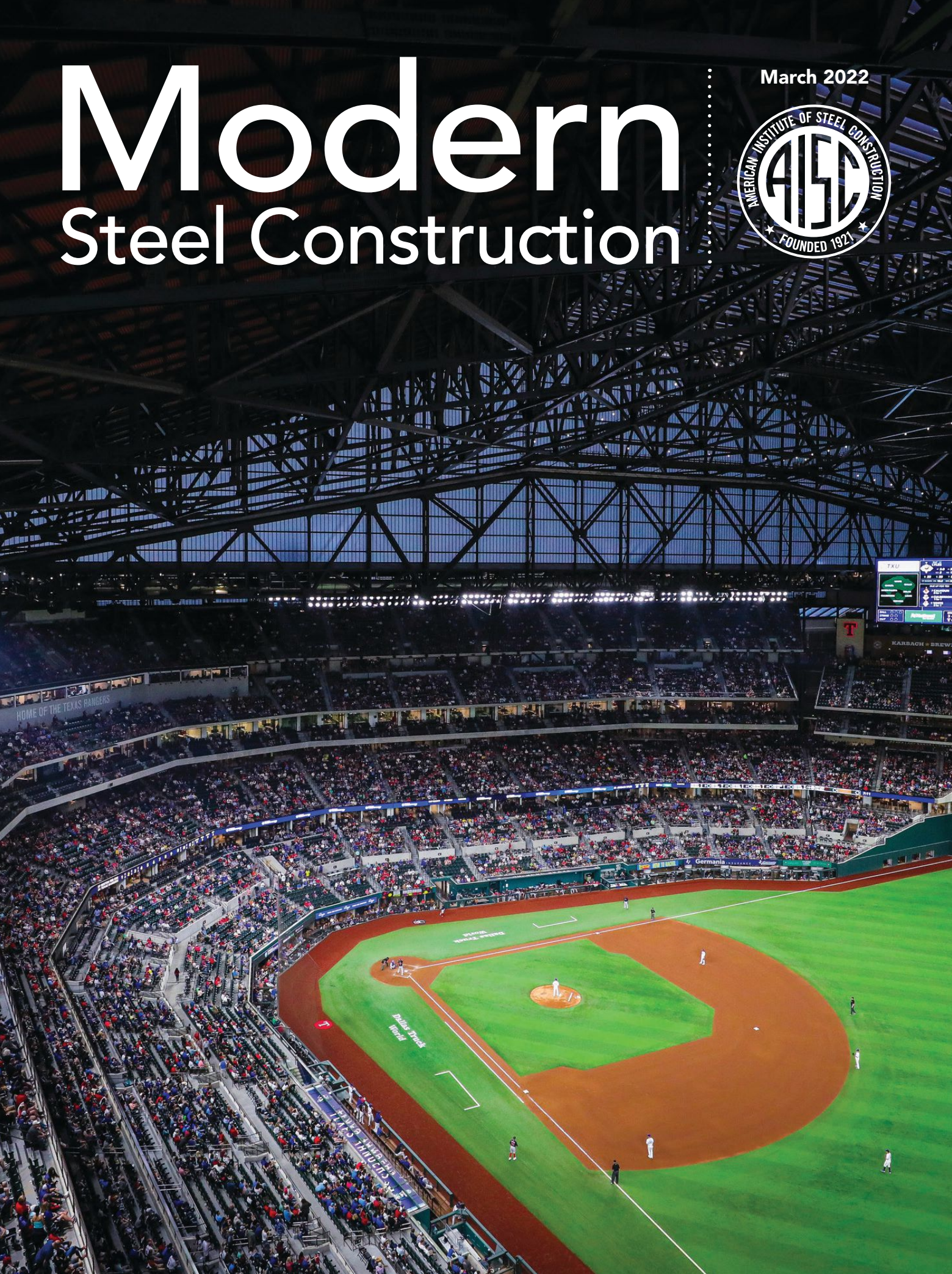
Modern Steel Construction

March 2022



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Modern Steel Construction

March 2022

in every issue

features

columns

ON THE COVER: Play ball! Globe Life Field, MLB's newest venue, is ushering in a new era of ballparks, p. 30. (Photo: Kelly Gavin/Texas Rangers)

MODERN STEEL CONSTRUCTION (Volume 62, Number 3) ISSN (print) 0026-8445: ISSN (online) 1945-0737. Published monthly by the American Institute of Steel Construction (AISC), 130 E Randolph Street, Suite 2000, Chicago, IL 60601. Subscriptions: Within the U.S.—single issues $6.00; 1 year, $44. Outside the U.S. (Canada and Mexico)—single issues $9.00; 1 year $88. Periodicals postage paid at Chicago, IL and at additional mailing offices. Postmaster: Please send address changes to MODERN STEEL CONSTRUCTION, 130 E Randolph Street, Suite 2000, Chicago, IL 60601.


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editor's note

There's nothing quite like touring a high-rise in Chicago in January. Is it warm and sunny? Are you crazy? Of course not. It's windy and cold and makes you want to find the nearest fireplace and sip hot chocolate. Or whisky. (Or both?)

But it's exhilarating. And it also forces you to acknowledge the fact that you are surrounded by ironworkers and countless others that have to actually *work* in this type of environment all day for several months. (Remember, Chicago has four seasons: summer, fall, winter, and second winter.) It makes you appreciate the process—and the people involved in it—that much more.

The specific building I'm referring to is Salesforce Tower, which was designed by structural engineer Magnusson Klemencic Associates (MKA). (See this month's Field Notes column for an interview with Dave Eckmann, the MKA Chicago office's managing principal.) AISC recently organized a tour of the building that was preceded by presentations from various project team members. Nearly 50 area design and construction professionals braved the cold that day to get an inside look at the 58-story, 850-ft-tall, 1.4 million-sq.-ft modern Art Deco tower.

The steel-framed (obviously) building is the last piece of the puzzle on Chicago's Wolf Point, a high-profile corner of land at the confluence of the three branches of the Chicago River. Once open, it will complete a trifecta of high-rises on this previously undeveloped yet highly visible location just across the river from Chicago's Loop. The building was designed by architect HKS, with Cives Steel serving as the steel fabricator and erector. Note that the framing system incorporates Nucor's new Aeos high-strength grade 65 steel, North America's only domestically produced A913 steel, whose preheat requirements are substantially less than that of A992. While the project won't be completed until next year, you can learn about Aeos now at **nucor.com/aeos**.

You can also find out more about Aeos and other steel innovations at NASCC: The Steel Conference, which takes place later this month (March 23-25; visit **aisc.org/nassc** for more information and to register) in Denver. If you want a taste of some of the sessions (or want to peruse the list of more than 200 exhibitors) at this year's conference, keep turning the pages (we also featured a handful of session previews in the January and February issues). On that note, we often receive more session preview papers than we're able to run in the print version (not a bad problem to have). Of course, the topics remain relevant after the conference, and we tend to run these "bonus" articles throughout the year. We'll continue doing that, but this year, we've also posted them online. So be sure to check out our Project Extras section at **www.modernsteel.com** for a handful of additional session previews. And remember, if you're not able to make it to Denver, you can register for our streaming sessions.

But for those of you who can make the trip, it will be worth your while. See you there!

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Chief Editor

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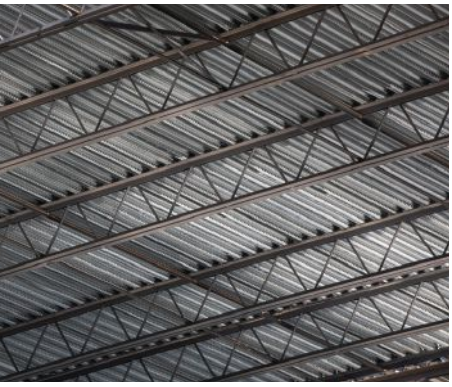

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Chevron Brace Force Distribution

I am reviewing Design Example 5.9 in AISC Design Guide 29: *Vertical Bracing Connections–Analysis and Design*. Can you explain how the values for N', V', and M' are determined (see Figure 5-20)?

The determination of these values is discussed on page 199 of Design Guide 29 (**aisc.org/dg**). The guide refers to the equations provided in Figures 4-5, 4-6, and 4-7 (pages 22–23). The derivation of these equations is based on statics. The equations provided have been simplified, so looking at the equation itself may not make the approach readily apparent. The equations are provided to more easily create a spreadsheet or program to design a large number of chevron brace connections quickly. If you are looking to verify the values for one design, a simple free-body diagram is the way to go. The following steps outline one quick path to doing just that.

Step 1. Determine what the basic load path will be. The design example indicates a bracing force equal to 289 kips. The bracing angle is at 45° so that this brace force can be shown as 204 kips in both the vertical and horizontal directions. The horizontal component of the brace force totals 408 kips. There is a total axial force of 408 kips in the beam transferred into the braces. This force is shown being evenly applied at both ends of the beam.

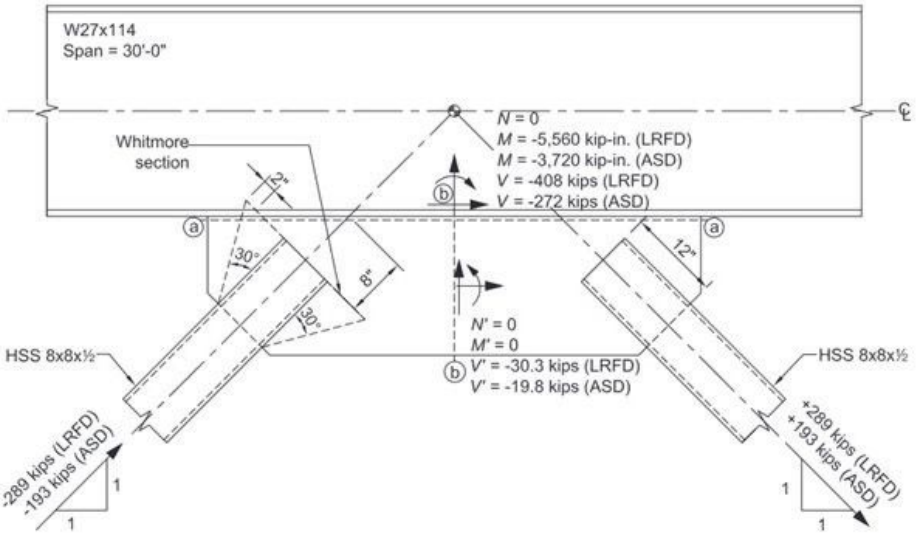
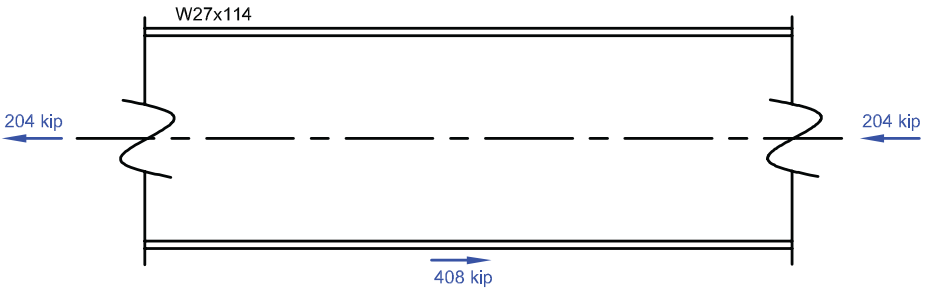
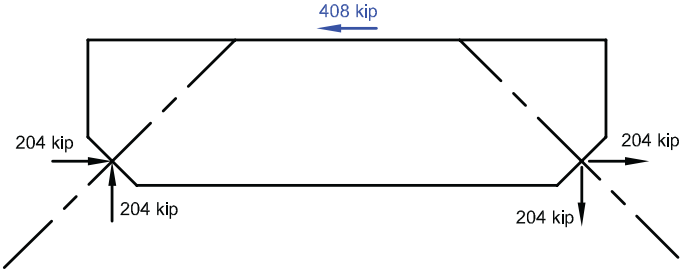


Fig. 5-20. Admissible force fields.





Step 1.

Step 2. Looking at the forces on the beam, due to the eccentricity, a moment needs to be applied to keep everything in equilibrium. Since the force is being applied at the bottom of the beam, the eccentricity to the center of the beam is equal to one-half of the beam depth. The moment that needs to be applied would equal 408 kips × 13.65 in. = 5,569 kip-in, which will be rounded down to 5,560 kip-in. to be consistent with the rounding in the design guide design example.

Step 3. The 5,560 kip-in. moment also needs to be applied to the gusset plate. The moment will be illustrated as a force couple. Based on the length of the gusset plate (64 in.), the force couple will be calculated using 32 in. This force comes out to 5,560 kip-in./32 in. = 173.7 kips.

Step 4. Now, focus on one half of the gusset plate and determine what forces are transferred at Section b-b. Sum the forces in the vertical dimension to determine the required shear force, V', at Section b-b.

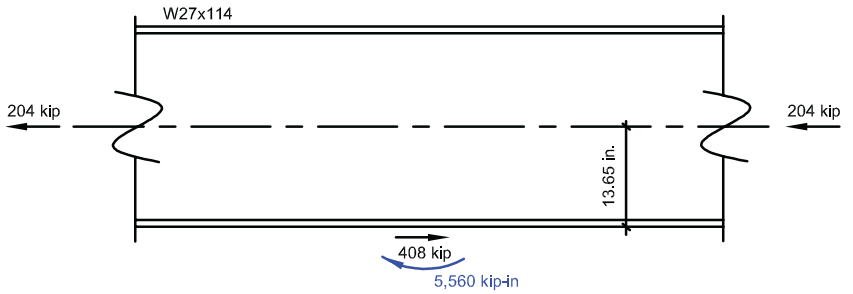
204 kip – 173.7 kip – V' = 0

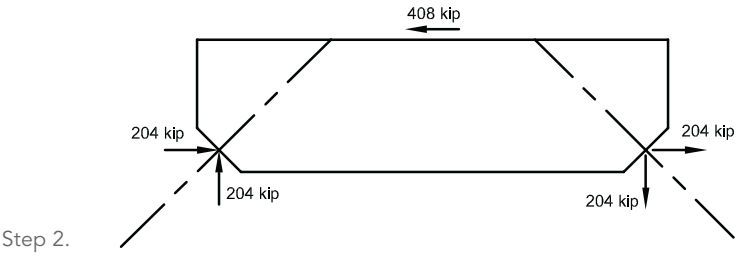
V' = 30.3 kips, which is the same value calculated in the design guide.

The sum of the forces in the horizontal direction and the sum of the moments will show that N' and M' both equal 0 (neglecting minor differences due to rounding), which is also consistent with the design guide calculations. (Note that equations for V', N', and M' are provided on page 23 of the design guide.)

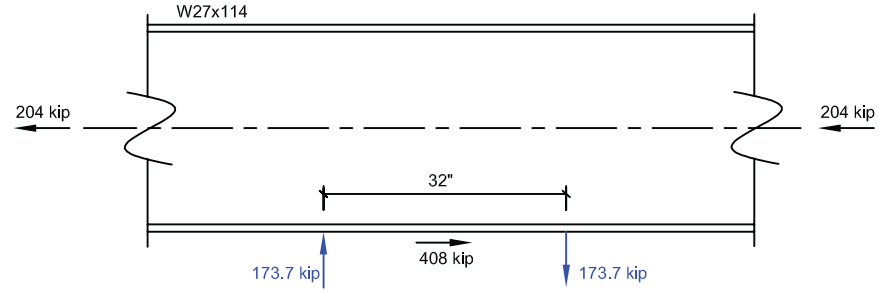
Carlo Lini, PE

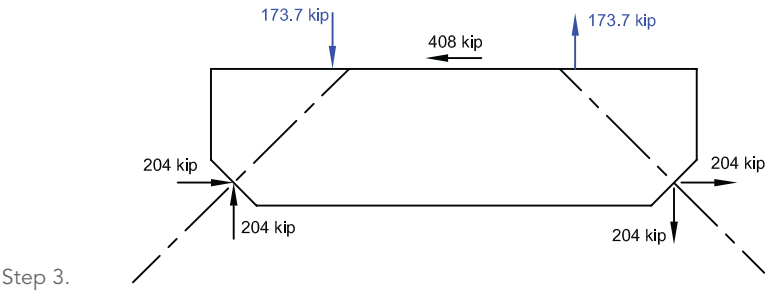
Carlo Lini (**lini@aisc.org**) is the director of the AISC Steel Solution Center.



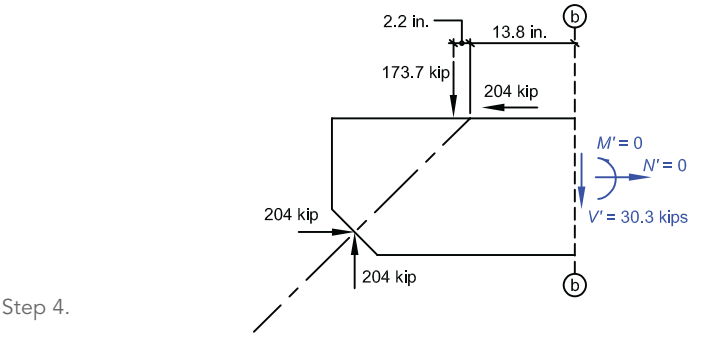


Step 2.





Step 3.



Step 4.

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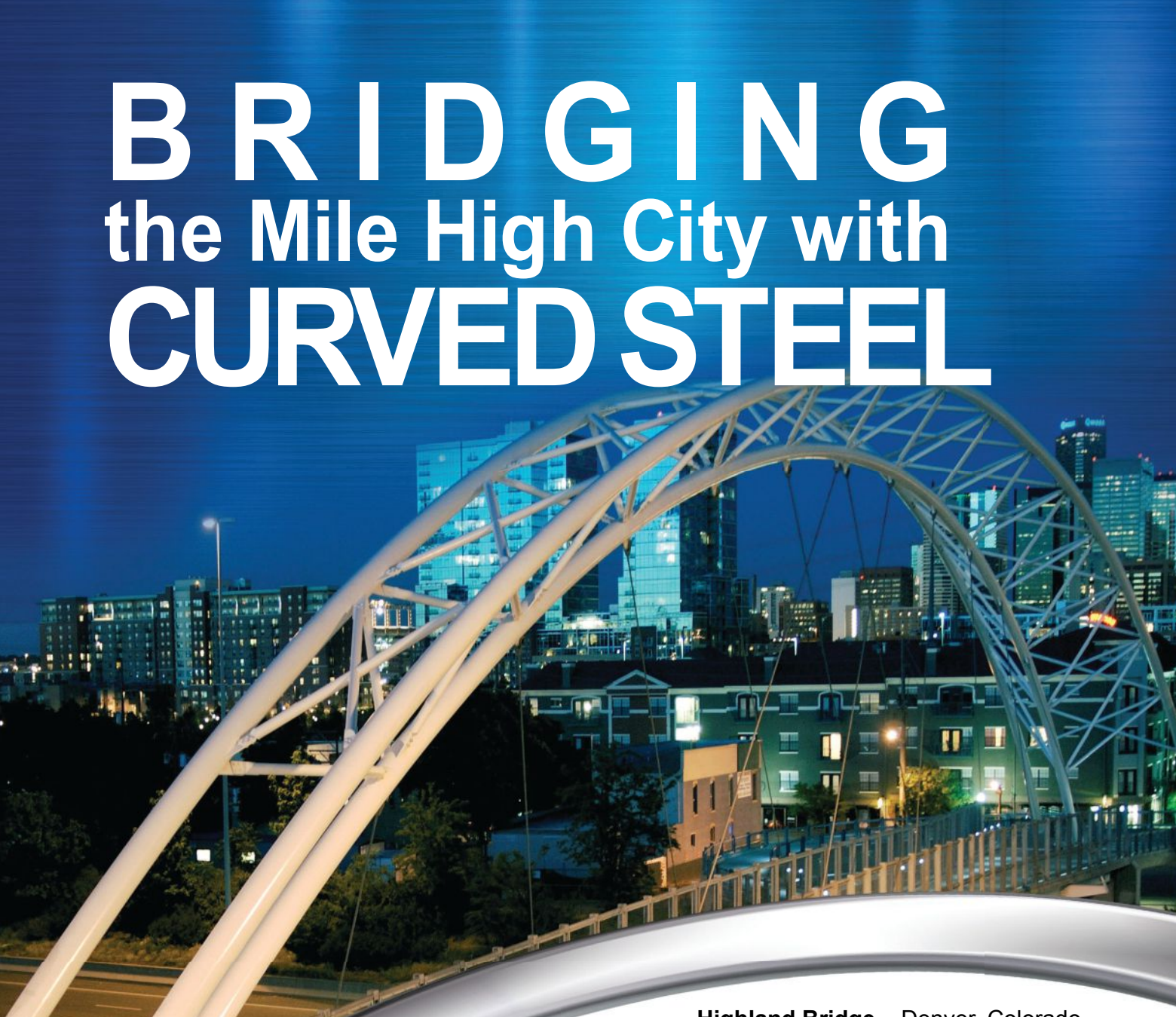

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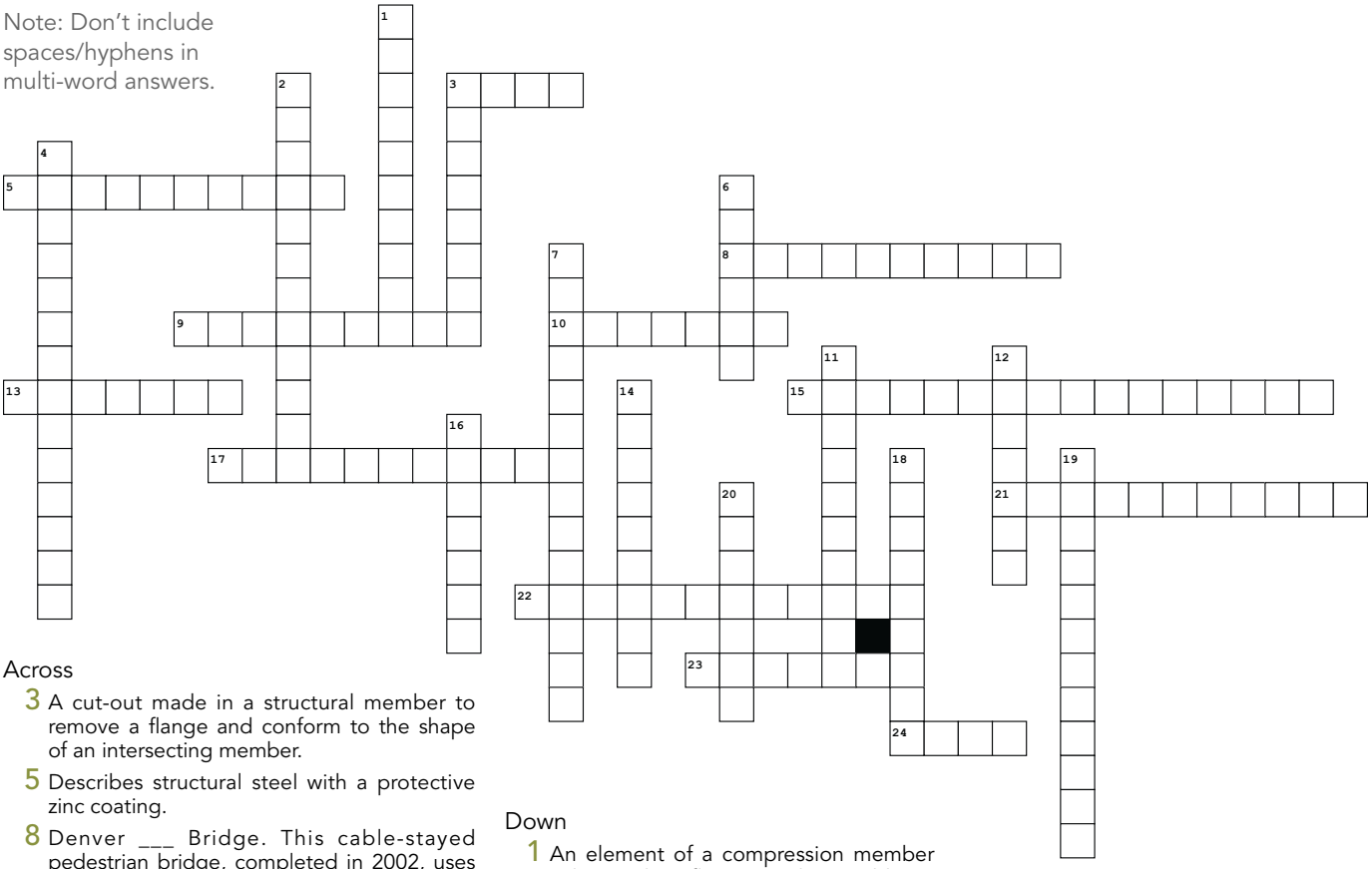
This month's questions and answers were developed by Michael Desch, an AISC intern and current graduate student at the Illinois Institute of Technology. Thanks, Michael!

