MSC

MODERN **STEEL** CONSTRUCTION

August 2009

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
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Blast Off!

NASA's New A-3 Test Stand

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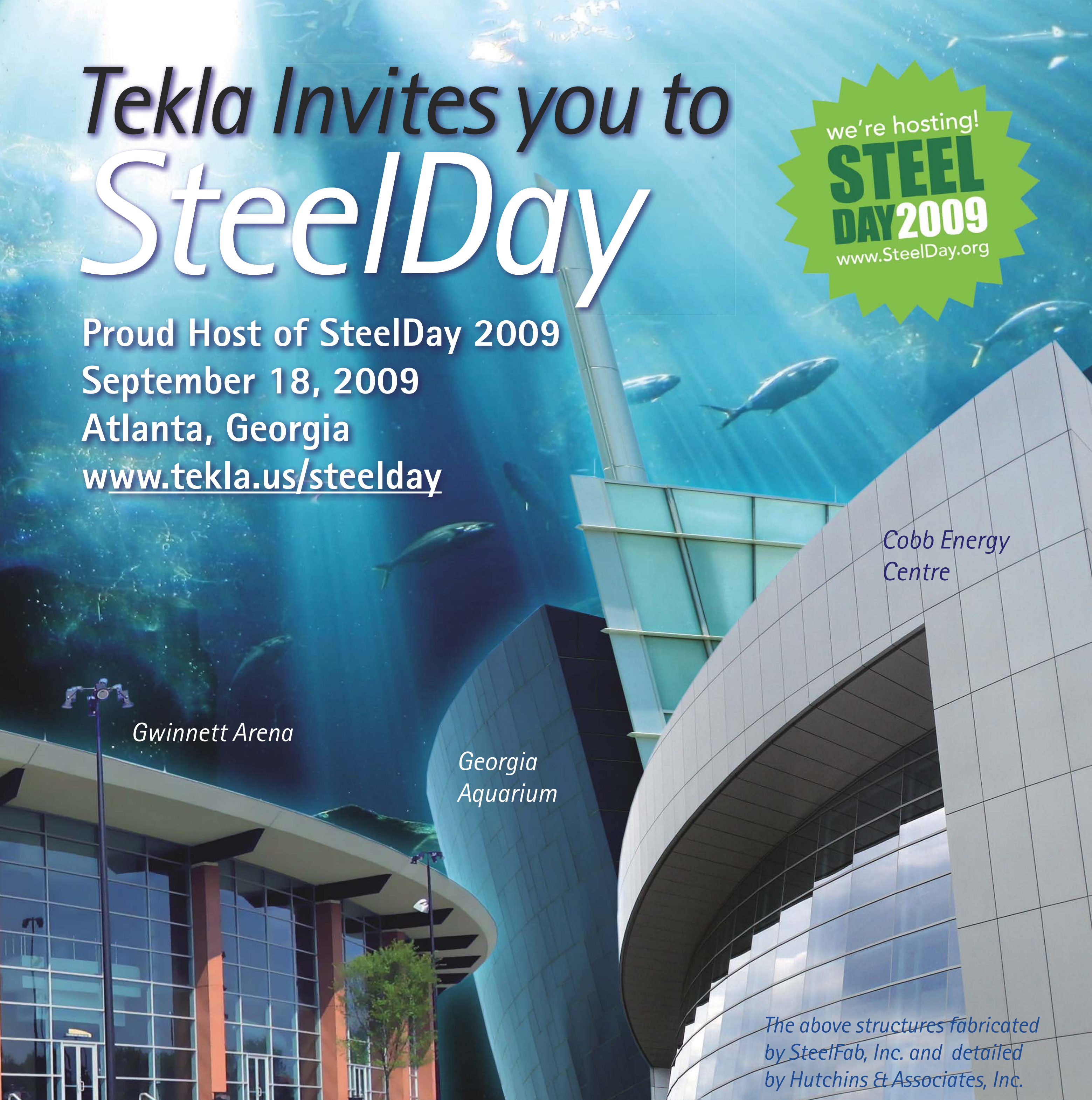

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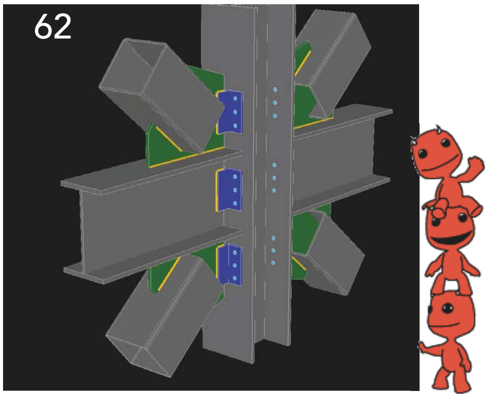

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ON THE COVER: The A-3 Test Stand at Stennis Space Center in Mississippi. Photo: Prospect Steel Company

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editor's note

EACH AUGUST MY FAMILY TRAVELS NORTH AND EAST TO A WONDERFUL RESORT ON LAKE HURON ABOUT TWO HOURS NORTH OF TORONTO. My wife and kids love it—there are camp activities, swimming (lake and pool), miniature golf, boating, movies and live shows in the evening, good food, and great relaxation (check out the live cam at **www.delawana.com** and maybe you'll spot me on the dock). Two years ago I even learned how to juggle!

Unfortunately, most of the drive from Chicago to Honey Harbour is pretty boring, with one notable exception. We usually cross into Canada from Port Huron, Mich., which gives us the opportunity to see not just one, but two, Prize Winning Bridges.

The original Blue Water Bridge won an honorable mention in the AISC/NSBA Prize Bridge Competition back in 1938. Designed by Modjeski, Masters and Case, the cantilever truss main bridge was fabricated by American Bridge Co. and is still in service. However, as traffic increased it became obvious that more lanes were needed. The solution six decades after the original Blue Water Bridge opened was to place a new bridge next to the old, thereby doubling the amount of traffic that could be handled. Amazingly, this new bridge, a continuous tied arch with box girder approaches, was also designed by Modjeski & Masters. And this new bridge won a prize bridge award in 1990. (According to the jurors it was a "classic concept of semi-through arch in a modern, simple and clean design..side by side technologies, 60 years apart…elegant long-span structure.")

Since the Prize Bridge Awards began in 1928, AISC and the National Steel Bridge Alliance have honored around 900 bridges. And while we have photos of most of the bridges when they first opened, we don't have current images. I volunteered to take a year's sabbatical and travel around the country snapping pictures, but apparently neither my wife nor my boss thought much of that idea.

Instead, we're asking *MSC* readers to help out. You can visit **www.steelbridges.org/bridgewinners** to get a list of all the bridges that have been honored over the years. Take a picture of a bridge near your home or office (or one you see on your family vacation) and e-mail it to Tasha O'Berski at oberski@aisc.org. We'll post all of the pictures at **www.flickr.com/people/nsba_prize_bridge_award_winners** for everyone to enjoy.

Scott Melnick

SCOTT MELNICK
EDITOR

P.S. Have you made your plans for SteelDay on September 18? This is a great opportunity to tour a fabrication facility, check out a steel mill, or see the galvanizing process up close. To find a SteelDay event near you, visit **www.aisc.org/steelday**.

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Editorial Offices
1 E. Wacker Dr., Suite 700
Chicago, IL 60601
312.670.2400 tel
312.896.9022 fax

Editorial Contacts
EDITOR & PUBLISHER
Scott L. Melnick
312.670.8314
melnick@modernsteel.com

SENIOR EDITOR
Geoff Weisenberger
312.670.8316
weisenberger@modernsteel.com

DIRECTOR OF PUBLICATIONS
Areti Carter
312.670.5427
areti@modernsteel.com

GRAPHIC DESIGNER
Kristin Egan
312.670.8313
egan@modernsteel.com

AISC Officers
CHAIRMAN
Rex I. Lewis

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Louis F. Geschwindner, Ph.D., P.E.

VICE PRESIDENT
Scott L. Melnick

Advertising Contact
Account Manager
Louis Gurthet
231.228.2274 tel
231.228.7759 fax
gurthet@modernsteel.com

For advertising information, contact Louis Gurthet or visit **www.modernsteel.com**

Address Changes and Subscription Concerns
312.670.5444 tel
312.893.2253 fax
admin@modernsteel.com

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The Reprint Outsource, Inc.
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IF YOU'VE EVER ASKED YOURSELF "WHY?" about something related to structural steel design or construction, *Modern Steel Construction*'s monthly Steel Interchange column is for you! Send your questions or comments to solutions@aisc.org.

Bolt Spacing for Prying Action

All of the equations for prying action include the symbol *p* (the spacing between bolt rows). However, if we have only one bolt row in a connection, there is no spacing between rows. If *p* = 0, it seems to invalidate equations related to calculation of prying action. Are there alternative equations when *p* = 0?

Think of *p* as the tributary width per pair of bolts, which is the definition given on Page 9-11 of the 13th Edition AISC *Steel Construction Manual*. If you have only one pair of bolts (or one bolt in the case of a single angle as shown in Figure 9-4b), the tee or angle length along its axis can be used. Note that the definition of *p* says to preferably not exceed the gage, though, so if the tee or angle is long, *g* should be used as the upper limit on p.

Brad Davis, Ph.D., S.E.

Shear Center

How do I calculate the shear center of a rolled shape?

The shear center of an open cross section is the point where the resultant moment of external forces and internal stresses in the plane of the section must be zero. For most common rolled shapes, the location of the shear center is illustrated in AISC Design Guide No. 9 *Torsional Analysis of Structural Steel Members* (a free download for AISC members at **www.aisc.org/epubs**). See Figure 2.1. For symmetric shapes, the shear center is on the line of symmetry. For doubly symmetric shapes, such as W-shapes, the shear center is at the centroid. For channels, see Figure 3.1 and the associated equations for e_0. For angles and tees, the shear center is at the intersection of the midlines of the elements of the cross-section.

If you are looking for the general location of the shear center with respect to the geometric axes for other shapes, I suggest looking at the information in Design Guide No. 9 or a structural steel design textbook.

Kurt Gustafson, S.E., P.E

Section Modulus Relative to Angle Leg Toe in Compression

How does one calculate S_c for Section F.3 in AISC 360-05? What does "elastic section modulus to the toe in compression relative to the axis of bending" mean? What if the entire angle leg is in compression? When one has an equal-leg angle with no lateral-torsional restraint bent about a geometric axis, $S_c = 0.8S$, what if the angle does not have equal legs?

S_c refers to the section modulus of the entire shape taken about the axis of bending, with respect to the extreme fiber that is in compression. For example, the value of S_x published for angles in Table 1-7 of the Manual represents the smaller S_x for the shape. If the leg tip closest to the x-axis is in compression, the value of S_{xc} would be larger.

If the entire leg of the angle is in compression, the toe of that leg is also in compression. That would be the leg in compression due to flexure about the geometric axis of an equal leg angle. If the angle has unequal legs, the 0.8 simplification method does not apply; the provisions for principal-axis bending would apply instead.

Kurt Gustafson, S.E., P.E

Edge Distances for Single-Plate Shear Connections

In the October 2006 issue of *Modern Steel Construction*, a range for the support line to bolt line (a-distance) is given as 2½ in. to 3½ in. for single-plate shear connections. Does this necessarily mean *a* = 2 would not work properly? If the connection were a through plate passing through a 6-in. column could *a* = 2 in. be used?

It is not prohibited to use *a* = 2 in. with the procedure in the 13th Edition AISC *Steel Construction Manual*. However, 2½ in. to 3½ in. is the typical range. There are a few dimensional limits to consider, though, depending on whether you're using the "conventional configuration" or the "extended configuration" (which covers anything that's not a conventional configuration).

Conventional Single-Plate Shear Connections:

Dimensional limit #2 requires that *a* must not exceed 3½ in., so a = 2 in. satisfies this.

Dimensional limit #4 might cause problems with *a* = 2 in. though. The horizontal edge distance from the center of bolt hole to end of steel beam must be equal to or greater than twice the bolt diameter. If your beam has a ½-in. setback from the face of support, the horizontal edge distance is only 1½ in. Granted, if you're using typical ¾-in. bolts, 2(¾ in.) = 1½ in., but don't forget about the beam length tolerance here. If the beam is cut just a little short, then the edge distance will be less than 1½ in. This matters because this connection gains its rotational ductility from the bolt causing bearing deformation at the side of the hole. If it's too close to the end, it might tear-out the end of the beam web. Note that the developers of these provisions felt the necessity to impose a requirement for $2d_b$ edge distance, which exceeds the requirements in AISC Specification Table J3.4. If your connection satisfies this limit somehow, it can be designed using the conventional configuration procedure. If not, then perhaps it can be treated using the extended configuration procedure.

Extended Single-Plate Shear Connections:

Dimensional limit #4 is easier for extended shear tabs. For ¾-in. bolts in standard holes, the minimum edge distance is 1¼ in. at a sheared edge. Assuming a ¼-in. beam length tolerance, this limit is still satisfied.

Design check #2 might cause problems, though. This is the method for ensuring rotational ductility for in the extended configuration; the plate must be able to yield in flexure at a lower moment than will cause bolt shear failure in pure moment. The exceptions below this design check are probably not useful in this case because they are based on bearing deformation as in the conventional procedure.

Brad Davis, Ph.D., S.E.

Use of the Overstrength Factor Ω_0

How do I use the system overstrength factor Ω_0. Is it used as a multiplier on the load side or the strength side of the equation?

The system overstrength factor Ω_0 is used as a multiplier on the load side of the equation. For example, in a braced-frame system, it is applied as a multiplier on the axial load in the brace. The resulting amplified force is used to compare to each applicable limit state.

Kurt Gustafson, S.E., P.E.

Evaluating Existing Bracing Connections

We are modifying an existing structure that has wide-flange vertical bracing members that were designed using the 7th edition AISC Manual. The connections used friction-type bolted joints with oversize holes in web plate connections to the gusset on both edges. The AISC Specification requirements applicable to the 7th Edition did not require friction bolts to be checked for bearing, as is required today.

In general, the connections work for the slip-critical portion of the calculation, but many fail the bearing strength check. In order to prevent the connections from slipping into bearing, I've considered adding welds to the joint. Do you have any suggestions as to how to evaluate these connections?

You are correct that these connections should be checked for bearing as we do today. Where the bearing limit state will not satisfy the design loads, something should be done to ensure that slip into bearing does not take place. The welding approach you have suggested seems like a good option, and I would design the welds to resist the full design load, neglecting the bolts entirely. This eliminates the difficulty of addressing the differing stiffness and ductility of the welds and bolts were they to be used to share the load.

Larry S. Muir, P.E.

Beam Bracing

What constitutes a lateral brace for a beam? Does properly attached roof deck act as a continuous brace for the compression flange?

Beam bracing can be lateral, torsional, or a combination of these. Accordingly, a brace for a beam must restrain lateral movement of the compression flange (lateral brace), twist of the entire section (torsional brace), or a combination of these. Lateral braces are covered in Appendix 6.3.1 of the 2005 AISC Specification, and torsional braces are covered in Appendix 6.3.2. These sections address both the strength and stiffness requirements that must be met to consider a point braced.

This information also can be used to determine the answer to your second question. For the typical case, it is easy to see that roof deck spanning perpendicular to the beam and attached to the compression flange with typical deck welds is strong and stiff enough to be considered a lateral brace. If you have an atypical case, such as a heavy beam with large loads combined with a small deck, or long-span deck, you should evaluate it using the strength and stiffness equations in Appendix 6.

Note that if you have an uplift case, the deck won't count as a lateral brace because it is attached to the tension flange. It may provide enough restraint to be considered a torsional brace, however. Another case to evaluate further is that of deck spanning parallel to the beam.

Brad Davis, Ph.D., S.E.

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

Kurt Gustafson is the director of technical assistance in AISC's Steel Solutions Center. Larry Muir and Brad Davis are part-time consultants to AISC.

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

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

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

Steel Solutions Center
One East Wacker Dr., Suite 700
Chicago, IL 60601
tel: 866.ASK.AISC • fax: 312.803.4709
solutions@aisc.org

steel quiz

LOOKING FOR A CHALLENGE? *Modern Steel Construction*'s monthly Steel Quiz tests your knowledge of steel design and construction. Most answers can be found in the 2005 *Specification for Structural Steel Buildings*, available as a free download from AISC's web site, **www.aisc.org/2005spec**. Where appropriate, other industry standards are also referenced.

1 True/False: According to Appendix 3 of the AISC Specification, evaluation of fatigue resistance is not required if the number of cycles of application of live load is less than 200,000.

2 What is the maximum temperature to which a structure can be subjected before the fatigue provisions of Appendix 3 are no longer applicable?
(a) 200 °F (b) 300 °F
(c) 400 °F (d) 500 °F

3 True/False: According to Appendix 3 of the AISC Specification, evaluation of fatigue resistance is made using stress ranges that are based on service loads.

4 True/False: Fire resistance and fire protection are interchangeable terms.

5 What are some examples of active fire protection systems?

6 What are some examples of passive fire protection systems?

7 True/False: Hooked anchor rods should not be used when there is a calculated tension load or moment on the column base.

8 The AISC-recommended maximum hole size for a 1-in.-diameter anchor rod is:
(a) 1$\frac{1}{4}$ in. (b) 1$\frac{1}{2}$ in.
(c) 1$\frac{13}{16}$ in. (d) 2 in.

9 When connecting elements are large in comparison to the bolted or welded joints within them, such as for a bolted connection of the brace to a gusset plate, how can the engineer determine the effective width when checking the gusset plate?

10 True/False: The strength level of ASTM A325 bolts can be obtained in twist-off-type configuration using the ASTM F1852 specification, and ASTM F2280 is the twist-off equivalent for ASTM A490 bolts.

TURN TO PAGE 14 FOR ANSWERS

steel quiz ANSWERS

1 False. The threshold given in Appendix 3 of the AISC Specification (**www.aisc.org/2005spec**) below which fatigue resistance need not be evaluated is 20,000 cycles of application of live load.

2 (b) According to Section 3.1, Appendix 3 is applicable only to structures subject to temperatures in applications not exceeding 300 °F.

3 True.

4 False. Fire resistance is the duration during which a structural assembly or element exhibits adequate structural integrity, stability and temperature transmission. Fire protection on the other hand refers to insulative materials applied to the structural members as well as everything associated with providing fire safety (sprinklers, egress, separations, etc.) and fire resistance. See AISC Design Guide 19 *Fire Resistance of Structural Steel Framing*, a free download for AISC members at **www.aisc.org/epubs**, for further information.

5 Active fire protection systems are those that utilize automatic devices or human action to initiate countermeasures, such as to suppress the fire or alert occupants. Examples include sprinkler systems, smoke and fire detectors and alarms, and fire extinguishers. See AISC Facts for Steel Buildings Number 1: Fire, a free download at **www.aisc.org/freepubs**, for further information.

6 Passive fire protection systems are those that function without external activation. Examples of passive fire protection systems include building code limitations for the combustion characteristics of construction materials, compartmentalized design requirements, and fire protection materials that prevent or delay the temperature rise in structural elements.

