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December 2021

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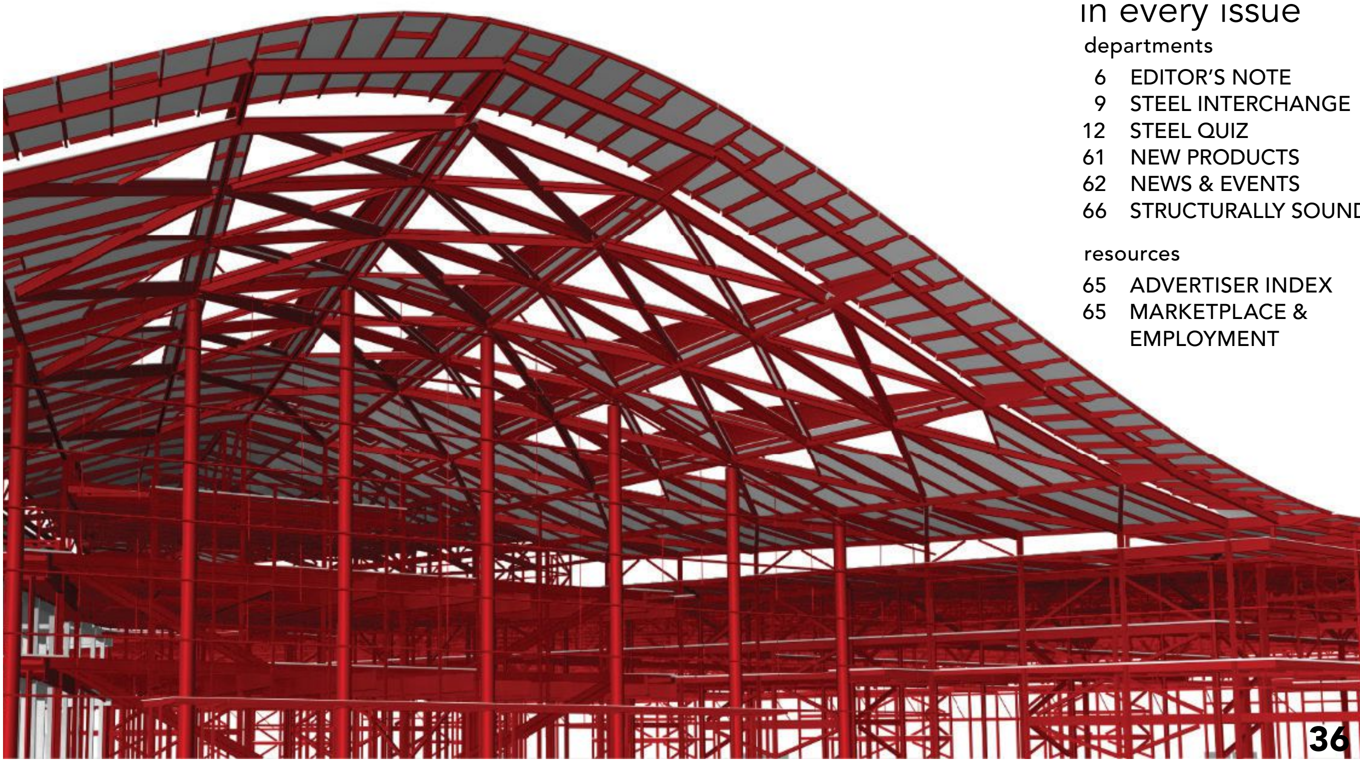

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ON THE COVER: A cool canopy covers an open market on the St. Petersburg, Fla., waterfront, p. 42. (Photo: WJ Architects)

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editor's note

The day before Halloween, I took my 11-year-old son to Six Flags Great America for the first time. He'd been bugging me about it for a while, season passes were cheap, and the weather forecast looked favorable, so why not?

He'd been to plenty of amusement/theme parks in the past but had never ridden a roller-coaster before (to clarify, he'd never ridden a *real* roller-coaster before—i.e., nothing with a major drop and nothing that goes upside-down). We went on several that day, and he loved them all. It was a sea change for him, a leveling up of sorts because they were taller and faster than any ride he'd braved in the past. He was happy, I was proud, we ate over-priced cotton candy. We wandered by several rides that were even more daunting, but he said he'd save those for next time. Fine by me. The lines were insane.

The previous week, I witnessed a different type of sea change—this one in the construction world—in the form of an under-construction project in San Jose, Calif.: 200 Park. What's next-level about it? Its core system. The building is the first in California and only the second one anywhere (the first is Rainier Square in Seattle) to implement a concrete-filled composite plate shear wall core system, better known as SpeedCore. When completed, the 19-story building (not including the penthouse and one below-grade level that also uses SpeedCore), designed by Gensler and Magnusson Klemencic Associates, will be framed with 10,000 tons of structural steel, fabricated and erected by AISC member Schuff Steel.

When first laying eyes on the system, the visual effect was almost confusing, given that most of us are accustomed to seeing concrete elevator cores with steel beams extending outward. The effect with 200 Park (which has two elevator cores) was more like looking at a "matching set" with the steel beams framing into, well, more steel. Another thing that became quickly apparent, especially on the upper floors where the core wall panels had yet to be filled with concrete, was the incorporation of circular holes in the plate, spaced every few feet, for the concrete to be pumped in, along with much smaller vent holes to relieve steam pressure in the event of a fire.

The building had been decked through the 11th floor—with the core erected up to the 13th floor—when we visited. Steel erection began in July and is expected to top out this month. The estimated time savings using SpeedCore instead of a traditional concrete core for this particular project? Three months. An entire season.

If you want to learn more about SpeedCore, check out the March, May, and November 2021 issues (in the Archives section at **www.modernsteel.com**) for a series of technical articles on the system. You can also attend the sessions "Erection Engineering in Support of a SpeedCore Tower Project in California" and "SpeedCore Design Guide: It's Finally Here!" at NASCC: The Steel Conference, taking place March 23–25, 2022, in Denver (visit **aisc.org/nascc** for more information about the conference and to register).

Speaking of the SpeedCore Design Guide (number 37 in the AISC catalog), it's expected to be available to the public in time for the conference. You can also visit **aisc.org/speedcore** for more details on the system, as well as **aisc.org/needforspeed** for information on AISC's Need for Speed initiative, whose stated goal is to increase the speed at which a steel project (either a building or a bridge) can be designed, fabricated, and erected by 50% by the end of 2025. Systems like SpeedCore are helping to make it happen. (I just hope the roller-coaster industry doesn't have a similar goal. I think they're fast enough as they are.)

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

steel interchange

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

Historic Steel and Available Strength

I am working on a circa 1911 public school that is being transformed into another use. I cannot find a reference that offers an allowable tensile value to evaluate the chord forces. I have looked through AISC Design Guide 15: *Rehabilitation and Retrofit* but did not find an answer there. Can you recommend an appropriate allowable tension to use for this steel—e.g., for example, 0.5 × Tensile Strength?

I assume your reference to "0.5 × Tensile Strength" is based on similar language in AISC Design Guide 15. The intended use of this language in the design guide is not to define an "appropriate allowable" tensile stress but rather to define what we would refer to as the nominal yield stress today. Table 4-1a in the publication suggests that for buildings in 1911, the steel likely conformed to ASTM A9 with a tensile strength of 55/65 ksi and "nominal" yield stress of 0.5(55) = 27.5 ksi, which is a pretty low stress for steel. But I think it is what would probably be assumed by most engineers.

With F_y and F_u established, it is recommended to apply the current provisions to the design to the extent this is possible. Appendix 5 of the AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360) addresses the evaluation of existing structures, and Section 5.3.4 provides requirements for strength evaluation. This section states: "The available strength of members and connections shall be determined from applicable provisions of Chapters B through K of this *Specification*."

Table 4-1a. Historical Summary of ASTM Specifications for Structural Shapes and Plates

Date	Specification	Material	Yield Point,† ksi	Tensile Strength,† ksi
1900	A7 for bridges	Rivet steel	30	50/60
		Soft steel	32	52/62
		Medium steel	35	60/70
	A9 for buildings	Rivet steel	30	50/60
		Medium steel	35	60/70
1901–1904	A7 for bridges	Rivet steel	½ Tensile str.	50/60
		Soft steel	½ Tensile str.	52/62
		Medium steel	½ Tensile str.	60/70
	A9 for buildings	Rivet steel	½ Tensile str.	50/60
		Medium steel	½ Tensile str.	60/70
1905–1908	A7 for bridges	Structural steel	Record value	60 desired
		Rivet steel	Record value	50 desired
		Steel castings	½ Tensile str.	65
	A9 for buildings	Rivet steel	½ Tensile str.	50/60
		Medium steel	½ Tensile str.	60/70
1909–1913	A7 for bridges	Structural steel	Record value	60 desired
		Rivet steel	Record value	50 desired
		Steel castings*	½ Tensile str.	65
		*Deleted 1913		
	A9 for buildings	Structural steel	½ Tensile str.	55/65
		Rivet steel	½ Tensile str.	48/58

The commentary to this section states: "Resistance and safety factors reflect variations in determining the strength of members and connections, such as uncertainty in theory and variations in material properties and dimensions. If an investigation of an existing structure indicates that there are variations in material properties or dimensions significantly greater than those anticipated in new construction, the engineer of record should consider the use of more conservative values."

How would the 2016 AISC *Specification* compare to what was likely done at the time? Well, a lot has happened in the last 100-plus years, so there would undoubtedly be differences, but let's just consider the bending strength of a fully braced member.

Per the 2016 AISC *Specification:*

Ω_b = 1.67,

So F_y/Ω_b = 27.5/1.67 = 16.5 ksi

Per the 1923 AISC *Specification:*

The allowable stress was given as 18,000 psi.

This would equate to a Ω_b of 27.5/18 = 1.52.

However, back in 1923, engineers would have been using S_x, not Z_x. The ratio of Z_x/S_x for rolled wide-flange shapes varies, but it is around 1.10-1.12. If we assume 1.1, we get 1.52 (1.1) = 1.68, which is pretty close to the 1.67 safety factor we have today.

In the end, the allowable tension (available strength) would not be "0.5 × Tensile Strength." It would be closer to 0.5/1.67 × Tensile Strength or 0.3 × Tensile Strength—relative to yield.

Back in 1923, the same stress would have been assumed on the net section relative to rupture. This is not recommended when evaluating a structure today. As stated in Section 5.3.4, the available strength would be determined from the applicable provisions of Chapters B through K of a more current AISC *Specification*, which would be one that is required per the authority having jurisdiction.

If you have not established the material properties of the existing material, the requirements for doing so are in Section 5.2 of the AISC *Specification*.

Specification Section 5.2 states: "The EOR shall determine the specific tests that are required from Sections 5.2.2 through 5.2.6 and specify the locations where they are required. Where available, the use of applicable project records is permitted to reduce or eliminate the need for testing."

Section 5.2.2 states: "Where available, certified material test reports or certified reports of tests made by the fabricator or a testing laboratory in accordance with ASTM A6/A6M or A568/A568M, as applicable, is permitted for this purpose. Otherwise, tensile tests shall be conducted in accordance with ASTM A370 from samples taken from components of the structure."

Larry Muir is a consultant to AISC.

And the commentary states: "The number of tests required will depend on whether they are conducted to merely confirm the strength of a known material or to establish the strength of some other material."

If you are very confident that you know what steel was used in the structure, then it's likely that few tests would be required as all you are doing is confirming what you already (presumably) know to be true. Once the grade is known with some certainty, the structure can be checked using the *Specification* described above.

Larry Muir, PE

HSS Y-Connection Weld Design

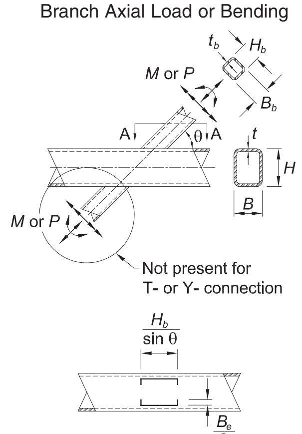
I am designing a hollow structural section (HSS Y-connection with a branch subjected to axial loading. The angle of the branch is less than 60°. I want to make sure that I interpret the provisions in AISC *Specification* Table K5 correctly. Assuming the branch wall will not fail, is it possible to use an actual weld length equal to only the effective length shown in the table? Or is an all-around weld required, and the table shows how much of that weld is effective?

Placing a weld length that is only equal to the effective weld length shown in Table K5.1 would not be correct. The effective lengths are derived from tests, and the tests involved connections for which "a constant weld size around the full perimeter of the HSS branch" was provided.

It may be possible to achieve the required strength using less than "a constant weld size around the full perimeter of the HSS branch," but this is not addressed in the *Specification*. In other words, if you need/want to do this, you will have to rely on your knowledge, experience, and judgment. It would seem that the required length of a partially welded condition would be greater than the effective length derived from tests in which "a constant weld size around the full perimeter of the HSS branch" was provided.

If you are going to use the provisions in Table K5.1, you have to satisfy the assumptions upon which they are based and provide "a constant weld size around the full perimeter of the HSS branch."

TABLE K5.1
Effective Weld Properties for Connections to Rectangular HSS

Connection Type	Weld Properties
T-, Y- and Cross-Connections under Branch Axial Load or Bending  Section A-A: Effective weld	Effective Weld Properties $l_e = \frac{2H_b}{\sin\theta} + 2B_e$ (K5-5) $S_{ip} = \frac{t_w}{3}\left(\frac{H_b}{\sin\theta}\right)^2 + t_w B_e\left(\frac{H_b}{\sin\theta}\right)$ (K5-6) $S_{op} = t_w\left(\frac{H_b}{\sin\theta}\right)B_b + \frac{t_w}{3}\left(B_b^2\right) - \frac{(t_w/3)(B_b - B_e)^3}{B_b}$ (K5-7) When $\beta > 0.85$ or $\theta > 50°$, $B_e/2$ shall not exceed $B_b/4$.

This is an excerpt from Table K5.1. The complete table can be found in the AISC *Specification*.

Larry Muir, PE

steel quiz

This month's Steel Quiz looks at building information modeling (BIM) and virtual design and construction (VDC).

The answers can be found in the AISC publication *BIM & VDC for Structural Steel*, available at **aisc.org/bim**.

The questions and answers were developed by Maysaloon Abugrain, an AISC intern who recently received her master's degree in structural engineering from Oregon State University. (Thanks, Maysaloon!)

1 BIM is most successful when the software is implemented by which of the following management levels?
a. Upper management (top-down)
b. Employees (bottom-up)
c. Mid-level
d. Both b and c

2 **True or False:** A challenge that arises with interoperability is transferring data from the design phase to the fabrication phase.

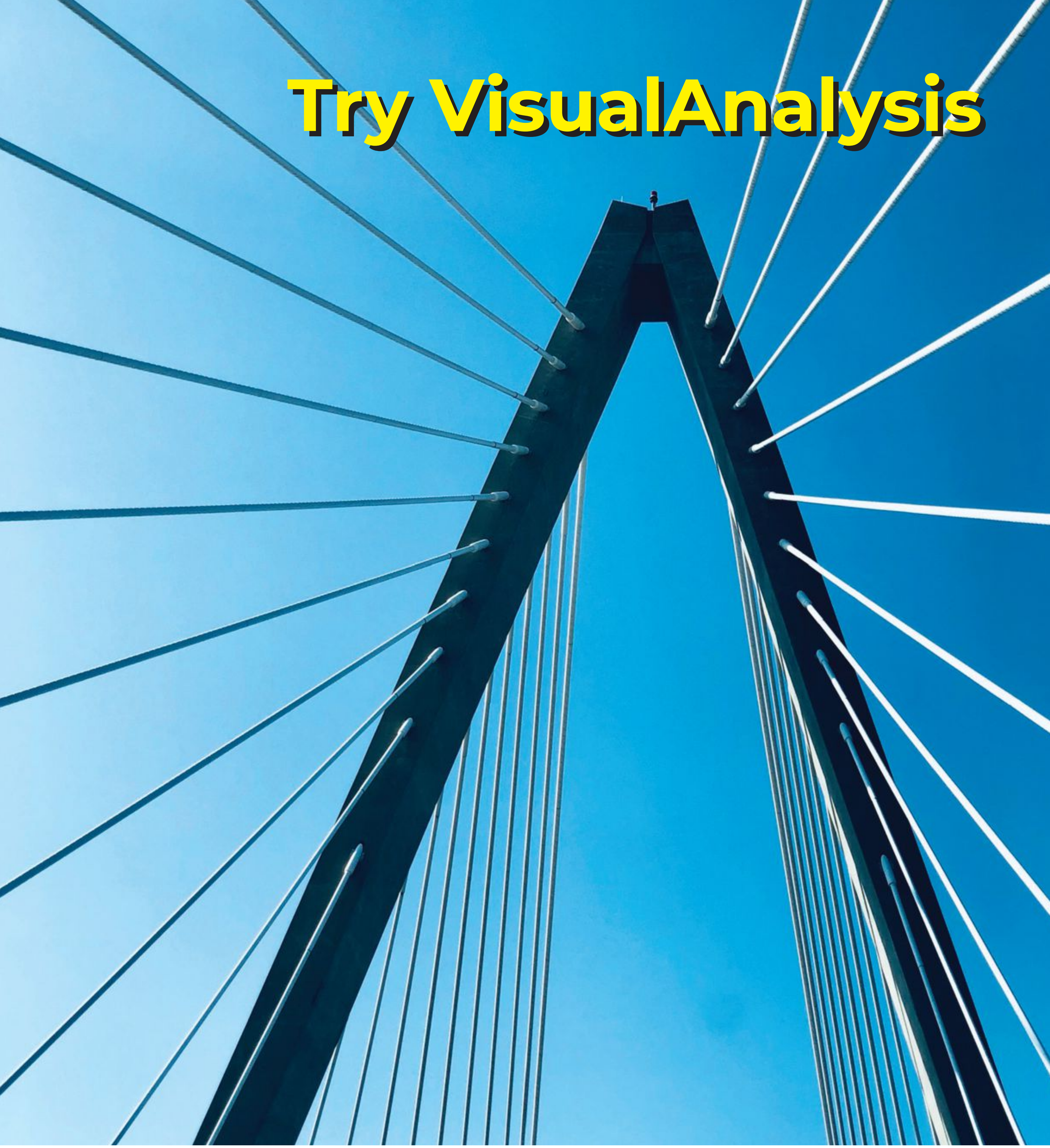
3 Which of the following software packages is used for a structural analysis-type model?
a. ArchiCAD
b. RISA
c. Solibri
d. Trimble Connect

4 Which of the following level of development (LOD) categories relates to the field verification and is not indicative of progression to a higher level of geometry information?
a. LOD 300
b. LOD 350
c. LOD 400
d. LOD 500

5 According to AGC BIM 101 guide, there are four methods of implementing a BIM execution plan (BEP). Which of the following methods is used by individual employees who want to familiarize themselves with new tools?
a. Top-down
b. Bottom-up
c. Parallel
d. Organic

6 Which of the following file formats is designed to support a wide range of construction model views?
a. DWG
b. EM11
c. IFC 2×3, IFC4, IFCXML
d. KISS

TURN TO PAGE 14 FOR THE ANSWERS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steel quiz ANSWERS

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

1 **a.** Top-down. In general, BIM is most successful when it's being driven by and comes with full buy-in from management. It is, however, not unheard of for the BIM adoption process to originate in mid or lower-level management. Successful BIM implementation typically requires careful planning, scheduling, and purchasing, which is why top-down BIM is generally regarded as having a better opportunity to succeed. (See page 6 of *BIM & VDC for Structural Steel*.)

2 **True.** One of the challenges of interoperability is the transfer of data from the design or development phase of the process to the construction or fabrication phase. In situations where the design is communicated through a 3D model, expect to spend a significant amount of effort adding the fabrication information. Design models will typically contain only primary members, requiring a professional steel detailer to input items such as connections, stairs, rails, lintels, and pour stops. It is important that the design team can effectively communicate the information required for these secondary and miscellaneous items when traditional 2D contract drawings are not being used. (See page 9.)

3 **b.** RISA. Other programs, such as ETABS, Robot, SCIA, RAM, Tekla Structural Designer, can also be used. Structural engineers build several analytical models for different building components (lateral, gravity, etc.), which may be created before a documentation model. (See page 10.)

4 **d.** The *LOD Specification* is organized by CSI Uniformat 2010, with the subclasses expanded to Level 4 (and in a few cases to Level 5) to provide detail and clarity to the element definitions. The *LOD Specification* addresses only LOD 100 through LOD 400 of the AIA's LOD Schema, along with a new level—LOD 350—which was added between LOD 300 and LOD 400 to better address the information levels required for effective trade coordination. The *LOD Specification* does not address LOD 500 since that LOD relates to field verification and is not an indication of progression to a higher level of geometry or information. (See page 12.)

5 **b.** Bottom-up: Individual employees who want to learn the new tools start the process of implementing BIM within the organization. This action frequently takes place with little or no management support. (See page 15.)

6 **c.** IFC 2×3, IFC4, IFCXML. IFC (industry foundation class) is a neutral file type that supports a wide range of construction model views. IFC formerly offered little depth for steel beyond geometry but has since been expanded to include steel fabrication information. (See page 17.)

steelwise

NAVIGATING THE NEW AWS WELDING CODE

BY TRISH FLISS AND CHUCK SCHROEDER

The latest version of the AWS steel welding code features several enhancements, starting with improved navigation.

