability, non-combustibility and resistance to decomposition of structural steel make it the most robust building material available.

Resourcefulness is the ability to be best prepared for and accurately respond to an extreme event. Structures having "as-built" plans available, structural engineers to perform on-demand investigations of damage to the structural frame and material suppliers identified for providing repair materials greatly increase resourcefulness. As structural steel is stocked in service centers throughout the entire country, steel can be rapidly delivered to a structural steel fabricator, who can quickly customize the steel sections required to implement the repairs identified by the structural engineer.

Recovery is the ability of a building to restore key operations as quickly and efficiently as possible after an extreme event, with the goal of returning to full operation as quickly as possible. The time required to perform a certain level of recovery is a direct relationship to the robustness, redundancy and ease of repair of the structural system, as well as the availability of resources to complete the repair. While it would be impossible and impractical to design a building to withstand every extreme event, the robustness and wide availability of structural steel make it a building material capable of fast recovery.

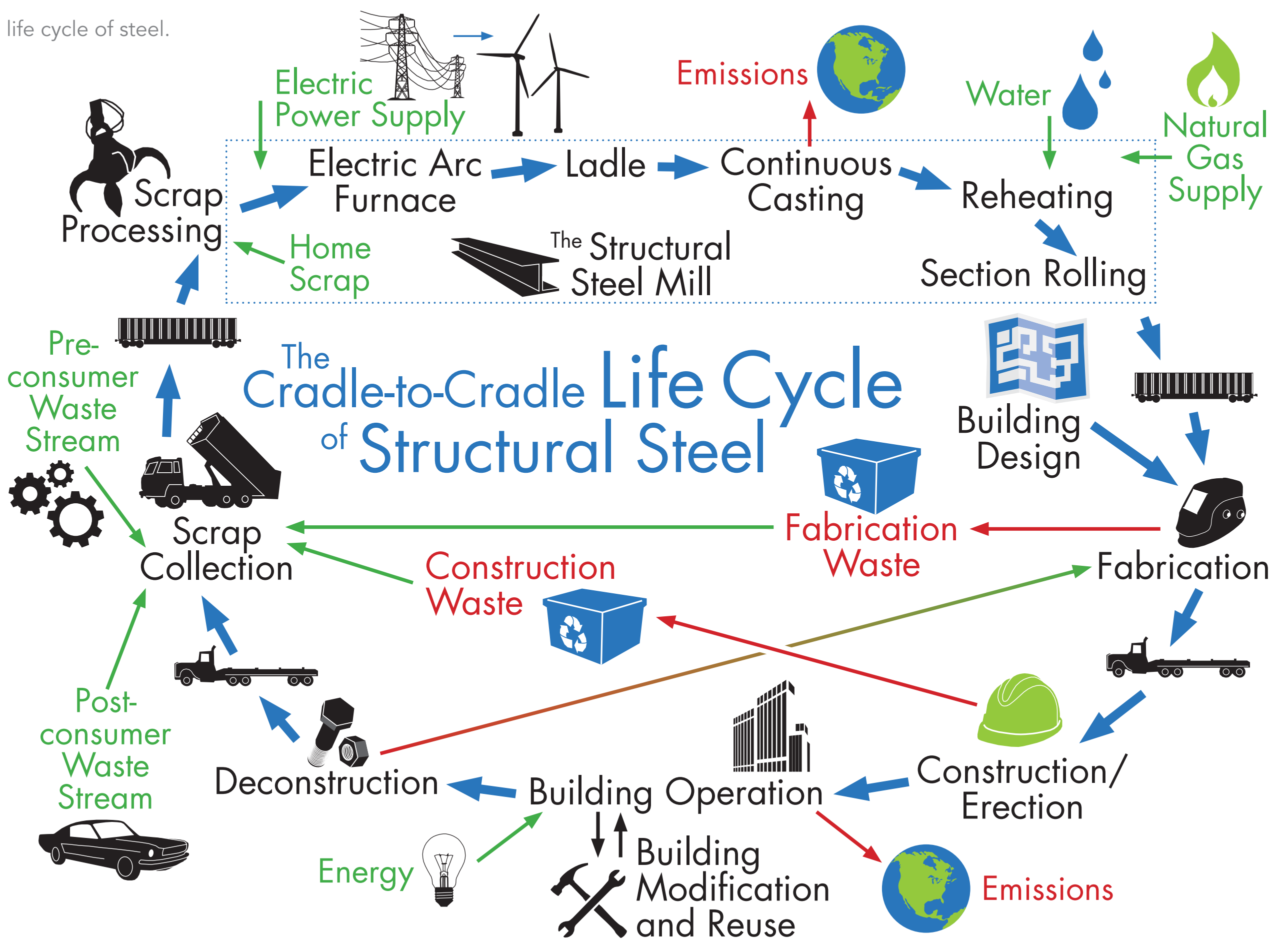
Redundancy in a building can be best described as the ability of the framing system, as well as the structural material used, to provide additional load carrying capacity and alternative load carrying paths as the transfer of loads becomes necessary. The specifications for the design of structural steel are based on past successful usage along with current research and result in structures with reserve capacity "built in" to the design process. In addition, current design practice for essential facilities provides additional redundancy so that key supporting members, such as columns, can be damaged or completely removed from the structure without collapse.

When all of the above criteria are considered in a building design, structural steel is the ideal choice when it comes to building resilience.

Buildings that are constructed from both a) sustainable materials and b) resilient framing systems provide better overall living and working environments for their occupants, deliver structures capable of resisting impacts imposed by extreme events and reduce overall environmental impacts by reducing landfill waste, raw material consumption and greenhouse gas emissions. Not only are they themselves built to last, but they are also built to help the environment and our natural resources last as well. In other words, they are built with the future in mind—and structural steel checks both boxes. ■

For resources on domestically fabricated structural steel and sustainability, see ***www.aisc.org/sustainability****.*

The life cycle of steel.



Amazingly Affordable

The winning projects in the 19th annual Steel Design Student Competition rethink affordable housing.

SIXTEEN EXCEPTIONAL STUDENT DESIGN PROJECTS have been recognized as winners in the 19th annual Steel Design Student Competition for the 2017-2018 academic year. Administered by the Association of Collegiate Schools of Architecture (ACSA) and sponsored by AISC, 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 was awarded to the winning students and their faculty sponsors.

More than 900 students and faculty participated in this year's competition, and more than 300 entries were submitted. Students participated in one of two categories. The Affordable Housing category challenged students to design affordable multi-family housing in an urban context. In the Open category, students were given the flexibility to select a site and building program.

The jurors for the affordable housing category were Margaret Griffin, Griffin Enright Architects & Southern California Institute of Architecture; Hans C. Herrmann, Mississippi State University; and Joanna Zhang, Skidmore Owings & Merrill. The jurors for the open category were Diogo Burnay, Dalhousie University; Ming Hu, University of Maryland; Elizabeth Martin-Malikian, Kennesaw State University.