7 True. Hooked anchor rods are meant for compression-only column bases and locating and erecting columns. Calculated tension at column bases should be transferred with headed rods, or rods that are threaded and nutted. See Part 14 of the 13th Edition AISC Manual (page 14-10) for further discussion.

8 (c) For a 1-in.-diameter anchor rod, Table 14-2 of the 13th Edition AISC Manual recommends a maximum hole size of $1\frac{13}{16}$ in. These hole sizes are larger than for steel-to-steel structural connections because of differences in tolerances between steel and concrete.

9 The Whitmore section is used to determine the effective width for design. Figure 9-1 in Part 9 of the 13th Edition AISC Manual provides an illustration of how to apply this principle.

10 True.

Anyone is welcome to submit questions and answers for 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 at **solutions@aisc.org**.

Steel Solutions Center


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ENGINEERING JOURNAL

Third Quarter 2009 Article Abstracts

The following papers appear in the third quarter 2009 issue of AISC's *Engineering Journal*. EJ is available online (free to AISC Members) at **www.aisc.org/epubs**.

Estimating Inelastic Drifts and Link Rotation Demands in EBFs

Paul W. Richards and Brandon Thompson

When designing eccentrically brace frames (EBFs), the inelastic rotation of the links is estimated to ensure that links will not experience excessive rotations. Typically, design engineers amplify elastic analysis results to estimate EBF link inelastic rotations. Twelve EBF frames of different height (3-, 9-, and 18- story) and strength were designed and two types of analyses performed: static elastic analysis under the design base shear; and non-linear dynamic analysis under ten design-level earthquakes. Roof drifts, story drifts, and link rotations were estimated by amplifying values from the static elastic analyses, and then compared with average values from the dynamic analyses. Poor correlation was observed. For the 3-story frames, estimated link rotations were as much as 63% lower than the rotations observed in the dynamic analyses. For the 9- and 18-story frames, estimated link rotations were as much as two times greater than those observed in the dynamic analyses. Calibrated amplification factors were developed for better estimation of link inelastic rotation. It is demonstrated that amplifying only the shear component of the elastic story deformations will lead to more reasonable estimates.

Experimental Study of Bolted Connection Strength at Elevated Temperatures

Liang Yu and Karl H. Frank

Single bolt (A325) connections were tested at temperature up to 800 °C (1472 °F) to investigate the effect of temperature upon their bearing capacity. Significant stiffness and strength losses were found between 400 °C (752 °F) and 800 °C (1472 °F). The failure mode changes from bearing to bolt shear between 300 °C (572 °F) and 400 °C (752 °F). Two-bolt (A490) connections are tested from ambient temperature to 800 °C (1472 °F) to study the effect of temperature upon the block shear capacity. Both the stiffness and the strength of the two-bolt connections decrease between 400 °C (752 °F) and 800 °C (1472 °F). The estimated strengths of steel at elevated temperatures given in the Appendix 4 of the 2005 AISC *Specification* overestimated the strength of the connections which failed in block shear of the plate or shear of the bolts. The constant load test results agreed well with constant temperature quasi static test results indicating that creep under constant load does not change the strength of connection at elevated temperature. Residual slip resistance capacity of fully tightened A490 bolt connection was tested after exposure to temperatures up to 800 °C (1472 °F). After exposure to a temperature above 400 °C (752 °F), the slip load resistance reduces considerably.

Collapse Performance of Low-Ductility Chevron Braced Steel Frames in Moderate Seismic Regions

Eric M. Hines, Mary E. Appel, and Peter J. Cheever

This paper discusses non-linear dynamic collapse behavior observed in analytical models of low-ductility chevron braced steel frames designed for 3-, 6-, 9- and 12-story building configurations in Boston, Massachusetts. For each building configuration, three separate designs were developed assuming $R = 2$, 3, and 4 with no seismic detailing, but accounting for some lateral capacity in the gravity system. A fourth design was developed as a low-ductility dual system, with a primary braced frame system designed to resist wind only, and a secondary moment frame reserve system. These analyses bring to light the need for a clear design philosophy for low-ductility structures in moderate seismic regions. Based on encouraging results for the low-ductility dual system, the concept of reserve system design offers a step toward the definition of this philosophy.

Experimental Evaluation of Kaiser Bolted Bracket Steel Moment-Resisting Connections

Scott M. Adan and William Gibb

The Kaiser bolted bracket (KBB) is a new beam-to-column moment connection that consists of proprietary cast high-strength steel brackets that are fastened to the flanges of a beam and then bolted to a column. This fully restrained connection is designed to eliminate field welding in steel moment frame construction. This paper summarizes the development of bolted bracket connections and presents the results of seven full-scale KBB tests. These tests were conducted to evaluate the connection for both the retrofit of existing and the construction of new steel moment frames. More specifically the tests were intended to assess the ductility of the connection under cyclic inelastic loading and to qualify their performance with respect to code requirements.

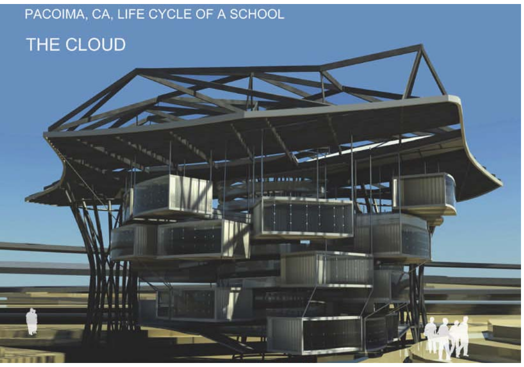
Experimental Investigation of Fillet-Welded Joints Subjected to Out-of-Plane Eccentric Loads

Scott M. Adan, Amit M. Kanvinde, Gilbert Y. Grondin, Ivan R. Gomez, and Yukay Kwan

The current AISC design specification for welded connections does not make a distinction between joints subjected to eccentric loads in the plane of the weld group, and those subjected to eccentric loads not in the plane of the weld group. To address this issue, results from 60 tests on cruciform joint specimens are presented to examine the effect of combined shear and out-of-plane bending on the strength of fillet welded joints. All specimens are loaded in a three point bending configuration, such that the out-of-plane bending is resisted through a combination of tensile weld stresses and compressive bearing stresses between the connected plates. Two welding filler metals (flux-cored wires, toughness rated E70T7-K2 and non-toughness rated E70T-7), two nominal weld sizes (5⁄16 in. and ½ in.), three nominal load eccentricity ratios (0.75, 1.375 and 2.125) and three plate bearing widths (1.25 in., 1.75 in. and 2.5 in.) are investigated. Analysis of the test data, in addition to similar data available in the literature, reveals that the current (13th Edition *Steel Construction Manual*) AISC design tables for eccentrically loaded welds are highly conservative (i.e. test-to-predicted load ratios are, on average, 1.75; with a coefficient of variation = 0.25) for joints with out-of-plane eccentricity. This conservatism is attributed to the disregard of plate bearing stresses that significantly alter the stress distribution in the joint. An alternate approach that explicitly incorporates this bearing effect is proposed, and the resulting strength predictions are determined to be significantly less conservative when compared to the current design standards. Limitations of the research and future work are outlined.

DESIGN COMPETITIONS

ACSA/AISC 2008–2009 Steel Design Student Competition Winners



First-place winner "The Cloud," designed by the Woodbury University team. For photos of the other winning projects, visit www.acsa-arch.org.

Woodbury University students took top honors in both categories of the ninth annual Steel Design Student Competition. Administered by the Association of Collegiate Schools of Architecture (ACSA) and sponsored by AISC, the program challenged students—working individually or in teams—to explore a variety of design issues related to the use of steel in design and construction. Students from four other schools also took home awards from the competition.

The first category, Life Cycle of a School, challenged architecture students to design a school for the 21st century that critically examined life cycle and proposed an innovative solution in steel. With the premise that the problem of urban growth and decay is larger than an individual building, entrants were tasked with considering a total life-cycle assessment approach to designing their building to be adaptable and flexible. The second category was open, with limited restrictions. Following are this year's winners.

Category I

First Place: The Cloud
Students: Reza Hadian and Sara Shakib
Faculty Sponsors: Scott Uriu
Woodbury University

Second Place: Didactic Shift
Students: Wilson Hugo Diaz and Liliana Gonzalez
Faculty Sponsor: Mark Owen and Gerard Smulevich
Woodbury University

Third Place: Air-Right School
Students: Yong Tan and Vanessa Banos
Faculty Sponsor: Mark Owen
Woodbury University

Honorable Mention: The Bio Rhythmic Charter School
Students: Erin Chapman and Nick Respecki
Faculty Sponsor: Pamela Harwood
Ball State University

Category II

First Place: The American Institute of Steel Reclamation
Students: Jeffrey Dahl and Jan Lim
Faculty Sponsor: Gerard Smulevich
Woodbury University

Second Place: Lakeside South Condominium
Student: Brian Pugh
Faculty Sponsor: Joy Monice Malnar
University of Illinois, Urbana-Champaign

Honorable Mention: Frequency In-Flux
Student: Rachel Glabe
Faculty Sponsors: Thomas Fowler IV, Mark Cabrinha, Ansgar M. Killing, and James Doerfler
California Polytechnic State University, San Luis Obispo

Honorable Mention: Transparency
Students: Kyle Doman and Breton Lujan
Faculty Sponsor: Michael Jenson
University of Colorado

For more on the program and winners, visit **www.acsa-arch.org**—and see the related news item at **www.aisc.org**.

SPECIFICATIONS

2010 AISC Specification Second Public Review

A limited portion of the 2010 draft of the AISC *Specification for Structural Steel Buildings* will be available for public review from August 14 through September 28, 2009. This is the second opportunity for the public to submit comments on the new specification; however, only portions that have been revised since the first public review (March 2009) will be open for comment. Look for a press release announcing the public review listed under "News" on the AISC home page (**www.aisc.org**) during this time. The draft specification and comment submittal form will also be available for download at **www.aisc.org/AISC341PR2** and **www.aisc.org/PRForm**. Hard copies will be available (for a $12 charge) by calling 312.670.5411.

Please submit comments using the form provided online to Cynthia J. Duncan, director of engineering, at duncan@aisc.org by September 28, 2009 for consideration.


WELCOME TO THE HOUSE THAT STEEL BUILT.
AS ONE OF THE NATION'S PREMIER BUILDERS OF STADIUMS AND ARENAS, W&W/AFCO Steel proudly presents its latest success story, the new home of America's Team.
The new Dallas Cowboys Stadium and its signature quarter-mile arch trusses boast numerous records including the world's longest single span structure and world's largest domed stadium.
W&W/AFCO Steel works coast to coast and internationally, satisfying customers in all construction markets. With 1.8 million square feet of fabrication space under roof and more than 165 years of experience in the industry, there isn't a project too big, a design too complex, or a schedule too aggressive for W&W/AFCO Steel to tackle.
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PHOTO | TOM FOX

Steel has its Day

BY CHRIS MOOR

If the question "What are you doing for SteelDay this year?" isn't familiar yet, it very well may be in the future. This September 18 marks the first annual day dedicated to the structural steel industry.

THE STRUCTURAL STEEL INDUSTRY OFTEN flies under the radar. Communities don't always realize there is a structural steel fabricator or service center right in their own backyard, perhaps even their zip code. In fact, when they hear the word "steel," they think of dirty factories in "industrial areas" spewing pollution into our environment. Of course, those of us in the industry know that this image couldn't be farther from the truth.

Today's structural steel industry is a modern, efficient business that uses some of the most advanced and efficient technologies, tools, and processes available. Steel is the most recycled material on the planet, and in terms of environmental friendliness there is no greener building material out there.

Opening the Doors

But oftentimes, people need to be shown something rather than just told it, and this is where SteelDay comes in. If you haven't heard about it yet, SteelDay is an AISC-sponsored day promoting and celebrating the fabricated structural steel industry. It is a unique opportunity for steel industry players to open their facilities to the public and show them how their processes work, provide hands-on education about the latest advances in our industry, and put to rest any notions the steel supply chain as an inefficient, earth-harming juggernaut. On top of this, SteelDay can serve as an interactive networking day for members of the design, construction, and steel communities. Across the nation, steel fabricators, mills, service centers, galvanizers, HSS producers, bender-rollers, and others will open their facilities, jobsites, and offices, offering tours and inviting the AEC community and general public to see how the steel industry contributes to building America.

The idea for SteelDay was borne out of AISC's Industry Mobilization program, an initiative dedicated to aligning the various players in the structural steel industry and promoting the industry on a grass-roots level across the country. As part of this initiative, AISC hosted various seminars and facility tours for architects and engineers showing off steel fabrication plants, service centers, and mills. The feedback from these events was incredibly positive, with many participants requesting tours at other types of facilities.

For example, AISC member Lyman Zolvinski, president of structural engineering consulting firm Zolvinski Engineering in Michigan City, Ind., attended an AISC seminar at a service center last year and hoped to see more fabricator and mill tours become available in his area. "A wealth of information can be obtained by visiting service centers, fabricators, and mills that can't be put into literature," he says. "It also keeps one up to date on the latest supply and fabrication techniques and availability." (On September 18, Zolvinski plans to attend a mill tour at AISC member Steel Dynamics, Inc. in Columbia City, Ind.)

With comments like these, it became clear rather quickly that we were onto something that people found really engaging. Rather than continuing to do ad-hoc events on random days, we decided to try another approach altogether, focusing our efforts into one large, national event: SteelDay.

We spent several months planning, preparing, and sharing the SteelDay idea with our members, and by the time we officially announced SteelDay on April 22, we had more than 100 events scheduled in 43 states. (As of this writing, we have 155 events happening in 48 states.) SteelDay will be a massive event for structural steel and will provide (and is already providing) tremendous exposure to the industry. At a time when the economy weighs so heavily on people's minds, SteelDay has created excitement and anticipation, and has given the design and construction community something to look forward to—not only on the actual day itself but also as the economy begins to rev up again.

Tours, Seminars, and Presentations

Attendees of SteelDay events will get to interact with structural steel industry professionals, tour facilities and jobsites, and attend seminars and presentations. They'll learn about the advances the structural steel industry has made toward a sustainable environment and get first-hand knowledge of how design can affect production and efficiency—positively or negatively. They'll get to witness advanced technology in action—e.g., they'll see how the steel industry has taken advantage of building information modeling (BIM) for more than 20 years and how this method has streamlined production and increased efficiency. And in the end they'll go away with new relationships and contacts, and will be better equipped to build high-performance projects that have minimal impact on our planet—on time, on budget, and using steel.

SteelDay events range from the very simple ("come on over and we'll show you around") to the very complex ("we'll take you on a journey spanning the entire supply chain") and everything in-between. The industry has stepped up to the plate in unprecedented fashion to put our every

Photos: Geoff Weisenberger

Chicago's Millennium Park (right photo) will play host to SteelDay's flagship event.

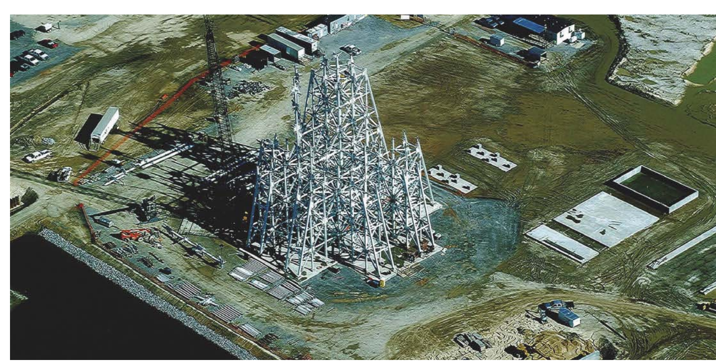
process on show for the world to see and experience.

Wabash Steel in Vincennes, Ind., for example, is hosting an all-day event for local architects, engineers, contractors, and even students. The AISC-member and Certified fabricator, which pursues work across the Midwest, will be running guided facility tours every half-hour and even serving lunch. Lori Gillett, president of Wabash, emphasizes the opportunity for visitors to see advanced steel fabrication machinery in operation, up close. "They can talk to the employee who programmed our plasma machine or ask the operator who's punching stiffeners how he keeps up with the fully automated Fabripunch," she says. "I promise you that it will be educational."

Brian Smith, general manager/CFO of AISC-member bender-roller Albina Pipe Bending Co., Inc. in Tualatin, Ore., notes that many in the design community "have never had an opportunity to see, first-hand, steel being bent." According to Smith, Albina decided to host a tour to "help educate people in pipe, tube, and structural steel bending in the hopes that attendees will better understand the process and not shy away from working with or designing future projects out of bent steel."

All the way across the country in Fort Howard, Md., Dennis McCartney of AISC member B&B Welding Company, Inc. explains, "We are hosting a SteelDay event to help extol the beauty of steel in construction, as well as the beauty of the interoperability of design, estimating, detailing, and barcoding software, and state-of-the art CNC fabrication equipment. Architects, engineers, and students should attend our event to have a greater appreciation of the assumed safety, beauty, and utility of the many structures they pass over or pass by during their day's activities." B&B is hosting a facility tour, followed by a celebration and pig roast!

And then there's Texas. Everything is big in Texas, and SteelDay is no exception. When Beverlea Bons, general manager at AISC member Metals USA's Cedar Hill, Texas facility, got wind of SteelDay, her mind immediately kicked into high



gear. "When I first heard about SteelDay, I just took the directive to 'be imaginative' and ran," she says. "Steel is versatile, readily available, and eco-friendly, and it's time to get the news out to the construction industry. I wanted to capture not only the start and finish of structural steel, but also some of the many variables in between."

Bons approached Matt Gomez, national sales manager for Fast-Frame at AISC member Gerdau Ameristeel, and together they came up with the idea of the North Texas Integrated SteelDay Tour. The two companies, along with AISC-member fabricator Qualico Steel Company of Midlothian, Texas and Sabre Galvanizing in Alvarado, Texas (a division of AISC member Sabre Industries), have devised a once-in-a-lifetime opportunity for attendees to see every aspect of the structural steel supply chain in just a few hours. Starting at Gerdau's Midlothian steel mill, guests will witness the steel-making process before being taken by bus to Metal USA's service center facility. From there, everyone moves on to Qualico Steel's structural fabrication facility before capping it all off with a tour of Sabre Galvanizing's plant. "Through the guided tours of our four operations, we hope to help people learn about aspects of steel projects typically unseen during planning and construction," says Gomez.

And the response has been dramatic, with both professionals and students signing up at a faster-than-anticipated rate. "For all four of our organizations, this is an excellent opportunity to share our story of steel construction as both cost-effective and environmentally friendly in market conditions that demand both aspects," Gomez says.