Trish Fliss (**tafliss@aws.org**) is the American Welding Society's content manager, and **Chuck Schroeder** (**chucks@imipr.com**) is the owner of Insight Marketing. AWS Staff worked closely with members of the AWS D1 Committee on Structural Welding on this article, including: **Mike Gase**, corporate quality director for Midwest Steel, Inc., and Chair of AISC Task Committee 12 on Quality; **Tom Schlafly**, AISC's chief of engineering staff and former Chair of the AWS D1Q Subcommittee on Steel; **Phil Torchio**, current Chair of AWS D1Q; **Duane K. Miller**, manager of engineering services and welding design consultant with Lincoln Electric and former Chair of AWS D1; and **Robert E. Shaw, Jr.**, president of the Steel Structures Technology Center and Chair of AWS D1L: Seismic.

THE AMERICAN WELDING SOCIETY (AWS) D1.1/D1.1M:2020 *Structural Welding Code–Steel* was first published in 1928—and of course has seen numerous updates in its 90-plus years of existence.

With each new version, the D1 Committee on Structural Welding considers evidence of the need for changes and updates to keep current with technology, and the code is now updated on a five-year cycle. Here, we'll explore some substantive updates and changes between the latest version, 2020, and the previous (2015) version.

Navigation Conventions

Improved navigation is one of the more apparent and overarching changes. The 2020 version displays improved organizational consistency relative to previous versions so that, moving forward, users can follow common navigation conventions. No matter which AWS D1 code users pick up, having a similar sequence of clauses will enable them to find the desired subject without a struggle.

To achieve this goal, essential information has been moved to the front of the code from annexes at the back. The listing of Normative References now resides in Clause 2, and "Terms and Definitions" are in Clause 3 (previously Annex J). These changes have shifted the location of all Clauses (except Clause 1, "General Requirements") in the 2020 version. The Foreword (page xiii) to the new edition provides a Summary of Changes, which can be used as a roadmap. Readers will note a two-clause shift for Clauses 2 to 7, which are now Clauses 4 to 9.

The Clauses are now as follows:

1. General Requirements
2. Normative References
3. Terms and Definitions
4. Design of Welded Connections
5. Prequalification of Weld Procedure Specifications (WPSs)
6. Qualification
7. Fabrication
8. Inspection
9. Stud Welding
10. Tubular Structures
11. Strengthening and Repair of Existing Structures

Major Updates

While there are a host of various changes that are summarized in the Forward on page xiii, there are particularly substantive updates to the following areas: prequalification, requirements for Charpy V-notch (CVN) tests when required in the qualification of WPSs, partial-joint-penetration (PJP) qualification, pulsed gas metal arc welding (GMAW-P) heat input calculations, repair of mislocated bolt holes, QC/QA qualifications, phased array ultrasonic testing (PAUT), and radiographic testing (RT). Following is a detailed look at each area.

2015 Code – Clause 3	2020 Code – Clause 5
3.1 Scope	5.1 Scope
3.2 Welding Processes	5.5 – 5.5.5 Part D—Processes
3.3 Base Metal/Filler Metal Combinations	5.3 Part B—Base Metal
3.3 Filler Metal	5.6 – 5.6.2.2 Part E—Filler Metal and Gas Shielding
3.7.4 Shielding Gas	5.6.3 Shielding Gas
3.4 Engineer's Approval for Auxiliary Attachments	5.3.1 Part B—Base Metal
3.5 Minimum Preheat and Interpass Temperature Requirements	5.7 – 5.7.3.1 Part F—Preheat and Interpass Temperature Requirements
3.6 Limitation of WPS Variables	5.8.2 Part G—WPS Requirements
3.7 General WPS Requirements	5.2 Part A—WPS Development 5.8.1 – 5.8.2.1 Part G—WPS Requirements
3.8 Common Requirements for Parallel Electrode and Multiple Electrode SAW	5.5.5 Part D—Welding Processes
3.9 Fillet Weld Requirements	5.4.3 Part C—5.4 Weld Joints
3.10 Plug and Slot Weld Requirements	5.4.4 Part C—Weld Joints
3.11 Common Requirements of PJP and CJP Groove Welds	Removed and separated into CJP and PJP
3.12 PJP Requirements	5.4.2 Part C—5.4 Weld Joints
3.13 CJP Groove Weld Requirements	5.4.1 Part C—5.4 Weld Joints
3.14 Postweld Heat Treatment	5.9 Part H—Post Weld Heat Treatment

Fig. 1. Prequalification of WPSs—main clause.

Prequalification organization. Clause 5 has been reordered and divided into eight parts (Parts A to H); Figure 1 compares the 2015 and 2020 editions. The updates to Clause 5 provide a logical flow of requirements for the writer, reviewer, or inspector of the WPS to follow.

Among many tasks, designers specify members and materials to be used. Contractors need to know, even as early as the preparation of their bid, whether the materials specified are approved in AWS D1.1 for use in prequalified WPSs. And approved base metals—including most materials typically used for fabrication and erection of structural steel buildings—are shown in Table 5.3. WPSs using materials not listed in Table 5.3 need to be qualified via testing.

CVN toughness testing. Steel is a ductile material, and well-designed structures take advantage of that ductility. Toughness is not the same as ductility, but the two work together. One measure of toughness is the CVN test. Most U.S. building structures are built without CVN test requirements, and the AWS D1.1 does not specify where CVNs are required. Where a measure of toughness is desired, one way to provide it is by using materials that have been CVN tested by the producer. Two AISC publications use this method: the *Specification for Structural Steel Buildings* (ANSI/AISC 360), in sections A3 and J2, and *Seismic Provisions for Structural Steel Buildings* (ANSI/AISC 341); both are available at **aisc.org/specifications**. Weldments subject to extreme conditions can be welded using WPSs that have been CVN tested. In some cases, the heat-affected zone (HAZ) is toughness tested, and AWS D1.1/D1.1M clarified the requirements for those rare cases where CVN tests are conducted in the HAZ. The current edition also provides for welds that intermix self-shielded flux-cored arc welding (FCAW-S) with other welding processes.

PJP weld qualification. Subclause 6.12 (page 130) of AWS D1.1 provides three methods for qualifying PJP groove welds and one for qualifying PJP flare groove welds. The three PJP groove weld methods are as follows:

- Method 1 allows qualification of a PJP WPS using joint details permitted for prequalified PJP groove welds (on pages 104 to 119) "provided the essential variables for a qualified CJP WPS are within the limits of PQR Essential Variable Changes Requiring WPS Requalification listed in Tables 6.5 and 6.6 (when applicable)."
- Method 2 provides directions for preparing test specimens to "demonstrate that the specified weld size is met or exceeded."
- Method 3 alternatively allows a PJP WPS to be qualified and tested as required in Table 6.3, WPS Qualification—PJP Groove Welds: Number and Type of Test Specimens and Range of Thickness Qualified.

GMAW-P. The GMAW-P process has been in existence for some time but is just now being introduced to structural steel. AWS has issued two Interpretations on waveform power supplies (see the 2010 Interpretation and 2015 Interpretation) that clarify their use, and the 2020 AWS D1.1 is the first edition of the code to explicitly recognize GMAW-P. Though it had not been previously stated, GMAW-P is permitted for use in prequalified WPSs. But there is a caveat: In those rare cases when heat input is a consideration, it must be calculated in a different way (see Figure 2).

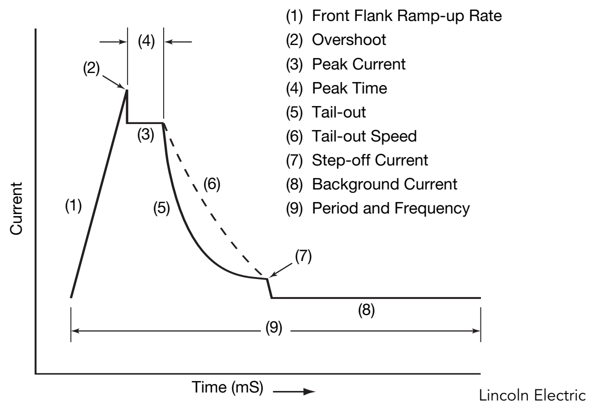


Fig. 2. Example of a current over time in a waveform-controlled process (this waveform shows why voltage times peak current is not an accurate measure of heat input in waveform-controlled applications).

Heat input. Traditionally, heat input has been calculated by multiplying amperage times voltage and dividing by travel speed, along with the use of some constants to deal with unit conversions. However, more accurate heat input calculations for waveform-controlled (pulsed) applications are now achievable thanks to modern electronics, such as those used for GMAW-P, that are able to measure volts to amps virtually instantaneously. Heat input of welds deposited with these power sources is calculated with either "total instantaneous energy" or "instantaneous power," depending on the power source used.

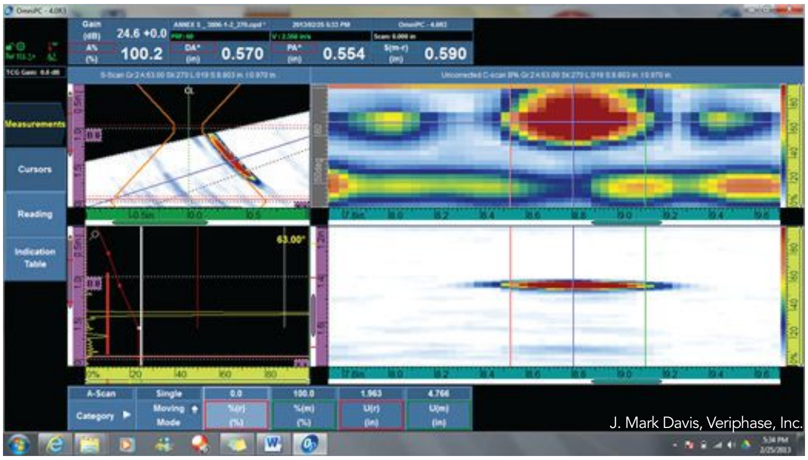
In the 2020 edition of D1.1, Clause 6.8 provides methods to calculate the correct heat input. Clause 6.8 Essential Variables of the 2020 code clarifies the preparation of a written WPS using GMAW-P by providing heat input guidance (6.8.5 Heat Input) and calculation formulae (6.8.5.1 Heat Input Calculation Methods, page 127). D1.1:2020 also provides a way to convert between pulsed and other power sources, so WPSs do not have to be requalified by test.

Mislocated bolt holes. Clause 7.25.5 has provisions for the repair of mislocated holes. These are usually bolt holes, and holes that are not bolt holes or very similar to them deserve separate consideration. The code permits mislocated holes to be left open, and this is most often the best solution for mislocated holes. When the contractor or engineer requires mislocated holes to be filled, the code requires the use of a qualified or prequalified WPS and gives conditions where NDT is required. (Note that the authors encourage engineers to review the new commentary for hole repair on page 203.)

Expanded QC and QA qualifications. Clause 8: Inspection contains requirements for inspection, procedure requirements for nondestructive testing (NDT), and discontinuity acceptance criteria, and the 2020 edition contains an updated and expanded list of welding personnel qualifications for welding inspectors. Clause 8.1.4.1: Engineer's Responsibilities notes, "If the engineer requires a specific basis of inspection personnel qualification other than those listed in 8.1.4.2, the basis shall be designated in the contract documents." 8.1.4.2 states the acceptable qualification basis shall be *one* of the following (with qualifications 3 and 4 being the new code additions):

1. Current or previous CWI QC1 or SCWI certification in conformance with AWS QC1.
2. Current or previous certification as a Level 2 or Level 3 Welding Inspector in conformance with CSA. Canadian Standards Association 178.2.
3. Current or previous qualification as a Welding Inspector or Senior Welding Inspector in conformance with the requirements of AWS B5.1: *Specification for the Qualification of Welding Inspectors*.
4. Current or previous qualification as an ASNT SNT-TC1A-VT Level II (American Society for Nondestructive Testing; SNT-TC-1A is an employer-based program, where employers develop, administer, and grade their own qualification examinations).
5. An individual who, by training or experience or both, in metals fabrication, inspection, and testing, is competent to perform an inspection of the work.

Clause 8.1.4.5: Basis for Qualification of Assistant Inspectors similarly expands the qualifications for assistant inspectors to include AWS B5.1 and ASNT qualifications.



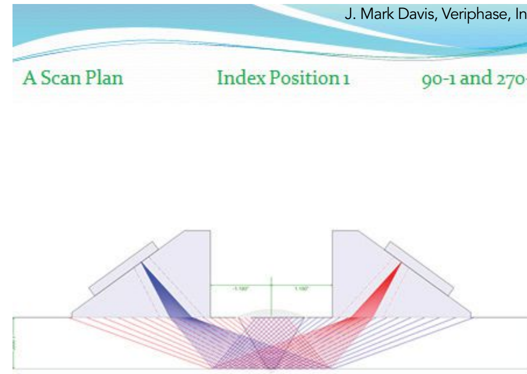


Fig. 3. A sample PAUT data screen presentation, left.

Fig. 4. A sample PAUT plan scan, above.

PAUT. PAUT is ultrasonic testing that uses multiple transducers in the same sending unit, activated in a sequence designed during the PAUT procedure qualification, to direct the sound path. When the sending unit is attached to a locating device, which may or may not be encoded, the resulting data can be compiled and displayed to reveal discontinuities in a variety of useful formats. Benefits of PAUT include quickly scanning large surfaces with high resolution, accuracy, repeatability, geometry flexibility, ability to visualize and provide a characterization of indications (see Figures 3 and 4 for a sample PAUT data presentation and plan scan). In some cases, PAUT is substituted for RT to avoid the radiation component of RT. And note that PAUT requires expensive equipment and technician training and qualification in addition to conventional UT qualification.

PAUT was added to the 2015 D1.5M/D1.5: *Bridge Welding Code*, and it is now included in the 2020 D1.1, with requirements found in Annex H (page 383). Annex H provides definitions, personnel and equipment qualification requirements, scan plan requirements, examination and evaluation procedures, data analysis and management guidelines, and more. The procedures and standards govern PAUT examination of groove welds, including HAZs, for thicknesses between $3/16$ in. and 8 in. using encoded linear scanning. The procedures exclude PAUT examination of tubular T, Y, and K connection welds.

RT digital archive. Traditional radiography consists of exposing a film to a source of radiographic energy through a weld. Discontinuities in the weld change the radiographic density of the metal, which is indicated on the developed film. That said, film (and its storage) are expensive, development is time-consuming, and sensors are now available that convert radiographic energy to digital records. The 2020 D1.1 now recognizes digital radiography and provides for its use.

Enduring Change

With these changes, AWS D1.1 is now more user-friendly and up to date with modern welding technologies and practices, making for more efficient welding processes on your steel building projects. You can download the 2020 version at **www.pubs.aws.org**.

And looking forward to the 2025 edition, the D1 Committee invites suggestions to improve the code as well as encourages new volunteers (in particular, the Design, Materials, Prequalification, and Stud Welding Task Groups are looking for new members). Experienced committee members willingly share their knowledge, and they welcome the exchange of new information and perspectives with new volunteers. Contact D1.1 Committee secretary Jennifer Molin at **jmolin@aws.org** if you're interested in becoming part of the process. ■

Notes on the Revision Process

Beginning with the 2010 version of D1.1, AWS adopted a five-year publication cycle. When the next version enters the process, the D1 Committee starts with proposals that didn't make it into the previous edition, then adds proposals based on their ever-evolving experiences, inquiries, and new technologies.

Each proposal is crafted and approved by a task group, then reviewed and approved by a subcommittee. After comments and negatives are considered and resolved, the revised proposal is reviewed and approved by the AWS D1 Committee, and then comments and negatives are considered and resolved again. Finally, about a year before publication, the committee sends its proposals to the AWS Technical Activities Committee (TAC). Once more, comments and negatives are considered and resolved. After TAC approval, the draft is typeset, and the proofs are reviewed and rereviewed until the proof is ready for publication. There were at least five proofs of the 2020 version of D1.1.

Still, typesetting errors are possible. One to be aware of is on page 79 of the first printing, which lists incorrect preheat temperatures for Category B materials in Table 5.8. (The correct temperatures are shown on page 78.) The corrected Table 5.8 is available at **www.aws.org** and is included in more recent printings.

AWS encourages readers to point out errata to the committee, and AWS lists errata for current and historical standards at **www.aws.org**. To voice concerns about the code or a revision, contact D1.1 Committee secretary Jennifer Molin at **jmolin@aws.org**.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This time, we're looking for the next great idea to change the way the industry approaches column splices. The key words are FAST and EASY—to design, fabricate, and erect safely.
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herox.com/speedconnectioncolumn
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1921–2021

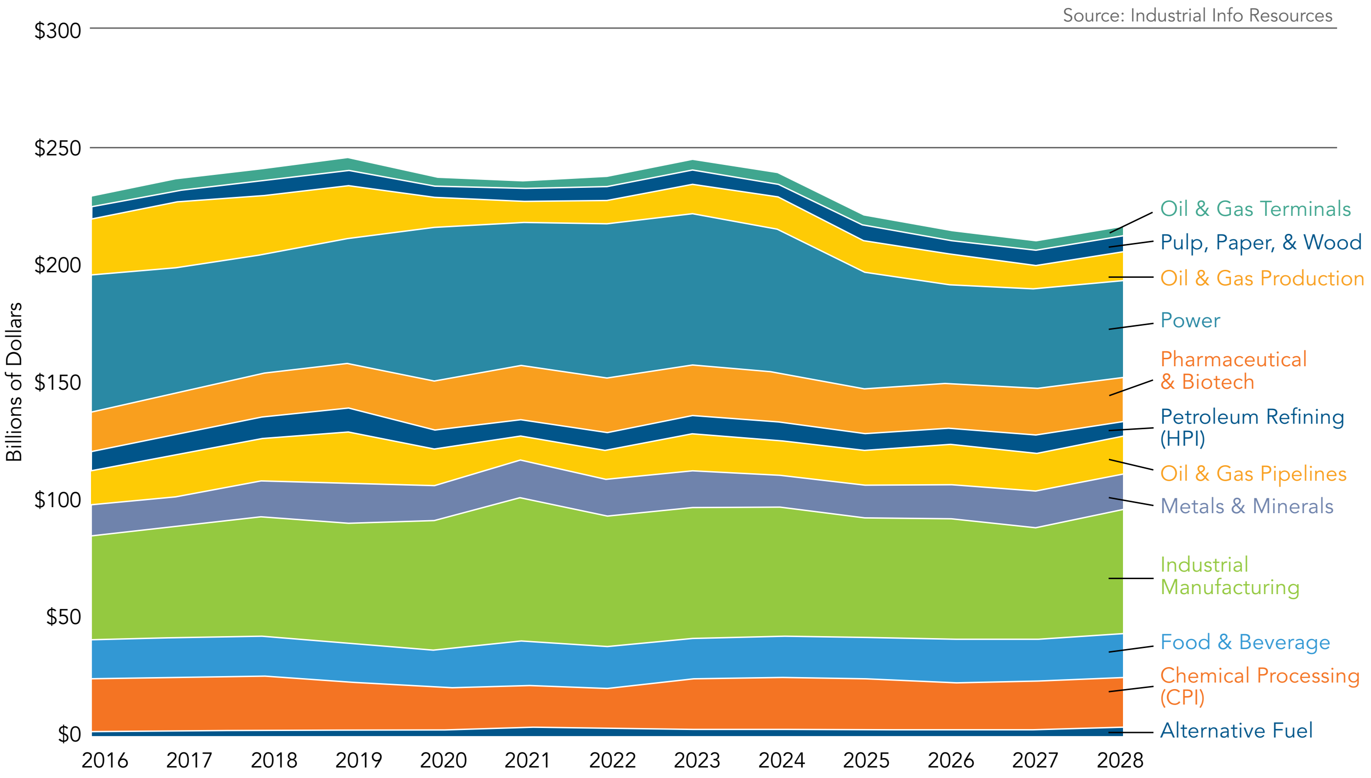
A look into the industrial market provides some details on what structural engineers and steel fabricators can expect over the next few years.

data driven

INDUSTRIAL INSIGHT

BY JOE DARDIS

Industrial Forecast



INDUSTRIAL PROJECTS HAVE LONG BEEN a significant portion of the construction puzzle.

On average, the industrial market is only slightly smaller than the commercial building market (defined as nonresidential buildings and residential buildings higher than four stories). And in 2020, which experienced a decline in commercial construction starts, the industrial market was actually larger than the commercial sector ($237 billion vs. $224 billion) and accounted for nearly two million tons of structural steel.

Total historical and projected U.S. capital spending for industrial projects is shown, by sector, in the Industrial Forecast chart (above). The industrial market showed steady growth over the last several years, from 2013 ($191 billion) to 2019 ($246 billion), though 2020 brought on the first decline in nearly a decade, when the market, again, dropped to $237 billion. According to analytics company Industrial Info Resources (IIR), this sector is expected to hover around the $240 billion mark until 2024, though significant declines are forecasted for 2025 and beyond, based on changes in a handful of specific sectors.