This special Steel Quiz tests your knowledge on steel design and construction—and the 2022 NASCC: The Steel Conference.

Note: Don't include spaces/hyphens in multi-word answers.



Across

3 A cut-out made in a structural member to remove a flange and conform to the shape of an intersecting member.

5 Describes structural steel with a protective zinc coating.

8 Denver ___ Bridge. This cable-stayed pedestrian bridge, completed in 2002, uses a post-tensioned structural steel system to minimize the height pedestrians must climb.

9 The 2023 NASCC: The steel Conference will be held in this city.

10 ANSI/AISC 303, *Code of Standard Practice for Steel Buildings and* ___.

13 ___ Section Modulus, *S*, the ratio of the moment of inertia to the distance between the neutral axis to the most extreme fiber.

15 This Denver steel-framed building with curved "cash register"-shaped upper floors was completed in 1983 and is currently the city's third-tallest building. (Three words.)

17 Plate element connecting truss members or a strut or brace to a beam or column. (Two words.)

21 This type of fireproofing paint expands when it is exposed to heat to insulate the object on which it is applied.

22 This historic Denver building, renovated in 2014, now includes a new open-air train hall. The hall features large AESS trusses that support a PTFE canopy. (Two words.)

23 A limit state of crack initiation and growth resulting from repeated application of live loads.

24 ANSI/AISC 360, *Specification for Structural Steel Buildings*, is often abbreviated as: ____.

Down

1 An element of a compression member subjected to flexure with a width-to-thickness ratio between λ_p and λ_r is ___.

2 ANSI/AISC 358, *Prequalified Connections for Special and Intermediate Steel* ___ *for Seismic Applications* specifies design, detailing, fabrication, and quality criteria for connections that are prequalified for use in SMF and IMF systems in accordance with the AISC *Seismic Provisions*. (Two words.)

3 A ___-joint-penetration weld is a groove weld in which the weld metal extends through the joint thickness.

4 A procedure to determine maximum and minimum moments when there is an uncertain live load distribution on a structure. (Two words.)

6 Curvature fabricated into a beam or truss to compensate for deflections induced by loads. (Hint: It is the subject of Design Guide 36.)

7 Distance between braced points of a member. (Two words.)

11 This is a term for corrosion-resistant steel that forms a protective surface layer by oxidation, eliminating the need for other protective coating systems.

12 A phenomenon where the threads of a nut and bolt seize during tightening.

14 A composite steel plate and concrete shear wall system that can dramatically reduce construction time.

16 ___ Section Modulus, Z, the ratio of the moment of inertia to the distance between the ___ neutral axis to the most extreme fiber.

18 With at least 10.5% chromium, ___ steel is the subject of the new standard ANSI/AISC 370 *Specification for Structural* ___ *Steel Buildings*.

19 One of the four methods for determining the nominal strength of a composite section, the effective ___-___ method assumes strain compatibility and effective ___-___ relationships for steel and concrete that account for the effects of local buckling, yielding, interaction, and confinement. (Two words.)

20 A___-joint-penetration weld is a groove weld in which the penetration is intentionally less than the complete thickness of the connected element.

TURN TO PAGE 14 FOR THE ANSWERS.

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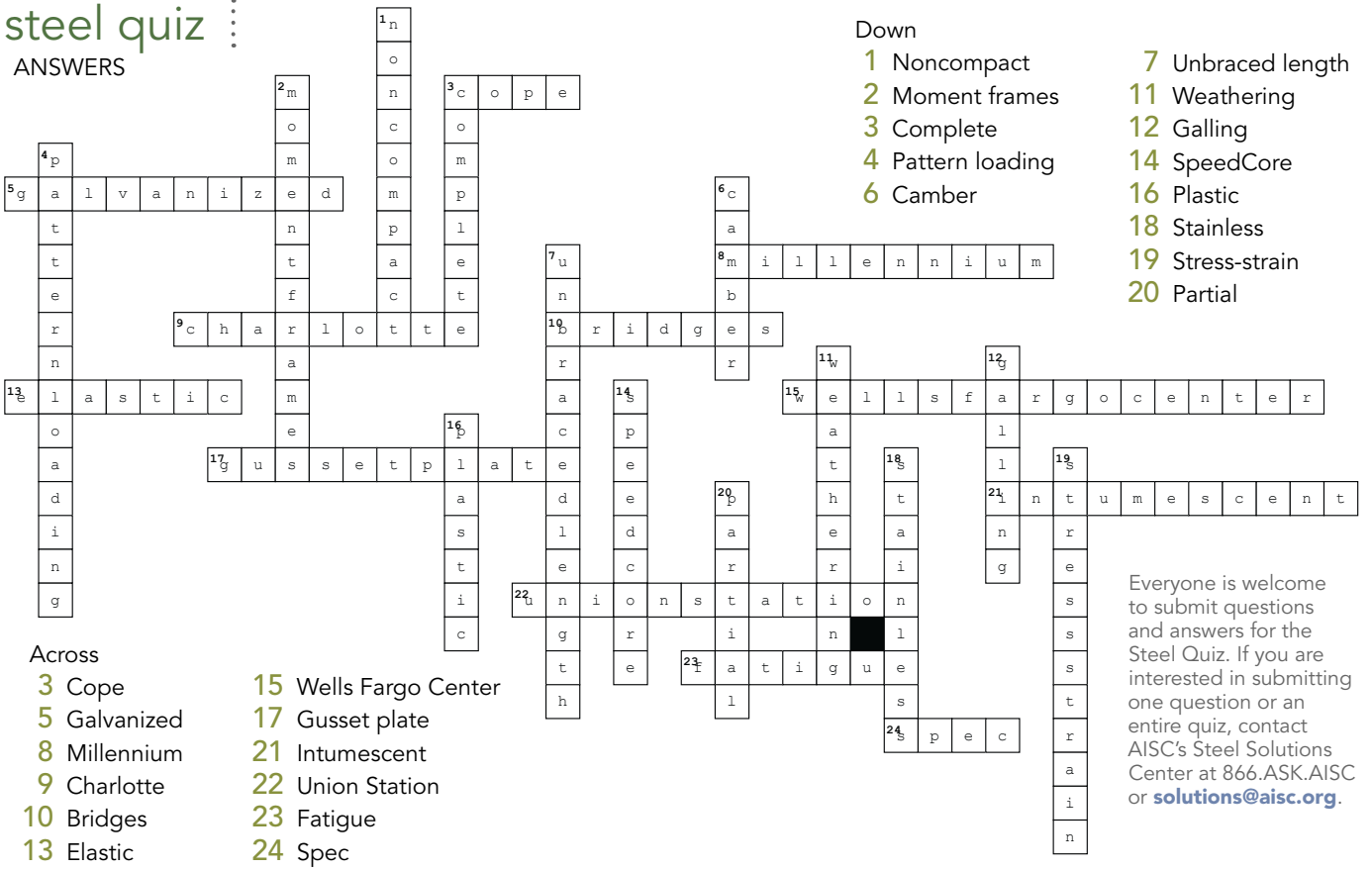
ANSWERS



Across

3 Cope
5 Galvanized
8 Millennium
9 Charlotte
10 Bridges
13 Elastic
15 Wells Fargo Center
17 Gusset plate
21 Intumescent
22 Union Station
23 Fatigue
24 Spec

Down

1 Noncompact
2 Moment frames
3 Complete
4 Pattern loading
6 Camber
7 Unbraced length
11 Weathering
12 Galling
14 SpeedCore
16 Plastic
18 Stainless
19 Stress-strain
20 Partial

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**.

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Tech Tips for Tapered Members

BY DONALD W. WHITE, PHD, WOO YONG JEONG, PHD, AND RYAN SLEIN, PHD

The updated AISC/MBMA Design Guide on nonprismatic members provides substantial guidance on designing stepped or tapered steel I-section members for stability, as well as on overall stability design of clear-span and modular gabled building frames, including buildings supporting cranes.

HAVE YOU EVER HAD to design a framing system involving stepped and/or web-tapered columns?

Or a frame in which axial loads are introduced into members at intermediate positions along their length? Or perhaps a variable-web-depth plate girder with steps in the plate thicknesses and/or flange widths along its length?

These are all examples of nonprismatic members, and the first edition of AISC/MBMA Design Guide 25: *Frame Design Using Nonprismatic Members* was released in 2011 to address these considerations. A key focus was on balancing generality, comprehensivity, and simplicity in tackling the corresponding design complexities, with the presentations emphasizing web-tapered members. This edition also addressed the broader application of the methods to members containing cross-section transitions and/or axial loads applied at intermediate positions, as well as the overall system design of frames using these types of members.

However, all of this was accomplished in an abbreviated manner. An expanded

discussion of the various considerations associated with frame analysis and member-proportioning rules for these types of structures was needed. And now it's here, in the form of the second edition of Design Guide 25, which is based on the 2016 *Specification for Structural Steel Buildings* (ANSI/AISC 360, **aisc.org/specifications**). Aside from handling nonprismatic member geometry, a key focus of the second edition is the characterization of two specific stability design attributes common to metal building frames:

1. The influence of axial compression in rafters and roof girders
2. The influence of leaning column P-Δ effects on the sidesway stability of modular frames—i.e., frames in which the roof girders or rafters are supported vertically by light interior columns, subdividing the frame into multiple bays

The second edition of DG 25 provides the following advancements pertaining to frames containing general nonprismatic members:

- Calculation of column axial resistances using a streamlined, unified plate effective width procedure, extending the method for prismatic members in Section E7 of the 2016 *Specification*
- Consideration of substantial shear postbuckling strengths in thin unstiffened I-section member webs, extending Section G2.1 of the *Specification* to nonprismatic members
- Inclusion of the contribution from inclined flanges in member shear strength calculations
- Simplified estimation of member elastic lateral-torsional buckling (LTB) resistances, as well as advanced elastic buckling predictions using thin-walled open-section beam computations
- Direct evaluation of general nonprismatic column, beam, and beam-column design resistances using efficient inelastic buckling method
- Achievement of significant benefits by applying the most up-to-date recommendations for the AISC direct analysis, effective length, and first-order analysis methods of system stability design

The updated Design Guide 25 also provides extensive examples illustrating the application of the recommended methods. Following is a snapshot of some of the key concepts introduced in the new edition.

Nonprismatic member design in long-span facilities such as airplane hangars is addressed in the new edition of Design Guide 25.

Unifying Concept

For the calculation of member axial compressive resistance, the basic procedures discussed in Design Guide 25 focus specifically on:

(1) The governing elastic buckling load (or stress) ratio

$$\gamma_e = \frac{P_e}{P_r} = \frac{F_e}{f_r}$$

which is a constant for a given member unbraced length, where $f_r = P_r / A_g$ at a given cross section, and

(2) The axial load or axial stress level, P_r or f_r, and the cross-section effective area, A_e, at a number of potentially critical cross sections along the unbraced length

Any member subjected to axial compression has a buckling load ratio, γ_e, by which the required strengths (i.e., the internal stresses or forces from the applied loading) are multiplied to obtain the governing elastic buckling strength (i.e., $F_e = \gamma_e f_r$ or $P_e = \gamma_e P_r$). In general, $F_e = \gamma_e f_r$ and/or $P_e = \gamma_e P_r$ can be different at different cross sections along the member length. However, there is only one governing value of γ_e. Thus, the use of γ_e provides significant advantages for members with complex nonprismatic geometries and members subjected to nonuniform axial compression. Furthermore, numerical buckling solutions provide γ_e directly as the eigenvalue—i.e., the multiple of the reference applied load, at incipient elastic buckling.

Given the value of $F_e = \gamma_e f_r$ at different locations along the length of a member subjected to nonconstant axial compression and/or containing a general nonprismatic geometry, engineers can evaluate the nominal strength, P_n, at these locations. The P_n calculation is accomplished by applying the provisions defined in *Specification* Section E7. The calculations for the various potentially critical cross sections are akin to the evaluation of multiple members with distinct buckling characteristics in a general structure, each subjected to different axial compressive forces, P_r , using an overall buckling analysis of the system. Once the critical cross section (the one giving the largest demand-to-nominal strength ratio) is identified, the corresponding P_n calculation can be envisioned as being conducted on an equivalent uniformly loaded prismatic member. This equivalent member has the same

overall γ_e , and the same fr $/F_y$ and A_e $/A_g$ [or f_r / (A_e $/A_g$) / F_y = P_r / P_{ye}], as the critical cross section (see Figure 1).

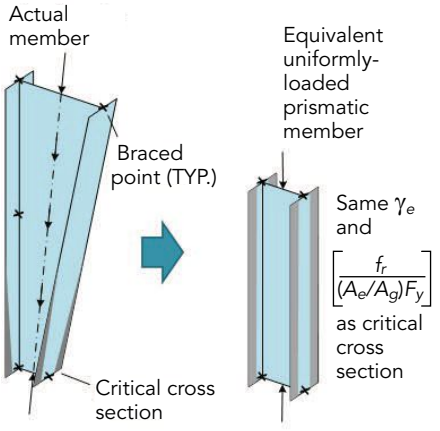


Fig. 1. Equivalent uniformly loaded prismatic member concept.

The approach in the second edition can be applied to all three system stability analysis and design approaches in the AISC *Specification*—the direct analysis method, the effective length method, and the first-order analysis method (FOM). A similar approach is recommended by Design Guide 25 for calculation of the flexural resistance of I section members. This approach captures the out-of-plane LTB limit states.

Which Method?

In a 1985 ASCE *Journal of Structural Engineering* paper, author Watwood touched on a particular anomaly of the effective length method (ELM) for structural stability design. Members that have relatively small axial stress at incipient buckling of a frame tend to have large effective length factors, *K*, when considered as part of the evaluation of the overall structural system. In some cases, these *K* factors are justified, while in other cases, they are not. If the member participates significantly in the governing elastic flexural buckling mode, a large *K* value is justified. On the other hand, if the member is essentially undergoing rigid-body motion in the governing buckling mode, and/or if it predominantly serves to restrain flexural buckling of other members, a large *K* value is sometimes not justified. The distinction between these two situations requires significant engineering judgment.

Effective length calculation procedures are typically implemented on subassemblies extracted from the overall structure. For instance, in multi-story buildings, *K* factors are commonly calculated on a story-by-story basis with limited consideration of the interaction between the stories. Suppose one conducts an elastic buckling analysis of an entire multi-story frame that has a large number of stories. In that case, it is common to obtain *K* factors that are relatively large in the upper stories of the frame and relatively small in the lower stories. If a *K* factor is back-calculated for a typical girder of such a frame, then the *K* value will be quite large because the axial force in the girder is relatively small.

The updated Design Guide addresses these issues, placing particular emphasis on applying the ELM to typical metal building frames composed of nonprismatic members. It also explains that the AISC direct analysis method (DAM) eliminates the above complexities by avoiding a focus on the stability limit states behavior of the structural system (or a structural system subassembly) in which all the members are subjected to pure axial compression (i.e., no bending). Frames are rarely subjected just to pure axial compression of their members. Instead, the DAM focuses on the load-deflection stability behavior of the geometrically imperfect structural system subjected to the estimated actual forces at the strength design levels, rather than the bifurcation response associated with pure axial compression in the various members of the idealized geometrically-perfect structure. As a result, the DAM provides significant advantages for design in that: one, it may be used for all structures and load combinations; two, it provides the most representative assessment of the actual internal forces and moments of the elastic analysis-and-design methods; and three, it may be used to design the members without calculation of *K* factors.

When using the DAM, the in-plane flexural buckling strength of columns and beam-columns, P_{ni} , is often calculated using the actual unbraced length with K = 1.0. However, this approach can also misrepresent the physical strength behavior in certain situations. For example, in clear-span portal building frames, the use of K = 1.0 to calculate the in-plane flexural buckling strength can be very conservative for the roof girders or rafters. Particularly in cases where the roof girder span is large and the eave height of the structure is relatively small, the columns can provide significant rotational restraint to the girder ends. Furthermore, the concept of a *K* factor is rather complex when the roof girder has, for instance, multiple tapers and multiple steps along its length. Design Guide 25 resolves this problem by the following extensions to the AISC *Specification*:

1. For members with $\alpha P_r \le 0.10 P_{eL}$ at all locations along their length, or stated more simply, for $\alpha/\gamma_{eL} < 0.10$ (where α and γ_{eL} are defined below), and where $A_{es} > 0.5A_g$, the member P_{ni} may be taken as the equivalent cross-section axial yield strength accounting for local buckling effects, $P_{ns} = A_{es}F_y$. This simplification is permissible because the in-plane stability effects are minor at the member level for columns and beam-columns that satisfy the above limits. The term P_{eL} here is the in-plane elastic flexural buckling load for the member unbraced length under consideration, assuming idealized simply supported end conditions, and γ_{eL} is the corresponding elastic buckling load ratio. The term α is employed by the AISC *Specification* to scale the required ASD loads up to an ultimate strength design load level. It is equal to 1.0 for design by LRFD. Typical single-story metal building frame members will often satisfy this limit.

2. If P-δ effects are included in the structural analysis model, and an appropriate out-of-straightness between the member ends is also included, P_{ni} may be taken as P_{ns} even when $\alpha/\gamma_{eL} > 0.10$. This is permissible because the combined reduced stiffness and out-of-straightness in the DM-based analysis account sufficiently for the in-plane stability effects at the member level. The appropriate member out-of-straightness is an imperfection of $0.001L$ in the direction that the member deforms (due to the applied loads) relative to a chord between its support points or points of connection to other members, where L is the overall member unsupported length. A chorded representation of the out-of-straightness with maximum amplitude at the middle of the unsupported length is considered sufficient. For clear-span gabled frame rafters subjected to loads causing a net downward displacement at the ridge, this requirement may be implemented by shifting the

Gabled portal frames housing a tennis facility.

ridge downward by 0.001L, where L is the on-slope length between the columns. For an unusual situation where the loading may cause an upward movement of the ridge, the ridge should be shifted upward by 0.001L.

The use of $P_{ni} = P_{ns}$ with the DAM, based on satisfying one of the above two requirements, is the most accurate and the preferred approach for the in-plane stability design of rafters in clear-span frames. Within the above contexts, the load-deflection analysis of the DAM sufficiently captures all the essential attributes of the in-plane stability behavior. Therefore, the member in-plane axial compressive resistance may be calculated as the axial compressive resistance of its cross sections. Furthermore, since the out-of-plane axial compressive resistance is always less than P_{ns} for any finite out-of-plane unbraced length, the out-of-plane buckling resistance will always govern when the in-plane strength is taken as $P_{ni} = P_{ns}$.

The accurate design of rafters and roof girders using the ELM requires the recognition of end restraint from the columns within an elastic buckling analysis or a related $K < 1$ solution. As stated previously, the use of $K = 1.0$ with the DAM for calculating P_{ni} in roof girders or rafters of clear-span portal frames can result in a significantly conservative characterization of the axial compression effects in these members.

Regarding the FOM, the guide recommends that for frames in which the internal axial force in any of the girders or rafters exceeds $0.08P_{eL}$ (i.e., $\alpha/\gamma_{eL} > 0.08$), the FOM should be limited only to preliminary design. In this context, P_{eL} is the nominal in-plane elastic flexural buckling strength of the girder or rafter, based on the on-slope length between the columns and assuming simply supported end conditions. The simplifying approximations embedded in the FOM can become suspect for frames that fall outside of these limits.

Dedications

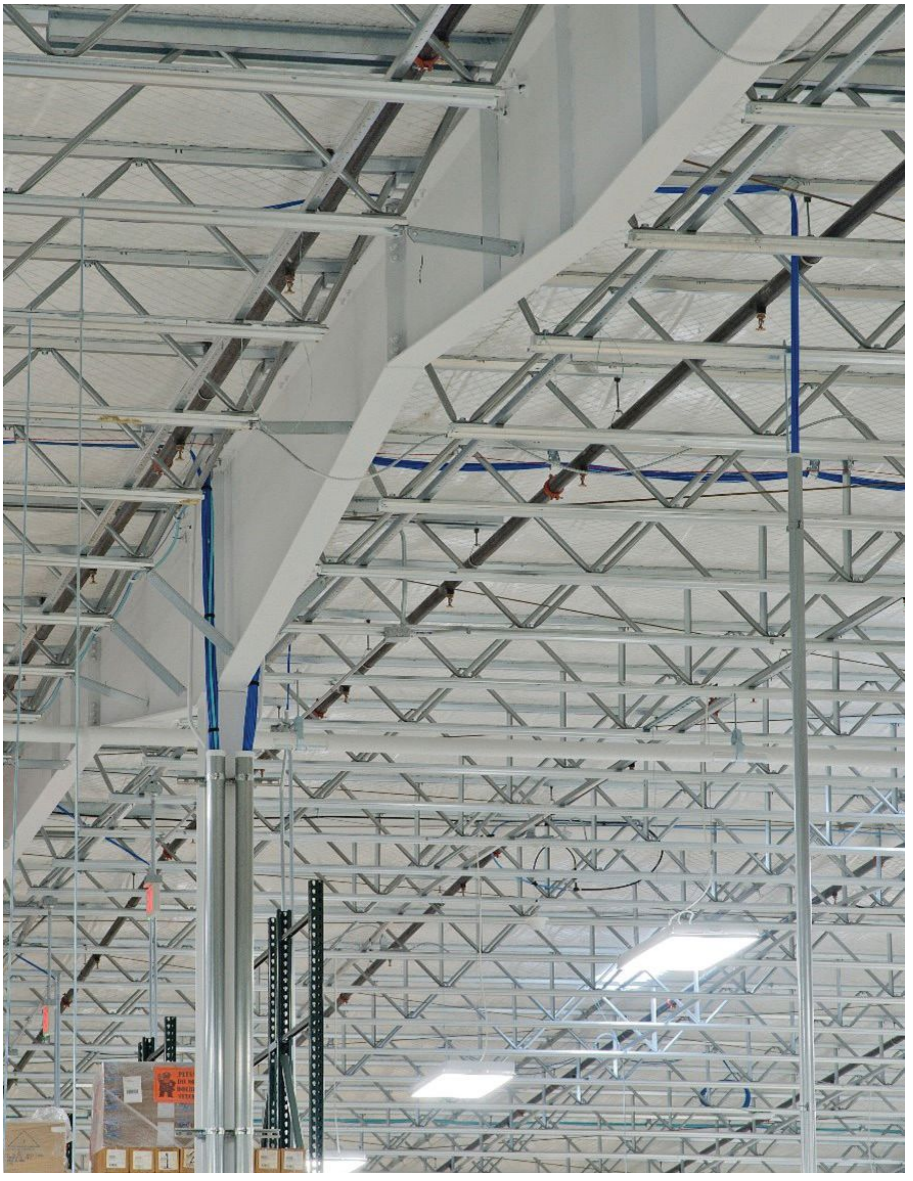
The second edition of Design Guide 25 is dedicated to **Richard C. (Dick) Kaehler, PE**. Dick provided quiet and steady friendship and leadership as the first author of the first edition and as a colleague in numerous technical committee activities for AISC and AISI before his passing in 2015. The second edition is also dedicated to **Yoon Duk Kim, PhD**, who contributed significantly as a co-author of the first edition and as a collaborator in the second edition's early developments, and who passed away in 2018.