The selected projects will be on view at the 107th ACSA Annual Meeting, March 28-30 in Pittsburgh and at the 2019 NASCC: The Steel Conference, April 3-5 in St. Louis (see **www.aisc.org/nascc** for more information). You can get more information and see more renderings of all the winners at **www.acsa-arch.org**.

WINNERS: CATEGORY I – AFFORDABLE HOUSING

First Place Balloonité
Students: Austin Vandepoll and Nathalie Altamirano, University of North Carolina at Charlotte
Faculty Sponsor: Marc Anthony Manack

Charlotte, North Carolina's "Leading on Opportunity Task Force Report" (**www.leadingonopportunity.org**) identifies strategies to mitigate the city's perceived lack of upward mobility. Key to the strategy's success is developing housing that does not overburden residents in terms of cost and also allows a variety of people to stay in established neighborhoods. Balloonité addresses this urgent need for affordable housing with a vivid and experimental architectural response.

The project seeks to re-animate the architectural approach of Le Corbusier's Unité d'Habitation through the use of inflatable steel technology. While most inflated steel experiments have been rendered as small objects and intimate installations, they have revealed the technology's capacity to produce thin-shelled, strong and rapidly deployable structures. From the housing unit to the structural frame and shell, Balloonité capitalizes on the potential of this technology at various scales within the project.

Inflated steel works as a relatively simple procedure. First, two 18-gauge steel sheets are cut into a desired shape. Next, edges and seams are welded together, making sure to keep the blowhole open. Lastly, 90-psi air is pumped into the cavity. Extrapolated as a modular building system, the time-saving prefabrication, coupled with the material efficiency of the Balloonité components, results in tremendous construction cost savings. Given that structural steel is already highly recycled and recyclable and has a long life cycle, and also that project's construction is very low-maintenance, Balloonité a truly sustainable approach, one that can help bring life, creativity and innovation to a rapidly growing city. The project's aesthetic appeal could help Charlotte move past the affordable housing stigma of "not in my backyard" and push culture forward in the way people think about affordable housing—as well as help rethink modern social housing projects in a fresh, eclectic and humane way.

WINNERS: CATEGORY I – AFFORDABLE HOUSING

Second Place **The Beta Commune**

Student: Cera Yeo, California College of the Arts
Faculty Sponsors: Christopher Falliers and Antje K. Steinmuller

San Francisco has long been seen as a creative, bohemian haven. However, the growing influx of tech workers into the city has generated conflict due to displacement of the former residents, making the need for more affordable housing options for artists greater than ever. The Beta Commune tackles this by offering communal living for both groups.

The formal design was developed via case studies of clustering systems for housing, such as Moshe Safie's Habitat 67 and Kisho Kurokawa's Capsule Tower. But instead of the concrete structures explired by those projects, the Beta Commune introduces an innovative use of steel.

The Beta Commune is structured to hold communal spaces with individual room units. Five types of minimalist units will plug into a steel frame, with long-span trusses running throughout the communal spaces. These trusses then hold up cantilevering plug-in units on perpendicular sides of the building. The steel structure forms large, open spaces that are sectionally divided. A 5-ft difference produces visual boundaries for social spaces that occur within the clusters. There are a total of 90 units that range from 200 sq. ft to 400 sq. ft, housing a total of 148 residents (some units can hold two inhabitants).

The units are constructed with insulated steel panels. Panelization can be factory-built, with insulation and electrical embedded, a method that allows the plug-in units to be built with a high degree of precision, ultimately leading to less work on the site.

The communal spaces include routine areas such as living, dining and kitchen spaces, and the ground floor holds a social space for the community to interact with residents. The abstract exterior cladding tucks away the life of the building and relates to protrusions generated by modern bay windows that will coexist peacefully with the urban fabric of the neighborhood. The Beta Commune has the potential to be recreated at larger scales and using the same steel fabrication method.

Third Place **Pressing Matters of Affordability**

Students: Arturo Lujan, Pedro Pinera-Rodriguez and Ryan Smith, University of North Carolina at Charlotte
Faculty Sponsors: Peter L. Wong and Christopher Jarrett

The strength of modern structural steel supports both the aesthetic and functional attributes required of buildings. In the early years of structural steel, the development of modern structural analysis and the advent of industrial standards helped anchor the use of steel framing as a kit-of-parts for a structure that was regular, repetitive and rational. The frame expressed a system, a universalizing order that shaped the quality and memory of contemporary building space.

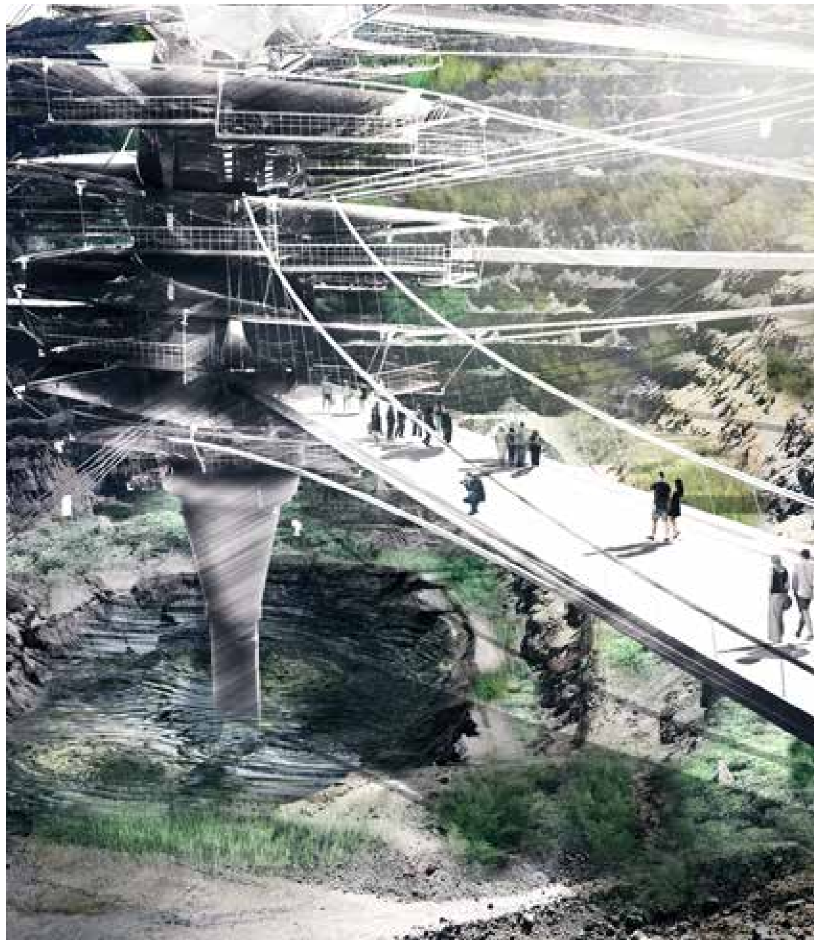
Today, steel can be used in more specific and singular ways in construction. As architects and engineers can now accommodate more complex program arrangements, steel framing systems have become even more innovative, challenging and fun. Steel is now called upon to balance the individualized and often dramatic relationships in new and complex building configurations. We can cite OMA's use of a 100-ft-long double-wide-flange strut reaching to support the diagrid envelope at the Seattle Public Library as an example of the unique and powerful use of steel.