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

Fig. 1. Percent Change in Spending from Previous Year

	2020	2021	2022	2023	2024	2025	2026	2027	2028
Alternative Fuel	–	49%	-2%	-11%	-8%	1%	-12%	10%	11%
Chemical Processing (CPI)	–	-3%	-4%	23%	6%	-4%	-6%	2%	8%
Food & Beverage	–	20%	-5%	-2%	1%	2%	3%	-3%	1%
Industrial Manufacturing	–	11%	-10%	1%	-1%	-8%	1%	-8%	12%
Metals & Minerals	–	4%	0%	-1%	-13%	3%	3%	7%	-1%
Oil & Gas Pipelines	–	-32%	17%	27%	-7%	0%	11%	-1%	-5%
Petroleum Refining (HPI)	–	-11%	4%	9%	1%	-10%	6%	-1%	-11%
Pharmaceutical & Biotech	–	9%	1%	-8%	-4%	-8%	2%	4%	-6%
Power	–	-7%	8%	-2%	-5%	-18%	-16%	1%	-3%
Oil and Gas Production	–	-28%	12%	23%	12%	-3%	-4%	-24%	25%
Pulp, Paper & Wood	–	13%	11%	-3%	-9%	18%	-11%	15%	-2%
Oil and Gas Terminals	–	-23%	28%	17%	-1%	-15%	4%	0%	-2%

Fig. 2. Total Change in Capital Spending from Previous Year

	2020	2021	2022	2023	2024	2025	2026	2027	2028
Alternative Fuel	–	1.13	-0.09	-0.37	-0.23	0.03	-0.32	0.24	0.30
Chemical Processing (CPI)	–	-0.57	-0.72	3.89	1.23	-0.79	-1.21	0.32	1.66
Food & Beverage	–	3.14	-1.00	-0.44	0.11	0.37	0.52	-0.48	0.25
Industrial Manufacturing	–	6.18	-6.00	0.48	-0.61	-4.25	0.72	-3.91	5.47
Metals & Minerals	–	0.59	0.06	-0.19	-2.10	0.44	0.44	0.98	-0.23
Oil & Gas Pipelines	–	-5.07	1.86	3.45	-1.17	0.04	1.70	-0.13	-0.78
Petroleum Refining (HPI)	–	-0.87	0.26	0.61	0.05	-0.74	0.40	-0.10	-0.78
Pharmaceutical & Biotech	–	1.84	0.34	-1.95	-0.89	-1.65	0.36	0.83	-1.24
Power	–	-4.34	4.57	-1.06	-3.22	-11.22	-8.01	0.61	-1.14
Oil and Gas Production	–	-3.56	1.08	2.37	1.55	-0.44	-0.52	-3.18	2.50
Pulp, Paper & Wood	–	0.63	0.60	-0.20	-0.51	0.98	-0.70	0.85	-0.15
Oil and Gas Terminals	–	-0.94	0.86	0.67	-0.03	-0.68	0.16	0.02	-0.07

Figure 1 shows the percent change in spending by sector, and Figure 2 shows the total spending change by sector. For 2021, we are expecting a significant decline in the oil and gas sector, which includes pipelines, production, and terminals. However, gains in the food and beverage and manufacturing sectors should mostly offset these losses. Further, while fairly small relative to other sectors, it is worth noting that alternative fuel spending is projected to rise almost 50% in 2021.

Beyond 2021, the oil and gas sector should recover fairly quickly and grow for the next several years. The main sector moving the needle in the long term is electric power, which is also the largest category by spending, totaling $65 billion in 2020. IIR projects capital spending on power generation to remain relatively flat until 2024, then decline significantly through 2028.

While the industrial forecast is less optimistic for the long term, it's important to remember that factors such as the successful passage of an infrastructure bill or government energy and climate policies could drastically change what the industrial landscape looks like, for better or for worse. But for the short term, the overall industrial market is expected to remain relatively stable, and structural designers and steel fabricators can have an idea for what types of industrial projects to plan for. ■

OIL (AND STEEL) ON CANVAS

INTERVIEW BY
GEOFF WEISENBERGER

Gwyneth Leech brings out the bold beauty of steel construction in her portraits of under-construction Manhattan high-rises.

Gwyneth Leech painting at 53W53, fall 2018.

All images: Gwyneth Leech Studio

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

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

LET'S TALK ABOUT ART for a bit.

Or rather, let's listen to an artist talk about *her* art. (And don't worry, you're still reading a steel magazine, not an arts publication.)

Field Notes typically focuses on people working directly in the building design and construction industry or who might, for example, be design or construction-related professors. However, this month's guest is an artist, Gwyneth Leech.

Think of her as an outside observer—and painter—of our industry. And perhaps "outsider" is unfair. After all, she's been painting Manhattan steel construction projects for the last few years, to the point where she's somewhat of a regular fixture at high-rise job sites, talking with project personnel and learning—and expressing—a thing or two about the steel construction process.

Her paintings focus on, in her words, the rapidly changing urban landscape as seen through the construction sites of supertall buildings. Her interest in the arts started very young, and her appreciation for buildings began in college. Here, she talks about how the two paths have intersected throughout her adult life and how they've merged indefinitely into her current "phase."

Where are you from, and how did you end up in New York?

I was born in Philadelphia in 1959, grew up there, and went to the University of Pennsylvania. When I graduated, I went to study art in Edinburgh, Scotland, and was there for 17 years. I met a man, married him, had a child, and moved back to the States. We came to New York because he works in film and TV, and there was no work for him in Philadelphia, so we've been here since 1999.

Edinburgh is high on my list! How did you get into art?

My mother was a painter, and her parents were both artists. They met at art school in Philadelphia in the 1920s. I grew up in a very artistic household, and I always knew I was going to be an artist. But my mother was very keen for me to get an academic foundation. My father was a law professor at the University of Pennsylvania, so Penn was where I was going to go. But they didn't have an undergraduate fine arts degree in the late 1970s, so I actually studied anthropology and French. I did well with that, but I was really unhappy. And by my senior year, I knew I had to go to art school. So I applied for a fellowship that I could use to study art. It had to be in Britain—it was a British American Exchange Fellowship—so that's how I ended up in Edinburgh. But I've always loved making art, I was always very good at drawing as a child, and I knew that was a pathway that I needed to pursue, so I pursued it at the Edinburgh College of Art.

I also did my junior year (as an undergraduate) abroad in Paris and spent a lot of time drawing architecture. Penn had an undergraduate architecture prep track that included architectural drawing classes, and I took a bunch of those. So my earliest formal training in fine arts was drawing buildings freehand in ink. And it's very interesting to me that after many years of doing other things, I came around full circle to making art that's totally focused on architecture!

Funny how life works! What sort of art were you doing before you started painting construction sites?

I have ranged widely as an artist, from travel and cityscape paintings to family portraits to making art on paper coffee cups. I have a strong sense of exploration, and I love to learn new materials and techniques. And thinking back to my childhood, I always liked to make three-dimensional objects. But I was also very good at drawing, and that was encouraged and appreciated by my family. So I do wonder why it was that I selected painting when it came time to go to art college, and looking back, I think it was because if I had gone into the sculpture school, it would just be sculpture. But if I went into painting and drawing, I could do printmaking and photography too, all of this two-dimensional stuff, so I ended up going a very 2D route. But once I graduated, I went on to work in 3D art installations and did video and all kinds of things. I painted murals in a church. I was an artist in residence in a theater. I spent a year drawing theater architecture and opera productions at the Theatre Royal Glasgow. So that architecture theme keeps coming back around, even though I've been in many different places artistically.

On that note, can you tell me how you got "back" to buildings? And maybe walk us through the process for a project?

An important factor here is biking. I do Citi Bike, the NYC bike-share program, and I pedal around the city, and I usually have something I can draw on, whether it's a spiral-bound notebook, a paper bag, or some scrap piece of paper. And I often start an idea by drawing a thumbnail of a project on a piece of paper with a Bic pen. I'll identify a site that interests me, and then I'll go back and do larger drawings or often watercolors. And as I've gotten into this interest in architecture over the last five or six years in New York, I began to work bigger and bigger, lugging an easel all over the place and actually taking canvases out and setting them up on the sidewalk and painting. Then I bring it back to the studio and do more work on it. And sometimes I work a lot bigger and make a large painting that I couldn't do out on the street. And I do take a lot of photographs in and amongst all of that to record very specific times of day and stages of construction. So I have a lot of material, a lot of research content that I work with, but COVID did put a stop to my going out with an easel. The sidewalks of Midtown Manhattan were gloomy—empty,

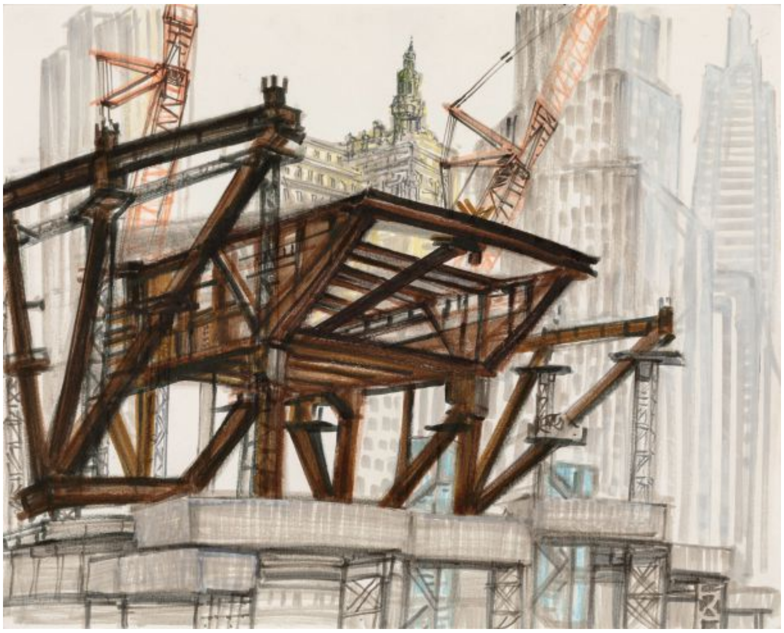
previous page:
OVA Steel Rising
winter 2017/2018
oil on canvas, 24 in.×48 in.

above:
The Shed Under Construction
June 2017
oil on canvas, 24 in.×48 in.

left:
One Manhattan West Rising
November 2017
oil and acrylic on canvas
30 in.×15 in.

below:
270 Park Steel Rising
March 2021
India ink on paper, 16 in.×20 in.

opposite page:
Hudson Yards with Encampment
View from West 30th Street
Summer 2021
oil on canvas, 36 in.×44 in.



lots of desperate people, very depressing. So I had a lot of time holed up in my studio, working on a backlog of things that interest me.

I can imagine. So during "normal" times, when you've got an easel set up by a project, do people tend to ignore you, or do they come up to you and ask what you're doing?

It's actually a complete mix. Some people walk by without a glance, and other people stop and watch me from behind. And if I'm in the zone, if I'm very involved with a painting, I don't even notice. I meet a lot of people who work in construction and who are working on the building sometimes. I've often had this experience where people working on the building come and check me out and ask what I'm doing, and over time I've gotten to know a lot of construction workers, surveyors, engineers, ironworkers, carpenters, electricians, safety control officers. I bump into them on the street, and they say, "Oh, I met you at 270 Park," and here we are at another site, so it's a kind of small world, but it's very interesting. I've learned a lot about construction in all of this, and I *almost* feel like I could build a building.

I'll bet! So what was the first building site you painted, and how did that come about?

The very first building was the one right outside my studio window, and that's what started this whole thing. I used to have a spectacular open view to the north, which I painted again and again, in different seasons, the reflections on the buildings, the very iconic towers of Manhattan. And then in 2015, a building started to go up right outside the window. I could throw my coffee cup and hit it. And at first, I was really devastated and thought, "I'm just going to move. I can't stay here." But then it occurred to me that if I stayed and made drawings and paintings of this building, it would be an interesting sequence. So that's what I did, from the time it was way down below to when it came right up past my (13th) floor and kept going, and now it's 40 stories. It was like Jack and the Beanstalk; it kind of disappeared in the clouds. But for a time, construction workers were right there at eye level, and we had these visual conversations, and I would open the window and turn my canvases around to show them what I was doing. It was actually a lot of fun. I was amazed by the choreography of this skinny building with a small floor plate and all these people that were working on it.

But then, when it was done, it was just a brown brick wall, and I didn't have the view, and I thought, "OK, what else can I go and paint?" So I went out and started doing watercolors of Hudson Yards from the High Line. And I was doing a lot of watercolors at that time, and that was when I first painted steel buildings, but I didn't know what I was looking at. I didn't know why they had that massive dark quality, which totally fascinated me because I didn't know what was going on. And I kept going, like, every week painting and painting and painting. So that was when I first encountered steel construction.

And then I got interested in 53 West 53, which, like the first building I painted, is concrete, but somebody who works at MoMA just across the street came over and said, "Have you seen what's going on next to Grand Central Station? You should check that out." This was One Vanderbilt. So I went over there and, oh my God, it was just a few floors above the street, but the size of the steel, these thrusting angled steel columns and trusses, it totally blew my mind. But at that time, I hadn't seen a rendering; I didn't know where it was going. So at that point, it could have been anything. It could have been a ship or the Eiffel Tower. It just was so extraordinary. And I just began to draw and paint it, and I have a total of 22 paintings of One Vanderbilt going up.

So when you're talking about doing several different paintings of the same building, is the effect like a flipbook, like you're doing multiple "takes" from the same vantage point? Or are you just hitting it from as many different angles as you can?

I've done both. For Hudson yards, on the High Line, there was a spot along the railing that I kept coming back to, and I knew it was my spot because I accidentally hit it with some white acrylic paint, so my "mark" was always there. You could do a little stop-frame animation with that series. So I am aware of trying to match up the vista to get that feeling of the building going up. With One Vanderbilt, I had a few different angles that I favored, and I moved around more with that one from different vantages, but I did maybe four or five from one vantage to see the transitions. There's a big transition from when it was just the base to when it gets higher up, where it begins to take its proportions and starts to speak more to the surrounding buildings. And from there, it's doing more with the skyline, and then the curtain wall changes, and the skeleton disappears, and it's a different kind of atmosphere. So, I always feel a little sad when a building has "disappeared" behind the curtain wall since I'm very attracted to the steel skeleton.

Is there a "sweet spot" in the construction process—before it's completed—where a building is at its most attractive?

One example that comes to mind is Manhattan West, the northeast tower, because it was core first. They built out this massive steel base, which was extraordinary and sculptural, and people didn't know what was coming next, and then they began with the concrete, then the steel came after. So for a long time, there was this weird skinny, pale tower that was going up with blue at the top, which was the construction wrap or whatever, and at a certain point all of the phases of the construction were clearly visible with that building. It was tall enough that they started the curtain wall, but above that, you could see where they'd done the fireproofing on the steel, and above that it was still the bare steel, and then there were several black nets, and then above that the core went up to the work floors, and then there was a crane at the top. So everything was going on at once, and that made a very dynamic

series of paintings—all of which have been purchased by people involved in that project, mostly on the steel side.

So after painting all of these buildings, and based on the construction knowledge you've gained, is there a small part of you that would like to be an architect or engineer?

Ha! It doesn't make me want to become an architect and engineer. However, watching the building go up outside my studio window made one of my *daughters* want to become an architect. I remember sitting in the window, watching the construction, and we were both so absorbed. She went to Stuyvesant High School and did an internship with an architecture firm in New York after her junior year, and then she said, "Not architecture." But in college, in her second year, she said, "It's engineering. I want to build the buildings." So she got a degree in structural engineering, and she's working for an engineering firm in Boston! So I get vicarious pleasure from her, and we swap photos of ourselves in hard hats and work boots. And this also actually goes back to the project I was doing before I got involved with buildings. For a number of years, I was making artwork with my used paper coffee cups, which became an obsession. In my later explorations of the possibilities of art with coffee cups, I cut them up and reassembled them. And I still do that from time to time in my studio, and that's my own form of very small construction exploration in paper. ■

*This article is excerpted from my conversation with Gwyneth. To hear more about her, including her initial apartment search in New York, her series Split Vision—which juxtaposes massive structural building frames with "informal" structures at street level—her gardening and singing endeavors, and her opinion (as a native Philadelphian) on who makes the best cheesesteak, check out the December Field Notes podcast at **modernsteel.com/podcasts**. And to see more of Gwyneth's work, visit her site at **www.gwynethleech.com** or follow her on Instagram at **@gwynethleech**. In addition, you can view a documentary about her,* The Monolith, *at **gwynethleech.com/documentary**.*

business issues

EVERYONE'S A CRITIC

BY DAN COUGHLIN

What we criticize in others might look very familiar to us.

Since 1998, **Dan Coughlin** has worked with serious-minded leaders and managers to consistently deliver excellence. He provides Executive Coaching, Group Coaching Programs, and seminars to improve leadership and management performance. His topics are personal effectiveness, interpersonal effectiveness, leadership, teamwork, and management. Visit his free Business Performance Idea Center at **www.thecoughlincompany.com**.

Dan has also presented several presentations over the past few years at NASCC: The Steel Conference. To hear recordings of them, visit **aisc.org/education-archives** and search for "Coughlin."

BACK IN 1993, I read a book called *Keeping the Love You Find* by Harville Hendrix, who also wrote *Getting the Love You Want*, which I read in 1994.

Hendrix is an acclaimed expert on relationships. The biggest lesson I learned from him applies not only in romantic relationships but also in work relationships.

One idea has stood out for me more than any other: "What we criticize in others is what we are most critical of in ourselves."

A work relationship where we invest as much or more time with other people than we do with those in our own houses is one where people often criticize each other either directly or indirectly. However, the powerful insight from Hendrix is that we can come to a better understanding of ourselves by slowing down and thinking about what we are criticizing in someone else.

If we criticize someone else as being a know-it-all and arrogant, then it might be possible that we are also criticizing our own know-it-all, arrogant attitude. If we criticize someone else for never stepping up and taking charge, is it possible that we're thinking about ourselves when we don't step up and take responsibility?

Once I understood this idea, I started to understand myself so much better. The areas I needed to work on quickly began to reveal themselves to me. And this idea has stayed with me all these years. Yes, we might have a good point with what we are saying about other people, but in doing so, we might very well increase our awareness of what we need to work on. And once that happens, then we can begin to make real progress on ourselves. As I look back on my life and reflect on various relationships, work and otherwise, this way of learning from others has been of enormous benefit.

I used to criticize people for using foul language in meetings. Then I heard my own voice using foul language. I knew I didn't like the way it sounded in other people, but I also realized I didn't like the way it sounded coming from me. So I stopped.

Once we become aware of this insight from Hendrix, it becomes an incredibly powerful tool for improving ourselves. We start to see behaviors and words that we don't like in ourselves that have been subconsciously hidden from us. On an even deeper level, we realize that the other person really isn't doing something so awful, but rather that we are reacting to something within ourselves that we want to criticize.

If we criticize someone for being loud at parties, it might be that we are actually expressing our criticism of ourselves but projecting it on another person. Once we realize this, we can become more accepting of other people for demonstrating a small dose of the parts of ourselves that we are critical of.

Reading this can feel like a riddle at first. Just because you're critical of someone else doesn't *necessarily* mean you're projecting. However, once you apply the same awareness of your surroundings to yourself, opportunities for self-improvement can become more obvious to you the next time you are critical of someone else. Think of it this way: It's not necessarily a situation of "It's not you, it's me" but rather "It's not you, but it *might* be me—or it might be me *too*."

That being said, there are of course times when it is important to provide a critical voice, especially when it comes to the "big" stuff. For example, standing up for what you believe is right and wrong—or standing up for people who are being persecuted or bullied—is a worthy thing to do, and if it requires being (vocally and outwardly) critical of other people in doing so, then do it.

However, it's in the many small criticisms of other people that we may make on a regular basis where we can learn more about ourselves. It's in those criticisms where we might be talking more about ourselves than about the other person.

What you Mutter Matters

Let's take it a step further and discuss how we communicate negative criticism—whether we mean to or not. Sometimes a person will say to me, "I can't stand working with that other person, but it never shows. I keep my thoughts to myself." To which I usually reply, "It's almost impossible to keep your thoughts hidden all the time. Eventually, they find their way out. Be on the alert as to what you are about to say or do."

What you mutter matters. If you are keeping negative thoughts to yourself about other people and their past decisions and actions, you might eventually start talking to yourself and making comments under your breath. Those comments can be devastating to a relationship.

Entering into an interpersonal interaction is like stepping onto the field of play or a theatrical stage. Once you are on the field or stage, everything you do and say matters. Even if you are gracious and kind when the spotlight is on you, people will see what you are muttering to yourself when the spotlight is on someone else.

Be aware that people are watching you and prepare for that moment. Be clear within yourself what you want to say and how you want to think in those moments when you are with other people. Don't ever assume that you can fake your real thoughts and feelings on an ongoing basis.

Decide on the messages you will deliver and how you deliver them. Decide on how you will react and how you will respond no matter what the other person says. Be conscious of what is happening in your mind even when you don't think anyone is watching you.

It's the not-so-hidden moments when a person can really damage a relationship. Be careful of your throwaway comments that you toss out at the beginning or end or on the side of the main conversation; there's a very good chance they're passive-aggressive. (And has passive-aggressiveness ever been seen as a good thing?) Those throwaway comments might just cause the other person to throw you away and out of the interaction—or worse, the relationship.

Be aware of your criticisms and their true potential origins, and be conscious of and intentional with your interpersonal interactions. Doing so will help facilitate positive, honest, and productive relationships. ■

Evolutionary Optimization

BY STEPHEN REICHWEIN, SE, PE, AND PHILLIP R. BELLIS, PE

A discussion on parametric design and optimization of steel structures.

Stephen Reichwein (**sreichwein@severud.com**) is a senior associate with Severud Associates in New York, and **Phillip R. Bellis** is an independent consultant.

ACCESS TO RELEVANT DATA is essential for high-quality, fact-based decision-making.

While engineers have always approached their work in this manner, the modern project workflow has brought about a specific, significant change. Client expectations have grown beyond the concept of a "final" deliverable to now include a continuous influx of data upon which they base key business decisions. In other words, engineers are now purveyors of data just as much as they are consumers of it.