The Main Event

While events will be taking place all over the country, the epicenter, if you will, of SteelDay will be in Millennium Park in Chicago, a few short blocks from AISC's headquarters. This flagship event will serve as a unique interactive networking and learning opportunity in one of the city's most celebrated public spaces, in the shadows of the park's now-iconic Cloud Gate sculpture and the (steel-framed) Frank Gehry-designed Jay Pritzker Pavilion. Four education stations will be available at the site: the AISC Certification Education Station, AISC Steel Solutions Center Education Station, Sustainability Education Station, and Millennium Park Education Station (which focuses on the steel-framed structures at the park). In addition, the presentation "Structural Steel's Sustainable Contribution to the Architecture and Economy of Chicago" will be given twice (and is good for one AIA CES hour). And, complimentary lunches will be reserved for the first 300 registrants who arrive prior to 12:30 p.m. (There is a limit of 20 lunches per registered company.) The event lasts from noon until 2 p.m., so it's an excellent opportunity to get away from the office for a long lunch if you work in Chicago or the surrounding area. Visit **www.SteelDay.org/Chicago** for more information.

So, with events like this happening all over the country, the question remains: What are you doing for SteelDay? You can start formulating your answer (and registering for an event) by visiting **www.SteelDay.org**. We'll see you on September 18! MSC

Chris Moor is AISC's director of industry mobilization.

Steel Benefits

Why attend a SteelDay event? Here are a few reasons:

- You will gain hands-on knowledge of structural steel's sustainability, availability, erection speed, and efficiency
- You may receive free continuing education; many events are offering CEUs
- You can use an event as an opportunity to network/build relationships with local industry peers and facilities whose services you may wish to employ for future projects
- You will walk away with a better understanding and appreciation of what goes into the various areas—or one specific area—of steel-making and the steel supply chain
- You can learn how AISC can help with your projects
- You don't have to travel far; events are currently scheduled in 48 states
- You don't have to pay anything; all events are free!

For a list of events, see below—or visit: **www.SteelDay.org/FindEvent**

SteelDay Event Locations*

Alaska
ConocoPhilips, Anchorage
Alabama
Saginaw Pipe, Saginaw
Industrial Galvanizers, Birmingham
Independence Tube, Decatur
AZZ Galvanizing Services, Mobile
CMC Steel, Birmingham
O'Neal Steel, Birmingham
Chatham Steel, Birmingham
Arkansas
Nucor-Yamato Steel Corporation, Blytheville
O'Neal Steel, Little Rock
AZZ Galvanizing Services, Prairie Grove
Prospect Steel, Little Rock
AFCO Steel, Little Rock
AFCO Steel, Little Rock(2)
Arizona
AZZ Galvanizing Services, Goodyear
S & H Steel, Gilbert
Schuff Steel Southwest, Phoenix
J.B. Steel, Tucson
California
Fresno Fab-Tech, Sanger
PDM Steel Service Centers, Fresno
Pacific Drafting, Long Beach
Herrick Corporation, Stockton
PDM Steel Service Centers, Stockton
Conxtech, Inc., Hayward
LB Construction, Roseville
PDM Steel Service Centers, Santa Clara
Colorado
North American Galvanizing Company, Denver
Great Denver Iron, Denver
American Galvanizers Association, Centennial
PDM Steel Service Centers, Denver
Connecticut
Infra-Metals, Wallingford
Topper & Griggs, Plainville
Deleware
V&S Galvanizing, New Castle
District of Columbia
Ironworker International Union/IMPACT, Washington
Florida
Industrial Galvanizers, Tampa
Infra-Metals, Hallandale
Infra-Metals, Tampa
Chatham Steel, Orlando
Industrial Galvanizers, Miami
Tampa Tank & Florida Structural Steel, Tampa
Advantage Steel, Tampa
Steel Fabricators, Ft Lauderdale
Georgia
Universal Steel, Lithonia
Metals USA, Oakwood
Tekla, Inc., Kennesaw
Chatham Steel, Savannah
Steel, LLC, Scottdale
Iowa
Majona Steel, Waukee
Southwestern Community College, Creston
Idaho
Steel West Inc., Pocatello
Illinois
Peddinghaus Corporation, Bradley
Atlas Tube, Chicago
Infra-Metals, Marseilles
AZZ Galvanizing Services, Peoria
Independence Tube, Marseilles
AISC Special Event, Millennium Park, Chicago
AZZ Galvanizing Services, Dixon
AZZ Galvanizing Services, Joliet
St. Louis Screw & Bolt, Madison
Indian
Steel Dynamics, Columbia City
AZZ Galvanizing Services, Hamilton
AZZ Galvanizing Services, Muncie
AZZ Galvanizing Services, Plymouth
MacSteel Service Centers, Hammond
Benchmark Steel, Terre Haute
Wabash Steel, Vincennes
Kansas
TECHNI Waterjet, Lenexa
Kentucky
Precision Steel, Calvert City
North American Galvanizing Company, Louisville
Louisiana
Steel Fabricators of Monroe, Monroe
AZZ Galvanizing Services, Hobson
AZZ Galvanizing Services, Westside
Maryland
B & B Welding Co., Baltimore
Standard Supplies, Gaithersburg
Massachusetts
V&S Galvanizing, Taunton
Maine
Megquier & Jones, South Portland
Michigan
Jobsite Tour, Lansing

Continued on p. 26.

*For the most current list, visit **www.SteelDay.org.**

Continued from p. 25.

Atlas Tube, Plymouth
V&S Galvanizing, Redford

Minnesota

AZZ Galvanizing Services, Winsted

Mississippi

AZZ Galvanizing Services - Jackson, MS
AZZ Galvanizing Services - Moss Point, MS

Missouri

EXL Tube, N. Kansas City
North American Galvanizing Company, St. Louis
North American Galvanizing Company, Kansas City
Bi-State Fabricators Association, St. Louis
Atlas Iron Works, St. Louis

Montana

Roscoe Bridge, Missoula
Roscoe Steel, Billings

Nebraska

Design Data, Lincoln
Drake-Williams Steel, Omaha

Nevada

PDM Steel Service Centers, Sparks
PDM Steel Service Centers, Las Vegas

New Hampshire

American Steel Fabricators & Erectors, Greenfield

New Jersey

V&S Galvanizing, Perth Amboy

New Mexico

Southwest Ironwork, Albuquerque

North Carolina

Buckner Companies, Graham
Chatham Steel, Durham

North Dakota

Fargo Tank & Steel, Fargo
Mandan Steel Fabricators, Mandan

New York

Ironworkers Locals 40 & 361 JAC, Astoria
Stone Bridge Iron & Steel, Gansevoort

Ohio

North American Galvanizing Co., Canton
Kottler Metal Products, Willoughby
AZZ Galvanizing Services, Cincinatti
V&S Galvanizing, Columbus

Oklahoma

North American Galvanizing Company, Tulsa
AZZ Galvanizing Services, Chelsea
W&W Steel, Oklahoma City

Oregon

Albina Pipe Bending Co., Inc.c Tualatin
Valmont Coatings, Tualatin

Pennsylvania

High Steel Structures, Lancaster
Metals USA, Ambridge
Lehigh University, ATLSS Research Center, Bethlehem
V&S Galvanizing, Jonestown
Metals USA, Langhorne
Acecad Software, Exton

Rhode Island

American Welding Co., West Greenwich

South Carolina

Master Steel, Hardeeville
Industrial Galvanizers, West Columbia
Chatham Steel, Columbia

South Dakota

Dakota Steel & Supply, Rapid City

Nashville

North American Galvanizing Co., Nashville

Texas

Metals USA, Cedar Hill
AZZ Galvanizing Services, Crowley
North American Galvanizing Company, Hurst
North American Galvanizing Co., Houston
AZZ Galvanizing Services, Houston
AZZ Galvanizing Services, Waskom
AZZ Galvanizing Services, Beaumont
Qualico Steel, Midlothian
Gerdau Ameristeel, Midlothian
Central Texas Iron Works, Waco
Sabre Galvanizing, Alvarado
W&W Steel, Lubbock
Ford Steel, Porter
North Texas Integrated SteelDay Tour
Schuff Steel Gulf Coast, Houston

Utah

PDM Steel Service Centers, Spanish Fork

Virginia

Virginia Tidewater Group International, Virginia Beach
Industrial Galvanizers, Petersburg
Banker Steel, Lynchburg
Gerdau Ameristeel, Petersburg
Infra-Metals, Petersburg

Vermont

Reliance Steel, Colchester
Applied Bolting Technology, Bellows Falls

Washington

Jesse Engineering Co., Tacoma
PDM Steel Service Centers, Woodland
Urban Water Project, Tacoma

West Virginia

North American Galvanizing Co., Benwood
Huntington Steel, Huntington

Wyoming

Puma Steel, Cheyenne

Ruth's New DIGS

BY THOMAS Z. SCARANGELLO, P.E., AND MICHAEL J. SQUARZINI, P.E.

Built in the image of its former self, new Yankee Stadium carries on the architectural—and hopefully, winning—tradition of the House that Ruth Built.

OLD YANKEE STADIUM WAS KNOWN by many as the House that Ruth Built and was considered to be one of the shrines, if not *the* shrine, of Major League Baseball. Of course, the Yankees have a whole new set of star players these days—and as of this season, a brand-new stadium.

New Yankee Stadium consists of five seating zones (encompassing approximately 53,000 seats in all) within the bowl: the Field, Main, Suite, Terrace, and Grandstand levels. The Field and Main concourses were constructed with concrete, with the balance of the stadium framed in steel. The cast-in-place portion of the structural bowl was constructed simultaneously with the completion of construction documents and the fabrication of the surrounding steel superstructure. The building's lateral system is a mixed system; the lower portions of the structure are supported by continuous and uniformly distributed moment frames, and the rest of the stadium supported by a series of continuous and discreet bracing elements to provide circumferential stability. The lower Field and Main levels are supported by steel framing and are stabilized by the concrete moment frames, and supplemented by steel moment frames in the circumferential direction. The steel portion of the stadium is approximately 12,000 tons.

Vibration Consideration

To maximize seating and unobstructed views, the Suite and Terrace levels are cantilevered approximately 50 ft beyond the support columns of the Main level below. These long steel-framed cantilevers used full-story trusses hidden within suite walls. Wide-flange members with a maximum flange width of 8 in. were used in order for the trusses to fit within the suite walls; the depth of the trusses is approximately 24 ft.

Designing these cantilevers required a detailed evaluation of the vibration characteristics. Published design guidelines, including AISC vibration guidelines, do not specifically address vibration performance characteristics for long cantilevered structures supporting seating bowls, where both vertical and horizontal modes of vibration may be coupled. Historical precedents for limiting a main-bowl cantilever's fundamental vertical frequency to 3.5Hz have been successful in previous sports facilities to limit perceived vibration to an acceptable level. In addition to this guideline, an analysis was performed for each typical cantilever bent by applying spectator-forcing functions through multiple frequencies and capturing the acceleration response at resonance. Steel tonnage was then optimized within the cantilevers to limit the vibration response of the main cantilevers to within typical AISC acceptance criteria.

More Modeling

The project team for Yankee Stadium incorporated building information modeling (BIM) at the very early stages of design. The structural elements—including steel, concrete, deck and precast components—were modeled in Tekla Structures to provide both a medium

Rendering by Thornton Tomasetti/Koch Skanska/Canam

The historic frieze that was an ornamental icon of old Yankee Stadium serves both an ornamental *and* structural purpose in the new stadium. (3D model created in Tekla Structures.)

Photos by Chris Linder

The new incarnation of Yankee Stadium uses 12,000 tons of structural steel—and seats a whopping 53,000.

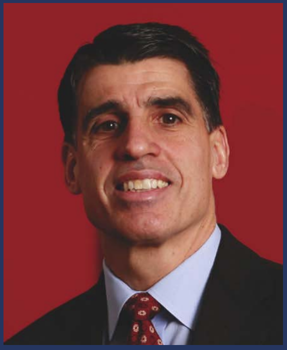
for aesthetic review of the structure and to accelerate procurement and fabrication schedules for the steel. All steel member information—including sizes, elevations, and geometry—were included in the completed model and issued to the erector/fabricator team in sequences that suited their preferences. These models were used for advance mill orders and as the basis for completed fabrication models.

Because of the aesthetic importance of the exposed steel connections, the connection design of all major steel elements was completed on the structural documents. All major exposed connections were further modeled in Tekla Structures, allowing connection design and geometry to be modified to suit the architectural aesthetic requirements. Fabrication models were also submitted for review prior to detailed shop drawing submissions for approval, allowing for a simplified and expedited approval process.

The Frieze

Perhaps the best example of the successful use of BIM and 3D modeling in the stadium design is the signature element of the Yankee Stadium brand: the historic frieze that ringed the old Yankee Stadium prior to its renovation in 1974. The old frieze was ornamental in nature, with a backup truss structure providing its structural support, and initial concepts for the new stadium followed a similar approach. However, the structural engineer eventually offered a different approach in which the frieze in the new stadium would serve both ornamental *and* structural functions, and would be constructed as a self-supporting structural element. The 1,465-ft-long frieze ringing the new stadium is constructed of single 350-lb/ft units, between bents, of $\frac{5}{8}$-in. continuous plate (laser cut) for the arches and openings, and 8-in. x 6-in. curved standard hollow structural sections (HSS). The sections are supported by built-up inverted columns at each bent and cantilevered from the main canopy girders.

Since the frieze is self-supporting, the visual appearance is the same from both the field and the upper seating; the connections were detailed such that there are no visible connections from the field side



Thomas Z. Scarangello is Chairman of Thornton Tomasetti, Inc.

Michael J. Squarzini is a senior principal with Thornton Tomasetti, Inc.

of the frieze, creating continuously clean lines. These critical details were modeled in Tekla Structures, allowing the team to visualize and modify the connection shape and geometry, such as adding chamfers to end plates to lessen their visual impact, and resulting in a signature element seamlessly connected to the main structure.

Yankee Stadium certainly pays its respects to its former self but also serves as a symbol of a new era for the team. Attendance has been high at the stadium so far this season—and there's still plenty of baseball yet to be played. MSC

Developer
Tishman Speyer, New York

Architect
Populous (formerly HOK Sport+Venue+Entertainment), Kansas City

Structural Engineer
Thornton Tomasetti, Inc., New York

Steel Fabricator and Detailer
Canam Steel Corporation, Point of Rocks, Md. and Saint-Gédéon-de-Beauce, Quebec (AISC Member)

Steel Erector
Koch Skanska, Carteret, N.J. (AISC/TAUC Member)

PNC Park

Consol Energy Center

Heinz Field

OTHER STADIUM / ARENA PROJECTS WE HAVE SUPPLIED:

New York Mets Stadium
Flushing, NY
Lucas Oil Stadium
Indianapolis, IN
Safe Mart Center
Fresno, CA
Chicago Bulls Arena
Chicago, IL
Cleveland Browns Stadium
Cleveland, OH
Miller Park
Milwaukee, WI
Ford Field Stadium
Detroit, MI
Minute Maid Field
Houston, TX
Soldier Field
Chicago, IL
Sprint Center
Kansas City, MO
Cincinnati Reds Ballpark
Cincinnati, OH
Iowa Events Center
Des Moines, IA
Jones AT&T Stadium
Lubbock, TX
John O'Donnell Stadium
Davenport, IA
Paige Sports Arena
Columbia, MO

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New Era in NEW YORK

BY JEFFREY SMILOW, P.E., AND ALLEN THOMPSON, P.E.

Photo: Mark S. Levine/New York Mets

Jeffrey Smilow is an executive vice president with WSP Cantor Seinuk.

Allen Thompson is a senior associate with WSP Cantor Seinuk.

The New York Mets' new home pays homage to historic Ebbets Field, while also bringing a 21st-century baseball facility to Queens.

IT'S ALWAYS A BIG DEAL when a new Major League Baseball park opens. It's an even bigger deal when two open at the same time in the same city, which is why 2009 has been a particularly special year for both the New York Mets and New York Yankees; both teams have been playing in their respective new ballparks since April.

The Spirit of Ebbets

In Queens, Mets fans have been enjoying better sight lines, wide concourses with panoramic views of the playing field, and improved culinary experiences at the new 41,800-seat, 1.2 million-sq.-ft. Citi Field, which replaced Shea Stadium. The architecture is based on Ebbets Field, home of the Brooklyn Dodgers until the 1950s, and features plenty of exposed steel in order to achieve a retro appearance, as well as brick cladding resembling masonry used at the famous old ballpark.

Design

Populous, the architect of record, began designing the ballpark in late 2005. In order to achieve the design and construction schedule, the construction manager and the design team agreed to break the steel construction of the ballpark into phases. The steel contract was awarded before the construction documents were completed, and the design team completed the construction documents following the phases set forth by the construction manager. This allowed the design to stay ahead of the steel fabricator and erector, since the design team could focus on coordinating one section at a time. In all, the project used 12,700 tons of structural steel.

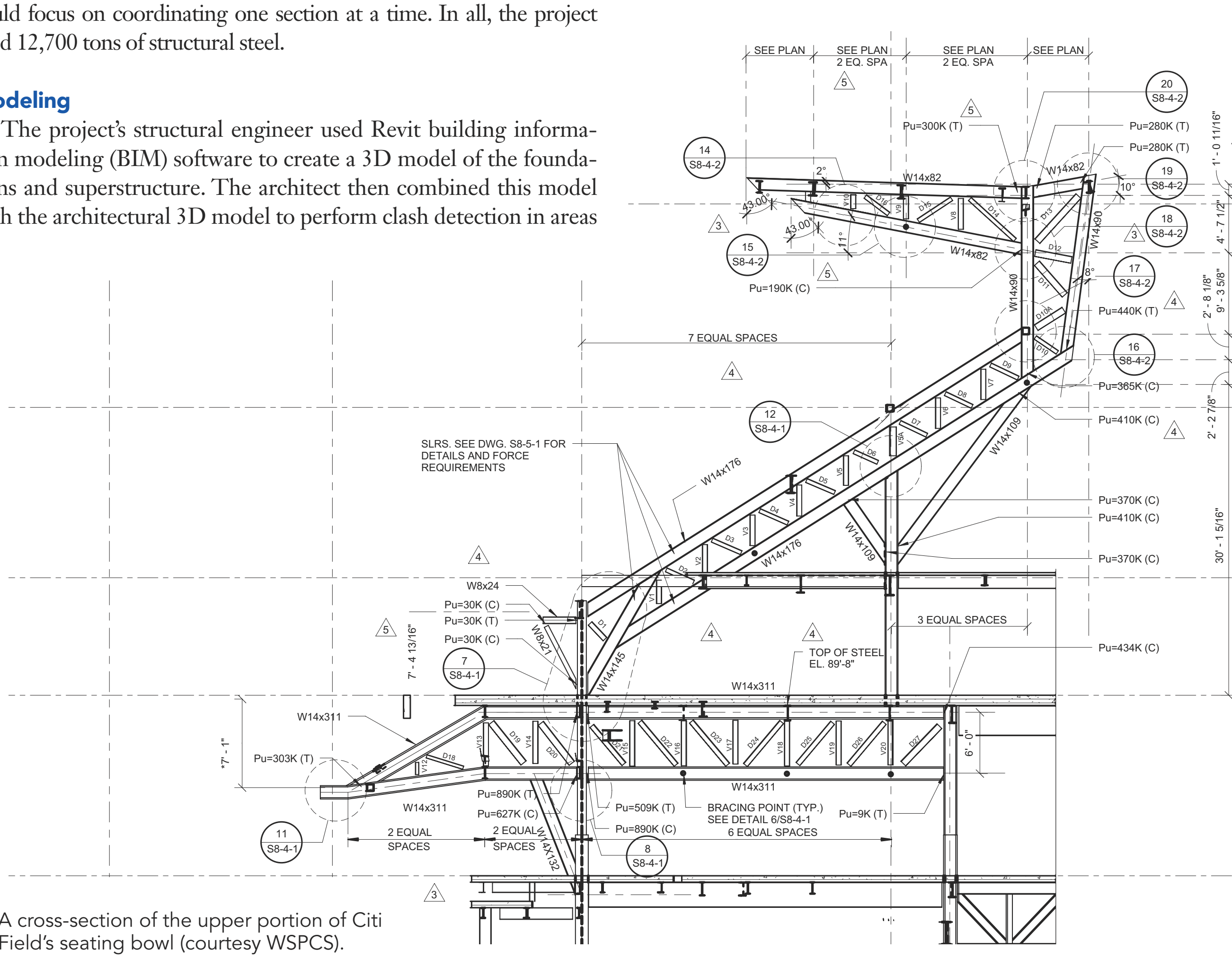
Modeling

The project's structural engineer used Revit building information modeling (BIM) software to create a 3D model of the foundations and superstructure. The architect then combined this model with the architectural 3D model to perform clash detection in areas such as door clearances next to columns, head room heights in the seating bowl under diagonal members, head room heights under the trusses, and sight line-analysis.