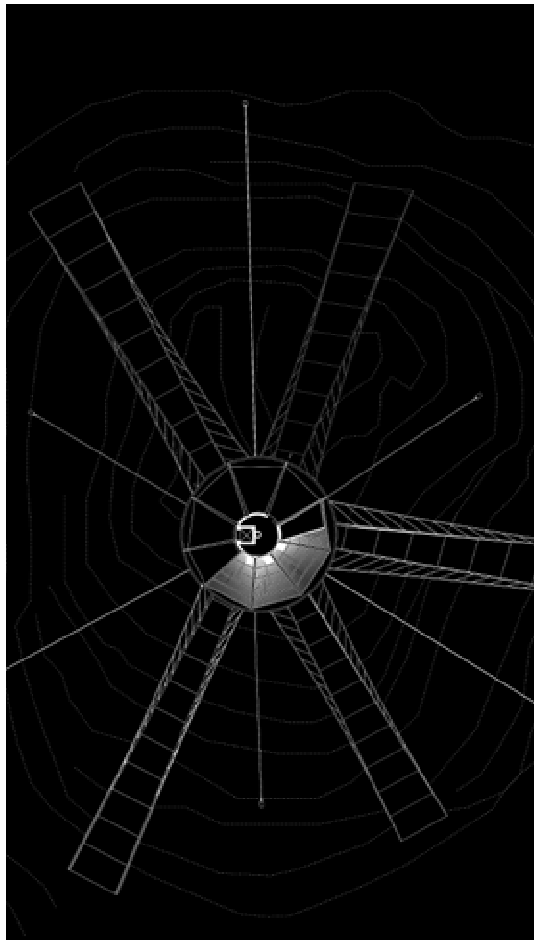
Our proposal for an affordable housing complex in a former industrial zone seeks to shift from the heroic use of steel to a softer, smoother state. We propose that pressure-forming metal via stamping and tooling processes can advance steel as a more subtle and seamless alternative to tectonic techniques. Sheet materials offer sophisticated shaping opportunities, demand lower energy use and provide lateral resistance due to their planar and stress-skinned capabilities. In order to test these techniques, we imagine this design as an innovative use of blanking, stamping, drawing and piercing methods common to automotive and other industrial manufacturing. A series of customized unitized frames function as vertical supports running the length of the building, while a system of double-layered, stress-skinned floor plates comprises the horizontal structure. Lateral support is afforded by external skins and panels serving both structural and shading roles.

Pressing serves as an activity for the smoothness of this reconsidered technology. It also imagines the bumpy yet urgent matter of housing opportunity in urban areas of gentrification.

WINNERS: CATEGORY II – OPEN

First Place UPROOT
Student: Tatiana Estrina, Ryerson University
Faculty Sponsor: Vincent Hui