In the field of structural engineering, the potential data includes, but is not limited to: structural steel tonnage associated with various framing configurations, economies of scale projections for repetitive connection types, and the relationship between steel tonnage and occupancy comfort for various serviceability considerations. The relevant data varies for each project, and engineers have a powerful tool to efficiently acquire the data most useful to a given project: parametric design.

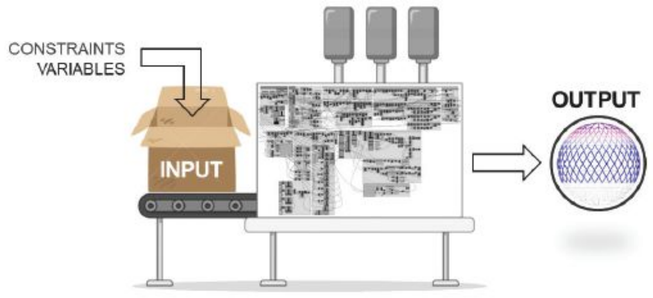
While this approach has been around for roughly a decade, it's not particularly widespread. But it can prove to be exceptionally useful. Depending on the complexity of the problem, engineers can automate millions of simulations, process data, and have presentation-ready graphics in a matter of hours. Here, we'll cover three real-world examples that used parametric design to optimize the design of a steel structure:

- Performance/cost optimization for a structural steel truss
- Performance optimization for a structural steel high-rise braced frame core
- Comprehensive optimization of a steel grid shell structure

The possibilities of this design approach are only limited by the user's ambition. While it is true that the upfront cost associated with learning the approach can be a barrier to entry, the long-term benefit certainly outweighs any initial setback. All projects, regardless of scale, can benefit from this design process and the associated data that becomes available through its use.

Parametric Design, Explained

The parametric approach can most easily be understood by looking at the design approach as a mathematical function. The algorithm is the function itself, comprised



The parametric machine, a simple function.

of constants, variables, and constraints. The parametric aspect of the function is the set of variables being explored and the constraints that these variables must satisfy. Rather than test for validity after output has been obtained, variables are often associated with a domain to ensure that constraints are satisfied. For example, when looking at the design of a simple truss, the span, supports, and loads would be considered constants. The depth of the truss, however, would be considered a variable, hypothetically constrained by the architecture to a depth between 5 ft and 10 ft.

Once the algorithm is assembled, verified, and run to completion, the user has access to the output they set out to obtain. In structural engineering, this output could be a geometric model, analysis model, member forces, member sizes, etc.

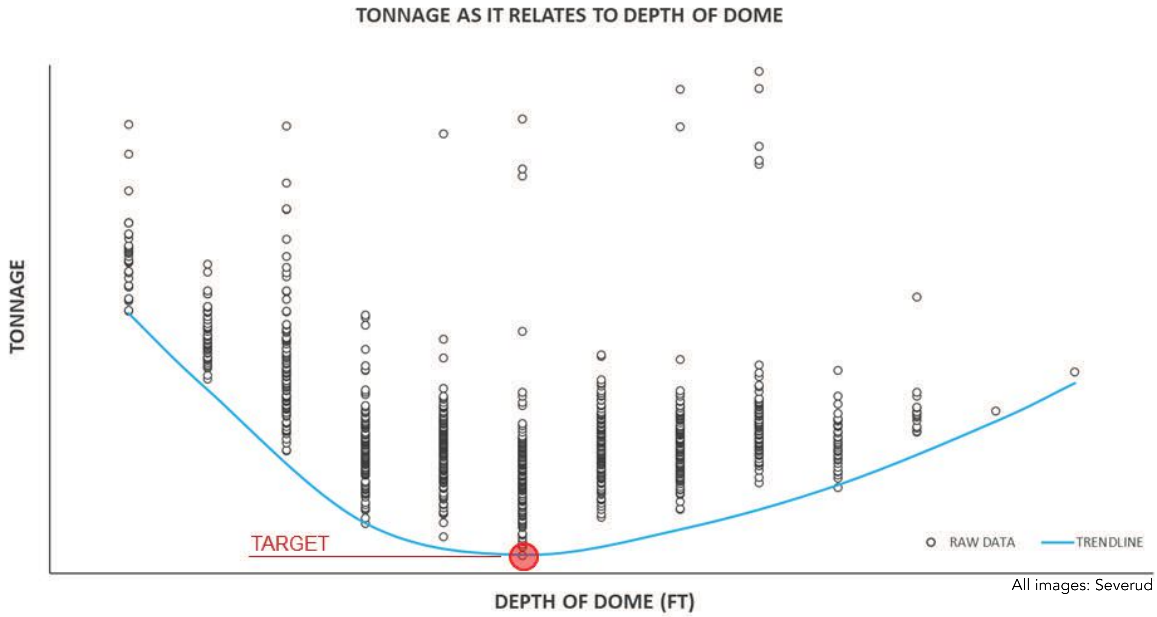
So how can parametric design be used to optimize structures? The process described thus far is manual. The designer develops an algorithm and determines the output they would like to obtain. Should this process continue, they would then be responsible for changing inputs to obtain results for different permutations of the defined variables. This could be a lengthy process depending on the complexity of the algorithm—regardless, this is certainly not the most efficient way to proceed. It is thus in the best interest of the designer to use an evolutionary solver to quickly iterate through the possible solutions.

Evolutionary solvers are not a new concept. The most common example is the Solver add-in for Microsoft Excel. This add-in allows the user to achieve a goal by setting the solver to change the value of certain cells within specified constraints. Similarly, Revit/Dynamo has an evolutionary solver called "Optimo," and Rhino/Grasshopper has one called "Galapagos." While not the only evolutionary solvers available for each of the programs, they are the most common.

An evolutionary solver repeatedly runs a design algorithm until it obtains the closest possible result to the user's set target. During each of these runs, the solver identifies the specific variable permutations that produce the most favorable results. The favorable permutations are stored and then incorporated within the next generation of the iterative process to improve upon the solution. The outcome is the permutation of variables that results in an output closest to the designer's set target.

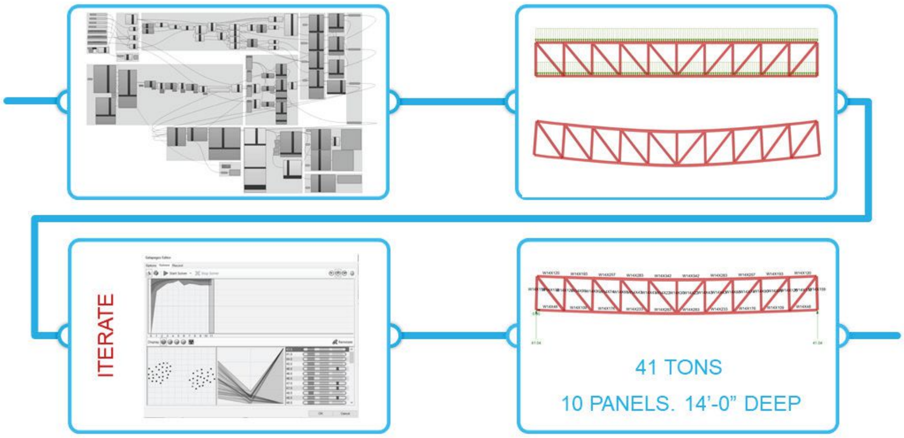
As the goals of individual users can vary widely, a fitness function is commonly applied when using an evolutionary solver. A fitness function takes the user's goal and converts it to a value to be either maximized or minimized by the solver. The value can be a singular output, such as tonnage or self-weight, or it can be the result of a multi-variable function, such as cost. Though it requires more input from outside parties, cost is often the most impactful fitness function to use when comparing design alternatives within structural engineering. For example, the tonnage of a steel structure is only one component of the total cost. An engineer must also consider fabrication, labor, erection, procurement, etc. Let's assume a steel structure has the following general costs—acknowledging that both (a) this pricing is theoretical (and may vary based on region) and (b) there will, of course, be others, depending on the project:

Raw material = $2,000/ton = X
Cost per fabricated and erected member = $2,000/piece = Y
Cost per connection = $1,000/connection = Z
The fitness function (FF) for cost therefore becomes:
FF = 2,000 × X + 2,000 × Y + 1,000 * Z
Where X, Y, and Z are outputs of the algorithm.



All images: Severud

Illustrating the goal of structural efficiency/optimization in terms of steel tonnage.



Workflow for the parametrically optimized steel truss.

OPTIMIZED FOR WEIGHT	
PANELS:	10
DEPTH:	14 FT
TONS:	41 TONS
COST:	$186,000

OPTIMIZED FOR COST	
PANELS:	6
DEPTH:	16 FT
TONS:	46 TONS
COST:	$156,000

The parametric truss, optimized for cost.

Parametric Optimization of a Structural Steel Truss

Now let's run through the first of the three examples we mentioned at the beginning of the article: optimizing a steel truss, adhering to the given constraints, variables, and targets.

Constraints:

- Span: 125 ft
- Depth: Minimum of 5 ft, maximum of 25 ft (note that trusses depths are typically 1⁄10 of the span; these numbers simply refer to this example)
- Support condition: Pin-roller
- Load: Dead and live loads are evenly distributed along the top and bottom chords
- Maximum deflection: L/240 (TL)
- Structural steel shapes used: W8, W10, W12, and W14 families

Variables:

- Evenly spaced panels (quantity)
- Truss depth variation (in feet)

Targets:

- Performance optimization in the form of minimized tonnage
- Cost optimization

The workflow is similar to the general workflow previously discussed. The algorithm and model are developed in Rhino and Grasshopper. Structural analysis is then performed using Karamba3D. Next, Galapagos (evolutionary solver) is introduced to the algorithm, and the optimization process is started. Finally, the evolutionary solver converges on the targets, and the optimized result is chosen.

In this case, the optimized result is a 10-panel truss that is 14 ft deep and weighs 41 tons. This result, however, does not necessarily coincide with the cost optimization target. The following cost function will be used as the fitness function:

Cost = $2,000/ton raw material + $2,000/fabricated piece + $1,000/connection

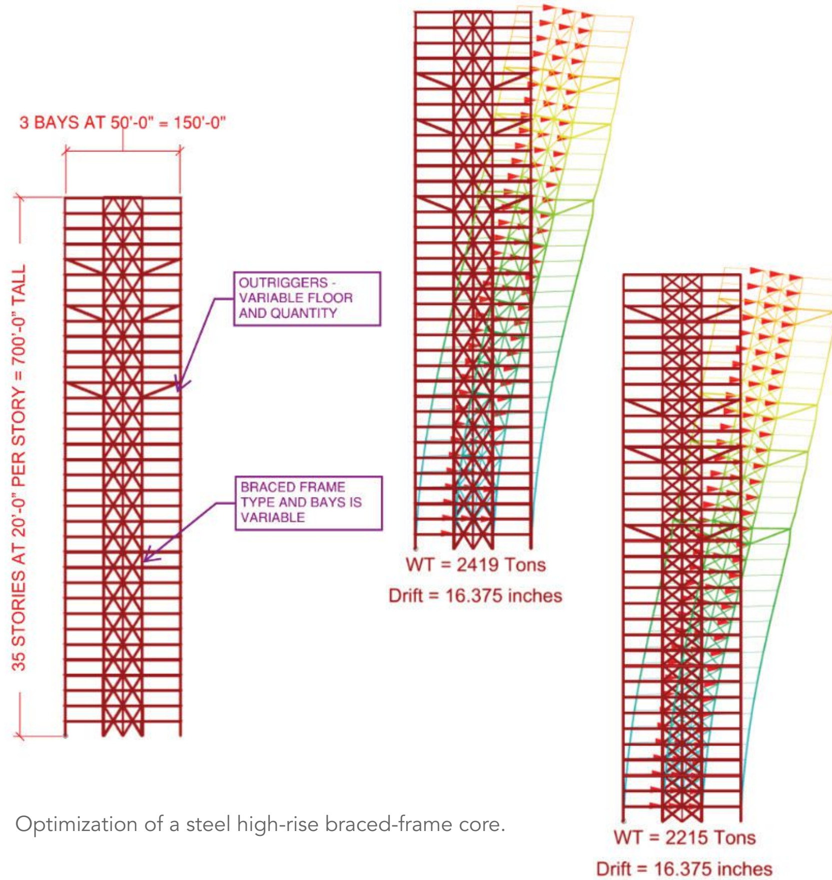
The evolutionary solver is now run to target the truss with the least cost. As expected, the result does not match the truss from the optimization run for least tonnage. The truss optimized for cost has six panels, is 16 ft deep, weighs 46 tons, and costs $156,000. The truss optimized for tonnage costs $186,000.00, so the savings here is $30,000 per truss. In order to be certain that the cost function being used is accurate, it is imperative for the steel fabricator and erector to be involved with the optimization process as early as possible. The client will greatly appreciate the cost savings—and parametric-enabled projects aside, early collaboration with fabricators and erectors brings benefits to *any* steel project.

Parametric Optimization of a Structural Steel High-Rise Braced Frame Core

The newest generation of high-rise structures features an aggressive combination of complex geometry and height. This is made possible by recent advancements in materials, construction methods, and analytical procedures. Parametric optimization, when combined with these other advancements, can help engineers identify crucial information regarding design alternatives early in a project. The most effective solutions can thus be implemented without causing delays or other unforeseen complications, and include structural form, bracing and outrigger configurations, custom structural shapes, and more.

In this simplified example, the high-rise structure is a 700-ft-tall, 35-story office building incorporating three structural outriggers. The building is a 150-ft by 150-ft square in plan, and each major-axis direction has three 50-ft bays, the center bay being a 50-ft by 50-ft braced elevator core. The parametric workflow is the same as in the steel truss example, but for simplicity, the optimization only considered structural tonnage.

The results of this example show that by introducing a fourth outrigger, repositioning the outriggers, and changing the bracing configuration, 200 tons of steel can be removed from the building without sacrificing lateral performance.



Optimization of a steel high-rise braced-frame core.

Parametric Optimization of a Structural Steel Grid Shell

Long-span structures, specifically grid shells and domes, are another great application for parametric optimization. For example, a dome roof consists of radials, rings, and diagonals, all of which may vary in location, quantity, and member type. The triangularization/mesh of the grid shell may also vary depending on the goals of the project. Is it possible to alter the mesh such that all members have an equal length? Is the goal to solely minimize tonnage? Perhaps the designer desires tonnage and economy of scale to be optimized simultaneously?

This third example looks at a spherical grid shell with the following constraints:

- Diameter/span: 480 ft
- Loads: Dead (self-weight, cladding, catwalks), live (catwalks), wind, and seismic
- Maximum steel element length: 50 ft (due to transportation and erection constraints)
- Maximum deflection (vertical): L/1920 (at the apex)

A spherical grid shell, in theory, can be structured in an infinite number of ways. The logical starting point for this example is the classical geodesic sphere based on an icosahedron (a polyhedron with 20 faces). This structural configuration will provide the minimum steel tonnage. Optimization is still required, however, to determine the ideal subdivision of the icosahedron face, often referred to as the geodesic frequency.

In this example, a frequency of 6 is determined to be the optimal solution when all constraints are considered. This amount of subdivision shortened member lengths to the required 50 ft (connection nodes excluded). As shown below, the optimal frequency varies with the constraints of the problem.

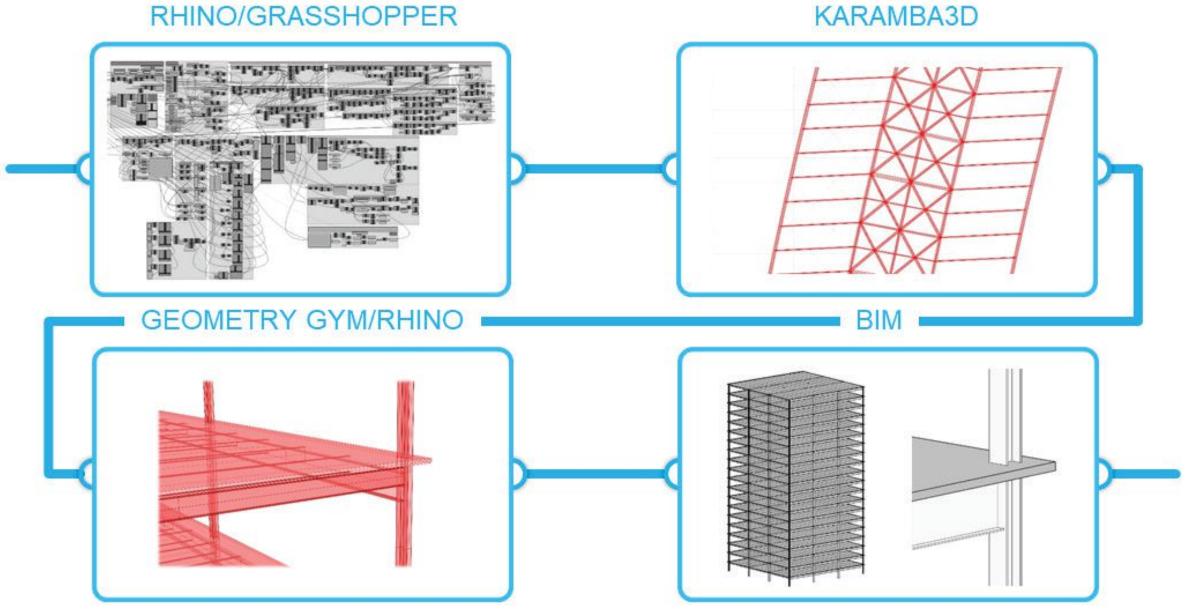
The optimization process for the sphere does not stop at this point, however. The goal is to minimize total cost, not just steel tonnage. As previously stated, cost is a function of many variables, such as material, number of pieces, and connections. A diagonalized, latitudinal/longitudinal configuration is thus studied. A fitness function is used that accounts for latitudinal repetition as opposed to the

An Example Workflow

There are multiple workflows for structural optimization that incorporate parametric design. Through trial and error, engineers will find the workflow that works best for them on any given project. The workflow outlined below is one of many used by the authors and has been successfully implemented on a variety of projects.

To begin, the geometry of the model is built using Rhino and Grasshopper. The algorithm is scripted in Grasshopper and viewed in the Rhino display window. Once the algorithm for the geometry is finished, the structural analysis component is added. There are multiple plug-ins that cater to the preferred choice of structural analysis program. We prefer to use Karamba3D at this point in the workflow because all analysis takes place within Grasshopper, and this greatly increases the speed at which the user can iterate through multiple design options. All results are viewable within the same Grasshopper/Rhino window but can also be exported in a table format should the user prefer to process data in such a manner. In this workflow, the results are kept within Grasshopper so they can be used to run its evolutionary solver (Galapagos).

It is up to the designer to determine the fitness function that will best achieve their desired outcome from Galapagos. Once that has been decided upon, the fitness function is input into the solver, variables assigned, and the optimization run started. The optimization will converge upon a result based on the options selected by the user prior to the onset of the run. All solutions are temporarily saved within the Galapagos window for the user to look through prior to making a final selection. Once the selection is made, the geometry (complete with structural member sizes) may be converted to 3D modeling elements. We typically use Geometry Gym for this task. Geometry Gym streamlines the export of models to Revit and/or other structural analysis programs, such as SAP, ETABS, and RAM. The structural analysis model is then verified in one of the programs previously mentioned and the model detailing completed in Revit.



Example of a common parametric workflow.

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10. **Channel The Hard Way (X-X Axis)** — INSIDE DIA. — All Sizes
11. **Tee Stem In** — OUTSIDE DIA. — 22" x $142\frac{1}{2}$# Tee

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13. **Tee Stem Up** — MEAN DIA. — 22" x $142\frac{1}{2}$# Tee
14. **Angle Heel In** — INSIDE DIA. — 8" x 8" x 1" Angle
15. **Angle Heel Out** — OUTSIDE DIA. — 8" x 8" x 1" Angle
16. **Angle Heel Up** — MEAN DIA. — 8" x 8"x1" Angle
17. **Square Tube** — INSIDE DIA. — 24" x $\frac{1}{2}$" Tube
18. **Rectangular Tube The Easy Way (Y-Y Axis)** — INSIDE DIA. — 20" x 12" x $\frac{5}{8}$" Tube
19. **Rectangular Tube The Hard Way (X-X Axis)** — INSIDE DIA. — 20" x 12" x $\frac{5}{8}$" Tube
20. **Square Tube Diagonally** — MEAN DIA. — 12" x $\frac{5}{8}$" Square Tube
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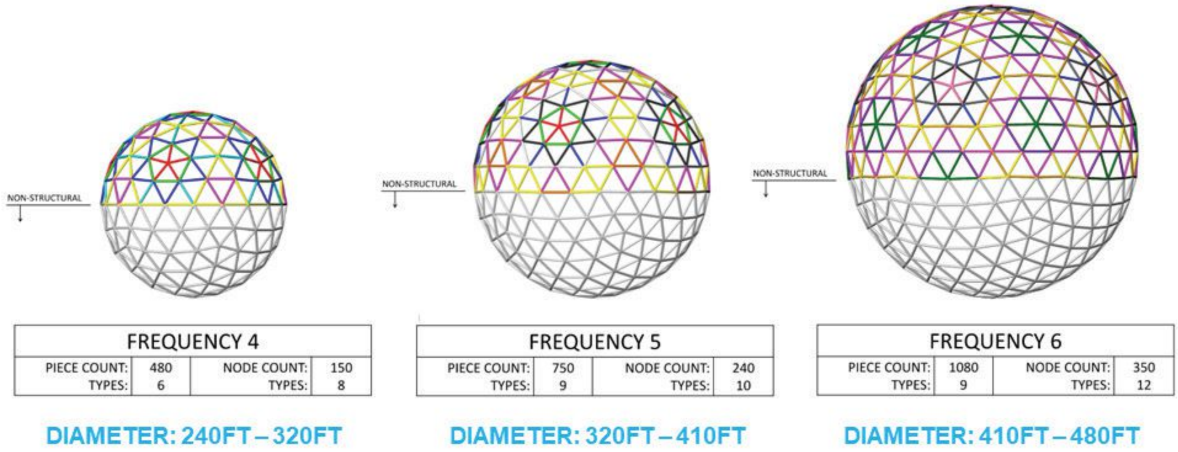
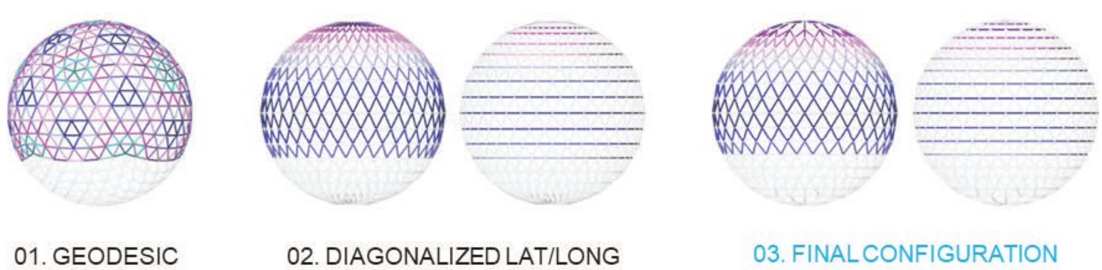


Structural optimization of the classical sphere categorized by diameter.