Advanced Calculations

The basic procedures recommended in Design Guide 25 require the calculation of member elastic buckling load ratios, γ_e, followed by mapping to the corresponding design resistances. However, suppose the stiffness reduction factors (SRFs) associated with the *Specification* strength curves are embedded within the buckling calculations. In that case, the buckling analysis can be configured to provide the column, beam, or beam-column design resistances directly. This type of inelastic buckling analysis is discussed in the updated guide as a supplement to the basic or more routine methods. The advantage of inelastic buckling analysis is that it can more rigorously account for a wide range of attributes such as:

- Nonprismatic geometry
- Moment gradient
- Variations in axial force along member lengths
- Load height
- Member end restraint
- Member continuity effects across braced locations
- Beam-column strength interactions

In addition, inelastic buckling analysis removes the need for tedious and relatively inaccurate C_b , K, and beam-column strength interaction calculations.



Interior column and roof girders of a modular frame.

Organization

Now, let's take a look at how the new edition of Design Guide 25 is organized and what information it includes:

Chapter 1: Introduction summarizes the scope and basis of the guide's recommendations and their relationship to the 2016 *Specification*. This chapter also highlights the key benefits of and outlines key attributes pertinent to the fabrication of web-tapered members.

Chapter 2: Literature Review and Summary of Recommended Methods discusses the extensive research and development achievements relevant to the design of nonprismatic steel I-section members and frames using these member types over more than 100 years. These include seminal actions by the Column Research Council, the Welding Research Council, and AISC.

Chapter 3: Design Basis explains key terminology and over-arching limit states design concepts employed within the guide.

Chapter 4: Stability Design Requirements introduces important stability design terminology and provides a treatise of the primary *Specification* system stability design methods, including specific qualifications relevant to the design of frames using nonprismatic members. In addition, this chapter outlines important ASCE/SEI 7 and *International Building Code (IBC)* stability design requirements, and it relates the recommended procedures to these requirements. Streamlined guidance is provided on how to ensure sufficient accuracy of second-order frame analysis calculations.

Chapter 5: Member Design details specific recommended procedures for calculating the design resistance of nonprismatic members subjected to axial tension, axial compression, flexure, combined flexure and axial force, and shear. This is the longest chapter of the guide, providing multiple integrated member design resistance calculations.

Chapter 6: Frame Design summarizes reasonably comprehensive guidance on the proper first- and second-order analysis modeling of frames composed of nonprismatic members, emphasizing the analysis of gabled clear-span and modular building frames. This includes guidance on manual second-order amplification factors, stiffness reduction factors associated with the DAM, notional loads and corresponding

explicit geometric imperfections, and handling of lean-on structures. Chapter 6 finishes with an overview of four framing system examples in Chapters 7 through 10, including a roadmap and suggestions on how to use them (depending on the type of guidance the engineer wants).

Chapter 7 shows the member and system calculations for a clear-span monoslope frame having a relatively complex nonprismatic roof girder geometry.

Chapter 8 illustrates the member and system calculations for a clear-span gabled crane building frame in which the crane girders are supported by brackets attached at an intermediate height of the columns. The columns are tapered below the crane girder support brackets.

Chapter 9 presents calculations for a modular crane building frame containing columns with a step in the cross-section geometry at the crane girder support level and significantly smaller cross sections above this level. The columns in this frame are otherwise prismatic.

Chapter 10 focuses on analyzing and designing a clear-span gabled building frame with a large span-to-eave height. The roof girder second-order effects are relatively substantial in this frame. This example emphasizes checking of the system's in-plane stability associated with and impacted by the roof girder second-order effects. The nonprismatic roof girder cross-sections in this frame are highly optimized. The girder compression flange is substantially larger than the tension flange at the knees of the frame, making the cross sections significantly singly symmetric.

Chapter 11 provides an annotated bibliography. This bibliography summarizes the results of numerous research efforts aimed at the stability design of frames composed of web-tapered and general nonprismatic I-section members over the years. The citations range from the early 20th century through June 2020, including references to some of the earliest pioneers of structural engineering, Euler and Lagrange.

The second edition of Design Guide 25 also contains several substantive appendices:

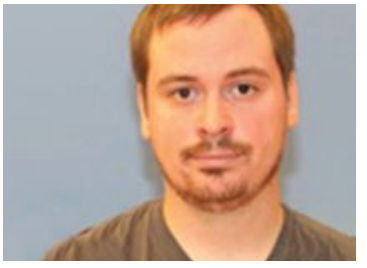
Appendix A outlines specific guidelines for the calculation of P_{eL} and γ_{eL} for nonprismatic members. This includes using an equivalent moment of inertia with the Euler buckling equation, applying the method of successive approximations promoted by Timoshenko and Gere and Newmark, and implementing modern eigenvalue buckling analysis computations.

Appendix B discusses the calculation of girder and column γ_e factors quantifying the elastic sidesway buckling resistance of framing systems. These calculations are primarily of use with the ELM. The first section of this appendix establishes the relationship between a generalized effective length factor, K, and the elastic buckling load ratio, γ_e, for frames composed of nonprismatic members

Appendix C provides guidelines for out-of-plane buckling analysis, addressing the essential features of finite elements necessary to provide accurate solutions. In addition, this appendix addresses the required number of elements per member, the use of notional loads to remove interaction between different buckling modes in members containing stepped and/or doubly tapered geometry, and the implications of using idealized torsionally and flexurally simply supported boundary conditions versus the actual member end conditions. Lastly, manual procedures are presented for estimating the elastic LTB flexural resistance of general nonprismatic members.

Appendix D recommends various benchmark problems intended for software developers and users to establish the correctness and accuracy of their analysis procedures. Although the subject of the Design Guide is nonprismatic members, informative solutions for prismatic members are provided as a first step in evaluating software capabilities. These can be employed to establish the correctness with more straightforward cases before addressing the complexity of nonprismatic members. The appendix closes with two benchmark examples showing the application of successive approximations to calculate the in-plane buckling resistance of a web-tapered column and a stepped web-tapered column with an intermediate applied axial load.

The second edition of Design Guide 25 brings all the latest information on frame design using nonprismatic members into a single document compatible with the 2016 *Specification* and is intended to be a helpful resource for engineers tasked with designing nonprismatic members. As with all AISC Design Guides, it is available at aisc.org/dg. ■



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A Wild Ride

BY JOE DARDIS

This month's Data Driven looks at the expected performance of a handful of sectors in nonresidential construction.

THE LAST FEW YEARS have been a wild ride for the construction market.

After a very promising start in 2020, nonresidential construction starts shrunk as COVID crippled the market. However, the market bounced back in 2021, surpassing pre-COVID 2019 levels. So, what lies ahead? Will this upward momentum continue?

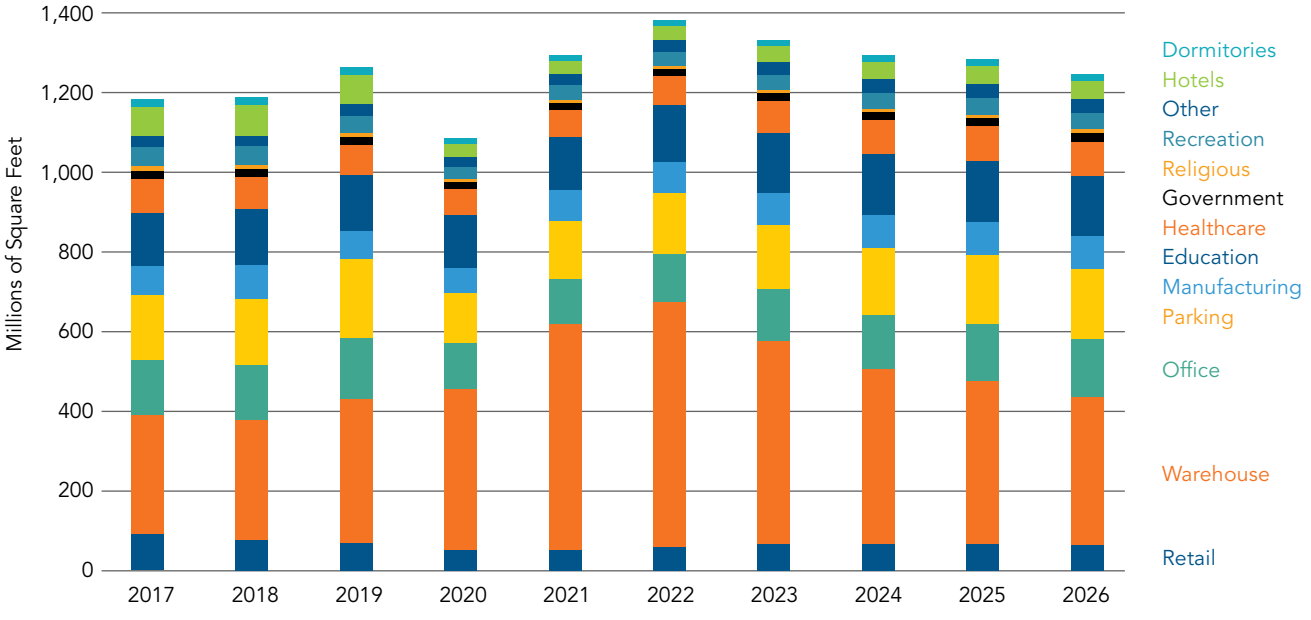
According to Dodge Data and Analytics, nonresidential starts look very promising for 2022. In fact, 2022 starts are projected to total roughly 1.38 million sq. ft, the highest level for this sector since 2008. Beyond 2022, we should expect to see a slight contraction every year until 2026, but starts will still remain above average relative to the last decade (see Figure 1).

To fully understand this projected growth and contraction, it is important to look at the market on a more granular level specific to project type. The main catalyst for growth is the warehouse sector (for more on warehouses, see last month's Data Driven, available at **www.modernsteel.com**). Figure 2, which shows the percent change in nonresidential projected construction starts by sector relative to 2019, highlights how the warehouse sector has grown and how most other sectors have not bounced back from pre-COVID levels. Combining this knowledge with the fact that 2022 starts will be at their highest levels since 2008 further demonstrates how warehouses are carrying the market on their backs.

Another sector—offices—is expected to bounce back this year, though it's not projected to reach pre-COVID levels in the foreseeable future. While a mass return to the office could certainly create an increased demand for office projects, the reality is that companies are expected to continue switching to hybrid arrangements, allowing employees to work from home at least part-time—and some aren't returning to the office at all. Even if companies are looking to expand, adopting a full- or part-time work-from-home arrangement would allow them to do so without the need to build or seek out additional office space. And while many companies are still under office leases that tie them to their current office space but with fewer workers going in every day, office space demands would decrease even further as these leases expire.

One bright spot for the office sector is the sub-sector of data centers (Dodge categorizes data center construction as office construction). Demand for data centers has been strong, driven by increased demand in digital bandwidth as people work remotely, plus a surge in online shopping. That being said, with data centers "counting" as offices, the demand for traditional office space is likely even lower than what the numbers represent at first glance.

Fig. 1.
Historical and Projected Nonresidential Construction Starts



Hotels will also have an uphill battle for the foreseeable future. In the second quarter of 2020, hotel occupancy rates dropped to 28% and have seen revenues fall year over year by 75%. The Center for Exhibition Industry Research reports that 98% of exhibitions were canceled during the second half of 2020. To put this in perspective, NASCC: The Steel Conference has roughly 5,000 attendees every year. Conservatively, if a hotel room costs $200 per night, that adds up to a million dollars every day of lost revenue to the hotel, not to mention catering, room rentals, and all the other revenue sources. There are tens of thousands of conferences in the U.S. every year, many of which are smaller than NASCC, though some are much larger. The drop in hotel occupancy was also affected by leisure travel, which came to a screeching halt in the second quarter of 2020.

The good news is that in 2022, the hotel market should begin to recover as both business and leisure travel are expected to pick back up, as are conventions and conferences (speaking of which, NASCC takes place March 23-25 in Denver; visit **aisc.org/nascc** for more information and to register). The bad news is that hotels will still need to dig themselves out of a huge financial hole before recovery fully starts to take shape.

There are pros and cons here for the steel industry. Overall, more square footage in the market is a good thing. Warehouses tend to be steel-framed, albeit simpler structures that don't require as much detailed fabrication. Office buildings also tend to be steel-framed, so the reduction in office demands can be discouraging—but possibly offset by an increase in data center construction. And while hotels are often concrete structures, there are enough steel hotels such that a downturn in that sector stings a bit for the steel industry as well.

Fig. 2.
Percent Change in Square Footage Relative to 2019

	2020	2021	2022	2023	2024	2025	2026
Retail	-26%	-23%	-13%	-5%	-3%	-5%	-8%
Warehouse	12%	58%	71%	42%	22%	14%	3%
Office	-23%	-26%	-22%	-15%	-12%	-7%	-5%
Parking	-37%	-27%	-22%	-19%	-16%	-13%	-12%
Manufacturing	-11%	9%	10%	16%	19%	20%	18%
Education	-6%	-4%	2%	7%	9%	9%	8%
Healthcare	-12%	-9%	-3%	8%	15%	18%	16%
Government	-6%	-7%	-1%	5%	7%	9%	10%
Religious	-18%	-30%	-27%	-25%	-23%	-20%	-18%
Recreation	-32%	-19%	-23%	-15%	-11%	-8%	-7%
Other	-25%	-6%	-4%	4%	11%	13%	12%
Hotels	-51%	-58%	-49%	-43%	-40%	-38%	-38%
Dormitories	-36%	-28%	-29%	-22%	-17%	-15%	-13%

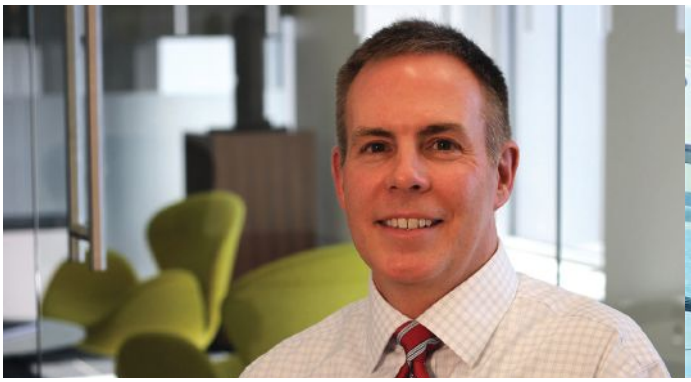
On the bright side, the traditionally steel-friendly education and healthcare sectors have been relatively steady and are projected to show positive growth for the next several years. As always, it's a matter of pivoting to different facilities and job types as necessary, not only to "fill the gap" while other industries are down but also to broaden your company's experience. ■

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

Building Balance

INTERVIEW BY GEOFF WEISENBERGER

Dave Eckmann's approach to his work as a structural engineer is influenced by his architectural aptitude and education, not to mention his lifelong desire to build things.



DAVE ECKMANN, SE, PE, FAIA, has always enjoyed building things, from sandcastles as a child to high-rises that have redefined Chicago's skyline in his 35 years as a structural engineer. Currently the managing principal of Magnusson Klemencic Associate's (MKA) Chicago office, he has spent most of his life in and around Chicago but has an integrative—and worldly, thanks to a fellowship that took him all over Europe—outlook on the building design process.

Where did you grow up?

I was born and raised in a suburb called Downers Grove, located about 25 miles outside Chicago. Other than a couple-year stint in the Indiana Dunes area, a few years living in Chicago itself, and then a couple of years of living in Seattle, when I joined MKA—well, and also when I lived in Europe for four months as a recipient of a traveling fellowship—I've spent my entire life in Downers Grove. It's been a great place to live and raise a family.

That's pretty neat to live by the Indiana Dunes.

I just have vague memories of it. My dad was transferred out there for a project assignment for a couple of years, and we were in a small house along the lake there. And I just remember being able to play in the sand and build massive sandcastles.

Speaking of building things, let's talk about how you got into architecture and engineering.

Yes, I guess that goes back to when I was a young boy, always fascinated with building things with Legos and Erector Sets and doing woodworking projects. I also remember being in my basement, drawing plans of my dream home and designing and making forts out of tables and boxes and things like that. So I was always interested in building things. My dad, who was a civil engineer, designed water treatment plants and always wanted me to be an engineer. But I was actually more interested in building vertically, so I wanted to be an architect. That's what I decided to study in college, but when I was in school, I actually found myself gravitating more towards math- and science-based classes, and I just realized that engineering was probably more in my wheelhouse in terms of my strengths, so I decided to go in that direction.

Where did you go to school?

I am a Fighting Illini! I studied at the University of Illinois down in Urbana-Champaign. They have a really great program where you can get a bachelor's degree and a master's degree in architecture, and during the master's program, you can choose a specialization—design, preservation, etc. One of the options is structures, which is the direction that I took. It allowed me to get licensed as both an architect and a structural engineer. And that's exactly what I did.

My real passion was in structural engineering, so that became my day job. Because of my interest in architecture, I actually spent the first 18 years of my career working in architectural engineering firms. I then joined MKA 17 years ago, which is a civil and structural engineering consulting firm.

The architectural side of my education provided me with a great understanding of all the building systems and how buildings go together. It allowed me to better understand what architects are trying to achieve and how I could design the structure to better suit their needs and desires. And as a result, I became a better collaborator instead of being an engineer who rolls their eyes when there are creative or nonorthogonal ideas out there. Having an architectural license was also beneficial because it gave me a bit more credibility in the architectural community, making it even easier to collaborate with architects.

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**.

You mentioned a four-month fellowship in Europe. What did that involve? And did you encounter any particularly impressive steel structures during your trip?

I was incredibly fortunate to be the recipient of something called the Plym Traveling Fellowship, which is offered by the University of Illinois' School of Architecture. It's awarded to a seasoned professional that's been practicing for a decade or two. The objective is for the recipient to go to Europe for a minimum of four months to study something related to architecture. Given my background in both architecture and engineering, I focused on the topic of structural influences in the design of great European architecture. I felt like so many European projects were on the front covers of architectural magazines, and I wanted a better understanding of how European architects and engineers collaborate because they seemed to be leading the way at the time (this was in 2001). So my objective was to see and touch as many projects as I could. But equally important was meeting with the architects and engineers that created these beautiful pieces of architecture. Again, trying to learn more about how they collaborated. I traveled all over western Europe. I was in nine different countries and, I think, 56 cities. I met with many of the leading architects and engineers and people from their offices to just try to better understand how they work. I was exposed to a lot of things and was introduced to something I really love now: steel castings.

As far as projects, some of them were classics like the Centre Pompidou Center in Paris and the Munich Olympics facility (Olympiapark). I also became really intrigued and inspired by some of Santiago Calatrava's work. I met Jorg Schlaich and learned about his work with cable structures. One of Schlaigh's projects that stood out for me in particular was a small but beautiful lookout tower in Stuttgart, Germany (Killesberg Tower). It's a simple pedestrian lookout in a park that has a winding steel staircase to the top. It has a set of stairs that spirals around a slender central steel column. The central column was supported at the base by a beautiful steel casting. The lookout tower is stabilized by a delicate perimeter mesh of steel cables.

I'd like to see that one. Back to collaboration in architecture and engineering, you were a judge for our 2022 IDEAS^2 Awards program, which, of course, focuses on the successful integration of architecture and engineering. The winners haven't been revealed yet, but I was wondering if you could point to any other buildings, even past winners, that you feel are great examples of the successful integration of those two disciplines.

One that immediately comes to mind is down the street from my office: the John Hancock Center/875 North Michigan Avenue in Chicago. It's a very clean, simple, elegant structure, and the lateral system for the building is integral to and expressed as part of the architecture. There's also the Amazon Spheres in Seattle, which we recently completed (you can read about it in the May 2019 issue at **www.modernsteel.com**; it was an IDEAS^2 winner that year). The perimeter structural form is an architectural shell of steel. It's a very complex form, and yet it's comprised of repetitive modules that could be mass-produced and in a fairly cost-effective way. But it was designed in such a way that most people can't even see or find the repetitive pattern within the organic form.

I understand you're involved with the Chicago Committee on High-Rise Buildings. Can you talk a bit about that group?

It started in the late 1960s with Fazlur Khan, the great structural engineer with SOM, along with a small group of architects and engineers. At the time, they were trying to figure out how to design the Sears (now Willis) Tower well as other tall buildings, and they would get together once a month in a restaurant basement here in Chicago to swap ideas, challenges, and solutions. The group got larger over time and now consists of about 75 of Chicago's leading architects, engineers, developers, contractors, educators, and vendors—a very diverse group—that continues to meet and learn and solve problems for the next generation of tall buildings. We also work with the city of Chicago to help them with codes and other building-related topics.

Speaking of groups, I hear you like to play the drums.

Ever since I was a small kid, I wanted to be a drummer in a rock band. One of the prerequisites to play drums in the school band was to take a couple of years of piano, so I did that—reluctantly. I hated it, but I did my time and I was finally able to sign up to play the snare drum in my school band. And I kept practicing and got better. I then moved into all of the percussion instruments, playing the marimba, xylophone, timpani, all that kind of stuff. I kept getting better and was the first chair percussionist in the high school band, orchestra, and jazz band. Jazz was great, but I still really wanted to be a drummer in a rock band. Luckily, my sophomore year in high school, I was approached by three seniors about joining their rock band! We played stuff like Ted Nugent, Rush, Black Sabbath, and Aerosmith—and my hair was a little longer hair back then. We played parties and the local battle of the bands, which was in front of, like, 1,200 people. It was incredibly exhilarating! Actually, I almost went into music instead of architecture at college. However, I realized that maybe from a financial perspective, that wasn't the right choice, so I chose what I did. I've got absolutely no regrets, but I still tinker with the drums on the side. My drumming has been scaled back these days. I'm just playing in a contemporary service at my church, but I still have the dream of getting the band back together in retirement. ■

This column was excerpted from my conversation with Dave. To hear more from him, including some of his projects that he's most proud of, his boating adventures, what he loves about Chicago, and his thoughts on late Rush drummer Neil Peart, check out the March Field Notes podcast at ***modernsteel.com/podcasts****. Also, the winners of the 2022 AISC IDEAS^2 Awards program—for which Dave was a judge—will be revealed later this month at NASCC: The Steel Conference in Denver (****aisc.org/nascc****) and featured in the May issue.*

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

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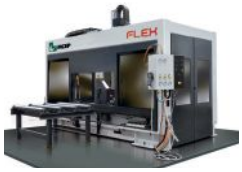

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Connecting for Optimization

BY JEF SHARP

Thoughts on how early connected models can help every link in the steel supply chain.

LAST MONTH, I wrote about how early connected models can help steel fabricators.

This month, let's expand the discussion to include the myriad ways that early connected models help the steel industry as a whole.

At Qnect, we call early connected model delivery projects "ISD" for integrated steel delivery. There are many advantages to integrating the connection engineering, detailing, and optimization of the model before the bidding process begins (which I'll explore in a second). Using these benefits makes steel less expensive and faster than other building materials—and also more sustainable.