The owner authorized the creation of a 3D detailing model (using Tekla Sturctures) in order to get a head start on the steel shop drawing process, and steel detailers were subcontracted during the design phase in order to develop the model. Three primary benefits resulted from this effort. First, time was saved in the fabrication schedule, because a fully developed model was already available upon award of the steel contract. Second, the bid phase period was shortened, since the steel bidders were provided with the model. Third, the data that the detailer needed to create the model was incorporated into the design drawings, resulting in minimal RFIs during construction.

Lateral Systems

The soil conditions below Citi Field are extremely poor and therefore affected lateral load resisting design for the ballpark. Because of the high likelihood of liquefaction during a seismic event, the soil conditions result in high seismic forces upon the structure. The design team chose special concentrically braced frames (SCBFs) for the lateral systems, a decision that not only reduced the design seismic forces but also saved a considerable amount of structural steel, piles, foundation concrete, and rebar. In addition, the use of SCBFs also allowed the design team



A cross-section of the upper portion of Citi Field's seating bowl (courtesy WSPCS).

to reduce the amount of braced frames required, allowing for more open concourse plans.

Vibration Analysis

Jeff Wilpon, the Mets' COO, sought an intimate ballpark. In order to achieve his request, the architect stacked the seating bowl levels vertically, allowing for all the seats, including those on the Excelsior Level and Promenade Level (upper deck) levels, to be as close to the field as possible. Since the levels do not step back and the columns must be located behind the seating bowl, large cantilevers were required at these two levels. Given that this is a ballpark, the cantilevers were susceptible to fan-induced vibrations. As such, the engineers performed a thorough vibration analysis on the entire seating bowl superstructure. The analysis modeled the entire structure, including the precast seating bowl, so as to consider the interaction between it and the steel cantilevers. An optimized vibration analysis enabled the design team to tune the cantilevers by adding steel where it would be most effective in reducing vibrations. The design team added kickers—one-story diagonal members spanning from a work point at the column centerline on the level below and a work point on the cantilever—to reduce the cantilevers' lengths and thereby increase their natural frequency. It also increased the top and bottom flanges of the trusses to increase the stiffness of the cantilever and, again, increase the natural frequency of the truss.

Permanent Exposure

More than half the steel in the ballpark is permanently exposed to the environment. In order to provide the most corrosion-resistant structure possible, the design team invested considerable effort in creating details that allowed for completely shop-painted members. Most members have shop-applied primer and finish coat, and *all* members are completely shop-painted with zinc-rich primer. At the connections, specifically at the faying surfaces, the top coat was left off to allow for slip-critical connections. The zinc-rich primer allowed for a class-B faying surface, which provides 50% greater slip-critical bolt capacity compared to a class-A faying surface.

Moving inside, the Jackie Robinson Rotunda portion of the project features two crossing 183-ft-long arched steel roof trusses with bow-shaped cable tension chords. These massive trusses support considerable loads, including two levels of steel-supported concrete slabs with 100-psf live loads and a 4-in. concrete topping slab. MSC

Developer
Queens Ballpark Company, LLC, New York

Architect
Populous (formerly HOK Sport+Venue+Event), Kansas City

Structural Engineer
WSP Cantor Seinuk, New York

Steel Fabricator and Detailer
Canam Steel Corporation, Point of Rocks, Md. and Saint-Gédéon-de-Beauce, Quebec (AISC Member)

Steel Erector
Cornell and Company, Woodbury N.J. (AISC Member)

Construction Manager
Hunt/Bovis Lend Lease Alliance II (a Joint Venture), New York

Chicago Metal Rolled Products Saved Their Customer More Than 80,000 lbs. of 12 Sq. Tubing.

Early involvement in the University of Phoenix Stadium (2007 IDEAS^2 National Award Winner) allowed Chicago Metal Rolled Products to save their customer time and money when curving 402 tons of 12 x 12 x $\frac{5}{8}$ and 12 x 12 x $\frac{1}{2}$ tubing to radiuses from 1000 to 1200 feet for the roof trusses.

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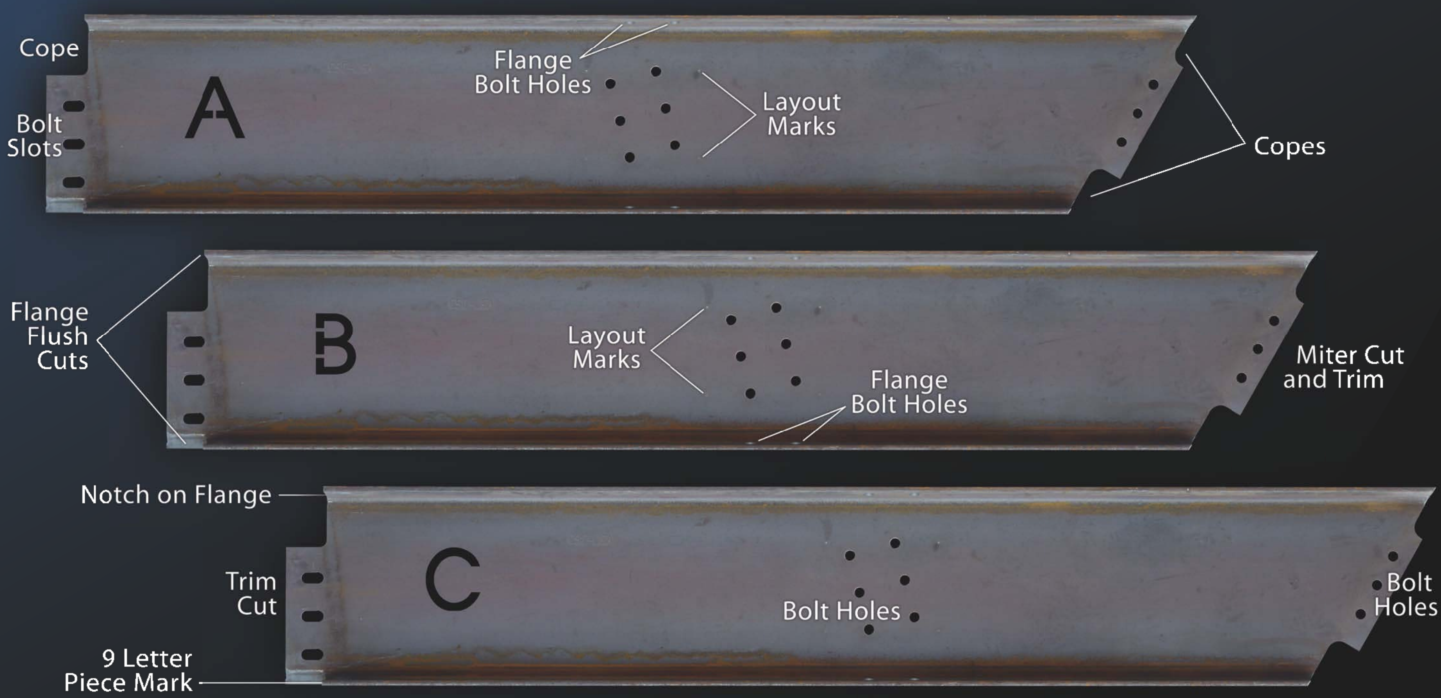

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Total process time was 119 minutes.

This doesn't include the time moving the beam between operations, the double or triple handling required for flipping, or the 'dead time' waiting in queue for the next operation.

Beam B **was produced in an 'CNC automated' fab shop.** Operators can load a drawing file into the drill line and bandsaw controls for automated operation. The notch, copes, flange flush cuts, letters and layout marks still must be laid out and made by hand.

Total process time was 82 minutes.

Again, this does not include the time involved in moving the beam between operations, the handling time for flipping, or the time spent waiting in queue for the next operation.

Beam C **was produced in a single pass on PythonX.** The operator called up the part file, gave the 'START' command, and PythonX performed all 40 operations without a pause, tool change or operator intervention.

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The Next Level

BY DYLAN S. RICHARD, P.E.

A renovation to Oklahoma State's football stadium brings the facility up a tier.

A MAMMOTH STEEL HORSESHOE HAS TAKEN SHAPE in Stillwater on the Oklahoma State University campus. On September 5, this revered structure—the newly renovated Boone Pickens Stadium—will play host to OSU's 2009 home opener and usher in a new era of Cowboy football. After nearly a decade of planning, a $250 million budget, seven years of design and construction, and 10,000 tons of steel, the new version of the stadium will be game-ready for the team and the approximately 60,000 fans that come to each home game in the fall.

In Phases

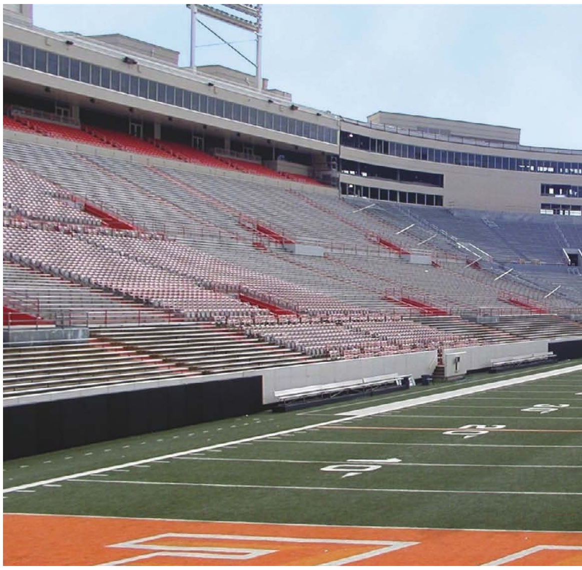
The impetus behind the expansion, the Next Level Campaign, was divided into three phases over a seven-year period. Phase 1 laid the groundwork from 2003-2004 with the retrofit, restoration, and expansion of the stadium's south grandstands. The original structure contained concession and restroom buildings at the Plaza (ground) Level only, forcing patrons in the upper half of the seating bowl to endure a long walk down winding ramps to get to basic amenities such as restrooms or concession stands. A new elevated Mezzanine Level with full amenities was added inside the existing steel framed structure, allowing the Ground Level concession and restroom buildings to be replaced with two-story concession and restroom buildings serving both concourses. A new structure built behind the grandstand provides elevator and escalator access to the new concourses and adds new Arena, Lower Club, Upper Club, Suite, and Upper Concourse Levels. A press box and three new light towers topped off the Phase 1 structure. From 2005-2006, the Phase 2 construction mirrored the south grandstand retrofit, restoration, and expansion (minus the press box) to the field's north side.

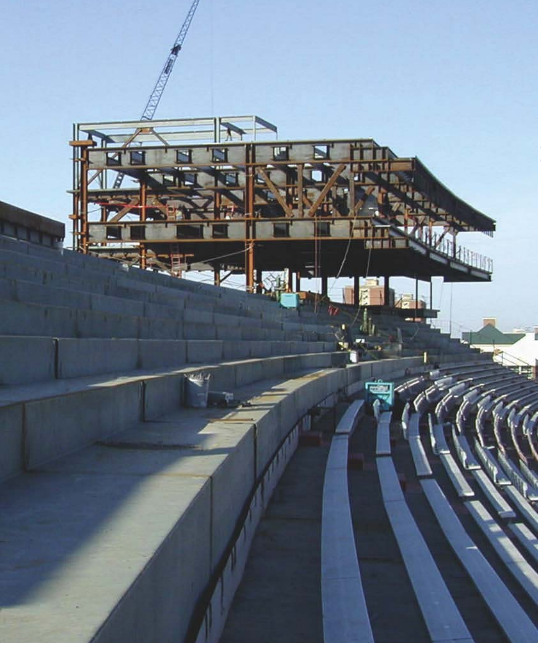
Completing the Horseshoe

The final portion of the Next Level Campaign was the Phase 3 west end-zone construction that began in 2007. The west end-zone's primary purpose was to complete the horseshoe by linking the south and north grandstands, but it resulted in much more: over one million sq. ft of programmed space. Using more than half of the

Courtesy Oklahoma State University

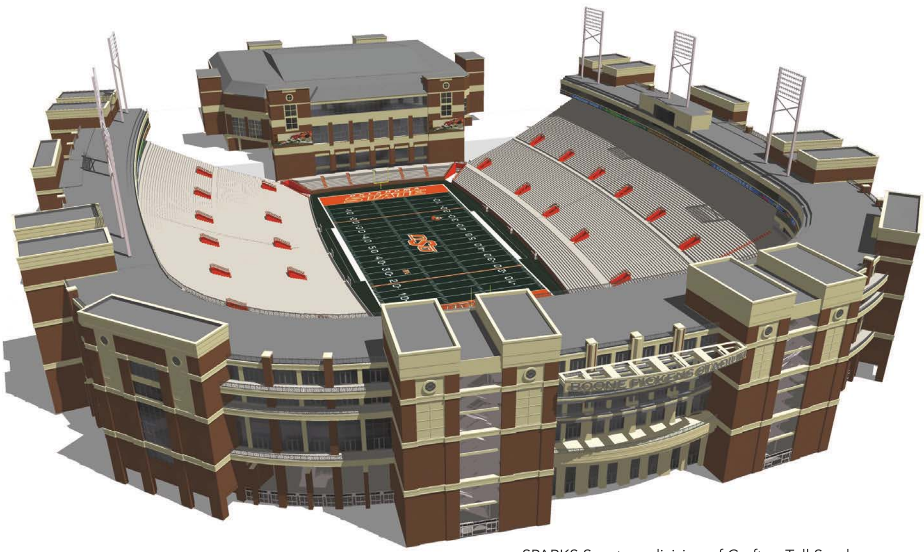
The Boone Pickens Stadium expansion used 10,000 tons of structural steel.





WALTER P MOORE

The cantilever emerges over the existing south grandstand.



SPARKS Sports, a division of Crafton Tull Sparks

The renovated stadium is scheduled to open this fall—and should look something like this, only filled with tens of thousands of fired-up Cowboys fans.

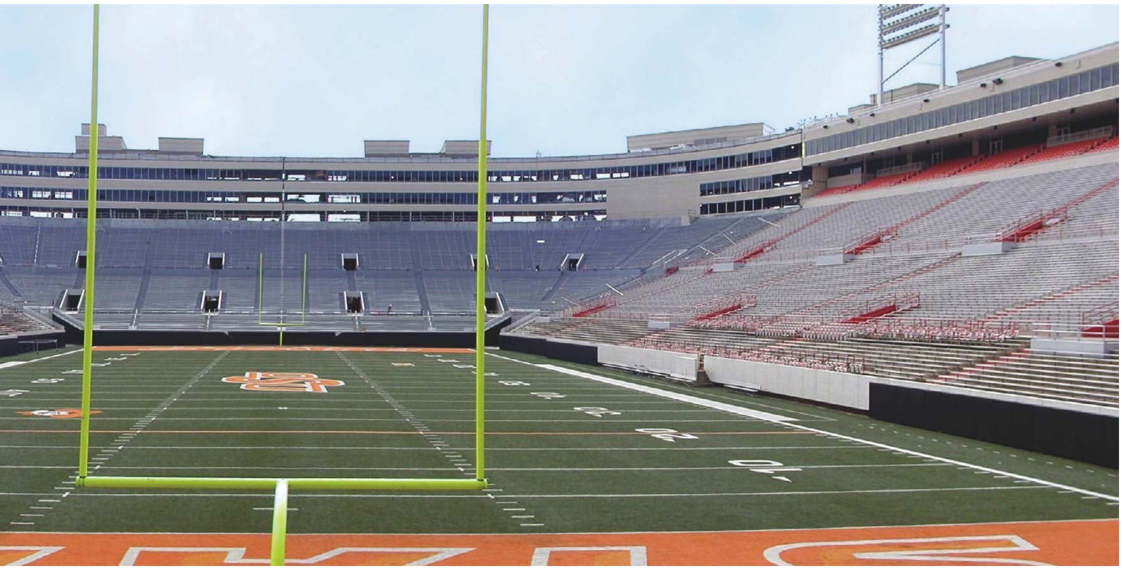
overall project steel tonnage of 10,000, the west end-zone structure provides a continuous seating bowl between the existing south and north grandstands and continuous Plaza, Mezzanine, Arena, Lower Club, Upper Club, Suite, and Upper Concourse Levels. A substantial portion of the Phase 3 square footage is occupied by a new Field (basement) Level below the entire west end-zone.

Modern and Robust

Steel was chosen as the primary framing type for the Boone Pickens Stadium expansion in order to bring the design team's vision of a modern, robust structure to reality. In the key areas where steel was used, the overall weight of the structure was minimized, the existing facility was easily retrofitted, the new cantilevers were made possible, the new structure expansion joints were minimized, and the new-to-existing structure expansion joints made the stadium one.

The original south and north grandstands contained traditional 2-ft 3-in. tread depths with mostly bench seating and limited chair back seating. New Club Level seating was added to the existing grandstands by replacing the top ten rows with nine 2-ft 9-in. rows for club seats. The existing treads and risers were composed of a relatively light system of steel channels, angles, form deck, and concrete treads. To minimize the impact to the existing foundations, designers chose an equally light system of 5/16-in. steel bent plate treads and risers for the new club seats. Results of extensive field surveys of the existing steel rakers let the fabricator provide units that matched up with the existing steel supports and followed the 18- to 20-ft articulating steel column grid (the spacing from grid to grid was around 19 ft, 6 in.). The steel bent plate tread-and-riser units were then set and seal welded to each other and protected with a Neogard roller-applied urethane traffic-coating system.