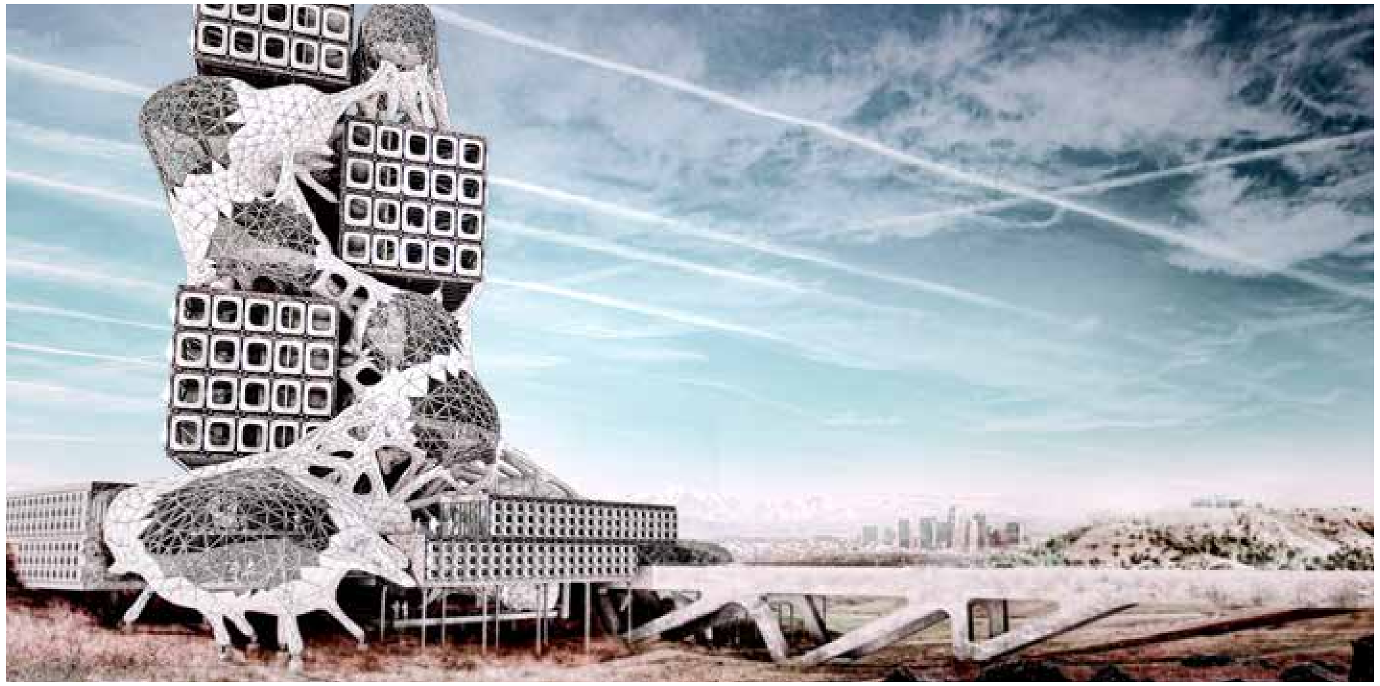


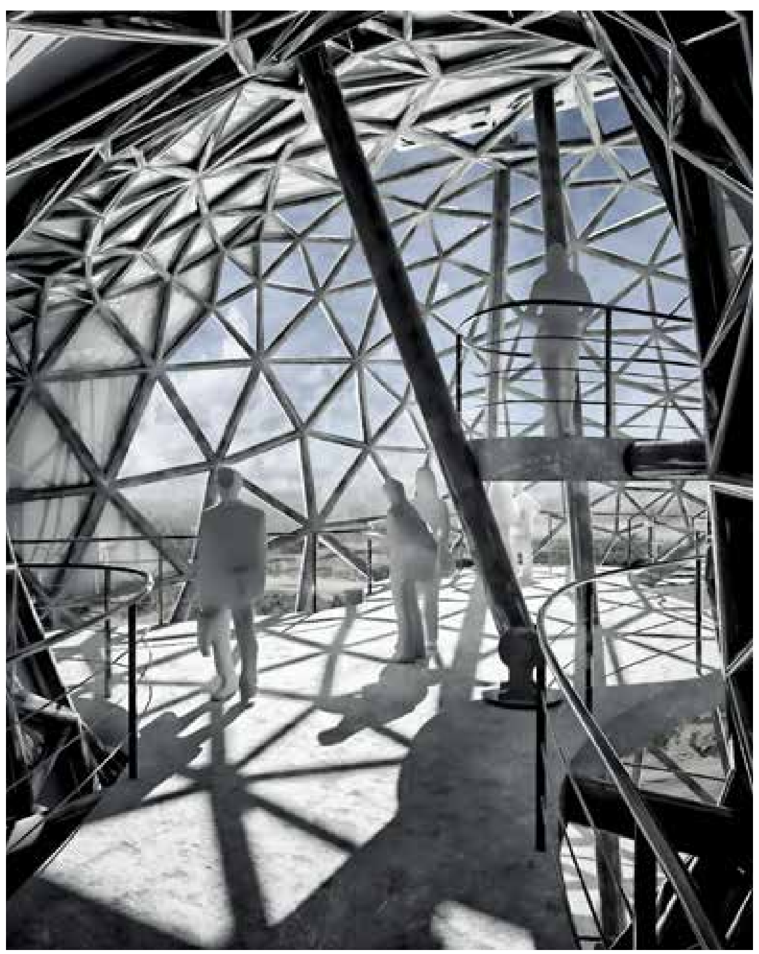


In Northern Ontario, open-pit mining is frequently used to extract minerals such as gold and diamonds. However, when the mine closes, the area is often left empty while the miners' families face unemployment and uncertainty. In anticipation of the closure of several Ontario's mines, UPROOT provides a structure with an alternative use for these areas. UPROOT calls for the redevelopment of open-pit mines into terraced community farmland, offering new possibilities for its use after closure. It provides a sustainable solution to global environmental concerns regarding abandoned mines and also creates new opportunities in response to Ontario laws requiring the mining industry to take responsibility for regenerating an area after its natural resources are depleted. The design itself acts as a linkage within the pit as well as reestablishes the relationship between towns and their local food production. By taking advantage of structural steel's strength under tension, UPROOT becomes a suspended hub for agricultural and social activities.

Second Place Contagion

Student: Tyler Armstrong, California Polytechnic State University
Faculty Sponsor: Margarida Yin





There is an open wound that festers within the fabric of Los Angeles. Exposed by the economic forces that once served to stitch the region together, the Inglewood Oil Field is one of the few visible reminders of a resource that was in many ways the genesis of modern Southern California. This resource? Black gold, aka oil. As the British historian Reyner Banham once stated, "Los Angeles floats on an ocean of oil." But over the course of decades, this ocean has been steadily drained to fuel the urbanism-on-overdrive that has spread across the surface of the region. Contagion seeks to speculate upon not just the future of the Inglewood Oil Field but also upon the very nature of Los Angeles' continued relationship with fossil fuels. The project explores the notions of a deferred authorship through computational design, architectural succession within the landscape of Los Angeles and the built form as a kind of cultural layer cake.

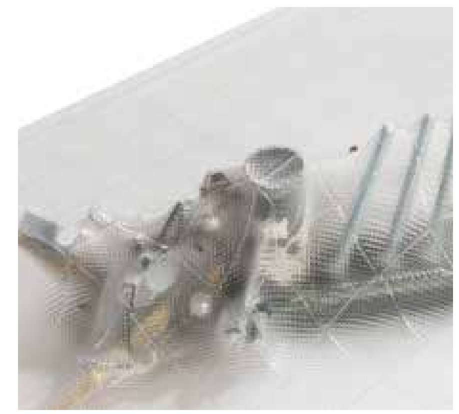
The idea of a deferment of authorship was formulated in response to the architecturally spontaneous nature of Southern California. The fluid forms are a result of a generative algorithm that uses swarming logics to simulate the growth of moss-like blob structures over rigid boxes. The next design driver, architectural succession, is tied to the rather linear nature of Southern California development, from virgin landscapes to resource extraction and finally to a kind of decentralized urbanism in which the land is carved up between numerous areas of dense wealth and sprawling poverty. This issue of the social and economic fragmenting of Los Angeles through architectural means is simultaneously accepted and rejected by the project, which possesses elements both freshly written and half-erased by time.

Third Place Exocarpic Interceptor

Students: Stephen Breaux and Cutler Price, California Polytechnic State University
Faculty Sponsor: Thomas Fowler

The skyline of Detroit was once defined by the endless valleys and peaks of the gables of single-family homes, punctuated by the occasional mid-rise factory or exhaust tower and its endless trail of vapor fading into the sky. Today, this skyline has eroded, the once constant landscape of gables has become sparse, many mid-rises are in mid-collapse and the vapors all but evaporated.

Our project introduces a new industry to revitalize Detroit through hyper-efficient vertical farming towers. The farming tower, whose verticality harkens to the prosperity of a younger Detroit, creates a new industry on a sustainable foundation for future generations to rely upon. Just as the economic viability of the towers impacts the social fabric of the city, the structures interpolate the topography of the site, generating spaces in which community vitality can gather and flourish around the new industry of the city.



Affordable Housing
Students: Alnaim Ahmad and Anas Mahjoob, University of Colorado Denver
Faculty Sponsor: Osman Attmann

The goal of our affordable housing design is to have a building that is able to adjust to social, economic, cultural, political, environmental, ecological and physical changes throughout time, regardless of where it is placed within a city. At the same time, we also want to create some sort of continuity in all aspects of the project—the concept, envelope, structure, materiality and program as well. In this spirit of continuity, steel is woven throughout the project as a folded ribbon of sorts.

The site is in downtown Denver, the main financial, commercial and entertainment district for the city, and is bounded by the 16th Street Mall, the area's primary corridor and an important transit connector for locals and visitors to the region. It is also located next to a light rail station and close to multiple bus stops, thus enhancing accessibility to the site.

Margin
Student: Kengo Kawagashira, Texas A&M University
Faculty Sponsor: Ahmed K. Ali

From ancient times to now, human beings have always found ways to adapt to their immediate environment. No matter the shape of the physical environment, we seek to manipulate the boundaries around us. For example, in Austin, Texas, there are throngs of musicians who play at the "margins" of buildings and engage with the public. The same can be said for those enjoying activities on the river, in the grass and in the parks around town. These people are released from their fixed atmospheres and can enjoy a freeing self-defined life.

These moments should also be found within architecture. In architecture that contains "margins," people would actively help to create their own suitable space. In other words, this is open-ended architecture, with the idea that people have the right to decide the future of their own built environments. This seems to be an extremely necessary form of architecture in the current world, where numerous types of lifestyles and values are coming to the forefront.