There are many factors to consider when deciding which material to use. Let's start with cost. Every developer must crunch the numbers before making the choice to design a steel structure. Once they've made that (wise) choice, material, fabrication, and erection are the big three cost buckets, followed by design, detailing, and other miscellaneous costs. By delivering a fully connected and optimized ISD model early, a relatively tiny amount of cost moves upstream in the process and significantly impacts these costs and even general contracting costs. Here's how:

Material. If the model is connected early and is ready at the time of award, a more exact bill of material can be determined, eliminating tons of "drop waste" in the shop. Accurate bidding quantities for bolts, weld, studs, plate, and other related items further support efficient bidding as each fabricator will have the same connected model to bid from. On top of that, steel costs and rolling/delivery dates are secured earlier, which is advantageous from a cost and availability standpoint.

Erection. Early connection data about the structure allows engineers to put their eager minds toward finding ways to design for shop and erection efficiency. When this happens, they can identify complex issues—such as gusset or splice plate clashes or bolting /welding access hindrance—that might not otherwise be discovered until it's too late to efficiently correct them. For example, by exploring extended shear plates as one connection type option, 30% more erection picks per day can be achieved. Early solutions help both steel's performance and steel's reputation.

Fabrication. Knowing the connections in advance helps fabricators better understand assemblies and reduces the hours required for shop and field construction—and also allows fabricators to use their expertise to suggest alternate assemblies. And if the connections are optimized, then material and labor costs will be trimmed, too.

Design. For the architect and engineer, connecting the model early in the process broadens the scope of design options. According to one of the original proponents of early connected models, Allan Paull, senior vice president at AECOM Tishman, "Connecting the model early identifies problem areas that can then be solved, reducing the number of RFIs and change orders by 15% to 25%." Solving issues early also helps steel's performance and reputation. In addition, the engineer gets an early look at connection details and is able to review and approve the already optimized and worked-through connections much more quickly.

General contracting. The general contractor benefits from all these savings.

The result is having steel on-site earlier, faster erection times, faster fabrication, faster engineering and design changes, faster submittal package approvals, and faster bidding. And among other things, faster steel construction also results in lower interim financing and builder's risk insurance costs.

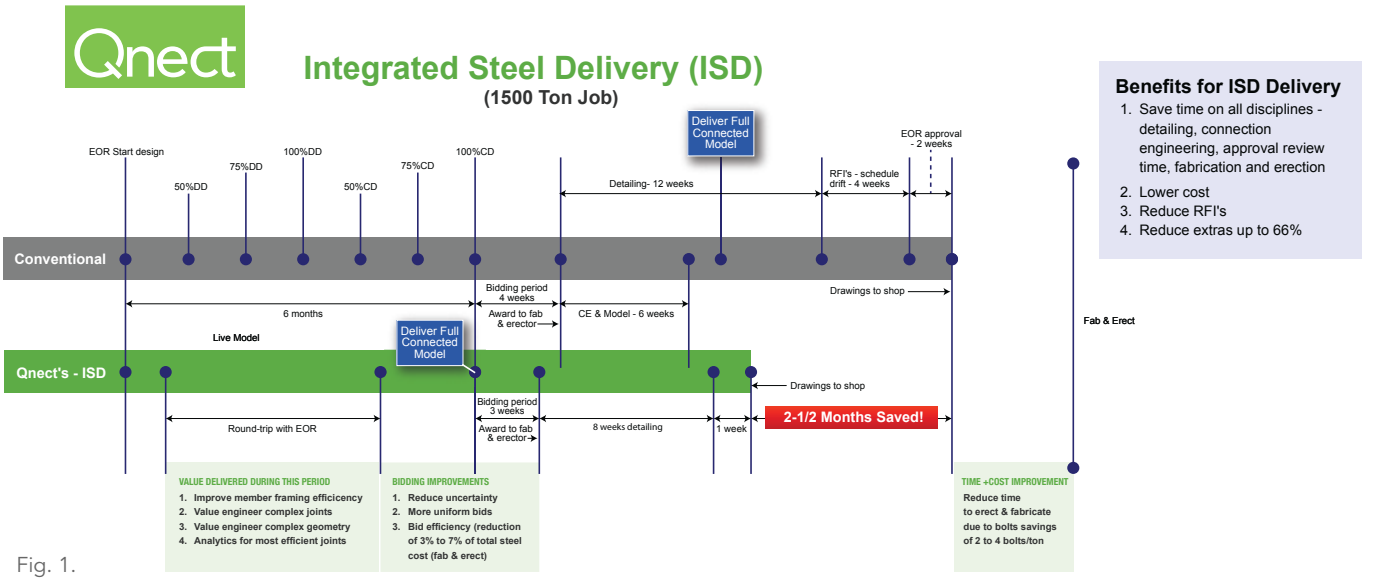


Fig. 1.

Preference Optimization Analysis

CONNECTION TYPE AND BOLT SIZE	Standard Number of Bolts, type 3" spacing	Optimized Number of Bolts Variable spacing
Base Line	9,612	5,479
Double Angle Bolted on Column Web, Single Angle, 7/8"	9,702	6,734
Double Angle Bolted/Bolted on Column Web, Shear Plate on Column Flange 7/8" A325 and 1 1/8" A490	8,801	7,028
Double Angle Bolted/Bolted on Column Web, Shear Plate, 7/8" and 1 1/8" A325	8,772	7,212
Double Angle Welded/Bolted- 1" A490	8,271	6,035
Extended shear plate at beam to beam-3/4" A325 and 1" A490	12,043	7,358
Shear Plate- 1" A490 only	6,371	5,325
Shear Plate, 3/4" A325 and 1" A325 and 1 1/8" A490	11,893	7,009
Shear Plate, 3/4" A325 and 1" A490 and 1 1/4" A490	11,650	5,350

Qnect

Let's move on to how ISD models can help with schedule and predictability. Here's an example. According to Charles Hongell, vice president at WSP, "Using a more conventional delivery, the time required to create the 3D model for the steel mill order, develop connections, and then add them to the model creates an inherent delay in shop drawing production. By moving this process upstream, steel shop drawing production and possibly fabrication can begin immediately upon award."

"By connecting the model early, the engineer can upsize columns or beams to reduce web doublers needed to reinforce steel at coped sections. This can reduce not only the overall fabrication cost but also the time required to fabricate the steel."

Figure 1 (previous page) shows a timeline from a 1,500-ton steel-framed project that was used to compare conventional delivery with ISD.

Clifford Schwinger, vice president at The Harman Group, provides further perspective.

"Fully connected models help designers spot unusual and/or unconstructable connections during design," he explains. "Being able to identify and address non-standard connections—particularly those requiring member reinforcement at the connections, as required by the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303)—makes the engineer's job easier and makes the project more profitable for everyone. Identifying unconstructable connections during design allows designers to reframe areas to improve constructability, something that cannot be done without huge cost implications after the project has been awarded and the steel has been ordered."

One example of cost savings comes from a presentation that Jason Pederson, vice president at Meyer Borgman Johnson, made recently at the Lean Construction Institute Congress. Pederson presented a Mayo Clinic hospital project that used an optimization approach to deliver an ISD model in two steps. In step one, the 3D model was created and connected early.

"We provided an apples-to-apples comparison for our fabricators to bid on, and it turned out to be a very competitive process since there were many fewer unknowns with the connections," he explains. In step two, the company worked with the selected fabricator to redo the connections based on some shop preferences. This step was only possible due to the speed of the software. In the end, Pederson figured the approach was a significant contributor to an overall $1.1 million in steel cost savings compared to the original budget.

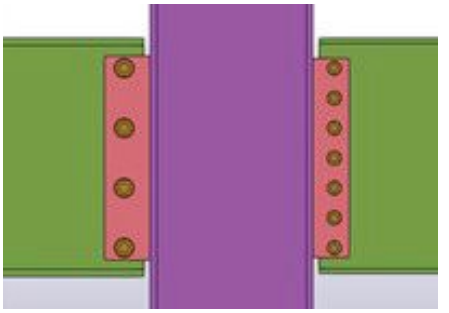
Figure 2 is a table from a smaller Qnect project (2,000 tons) showing a reduction in more than 40% of the bolts. The table compares standard spacing in a model vs. optimized spacing on nine complete runs of the project using different connection and bolt combinations.

Figure 3 shows a close-up of how optimization can have a big impact. Both sides of the column were connected using 115-kip loads. The left is optimized and the right is standard spacing.

If speed, schedule, and cost savings aren't enough, the steel industry is further elevated by the increased sustainability benefits of using an optimization approach. Anything we do as an industry to make a steel package more efficient will yield a lower carbon footprint.

above: Fig. 2.

below: Fig.3.



By keeping steel optimized and lean using the ISD process, everyone in the steel supply chain will benefit, as will the industry as a whole via more steel projects. ■

You can learn more about the ISD process by attending the panel discussion "T5: The Myriad Ways that Connected Models Drive Efficiency" at the upcoming NASCC: The Steel Conference in Denver, taking place March 23-25. To register, visit ***aisc.org/nascc****.*

Jef Sharp (**jsharp@qnect.com**)
is the CEO of Qnect.

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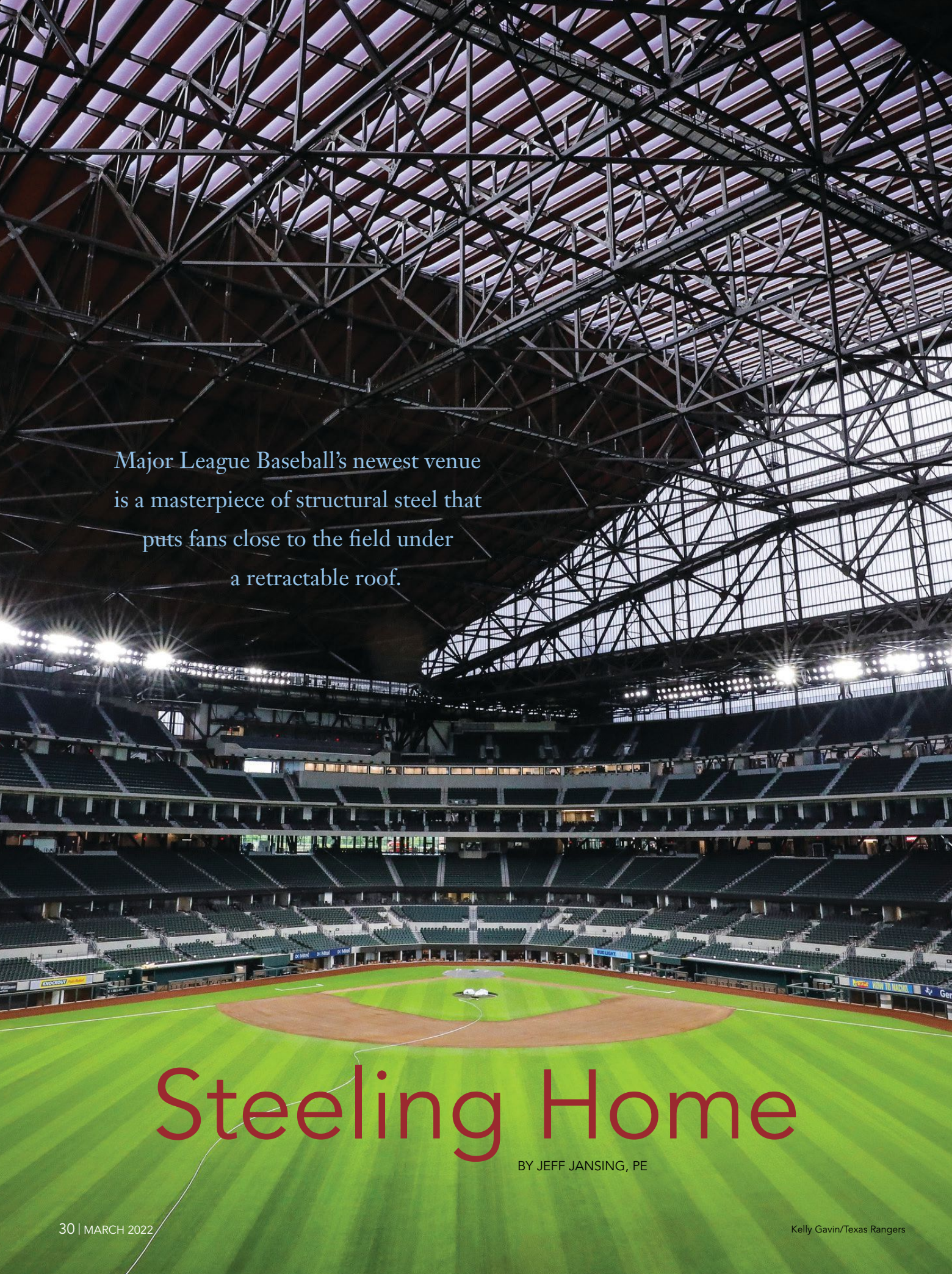


Major League Baseball's newest venue is a masterpiece of structural steel that puts fans close to the field under a retractable roof.

Steeling Home

BY JEFF JANSING, PE

Kelly Gavin/Texas Rangers

opposite: The steel-framed roof closed...

GLOBE LIFE FIELD in Arlington, Texas, hit it out of the park in its first season as the new home of Major League Baseball's Texas Rangers.

Due to COVID-19, the official opening of the multi-purpose venue was delayed as the MLB played a condensed schedule in 2020. However, the ballpark did host the 2020 World Series—the first neutral-site Series in MLB history—and the Rangers' first full season in Globe Life Field followed in 2021.

With the 2022 MLB season right around the corner, the team is once again ready to welcome fans into its structural steel-framed, retractable roof-topped shrine to America's pastime.

A number of factors were considered when it came to the park's steel structural framing system. The greatest concerns were achieving the architectural vision, balancing cost efficiency, and meeting the accelerated project schedule—design began in early 2017—which required the ballpark to be completed in a mere 38 months.

Walter P Moore provided structural engineering, construction engineering, and secure design services, working with general contractor Manhattan Construction Company to ensure the steel scope for the entire project correlated with the erection sequence and schedule.

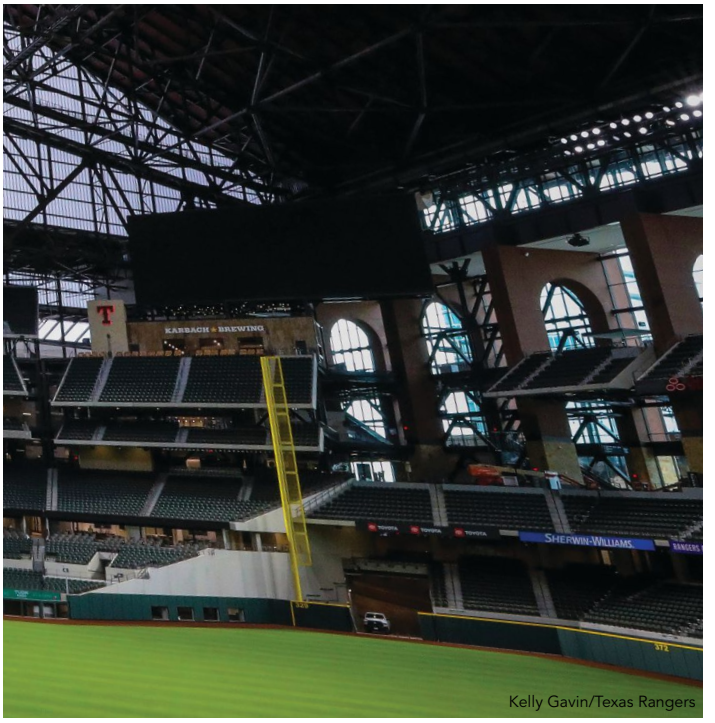
"The steel erection was one of the driving factors for the overall project schedule," said Greg McClure, senior vice president at Manhattan Construction. "Starting with the engineering review and throughout fabrication and erection of the structural steel members, priority and detail were exhibited by the design, engineering, and construction teams."

Steel fabrication for the ballpark's lower bowl started in March 2018, according to Bryan Irwin, vice president at Irwin Steel. The structure incorporates 34,000 tons of steel in all: 15,000 tons below the roof, for which Irwin Steel was responsible, and 19,000 for the retractable roof, which was fabricated and erected by W&W|AFCO Steel (WWAS) and W&W Steel Erectors (WWSE).

"The seating bowl steel was so critical to all other trades, especially the roof steel, that the schedule was determined before we began fabrication," Irwin said. "It was our job to ensure we met the schedule deadlines."

Site logistics also played a critical role in the project, especially when there were more than 130 ironworkers and six crawler cranes on the job site during the peak of steel erection for the bowl. The infield was used as a lay-down area for the bowl and roof steel and also to build sections of the roof trusses on the ground prior to lifting them into place. The various cranes were staged on the infield and around the exterior of the ballpark and were also employed for multiple other trades in addition to the steel. Therefore, communication between all members of the building team was critical.

"In our office, we had project managers from Irwin Steel and Dowco, the steel detailer," explained Vince Bosworth, president and CEO of bowl steel erector Bosworth. "Immediately next to our office were other key team members from Manhattan Construction, Walter P Moore, HKS, and other subcontractors. Several months prior to the start of erection, we were able to hammer



Kelly Gavin/Texas Rangers

above and left: While much of the steel is left exposed, it also frames elements like the historic brick-clad arches, as shown in the photo above and REVIT model at left.

opposite: The roof's framing system incorporates 19,000 tons of steel.

below: A steel-framed overhang on the park's exterior.

Daryl Shields, HKS, Inc.

out all the design-assist activities, as well as detailed schedules and logistics coordination. Our teams were able to eliminate nearly all of the field welding to ensure very aggressive turnover dates."

"I am committing the full resources of my companies to ensure the first baseball game and initial events start on time," said Rick Cooper, president and CEO of WWAS. The company designed steel connections, performed detailing, and fabricated the steel in several of its 17 fabrication facilities. Also included in the roof contract was the mechanization and continuous welded rail on which the roof traveled.

"WWAS assembled a team able to fabricate and erect the steel, furnish and install the mechanization systems, and design, furnish, and install the ethylene tetrafluoroethylene (ETFE) and metal deck roof system," noted Mike Hankins, senior vice president of WWAS. This scenario allowed the Rangers and Manhattan Construction to rely on one company to execute the roof contract.

The retractable roof, which is the largest movable roof in the world, consists of two rail truss structures, the movable portion of the roof, and two fixed roofs. Roof erection required very close coordination with the bowl steel and precast activities along with the cast-in-place concrete work performed by Manhattan. The WWAS team generated a 4D model incorporating all steel and concrete activities to ensure schedule certainty for the stadium superstructure.

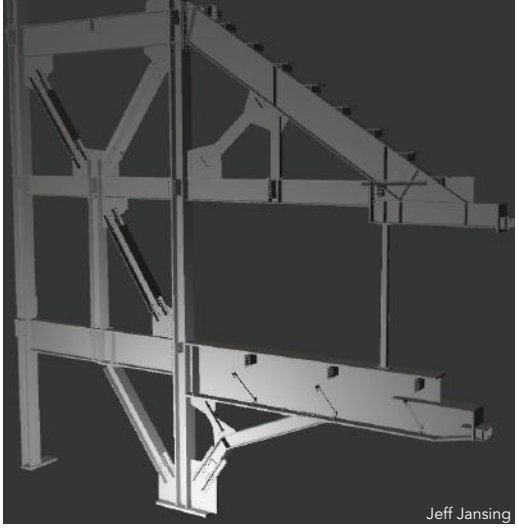
Daryl Shields, HKS, Inc.

Construction of the roof steel by WWSE incorporated many unique construction methods. The movable roof and fixed roof trusses were ground-built into large assemblies weighing up to 600 tons each and hoisted using a 2,535-ton-capacity Manitowoc 31000, the largest crawler crane made in the U.S. WWSE also designed, fabricated, and installed temporary shoring towers to allow the long-span trusses and the entire roof system to be erected from inside the bowl.

WWAS and WWSE worked around the clock both in the shops and field to turn the roof structure over to the Rangers. The field crew worked two shifts, with 275 workers and 11 cranes in all, in close coordination with Manhattan and its subcontractors.

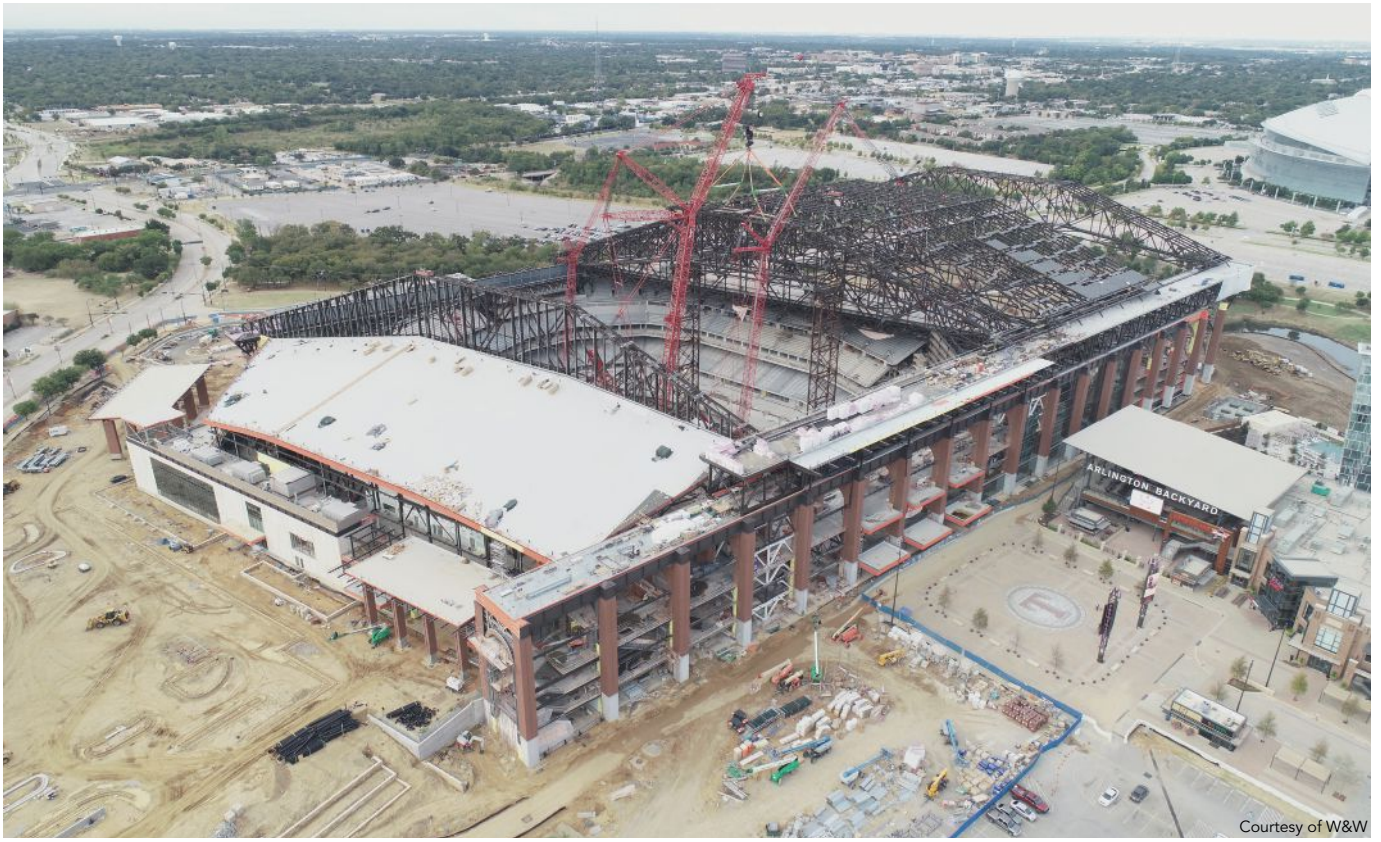
Because the Rangers wanted fans as close as possible to the field, architect HKS designed multiple seating options, each with unobstructed views of the field. The seating bowl was also divided into seven tiers stacked vertically, leading to seven distinctive front row experiences. As a result, the first row of the seating bowl at the field level is 7 ft closer to the baseball diamond, the second tier is 14 ft closer, and the upper bowl seating tier is 23 ft closer compared to the Rangers' old ballpark (now called Choctaw Stadium and located immediately north of Globe Life Field).