The new Mezzanine Level immediately above the Plaza (ground) Level services the upper grandstands and accesses 21 new two-story concession and restroom buildings. At the existing grandstands, 14 of the concession and restroom buildings were constructed within the existing web of steel framing. A new steel-framed floor, optimized with W16 and W18 beams, was installed to create the Mezzanine Level concourse and Roof Level of the concession and restroom buildings. The steel framing was conveniently attached to the existing steel frame with shear tab steel connections and allowed for nominal strengthening of the existing foundations below. Addition-



WALTER P MOORE

The Phase 3 west end-zone portion, nearing completion.

Dylan S. Richard, P.E., of Walter P Moore was the project manager for all three phases and Engineer-of-Record for Phase 3. He can be reached at ***Drichard@walterpmoore.com***.

Pre-Game Story

The original Lewis Field was constructed in the 1920s with steel-framed grandstands and had a total seating capacity of 13,000. With the playing field oriented east-west, the grandstands were built on the north and south sides of the field to block the prevailing winds. A pair of expansion projects in the 1940s brought the stadium's capacity to 39,000 and added a press box in time for the 1950 season. In 1971, seating capacity was increased to 50,000 by removing the running track around the playing field to make way for 20 new rows of seating. The press box was replaced and lights were added for night games and practices in the 1980s.

In January 2001, OSU decided it was time to turn its attention to the 80-year-old football stadium. From 2000 to 2002, a master plan was developed to transform the aging two-sided facility into a single horseshoe-shaped football palace. In 2003, the Next Level Campaign was approved. OSU alumnus T. Boone Pickens helped set it into motion with a $70-million donation, an act OSU recognized by renaming Lewis Field as Boone Pickens Stadium. In 2006, Pickens made an additional $165 million donation to help the Next Level Campaign maintain its momentum.

ally, several steel braces were relocated and several steel columns and beams strengthened to create a brace-free concourse to service the second floor of the concession and restroom buildings and the existing upper vomitories leading to the seating bowl.

At 500 ft long, the new Phase 1 and 2 steel structures would ordinarily require a single expansion joint near the midpoint. The design team was able to eliminate any expansion joints in these steel structures by locating a single anchor brace at the center of the 500-ft (east-west) direction. The anchor braces allow the structures to expand and contract away from and toward the center of the building during temperature differentials. The short (north-south) direction of these structures are stabilized with six traditional brace-frames made of WF (enclosed) and HSS (exposed) sections in a variety of single-brace and chevron-brace configurations.

The Suite Level was designed to get fans as close to the field as possible while providing overhead cover for the new Club Level seating on the existing grandstands directly below it. The design team used trussed 48-in. plate-girders at the Suite and Upper Concourse Levels to cantilever the suites 30 ft over the existing grandstand structures. In addition to allowing the cantilevered suites to function, the plate-girders were very beneficial in limiting floor vibrations and were able to accommodate approximately 240 penetrations for distribution of piping, wiring, and heating ducts within limited ceiling space.

Seamless Integration

The existing south and north grandstands were joined to four new steel structures to create the completed horseshoe-shaped stadium. During Phases 1 and 2, the existing grandstands were joined to new steel structures at the Mezzanine and Club Levels. The expansion joints were achieved with a variety of cantilevered steel beams and miscellaneous steel framing. The massive west end-zone structure was joined to the existing grandstands to complete the 10,000-ton horseshoe in Phase 3.

At the Top of its Game

Through its Next Level Campaign, Oklahoma State University successfully brought the outdated Lewis Field into the 21st century. Boone Pickens Stadium melds OSU's commitment to tradition and quality into a point of pride for the campus. The designers used innovation and steel to replenish and renew portions of the outdated and aging stadium and connect it with new structures to form a single sports venue that's a level above its former self. MSC

Architect
SPARKS Sports, a division of Crafton Tull Sparks, Tulsa, Okla.

Structural Engineer
Walter P Moore, Tampa, Fla.

Steel Fabricator
W&W AFCO Steel LLC, Oklahoma City (AISC Member)

Steel Erector
Bennett Steel Inc., Sapulpa, Okla. (AISC/TAUC Member)

Steel Detailer
M & K Detailing, Inc., Breckenridge, Colo. (AISC Member)

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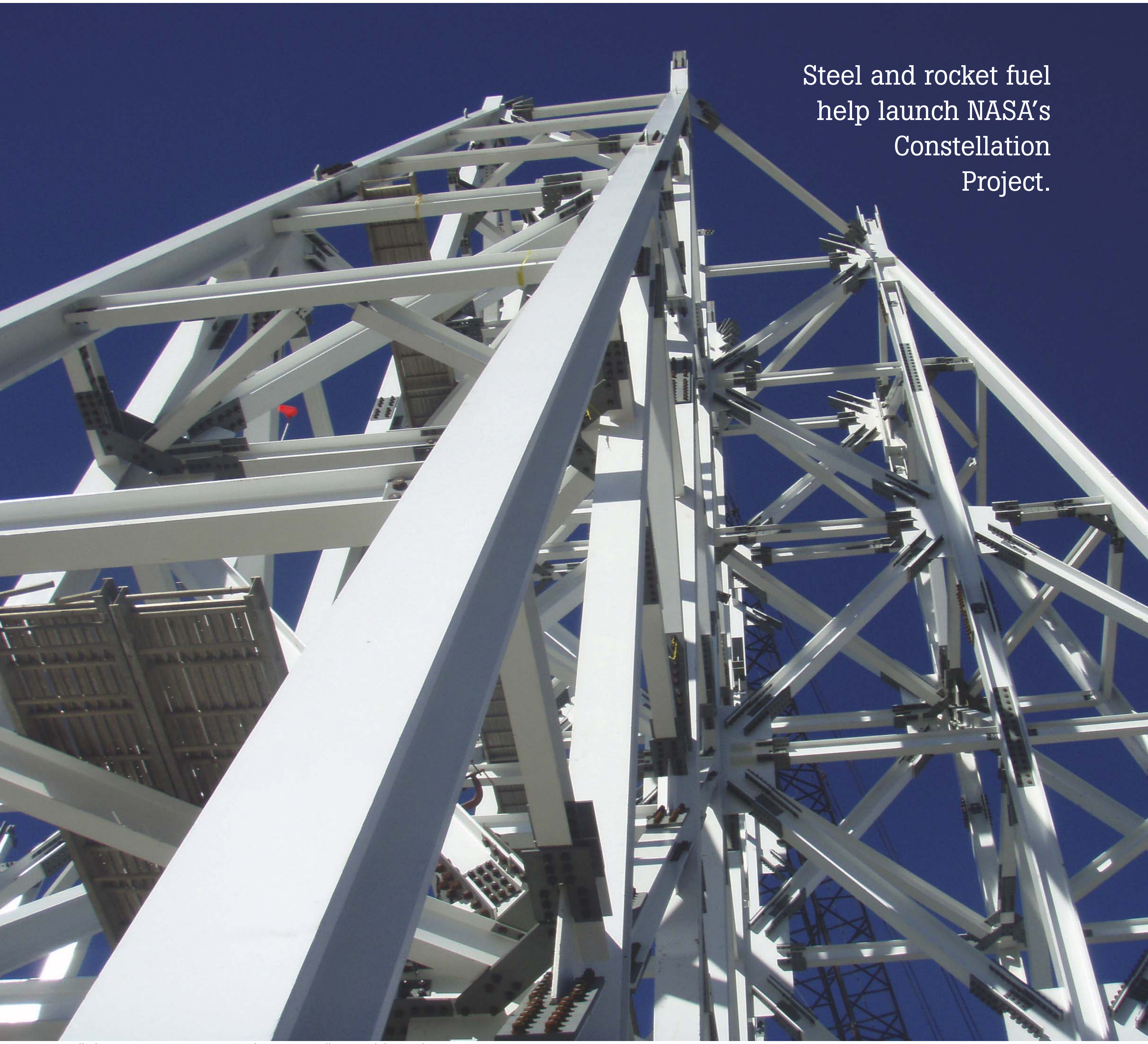


Steel and rocket fuel help launch NASA's Constellation Project.

All photos: Courtesy Prospect Steel Company; All 3D models: Steel Systems Engineering

and Beyond!

BY GEOFF WEISENBERGER

IN MANY WAYS, THE A-3 TEST STAND at Stennis Space Center in western Mississippi is a structural engineer's dream project. It's big, it's functional, it puts all of the structural steel in plain view, and it's relatively isolated and doesn't have to complete visually with other structures.

And, for goodness sake, it involves space rockets! Once it becomes operational in May of 2011, the 235-ft-tall stand will be used to test NASA's newest rocket engine, the J-2X, which will power NASA's Constellation spacecraft, the Ares I, on manned missions to the moon, Mars, and possibly even other planets. The purpose of the test stand is to simulate a zero-gravity environment for up to 550 seconds, as the rocket will need to be able to fire in outer space, 100,000 ft above the earth. No other current test stand can replicate this atmosphere for this duration.

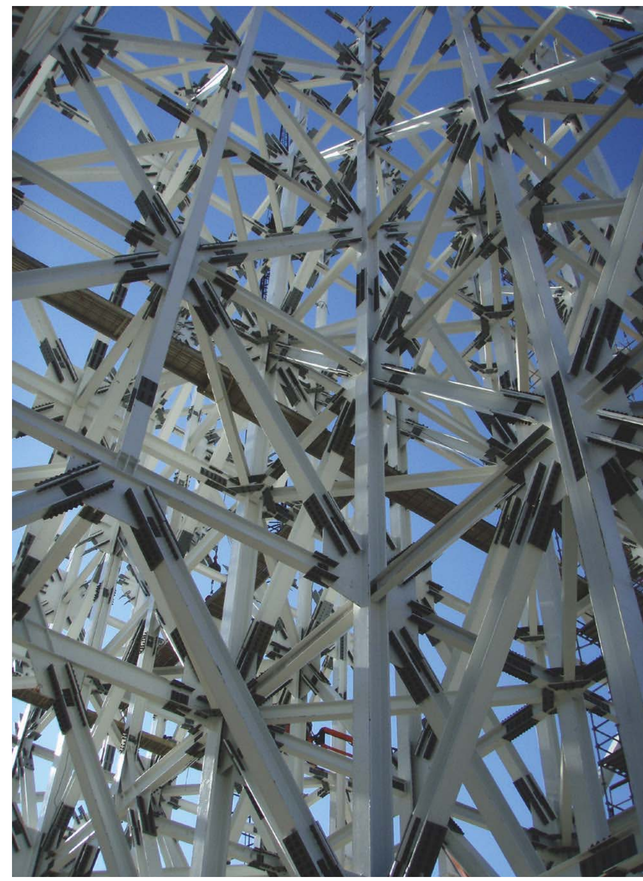
Nothing but Steel

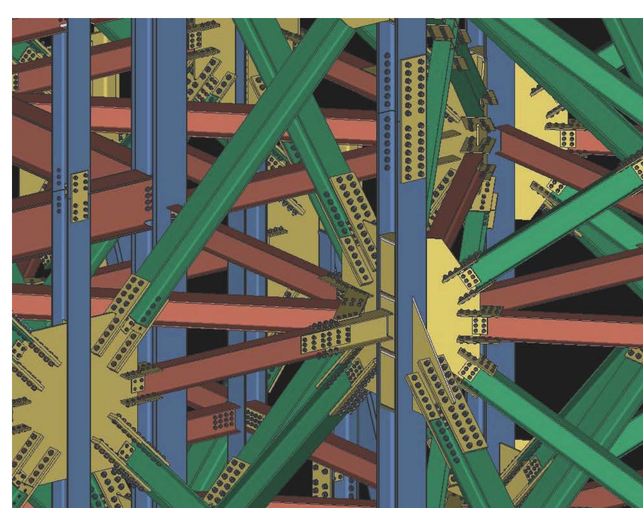
Besides involving rocket science (literally), the tower is also complex from a design—and visual—standpoint. The dense, open-to-view structure features wide-flange beams, painted white, jutting out in all directions and dimensions, without visual hindrances such as walls, windows, and facades. The structure is reminiscent of an old-fashioned wooden roller coaster, except much taller and certainly not as rickety. There's so much steel that it takes the eyes and brain a few seconds to take it all in.

"During erection, we kept calling it the bird test," said Mark McCrindle, project manager with Prospect Steel Company, the project's steel fabricator. "The open structure had so many members projecting out from the central work points—but still, no bird would be able to fly straight through it."

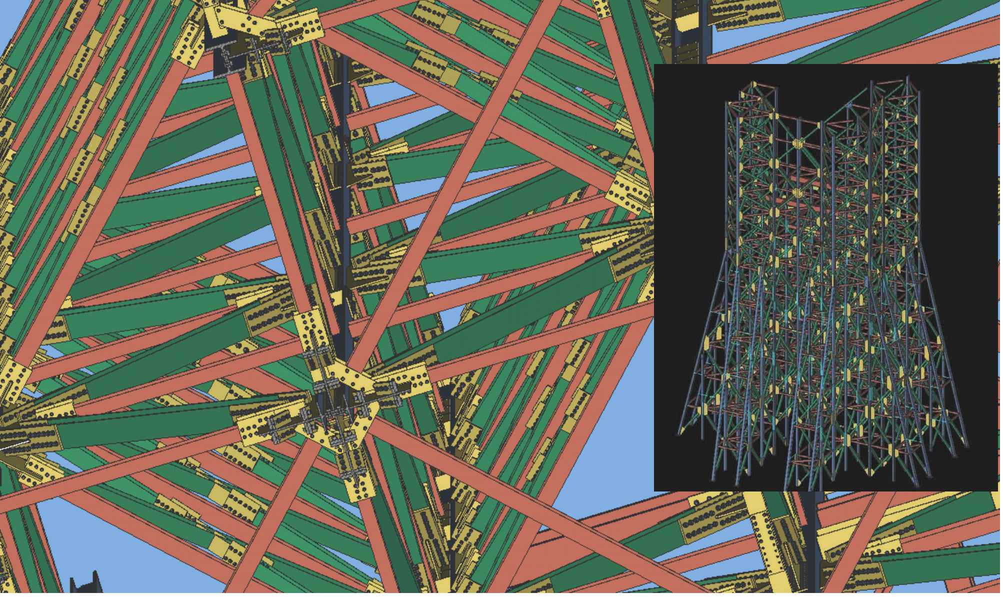
"Some evenings, if you stand in the right position and look at it, you can't even see the sky through it," said Mike Rourke, project/safety manager with the project's erector, Lafayette Steel Erector, Inc.

Perhaps the biggest challenge of the A-3 stand from a design standpoint wasn't that it will be used to test rocket engines; it was that rocket test stands aren't exactly typical projects. In fact, a major test stand hadn't been built at Stennis since the 1960s, so it wasn't as though there were plenty of case studies to learn from. And while there are other test stands that have been built with steel, none of them are nearly as large as the A-3 stand.





Multiple steel members project from several "starburst" points throughout the project, as illustrated by the real thing and a 3D model.



The framing of the A-3 Test Stand was so complex that from some angles, the viewer can't see all the way through it.

"All of the technology is long-since gone for this type of project," said Dick Davis, construction project manager with JACOBS, the structural engineer for the project. "We had to start from scratch and create this design from the ground up. The project wasn't so much design-build as it was 'design-as-you-go.'"

"We haven't done anything like this, so we had to make a lot of assumptions, think ahead, and anticipate," agreed the project's lead structural engineer, David Edgar, also with JACOBS.

Stripped Down

As aesthetics weren't driving force behind the design, there was no back and forth with an architect and no worrying about the building fitting in with its surroundings. Besides trees as far as the eye can see, the stand's only real structural competition was three other rocket test stands at the facility, all of them relatively far away. This isolation was a mixed blessing. On one hand, steel had to travel from Prospect Steel's fabrication facility in Little Rock, Ark. to the job site near Gulfport, Miss.—but on the other hand, lay-down area was plentiful. Even so, the work was sequenced very carefully; the material was laid down in phases, as the crane constantatly rotated around the four "quadrants" that make up the structure.

The designers were also presented with a project that wouldn't need to accommodate typical buildings systems. While special piping and equipment for the testing is incorporated into the project, the middle of the tower was left open to accommodate these items. Even so, the design team created a 3D model, using RAM Staad, and integrated this structural model with a model of the piping/exhaust system, designed by Oak Ridge National Laboratory via PlantWorks (an add-in to SolidWorks 3D design software). The stand will also support fuel tanks on top (103 ft tall), the pad/deck at the top, a lightning mast, and eight different levels of platforms, as well as two stairwells and an elevator. The entire assembly sits atop a massive concrete deck, supported by 300 pilings that go down 100 ft into the sand.

The overall goal was to get the structure as rigid as possible while using as little steel as possible. And given its large size, the project does use what would appear to be a relatively small amount of steel: 3,100 tons. There were 2,161 members in all, not including plates. Again, the stand doesn't need to support the weight of decking, building systems, cladding, or architectural elements. But it does need to be able to withstand up to one million lb of thrust. In addition, the structural integrity of the stand has to meet stringent deflection requirements; only ¼ in. lateral deflection is allowed at 300,000 lb. And since it's smack-dab in the middle of hurricane country, the tower was designed to withstand winds up to 150 mph.

While the A-3 Test Stand uses a relatively small amount of steel, the number of connections was a different story. Prospect Steel prepared more than 450,000 bolt holes and supplied 150,000 field bolts, the majority of which were 1¼ in. in diameter and 4½ in. long, with direct-tension indicating (DTI) washers. In addition, more than 6,000 ft of 2-in. complete joint penetration (CJP) demand-critical welds were required.

Four into One

The test stand is basically laid out in four quadrants. In theory, if you look at the tower from above, it would appear as four Ls with the corners all pointing toward the center. The tower was erected in 16 sequences in all: four vertical stages for each of the four quadrants. Each vertical stage/tier was approximately 70 ft in elevation, and 47% of the steel is contained in the first vertical stage.

The skeletal nature of the project made for a unique erection challenge. As there is no decking, the ironworkers didn't have platforms from which to work (although some temporary walkways were employed). The "floors" (in this case, the vertical spacing between horizontal members) are 20 ft apart, except toward the top, where the gap narrows to 15 vertical ft. In addition, the column splices were 10 ft above each level, so Lafayette Steel was faced with finding a way to get their workers high enough to make the connections. For the lower levels, a 120-ft man-lift sufficed. But for higher areas, Lafayette employed special "spider" harnesses—essentially, man-baskets with seats—that provided excellent mobility and reach for the workers, as well as a stable, safe position from which to work. These baskets were suspended via cranes.

Busy Junctions

The connection points, in a sense, were the stars of the show—and actually do resemble stars; in some cases, up to 16 members burst in all directions from one point. "Whenever we were done working on one point—where 16 members were framing into—a burst of "Wow!" was uttered while rotating its solid form in the model," said David Schusterman of the project's detailer, Structural Steel Engineering. "It was even more stupendous when the entire 3D model was done. However, we really appreciated it when we saw the pictures of the erection, with the cool contrast of the tower's white paint and against the clear blue sky." (The detailing was performed with SDS/2 3D modeling software.)