This creates a compelling opportunity for affordable housing. In a residential unit that contains only three or four walls, residents could be released from a fixed atmosphere and create a space that works for them. In turn, the total cost of the building would decrease due to the small number of components. Additionally, where the "margin" and "void" meet, there would be great spaces for tenants' hobbies like playing musical instruments, singing, reading books, taking a nap and so on. In this open-ended architecture, people would live in a space of their own margins and populated by the activities they partake in.

Interstitial Fabric
Students: Stephanie Kortman, Kirk Paisley and Alin Codreanu, Lawrence Technological University
Faculty Sponsor: Scott Gerald Shall

Housing as currently constructed is not sustainable. Consider that housing sizes are averaging the largest in history and mortgage costs are reaching 50% of the average income. On top of that, our skilled labor force is limited while building materials and energy are dwindling. In response, the Airscraper proposes an urban architecture that focuses on adaptable multi-generational housing within a parametric steel envelope crafted to enhance the quality of life.

Although Airscrapers can be of value in any setting, the designers chose Pittsburgh as the site for the first version due to mapping of steel manufacturing plants and pollution zones. This approach was combined with an overlap of existing zones of affordable housing to locate the project so as to not reinforce the cycle of poverty.

The formal shape of the building was determined through rigorous wind tests, defining wind eddies that funnel polluted air into exterior and interior air gardens located throughout the structure. The interior air garden housed in the double-skin facade cleans the air of toxins, allowing residents to open their windows to newly fresh air.

Units are crafted to adapt to the ever-changing family makeups and allow aging-in-place in the most efficient footprint at each life phase, thus maximizing the usage of residential program space.

To keep steel manufacturing efficient and cost-effective, we have taken an iterative approach using parametric software to produce a solution with a reduced amount of unique steel shapes. Our diagrid system on the perimeter of the building, coupled with vertical columns inside the core, achieved our goal.

Through adaptability and efficiency, we are able to keep the cost of the base project elements down while investing the remaining available resources back into the occupants.

The Void
Student: Adan Ramos, University of Maryland
Faculty Sponsor: Peter Noonan

An architect cannot create community, but The Void can help cultivate it. Located in Southwest Baltimore on West Baltimore Street, the site is a key piece to the revitalization of the area. Reaching out to the University of Maryland Bio Park and downtown to its northeast and James McHenry Elementary and residential community to its southwest, The Void is at a key intersection in the urban fabric of the city. Using growing, cooking and eating food as a catalyst, The Void seeks to turn vacancy into vibrancy.

The building's public spaces include a courtyard, grand stair, greenhouse, outdoor food vendors, teaching kitchens, restaurants and retail spaces. To facilitate social interaction among residents, access to shared kitchens, balconies, a gym and other common spaces was incorporated.

The facades on this courtyard building use a weathering steel skin on outward-facing elevations and expose steel framing on inward-facing elevations to represent a need to look past the facade of the neighborhood and find the community within. Through this articulation and the theme of growth, The Void represents the intangible human potential of Baltimore.

The large retail acts as a "food lab" featuring a greenhouse, teaching kitchens and food stands. This was inspired by the food desert designation of the site as well as its proximity to an elementary school and a higher education science facility.

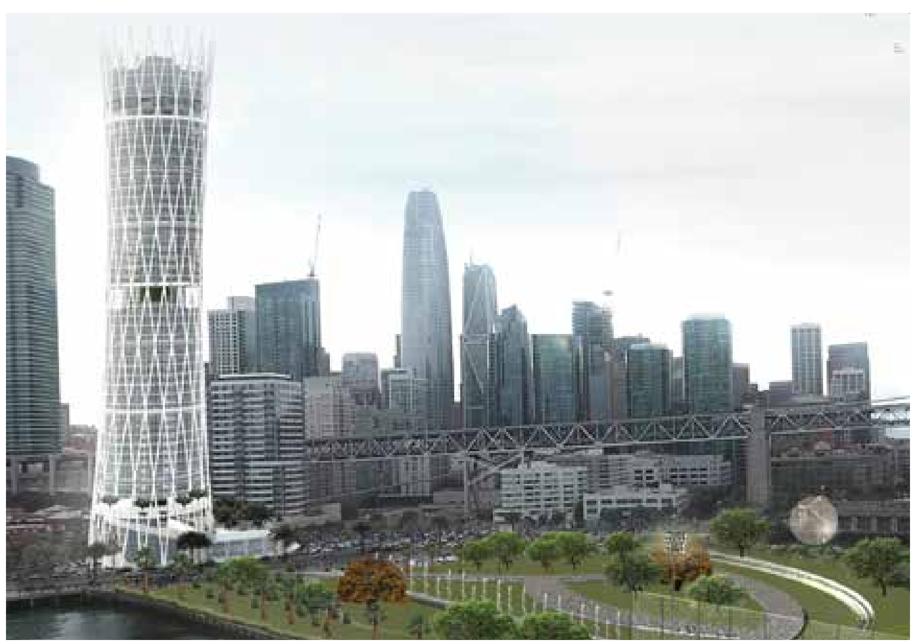
Additionally, the residential program features shared kitchens on each floor, allowing for the kitchens in the units to be slightly smaller and providing social opportunities. Lastly, the second-floor outdoor public space doubles the amount of storefront area for the retail program while allowing light to enter the center of the retail space on the first floor. These three program augmentations help to cultivate community in this disinvested Baltimore neighborhood.

HONORABLE MENTION: CATEGORY I – AFFORDABLE HOUSING

118 Main Street Revival
Student: Shane Powers, Virginia Tech
Faculty Sponsor: Heinrich Schnoedt

There exists an opportunity to introduce a new architecture to the downtown community in order to support Blacksburg, Virginia's estimated growth of 5,000 Virginia Tech students by 2020. What currently exists as a mostly vacant city block hosting the local U.S. Postal Service is to be repurposed as a residential mid-rise tower and commercial/retail center, though the post office shell must be retained for historic preservation purposes.

Morphologically driven by infill constraints of structures and easements within proximity, the building footprint is sensitive both to its low-lying neighbors and adjacent streetscapes. Typologically, the building is a series of cantilevered floor plates synchronized around a collection of rigid "outdoor" circulation cores. Steel and masonry are the primary building materials, though the brickwork is predominantly a tribute to the existing downtown vernacular. Heavy emphasis was placed on revealing the building's structure and program rather than concealing it, as well as on the architecture's ability to connect people to each other and the outdoors.



The Sheath
Students: Ariel Adhidevara and Saul Serrano, Diablo Valley College
Faculty Sponsor: Daniel Abbott

This is a tower whose modus operandi is layering. The structure's living, circulation and public spaces are all components of this concept. Within the structural layers, the tower employs a double-diagrid that eliminates the function of the concrete core. By doing so, we open up space for a vertical atrium.

The project is a residential tower with 22 micro-units, 19 medium-size units and five luxury units. Between these various programs are sky lobbies. The tower also includes a base with a lobby, retail space and a public roof garden/atrium to enjoy the city.