"It's all about intimacy and making the spectators part of the game," noted Greg Whittemore, principal at HKS. "We also integrated the typical club level into the lower bowl in lieu of having

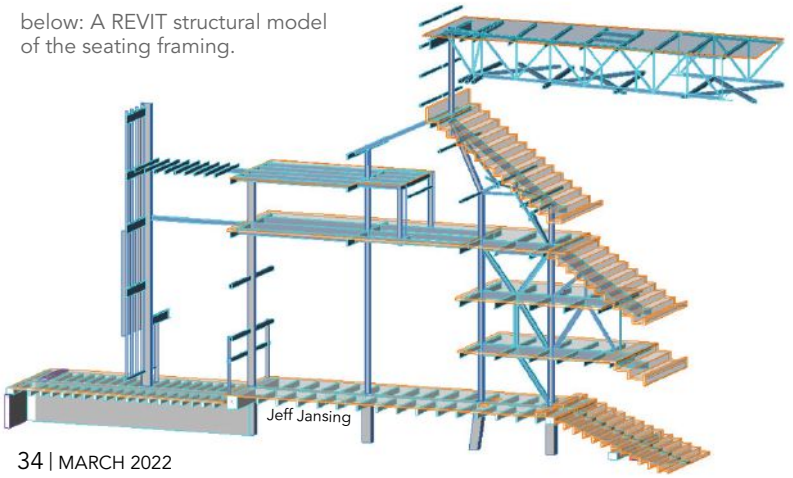


above: Y-shaped columns (bottom-right section of image) support the party suites from below while angling the support behind the lower bowl seating.

right: A roof truss section being lifted into place.

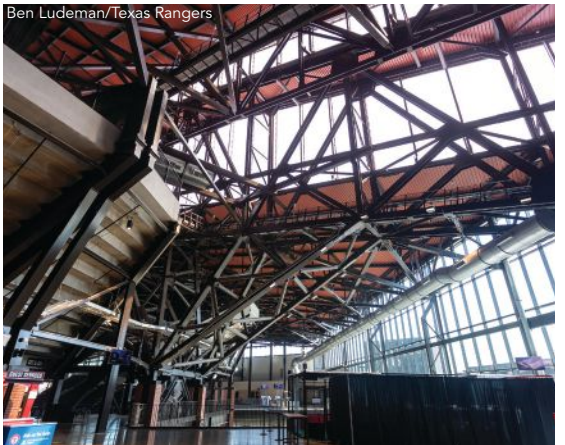


below: A REVIT structural model of the seating framing.



above: Erecting the roof elements.

below: A steel truss column supporting a roof truss.



a separate level, which would have pushed the upper deck fans higher and further away from the playing field."

Faced with the challenge of supporting multiple elevated seating decks and suites above the lower bowl, Walter P Moore designed multi-story cantilevered steel trusses concealed within each suite divider. This eliminated the need for columns within the lower bowl, which would have obstructed field views.

"Any structural framing, such as truss chords or web members, was concealed within the divider walls separating the two adjacent suites," said Shruti Sharma, principal at Walter P Moore. "We coordinated the truss locations and divider walls to align with the steel column behind the suites to optimize the space within the suites."

Additionally, there was inadequate space for stacked trusses alongside the party suites where multiple suites connect. Again, Walter P Moore leveraged the flexibility of steel by creating distinctive asymmetric steel Y-columns to efficiently support the plate girder framing for these suites and not interfere with sightlines.

"It was desired to connect two adjacent suites, and we could not add a truss between them as the truss members would have hindered the free flow of the crowd between the suites," Sharma explained. "A traditional straight column was also not an option as it would have punched through the lower seating tiers and rendered some of the seats unusable."

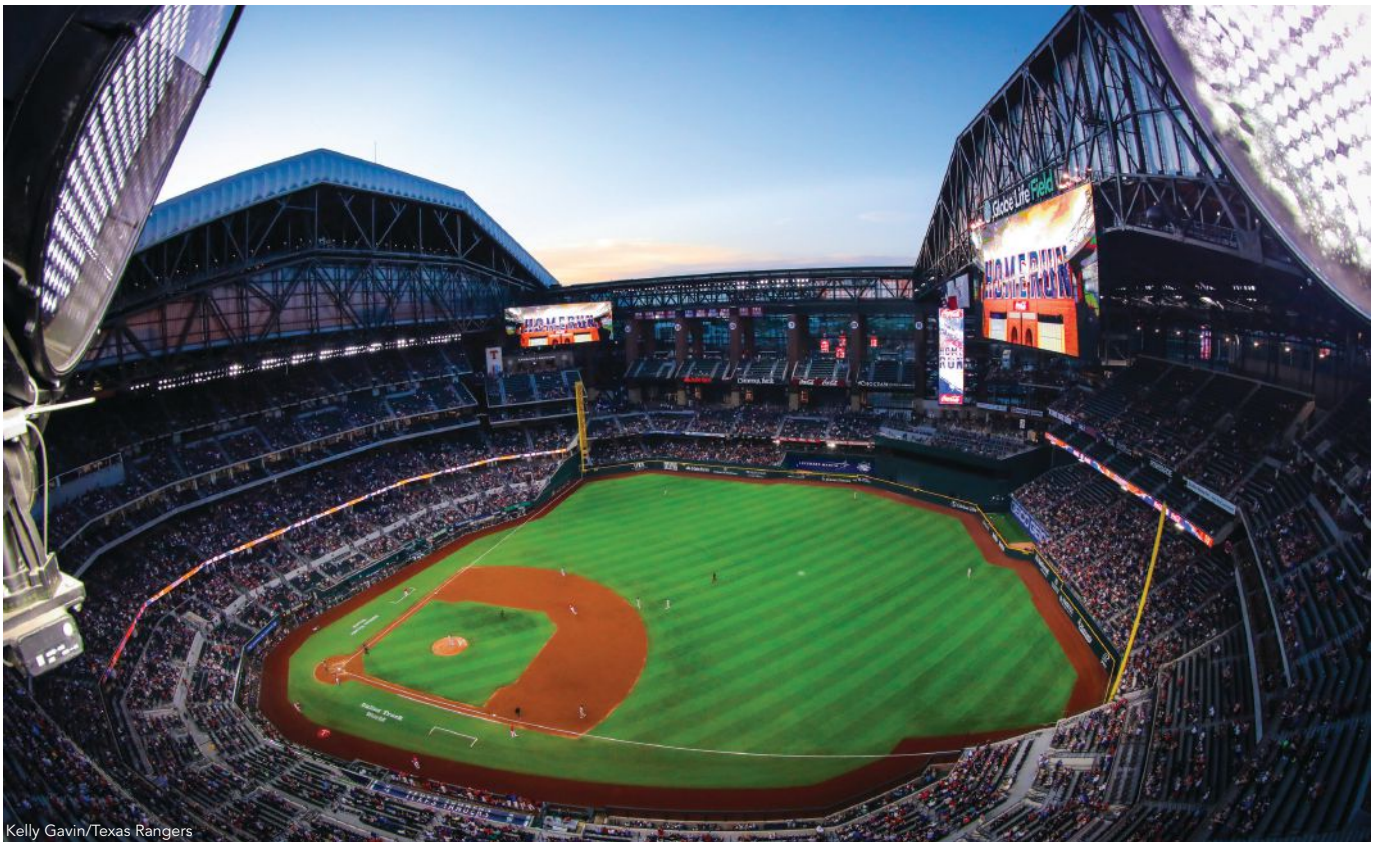
The Y-shaped columns support the party suites from below while angling the support behind the lower bowl seating, ensuring connectivity in the party suites and fully usable seats in the lower bowl.

In order to keep fans in the seating bowl comfortable, the Rangers wanted a retractable roof for their new home. The roof provides a climate-controlled ballpark during inclement weather and enables an open-air atmosphere during pleasant weather. Drawing on previous experience with the design of retractable roofs, Walter P Moore created a lightweight and adaptable moving roof, leveraging two distinctive attributes of structural steel.

With dimensions of 420 ft by 680 ft, the 300,000-sq.-ft single operable roof panel travels more than 400 ft to open in 12 minutes and is flanked by fixed roof trusses on the east and west sides. The panel is supported by steel trusses with depths up to 65 ft.

Walter P Moore and HKS also wanted to introduce a steel support element for the east box truss at the south side of the venue. This signature sloping steel truss column slices through the seating bowl, creating a dramatic structural feature that is both functional and visually engaging. It also serves as an intermediate support and helped reduce the span of the fixed roof truss to 520 ft from 650 ft.

"The support is comprised of a series of planar-truss columns interconnected by web members, creating a three-dimensional spaced trussed column," said Joseph Dowd, principal at Walter P Moore. "The planar trusses connect to the east fixed roof truss and pinch down to singular points where they are supported by columns extending vertically from the bowl structure, creating an aesthetic expression to marry the structural steel of the roof with the fan experience of the seating bowl." The sloping steel truss columns also significantly reduce the span



Kelly Gavin/Texas Rangers

The infield was used as a lay-down area for bowl and roof steel and also to build sections of the roof trusses on the ground prior to lifting them into place.

of the east box truss, allowing the box truss to efficiently carry the east fixed roof and the primary video board.

Connecting the intersection of the box trusses that support the fixed roof and the rail trusses that support the operable roof presented the opportunity for another innovative steel-based design.

"At each of these four knuckle joints, two three-dimensional trusses with different panel point rhythms intersect at an acute angle while transferring large forces from one truss to the other," Dowd explained. "The flexibility of structural steel allowed for this complex arrangement of steel members to create these crucial joints."

Even with the roof closed, the Rangers wanted to give fans the feel of an outdoor experience. Therefore, the primary roof trusses were spaced 45 ft apart, and shallow steel purlins were used as infill to maintain the desired aesthetic. In order to maximize the indoor/outdoor experience for fans, glass and three-layer ETFE façade elements are located throughout the ballpark to allow daylight to fill the entire structure. The most significant use of ETFE was on the roof, which features a 420-ft by 180-ft stripe of ETFE supported by a series of low-profile steel tube members and upstand steel brackets.

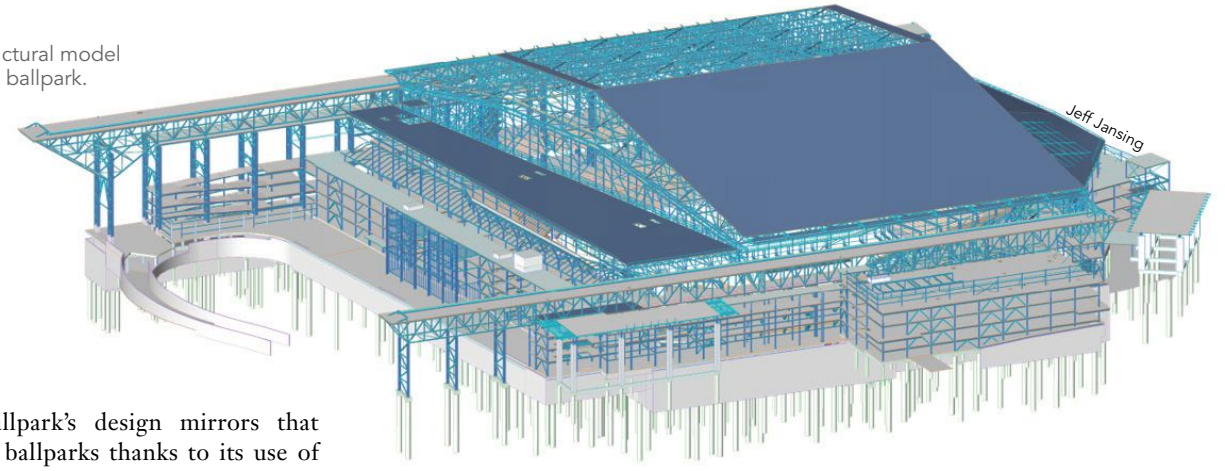
Throughout the design, engineering, and construction of Globe Life Field, software played a critical role—especially for the roof. For example, as the operable roof makes its way along the travel path, thousands of structural steel members experience variable forces and deflections based on the fluctuating location of the moving roof. Walter P Moore wrote a programmatic script to interface with the SAP2000 software analysis model that allowed the designers to input an interval distance and observe various roof elements as it moved along the rail to fully analyze the structural model at the closed and open positions, and every interval in-between.

"The interval could be as large or small as desired depending on the required fidelity of the results," Dowd said. "The team mined the resulting data to create variability plots of any selected force or deflection for any steel member of interest in the model. This tool was enormously powerful in allowing the team to visualize the impact of the moving roof and intentionally design each member and its connections for the required structural behavior."

For other aspects of Globe Life Field, Walter P Moore streamlined the process to accelerate design without compromising quality. Due to the size of the project, multiple engineers were coordinating different parts of the building and needed to continuously update the analysis model to keep the project on schedule.

However, SAP2000 only supported a single user working in the model at one time. Walter P Moore developed a script that allowed engineers to check out a portion of the central analysis model and update it while another engineer concurrently checked out a different portion. The changes from multiple users were saved to the central analysis model to study the combined behavior.

These changes were pushed from the analysis model to the BIM 360 Revit model for design coordination. This advancement from one engineer to multiple engineers having access to the central analysis model was key to the success of the project, offering a swift turnaround of design changes for coordination and analysis purposes. More importantly, it allowed the design team to maintain the project's momentum and facilitated early steel delivery. It was truly a team effort between the various disciplines to complete the project in 38 months.



A REVIT structural model of the entire ballpark.

The ballpark's design mirrors that of historic ballparks thanks to its use of exposed structural steel. With this traditional approach working in concert with modern-day elements like the ETFE retractable roof, Globe Life Field has stepped up to the plate as the lead-off hitter for a new era of ballparks. ■

Owner
Texas Rangers

General Contractor
Manhattan Construction

Architect
HKS

Structural Engineer
Walter P Moore

Steel Team

Fabricators
Irwin Steel, Justin, Texas (seating bowl/below roof steel)

W&W | AFCO Steel, Oklahoma City (roof steel and connection design)

Erectors
Bosworth Steel Erectors, Dallas (seating bowl/below roof)
W&W Steel Erectors, Oklahoma City (roof)

Detailer
Dowco Consultants, Langley, B.C., Canada (seating bowl/below roof)

Jeff Jansing
(jjansing@walterpmoore.com)
is a principal at Walter P Moore.

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Augmented Approach

BY HANNAH B. BLUM, PHD

Augmented reality provides a tool for steel fabricators to improve their processes, and a university research team is developing a program to make it accessible to fabricators across the country.

MISTAKES IN THE STEEL FABRICATION PROCESS can result in material costs and delays, which can strain the existing project budget and schedule, leading to additional challenges.

To help prevent fabrication errors, a University of Wisconsin-Madison (UW) research team is working on a custom augmented reality program that will assist steel fabricators in indicating where and which fabrication operations need to be performed on a given steel section using a model of the fabrication documents. This custom program can be used for quality control purposes before shipping the finished parts to the construction site.

The team envisions that the custom program, once finished, can be widely implemented in various structural steel fabrication shops across the country to supplement their existing workflow. The goal is to create a more effective process that will elevate the competitiveness of the structural steel industry.

Multiple Realities

You may be wondering what the difference is between virtual, augmented, and mixed reality. Virtual reality (VR) fully immerses the user in the virtual environment. Augmented reality (AR) overlays virtual objects on the real world. (The most popular applications of AR are Pokemon Go and Ikea's furniture app.) Mixed reality (MR) is an extension of augmented reality where virtual and real objects interact together in their environment. For example, the virtual object may move with you as you move in the real world, and you can manipulate and interact with the object. Extended reality (XR) is a catch-all term that encompasses VR, AR, and MR.

The UW project involves the overlay of holograms onto the real structural steel parts with limited additional information available. The current experience would be classified along the boundary of AR and MR; as the project develops and new functionality is added to the custom program, it would venture further into MR.

The team selected Microsoft's HoloLens 2 Mixed Reality headset for the project. Currently, HoloLens 2 is the most widely available technologically advanced MR headset and has a version with a hard hat for use in the construction industry.

Living in a 3D World

Although many fabrication operations are automated, some complex custom connections and shapes may be created manually by a skilled fabricator using fabrication documents to indicate the needed steps. Detailing complex 3D components on 2D documents can lead to challenges in visualizing the real-world structure.

NEED FOR SPEED

AISC's Need for Speed initiative recognizes technologies and practices that make steel projects come together faster. Check out **aisc.org/needforspeed** for more.

above: AISC Undergraduate Research Fellowship recipient Eddie Elder using the custom program on the HoloLens 2 headset.

below: Eddie's view through the HoloLens, with the holograms overlaid on the steel tee and plate.

Team Effort

For any project, the right team is crucial, and the AR tool project combines the expertise of various UW structural engineers and computer engineers. The structural engineering team consists of assistant professor Hannah Blum, the principal investigator of the project; PhD student Ed Sippel, PE; former student Eddie Elder, a recipient of AISC's Undergrad Research Fellowship; and former student Ben Liang. The computer engineering expertise comes from the Web and Mobile Solutions team led by Will Kraus and undergraduate researcher Nick Greene. The project is supported by AISC's research and technology divisions.

Using 3D holograms allows the technician to view the finalized connection or part and has two major advantages over viewing separate 2D section cuts. First, rather than mentally combining individual documents, the technician can view the complete part at full scale from multiple orientations. Second, the process can be completed hands-free, avoiding the need to consult various paper drawings or a tablet.

Accuracy and Key Features

The team found that accuracy within $\frac{1}{16}$ in. can be achieved when placing QR codes on the steel parts. This minimum accuracy allows holograms of the steel components to be accurately overlaid on the real steel components. As such, the steel components can be checked for accurate placement and size of holes and other features. (This was an important barrier to pass before additional work could proceed.)

The team is developing several key features, some of which are already completed and some of which are still in progress, to develop the custom program into a useful tool:

- The ability to capture dimensions from a design file and allow the user to select a dimension to display on the overlaid hologram. A user interface will be designed to display all relevant information needed from the connection documents
- A virtual tape measure, which allows the user to measure features on the steel components. This will provide a quick quality control check
- Information recording, including tracking to take pictures as needed and speech-to-text for the technician to note deficiencies quickly
- A step-by-step tutorial of how a complex fabrication process is completed. This will indicate to the technician which operations need to be completed to which part of the steel section and in what order

Future Directions

Implementing AR in steel design and construction can help increase quality, improve collaboration, permit timely decisions, and allow for shorter project timelines. Eventually, the steel construction industry may use AR and MR for the overall QA/QC of buildings and other structural projects. ■

This article is a preview of the 2022 NASCC: The Steel Conference session "Applications for Smart Glasses and AR in Structural Steel." The conference takes place in Denver, March 23-25. For more information and to register, visit ***aisc.org/nascc****.*

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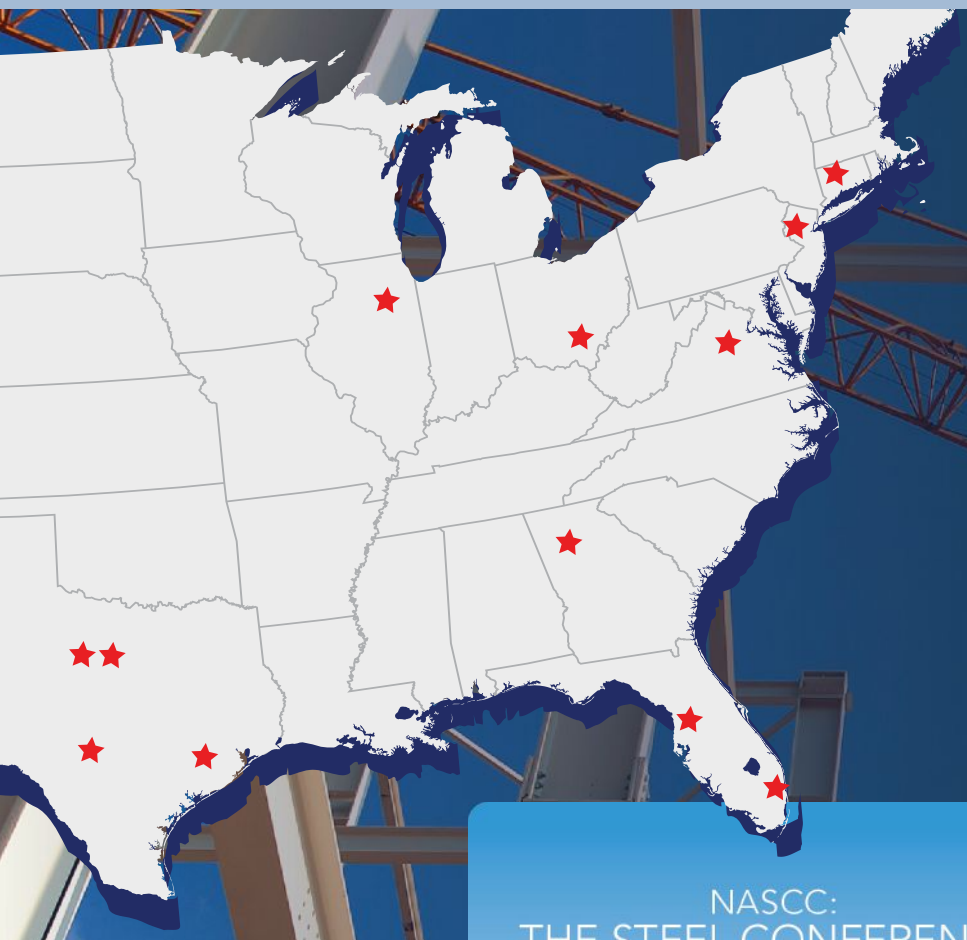

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Updated Requirements, Same Intent

BY LARRY GRIFFIS, PE, LARRY MUIR, PE, AND LARRY KRUTH, PE

Changes are coming to design document requirements in the 2022 AISC *Specification* and *Code*. But fear not! The intent remains unchanged, and the impact on users should be minimal.

ISSUING COMPLETE CONSTRUCTION DOCUMENTS has always been the best practice to ensure a safe and economical steel structure—emphasis on *complete*.

This has been AISC's mantra for its *Specification for Structural Steel Buildings* (ANSI/AISC 360) and the AISC *Code of Standard Practice for Steel Buildings and Bridges* (ANSI/AISC 303) since they were both first published in the early 1920s (you can access current and past versions at **aisc.org/specifications**).

Users of both publications will see changes in the 2022 editions that are intended to make structural steel projects safer and more economical. These changes involve requirements for structural steel documents and specifications and the approval process and are focused on improving what arguably is the most important aspect of any construction project, clear and timely communication.

How It Started, How It's Going

Before we dive into the details of these updates, let's take a brief look back at the relationship between the *Code* and *Specification*. Beginning with the first version, published in 1924, the *Code* has included language delineating the requirements for design drawings. Similar language appeared in the *Specification* beginning in 1936. As time went on, the two lists of requirements began to differ, although the intent was always the same. When the 2005 *Specification* was being drafted, it was decided to just refer to the list of requirements for design drawings that appeared in Section 3 of the *Code* rather than duplicate the list in the *Specification*.

Section 1.1 of the *Code* states: "In the absence of specific instructions to the contrary in the contract documents, the trade practices that are defined in this *Code* shall govern the fabrication and erection of structural steel." Unfortunately, there have been cases where the requirements of Section 3 of the *Code* were being modified or excluded altogether in the contract documents, thereby resulting in incomplete design documents for bidding and/or construction.