"We had to get inventive in terms of locating bolt holes so the erector could actually reach each bolt without interferances," said McCrindle. Given the complex geometry of the project, the chances of steel not fitting up properly in the field were great. So much steel coming from so many directions converging on one point required a very slim margin of error. But in the end, the level of actual error was even slimmer, enabling the project to be completed four months ahead of schedule.

"Less than 1% rework of all connections was performed in the field," noted Al Green, vice president of the Romulus, Mich. office of Prospect Steel. And despite the com-

The test stand used 2,161 steel members in all. This number doesn't include plates, which, as illustrated in these photos, were a crucial and significant portion of the project, given the numerous instances of several members converging on one point. The field bolt count was 150,000.

plexity of the connections, the project was fairly repeatable from an erection standpoint, resulting in only 29 erection drawings being used.

Reaching for the Stars

The steel for the stand topped out in April, and rocket testing is expected to begin in May 2011. In terms of the overall significance of the project, Lonnie Dutriex of NASA summed it up best with an anecdote from early in the project, when he was approached by a former astronaut who happened to be onsite. "When he approached us, our attitude was, 'What are you doing here? This is just a construction site,'" Dutriex recalled. "And he said, 'You guys don't have a clue what you're doing here, do you?' And we told him that we were building a rocket test stand. Then he said, 'No, you're building the first steps of man going to another planet. And one day your grandkids will be able to say that their grandpa worked on that."

When put that way, it's pretty clear that the A-3 Test Stand will be one of the most memorable projects for anyone that worked on it. MSC

Structural Engineer/Designer
JACOBS, Tullahoma, Tenn. and St. Louis

Steel Fabricator
Prospect Steel, Little Rock, Ark. (AISC Member)

Steel Erector
Lafayette Steel Erector, Inc., Scott, La. (AISC/SEAA Member)

Steel Detailer
Steel Systems Engineering, Inc. Sherman Oaks, Ca. (AISC Member)

General Contractor
IKBI Incorporated, Philadelphia, Miss.

Subcontractor
Yates Construction, Biloxi, Miss.

Hangar Life

BY KEVIN LEWIS, AIA, AND GREG FOSSETT

Massive steel box trusses support the U.S. Navy's largest aircraft hangar in hurricane-prone Jacksonville.

THINK ABOUT HOW BIG a football field is. Now imagine having to construct a building three football fields long and almost one football field wide. As if such a large undertaking weren't challenging enough, suppose it had to have two, 450-ft-long unobstructed openings—and the building interior had to accommodate several different types of aircraft.

Such a project can be summed up in two words: Hangar 511. The massive building, and its attached apron, was recently constructed under the U.S. Navy's Naval Facilities Command (NAVFAC) procurement at the Jacksonville, Fla. Naval Air Station. The project is now the Navy's largest active aircraft hangar and administrative facility; it opened this past spring.

The $123 million project, prompted by the military's Base Realignment and Closure (BRAC) program, will support the relocation of six aircraft squadrons to the Naval Air Station in Jacksonville. Initially, the hangar will house the Navy's P-3C Orion (99-ft wingspan) squadrons and a C-130 Hercules (132-ft wingspan) logistics squadron. Ultimately, the Navy will replace those aircraft with the advanced P-8 Multi-Mission Maritime Aircraft (117-ft wingspan).

Expansive and Flexible

With a variation in wingspans between the P-3 and the P-8 of 33 feet, the hangar certainly needed to be flexible, but it also needed to provide easy access for maintenance crews and house the necessary support spaces, shop areas and tool rooms and adhere to strict budget and schedule requirements.

To determine the most efficient framing scheme, the team created and tested several 3D models, and a long-span steel box truss system ultimately proved to be more than 25 percent more efficient than the second most efficient design. Overall, the 137,000-sq.-ft hangar bay space and the 140,000-sq.-ft, two-story office portion use approximately 3,000 tons of structural steel.

The massive hangar bays, at a combined 950 ft long by 213 ft deep by 86 ft tall, required a customized structural design using robust, three-story-deep box trusses each measuring 15 ft wide by 25 ft tall. These box beams, more common in bridge design, support 15-ft-deep roof trusses that span 141 ft across the depth of the hangar. Structural frames, built within each of the six "lanterns," brace the entire long-span structure, allowing the hangar to withstand wind speeds of up to 120 mph.

Because of the large scale of the box trusses, each section was assembled on the ground, hoisted into place by a 75,000-ton Manitowoc 2250 crane—which cantilevered out almost 72 ft—and supported by temporary 51-ft shoring towers, as the spans were extended in either direction from the hangar's core. Besides supporting the overall structure, the trusses also support multiple overhead cranes, as well as the vertical lift fabric hangar door system, which provides the flexibility to open smaller sections of the door as opposed to the entire door section.

The hangar's structural frame consists of steel beams with girts and a factory-insulated metal panel skin. Lightweight concrete floor slabs poured on a composite steel deck were supported by open-web steel joists spanning to wide-flange steel girders from the elevated floors. The hangar doors openings were comprised of typical box truss sections, which created the large clear span, and were wrapped with 2-in. pre-insulated panels installed vertically. A 1,400-linear-ft steel catwalk allows access for overhead and door maintenance.

Conventional steel framing was used for the administration building, which provides office space for more than 1,525 personnel. NAVFAC also expressed early concerns about balancing the contrasting scale of the massive aircraft hangar against the long two-story administrative wing. To overcome this, a hierarchy of building heights was developed. Six translucent-paneled "lanterns" were positioned to visually break down the scale of the hangar while providing natural light to each squadron plane location. The office component of the structure had three different types of wall panels that were installed horizontally: single span, one-layer panels; 2-in.-thick insulated metal panels; and translucent panel systems.

High Winds

Butler Heavy Structures provided the STAAD model, a structural engineering and design software program, to HNTB to incorporate into BIM. HNTB then used Autodesk Revit to ren-

Kevin Lewis is the architecture practice leader for HNTB Federal.

Greg Fossett is a senior project manager for M.A. Mortenson Company.

M.A. Mortenson Company

The massive hangar bays (below) are a combined 950 ft long. Three-story-deep box trusses (photo above), each measuring 15 ft wide by 25 ft tall, support 15-ft-deep roof trusses that span 141 ft across the depth of the hangar.

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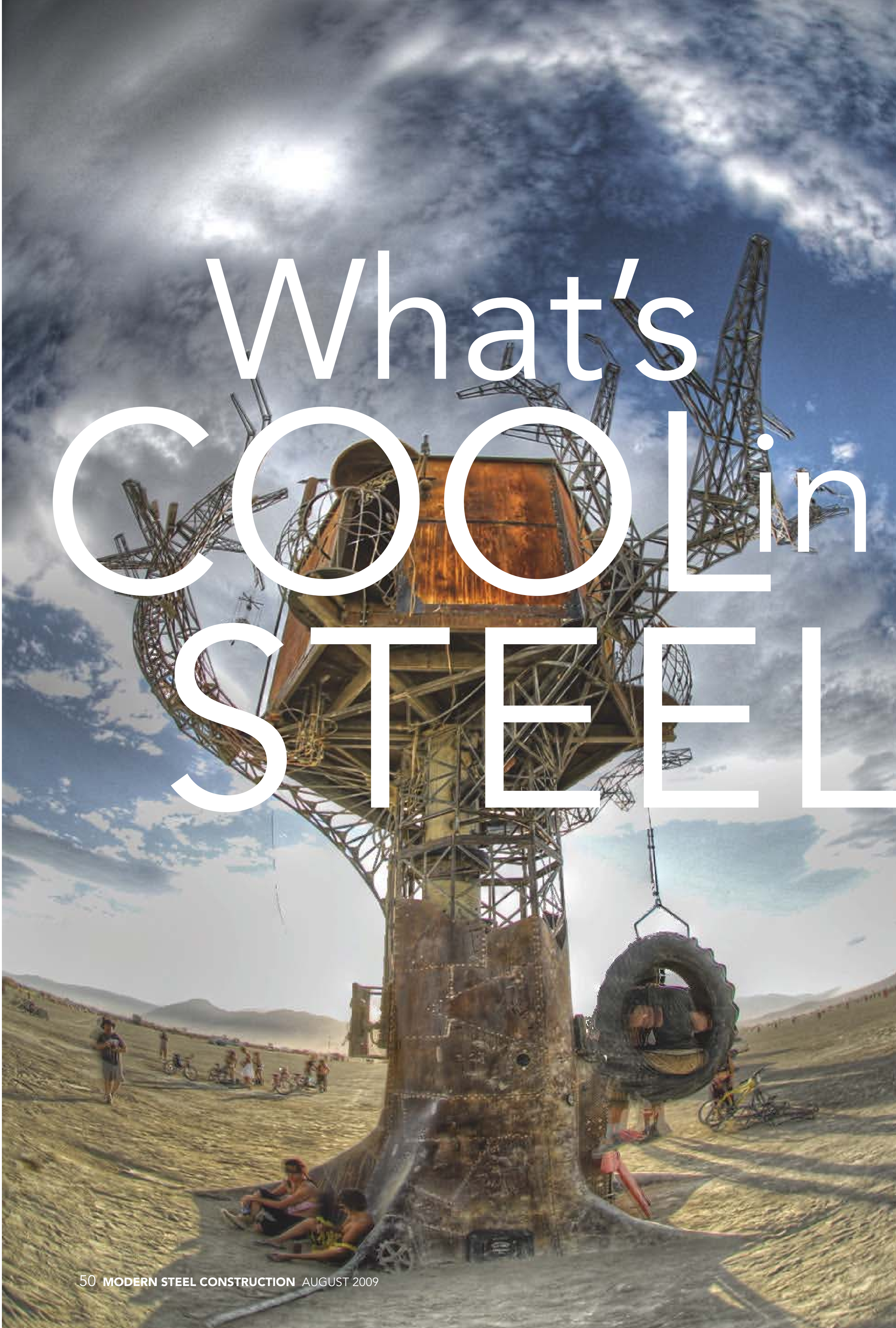
Hangar 511 is the Navy's largest active aircraft hangar and administrative facility.

der the virtual pre-built hangar and office complex. But the model didn't just help with the design process; it also helped with the scheduling and sequencing, particularly important when building massive structures through a hurricane season. As the area is hit by a hurricane approximately once every three years, it was important that the building was designed to resist 110-mph winds after it was complete. However, it was also critical for the structural elements of the building to be completed to a point where it could withstand a hurricane prior to the first hurricane season the building would have to endure mid-construction in June 2008. Using BIM allowed the team to create a building design and test the building against wind scenarios at various points in the construction process—a very fortunate situation, as hurricane season arrived with a storm stalling over the greater Jacksonville area. As a result of aggressive schedule management and pre-planning—and BIM—the project suffered no structural damage and was impacted only by the excessive rainfall (more than 28 in.). In addition to hurricane protection, fire-proofing and antiterrorism standards were implemented to ensure the safety and security of the operators and installation assets.

BIM also assisted builders to track sustainable features as outlined by the U.S. Green Building Council's Leadership in Energy and Environmental Design. Builders were able to assign points to the project's sustainable features—such as translucent panel systems that provide natural light, solar shading, light shelves, and heat-resistant designs—which helped the project pursue a Silver LEED rating (certification is pending). The Navy is considering purchasing the BIM model to aid in facilities management once the project is complete. MSC

Architect and Structural Engineer
HNTB Architecture, Washington, D.C.

Design-Build Contractor
M.A. Mortenson Company, Minneapolis



What's COOL in STEEL

COOL STRUCTURES

Desert Art

BY GEOFF WEISENBERGER

FOR MANY OF US, a minor in our undergraduate studies is a way of staying attached to or learning more about a field of interest. Or it's a back-up plan to our major. Or a resume-builder. Or a creative outlet. Or a way to seem more well-rounded.

Or in the case of Corbett Griffith, who graduated at the top of his mechanical engineering class at Georgia Tech while minoring in sculpture, it's a way to combine the artistic with the practical into a unique job. Griffith is the president of Instinct, a Bay Area-based design and engineering company that creates physical products and sculptures from conceptual designs (**www.withinstinct.com**). He describes himself as a mechanical designer that can interface between artists and structural engineers—a "sculptor consultant," if you will.

"I begin with the artists and their ideas," Griffith explains. "I work to develop a framework around their concepts instead of running them over with engineering. I think of my work as building kits for artists, like erector sets out of monumental steel. They come to me with a concept, and I deliver a truckload of custom steel and a set of assembly instructions."

BURNING MAN

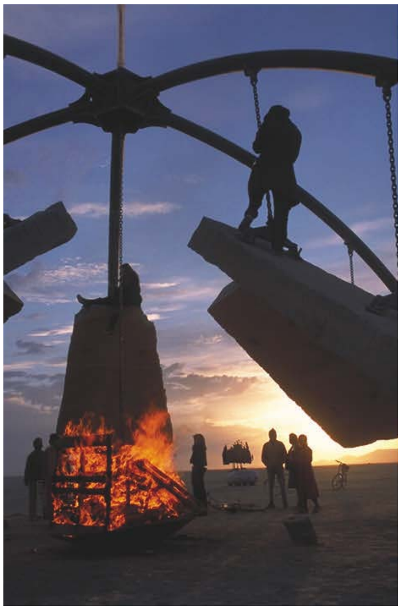
For the last few years, Griffith has tapped into his artistic and engineering knowledge to create fascinating, complex, strangely beautiful—not to mention huge—steel sculptures for the annual Burning Man festival; the weeklong event takes place around Labor Day weekend in Black Rock City, a temporary city in the Nevada desert, and is dedicated to community, art, self-expression, and self-sufficiency (**www.burningman.com**).

Griffith's first sculpture for Burning Man (2003) was the Temple of Gravity, which he describes as a "modern-day Stonehenge." The sculpture was his senior design project at Georgia Tech. The 80-ton installation, designed by Atlanta-based sculptor Zachary Coffin (**www.zacharycoffin.com**), is an open-air dome of curved steel. The structure, 50 ft in diameter and 21 ft tall, consists of five round steel tubes (schedule 40 steel pipe) that connect at a central point and bend down to five slabs of granite (13,000 lb each) on the ground. Slabs of granite (17,000 lb each) are also suspended, one each, by chains from the steel tubes, and people are able to climb on the suspended slabs and rock them back and forth.

In 2005, Griffith brought another of Coffin's ideas to life at Burning Man in the form of Colossus. Smaller in weight (20 tons of steel) but taller in height (70 ft), this sculpture is similar to the Temple of Gravity in that it suspends rock—15 tons of it—from three steel "arms" that bend toward the earth. Each of the three rocks hang from the armature in a different way. One is suspended from a hanger so it can swing back and forth, one is on a bearing so it can spin around, and the last rock is stationary and flat. Another similiarity Colossus shares with the Temple of Gravity is that it too is set in motion by people; ropes attached to the suspended boulders allow people to rotate the metal and rock, providing quite a workout.

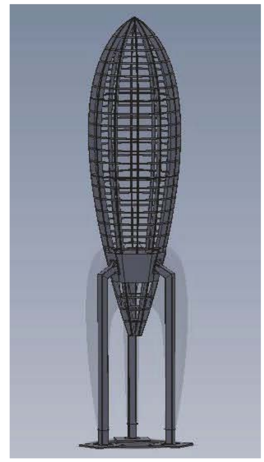
"My design sense flows from both the aesthetic of the piece and the fundamental engineering problem at hand. I try to let the aesthetics guide the engineering as much as possible." says Griffith. "On Colossus, I began with an artist's rough drawing. He envisioned the feel of the piece. Through a number of revisions, I developed the look and construction scheme, and fleshed out the concepts with engineering. This ended up dictating the majority of the end experience with the sculpture."

left page: Steampunk Treehouse, designed by Sean Orlando and crew.
this page: Temple of Gravity (left and center) and Colossus (right), two projects that Griffith assisted artist Zachary Coffin in bringing to life.



Keith Helfrich (left, center)

Daniel Bauen



Raygun Gothic Rocketship will premiere at this year's Burning Man festival.

Nick Winterhalter (left); Instinct Design (right)

OF DERRICKS, TREES, AND ROCKETS

Besides Coffin, Instinct has built Burning Man sculptures designed by several other artists as well. Crude Awakening, which debuted at Burning Man 2007, is a 100-ft-tall wood and steel oil derrick that was detonated with 3,000 gallons of jet fuel and propane (designed by artists Dan Das Mann and Karen Cusolito).

"In the case of Crude Awakening, the concept was nearly finished but needed my insight in fabrication to design a set of interlocking steel joints for the cross bracing," says Griffith. "Also, designing a flight of stairs that follows the inside walls of a pyramid is no simple task. We ended up fabricating custom steel brackets to attach the stringers to the tower framework and supported the landings from steel cables." (Structural engineering advice for this project, as well as Griffith's latest project—discussed below—was provided by Mark Sinclair of structural engineering firm Degenkolb.)

Steampunk Treehouse, a metal tree with a wood and metal house perched in the branches, is another one of Instinct's jobs that appeared at the 2007 festival. Designed by Sean Orlando and crew, the sculpture is exceptionally complex, with a trunk and branches made of twisting steel pipe trusses. According to the official web site for the sculpture (www.steamtreehouse.com), the three main load-bearing branches were fabricated as separate units and bolted to the tree trunk with flange plates and ¾-in. bolts. The house is built on a 10-ft by 15-ft dual square tube frame with a ¾-in. plywood floor in a circular pattern at the house level (approximately 15 ft from the ground). The lower section of the branches is welded to the trunk while the upper branches bolt to the lower section using flange plates for ease of transportation. The lower steel frame is welded to the upper gussets of the trunk, and the upper steel frame, with house attached, is bolted to the lower steel frame. The main structure of the house is wood, reinforced with a steel sub-structure that ties the three branches and the house together for added support.

Instinct's latest Burning Man mega-sculpture, to debut at this year's festival (August 31-September 7) is the Raygun Gothic Rocketship (www.raygungothicrocket.com). Designed by Sean Orlando, Nathaniel Taylor, David Shulman and Crew, the 40-ft-high gothic-styled rocket ship is framed in steel and clad with aluminum and copper. The piece was built, detailed, and output in only 16 hours of Solidworks 2009 seat time. "A new personal record for art to parts to art!" says Griffith (Solidworks is his current go-to software for detailing large-scale sculptures).

Courtesy of Instinct Design

Crude Awakening at the 2007 edition of Burning Man.