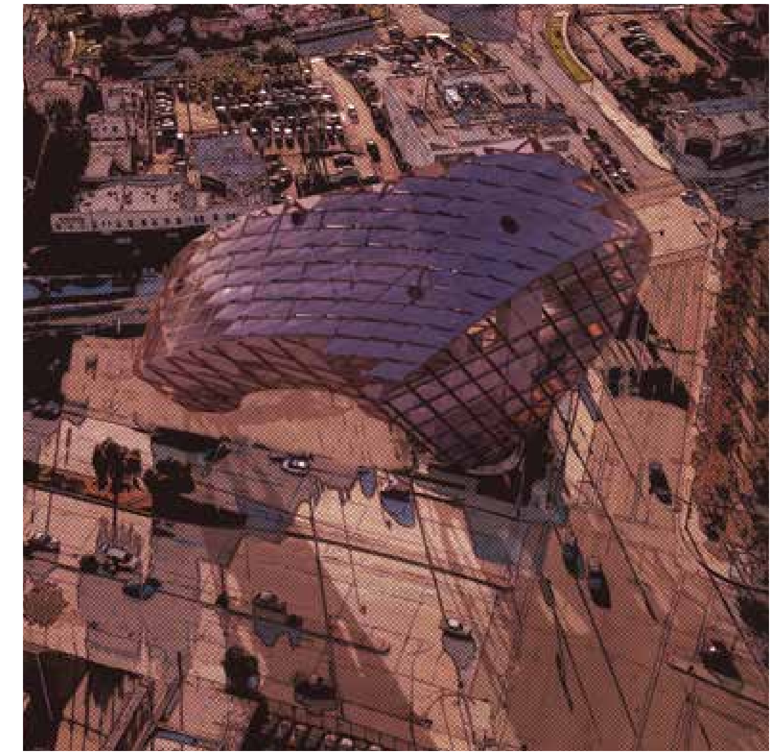
HONORABLE MENTION: CATEGORY II – OPEN

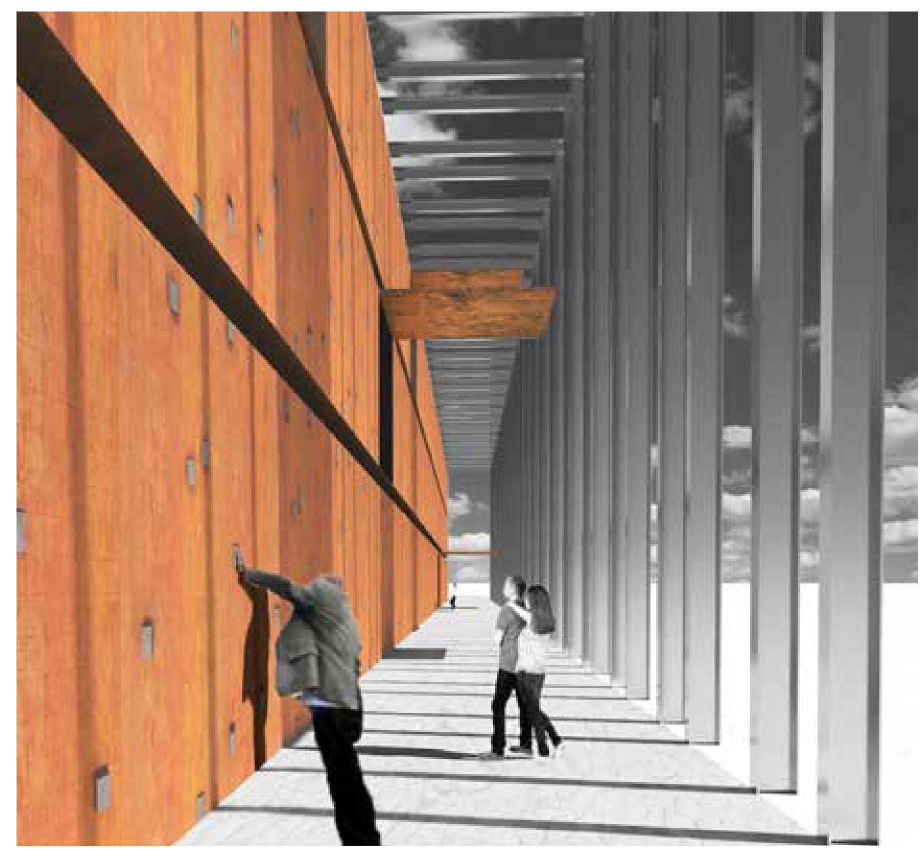
The Silhouette: Kara Walker's Art Museum
Students: Jesse Gomez and Hanshi Li, Woodbury University
Faculty Sponsor: Duane McLemore

The steel structure for the Silhouette is orientated around the skin, according to the same solar angle that creates its form. The steel tubes have multiple functions, including acting as light tubes, forming the main structure and facilitating escalator travel through the building. And twice a year, the light tubes are in perfect align with the sun and cast a spotlight in the center of the shadows. In addition to these light tubes, a steel grid on the skin of the building also acts as the structural system. The project is a cultural response to the neighborhood, introducing Kara Walker as the main artist.

The ground level conveys the overall spatial requirements of the building, site and strategy for how people enter the building. The fourth level is where the program is broken down into each individual space, but also allows for public and private circulation.

The project acts as a giant showcase in the middle of a park, where it will attract visitors and welcome them to the neighborhood. Not only does it interact with the park, but it also and acts as an extension of it since the entire ground level and sunken sculpture garden are essentially woven into it.





Storing Memories
Student: John Harlan, University of Illinois, Urbana-Champaign
Faculty Sponsor: Erik M. Hemingway

Taking advantage of the rise in the self-storage industry, Storing Memories is a U.S. infrastructure project designed for the American Southwest. Rather than sprawling across the horizontal ground plane, this storage center is a three-level steel wall that has the capacity for expansion. A single storage unit is an 18-ft by 18-ft by 18-ft weathering steel module. Each module is connected to a rigid frame and can be rented out to the public. Weathering steel was selected for its capacity to express the passage of time while ensuring the security of the modules' contents. The Storage Wall can be expanded infinitely as geography allows. In Storing Memories, the public can invest in the future.

HONORABLE MENTION: CATEGORY II – OPEN

The Coney Express

Students: Dana Cameron and Zhi Mankin, California Polytechnic State University
Faculty Sponsor: Thomas Fowler, IV

Passengers of the Coney Express can travel from station to station, enjoying exciting features and events that are unique to each one. This fosters a sense of community identity and pride while simultaneously inviting non-local residents to engage in events across Detroit.

While the system's humongous, steel-framed and ETFE-clad buses house eclectic programs from speakeasies, restaurants, crop storage facilities and more, the immobile parts of the system aim to provide a supportive "docking" space for these programs.

The bus stations will be strategically placed on vacant lots around Detroit, addressing the city's issue of urban blight. By locating the stations in areas with increased property abandonment, we will create a network of community strongholds and begin to repair Detroit's urban fabric. In Hamtramck specifically, we aim to attract citizens to the bus station to promote the area's blooming multicultural integration and introduce people to its preciously odd offering of eateries, shops and traditions.