DESIGN ALTERNATIVES	GEODESIC		DIAGONALIZED LAT/LONG		FINAL CONFIGURATION	
	w/o APEX	w/ APEX	w/o APEX	w/ APEX	w/o APEX	w/ APEX
TONNAGE						
TONS	2100	3500	2400	3600	2600	3900
STRUTS						
COUNT	1470		1730		1410	
TYPES	13		16		18	
NODES						
COUNT	492		612		416	
TYPES	14		9		11	



Comparison of geodesic sphere structural types.

more "random" repetition of a traditional geodesic configuration. The study results in a higher tonnage, but efficiencies associated with the repetition of each connection node offset the cost associated with the higher tonnage. With this new baseline established, elements with low structural demand are targeted for removal. The iterative process is streamlined by the parametric set-up of the analysis model and results in a structural configuration with far fewer pieces and less congestion at the apex of the sphere.

Although the tonnage and number of distinct node types slightly increased, the overall cost of the structure is minimized due to the fitness function accounting for construction complexity. All nodes, diagonals, and ring members at each latitude are the same in the chosen design. This results in a more straightforward erection process and significant economy of scale in fabrication, especially if castings are used for the nodes the cost of castings is greatly reduced with increased economies of scale). It is determined that the diagonalized, latitudinal/longitudinal grid structure will have the lowest total cost and results in a 25% savings when compared to the lighter classical geodesic sphere.

Endless Possibilities

Although it can take some time to build an algorithm, the algorithmic, parametric modeling process is a valuable tool that structural engineers can use to rapidly compare design alternatives and make informed design decisions. More so, however, it allows engineers to provide clients with relevant data that can guide them in their decision-making process for the entire project. These benefits can be realized on jobs of all scales and types. The examples discussed in this article are just the beginning of the possibilities unlocked by this valuable design approach. ■

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The Times, They've Always Been a-Changin'

BY JON D. MAGNUSSON, SE, PE, HON. AIA

What propels the speed of structural engineering? In a word: technology.

Jon D. Magnusson (**jmagnusson@mka.com**), pictured in 1977 and 2021, is a senior principal with Magnusson Klemencic Associates.

REMEMBER *TOP GUN*?

More importantly, do you remember one of its most iconic lines?

As Maverick walks away from his fighter jet, he says, "I feel the need…" And Goose joins in, "…the need for speed!"

Structural engineers have always felt that same need in delivering their work.

But the reality is that at any point in time, they always believed that they were already going as fast as possible. In my experience over the last four and a half decades, it has only been through innovations in technology that engineers have been presented—and seized—the opportunity to deliver service faster.

To understand increases in structural engineering velocity, it is helpful to examine a few of the major elements of an engineer's work: communication, concept design, computing for analysis and member sizing, and drawings. In the discussion of each of these, many young engineers will marvel at how primitive previous methods were. And compared to the way we operate today, the "old days" honestly seem pretty primitive to me too. However, engineers were able to successfully complete countless amazing projects using "stone age" techniques.

Communication

When I first started work in 1975, letters and memos were all typed on electric typewriters. Actual carbon paper was used to create carbon copies. I've often wondered why, in our modern times, we still talk about cc'ing someone when there's no carbon involved at all. Every letter and memo that left the office needed to be reviewed by a principal before it could be mailed and, on a weekly basis, copies of all correspondence for all projects were routed to every principal for review. Clearly, there were opportunities for increasing the efficiency of this operation.

Prior to the 1990s, anything that is found in an email today would have been in a letter, memo, or handwritten note. When email was first available, all emails for the firm would arrive at the receptionist's desk, where it would be printed out, and then that copy would be routed by hand to the inbox of the intended recipient. (I know, hard to believe.) It didn't take long for the practice to change to what we have today: direct

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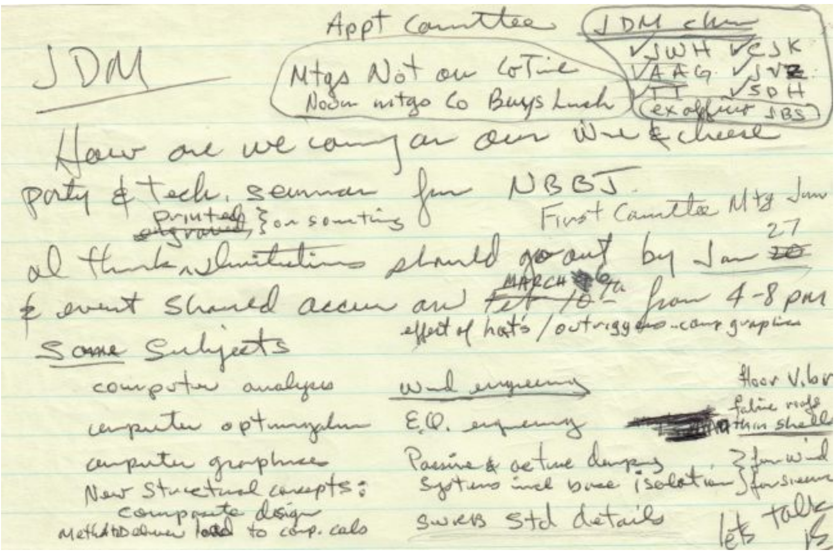
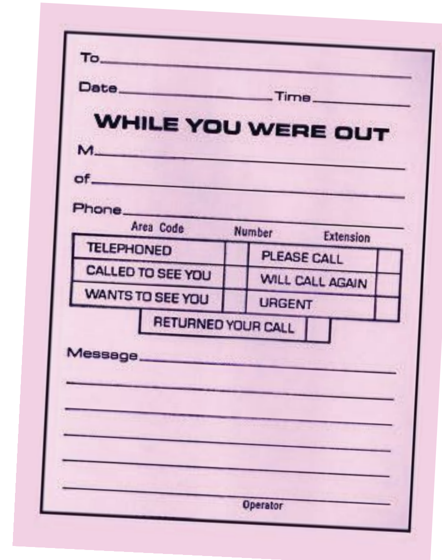




An '80s version of an "email" from my mentor, John Skilling, discussing the planning of an open house for a major client (above), and what used to serve as "voicemail" (right).

delivery to the recipient's computer and smartphone. In looking back, the advent of email was the single biggest advancement to speeding up communication (making it instantaneous), providing a paper trail, creating the opportunity to communicate with many people at one time, and providing freedom of location and time of day for both sender and receiver.

In the early days, transmitting drawings took a lot longer. They were typically mailed through the United States Postal Service. Or, if they needed to move faster, the most common method for local clients was to hand-deliver them. For clients on the other side of the state, we would take drawings to the local Greyhound terminal and send them on a bus ride. (Not quite as slow as the Pony Express, but close.) And for clients outside of the state, I would often take drawings to the airport and send them by United Airlines air cargo. With time, the speed and efficiency of services like FedEx became the dominant means of transmitting drawings and other important documents.

Instead of bus, airplane, or FedEx, you could also send a letter using a telecopier machine that could transmit a low-resolution copy of a letter by phone lines at the lightning-fast speed of over six minutes per page. In the early '80s, the technology of fax machines became available, and transmission speeds became about six times faster. Our first fax machine cost about $3,800 ($10,000 in 2021 dollars) and used thermal paper for printing. This technology was a game-changer even though the width of a document was limited to 8.5 in. There were times when a full-size drawing needed to be sent somewhere immediately. The solution was to cut the drawing into 8.5-in.-wide by 42-in.-long strips and feed them through the fax machine so that the recipient could tape together the long thermal paper strips at the other end. By the early 2000s, the fax machine was pretty much made obsolete by the internet.

Of course, the most common communication device was the telephone. In 1975, only the most senior engineers had phones at their desks. For young engineers and drafters, six people would share one phone. It was a wonderful day when everyone got their own phone. Fast-forward to today: At MKA, we no longer have phones on *anyone's* desk. The entire office is Zoom-based. Engineers can use their computers to make voice and video calls at their pleasure. And, as a bonus, an engineer can log in to their phone account from home, a job site, a hotel, or anywhere and have all of the same functionality that they would at the office.

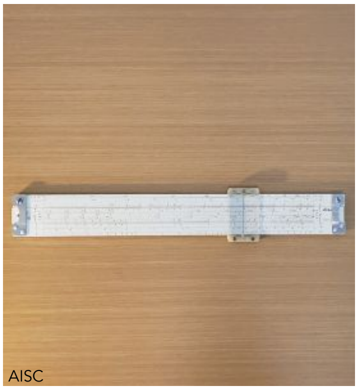
Early phone systems did not have voicemail. Instead, the receptionist would take messages and fill out a "While You Were Out" form. The forms would be placed on a small rack at the front desk for engineers to retrieve upon return to the office. The fact that many engineers would tend to read through everyone's messages provided great opportunities for practical jokes. A friend of mine once left the message, "Agent Jones of the IRS calling. Your tax returns have many irregularities. You must call immediately." Of course, it wasn't really an IRS agent but was simply done to shock my coworkers.

If you were on a business trip, the first thing that you would do after getting off of the plane was to find a payphone, use your long-distance calling card, and call the office. If it was during business hours, the receptionist would read you your messages. If not, everything would have to wait until the next day.

Where am I going with all of this? To make it abundantly—and nostalgically—clear, the advent of instantaneous communication, both inside and outside the office, and the ability to communicate from anywhere and at any time have made profound improvements to the speed of delivering structural engineering services.

Concept Design

Some elements of concept design have remained unchanged over the years. The inspiration, experience, and innovation still come from the minds of the engineers collaborating with other design professionals, contractors, and project owners. On most projects, the calendar time for concept development has not changed that much. However, the level of detail and the number of concepts considered have increased substantially. While we have the ability to study so many more options, it is an open question as to whether the speed that allows this volume always creates additional value. And, as one of my colleagues recently shared, an engineer now has the ability to go really fast toward the wrong answer. This is why the knowledge and experience of the engineer are just as important now as ever. An engineer should know the answer before the computer is allowed to run.



AISC

Seth Morabito

Slide rules and scientific pocket calculators like the revolutionary HP-35 (introduced in 1972) were the tools of the trade for structural engineering back in the day.

Computing

In 1974, during my junior year as a civil engineering student at the University of Washington, the primary tool for many calculations for students, faculty, and practicing professionals was the slide rule. If you are not familiar with a slide rule, it could easily perform multiplication and division, but the user could only determine the digits of the answer without any indication of where the decimal point occurred in the numbers. The engineer had to determine the proper order of magnitude and place the decimal point.

The engineering world changed when Hewlett-Packard introduced the HP-35, the world's first scientific pocket calculator (named for its 35 keys). This $395 machine (about $2,400 in 2021 dollars) placed decimal points, performed trig functions and square roots, and could even "remember" five numbers at a time. It immediately increased the productivity of its engineer users. Over the years, there was a steady stream of advancements in pocket calculators by HP and other manufacturers.

In 2000, on a family trip to the Smithsonian Institution, we visited an exhibit on the history of computing. It started out with a computer the size of a room and finished with pocket calculators, one of which was the HP-35. It is a little unsettling when you tell your kids that the calculator model you used as a student and for several years as a young engineer is in the Smithsonian. Isn't a museum for old stuff? And that was "only" 21 years ago!

As a young engineer fresh from Berkeley with my master's degree, I was often asked to perform structural analysis on some pretty large structures. The primary tool was an analysis program named (appropriately and for more than one reason) STRESS. Computer cards were used for input. The program had a capacity of 125 joints and 250 members. Within these constraints, structural models often needed to be simplified to run. Techniques like using symmetry and adjusting boundary conditions allowed the engineer to only model half, or even a quarter, of the actual structure. While this created more upfront and post-processing work, it was the only way to perform the analysis. As both hardware and software capabilities increased, it became possible to simply include the entire structure in the model.

A STRESS model at full capacity of joints and members would take three hours to run. Today, the same model run-time would be measured in fractions of a second.

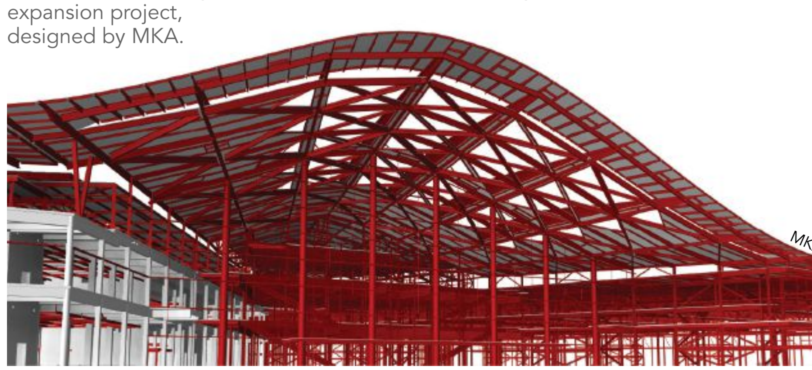
Consider this: We designed a 76-story office building with a triangular braced frame core in Seattle in the 1980s. All of our basic design was done using a plane frame model for each side of the core. To complete the final design, we created a 3D space frame model of the entire core that required 14,000 computer cards for input (yes, computer cards, and yes, 14,000 of them). It would take half an hour just to run the cards through the reader. Each run of this model would take 10 hours at a very expensive outside computer service. Today, a model of this size would be finished in less than 30 seconds.

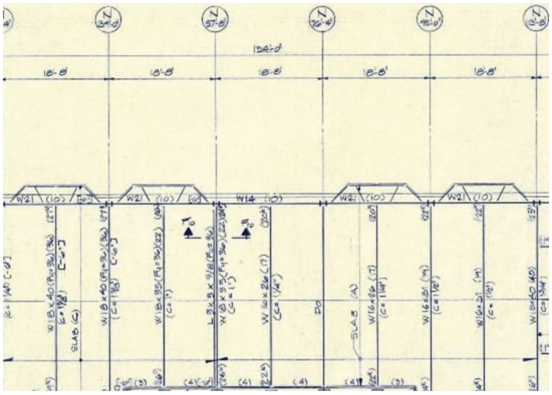
The expense of outside computing costs inspired us to purchase an IBM mainframe computer to use in-house. It had a whopping 8 MB of memory. It also provided our first opportunity to have access to a computer from each engineer's desk.

Today, we have models with more than 200,000 lines of input. These models make the "huge" 14,000-line models of the past seem small. The ability to create such large models is due to advanced preprocessing model generators.

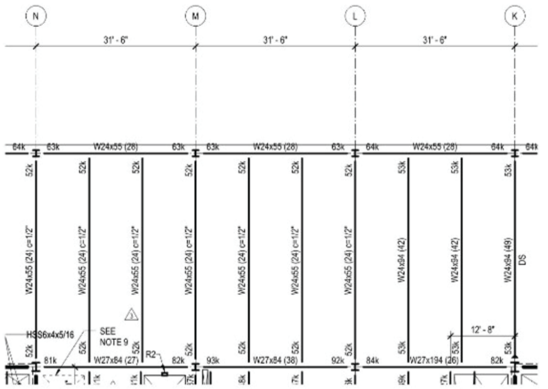
above: A virtual meeting using mixed reality.

below: A 3D building information model of the Las Vegas Convention Center expansion project,
designed by MKA.





Floor framing plans from 1980 (above) and 2021 (below).



Trimble XR10 with HoloLens 2 is an example of mixed-reality (MR) technology for use in the field.

Trimble

Great advances have occurred in model visualization for both input verification and analysis results. Model geometries can be checked with 3D views that can be rotated in real time. Stress levels in members are easily viewed with color-coding. This has increased both speed and accuracy.

Another evolution is the increased use of non-linear, time-history analysis. The hardware and software of today have made this kind of analysis possible in a design office. So, for major projects, much more work is being done in a shorter period of time.

The design software for structural members was fairly advanced when I started my career because we had written most of it in-house. Structural member design software is now universal in design offices. And even though code requirements have gotten more complex, computing power has continued to offset those impacts.

Needless to say, today's typical structural engineer does many more calculations in much less time.

Drawings

The look and content of structural drawings today really aren't all that different from the drawings from decades ago. However, the process of creating the drawings has changed dramatically.

In 1975, each drawing was printed from a single vellum that was drafted with a pencil. All of the grid lines, title blocks, and repetitive information had to be recreated on each sheet of the set. A short time later, our drawings transitioned to using ink on mylar.

In the '80s, taking advantage of the strength and dimensional stability of mylar, pin-bar drafting was adopted. With this method, each sheet of mylar was punched with a series of alignment holes across the top. Multiple mylars could be placed on top of each other using the pins attached at the top of the drawing board to maintain precise alignment of each sheet. The drafter would draw grid lines on one mylar, place it on the pin bars, and then place another mylar to draw framing plans. This was the brute force approach for what we now do as layers in digital drafting. The drawings would then be sent to the reproduction company for assembly into composites and printing the drawing sets.

The late '80s brought computer-aided drafting (CAD). Even though the ultimate product of CAD, a 2D drawing, was unchanged from before, the process was very different and offered many efficiencies. Drawings were now digital. No more bus rides, airplanes, or FedEx. Drawings could be sent by wire. The technology created the opportunity for many "draw it once, use it many times" opportunities. It was now possible to have several drafters work on the same sheet of sections and details because they were freed from the confines of a mylar.

On this last point of multiple drafters, I can tell you from personal experience that it is possible for more than one person to work on a hand-drafted structural drawing. John Skilling (my mentor) and I were once in Bangkok at a project concept meeting for a new high-rise building. We decided to make a drawing of the typical floor framing plan to document the discussion, but didn't have much time. So, John and I huddled on opposite sides of a drawing board. I was working from the top drawing lines, and he was working from the bottom doing lettering. The client was so amazed to see two people working like this on a single drawing that they ran and got their camera and quickly started taking multiple pictures. The next month, we appeared in the developer's monthly newsletter. So, it is possible for more than one person to work on a mylar.

And, of course, the latest advance in creating drawings was the introduction of 3D building information modeling (BIM) in the 2000s. This was a major departure from, and is much more robust than, CAD. The process is completely different, and the product is much more comprehensive than a 2D drawing.

The important process of shop drawing review has also changed dramatically. As a young engineer, I would receive a roll of shop drawings, place reviews comments on one set of prints, and then transfer those same marks onto multiple sets of prints (as many as four sets) for return to the rest of the team. Again, today speed and accuracy have dramatically improved with total electronic review of drawings. We have even completed reviews directly using the detailer's model.

The Finish Line

Have we reached the ultimate speed? Not a chance.

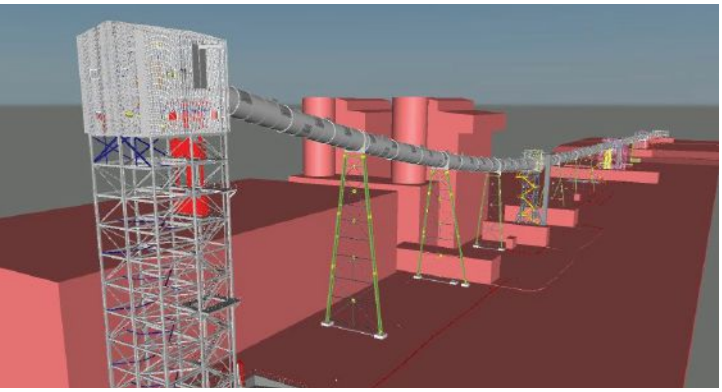
A few predictions for where we might see more velocity:

- Advancements will be made in the analysis-to-design-to-drawing interface. This is an area where the profession has already made some improvements, but there is an opportunity for even more. Many commercial software programs are now providing application programming interfaces (APIs). The opening of these programs will make the design process more efficient.
- Redundancy in modeling will be eliminated to shorten schedules. Through innovative project delivery, detailers will function within the design time to produce a single construction-focused steel model.
- Video conferencing will improve by using mixed-reality (MR) technology for 3D virtual meetings, resulting in less time spent traveling. Live meetings will not be eliminated but rather reduced in frequency. The built environment is not about steel and concrete. It is about people, and it is important to still meet in person.