To resolve this issue, the AISC Committee on Specifications and the Code of Standard Practice Committee jointly decided to work on resolving this issue in the 2022 versions of the *Specification* and *Code*. The solution was simply to revert to what was done in the *Specification* in the past and list the requirements for design documents in the *Specification* in Section A4—and refer to the same list in the *Code* in Section 3. This is exactly the opposite of what was done in the 2005 edition.

From the "Good Old Days" to Now

The main driver of the changes to the design document requirements was a change to the design document process. There was a time when the engineers produced structural design documents and specifications, the fabricators and erectors bid from nearly complete design documents, the chosen fabricators and erectors produced shop and erection drawings, and then the engineer of record (EOR) approved the shop and erection drawings—more or less in this order. Believe it or not, for quite some time, this seemed like the logical way to manage a project, and the practice was very successful. The design development and bidding process looked something like what's shown in Figure 1.

However, practice has changed. Many modern projects do not proceed in this sort of sequential manner where one task is complete, or at least nearly so, before the next is begun. It is now more common to begin soliciting pricing and awarding structural steel contracts well in advance of final design. The design development and pricing process of today often look more like Figure 2.

This is not a recent change or one that occurred overnight. The switch from an industry dominated by a sequential design-bid-build process to one increasingly dominated by something that might be called "fast-track" probably began in the 1960s. By the 1990s, it was already rare for structural steel fabricators to price from "complete design drawings."

The fast-track process evolved to reduce construction time, resulting in a reduction in the cost of steel structures from the time of conception by an owner to substantial completion and move-in, including the design stage, issuance of bidding and construction documents, preparation of shop drawings, approvals, fabrication, erection, and final project completion. Today, there is much focus on streamlining the process even further for economy and schedule improvements. However, history has taught us that there is a trade-off between speed and risk, as depicted in Figure 3.

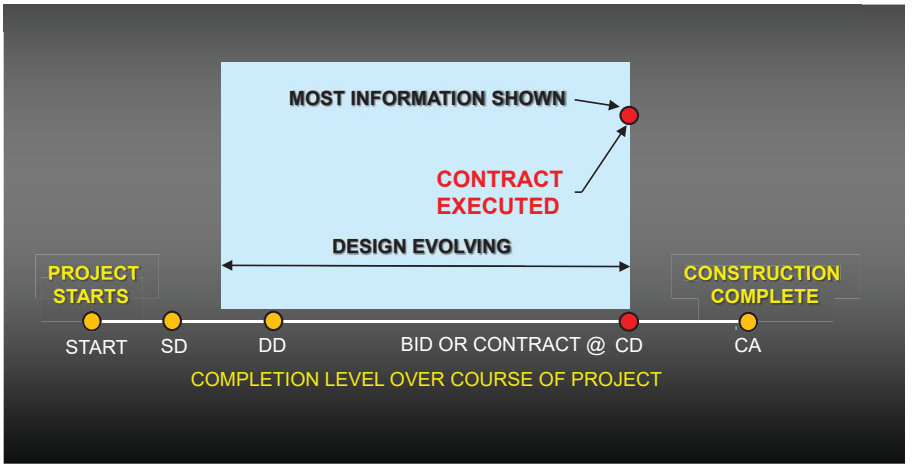

Fig. 1. The typical construction sequence before the fast-track approach became more common.

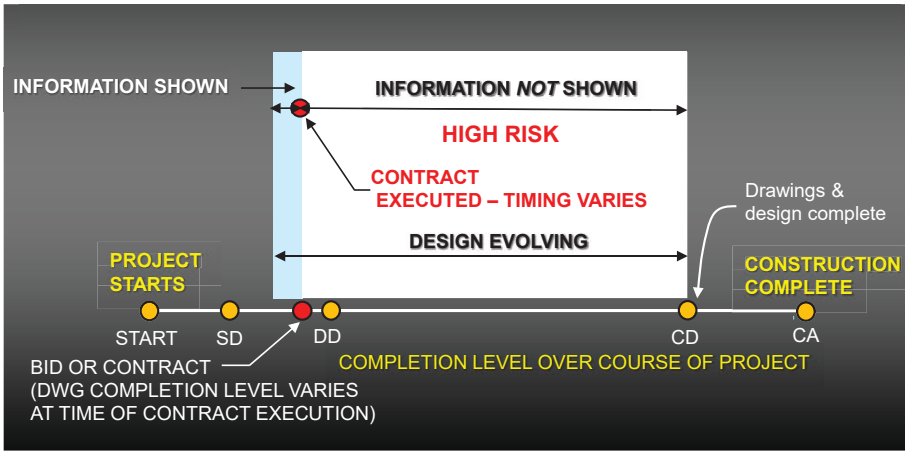

Fig. 2. The modern fast-track construction process.

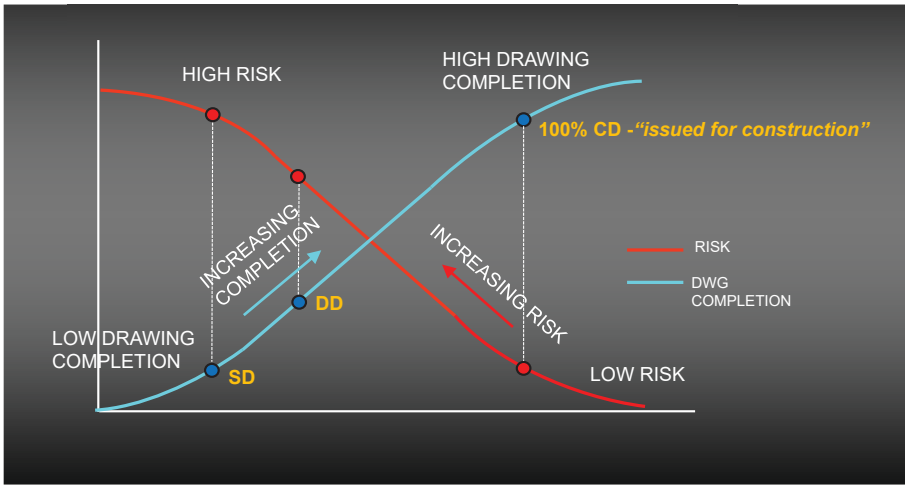

Fig. 3. The trade-off between speed and risk.

Why Change?

Users of the 2022 *Specification* and *Code* will probably be wondering why some of these changes have occurred. The most basic reason is that members of the AISC committees were observing behavior in the industry that could potentially threaten the safety of structures, and therefore it was decided that action was necessary.

In a more sequential design-bid-build process, it is easier to keep track of what information has or has not been finalized and what information has or has not been issued for various purposes. It is more difficult when the schedule is compressed. Though the relative timing of design completion and award of the structural steel contract has changed, the total amount of information that must be provided by the EOR to the fabricator and erector has not. Electronic transfer of information, whether in the form of scans of traditional drawings or digital models, means that there is less paper—and less time spent printing, copying, shipping, and receiving drawings—but the amount of information necessary to adequately convey the design intent has not changed. Whether the contract is awarded during the schematic design phase or when construction documents are complete, the physical parameters (material requirements, geometry, loads, etc.) of the final structure do not change, and therefore the amount of information required to turn the design into a final structure, again, does not change.

If the total information required to describe the work—the quantity, quality, and nature of the structural steel to be fabricated—hasn't changed, then at some point, all this information must be provided. Why? To ensure the design intent is satisfied. Why? To ensure the structure is safe. There is no real change here.

Specification Section A4 Changes

What has changed is information in the *Specification* regarding design documents. Structural design documents and specifications must contain enough information to ensure the EOR's intent is realized in the structure that is physically built. Currently, the 2016 *Specification* states, "The structural design drawings and specifications shall meet the requirements of the *Code of Standard Practice*," and the *Code* provides a detailed list of drawing requirements. Much of this list will be moved to Section A4 of the 2022 *Specification* with some additions and slight modifications. Structural design documents and specifications are required to be legible and drawn to an identified scale that is appropriate to clearly convey the information. This is pretty basic and obvious.

As shown in Table 1, every piece of information that will be explicitly required in Section A4 of the 2022 *Specification* is already currently required to be provided. This makes sense because this information is necessary to ensure the safety of the structure, and the AISC Committee on Specifications wanted to ensure this information was included in the *Specification*.

The information listed in Table 1 will only be required for structural design documents and specifications *issued for construction*. While the *Specification* doesn't require this information to be provided for bidding or contract, the Commentary does recommend that all this information be provided and states, "Release of documents for bidding or contract that are not sufficiently complete could have life safety implications if the structural design is not advanced to allow proper definition of the scope of work." This statement reflects the realities the committees had to struggle with when determining what was critical for safety and therefore belonged in the *Specification*, and what was less critical for safety and therefore could be placed in the *Code*.

It was ultimately decided that all the information that could impact safety had to be provided before construction began (otherwise, the risk to safety was too great) and therefore, this is where the committees drew the line. Theoretically, any of this information could be provided right up to the commencement of construction without impacting safety because things that do not physically exist cannot jeopardize safety. While last-minute design changes or information provided very late in the process technically do not lead directly to physical danger, they can cause strife on projects and can, if not properly addressed, lead to conditions that increase physical danger.

It is easy to see how bidding and contracting from incomplete information potentially (though not inevitably) increases the risk to safety. First, if partially complete information is released by various parties over time, it becomes difficult to keep track of what information has or has not been issued for various purposes and therefore more difficult to track and clearly and individually indicate the revisions on the contract documents. Second, as the project progresses, introducing changes tends to become more expensive, more contentious, and therefore more difficult. The difficulty of making such changes can be affected by the terms of the contracts that the various parties have agreed to, which is not within the purview of the *Specification*. However, some contract provisions can significantly disincentivize such changes, which arguably can be an intended feature of such provisions, or strongly incentivize parties to disguise changes as anything but a revision to the contract to prevent changes to the cost and/or schedule.

While the AISC Committee on Specifications recognizes the pressures that the EOR can be subjected to under such arrangements, ultimately engineers are professionals, and the *Specification* can only assume that engineers will, when necessary, stand up to such pressures and "do the right thing" to ensure the safety of structures.

Informed Consent

Structural design documents are issued for various purposes related to structural steel projects, including issuance for construction, permitting, fabrication, and erection, which can include ordering structural steel, commencing work on shop drawings, and commencing work on the project by the fabricator and erector. Structural design documents can also be issued for these purposes for all or only a portion of the project. Regardless of the purpose, it is vital that all affected parties (the project team) understand the intent and level of completion of the structural design documents. Therefore, the 2022 *Specification* will require the EOR, when structural documents are released, to identify the intended purpose and the date of release.

Section A4 of the 2022 *Specification* seeks to provide the EOR with some inviolable minimum level of control over the design documents they produce and retain responsibility for on every steel project. The 2022 *Specification* will require that "structural design documents and specifications released by any party for the purpose of bidding or as the basis of a contract shall be clearly identified by the (EOR) with the authorized intended purpose and shall include

Table 1. Required Information – Comparison of 2022 Section A4 to 2016 Requirements

Information Required for Structural Design Documents and Specifications Issued for Construction in the 2022 *Specification* Section A4	Where Required in 2016
Information as required by the applicable building code	The applicable building code
Statement of the method of design used: LRFD or ASD	*Code* Section 3.1.1(d) for connections
The section, size, material grade, and location of all members	*Code* Section 3.1(a)
All geometry and work points necessary for layout	*Code* Section 3.1(b)
Column base, floor, and roof elevation	*Code* Section 3.1(c)
Column centers and offsets	*Code* Section 3.1(d)
Identification of the lateral force-resisting system and connecting diaphragm elements that provide for lateral strength and stability in the completed structure	*Code* Section 7.10.1(a)
Design provisions for initial imperfections, if different than specified in Chapter C for stability design	Project-specific requirements
Fabrication and erection tolerances not included in or different from the *Code*	Project-specific requirements
Any special erection conditions or other considerations that are required by the design concept, such as identification of a condition when the structural steel frame in the fully erected and fully connected state requires interaction with nonstructural steel elements for strength or stability, the use of shores, jacks, or loads that must be adjusted as erection progresses to set or maintain camber, position within specified tolerances, or prestress	*Code* Section 7.10.1(b) and *Code* Section 3.1.4
Preset elevation requirements, if any, at free ends of cantilevered members relative to their fixed-end elevations	*Code* Section 3.1(f)
Column differential shortening information, including performance requirements for monitoring and adjusting for column differential shortening	*Code* Section 3.1 (Included in Commentary as "critical requirements…. that affect the integrity of the structure…"
Requirements for all connections and member reinforcement	*Code* Section 3.1 (Included in Commentary as "critical requirements…. that affect the integrity of the structure…" and *Code* Section 3.1.2
Joining requirements between elements of built-up members	*Code* Section 3.1(g)
Camber requirements for members, including magnitude, direction, and location	*Code* Section 3.1(e)
Requirements for material grade, size, capacity, and detailing of steel headed stud anchors as specified in Chapter I	*Specification* Chapter I
Anticipated deflections and the associated loading conditions for major structural elements (such as transfer girders and trusses) that support columns and hangers	*Code* Section 3.1 (Included in Commentary as "critical requirements…. that affect the integrity of the structure…"
Requirements for openings in structural steel members for other trades	*Code* Section 3.1 (Included in Commentary as "critical requirements…. that affect the integrity of the structure…"
Shop painting and surface preparation requirements as required for the design of bolted connections	*Specification* Chapter J – Required for slip critical connections.
Requirements for approval documents in addition to what is specified in the *Code* Section 4.	Project-specific requirements
Charpy V-notch toughness (CVN) requirements for rolled heavy shapes or built-up heavy shapes, if different than what is required in Section A3.	Project-specific requirements
Identification of members and joints subjected to fatigue	Appendix 3 – "The engineer of record shall provide either complete details including weld sizes or shall specify the planned cycle life and the maximum range of moments, shears and reactions for the connections."

the date of release." If the EOR is to retain responsibility for the design, which is something as a society we have long accepted, then the engineer must have a right to know what this information is being used for and by whom. In other words, when the EOR provides the design document(s), they have a right to full knowledge of the possible risks and benefits involved with doing so.

During the deliberations of the AISC Committee on Specifications, it was argued that this provision would interfere with the owner's rights to the design documents for which the owner had paid. However, other organizations and documents already recognize limits to the owner's rights. The *International Building Code (IBC)* does not make the owner or the owner's designated representative for construction (the general contractor) the party that must "review and coordinate certain aspects of the project… for compatibility with the design of the building or structure, including submittal documents prepared by others, deferred submittal documents, and phased submittal documents." Rather, it is the registered design professional in responsible charge that is assigned these tasks. Also, the National Society of Professional Engineers' *Code of Ethics for Engineers* states, "Engineers' designs, data, records, and notes referring exclusively to an employer's work are the employer's property. The employer should indemnify the engineer for using the information for any purpose other than the original purpose." Assuming such indemnification can even apply to buildings, it can only exist if the original purpose is clearly defined—and has been common practice and will be required in the 2022 *Specification*. Again, the changes have been made as a reaction to some potentially bad behavior that has been observed. The intent, as it has always been, is to highlight and reinforce existing and long-standing practices and requirements, not to introduce new requirements. The new language is provided in the interest of clear communication, common understanding, and ultimately the safety of steel structures.

Approvals: A New Section A5

The review and approval of fabrication (shop) and erection documents and "substantiating connection information" by the EOR is a vital part of the construction process that helps to ensure that the EOR's design intent has been adequately communicated and implemented. In other words, the approval process is vital to ensuring the safety of the structure.

With the advent of fast-track design and construction, it has been observed that a very small number of structural engineers have not been reviewing approval documents—and that some structural engineers refuse to even receive such documents. Various justifications for this behavior have been provided, including:

- "It allows me to reduce my fee and get jobs."
- "It reduces my liability because I cannot be held responsible for something I never saw."
- "I have no idea what I am looking at, so what is the point?"

Any engineer that agrees with the justifications above or feels, for other reasons, that structural engineers should not review approval documents might want to contact the authorities having jurisdiction over their projects, the applicable engineering boards, and/or legal experts. For purposes of this article, it will be assumed that the need to review approval documents is well-established, required by building codes, and simply not controversial. Most engineers have always reviewed submittals related to their structural designs.

In fact, a new Section A5 in the 2022 *Specification* states the following: "The engineer of record or registered design professional in responsible charge, as applicable, shall require submission of approval documents and shall review and approve, reject, or provide review comments on the approval documents," and, "When structural steel connection design is delegated to a licensed engineer working with the fabricator, the engineer of record shall require submission of the substantiating connection information and shall review the information submitted for compliance with the information requested."

Delegation of Connection Design

While the 2010 *Code* was the first version to explicitly address delegated connection design, delegated design, whether related to structural steel connections, roof trusses, open-web joists, viscous dampers, or countless other items, has long been a feature of building construction. In general, delegated design requires the EOR to define design criteria and the delegated engineer to satisfy the criteria provided. In jurisdictions and design standards where delegated design is explicitly addressed, the EOR is required to provide design criteria and ensure that the design criteria have been properly understood and implemented. This latter requirement involves some sort of review and approval process. To ensure effective delegation of connection design, the 2022 *Specification* will require that the design documents and specifications include design requirements for the delegated connection design and requirements for substantiating connection information. This change was made because the requirement has been placed in the *Specification*, as opposed to only in the *Code*, and because the phrase "if any" that was included in the *Code* language implied that substantiating connection information was not required—whereas the 2022 *Specification* will clearly require some form of substantiating connection information be defined to be submitted to the EOR.

What Isn't Changing?

As stated previously, there is no change to the intent of the language in either the *Specification* or the *Code*. The changes are meant to promote clearer communication and a common understanding of most existing requirements currently practiced by all the parties to a steel project.

Most responsible owners, engineers, general contractors, fabricators, and erectors are currently practicing all newly stated requirements. The *Specification* will continue to address the design, fabrication, and erection of structural steel buildings and other structures primarily as these factors relate to the safety of the structure. The *Code* will continue to address the trade practices involved in steel buildings, bridges, and other structures. There has always been and always will be interaction and overlap between safety and trade practices. In addition, the *Code* will continue to recognize three options related to connection design:

- Option 1: Complete connection design shown in the structural design documents
- Option 2: Connections selected or completed by an experienced steel detailer
- Option 3: Connections designed by a licensed engineer working for the fabricator

The *Code*, the *Specification*, and the overall industry will continue to recognize that only the EOR has all the information necessary to evaluate the total impact of connection details on the overall structural design of the project.

Corresponding Changes to the Code

Users of both publications will see that some changes and reorganization have occurred in *Code* Sections 1 and 3 that are tied to the *Specification* requirements. One important goal for the 2022 editions is to tie the *Specification* and *Code* language together and help users better understand the close relationship between *Specification* design requirements and *Code* specified contractual requirements. A few things are worthy of special note:

- The provisions of the *Code* represent standard trade practices involved in steel buildings, bridges, and other structures. They are balanced, fair, and consensus-based and represent the most efficient approach for the usual case. Variation from the *Code* will probably increase the cost of the work. However, specific instructions to the contrary are permitted and, in some cases, needed to suit specific project conditions. All parties should be familiar with the provisions of the *Code* and should carefully evaluate the impact of any variations from the *Code*. While this is generally true for all structural steel projects, it is especially important for projects with accelerated schedules employing unusual or innovative delivery methods.
- The *Code* is a balanced, consensus document written in a "party-neutral" manner and should not be modified for the purpose of dictating a commercial advantage. To that end, Section 1.1 requires any specific instructions to the contrary unrelated to design elements (e.g., relating to commercial terms) to include a reference to the specific *Code* section number. This requirement is intended to ensure that all parties are aware of and specifically agree to specific instructions to the contrary that may work to the advantage of one party and to the disadvantage of another.
- Extreme care should be taken to ensure that any modification is written in mandatory code language where applicable and is consistent with all other sections of the *Code* to result in a unified document. No modifications should be made to any *Code* section that violates the life safety or serviceability provisions of the applicable building code or results in a commercial advantage for any party that violates the intent of the *Code* to serve as a fair, balanced, and consensus document.
- Contractual requirements can have an indirect impact on safety by incentivizing or disincentivizing communication and the responsible handling of the revisions that are inevitable when schedules are compressed such that agreements must be made based on incomplete information.

The 2022 *Code* more widely references bidding quantities and allowances. Bidding quantities and allowances have long been used in the construction industry, though they were directly included in the 2016 *Code*, where they were used to better describe the treatment of member reinforcement at connections when connection design is delegated to a licensed engineer working for the fabricator. Whether addressing member reinforcement at connections or work-in-process structural design documents, the idea is that the bidding documents should include some clear description that can be assumed and used by the bidders. The intent is not necessarily for the EOR to provide a monetary quantity but rather that the information conveys an assumed quantity and complexity of the structural steel to be fabricated. There are obvious advantages to providing bidding quantities or allowances that are closer to the final conditions, though it will often not be possible to provide precise information.

The changes in the 2022 edition of the *Specification* and *Code* do not change the intent of the previous 2016 editions. The real intent of the changes is to clarify the requirements of current responsible practice in the design, fabrication, erection, and contracting of structural steel. The provisions emphasize the need for and benefits of clear communication, common understanding, and collaboration among all parties involved in the project. Ultimately, they benefit all parties and promote safety and economy on structural steel projects. ■

This article is a preview of the 2022 NASCC: The Steel Conference session "Seeing Eye to Eye: AISC Specification Design Document Requirements." The conference takes place in Denver, March 23–25. For more information and to register, visit ***aisc.org/nascc****.*

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The American Institute of Steel Construction (AISC) is a non-partisan, not-for-profit technical institute and trade association whose mission is to make structural steel the material of choice by being the leader in structural-steel-related technical and market-building activities, including specification and code development, research, education, technical assistance, quality certification, standardization, market development, and advocacy. AISC represents the total experience, judgment, and strength of the entire domestic industry of steel fabricators, distributors, and producers.

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American Steel Detailing is an all U.S. structural and misc. steel detailing firm. ASD does projects all over the U.S. Our team of 25+ detailers, checkers, and project managers are capable of doing projects large and small.

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toll free: 800.443.9353
www.aws.org
The American Welding Society (AWS) was founded in 1919 as a non-profit organization with a global mission to advance the science, technology, and applications of welding and allied cutting processes, including brazing, soldering, and thermal spraying. AWS offers industry-respected certifications, industry-trusted technical standards development, technical standards sales, education, membership, and expositions.

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Anatomic Iron Steel Detailing specializes in complex structural steel detailing, design-detailing, connection design, design consulting and 3D modeling. We operate both Tekla and SDS2. We also complete steel erection animations and 3D rendering. Our team oriented approach with our staff and clients has resulted in an outstanding track record of completing high profile complex projects accurately and on time. With over 150 staff, we can detail over 10,000 tons of structural steel per month. Please visit our website or call 510.984.4425 to discuss our project history.

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Association of Women in the Metal Industries
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www.awmi.org

Atema Inc.
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Chicago, Ill.
ph: 312.861.3000
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Atema is dedicated to providing quality related training and assistance for the structural steel industry with a specialty in AISC, AWS, and ISO certification/registration programs. Atema provides customized training programs and executive management assistance to structural steel firms. Atema's projects and clients reach across four continents and eight countries worldwide, with their headquarters located in Chicago, Ill.

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ATP, a division of Hy-Tech Engineered Solutions, started manufacturing air tool replacement parts in Pittsburgh, Pa. in 1923. Today ATP manufactures high quality pneumatic tools and replacement parts used for maintenance repair and operations (MRO) in oil and gas, power generation, industrial, construction, and heavy transportation markets in the U.S. and internationally. ATP manufacturers a large number replacement for use in products made by many of the leading OEM air tool brands, and provides engineered solutions to a broad group of OEM customers.