Imagine walking into Hamtramck's Coney Express station with the intent of jumping on a bus to go across town. You take the escalator from the front, lifting you into the main floor. You are immediately drawn to the kiosk for tickets, but you find there is an anathema of wild activity happening all around you in this greater, open space. You can see three buses stationed on their hydraulic jacks. One of them is blasting homemade funk music and spilling neon lights from its rear. One worker allows travelers to board the bus, and then slaps the door affectionately as the bus lowers itself through the void in the floor and rolls away, resolutely on its way to the next station. You turn around to see the restaurant bus, which looks like it's being rented by the local sausage factory for a promotion; chefs, kids, workers and gardeners all pour out with delicious samples of Hamtramck sausages. From the roof above, a troublemaking kid on a field trip drops an onion through the elevator shaft and it lands next to you with a thud. You glance up to wave your fist but are instead shocked by the realization that there is an expanse of urban farming plots up there! You've always been curious about how to grow your own food, so you push the button on the sausage bus and board, waiting eagerly for the bus to ascend.

These buses and their stations use a double-layered ETFE pillow cladding system, which invites diffused light into the spaces while adding an insulation zone between the inside and the harsh winter environment. On pleasant days, voids in the roof and second floor created by the bus elevator cores may be kept open for stack ventilation and flush-cooling.

The structural nature of the Coney Express is based on local industrial steel vernacular but adds a secondary cladding system holding the diamond-gridded pillows of ETFE in place. We further celebrate the industrial motif with exposed castellated beams supporting the double-story roof space and custom-built hydraulic jacks that elevate the buses.

Dynamic Force on Context Student: Guanzhou Ji, University of Washington Faculty Sponsor: Wyn Bielaska

Our project, Glass School, is located in the Uptown area of Seattle. The school will feature a large working hot shop with an audience chamber and will employ a huge chimney for the shop's ventilation. It will also accommodate cold-working shops and a large mock-up space for large-scale projects. It will include two galleries, a black box and a natural light-filled space, as well as back-of-house areas at each gallery for assembly and repairs. There will be six studio apartments for the visiting artists and their teams. An outdoor space for glass casting and display will serve as a third gallery space. Retail space and a small café will complete the facility.

Diagonal lines define the spaces, including the chimney, which reaches out as a landmark to convey the image of a gateway or anchor rather than being hidden inside the building. The design incorporates a steel truss as the main support frame to create the open and flexible interior space and also displays the building's materiality on the facades. ■

PUBLICATIONS

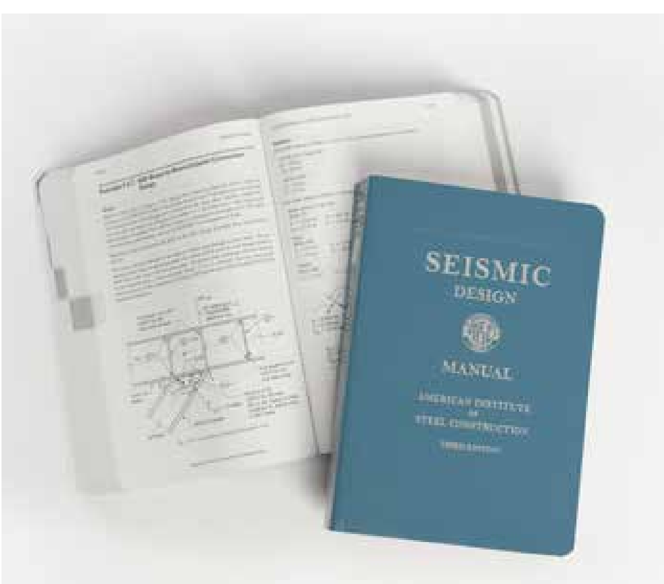
AISC Releases New Edition of *Seismic Design Manual*

Designers and fabricators can now access the most comprehensive information for performance-based seismic design with the 3rd Edition AISC *Seismic Design Manual*, now available at **www.aisc.org/publications**. This new edition of the manual has been expanded with additional information and design aids to help engineers navigate the design of steel and composite seismic resisting systems (SFRS). It includes discussion and practical guidance on applying the latest versions of AISC's core standards—the 2016 *Specification for Structural Steel Buildings* (ANSI/AISC 360), 2016 *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341), 2016 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications* (ANSI/AISC 358) and the 15th Edition *Steel Construction Manual*. Produced as a high-quality, vinyl softcover, the new edition is now available at a new, lower price of $100 for members and $200 for non-members.

"The new AISC Seismic *Design Manual* provides engineers with useful tools, detailed examples and extensive explanation to facilitate the design of structures complying with the AISC 341 *Seismic Provisions*," explained Rafael Sabelli, chair of the AISC seismic manual subcommittee and director of seismic design at Walter P Moore. "AISC brought together a team of dedicated volunteers, including experts in structural and connection design and developers of the seismic provisions, to develop this manual and ensure its utility for practicing engineers."

The new edition contains more than 60 examples that demonstrate how to design the key members and connections for the most commonly used SFRS. The examples go beyond just seismic-specific checks to also demonstrate the full design, limit state by limit state. The manual is a valuable resource not only for those who design in the seismic world, but for anyone interested in learning the procedures used for designing members, connections and systems.

"One of the goals of the AISC *Seismic Design Manual* is to be a valuable resource for all building design engineers, including those who infrequently do seismic design," noted Mark Holland, chairman of the AISC committee on manuals and chief engineer at Paxton and Vierling Steel Co. "Users will find it well organized, complete, accurate and a very useful tool."



Some of the major updates in the new edition include:

- Part 1 now includes a sample set of plan and detail drawings showing how the designer can indicate the seismic force-resisting system to the steel fabricator and erector. The tables in this part also incorporate the latest in larger rolled steel shapes and high-strength steel grades as they are permitted in various seismic applications.
- Design examples have been developed in Part 4 for special moment frame (SMF) systems to reflect updates to the *Seismic Provisions*. These examples provide guidance for bracing a beam in a moment frame, designing a bolted flange plate connection and designing a special truss moment frame system.
- The new design examples in Part 5 address multi-tiered ordinary concentric braced frames and connection design for buckling-restrained braced frames. The *Seismic Provisions* updates to ordinary and special composite shear wall systems are reflected in Part 7.
- Part 9 of the manual contains the *Seismic Provisions* and *Prequalified Connections*. These standards represent the latest innovations in engineering research, design and construction of steel buildings in seismic regions. In the 2016 *Seismic Provisions*, the inclusion of provisions for multi-tiered braced frames addresses a common seismic system for single-story and multi-story industrial building structures. Allowing the use of partial-joint-penetration (PJP) groove welds in the column splices of SMFs reduces the efforts of both fabrication and erection during construction of these seismic systems. Further clarifications in the requirements for continuity plates and web doubler plates in SMF panel zones reduce material congestion and minimize the cost of this reinforcement where it is required.

"This is a resource that all design engineers should have on their desk," added Cynthia Duncan, AISC director of engineering. "There is a chapter on $R = 3$ systems, as well as coverage of most types of steel seismic-force resisting systems included in the *Seismic Provisions*. There are more than 800 pages of comprehensive design examples demonstrating how to apply the provisions to the various systems from analysis to member and connection design."