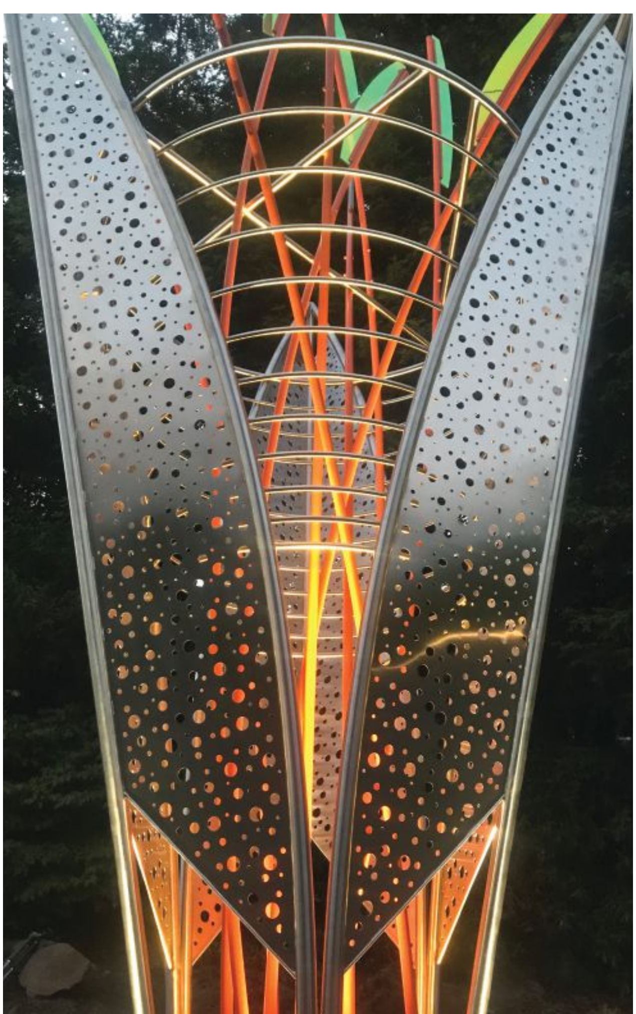
There has been much discussion about the role of artificial intelligence (AI) in the practice of structural engineering. While there may be some limited applications for artificial intelligence, the profession needs *real* intelligence. Quality practice demands the knowledge, experience, judgment, and wisdom of structural engineers.

Structural engineering practices today move at a pace that was unthinkable 45 years ago and at the same time are even more comprehensive in communicating, computing, drawing, and modeling. This increase in speed was made possible by ever-changing technology. That technology has also improved the speed and quality of specifications and shop drawing review. There isn't a part of a structural engineering practice that hasn't been changed by technology. The net result is projects of unprecedented scope and aesthetics that engineers of 45 years ago could not have even dreamed of. ■

Every year, *Modern Steel* presents a compendium of fun projects—typically smaller and/or more sculptural—showcasing the cool use of steel, as well as other steel-related initiatives and goings-on.



What's Cool in Steel



This year, our list includes a heartfelt thank you note of sorts to healthcare workers, a waterfront canopy that mimics a tree in terms of the shade it provides and the sunlight it absorbs, a cantilevered work platform that lets construction workers “hang out” above a bustling Manhattan sidewalk, a university facility geared toward training the next generation of welders, and more.

Cool Canopy

The twenty-acre Pier Approach promenade serves as a half-mile-long cultural connection between the urban landscape of St. Petersburg, Fla., and the city's harbor. With over 5,300 linear ft of waterfront, the goals were to bring people to the water in a more engaging way and improve the ecology of the area. The waterfront edges provide a variety of spaces for gathering and interacting with the water, including hard and soft edges. The area serves as an active local artisan market during the week and a quiet art promenade during market off hours.

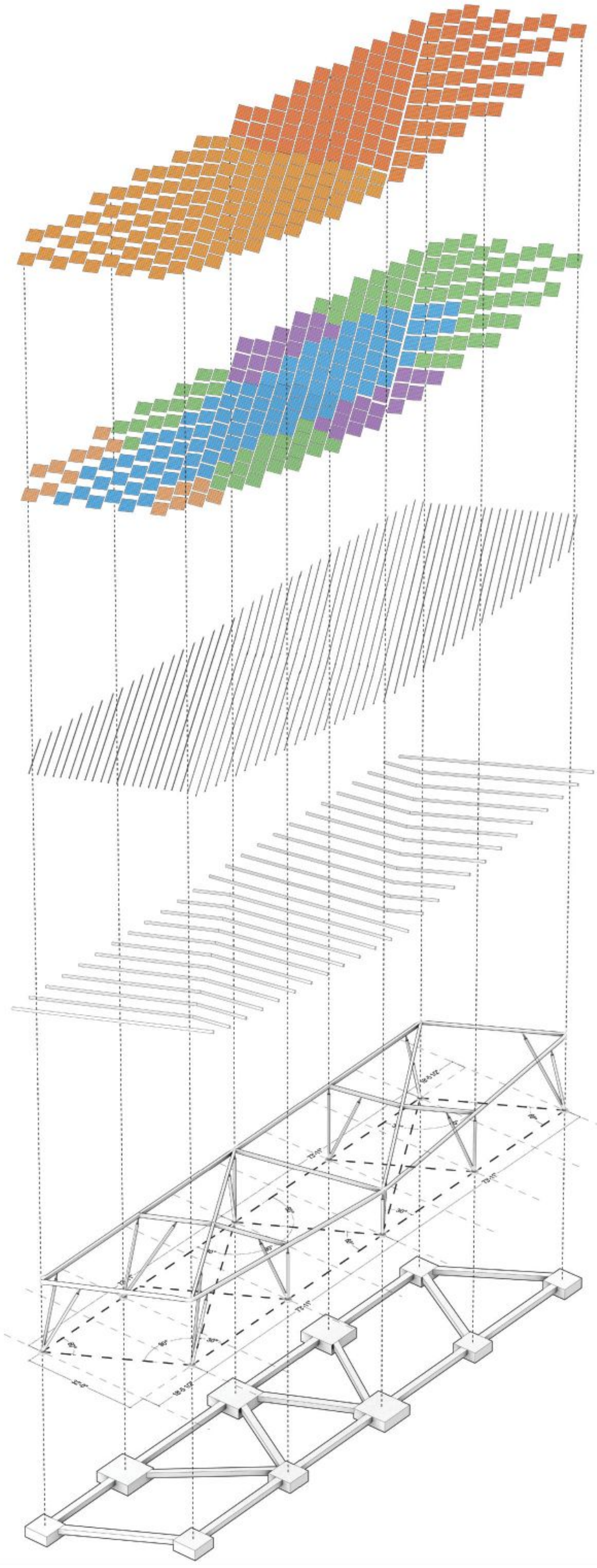
The promenade is highlighted by the steel-framed Pier Market canopy structure designed by Wannemacher Jensen Architects, Inc., and LERA Consulting Structural Engineers. The canopy's triangular folding planes provide support for a solar array that is denser at the center and more spread at its perimeter, representative of a tree canopy. The design of the V-shaped support columns draws its lines and playfulness from the constant rhythmic motion of the masts of the ever-present nearby sailboats.

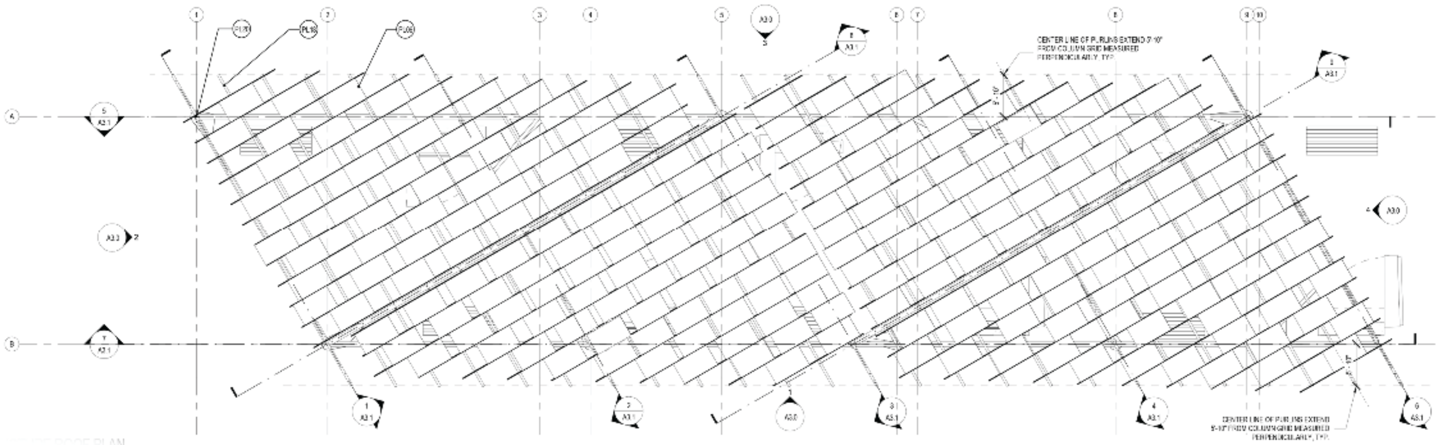
Round hollow structural sections (HSS), fabricated by AISC member E&H Steel Corp., were chosen as the framing material for both their aesthetically pleasing nature and their structural efficiency. And the V-column design scheme was chosen to simplify connections, with both sections of each V welded to a connecting plate rather than to each other. The design minimizes waste by not introducing another roofing material but rather by integrating the structural purlins directly to the photovoltaic panel supports rails.

Since the all-steel structure is completely exposed, one of the main structural challenges was to limit the visual impact of the connections. Accordingly, where possible, structural members were maximized in length to minimize the number of splice locations, and the connections themselves were simplified as much as possible, consisting of a mixture of shop welds and field bolting.

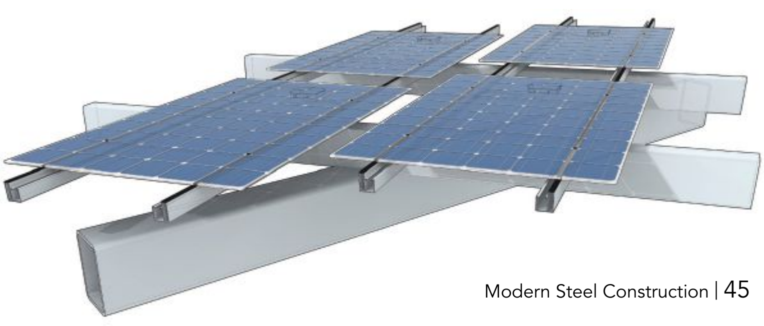
The geometry of each long, rectangular portion of the overall canopy is divided by four triangles that are sloped in varying directions and topped by an array of solar panels that power the pier. The V-columns supporting the canopies are also sloped at various angles that, while appearing to be random and incongruous, were thoughtfully selected by the structural design team to achieve maximum structural efficiency. The column support locations were also optimized using parametric modeling, leading to a careful integration between the structure and the photovoltaic panel support rails. The result is a structure that is at once architecturally dynamic and structurally harmonic, with the spaces between the market stalls and the canopy forming a passage for natural ventilation.

Since the canopies are located on a pier in an active hurricane region, the lightweight nature of the structure had to be addressed. To resist potential uplift from hurricane-force winds, the foundation footings were increased in size to ensure that the mass of concrete would hold the canopy down in the event of a major storm. Further, to counteract gradual corrosion from sea spray, the exposed steel (designated as Architecturally Exposed Structural Steel—AESS—Category 4: Showcase Elements) was hot-dipped galvanized then topped with a field-applied paint coat.





Photos: WJ Architects




Jamin Yeager


Justin Heine


Wayman Furlow

Cool Coal Conveyors

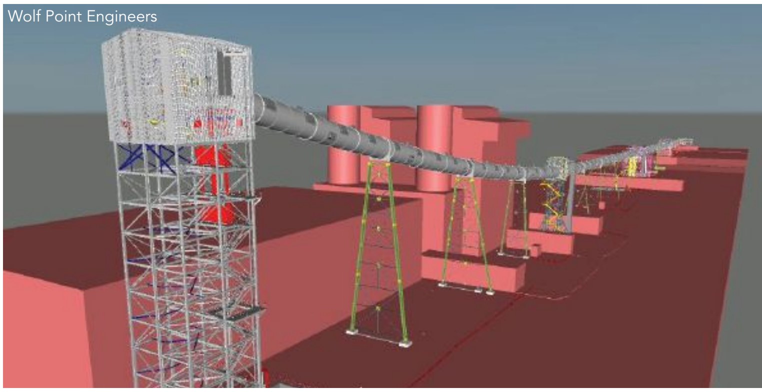
By 2019, two coal conveyors at the Sooner Power Station in Red Rock, Okla., run by Oklahoma Gas and Electric, were nearing the end of their design life and needed to be replaced for safety concerns and the reliability of the power station.

Engineered in the 1970s, the original conveyors were both 2,200 ft long and housed in enclosed galleries supported by a trussed, two-way structural steel system. The trusses were supported on structural steel framed bents that provided lateral support and, at quarter points, on structural steel framed towers that provided lateral and longitudinal support, maintenance access, and safety egress. The foundation system of the existing conveyor system used belled drilled piers, which were slated to be reused, if possible, for the new conveyor system. The change in elevation from the tail to the head of each conveyor was 132 ft.

Structural steel was chosen for this replacement project—which was fabricated by AISC member North Alabama Fabricating Company, Inc. (NAFCO) and designed by Wolf Point Engineers, a division of NAFCO—as it facilitated rapid erection of the structures during the allotted plant outage and also allowed for prefabrication to the greatest extent possible before construction began. Other materials were not really considered as they would not be suitable or cost-effective for the application and schedule. The entire removal and replacement of the 2,200 ft of the original dual conveyors had to be completed within a short shutdown window of just eight weeks. In addition, the locations of the cranes, the staging of the new gallery components, and the placement of the removed sections of the old gallery had to be configured around existing structures and over a 200-ft-wide intake channel waterway.

For the replacement system, the design team chose a solution involving structural steel towers and two-legged support bents with the conveyors enclosed in a 12 ft, 6-in.-diameter tubular steel plate gallery with a single center walkway. This solution offered several benefits. For one thing, fully enclosing the galleries in welded steel plate tubes facilitated the containment of dust and capture of water used for washing down the conveyors. In addition, the steel tube acted not only as the enclosure but also as the structure itself, and the tubes were able to span up to 200 ft. Preassembly was another advantage. The steel tube sections, their internal structural steel, conveyors, and most of the piping and conduits could be fully preassembled in a fabrication shop prior to shipping to the site, helping to reduce field costs and construction activities at the project site. Since


Wolf Point Engineers


Wolf Point Engineers


Waldemar Miczek


Wayman Furlow

the installation of the structures and conveyors would take place during a plant outage, this was a major benefit. Finally, using a single-diameter cross section of the tube structure allowed for a lot of standardization of the steel design, engineering, modeling, and fabrication.

The final design of the completed structural system included 2,110 ft of tube, three structural steel egress and equipment access towers (63 ft, 71 ft, and 82 ft tall), and 17 two-legged support bents ranging from 10 ft tall to over 110 ft tall and up to 40 ft wide. The total weight of structural and tube plate steel supplied for this project was approximately 1,325 tons.

The tubular gallery significantly reduced wind pressure due to its cylindrical shape and, in most cases—particularly at the lower gallery heights—some of the existing foundations were sufficient for the new structure. The gallery was also equal to or somewhat lighter than the existing system in some places. However, the controlling design issue for most of the bents was uplift instead of downforce, so the weight was not as important as the wind-force coefficient of the gallery. Some of the old foundations were incapable of resisting the uplift and, therefore, were replaced. Thanks to the connection options available via steel framing, the team was able to engage some of the existing foundations to help resist lateral forces, the controlling design force direction on some of the newer drilled piers that were added. By load sharing the lateral forces via structural steel struts between the new and existing drilled piers, new drilled pier costs were reduced.

Additionally, the team had to modify the existing transfer tower building steel framing to support a completely different structural system. This required new bracing, reinforcing steel, a completely new sub-frame to support the new tube gallery, an existing W21×55 beam being reinforced and notched 13 in., and a braced portal frame being welded in place to allow for the passage of a new chute.

The tubular gallery also needed to be designed with numerous large rectangular openings, including 69-in. by 44 in. openings to facilitate explosion relief panels and 24-in. by 54-in. openings for ventilation louvers. Since the gallery was made continuous from tower to tower, there was no way to avoid the openings being at locations of high stress. Since the tubes were made of steel, the team incorporated finite element analysis to see where stress concentrations would occur, then moved or reinforced the openings as needed to keep the overall tube plate thickness consistent for the whole structure.

Cantilevered Work Platform

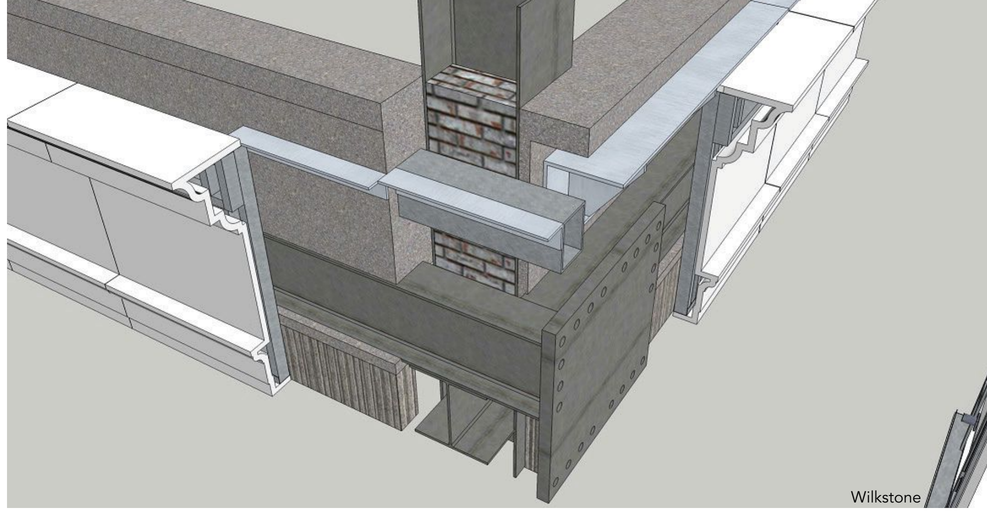
New York's sidewalks are integral components of the public realm. These connectors are places where people meet, gather, stroll, sit in cafes, and window shop.

At their best, the city's sidewalks enhance the urban environment and meet the needs of pedestrians, making the city livable and beautiful. Often, however, this quality of life is compromised by the ubiquitous sidewalk shed, a temporary structure needed during construction and façade maintenance to keep pedestrians safe and protected from the dangers of the construction work.

The typical sidewalk shed is erected from a kit of parts: posts, beams, and diagonal braces clamped together with timber planking and/or corrugated sheeting as the deck. The sheds disrupt the flow of pedestrians, cast dark shadows, and block the views of business signs and display windows. Typical sheds are also subject to impact load from cars or trucks, which could affect their overall stability.

But a renovation project at the historic Crown Building, located on the corner at Fifth Avenue and 57th Street in one of the world's premier shopping districts, took an elevated approach to the traditional shed concept. Designed by Gensler and Gilsanz Murray Steficek LLP Engineers and Architects, the project employed a cantilevered work platform on two sides of the building, thereby protecting pedestrians during future exterior work on the building while providing a column-free space down to the sidewalks.