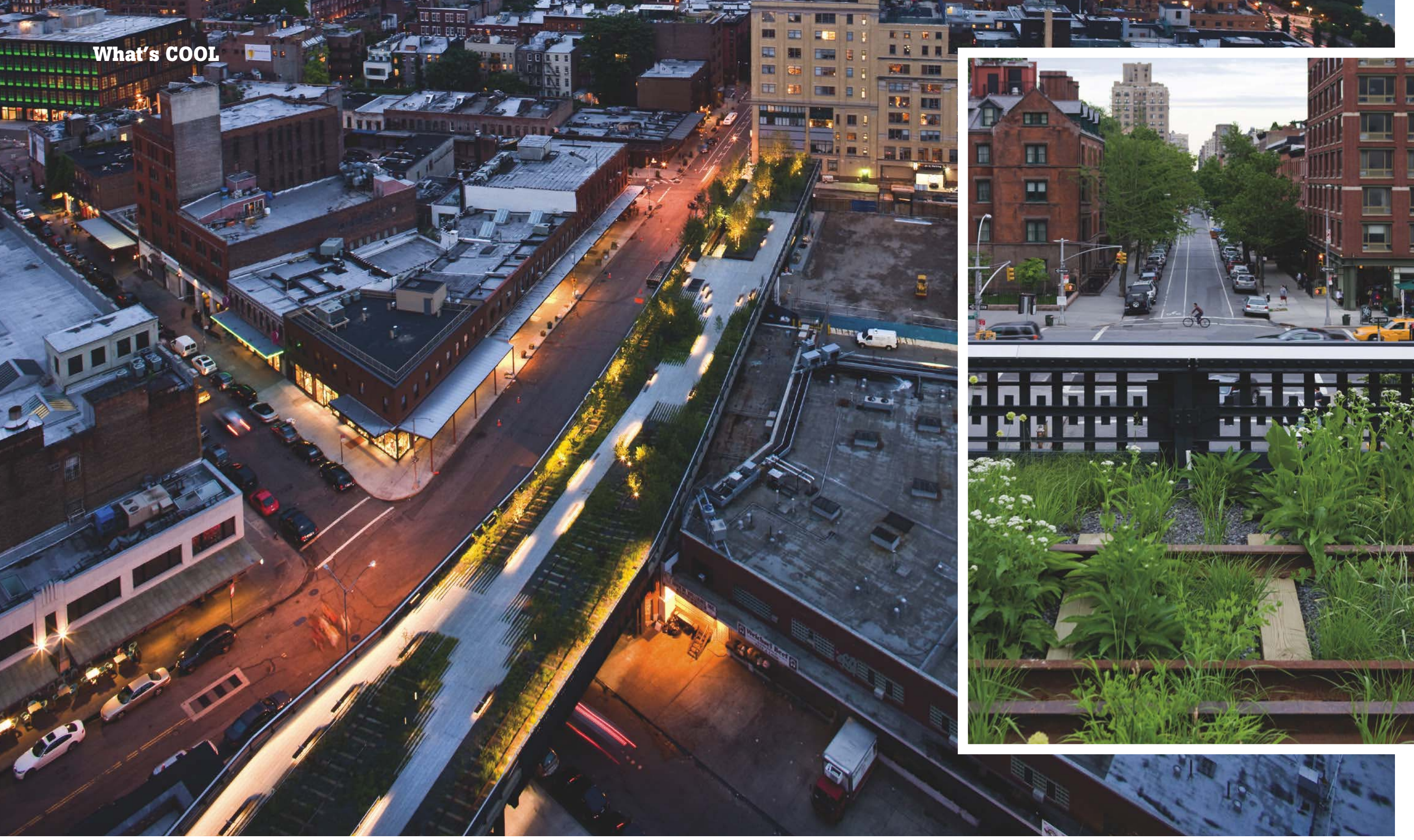
VOLUNTEER WORK

It takes more than just an artist and an engineer to put these large-scale sculptures together. Volunteers typically perform the steel fabrication as well as the erection; teams of up to100 volunteers, led by the artists, build them onsite. In addition, volunteer certified structural welders are used for the critical joints.

After Burning Man, the sculptures tour other festivals, are stored for future use, or find permanent homes—e.g., Temple of Gravity is currently installed at We Care Spa in Palm Springs, Calif. But Burning Man is the launch pad for these innovative works, thanks to its celebration of creativity and artisitc fervor.

"Burning Man has been a great playground and sand box for ideas," says Griffith. "The sculptures I've developed for the event have been as much a design challenge in construction and fabrication as they are an essay on the art of engineering and the beauty of structures themselves."

"In one week's time you assemble, display, and remove your piece. It's a strange place to build. In what other job do you have to battle 100-mph winds, blistering heat, undressing muses, and serious techno music to get access to a crane?"



Photos on this page: Iwan Baan © 2009

COOL PARK

Elevated Experience

BY CRAIG SCHWITTER, P.E., BURO HAPPOLD

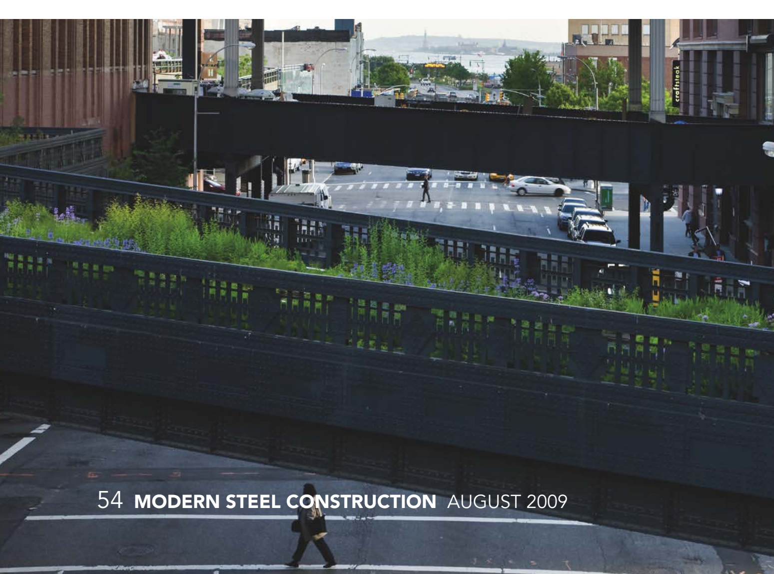
Manhattan's High Line Park used existing and new structural steel to turn an old elevated train line into a modern, unique public space.

JUNE MARKED THE OPENING of a new public green space on Manhattan's west side: the approximately ¾-mile long High Line Park. And it certainly lives up to its name, seeing as it was built 30 ft above the street.

The project transformed an outdated, early 1930s elevated train line, framed in steel, into an attractive new public park that appears to float in midair. Two structural engineering firms contributed to the project. Buro Happold North America was responsible for the structural engineering in support of the new landscaping and architectural components, as well as the MEP engineering and waterproofing. Robert Silman Associates provided structural engineering services to stabilize the existing structure.

The challenge for Buro Happold was to design new structural elements while making adjustments to and maintaining the historic look of the original steel structure. The existing High Line structure, which once moved trains, was robust. However, its steel structure had riveted connections, which made changes difficult. To insert the new components of the landscape architecture and architectural design, we had to cut into steel girders and add numerous components. We also added drains, elevators, electricity, and utility rooms.

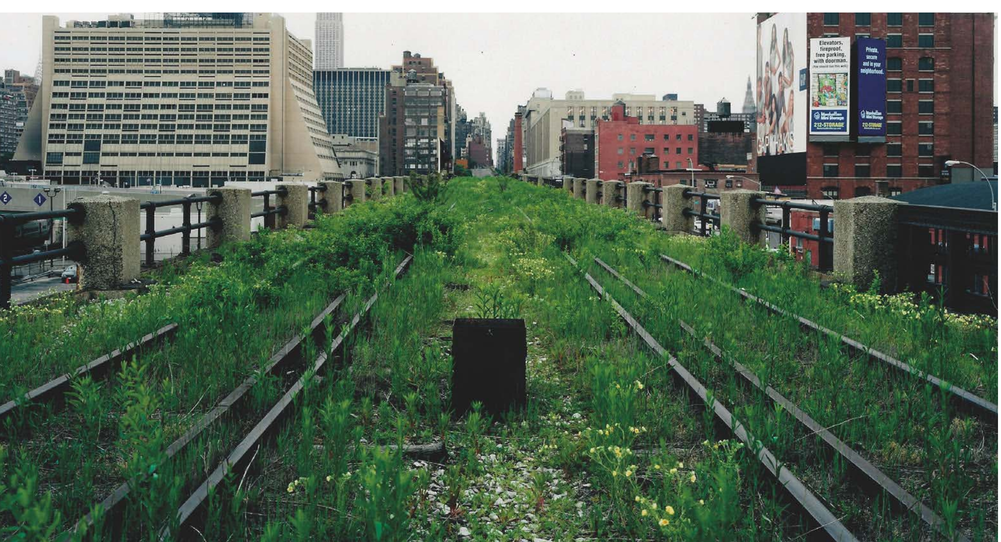
To support the landscaping and new architectural elements, our engineers cut into the existing steel girders to insert openings for staircases that provide stair access from the street to the elevated park. They also inserted expansion joints to coordinate structural shifts and avoid conflicts along the length of the High Line between the existing steel



structure and the precast concrete slabs forming the new pathway. Expansion joints in the exposed steel structure of the High Line are spaced approximately at 138-ft intervals. The anticipated movement of the structure due to thermal changes is ¾ in. between the joints; to accommodate this movement in the planks, expansion joints were inserted at approximately the same locations as in the existing structure. The geometry and interlocking layout of the planks, however, dictated that the plank joints needed to be staggered, with planks supported on neoprene bearing pads to accommodate the movement.

The design also called for removal of significant areas of a 10-ft-deep girder that spans 10th Avenue to create large glazed picture windows, as well as the removal of existing slabs and beams, to incorporate a new terraced platform for passive recreation. Also, a water tank supported above 15th Street by supplementary steel framing attached to the High Line stringers stores 2,900 gallons of water for a water feature along the 100-ft sundeck, which has movable lounge chairs and unobstructed views of the Hudson River. In addition, we designed a drainage system under the soil to support the plantings and new landscaped areas, which are complemented by an irrigation system. We also created an intricate waterproofing system to protect the facilities and streets located under the High Line from possible leaks.

This portion of the park is just the first of several phases. Construction for the landscaping phase of the second section is about to commence and will likely extend over an 18-month period. The site preparation for this section was executed during construction of the first section of the park and involved removal of the old track and ballast, repairing the steel and concrete deck, and preparing it to receive a new waterproofing membrane. When Section 2 is complete in 2010, the High Line will be a mile-and-a-half-long elevated park, running through the western Manhattan neighborhoods of the Meatpacking District, West Chelsea, and Clinton/Hell's Kitchen.



Joel Sternfeld © 2000

Courtesy Buro Happold

A view of the 10th Avenue Square portion of the project, with the pre-existing slab removed. Bleachers overlooking the street were being installed at this point.

All images: Courtesy Miró Rivera Architects

COOL RESTROOM

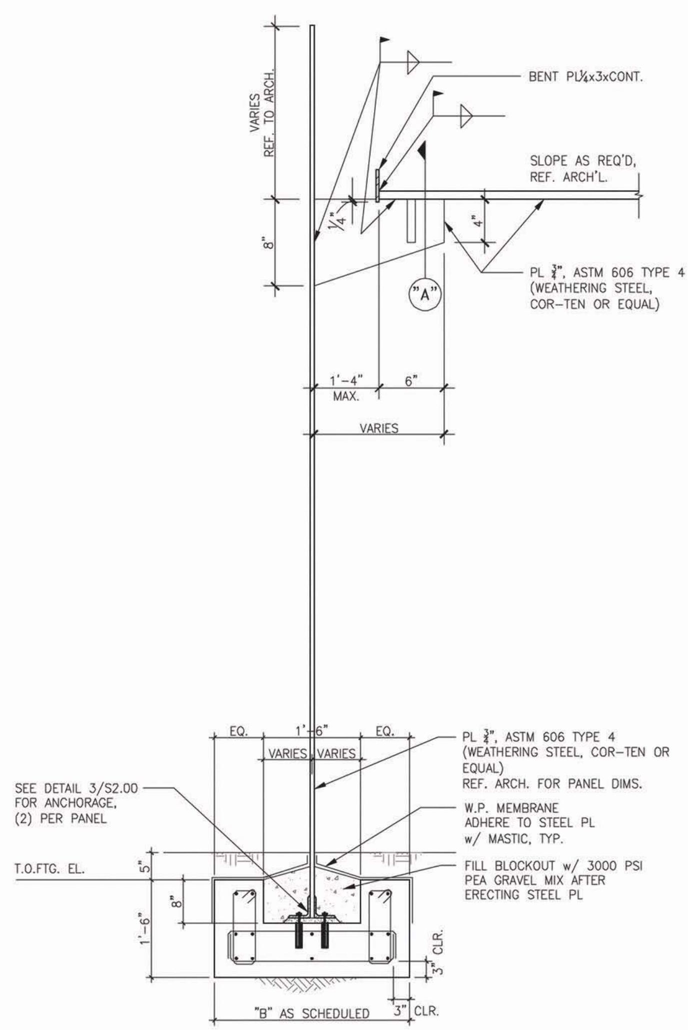
The Call of Nature

BY MIGUEL RIVERA, AIA, AND JUAN MIRÓ, AIA, MIRÓ RIVERA ARCHITECTS
PHOTOS BY PAUL FINKEL/PISTON DESIGN

THE LADY BIRD LAKE HIKE AND BIKE TRAIL is a linear park of scenic trails and landscaping that winds its way along the banks of the Colorado River in downtown Austin. The park, very popular among runners and bike riders, provides residents and visitors with a rural escape in an urban setting. It is also home to a small, yet impressive, public restroom.

The first public restroom built in the park in more than 30 years, it was designed by Miró Rivera Architects. It consists of 49 ¾-in.-thick vertical weathering steel plates whose widths and heights vary from 1 ft wide by 1.5 ft high to 2 ft wide by 13 ft high. The panels are arranged as a "spine" that begins elongated at one end, then tightens into a circle at the other to form the walls of the restroom; the pattern resembles an inverted, stretched-out number 6—or 9—from the air. The plates are staggered in plan to control views and to allow the penetration of light and fresh air. Both the door and roof were fabricated from ¾-in.-thick steel plate. L4x4s are welded to the bottom of both sides of each panel Anchor rods attach the angles to the trough portion of the grade beam, and the trough is back-filled with concrete.

The restroom is handicapped-accessible and—in addition to a commode, urinal, sink and bench inside—includes a drinking fountain and shower outside. It also requires minimal maintenance; the plumbing fixtures are made from heavy-duty stainless steel, there is no need for artificial light or mechanical ventilation inside, and the weathering steel panels will weather naturally over time, creating an ever-changing sculpture that combines form and, quite literally, function.



above: The plates' dimensions range from 1 ft wide by 1.5 ft high to 2 ft wide by 13 ft high.

right: Detail of the bracing of one of the steel plates.

The structure's function as a restroom and shower is revealed only when approached from the proper side.

Steel and straw work hand in hand in Hakata House, a single-family residence in Upstate New York. Completed project, above; steel framing, below.

Photos: Courtesy Secret Base Design

COOL HOUSE

Green—and Big Bad Wolf-Proof

THE BIG, BAD WOLF was able to blow down the straw house with ease. But what if the straw house had been framed in steel?

While a straw house may bring up thoughts of the "Three Little Pigs," buildings insulated with straw bales began appearing in real life in the 1900s. Straw is natural and renewable and provides tremendous insulation value. Most straw houses use wood framing; Hakata House, designed by Vestal, N.Y.-based architecture firm Secret Base Design, is a steel-framed structure that uses bales of straw for infill and insulation.

Straw helps fill in the gaps; the bales were shaped to fit around the steel columns.

Sustainability was a key goal of the project. Secret Base recognized the green advantages of steel; the steel for the frame used certified recycled content and was produced regionally, supporting the local economy and reducing shipping. Secret Base also based its decision on the fact that the steel frame provided for a much larger roof span as well as longer spaces between the posts; with fewer posts, there was less fitting of bales around the structure. The house uses a traditional steel frame structure; the bales were shaped to fit around the columns.

The line of structure for Hakata House is on the inside of the wall, so the exterior is a continuous line of bales, which provided optimal insulation value. Door and window openings were set to the outside of the wall to create deep window seats or sills, which resulted in better protection from water infiltration at these connections. Secret Base has designed and built four other more conventional straw buildings, but the steel frame of Hakata House is what makes it unique.

Having straw as an interior wall offers flexibility in terms of finish. It can be smooth and level, undulating, or bumpy depending on the desired look. For a smooth wall, the bales can be trimmed prior to plastering; undulating walls occur naturally, and curvy walls can be stacked irregularly or shaped after. In the case of Hakata House, both the interior and exterior walls were covered with a natural lime-based plaster.

The interior steel framing was left exposed in some areas and either painted or finished. Not only did this "honest approach" create the desired modern, industrial appearance, but also by eliminating extra finish materials, the cost and ecological impact were greatly reduced.

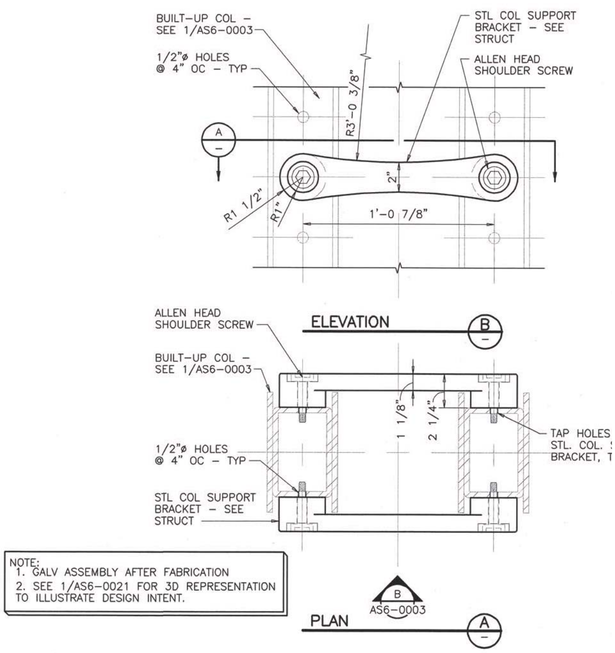
Aside from using steel and other materials/tactics geared toward sustainability—local wood, recycled content carpet, refurbished tin ceilings in the kitchen, soy-based insulation, low-VOC sealants, etc.—another notable element of the house is the "truth window," a tradition with straw bale structures. This small, wooden door on the inside of one of the exterior walls opens to reveal the straw behind the plaster.

While steel and straw seem to be on opposite ends of the material spectrum, they were able to join forces in an efficient, stable, and sturdy way in Hakata House—and helped make one straw house that is impervious to the Big Bad Wolf.

COOL SUN SHADES

Beating the Heat

BY JEFF CARPENTER, BIRDAIR, INC.



Photos: Courtesy Birdair, Inc.

left: A detail of one of the built-up columns.

above photos: Canopies like these—roughly 560 of them—dot Phoenix's mass transit landscape, providing shade from the intense sun.

LIVING IN THE VALLEY OF THE SUN doesn't mean having to bask in the relentless rays all day long. And thanks to a series of open-air shelters at stops along Phoenix's Valley Metro light rail line and bus routes—there area about 560 canopies spread over roughly 50 stations—commuters can wait for their trains without having to apply sunscreen.