The 2016 *Seismic Provisions* and *Prequalified Connections* documents, along with all other AISC standards, are available for free download at **www.aisc.org/specifications**.

Furthermore, designers can visit the technical resources page that is specific to seismic applications at **www.aisc.org/technical-resources/seismic**. A number of other useful resources that supplement the use of the *Seismic Design Manual* and the *Steel Construction Manual* are available at **www.aisc.org/publications**. AISC also posts archival NASCC conference proceedings, many of which are on the topic of seismic design, at **www.aisc.org/educationarchives**.

news

People and Companies

- **DeSimone Consulting Engineers** has opened a new office in Houston. The expansion will position the firm to better serve both existing clients and an expanding portfolio of clients in Texas and the Southwest. In other DeSimone news, **Luis Ramirez** has been promoted to principal and **Michael Schwarz** has been promoted to senior associate, both in the firm's structural design practice.
- Earlier this year, the **SmithGroup Equity, Diversity and Inclusion (EDI) Scholarship Program** was established to support and mentor students from historically underrepresented demographics in the disciplines of architecture, interior design, planning, landscape architecture and engineering. The program's mission is to provide these students with the opportunity to attain their professional goals while advancing the AEC industry and improving the built environment. The scholarship winners were selected from a pool of candidates who spent their summers as interns in SmithGroup offices around the United States. Each winner will receive a one-time award of $6,000 to offset their tuition costs. The engineering and architecture scholarship recipients are as follows:

  Lorena De Almeida is a senior at Calvin College working towards a BS in engineering, with a civil and environmental concentration. She will graduate in May 2019. Lorena spent her summer at SmithGroup's Madison office.

  Qudus Lawal is a senior at the University of Illinois at Chicago and intends to graduate in December with a BS in civil engineering. Qudus interned in the Chicago office.

  Everritt Phillips is a senior at the University of Michigan and will earn his BS in architecture in May 2019. Everritt served as an intern in SmithGroup's Detroit office.

MEMBERSHIP

AISC Board Approves New Full Members

Akins Manufacturing, LLC	Albuquerque, N.M.
Apex Metal Fabricating and Machine Co.	Toledo, Ohio
Clark Industrial, Inc.	Missoula, Mont.
E & Y General Construction Group Corp.	Staten Island, N.Y.
General Foundries, Inc.	North Brunswick, N.J.
Hambric Steel and Fabricators, Inc.	Albany, Ga.
KMA Steel, LLC	Albia, Iowa
Madlyn Metal Fab, LLC dba JT Metal Fab	Vancouver, Wash.
Mageba USA, LLC	Pottstown, Pa.
McAlister Welding and Fabricating, Inc.	Glassboro, N.J.
Mesa Fab Inc.	Pueblo, Colo.
Mike's Precision Welding, Inc.	Temecula, Calif.
Modern Shade, LLC	Austin, Texas
RJ Russo, LLC	Phoenix, Ariz.
Simpson Strong-Tie Co., Inc.	Riverside, Calif.
Southern Steel Fabricators, Inc.	Monroe, La.
Staley Steel, LLC	Pilot Point, Texas
Tuscarora Rigging, Inc.	Huntingdon, Pa.
Valley Mechanical, Inc.	Rossville, Ga.

news

UNIVERSITIES

University of Illinois Engineers Without Borders Chapter to Build Bridge in Malawi

The University of Illinois Urbana-Champaign student chapter of Engineers Without Borders, a nonprofit that designs infrastructures across the world in disenfranchised communities, is currently working on a project in Malawi.

UIUC's project began in 2014 with the goal of becoming the chapter's first structural project. The group is designing a footbridge over the Lunzu River in Chilaweni, Malawi, to allow community members to safely travel to and from their community.

Over the past four years, the student chapters have spent time surveying Malawi, collecting data and meeting with the community to decide which area most needed their design expertise. The team is now ready to design a steel footbridge, with plans to erect it next summer.

The chapter is looking for a variety of sponsors to raise the remaining $37,000 of its $40,000 construction budget. ARCO/Murray, Baldridge and Associates Structural Engineering, Inc., and W.E. O'Neil Construction have already donated. The team is also looking for more engineers to volunteer at least an hour a week to work with the students on the design. If you're interested in sponsoring or volunteering, contact **ewb.uiuc.malawi@gmail.com**.

CONSTRUCTION MARKET

SEAA Endorses Policies to Restore America's Workforce Development System

The Steel Erectors Association of America (SEAA) recently joined other industry stakeholders in publicly supporting seven policy recommendations to make the United States the world leader in workforce development.

Developed from the research report *Restoring the Dignity of Work: Transforming the U.S. Workforce Development System into a World Leader*, the seven policies are:

1. Establish and strengthen awareness of U.S. career opportunities.
2. Revitalize our work-based learning programs.
3. Measure performance and involvement in workforce development when awarding construction contracts.
4. Redefine how we measure the quality of our nation's secondary education system.
5. Increase participation of underrepresented groups in career and technical education through career and college readiness.
6. Establish and expand collaboration between industry, education and government.
7. Develop more balanced funding among post-secondary, technical and higher education.

The report can be viewed at **www.nccer.org**.

AISC

AISC Unveils New Tagline and Membership Logos

For more than a decade, AISC has proudly proclaimed, "There's Always a Solution in Steel!" Recently, AISC introduced a new tagline: "Smarter. Stronger. Steel." At the same time, the organization has rolled out a new, cleaner look to its printed materials, including modernized, simplified versions of AISC logos for full, associate and professional members. AISC has a long, committed history of service to the structural steel industry, and the new tagline and logos build upon this foundation to focus and strengthen AISC's and its members' communications with the industry.

AISC members can access the logos at **www.aisc.org/membership** under Member Resources and are encouraged to use them for their marketing and communications materials.

advertiser index

marketplace & employment

STEEL REIGNS SUPREME

THIS YEAR'S STEELDAY (the tenth one!) was manifested in several events across the country on Friday, September 28—from job site visits to shop tours to webinars and more. One such event was put on by AISC member and certified fabricator Supreme Steel, which hosted around 100 visitors at its shop in Portland, Ore. While the tour provided an overall look at the facility, its equipment and the various steps in the steel fabrication process, the highlight was the opportunity to see the revolutionary SpeedCore system (shown above) being fabricated for its first-ever use in a project, the 850-ft-tall Rainier Square tower in Seattle. The innovative system uses two steel plates connected by steel spacing ties, with the cavity between the plates filled with high-strength concrete. It provides the potential to shave months off the construction schedule—and significantly reduces costs—when compared to a traditional concrete core system.

*For more on the system and project, see "Core Solution" in the February 2018 issue, available at **www.modernsteel.com**. And to see photos from SteelDay, visit AISC's Facebook page at **www.facebook.com/AISCdotORG** and look for the SteelDay 2018 photo album. We'll also post a gallery of images at **www.modernsteel.com**.*