The cantilevered work platform projects 21 ft beyond the building façade and protects the public on the heavily trafficked sidewalks 47 ft below. This first-of-a-kind design, which required significant retrofit of the existing structure, offers a column-free alternative to traditional sidewalk sheds with three significant benefits: It improves the pedestrian experience by allowing unobstructed movement, it enhances the retail experience by ensuring the renovation work is completed without blocking the storefronts, and it eliminates the potential for vehicular impact. Steel was the logical material for constructing a cantilevered platform of this size; any type of concrete would have been too heavy by itself without the imposed construction and live loads, and timber and aluminum were impractical due to their load and span limitations. Island Steel and Detailing Corp. (an AISC member) served as the fabricator for the platform's structural steel framing as well as some interior framing.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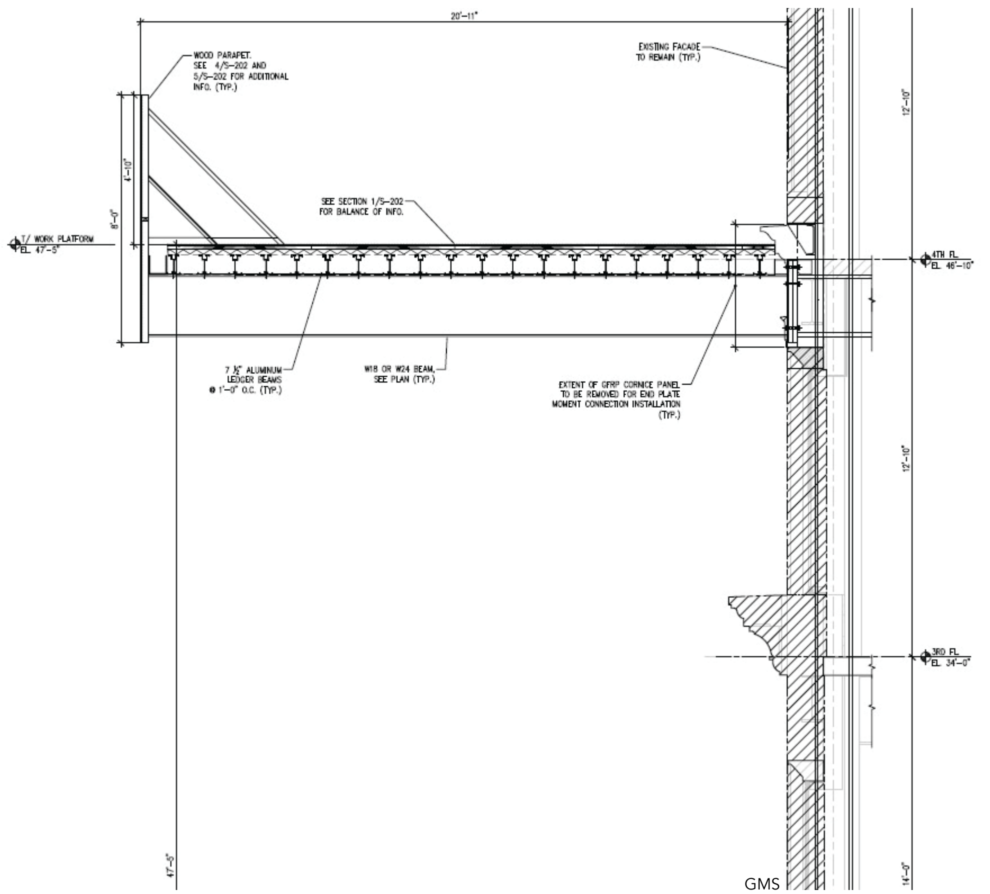
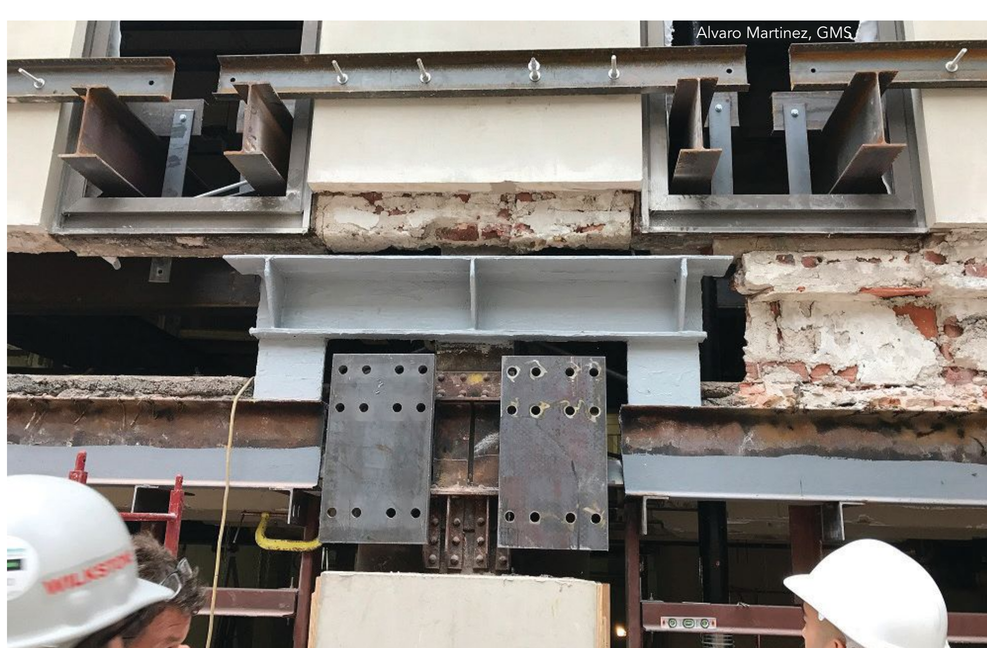


GMS


Alvaro Martinez, GMS

Alvaro Martinez, GMS

Alvaro Martinez, GMS


Alvaro Martinez, GMS

The design team met with the NYC Department of Buildings during several stages as the design progressed from concept to completion in order to obtain feedback and approval for this unusual sidewalk protection scheme. Construction of the structural alterations occurred over two major phases. First was the interior work, which included the reinforcement of the perimeter columns between the cellar and fifth floor to accommodate the loads of the working platform and the cantilever back-arms, retrofitting the existing façade, and installation of removable glass fiber reinforced concrete (GRFC) panels to cover the permanent end-plate connections. Second, the exterior phase included installing the cantilever steel members, intermediate framing, and working platform deck. These items were erected at night and constructed prior to the start of the upper-level façade work.

New interior steel girders were installed on both sides of the existing girders (perpendicular to the facades) at all exterior bays along Fifth Avenue and 57th Street (except the corner bay) to transfer the additional working platform loads directly to the reinforced existing building columns without imposing significant additional bending stresses. The existing interior beams within these bays were shored, cut, and reconnected to the new steel girders. The existing spandrels were reconnected to the perimeter columns above the fourth-floor framing level via a kinked shear connection prior to insalling the new girders. This permanent connection, hidden within the reconstructed exterior wall, also served as temporary shoring for the spandrel beams to allow the installation of the interior girders and provided the necessary clearance for the future installation of the 1½-in.-diameter bolts at the end-plate connections. At the corner bay, the existing spandrel beam along Fifth Avenue was replaced to facilitate the installation of two new built-up box members. Permanent end-plates were installed between the exterior flange of the perimeter columns and the removable fourth-floor GFRC cornice to serve as the connection points for the reusable exterior steel cantilever beams which support the work platform.

The interior structure required to support the work platform is permanently integrated into the building and will remain available for use as needed. The exterior work platform structure can be removed and replaced as many times as required for future work on the building, and the concept can be easily incorporated into new construction, similar to window washing or other maintenance provisions.

Cool Gateway

In a pocket park bordering the intersection of two main approaches at the northern edge of Lake Oswego, Ore., the city sought a gateway artwork.

After a competitive process to create an iconic installation, the Arts Council of Lake Oswego commissioned the *Flourish* sculpture by Ed Carpenter. Installed this past September, it addresses pedestrian and vehicular traffic along sightlines from the north and south.

The 25-ft by 15-ft by 15-ft sculpture is made from 304 stainless steel (fabricated and erected by AISC member The Lynch Company, with steel curved by AISC member bender-Roller Albina Company, and coated with an epoxy-based system with a UV clear coat) topped with laminated glass "fins" and bolted to a concrete foundation.

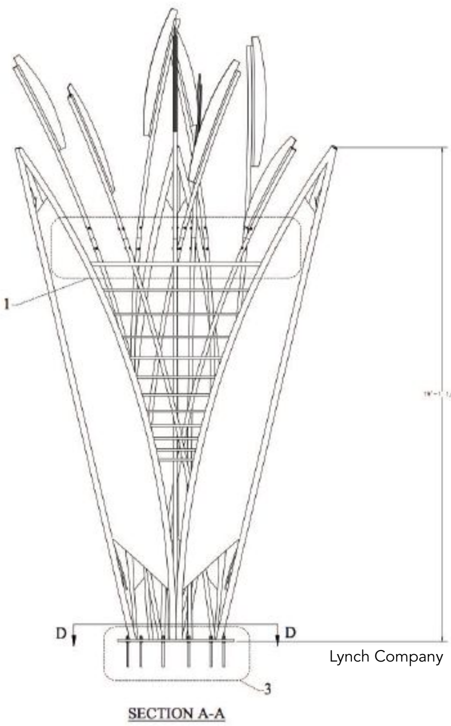
Lake Oswego's citizens see their city as beautiful, friendly, peaceful, clean, and green, among other qualities, and the area is known


Ed Carpenter

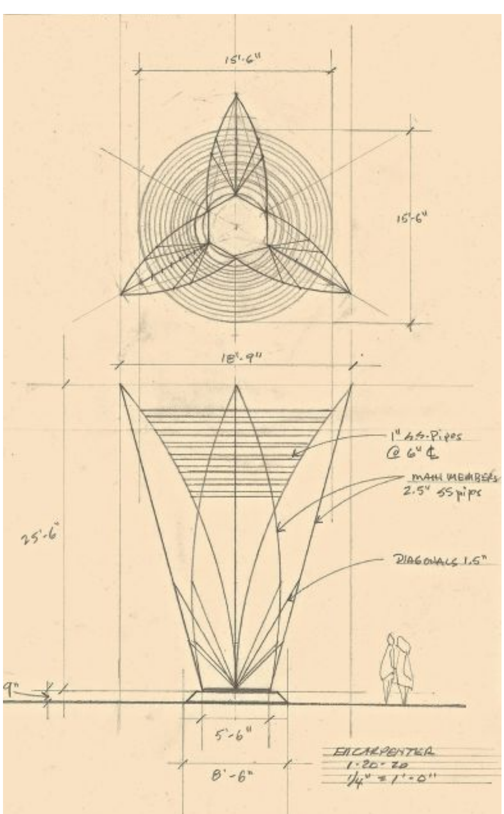

Ed Carpenter


Mario Gallucci

for its verdant trees and flowers. Therefore, Carpenter developed an abstractly botanical theme for the sculpture, with associated positive metaphors. Positioned along the side of the road near the park's entrance, the sculpture's natural form both stands out and blends in, and up-lighting causes it to glow like a beacon at night.

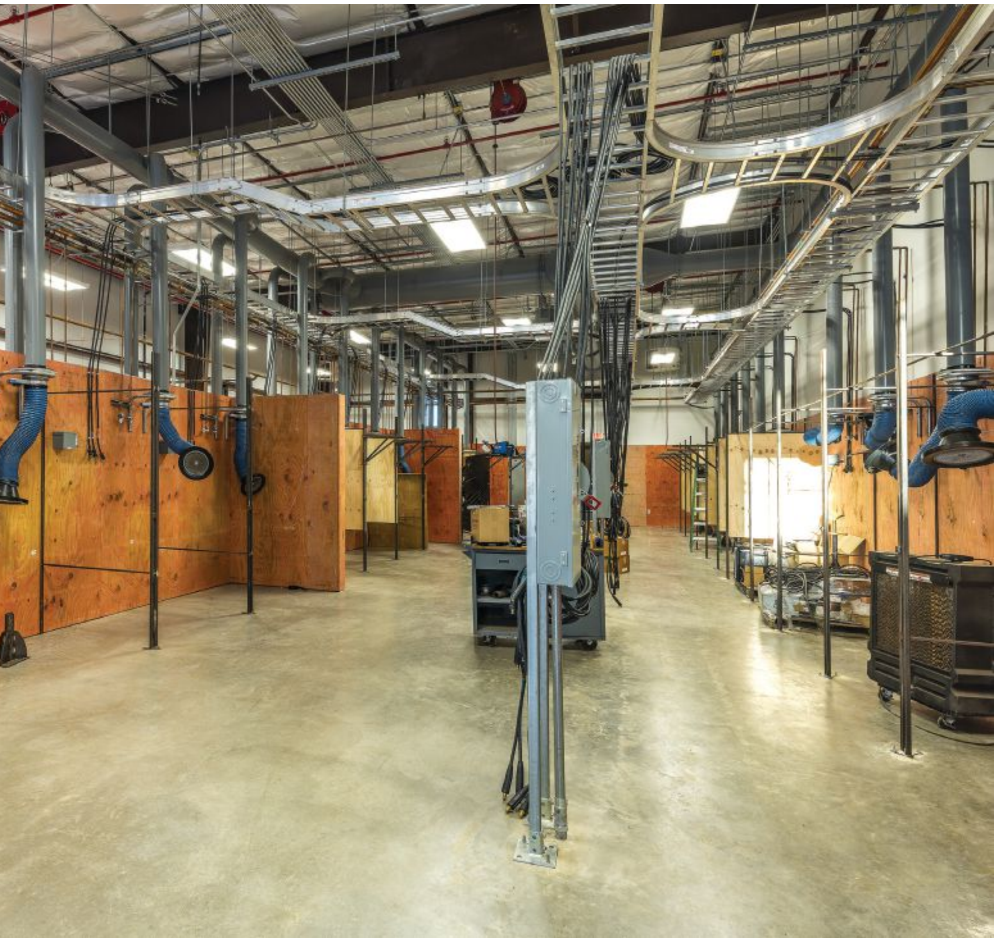


Lynch Company



Ed Carpenter

Images courtesy of RELLIS except as noted



Cool Classroom

For the last several years, 23-year-old Ulises Cruz, who was born in a small ranching community in Mexico and came to Texas when he was about 9, has been trying to figure out what to do with his life. He attended high school in the small town of Kaufman, just southeast of Dallas, and after graduating, his girlfriend encouraged him to try studying nursing. He tried it—and hated it.

So last year, on a whim, he decided to enroll in a welding program at the newly opened RELLIS Agricultural and Workforce Education Complex (AWEC) in Bryan, Texas. AWEC is under the Texas A&M University system and opened its doors in 2020, offering students the opportunity to learn various trades such as welding, electricians, plumbing, even floral design.

"Sometimes they have to kick me out," says Ulises, who says he loves learning everything about the trade. "I love being there. I like getting dirty."

The education that Ulises and countless others are receiving through this program is truly changing higher education for students. Another RELLIS student, 29-year-old Maureen Victoria, is currently studying to obtain her PhD in Agricultural Leadership Education so that she can teach at a college level. The AWEC campus has allowed her to learn new ideas and concepts that will one day benefit her students. This past year, 275 students were enrolled in the welding program offered by nearby Blinn College, an Academic Alliance partner with RELLIS.

So why is this program important? The RELLIS campus allows students to shift ideas from laboratories to the marketplace in multiple industries, especially those that are in need of more skilled laborers. It also offers student debt relief. Through this program, students obtaining their degrees (at Texas A&M or elsewhere) can take courses to learn a trade and earn money to pay for tuition while they're in college, providing an alternate pathway towards obtaining a college degree while also learning a trade. And in the case of the welding program, it provides students who want to pursue a degree in, say, structural engineering or industrial technology to gain a deeper and more comprehensive understanding of how structures come together, thereby helping to bridge the communications gap that can occur between the various design and build parties on a project.

Photo courtesy of Bob Baker

"The RELLIS Academic Alliance is a unique opportunity for students in that they can pursue training in the skilled trades and pursue an academic degree all on the same campus," said James K. Nelson, PE, PhD, associate vice chancellor and director of the RELLIS Academic Alliance. "It also provides great flexibility in that a student can pursue a trade only, or they can pursue a skilled trade certificate and work in that area while pursuing a degree, thereby likely reducing the amount of student loan debt that may be incurred."

And the building itself presents a teaching opportunity.

"The RELLIS Agriculture and Workforce Building is a state-of-the-art facility to educate the next generation of steelworkers," explained Jessica Brehm Soliz, AIA, associate principal with PBK Architects, Inc., which designed the building. "The Classroom and shop buildings used multiple types of steel structural systems to be able to control building costs, meet the tight construction deadlines, and to be able to maximize the amount of obstruction-free instructional and works spaces. These facilities provide a real-world environment to educate the students in all aspects of the industry."

Soliz explained that the complex used two primary building methods: pre-engineered steel building construction and conventional steel construction. This gives students a visual tool to understand the similarities (design, foundations, framing, and finishes) and differences (process, built on-site versus pre-fab elements delivered to site) between the two methods and consider factors such as flexibility in design, labor costs, construction waste, maintenance requirements, erection speed, and overall cost.

"The building was also designed to ensure that the students will completely understand all the different welding machines, the skills needed to work on any shape or style, and provide an environment with a holistic understanding of the industrial processes," continued Soliz.

"Over the last two decades, there has been a significant decline in obtaining a skilled workforce within the construction industry," said Marty Garza, higher education market leader with Bartlett Cocke General Contractors, AWEC's general contractor. "AWEC is providing a solution to this growing problem by educating today's youth of the benefits a career in construction can provide them while offering the training required to master these skills."

And several students have embraced the program.

"I got into structural welding because I have a buddy who was into it, and my dad is an architect and builds hotels, so I have been around the construction field, doing construction all my life," said RELLIS welding student Taylor Roesler. "My buddy introduced me to the welding side of construction. I have been welding ever since, and that is what I want to do with the rest of my life."

"I kind of fell into the field in high school," said another student, Jacob Salvato. "I ended up taking a welding class and fell in love with it. I researched my way through trying to figure out what I wanted to do, and structural is where I fell. From what I have found, there will be more job opportunities for me, and it is the kind of welding that I really like to do. There are so many different types of welding and different techniques that you do not get to experience in high school. I have gotten to learn much more than I expected."

Cool Heart

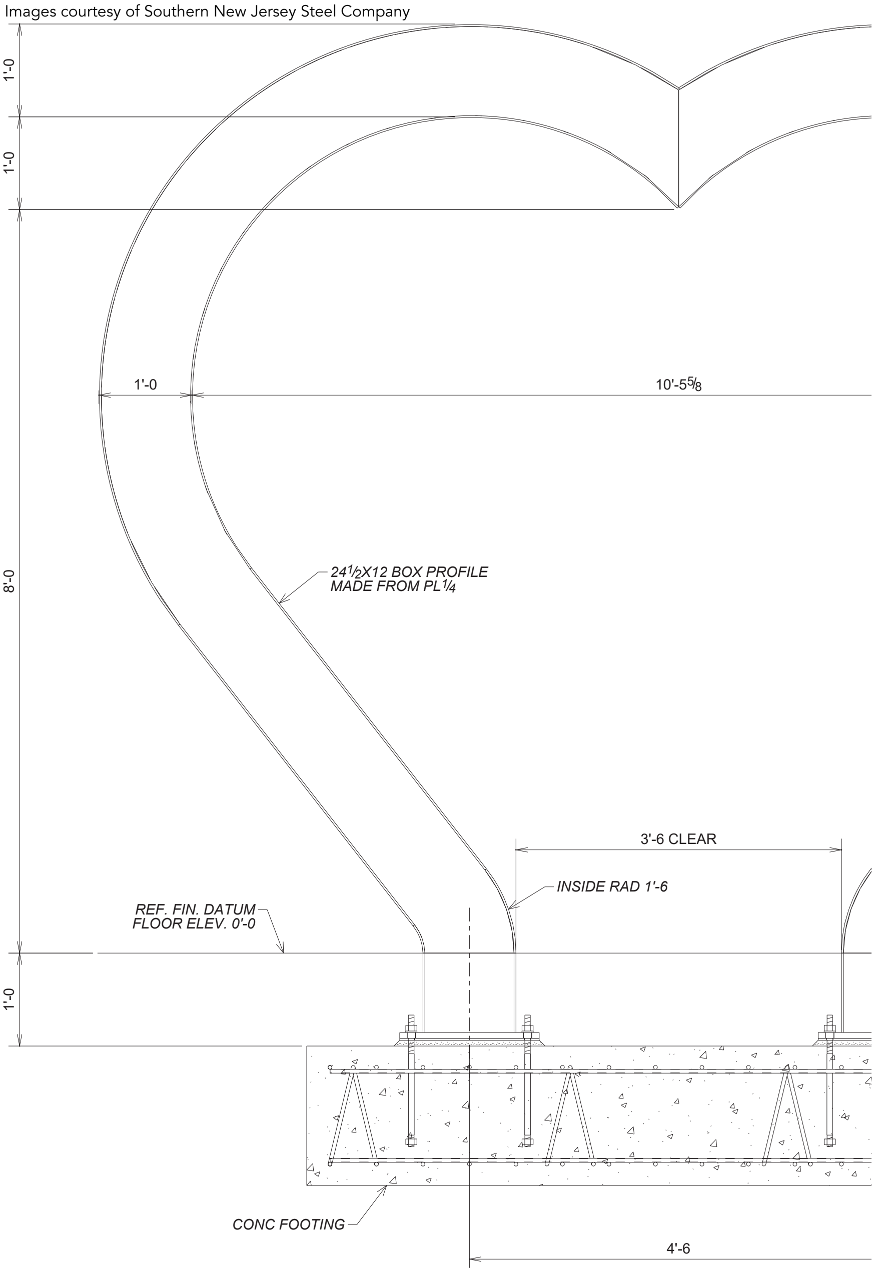
Inspira Medical Center Vineland in Vineland, N.J., wears its heart on its sleeve—or at least outside its front entrance.

The heart, made from structural steel, weighs 2.5 tons and stands 11 ft tall and 12 ft wide. Donated and fabricated by nearby AISC member Southern New Jersey Steel Company (SNJS), the sculpture is part of Inspira's Blue Hearts for Heroes campaign, which recognizes front-line workers in the battle against COVID-19.

Hugh McCaffrey, SNJS' owner, explained how the idea came about.

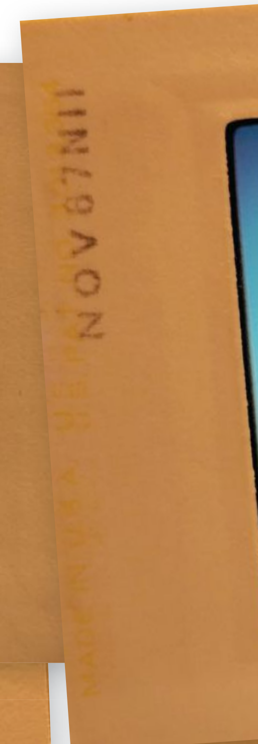
"I sit on the board of trustees of Inspira, and the chairman approached me to see if I could make a steel heart sculpture to tie in with the Blue Hearts campaign," he said. "We found some pictures of hearts that we liked that fit the concept we were discussing, and I informed him we would handle it from there. Plus, we had just completed a brand new $350 million hospital in Mullica Hill, N.J. that included a hand-blown artwork sculpture at its front entrance that was well received," he recalled. "We thought that with the entrance renovations that were in the process at the Vineland hospital, the heart sculpture would fit in nicely at its front entrance."