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AZZ Metal Coatings, a division of AZZ Incorporated, headquartered in Fort Worth, Texas, owns and operates 40 hot dip galvanizing plants strategically located across the U.S. and Canada. With kettles ranging from 16–62 ft. in length, we can easily handle a wide variety of material sizes. With our network of plants we are able to accommodate the largest projects with customized turnaround time at a competitive price.

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Founded in 2008 formerly as Midwest Structural Products, Bamal Fastener's Structural Division is a full line distributor of fasteners to the structural, solar and industrial manufacturing markets. Proudly offering the finest structural product manufactured by our partners in the U.S. and abroad. Bamal Fastener prides itself on its expertise and attention to detail in quality, cost and customer service. Our Structural Division is based out of Indianapolis, Ind. and corporate is located in Charlotte, N.C. The company has a network of eight locations throughout the U.S. and Mexico, strategically located for your needs.

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Bend-Tech products are at the forefront of designing and fabricating tube and pipe. The Bend-Tech Dragon is the essential production machine for any company that produces handrail or other miscellaneous metals. The Dragon accurately and efficiently plasma cuts round, square, rectangle, angle, and channel tubing. The Bend-Tech Dragon also accurately marks bend locations/rotations and part numbers. With over 27,000 customers Bend-Tech Software has reduced production time and material waste for companies since 2001.

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Birmingham, Ala.
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Cleveland Punch & Die Company is the world leader in manufacturing punches, dies and shear blades in the steel industry. All of our products are proudly manufactured in the U.S. Original Equipment Manufacturers continue to trust and recommend our products to meet and surpass our customers expectations for all steel applications. Our customers continue to trust and rely on the most experienced and friendly engineering and customer service support team in the industry. We are proud of our 141 Years of quality, experience, and tradition. Customer service hours: 7:00 a.m.–6:00 p.m. EDT. sales@clevelandpunch

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ph: 855.787.1980
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CSC – Canam Steel Corporation
booth 2620
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ph: 301.874.5141
toll free: 800.638.4293
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Canam Steel Corporation (CSC) is a service oriented manufacturer of open web steel joists and steel deck that services the entire U.S. via our six manufacturing facilities. We are a company that prioritizes safety and efficiency of the entire process for both our employees and our customers. We believe in the power of partnerships and the need for flexibility throughout the process for all of our partners. Our projects range from the small retail store at a local strip mall to some of the largest distribution centers, high-rises, schools, and stadiums. We are a participating member of both the SJI and SDI.

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cesteel.com
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The CWB Group is an industry supported private sector organization providing welding certification, management systems registration and training services to over 7,600 companies in 34 countries. Supported through CWB Certification, CWB Education, CWB Registration, CWB Consulting, and the CWB Association membership, the CWB Group provides a comprehensive and integrated service to the welding and joining industry.

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toll free: 800.237.0230
www.gerdau.com
Gerdau Long Steel North America (GLN) manufactures structural steel, piling, rebar, merchant bar, and special bar quality products for the agricultural, automotive, civil construction, distribution, energy, industrial, and mining markets. GLN operates seven mills in the United States and three in Canada, and is a wholly owned subsidiary of Gerdau S.A.

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GIZA is a connection design software that covers more than 400 different connection types in the shear, moment, vertical brace, horizontal brace, and splice categories. Compliant to AISC 14th, 15th editions—ASD and LRFD methods, GIZA provides a comprehensive set of calculations with references to all applied codes. We offer integration with Tekla Structures and Tekla Structural Designer but can also be used as a standalone option. GIZA has been in use for over 10 years and has successfully designed thousands of connections on thousands of projects over that time. Try it yourself free for 15 days!

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Grating Fasteners specializes in producing the G-Clip line of grating fasteners. G-Clips are used to attach grating to structural members using simple hand tools. The entire G-Clip line of fasteners are noted industry-wide as being a cost-effective, fast, and dependable way to fasten grating.

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ph: 765.529.0120
www.ncestainlessplate.com
New Castle Stainless Plate is an American-owned producer of stainless steel plate. We offer a full range of stainless steel grades (austentics, duplex grades, super austentics, heat resistant grades, enhanced machinability PRODEC, ferritics, and martensitics). We produce plates in dimensions that are wider, thicker, and longer than any other American stainless steel plate producer. We produce plates that are "tailor-made" to the dimensions required for the application design. We are certified to all apppropriate ISO standards as well as OHSAS 18001 and the European Pressure Vessel Equipment Directive.

New Millennium Building Systems
booth 2211
Fort Wayne, Ind.
ph: 260.969.3582
www.newmill.com
New Millennium structural steel building systems support your project and we support you. From steel joists and deck to long-span composite floor systems, we engineer and manufacture solutions that control costs, enhance performance, and ensure project success. Together, let's build it better. Over the years, our company has grown into one of the largest providers of cost-efficient, high-performance structural steel joist, joist girder and deck solutions for commercial steel construction projects. We have manufacturing facilities strategically located across North America.

NEW MILLENNIUM
BUILDING SYSTEMS

Nickel Institute/IMOA
booth 3621
Toronto, Ontario
Canada
ph: 416.591.7999
www.nickelinstitute.org
www.imoa.info
The Nickel Institute (NI) is the global association of leading primary nickel producers. Our mission is to promote and support the use of nickel in appropriate applications. Stainless steels account for about two-thirds of nickel produced. The International Molybdenum Association (IMOA) is a similar organization, representing the worldwide molybdenum industry. NI and IMOA have been actively involved in the Architectural, Building, and Construction industries, and instrumental in the writing of the AISC Design Guide 27 and the new AISC Specification for Stainless Steel.

Nitto Kohki U.S.A., Inc.
booth 1818
www.nittokohki.com

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Nucor – Beam Mill Group
booths 2403, 2603, 2803
United States
www.nucoryamato.com
www.nucor.com/products/Steel-Beam
Nucor has two beam mills: Nucor-Yamato Steel in Blytheville, Ark. and Nucor Steel Berkeley in Huger, S.C. Our Nucor-Yamato facility is the only North American producer of high-strength, low-alloy beams. Manufacturer of wide flange structural steel shapes (up through W14730 columns, and W44 beams), H-piles (including HP16 and HP18), sheet piling, angles, channels, and car building shapes. Grades include ASTM A36, ASTM A572, ASTM A588, ASTM A690, ASTM A709, ASTM A992, ASTM 913; and CSA G40.21-13 Grades 345WM and 345WMT.

NUCOR®
BEAM MILL GROUP

Nucor – Corporation
booths 2403, 2603, 2803
United States
www.nucor.com
Nucor and its affiliates are manufacturers of steel and steel products including: carbon and alloy steel—in bars, beams, sheet and plate; hollow structural section tubing; electrical conduit; steel piling; steel joists and joist girders; steel deck; fabricated concrete reinforcing steel; cold finished steel; precision castings; steel fasteners; metal building systems; steel grating; and wire and wire mesh. Nucor proudly uses recycled scrap to make high-quality steel with low emissions. Using one of the cleanest and most energy efficient steel-making processes available.

NUCOR®

Nucor – Fastener Division
booths 2403, 2603, 2803
United States
www.nucor-fastener.com
Nucor Fastener manufactures high-quality hex head cap screws, finished hex nuts, structural bolts, nuts, assemblies, flange bolts and built-to-print fasteners, head styles, dimensions and grades can be customized to meet individual specifications.

NUCOR®
FASTENER

Nucor – Plate Mill Group
booths 2403, 2603, 2803
United States
www.nucorhertford.com
www.nucortusk.com
Nucor Steel Plate Mill Group manufacturers a wide range of carbon, alloy, high-strength low alloy (HSLA), pressure vessel and heat treated (normalized and quench and tempered) products available as discrete, cut-to-length or coiled plate. Our mills offer a wide range of gauges, widths, lengths and grades that are customized to meet each individual customer's precise specifications.

NUCOR®
PLATE MILL GROUP

Nucor Skyline
booths 2403, 2603, 2803
www.nucorskyline.com
Nucor Skyline is the one source for all your piling needs, supplying and manufacturing an unparalleled assortment of bearing piles, sheet piles, spiralweld, rolled and welded, and ERW pipe, anchors, micropiles, threaded bars, tie rods, wide flange, other structural sections, and accessories. Skyline Steel, LLC (doing business as Nucor Skyline) is a wholly-owned subsidiary of Nucor Corporation, North America's most diversified steel and steel products company. Nucor Skyline serves the U.S., Canada, Mexico, the Caribbean, Central America, and Colombia markets.

NUCOR®
SKYLINE

Nucor Tubular Products
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United States
ph: 708.496.0380
toll free: 800.376.6000
www.nucortubular.com
Nucor Tubular Products is committed to unmatched quality and service. With eight locations located across the United States and a vast array of sizes and products produced, we can meet any specifications your project requires. NTP manufactures high quality HSS, piling, A53 pipe, fire protection sprinkler pipe, auto mechanical tubing, and electrical steel conduit meeting ASTM A500, A1085, A53, A513, A252, A153/A175 specifications among others. Our products are made from Nucor sheet steel from an electric arc furnace (EAF), making them the greenest tubular products available.

NUCOR®
TUBULAR PRODUCTS

Nucor Vulcraft/Verco Group
booths 2403, 2603, 2803
North America
www.vulcraft.com
www.vercodeck.com
Nucor, Vulcraft/Verco engineers and manufactures steel joists and deck (for structural roof or floor systems), as well as steel bar grating. We also provide, RediCor, a modular steel form system for concrete stair and elevator cores. Nucor, Vulcraft/Verco also provides multiple design aids and resources, such as our online design tools, to support the design community.

NUCOR®
VULCRAFT

Ocean Machinery, Inc.
booth 1211
Fort Lauderdale, Fla.
ph: 954.956.3131
toll free: 800.286.3624
www.oceanmachinery.com
Ocean Machinery delivers versatile and affordable solutions for the small to medium fabricator. Including: *Ocean AVENGER and AVENGER PLUS—the world's best-selling CNC beam drill lines *Ocean CLIPPER II—the most compact CNC angle line *Ocean LIBERATOR—the most affordable CNC beam coping machine *Ocean BLASTER—the smallest footprint shot blasting solution *Ocean CHALLENGER—a compact, automated welding robot. Plus, several other game changing solutions that improve the efficiency and profitability of fabricators worldwide!

Ohio Gratings, Inc.
booth 3406
Canton, Ohio
ph: 330.477.6707
toll free: 800.321.9800
www.ohiogratings.com
Ohio Gratings, Inc. is a leading manufacturer of aluminum, carbon, and stainless steel bar grating products—all proudly made in the U.S. We deliver a blend of artistry, safety, and seamlessness that's unmatched in the grating market. From design to manufacturing to custom fabrication services, we offer the complete solution. Our traction safety products—ALGRIP® and OnGrip® provide increased traction on grating and metal flooring applications meeting ADA and OSHA requirements. It's this search for the unexpected that helps us repeatedly surprise and satisfy customers keeping them "A Step Ahead."

OpenBrIM Platform
booth 3417
https://openbrim.org

OTH – Remote Controlled Hooks
booth 3914
https://othrigging.com

Ovation Services, LLC
booth 1907
Copley, Ohio
ph: 330.400.2833
www.4ovation.com
Ovation Services is a leading provider of engineering services. Combining experience, technology and a client-centric approach, Ovation Services provides Structural Steel Detailing, Connection Design and BIM Services across the United States. The Acquisition of MMW, Inc. a detailing firm with over 30 years experience in the steel industry, gives Ovation Services a talented project management team to ensure a quality product. Strong leadership, global resources and U.S. based checking uniquely qualify Ovation to be your preferred partner.

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P2 Programs
booth 3016
Dripping Springs, Texas
ph: 512.858.2007
toll free: 800.563.6737
www.p2programs.com
P2 Programs means efficient barcoding and tracking. We set the industry standard for quality barcoding and efficient tracking of structural steel from raw material receipt to erection on site. Employing P2 Programs' NEW web-based product—STSX—you get instant, real-time information accessible from virtually any device. Since 1986, we've used Auto-ID technology to improve manufacturing process tracking. With our real-time update capabilities, we offer you the technological expertise and on-the-job experience needed for an affordable and successful solution to the challenges of manufacturing operations.

Pacific Stair Corporation
booth 1807
www.pacificstair.com

Pan Gulf Technologies Pvt., Ltd.
booth 4015
Houston, Texas
ph: 832.615.3128
www.pangulftech.com
Pan Gulf Technologies Pvt Ltd an ISO 9001 : 2015 company) is a structural and concrete steel detailing company. We have a front office in Houston and design center in Mumbai, India. As one of the top five steel detailing sub-contractors in India, we use Tekla (135+ licenses), SDS2 (20+) and STAAD Pro to design and detail drawings for commercial, industrial and infrastructure projects, for American and European fabricators, design consultants and contractors. We have worked on projects ranging from 200-10,000 tons in structure and 50-50,000 tons in concrete, with a man power of 350+ team members.

Paramount Roll and Forming, Inc.
booth 4022
Santa Fe Springs, Calif.
ph: 562.944.6151
toll free: 888.400.3883
www.paramount-roll.com
Paramount Roll & Forming, Inc. specializes in the field of aerospace, architectural, commercial, construction, entertainment, food, industrial, oil, and pharmaceutical. We also specialize in curved staircases, heat induction bending, rolling for heavy plates, angles, tubes, pipes, and beams.

PDM STEEL
booth 2021
Elk Grove, Calif.
ph: 916.513.4548
www.pdmsteel.com
Established in 1954, and headquartered in Elk Grove, California, PDM Steel is a leading steel supplier with 10 service locations across the Western United States. The Company provides value-added processing services and distributes a full line of steel products across a broad range of industries.

Peddinghaus Corporation
booth 1400
Bradley, Ill.
ph: 815.937.3800
www.peddinghaus.com
Peddinghaus Corporation, headquartered in Bradley, Illinois, U.S., is an American manufacturer of CNC controlled equipment for the structural steel and heavy plate fabrication industries. With two manufacturing locations within the U.S., Peddinghaus focuses on providing highly innovative, and long lasting solutions to fabricators of all shapes and sizes. These solutions are designed to increase the production of steel components, and reduce costs for fabricators thus enhancing profitability. Beyond just machinery, Peddinghaus offers a 24 hour customer help line and consumables department.

Power of Design Group, LLC
booth 3305
Akron, Ohio
ph: 330.961.7440
www.podgrp.com
Power of Design Group, LLC (POD) is a consulting engineering firm supporting the private and public sectors. Our team of engineers and professionals design, analyze, and maintain new and existing infrastructure. We design retrofits to steel and reinforced concrete systems nationwide and have experience in the analysis of truss and moment frame structures. POD is also involved in connection detailing, fabrication review, and building design and alterations.

PPG Protective & Marine Coatings
booth 3216
Pittsburgh, Pa.
ph: 888.977.4762
toll free: 888.9PPGPMC
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PPG delivers protective coating solutions for a wide range of industries. Whether our customers need proven protection from corrosion, high temperatures and fire or want to ensure durability and aesthetic performance that will protect valuable assets, we have the advanced coating systems that can meet the specific needs of any environment.

Prodevco Robotic Solutions, Inc.
booth 411
Concord, Ontario
Canada
ph: 905.761.6155
www.prodevcoind.com
Prodevco Robotic Solutions offers Advanced Robotic Plasma Steel Cutting sytems. There are three models the PCR42, PCR41 and PCR 31 that will process standard structural steel profiles, and round tubes from 4 to 26 in., cuts copes, notches, holes and weld preps, splits beams, and scribes and marks on all four faces of H-beams, channels, angles, HSS and plates using automated robotic technology. All-in-one system reduces fabrication time, manpower and materials to meet everyone's goal: lower manufacturing costs.

Project + Quality Solutions
booth 4123
www.projectqualitysolutions.com

Qnect, LLC
booth 3003
Hadley, Mass.
ph: 413.387.4375
www.qnect.com
Qnect, an intelligent, cloud-based connection service gives fabricators, detailers and engineers fast and flexible connections with significant cost and schedule savings. In minutes, connect most steel buildings without capital cost and with minimal training. With Qnect, prevent schedule drift, utilize one-station fabrication and reduce time to fabricate and erect.

Qualis Solutions, LLC
booth 1914
Highlands Ranch, Colo.
ph: 303.493.5400
www.qualissolutions.com
The team at Qualis Solutions has over 30 years' experience detailing structures throughout the U.S. using AISC standards. Over the years, we've created drawings for a wide range of projects including office buildings, hospitals, schools, warehouses and airports. Qualis is best known for our focus on miscellaneous metal detailing. Our team of 18 detailers have mastered the art of stairs, railing, canopies, balconies and many other miscellaneous designs. You'll find us easy to work with and a reliable part of your project.

Quality Emphasis Steel Solutions Pvt., Ltd.
booth 3714
www.qessindia.com

QuickFrames USA
booth 3118
Mesa, Ariz.
ph: 480.656.1575
www.quickframes.com
QuickFrames USA is leading the industry with its bolt-on, adjustable, engineered structural support systems created for commercial roofs and floors. Designed for new construction and tenant improvement, QuickFrames can be easily moved when locations change and can be installed from under the deck. The company is based in Mesa, Arizona, and has earned a strong reputation around its exceptional customer responsiveness, quality and frames-to-job-site speed.

R.J. Watson, Inc.
booth 3314
Alden, N.Y.
ph: 716.901.7020
www.RJWatson.com
R. J. Watson, Inc. designs, manufactures, and tests high load multi-rotational bearings, seismic isolation devices, and bridge deck joint sealing systems. In addition, we offer spray-applied bridge deck waterproofing membranes, FRP strengthening products, and corrosion protection systems.

Radley, LLC
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ph: 616.541.6010
www.radley.com/steel
Increase visibility to materials with Job-site Tracking and Traceability while maximizing your workforce with Labor Tracking. Streamline and automate work flows with bar code or RFID scans while reducing errors with real-time data validations. Track Work-in-Progress (WIP) and validate loads against Tekla PowerFab (FabSuite), or other business systems.

REX Engineering Group
booth 3514
Naperville, Ill.
ph: 630.318.1725
www.rexeg.com
REX Engineering Group (previously known as REX Conn Design) is an integrated, multi-disciplinary engineering firm focused on Structural, MEP, and Connection and Construction Engineering, while also providing Construction services and Technology solutions. Our engineers are experts in their fields with decades of experience on a wide variety of markets and projects. Our designs are efficient and economic, and always focused on project budgets. We view every project as a unique solution, and look for opportunities to advance new ideas and technologies. We pride ourselves on our commitment to our clients and projects.

RISA
booth 2414
Foothill Ranch, Calif.
ph: 949.951.5815
toll free: 800.332.7472
www.risa.com
RISA has been developing leading-edge structural design and optimization software for over 30 years. Our products are used by 24 of the top 25 U.S. design firms in over 70 countries around the world for towers, skyscrapers, airports, stadiums, petrochemical facilities, bridges, roller coasters and everything in between. The seamless integration of RISAFloor, RISA-3D, RISAFoundation and RISAConnection creates a powerful, versatile and intuitive structural design environment, ready to tackle almost any design challenge.

Safehold Consulting, LLC
booth 3313
www.strongholdone.com

Scougal Rubber Corp.
booth 3403
www.scougalrubber.com

SDS2
booth 2411
Lincoln, Neb.
ph: 402.441.4000
toll free: 800.443.0782
www.sds2.com
SDS2 is a leading provider of 3D steel detailing software and other solutions that support the structural steel construction industry from concept to construction. SDS2's proprietary design engine uniquely incorporates steel connection design into the modeling process with 360-degree real-world intelligence. Built to ensure structural integrity, constructability, and erectability, SDS2 provides trusted automation where detailers and fabricators need it most.

SE University by SE Solutions, LLC
booth 3721
Holland, Mich.
ph: 616.546.9420
www.LearnWithSEU.com
SE University (SEU) helps structural engineers get high quality continuing education via web seminars in a format that is economical and easy to use. Every subscription includes access to both live sessions, as well as past session recordings through the SEU Session Library. In addition, subscribers get access to the "EIT Ramp Up" series to help younger engineers become productive faster. Provide the benefit of ongoing education to your engineers by participating in SEU!

Seismic Bracing Company
booth 3720
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ph: 801.550.7745
www.thesbcllc.com
We are makers of Buckling Restrained Brace (BRBs). The state of the art braces for bracing buildings and other structures during earthquakes. As the name implies, BRBs do not buckle. They smash and stretch axially absorbing seismic energy. We have patented a simple, easy and repeatable methods to manufacture BRBs, which brings better value to projects. Our methods have been fully tested and exceed governing building code requirements. All our projects to date have been a great success for our clients and us, delivering on time and without erection issues.

Shandong Hanpu Machinery Industrial Co., Ltd.
booth 3112
www.hanputool.com

Sherwin-Williams Protective and Marine
booth 3311
Cleveland,Ohio
ph: 216.566.2000
toll free: 800.524.5979
http://protective.sherwin.com
Sherwin-Williams Protective and Marine coatings are ideal for shop application and available through its over 4,700 distribution locations. Our Sherwin-Williams NACE and SSPC-certified corrosion experts ensure that your projects use technologies that reduce the critical planned timeline and achieves its expected service life. For more information, contact us at swprotective@sherwin.com.

Shop Data Systems, Inc.
booth 1816
www.shopdata.com

Short Span Steel Bridge Alliance
booth 3316
Washington, D.C.
ph: 202.452.7100
www.shortspansteelbridges.org
The Short Span Steel Bridge Alliance (SSSBA) is a group of bridge and buried soil steel structure industry leaders who have joined together to provide educational information on the design and construction of short span steel bridges in installations up to 140 feet in length.

Simpson Strong-Tie Co.
booth 2016
Pleasonton, Calif.
ph: 925.560.9000
toll free: 800.999.5099
www.strongtie.com
For 65 years, Simpson Strong-Tie has focused on creating structural products and software solutions that help people build safer and stronger structures. Simpson Strong-Tie was one of the first companies to develop connectors specifically for steel framing. Today, we continue to invest in product research and development to offer our customers connectors, fasteners, anchors, steel shearwalls and special moment frames, which feature our innovative Yield-Link® connection. Our commitment to the steel industry has never been stronger.

Skidmore-Wilhelm
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www.skidmore-wilhelm.com

SKM Industries, Inc.
booth 3804
Olyphant, Pa.
ph: 570.383.3062
toll free: 800.851.8464
www.skmproducts.com
Established in 1980, SKM Industries, Inc. is a manufacturer of Super Met-Al Markers and Metal Pro Galvanized Steel markers, specially formulated to come completely off in the tank during the galvanizing process. We make specialty markers for all of your marking needs.

SNC Engineering, Inc.
booth 4011
Norwalk, Calif.
ph: 562.584.4435
www.snceng.com
Since established in 1996, our goal has been to exceed our client's expectations on every project, big or small. We have project managers that are experienced, flexible, and helpful. We each work to get every project done on time, in the most cost effective way possible, while also conforming to the standards set by our clients and the National Institute of Steel Detailing. With the help of its branch offices in the Seoul and the Philipines, SNC has direct control over the production line, ensuring quality and efficiency.

Soitaab USA, Inc.
booth 1920
Naperville, Ill.
ph: 312.856.6970
www.soitaabusa.com
Since 1938, Soitaab has been a world leader in the manufacture of CNC Plasma, flame, Laser, and Water Jet cutting machines. Soitaab's equipment offerings range from simple plug-and-play machines to highly engineered all-in-one heavy fabrication lines. Our machines can be equipped with several accessories such as drilling and taping units, surface and hole milling, bevel heads for welding prep, countersinking, marking, pipe and dome cutting, sophisticated handling systems and many others.

South Atlantic Galvanizing
booth 1916
www.southatlanticllc.com

SRG Onesource, LLC
booth 2820
Mission, Kan.
ph: 913.297.3150
www.srgonesource.com
SRG Onesource is a professional steel detailing firm located in Mission, Kansas. We have been in business since 1996 providing our clients with a quality service.