Images courtesy of Southern New Jersey Steel Company



The team initially considered hollow structural sections (HSS) for the heart but eventually settled on ¼-in. steel plate for its ease of bending. SNJS completed all welding and assembled the two sections in its facility to form one piece. The company also rigged the sculpture to stand upright in its shop so that the painting contractor could come to the facility and shop-apply a primer, intermediate, and finish coat. Following assembly at the shop, the heart was transported to the site and installed as one piece on anchor rods/leveling plates atop the footings/piers designed by SNJS's engineer. The company provided a template to the concrete subcontractor to ensure precision, and then pavers were added to cover the anchor rods and piers as well as provide a walking surface under and around the heart sculpture.

Formally dedicated in November, the heart is permanently anchored in the garden island/walkway at the front entrance of the hospital and will serve as a constant reminder of the hard work and perseverance of healthcare workers.

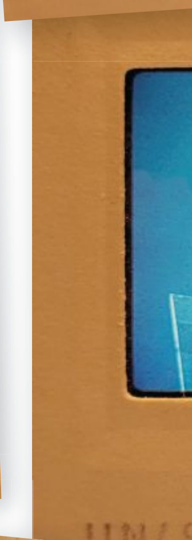


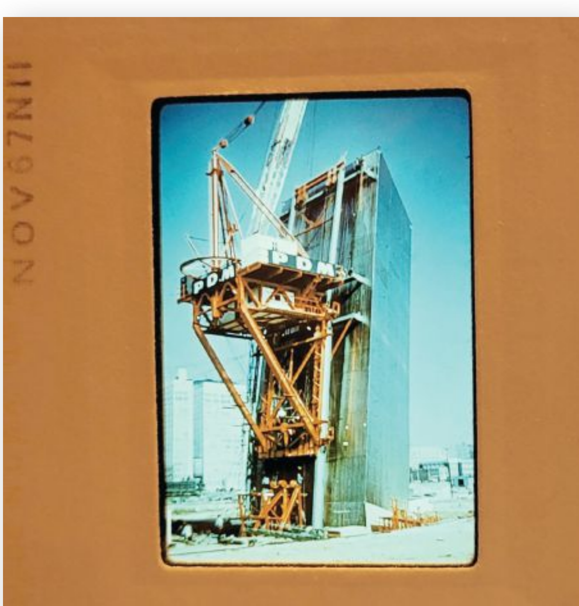
Cool Slides

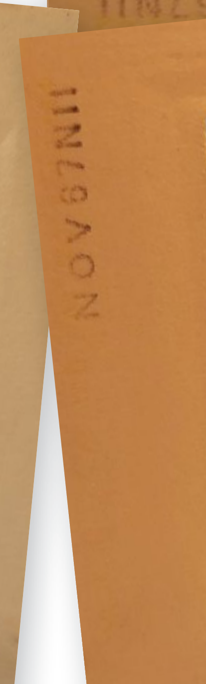
When's the last time you watched a slideshow? Not online but an actual, physical slideshow via a slide projector (if you're too young to know what this is, Google it).

During a recent office clean-up, AISC president Charlie Carter came across several dozen Kodachrome slides showing the construction process for the Gateway Arch in St. Louis (which opened 56 years ago this past October 28). This iconic steel masterpiece on the banks of the Mississippi River was built as the "Gateway to the West" for an overall construction cost of $13 million.

We've selected a handful of slides showing the construction process, which involved erecting triangular steel sections from each side and eventually meeting in the middle at the structure's apex. For more historic photos of the arch, see "(Not) Scratching the Surface" in the 2019 NASCC: The Steel Conference preview issue, available in the Archives section at **www.modernsteel.com**. ■








Scooping up the PDHs
AISC Continuing Education
Live Webinars
December 9
Direct Analysis Method Application and Examples
presented by David Landis
1:30 – 3:00 p.m. ET | 1.5 PDHs
aisc.org/webinars
Education Archives
Did you know that AISC offers 30-minute to 6-hour presentations on demand? Viewing is free—so grab some hot chocolate (extra marshmallows!) and check them out!
And if PDHs are what you're after, you can purchase, take, and pass a quiz to earn a certificate. There are over 200 hours of options to choose from.
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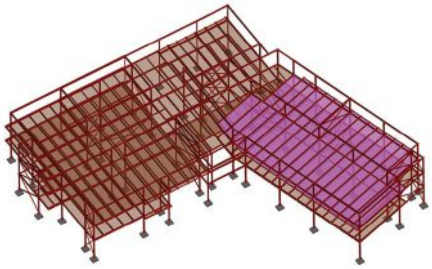
This month's New Products section includes some super software solutions, including the addition of an environmental component to a BIM package, improved code-checking and modeling capabilities to a connection design package, and the latest version of a longstanding analysis package.

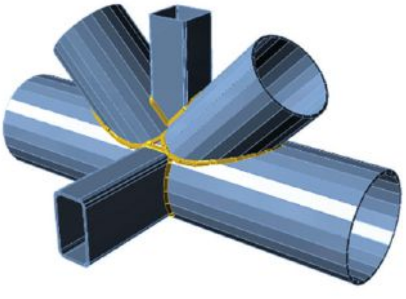
new products

IES VisualAnalysis

VisualAnalysis allows engineers to create frames, trusses, or finite element analysis (FEA) models of just about any structure. Sketch your model or generate/import it from CAD or Revit. Easily apply member or point loads and take advantage of automated area load distribution. Get fast static, P-delta, dynamic, and non-linear FEA results instantly for most projects. Get AISC or CISC design checks with intermediate values, check references, and enough information to double-check everything. VisualAnalysis also works with VAConnect for steel connection design. Download it for free in two minutes and get results within your first hour of use.



Visit **www.iesweb.com** for more information.



IDEA StatiCa 21.1

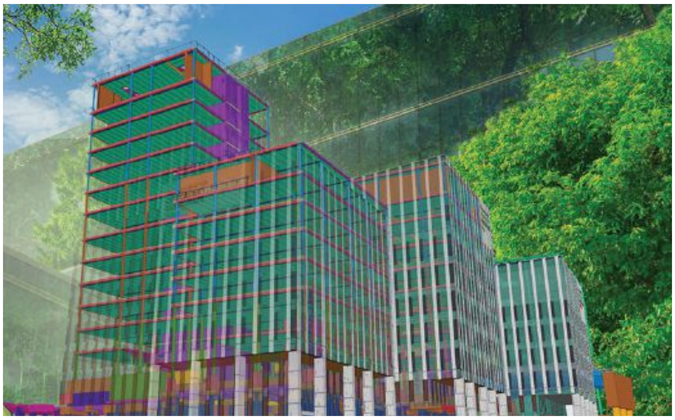
IDEA StatiCa 21.1—the second big update this year—brings code-checking and modeling improvements as well as a new approach to handling repetitive connection designs. The new Connection Browser tool is designed to assist users in finding a suitable design solution from a library of predefined designs and applying them right away. It works with three databases of steel connections: the set that comes within the software, a set that each user can save, and a set of company standards that the user can create (available soon). In addition, the Code-Check Manager application (the gateway to integration with other software packages) has been updated and renamed Checkbot. It provides complete control over imported connections and members, a clear list of all imported items, 3D visualization of imported members and loads, a conversion table for materials and cross sections, and the ability to manage load combinations. It can be started via a third-party application or as a standalone app, enabling users to combine inputs from multiple sources.

Visit **www.ideastatica.com** for more information.

Tekla with One Click LCA

Trimble has entered a collaboration with One Click LCA, which will enable users of the company's Tekla building information modeling (BIM) software to calculate carbon emissions at different phases of a project, helping to move the needle toward a net-zero future for construction. From early analysis and design through to finished construction, combining constructable data from Tekla with One Click LCA and its extensive environmental product declaration (EPD) database allows the embodied carbon emissions of materials in a design—down to every beam, nut, bolt, or rebar—to be calculated for their entire lifecycle.

Visit **www.trimble.com** for more information.



IN MEMORIAM

Ronald Sherrill, Former AISC Board Member, Dies at 72

Ronald "Ronnie" Glenn Sherrill, an AISC Board of Directors member from 2005 to 2018, died peacefully at his home, surrounded by his family, on October 3, 2021. He was 72.

Ronnie was born in Charlotte, N.C., on November 30, 1948, to Blanche Sparks Sherrill and Joseph Glenn Sherrill. He attended Charlotte public schools, graduating from South Mecklenburg High School in 1966 and from N.C. State University in 1970 with a degree in civil engineering. He spent seven years in the U.S. Army Reserve while also starting his career at AISC member fabricator SteelFab, which his father founded in 1955.

Ronnie spent summers and Christmas breaks working at the SteelFab plant and knew at a young age that he wanted to work with his dad in the steel business. He began his career at the company working as a supervisor in the plant and a draftsman. By 1973, he moved into the office full-time, assuming responsibility for sales, estimating, and project management. He became president in 1980 and retired as chairman and CEO in 2017. He often stated that one of the highlights of his life was being able to not only work with his father and two brothers but also his two sons.

He served on the boards of AISC, the Blumenthal Performing Arts Center, Dowd YMCA, McColl Center for Visual Arts, NorthWestern Bank, and First Union, as well as chairing the fundraising committee for Charlotte Muscular Dystrophy Association for several years.

"Ronnie had an infectious smile and was so dedicated to working for the good of the industry," said AISC president Charles J. Carter, SE, PE, PhD. "He got excited about projects we would undertake and would ask me what he and his company could do to help."

Ronnie is survived by his wife, Paulette Eckard Sherrill; sons Glenn and Stuart; stepsons David Brewer and Mathew Brewer; and grandchildren Jack, Will, Luke, Celia, and Sarah.

NEED FOR SPEED

AISC Offering $5,000 Prize for the Next Great Idea in Column Splices

AISC's Column SpeedConnection Challenge is looking for the next great idea in column splice connections—and there is $5,000 on the line for the best concept!

Column splices haven't changed much over time, typically using bolts, welds, or a combination of the two. But what if there is a better way to splice a column?

The keywords are FAST and EASY—to design, fabricate, and erect safely. We welcome all participants with a spark of inspiration and "back of a napkin" idea that we can help develop into a revolutionary concept.

To register for the challenge, visit **herox.com/SpeedConnectionColumn** and click the "SOLVE THIS CHALLENGE" button. The deadline for entry is January 14, 2022.

The SpeedConnection project—part of AISC's Need for Speed initiative, geared toward increasing the speed of steel construction by 50% by 2025—aims to provide speed improvements for how buildings can be erected related to connections. This transformative effort's overarching goal is to develop a solution that "changes the world" for steel connections.

People & Companies

DeSimone announced the recent promotion of **Danilo Nanni, PE**, to the position of principal in the firm's structural engineering practice. Since joining the company in 2006, Danilo has worked on many notable projects in the healthcare, hospitality, and residential sectors, including high-rise and large mixed-use developments.

Walter P Moore has recently promoted several senior principals, including **Manoj Adwaney, PE**, director of civil engineering/Infrastructure, Houston; **Brent Bandy, PE**, senior project manager/Structures, Atlanta; **Steve Blumenbaum, PE**, director of construction engineering/Structures, Tampa; **Dan Brown, PE**; managing director/Infrastructure, Kansas City; **Ernie Fields, PE**, managing director/Infrastructure, Dallas; **Vicki Ford, SE, PE**, managing director/Structures, Dallas; **Bart Miller, PE**, managing director/Structures, Denver; **Rafael Sabelli, SE, PE**, director of seismic design/Structures, San Francisco; **Tim Santi, SE, PE**, senior project manager/Structures, Atlanta; **Ryan Seckinger, PE**, managing director/Structures, Washington, D.C.; **Ted Vuong, PE**, managing director/Infrastructure, Houston; **Mark Waggoner, SE, PE, PEng**, senior project manager/structures, Austin; and **Karim Zulfiqar, PE**, senior project manager/Structures, Houston.

IN MEMORIAM

Billy Gene Heathcock, Former AISC Board Member, Dies at 76

Billy Gene Heathcock, better known as Gene, an AISC Board of Directors member from 1996 to 2008, passed away on October 19. He was 76.

Born July 11, 1945, Gene grew up in the Duke and Alexandria, Ala., communities, where he spent his teenage years farming. He graduated from Alexandria High in 1963, serving as senior class president, and where he was an all-county football star. After attending Jacksonville State University, he moved his family to Atlanta to work with Lockheed. He returned to the Anniston, Ala., area in 1970 and began working at Aseco Steel company. With his partners, he started AISC member fabricator FabArc Steel Supply, Inc., in 1979, which grew to 300 employees, and he retired from the company in 2013.

"We owe a great deal to Gene for his entrepreneurial spirit and vision in molding FabArc Steel into the company it is today," said Tony Pugh, FabArc's president. "We are forever grateful for these efforts. His spirit and ideals are embedded in our way of doing business and how we treat each other.

"Gene was a dedicated and motivated contributor to the activities of AISC," recalled AISC president Charles J. Carter, SE, PE, PhD. "He regularly asked the questions that got our work headed in a better direction."

Gene is survived by sons Eric and Greg; the mother of his children, Doris Heathcock; and grandchildren Kirin, Axis, and Zoe.

SAFETY

AISC Now Accepting Annual Safety Awards Submissions

To a customer, visiting an unsafe shop or job site is like visiting a messy house. Even if safety is not an explicit requirement, its absence leaves a bad impression.

On the other hand, seeing a shop or job site where the organization achieves a commendable level of safety gives a good impression. It is reasonable to think that a company managing safety is also successfully managing production and quality.

This, of course, is in addition to the fact that management of safety is increasingly an important part of many customers' selection criteria—and it is also the law. AISC encourages you to manage safety to achieve that commendable record, and we want to help you display your success with an AISC Safety Award.

AISC member steel fabricators and erectors are eligible and encouraged to submit their company's safety record for AISC's annual Safety Awards. The awards, given in the Fabricator Category and Erector Category, include the Honor Award (DART=0)—AISC's top safety award, presented for a perfect safety record of no disabling injuries—the Merit Award (0<DART≤1), and Commendation Awards (1<DART≤2).

"AISC's annual Safety Awards program recognizes excellent records of safety performance, and we commend these facilities for their effective accident prevention programs," said Tom Schlafly, AISC's chief of engineering staff and director of safety. "Periodic recognition of safety in the workplace has been demonstrated to provide worker incentive and a reminder of the importance of safe practices."

"Owners and clients pay attention to these awards," noted Kathleen Dobson, safety director for Hillsdale Fabricators/J.S. Alberici Construction (an AISC member and certified company). "They want to know that a fabricator or erector is proud of their safety records."

The AISC Safety Awards program is open to all full fabricator members and erector associate members of AISC. For more information about the program, safety resources for the fabricated and erected structural steel industry, and to enter a company for a Safety Award, please visit **aisc.org/safety**. The deadline for submissions is February 4, 2022.

MEMBERSHIP

AISC Board Announces New Members

The AISC Board of directors has approved the following companies for membership.

Full

1888 Industrial Services, Ault, Colo.
Arc Rite Welding and Fabrication, LLC, Pipe Creek, Texas
Castillo Iron Works, Inc., Bronx, N.Y.
Cutting Edge Steel, Inc., Dacono, Colo.
Dynamic Isolation Systems Inc., McCarran, Nev.
Elite Welding and Industrial Services, LLC, Millwood, Ky.
Melvin Wrought Iron, Inc., Ontario, Calif.
RMV Structural Steel, LLC, Mission, Texas
Triad Fabricators, LLC, Evansville, Ind.
W. A. New Steel LLC, Harpersville, Ala.

Associate

Arcusion, Laguna Hills, Calif., *Detailer*
Fabtech Consultant USA, Inc., Houston, *Detailer*
IDEA StatiCa, Brno, Czech Republic, *Software Vendor*
J. Mac Steel Detailing and Design, LLC, Cape Girardeau, Mo., *Detailer*
Marqway Steel Services, Inc., Redmond, Wash., *Detailer*
MLowe Services, LLC, Claremore, Okla., *Detailer*
MoldTek Technologies, Inc., Cumming, Ga., *Detailer*
Prestige Equipment, Melville, N.Y., *Equipment Dealer*
R.M.D. Technical, Clearfield, Utah, *Detailer*
Taylor Devices, Inc., North Tonawanda, N.Y., *New Equipment Manufacturer*
TurnBIM Engineering Services, LLP, Ideal Homes Township, Kenchenahalli, Bangalore, India, *Detailer*

STEEL SCULPTURE

AISC's Steel Sculpture Turns 35

AISC turned 100 this year, and one of our most educational elements—the AISC Steel Sculpture—recently hit a major milestone as well. The first installation of the well-known sculpture turned 35 on October 29. This valuable teaching aid exemplifies the many methods of steel framing and their corresponding connections.

The first steel sculpture was erected on the University of Florida's (UF) campus in Gainesville on October 29, 1986. Created by the late Duane Ellifritt, PE, PhD, Professor Emeritus of Civil Engineering at UF, the structure was envisioned to be a full-size 3D model providing engineering students with up-close, hands-on exposure to structural steel members and connections.

A few years after the first sculpture was installed, AISC requested and received permission to use and promote a scaled-down version of the sculpture as a teaching aid, and modified versions now exist on more than 170 campuses worldwide.

"Duane Ellifritt was an amazing person who combined his love of art with his practice of structural engineering," recalled UF Civil Engineering Professor David Prevatt. "This was nowhere more evident than in his prototype Steel Teaching Sculpture which has been used to teach steel design to steel design here at UF and has spread across the U.S. and to other countries."

"It's always a thrill to visit a campus and spot a steel sculpture," said AISC director of education, Christina Harber. "We know that those students can see and feel steel connections up close to gain a better understanding of what they're designing in class."

You can view the full list of these campuses, as well as images, plans on how to design the sculpture, and information on how to get a sculpture on your campus at **aisc.org/steelsculpture**.

BRIDGES

D.C.'s New Frederick Douglass Memorial Bridge Opens

The New Frederick Douglass Memorial Bridge opened on September 10, 2021—months ahead of schedule.

The steel-framed structure over the Anacostia River in Washington, D.C., spans 1,445 ft and holds six lanes for vehicle traffic as well as pedestrian paths for foot traffic and cyclists. The new bridge, commemorating American abolitionist Frederick Douglass, has helped decongest traffic in the capital city and connect the neighborhoods of Ward 6 and Ward 8 to improve economic development in both communities.

AISC member fabricator Veritas Steel had a significant role in the construction of D.C.'s largest infrastructure project to date. Constructing the bridge was no small feat. The company's Palatka, Fla., plant fabricated and shipped 4,250 tons of structural steel to make up the floor system of the $480 million bridge, and its Eau Claire, Wisc., plant fabricated some of the most complex hexagonal steel arch rib sections in the county. In total, 56 arch rib sections make up the six iconic free-standing arches that were shipped to the job site.

The bridge is now open to vehicle and pedestrian traffic, and two new traffic ovals on either end of the bridge will be reconstructed in the spring of 2022.

Letter to the Editor

Mystery: Solved

In your September 2021 Structurally Sound item "Time Capsule" (available in the Archives section at **www.modernsteel.com**), you mentioned that you couldn't identify, with 100% accuracy, the building the photo was taken from. It was indeed taken from one of the "prime suspects" you listed: the Empire State Building.

Check out page 65 in Lewis W. Hine's book *The Empire State Building*. It's remarkably similar to the September *Modern Steel* photo and is labeled "Steelwork, mooring mast." (I was once an employee of American Bridge and have an extensive collection of books on buildings, bridges, and stadiums.)

—F.D. (Frank) Vespaziani, PE (retired)

marketplace & employment

advertiser index

STEEL SKYLINE

JUST OVER 150 YEARS AGO, in early October 1871, fire reduced the city of Chicago to rubble. In a matter of hours, a bustling metropolis was reduced to smoldering ash.

But the people of Chicago were (and remain) resilient. They took the opportunity not only to rebuild what had been but also to build something entirely new for the future. They laid out a grid system for the streets. They looked for ways to make construction more resistant to fire. And as they built a new model of the American city, they reached for the sky, creating the first skyscrapers.

Today, the legacy of those extraordinary Chicagoans who embraced the opportunity in disaster lives on in remarkable architecture and engineering. We invite you to marvel at the innovations of a Chicago forged in fire—built stronger and better in steel.

Earlier this fall, the Chicago Architecture Center **www.architecture.org** celebrated the city with the in-person site visit portion of its popular Open House Chicago **www.openhousechicago.org** event, an annual happening where Chicago's famous (and not-so-famous) landmarks open their doors for visitors to get a glimpse of sumptuous interiors and behind-the-scenes spaces.

To do our part, AISC rereleased its popular walking tour, Chicago: City of Steel, available at **aisc.org/chicago**. Whether you take the walking tour in person on a crisp fall (or brisk winter) day or browse the sites virtually, you'll learn how steel has shaped the landscape of the city AISC calls home.

One of the buildings on the tour is also one of the city's earliest prominent—and most visually stunning—skyscrapers, the Carbon and Carbide Building, which opened in 1929, less than a decade after AISC was founded (in 1921). Designed by Burnham Brothers (founded by Hubert Burnham and Daniel Burnham, Jr., the sons of famed Chicago School architect Daniel Burnham), the steel-framed, 500-ft-tall, 37-story Art Deco tower (pictured here from AISC's elevator lobby) is known for its green terra cotta cladding and gold-leaf trim, elements that led to the urban legend that the building was designed to resemble a massive champagne bottle.

And if you hadn't heard, AISC turned 100 this year! For excerpts from a soon-to-be-released book celebrating AISC's first century of existence, check out the related articles in the September, October, and November issues. And to learn more about AISC reaching this milestone, visit **aisc.org/legacy**. ■


THE COUNTDOWN HAS BEGUN
LINCOLN ELECTRIC