St. Louis Screw & Bolt
booth 2003
Madison, Ill.
ph: 314.389.7500
toll free: 800.237.7059
www.stlouisscrewbolt.com
Selling direct to structural steel fabricators, St. Louis Screw & Bolt is one of the oldest structural bolt manufacturers in the U.S. Specializing in ASTM F3125 heavy hex and tension control structural bolts in grades A325/F1852/120ksi and A490/F2280/150ksi, types I and III, plain, mechanically galvanized, hot dip galvanized, F1136 and F2833 coatings. St. Louis Screw & Bolt also has a very large inventory of other construction fasteners including anchor bolts, weld studs, and concrete anchors just to name a few.

Stainless Structurals America

booth 2423
United States
www.stainless-structurals.com
Stainless Structurals is a global producer and supplier of stainless steel structural shapes and special custom profiles. Our structural sections are available from stock in both 304/L and 316/L. We also offer profiles in other alloys, including duplex, straight from production. Our innovative Laser Fusion technology is certified to ASTM A-1069 and allows us to offer profile solutions where others cannot. Start with the Solution. Start with Stainless Structurals.

Steel and Pipe Supply

booth 2823
www.SteelAndPipe.com

Steel Deck Institute

booth 3821
Glenshaw, Pa.
ph: 412.487.3325
www.sdi.org
Founded in 1939, the Steel Deck Institute (SDI) is a trade association representing steel deck manufacturers and those manufacturing products used in conjunction with steel deck. The SDI actively publishes design manuals, develops standards for steel roof and floor deck, offers website tools, provides an industry standard EPD, offers educational opportunities, and supports research related to steel deck. Our most recent publications are the 2022 ANSI Standards. These include the new and combined ANSI/SDI SD-2022, and the renewed ANSI/SDI T-CD-2022 and ANSI/SDI QA/QC-2022. Download at www.sdi.org.

Steel Dynamics Long Products Group

booth 2011
Columbia City, Ind.
ph: 260.625.8100
toll free: 866.740.8700
www.stld-cci.com
Steel Dynamics, Inc. is one of the largest domestic steel producers and metals recyclers in the United States based on estimated annual steelmaking and metals recycling capability, with facilities located throughout the United States and in Mexico. Steel Dynamics produces steel products, including hot roll, cold roll, and coated sheet steel, structural steel beams and shapes, rail, engineered special-bar-quality steel, cold finished steel, merchant bar products, specialty steel sections, and steel joists and deck.

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Steel Erection Bid Wizard
booth 3215
Bluffton, S.C.
ph: 505.249.2390
https://steelestimatingsolutions.com
Introducing The Steel Erection Bid Wizard "Only Software On Market Created For Steel Erectors By A Steel Erector" Reduce the time it takes to estimate by 50% or more Steel Erection Bid Wizard uses more than 300 built-in task as well as offers complete customization to make estimation a snap… Get immediate estimates of your costs—including labor, cranes, welders, fuel, and equipment. Learn how over 325 Steel Erectors have revolutionized the way they estimate. Take your estimating department digital with the Steel Erection Bid Wizard.

Steel Erectors Association of America
booth 3722
Winston-Salem, N.C.
ph: 336.294.8880
www.seaa.net
The Steel Erectors Association of America (SEAA) is dedicated to advancing the common interests and needs of all engaged in building with steel. Objectives include the promotion of safety, education and training programs for steel erector trades; development and promotion of standards; and cooperation with others in activities which impact the commercial construction business. SEAA develops strategic partnerships and works closely with industry groups to provide members with industry representation steel design, engineering, fabrication, labor, safety, and training groups.

Steel Founders' Society of America
booth 4122
Crystal Lake, Ill.
ph: 815.455.8240
www.sfsa.org
SFSA, akin to AISC, is a technical association. Members of SFSA are steel foundries that supply a range of cast steel products for demanding environments such as railroad, mining, construction, military, and nuclear. SFSA can assist you in utilizing steel castings for building construction. Steel castings offer performance, aesthetics, design freedom, and green manufacturing. SFSA leads the Steel Performance Initiative (SPI) program, a collaborative structure of steelmakers (mills, forge, cast), researchers, and end-users to advance steel technology development for commercial and defense applications.

Steel Joist Institute
booth 3723
Florence, S.C.
ph: 843.407.4091
www.steeljoist.org
The Steel Joist Institute (SJI), a nonprofit organization of active joist manufacturers and other organizations and companies connected to the industry, was founded in 1928 to address the need for uniform joist standards within the industry. Today, the Institute continues to maintain the standards for steel joist construction. In addition, the SJI provides educational opportunities for construction professionals utilizing a library of printed publications and both live and recorded webinars. We also offer assistance in identifying existing joists in buildings undergoing retrofit.

Steel Plate
booth 1225
United States
ph: 888.894.8818
www.steelplate.us
With two new locations strategically located in the Midwest and Southeast, Steel Plate Akron/Atlanta offers decades of experience with Steel Plate fabrication and production. We stock grades A36, 514, 516-70, 572-50, 588, and AR400 while burning material up to 22 in. thick using the large cutting surfaces on our 11 CNC Oxy and two HD Plasma machines. We also offer other in-house services to help complete your job's requirements while utilizing our own internal fleet to ensure the order arrives on time. Steel Plate is proud to be part of a strong U.S. supply chain and look forward to your inquiry.

Steel Plus Network
booth 2525
Canada
ph: 902.843.0054
www.steelplus.com
Steel Plus Network has traditionally organized meetings for members to provide opportunities for improvement to each of their operations through educational presentations, motivational messages, and industry expert reports. These meetings also fulfill our mission to coordinate our purchasing programs and networking opportunities. The regional meetings conducted by SPN along with the Annual General Meeting are deemed vital to the health and welfare of SPN's members and are considered an integral part of our operation.

Steel Projects Corp.
booth 600
www.steelprojects.com

Steel Tek Unlimited
booth 3217
Eden Prairie, Minn.
ph: 612.258.7531
www.steelteku.com
Steel Tek Unlimited is a leading-edge company in the steel industry that specializes in customizing CAD programs and offers steel detailing to fit your needs. We are proud to say that all of our work is done in the U.S. with an experienced team of people from the Bridge, Industrial and Commercial industries who understand today's construction market.

Steel Tube Institute
booth 3205
Glenview, Ill.
ph: 847.461.1701
www.steeltubeinstitute.org
The Steel Tube Institute is the leading technical resource in North America for all steel tube products. Our main goal is to increase utilization of HSS and other tubular products in construction and other industries, and to reveal the wealth of possibilities afforded by designing with HSS. STI's programs include continuing education, technical resources, technical assistance, and safety programs as we promote best practices in manufacturing techniques, industry safety, environmental concerns, and the overall steel industry.

Structural Stability Research Council
booth 3921
Chicago, Ill.
ph: 312.670.7015
www.ssrcweb.org
The Structural Stability Research Council is a technical organization that focuses on the state-of-the-art understanding of the impact of stability related issues on the analysis, design, and behavior of metal structures. SSRC is comprised of engineers, educators, and industry members with an interest in stability related issues.

STRUMIS, LLC
booth 2408
Collegeville, Pa.
ph: 610.280.9840
www.strumis.com
STRUMIS, LLC is the worlds leading developer of steel fabrication management software. The most comprehensive and powerful end-to-end solution available to fabricators globally, the result of this is that we now operate in over 50 countries. Our products, which include steel estimating, fabrication information and production management, and project collaboration tools work seamlessly with third party software and have consistently transformed our customers business within the structural steel construction supply chain.

Stubbs Engineering, Inc.
booth 3612
Las Cruces, N.M.
ph: 575.993.5228
www.stubbseng.com
Stubbs Engineering, Inc. is a full service structural engineering firm specializing in providing creative, economical structural designs that provide our clients with the aesthetics they desire at the most cost efficient means possible. Our vast experience in both design and construction methods gives us the unique ability to provide our clients with a level of service beyond that of our competition. We work diligently to ensure our clients receive the best structural designs, communication, cost awareness, and project management possible.

SY Stairs
booth 4220
http://systairs.com

Taylor Devices, Inc.
booth 2808
North Tonawanda, N.Y.
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X Steel Detailing was founded in 2019, and is headquartered in Sumter, S.C. We have detailed several thousand project hours of structural and miscellaneous steel. From the beginning of a project to the lessons learned after a project is completed, you will notice a big difference with our process driven approach that delivers consistent results and a better detailing experience for our clients. Our software tools and process create some unique advantages for ensuring that nothing slips through the cracks and that we are all on the same page during a project. ■

new products

This month's product section features a pair of cordless handheld tools for the shop or field, as well as an anti-fog coating that takes safety glasses to the next level.

Hilti Nuron

Nuron is a single 22V battery platform that enables cordless tools on all kinds of jobs. Launching with more than 60 tools, the battery platform enables heavy-duty applications that were once restricted to corded, gas-powered, or higher-voltage battery systems—and all the battery packs and chargers work interchangeably under a single ecosystem to help reduce complexity for tool cribs and cost for businesses. The redesigned battery interface ensures higher performance and longer operating times by allowing a significantly higher power transfer, helping customers meet tight deadlines. Nuron also brings intelligence to the core of the platform; all tools generate data which is then stored on the Nuron batteries and sent securely to the cloud during every charge without any operator interaction. The data collected includes information such as tool usage, tool use, charging location, and battery state-of-health. For more information, visit **www.hilti.com**.

Brass Knuckle BK-Anti-FOG

Fog means double trouble. First, it reduces visibility. Second, fogged-up lenses make workers want to remove their safety glasses. No eye protection equals "out of compliance," exposing eyes to potential hazards in those vulnerable seconds or minutes. Brass Knuckle BK-Anti-FOG is an anti-fog coating for safety glasses that offers excellent performance and a long-lasting, fog-free view under even the most demanding hot and humid conditions. Washable and durable, BK-Anti-FOG formulas allow lenses to resist fog longer than typical anti-fog treatments, and that extra time is what is needed for lenses to come into balance with temperature fluctuations, the principal cause of lens fogging. A second version, BK-Anti-FOG+, provides anti-fog protection 44 times better than the EN standard, delivering protection that lasts more than six minutes when tested under the standard. For more information, visit **www.brassknuckleprotection.com**.

Milwaukee M18 FUEL Grinders

Milwaukee Tool has expanded its cordless specialty angle grinder lineup with the new M18 FUEL 5-in. Flathead Braking Grinders and M18 FUEL 4½-in./5-in. Variable Speed Grinders. Designed for the toughest grinding and cutting applications, these grinders deliver the next level of job-site productivity and enhanced safety. The Flathead Braking Grinder delivers 8,500 rpm for maximum sustained power and allows users to push the battery-powered grinder harder and longer than ever before. The low-profile, flathead design provides greater accessibility to tight spaces to complete a cut or grind an edge where a traditional 5-in. grinder may not be able to reach. The Variable Speed Grinder features five-speed settings between 3,500 rpm and 8,500 rpm, providing greater control by allowing the user to slow down or speed up the accessory during grinding and cutting applications. Both grinders feature a RAPIDSTOP Brake for enhanced user safety, stopping most wheels in less than two seconds. For more information, visit **www.milwaukeetool.com**.

SAFETY

March Safety Focuses Include Brain Injuries, Eye Wellness, and Ladder Safety

March is designated as the month for a handful of construction-related and general safety awareness campaigns:

- Brain Injury Awareness (**www.biausa.org**)
- Workplace Eye Wellness Month (**www.preventblindness.org**)
- National Ladder Safety Month (**www.laddersafetymonth.com**)

Brain injuries. Traumatic brain injuries are a leading cause of lost workdays and temporary or total disability in the steel industry, with most being categorized as concussions. Some common causes of head injuries include:

- Being struck by a falling tool or material or a moving object, such as materials being moved by a crane or another worker
- Falling and coming into contact with an object or surface, such as equipment, a wall, or the ground
- Coming into contact with overhead hazards, such as equipment or electrical wires

In 2018 alone, almost 8,000 construction workers suffered a head injury, and 230 construction workers died from their injury. These deaths and injuries take a significant human and financial toll on the injured workers, their families, and their employers.

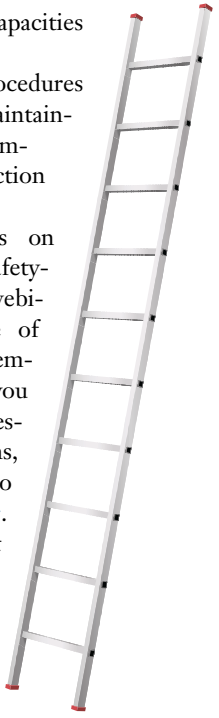
One way for organizations to reduce the effects of brain injuries is to adopt the use of helmet-style hard hats. These types of hard hats have chin straps to keep them on the wearer's head in the event of an impact, and they provide side-impact protection even if they have not been tested or passed the ANSI Z8901 Type II tests.

Eye wellness. Common traumatic eye injuries in our industry occur through blunt or sharp objects or chemical burns. Closed-globe injuries usually follow blunt trauma and have a varied clinical presentation, such as superficial corneal abrasion. Open-globe injuries usually follow sharp or high-velocity blunt trauma. Additionally, orbital floor fractures can occur when the face is struck by a flying object. Chemical burns of the eye can result in ocular pain, erythema (reddening), and blepharospasm (blinking or twitching). Treatment of traumatic eye injuries depends on the precise underlying injury, and prevention is simple: Wear safety eyewear, such as safety-rated glasses, goggles, and face shields.

Ladder safety. Significant and sometimes fatal injuries can occur while working from ladders. Ladders are so commonplace that we often forget that they may present hazards. Improper use is a major cause of ladder-related injuries. This includes overreaching and not maintaining three-point contact, such as when carrying tools or materials as you climb. Remember, OSHA requires employers to train workers on ladder use. Selection, set-up, and inspection should include:

- The nature of hazards in the work area, including ground conditions and fall hazards
- The proper construction, use, placement, and care in the handling of all ladders
- The maximum intended load-carrying capacities of ladders
- The correct procedures for erecting, maintaining, and disassembling fall protection systems, if used

AISC is always on the lookout for safety-related article and webinar ideas that are of interest to our member companies. If you have any safety questions or suggestions, please send them to **schlafly@aisc.org**. You can also visit AISC's Safety page at **aisc.org/safety** for various safety resources.

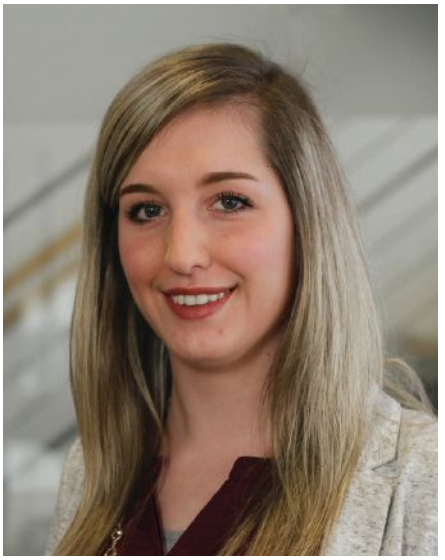


People & Companies

Keast and Hood recently announced the transition to its third generation of ownership. At the beginning of the year, firm veterans **Denise Richards, PE**, and **John Davis, PE**, assumed full ownership of the firm, with Richards as the majority shareholder. Former owners **Frederick Baumert**, **Constantine Doukakis**, and **Thomas Normile** will remain fully engaged with the firm to ensure a seamless transition and the transfer of institutional knowledge.

Stewart, an interdisciplinary design, engineering, and planning firm, recently welcomed **Bryan Covington, PE**, as a project manager for the structural practice in its Raleigh, N.C., office.
In his new role, Covington is collaborating with Stewart's structural practice to allocate resources, manage complex projects, and ensure client success.

Magnusson Klemencic Associates (MKA) announced that **Juliette Peyroux, SE, PE**, has been named one of *Building Design + Construction (BD+C)* magazine's 40 Under 40 honorees for 2021. A senior associate at MKA, Juliette, 32, focuses on promoting structural solutions for seismically safe and resilient airport terminals, concourses, and inspection stations in areas known for high seismic activity, such as San Diego, San Francisco, and Seattle.



MEMBERSHIP

AISC Board Announces New Members

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

Full

Metal Building Industries, Tulsa, Okla.
PVB Fabrications, Marana, Ariz.
Tomrook Steel, Bardstown, Ky.
United Weld Services, LLC, York, Pa.
Warren Fabricating and Machining Corp., Hubbard, Ohio

Associate

CRC Steel Detailing, Fort Worth, Texas, *Detailer*
Detailed Steel Solutions, Toledo, Ohio, *Detailer*
Galvanizadora De Estructuras De Frontera S.A. De C.V., Puebla, Mexico, *Welding Supplier*
Masibanda Construction Engineering, Rolleston, New Zealand, *Detailer*
Steel Masters, LP, Houston, *Erector*
Todd Karford Detailing, Idaho Falls, Idaho, *Detailer*
United Employment Associates, LLC, Emmaus, Pa., *Industry Recruiter*
Warnick Metal Building Erectors, LLC, Haltom City, Texas, *Erector*

NASCC

2022 NASCC Takes Place in Denver this Month

There's still time to register for NASCC: The Steel Conference!

Scheduled for March 23-25 in Denver, NASCC is the premier educational and networking event for the structural steel industry, bringing together structural engineers, structural steel fabricators, erectors, detailers, and architects. In addition to more than 200 practical seminars on the latest design concepts, construction techniques, and cutting-edge research, the conference also features 250 exhibitors showcasing products ranging from structural design software to machinery for cutting steel beams, as well as plentiful networking opportunities. One low registration fee gains you access to all of the technical sessions, the keynote addresses, the T.R. Higgins Lecture, and the exhibitor showcase.

NASCC is your once-a-year opportunity to learn from leading experts in the steel community and earn PDHs. Also included are multiple conferences within a conference: the World Steel Bridge Symposium, QualityCon, and the NISD Conference in Steel Detailing. One low registration fee gains you access to all of these conferences/sessions, the keynote sessions, and the exhibition hall.

For more information and to register, visit **aisc.org/nascc**. Also, see the table of contents for a couple of session preview papers as well as the exhibitor list. In addition, you can read several more session preview papers in the Project Extras section at **www.modernsteel.com**.

IN MEMORIAM

Rodney Baxter, Construction Engineering Specialist, Dies at 48

Construction engineering specialist Rodney Baxter, PE, whose work included such projects as New York's Yankee Stadium and Apple's Cupertino, California, headquarters, died on December 25, 2021. He was 48 years old.

Over the course of his 20-plus-year career, Baxter developed a reputation as a go-to person for structural steel design, fabrication, and erection engineering and worked for some of the leading firms in the business. Most recently, he served as director of engineering at Basden Steel Corp. in Burleson, Texas.

"From his first day with us, Rodney jumped right in and quickly carved out his role within our group," Nat Killpatrick, president of Basden Steel, said. "He began designing infrastructure modifications to the heart of our operations and mentoring young managers, both of which will leave an indelible mark on our team. Selfishly, we will miss him for what we hoped to do together, but the greater loss is to the steel community as a whole. Rodney's sphere of influence and gift of service to the industry exceeds his time at Basden Steel. His dedication to this profession is difficult to find these days."

Prior to joining Basden in August 2021, Baxter was a vice president at Thornton Tomasetti, where he spent much of his career. He served two stints with the firm, first in the Kansas City office, where he was instrumental in developing the firm's crane, heavy lift, and erection engineering business, and later as manager of the Phoenix office, which he helped to launch in 2018.

"Rodney was possibly the only person I ever met that was as comfortable and competent with a hard hat and spud wrench as he was with SAP and BIM," said Thornton Tomasetti senior principal and Construction Engineering Practice Leader Darren Hartman. "From the new hires he introduced to the art of field engineering to the senior engineers he coached on constructability, we all learned a great deal from him. He was a great friend and colleague, and his impact on us will be a lasting one."

Baxter, who got his start at Havens Steel Company in Kansas City, also spent several years as a construction engineering manager in Schuff Steel's Phoenix office, serving as one of the company's technical erection experts.

"Rodney had a passion for steel construction and engineering, especially in the unique field of erection analysis, temporary stability of structures, specialty heavy lifting, and complex rigging," recalled Dave Wright, Schuff Steel's director of preconstruction for the Western Region. "He had real-world experience that you just can't teach in a classroom or with a textbook. All his time spent in the field was a huge benefit during his career, allowing him to offer commonsense solutions to complicated situations."

Baxter was born and raised in Herington, Kan., and earned a bachelor's degree in architectural engineering from Kansas State University in Manhattan, Kan. He was a licensed professional engineer and a certified welding inspector and held two special inspector certifications. He was also an active member of the Research Council on Structural Connections (the Bolt Council).

"Rodney had a rare gift of passion and experience in steel construction and connection design that made him a key contributor to many complex structures," said Tom Schlafly, AISC's chief of engineering staff, who worked with Baxter on the Bolt Council.

"Rodney was one of the hardest-working people in the industry," said Brian Volpe, chief engineer with Cives Corporation, who worked with Baxter at Thornton Tomasetti and was a longtime friend. "Regardless of his vast resume, his work ethic is what made him the amazing engineer he was. If you needed a person to work out a complex problem, you would ask Rodney because he would get it done."

Letter to the Editor

Making Progress

Congratulations to Cindi on her upcoming retirement. I really enjoyed Geoff Weisenberger's Field Notes article about her ("By the Book," January 2022, available at **www.modernsteel.com**).

It is a big deal that you made it through your engineering career as a female pioneer starting in the 1980s. I received my civil engineering bachelor's degree from Clemson in 1970 and my structural master's degree from Georgia Tech in 1972. At Clemson, there were just a few women majoring in engineering, and the school was in the process of changing from all-male (with a few female day students) to a 50-50 mix for the class of 1974 and beyond. I don't remember any women in civil engineering while I was at Georgia Tech.

Over my career, I have seen an all-male engineering workforce change to a more even mix. Now our Georgia ASCE and NSPE chapters have women in top leadership roles.

I spent my early career as a structural engineer with a metal building manufacturer, and I appreciate all the hard work you have done over the years, keeping the various committees on track to meet the AISC publication deadlines.

Lastly, I retired early and have some advice for you. All that free time you think you will have will slip away. Take care of yourself first and plan to do the things you want to do most first.

Ted Spetnagel, PE

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advertiser index

Ashley Murphy

Branching Out

THE DENVER BOTANIC GARDENS keep growing—and not just the plants.

As part of a recently completed expansion to the verdant venue, the new Freyer-Newman Center, designed by Davis Partnership Architects, adds four art galleries, six classrooms, a library, auditorium, research labs, and other amenities.

One of the major goals was to infuse the botanical landscape into the structure itself. The solution came in the form of steel "tree" columns with curved "branches" that frame the archway entrance as well as the interior atrium (the trees were fabricated by Zimmerman Metals and erected by SNS Iron Works, with curving services provided by Albina Co., Inc.; all three are AISC member companies). Select portions of the exterior steel trees serve in a structural role while other components do not. Structural engineer KL&A developed design solutions to accommodate both the steel tree columns on the front façade curtain wall and the connecting elliptical branch-like shapes where the steel tolerances proved very tight for curved members. This process required the team to consider more simplistic solutions to make the tree branches less structural in nature so that the branches were lighter in weight and could allow for easier constructability. In the interior atrium, KL&A also designed the tree branches to serve as bracing members for the main structural truss to simplify the gravity load path, with conventional truss members eventually painted over to match the overall biophilic aesthetic.

To read more about the steel trees and the rest of the Denver Botanic Gardens expansion project, see next month's issue. And consider adding this facility to your itinerary of things to see in Denver when you attend NASCC: The Steel Conference (taking place March 23–25; visit **aisc.org/nascc** for more information and to register). ■

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Photo: Bead appearance of DW-50AY
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