Framed in steel and adhering to AISC architecturally exposed structural steel (AESS) standards, the shelters' signature elements are sun canopies composed of round hollow structural section (HSS) "arms"—5-in. Std. Pipe (CHS 5.563 × 0.258)—that support polytetraflouroethelene (PTFE, commonly known by the brand name Teflon) membranes. Each arm has "fins" that make the cantilevered elements more efficient for the unique type of loading they endure. Tensile membranes support all of their loads in tension within their own plane. In other words, external loads on the canopies not only resolve to be vertical loads on the steel, but also some additional loads applied to the steel in the plane of the fabric. These additional loads are some nonlinear factor of the gravity and wind loads (evaluated via nonlinear FEM analysis) and depend on the stiffness, deflection, and prestress in the membranes. Because these types of structures are typically designed to accept some type of conventional "hard deck" roof that automatically resolves their loads directly to the supporting steel, this "side load" factor was probably not considered in the architectural design phase. As a result we decided to use the architectural fins near the column supports to provide added in-plane stiffness to the arms by having them partial-penetration-welded to the support saddles. Also, the membrane roof structures generally end up having lesser vertical loads than conventional roofing materials because they are lightweight—which also makes them a good choice for long-span roofs.

Cast "saddles" connect the arms to the steel columns, and careful attention had to be paid to the welding, due to the relatively thin (0.258 in.) walls of the arms. In addition, special "bullet ends" for the end of each arm were pressed to the required shape in an attempt to save on cost and materials, as this avoided the need to machine thousands of parts from solid bar stock—and also created an additional bit of architectural flair.

The unique shape of the structures called for continuous curved helical plates bent to a slight helical shape for the attachment of the fabric. The "knife plates" at the bullet ends were slightly oversized to facilitate welding of the bullet halves. The cable terminations were specially designed and customized to comply with both the architectural intent of the knife plates and the hole size (¾ in.) that the fabricator could use most efficiently with a punch operation. Weight—including the arms, cable, and membrane—for the larger canopies was roughly 1,000 lb and about 750 lb for the smaller ones.

While Josserand Construction Company (the erector) devised its own erection template based on geometry provided by Birdair, Inc. (the maker of the PTFE membranes), the erection sequence itself played an important role in the design phase. The tensile canopy arms had to be neatly connected by fastening the arms' supporting saddles through a column to the other side where there would be a "dog-bone" connection or another saddle (depending on where the canopy was in the sequence). By design of an intricate system of threaded rods, jamb nuts, heavy hex nuts, and shim and spacer plates, the team was able to come up with a non-obtrusive solution for the connection that was so efficient that the entire tensile system could be tensioned to the full prestress value just by tightening a few nuts. A pneumatic wrench was used to hasten that process, although it could have been done via manual torquing alone. The system allowed for coordination and tolerance allowance with other steel elements such as the supporting columns and their dog-bone connections, and the spacer plates eliminated some special machining of the saddles.

While relatively small structures, the Valley Metro shelters are innovative when it comes to connections, graceful when it comes to aesthetics, and much-appreciated when it comes to providing some relief from the hot sun.

COOL TABLE

Under the Table

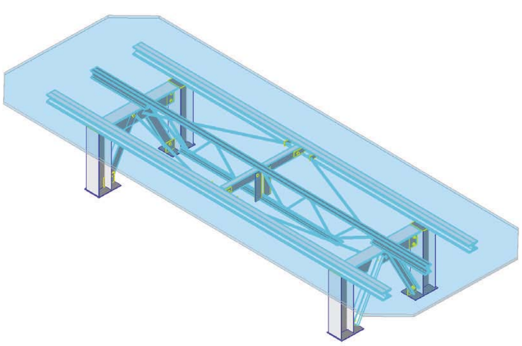
BY WILLIAM P. JACOBS, V, P.E., SDL STRUCTURAL ENGINEERS

DURING OUR RECENT OFFICE RENOVATION in Atlanta, SDL Structural Engineers decided that a standard conference table was not adequate to truly complement our chosen profession; we needed structural steel! Inspired by a smaller table in the Structures Laboratory at Virginia Tech, the resulting design easily accommodates 16 people and provides a focal point that is both functional and a conversation piece.

The table is supported on each end by a concentric braced frame (R=3, of course) made up of MC3x7.1 bracing members and W6×15 verticals. Spanning between these frames on each side are two sets of MC3x7.1 channels connected together to form wide-flange shapes. The center load-carrying member is a 12K1SP joist that was generously donated by Nucor-Vulcraft. (The "SP" designator indicates that the joist was designed for both uniform loading and for two traveling 250-lb point loads—in case a meeting gets out of control). Connections were field bolted with ½-in.-diameter A307 bolts.

The structural glass top surface is composed of two pieces, each ¾ in. thick, with an overall dead load of 1,000 lb. An etched band was added around the perimeter to complete the design. In order to visualize and detail the table for construction, a complete structural model was created in Revit Structure.

MSC



Images : Courtesy SDL Structrual Engineers

2009 HOT PRODUCTS

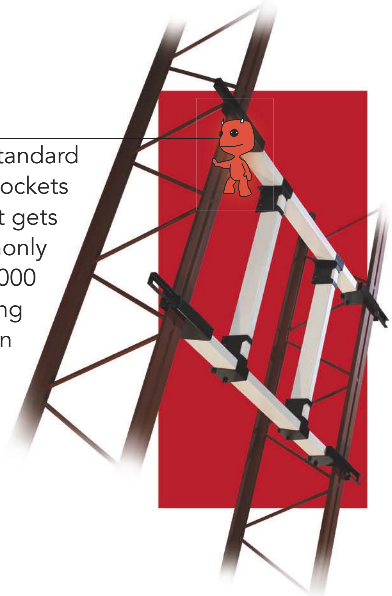
MACHINERY, SOFTWARE, TOOLS, AND SUPPLIES ARE the steel industry's most important accessories—and innovation among these products can mean faster, more cost-effective steel design and construction. This year's **Hot Products** are just a sample of some of the creative solutions recently introduced for designers, detailers, fabricators, and erectors. Some offer advanced technology, while others provide simple and practical applications in response to common problems. But all stand out as novel approaches to on-the-job difficulties.

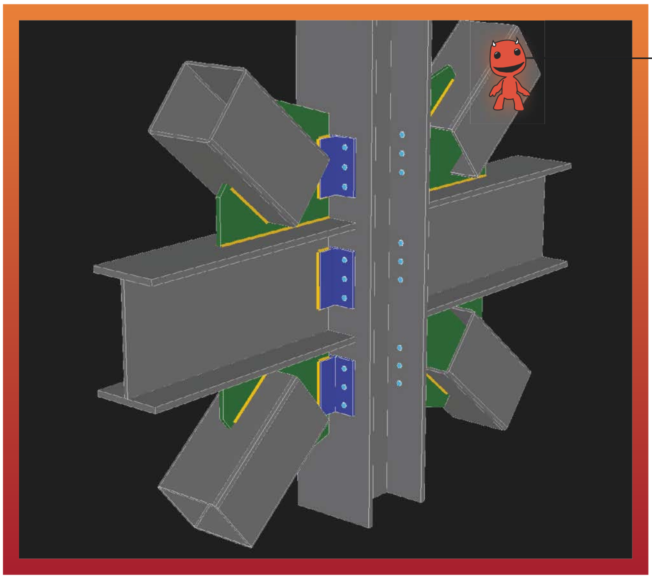
Hot Products were selected by *MSC* staff from products offered by exhibitors at **NASCC: The Steel Conference** in Phoenix in April. Their selection was based on descriptions and claims by the manufacturers; no product testing or evaluation was performed. This list does not constitute a product endorsement by *Modern Steel Construction* or by AISC.

Tube Framing Clamp System

The new Tube Framing Clamp System uses four end clamps, four T-Brackets, and four standard structural grade 2-in. x 4-in. rectangular tubes. The system takes advantage of the pockets of the roof deck, sliding under deck corrugations and over joists for easy retrofitting. It gets bolted in place so there is less concern over fire hazards and undercutting risks commonly associated with traditional welding methods. With a distributed load capacity of 3,000 lb per complete system, it is ideal for framing skylights and roof hatches or supporting rooftop loads. In addition, the design allows engineers and contractors great installation flexibility from simple roof openings to more complex support applications.

Contact: **Chicago Clamp Co., 708.343.8311**
www.ChicagoClampCompany.com

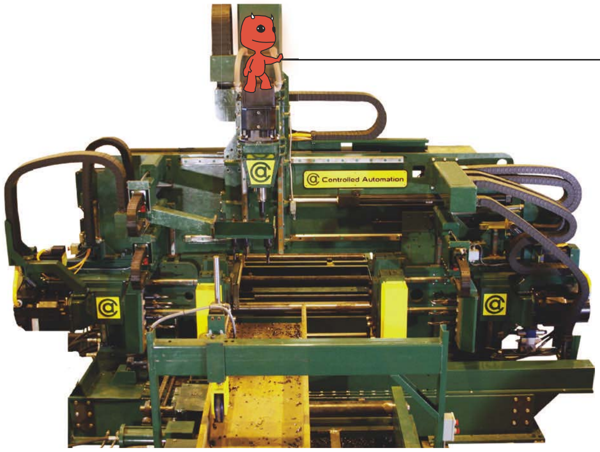




RAM Connection

RAM Connection now includes the AISC 341-05 *Seismic Provisions* for moment and braced frames and the latest steel standard provisions referenced by the 2006 IBC (AISC 360-05). The detailed DXFs are included for all connection types and even include the thorough reinforcement required for hollow structural section (HSS) braces per the *Seismic Provisions*. The program's recent integration with ProSteel provides collaboration in steel detailing, allowing users to design connections in RAM Connection and use ProSteel to create the fabrication drawings. It also works seamlessly with RAM Structural System, Bentley Structure Elements (formerly RAM Advanse), and STAAD.Pro, eliminating manual input of analysis and design forces and load cases from a structure into one standalone connection program.

Contact: **Bentley, 800.BENTLEY**
www.Bentley.com/RAMConnection



DRL-348TC Drilling Line

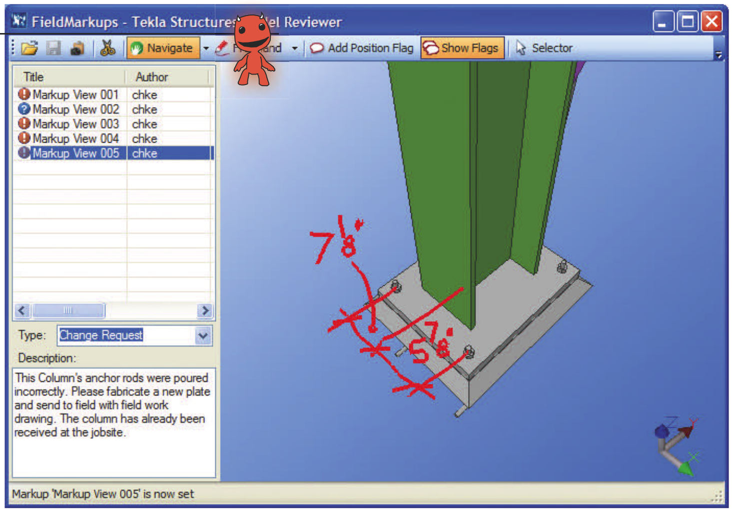
The DRL-348TC is a high-speed production drill line with a fully automated five-tool changer on each drill spindle axis. It has been designed to reduce operator error during production by allowing the machine to make any necessary changes in tooling size depending on the part being produced. With a maximum material width capacity of 48 in. combined with the 1,000-lb/ft conveyor system, the DRL-348TC can process anything from the smallest to the largest structural members.

Contact: Controlled Automation, 501.557.5109
www.ControlledAutomation.com

Tekla Structures Model Reviewer

Tekla Structures Model Reviewer is free and web-based. Tekla 3D models can now be downloaded and easily email redlined/commented back and forth for easier and more efficient project collaboration. The simple interface is designed so that team members who have never used CAD software can easily navigate and mark up comments into the 3D model. With the Tekla Structures Model Reviewer you can:

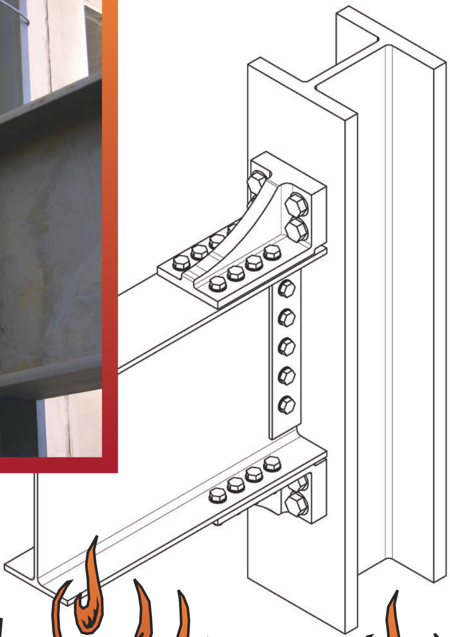
- ➜ Pan, rotate, zoom, and fly in the model
- ➜ Use mark-up view points to quickly present specific areas of the project or fly through a set of locations
- ➜ Create mark-ups with description and redlining
- ➜ Use clip planes to slice your project to provide perfect views of difficult areas
- ➜ Take snapshots from any angle of the model
- ➜ Change colors so that you can see structures



Contact: Tekla, 877.TEKLA.OK, www.Tekla.com

Kaiser Bolted Bracket

Kaiser Bolted Brackets are pre-engineered and shop fillet-welded to the beam, then bolted to the column to eliminate all field welding. Since they are cast in U.S. foundries to stringent control standards, quality is less dependent on field work. The brackets allow the frame to perform as it was originally designed without changing frame stiffness. In retrofit projects, they can be used to repair part of a building or upgrade the entire structure by drilling and bolting in place to eliminate all welding. In addition, they are now prequalified in ANSI/AISC 358-05s1 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*. (Kaiser Brackets will be the subject of an *Engineering Journal* article; see a description of the article in the News section on page 18.)



Contact: Steel Cast Connections, LLC, 206.250.7035
www.SteelCastConnections.com

COMBI-CB Multi-Directional Lift

The new COMBI-CB offers a material-handling alternative to service centers and other facilities with large stockpiles of steel, who today may be using standard conventional counter-balance forklifts, reach trucks, side-loaders, or electric four-way forklifts. With 6,000-lb capacity and multi-directional ability, the COMBI-CB is available in LP gas, diesel, and electric units and can lift to heights up to 25 ft. The 55-in.-wide fork carriage with optional integrated Fork Positioner offers excellent support for handling long products. As there is no platform, goods can be stacked directly from the floor up, enabling 100% use of lower storage areas. The small physical size allows it to stuff and de-stuff containers and transport pallets or long loads directly to the warehouse. The lift can operate in aisles as narrow as 75 in. regardless of the length of the load and, at the flick of a switch, can convert from forward drive to sideways mode; the ability to travel sideways allows this unit (and all of the manufacturers' lifts) to negotiate tight surroundings with long or awkward loads.

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A Tale of Two Fabricators

BY ERIKA WINTERS-DOWNEY, S.E., LEED AP, AND TERRY PESHIA

Every fab shop has its own story to tell.

IN THE FALL OF 2008, AISC's eight regional engineers were tasked with visiting every AISC member fabricator in their region to learn more about their specific businesses and how we, as regional engineers, can best assist them. Since November, I have personally toured more than 95 fabrication shops. In doing so, I was struck by how interesting the ins and outs are of a fab shop are, and also the differences between how each shop does business.

One of the biggest is connection type and style; every shop has its own preference. And efficient connection design is the topic of one of AISC's continuing education seminars this year. Certainly, the connection limit states (bolt shear, bolt bearing, weld shear, block shear, etc.) and connection types (welded, bolted, bearing, pretensioned, slip-critical, shear, moment, etc.) are all important considerations and options. But the final connection you use in your project may be influenced most by something much more applied: the type of setup your fabricator uses and the connections they prefer for that setup.

Some steel fabrication shops are set up to handle repetitive, beam-and-column-type work with low work hours required per piece. These shops run through a large amount of inventory annually and are experts at moving pieces through the "line" and out to the job site. Other shops specialize in more complicated work that can be labor-intensive and schedule less tonnage per year as a result.

Traditionally, shops that are set up for high-volume, low-labor work find their jobs in markets like commercial building construction, and shops that are set up for low-volume, high-labor work find them in markets like industrial construction. Of course, there always will be some overlap into other markets regardless of what segment a fabricator picks as its specialty. For example, a shop that does mainly industrial work will also do some amount of commercial work, probably in its geographic area. The reverse is true for a mainly commercial shop; it will probably do a small percentage of its work for local industrial jobs.

It's important to recognize that no one specialty will necessarily make one of these shops better or more efficient than the other. Rather, each has its place in today's construction market. Often, fabricators will collaborate with each other on projects to take maximum advantage of their respective strengths. Let's examine the layout of two fictional fabrication shops to see how one fabricator's capabilities differ from its neighbor.

Shop A

Shop "A" is a high-volume, low-labor shop. This shop is profitable based upon the sheer volume of tonnage that passes through, as the labor per piece is minimal. It often runs night shifts—especially when beams that require minimal to no fit-up work are run through the beam line—and have fabricated pieces ready to ship in the morning. An ideal project for this type of setup would be a framing scheme with rectangular bays and simple-span filler beams framing to girders.

The shop has a large lay-down area—outside in this case—that is full of inventory waiting to be run through two separate beam lines, which increase productivity inside. Both lines are set up to cut beams to length, but one is set up to punch holes and the other is set up to drill holes.

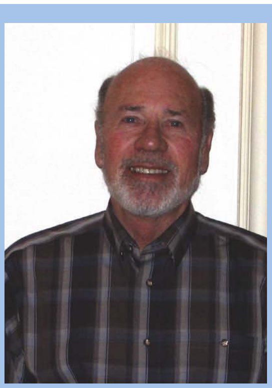
Punching holes is quicker and more economical, when it is permitted. When the thickness exceeds about 1 in., a member will generally need to be drilled rather than punched, because punching is a brute-force method that may damage the steel. Therefore, the punch line is used for smaller members with thinner webs and flanges, and the drill line is used for larger members.

After beams are cut to length and the holes are made, they will travel to a fit-up bay to have any connection materials, such as plates, angles, stiffeners, doublers, and base plates, applied. Because Shop A prefers low-man-hour jobs; it only has two or three workstations set up for welding. They will probably not bid a job that consists of mainly welded connections because it would tend to form a bottleneck in the fit-up bay—unless the bid could be based upon alternative connections proposed by the fabricator. Shop A also has:

- an angle line for cutting and punching angles for connections and members
- a plate cutting table where gusset plates and other connection plates are cut from larger plates
- a small bay off to one side for fabricating handrail and stairs for jobs that require miscellaneous steel only
- a painting bay
- a blasting machine to create surface preparation for painting, especially if architecturally exposed structural Steel (AESS) is part of the job

After the filler beams have been cut to length, had their holes drilled, and cambered if that is required, they are shipped out to the site with no further work required at the shop. Girders and columns, however, go to the fit-up bay


Erika Winters-Downey is AISC's Great Plains regional engineer.


Terry Peshia is Chairman and CEO of AISC member fabricator Garbe Iron Works.

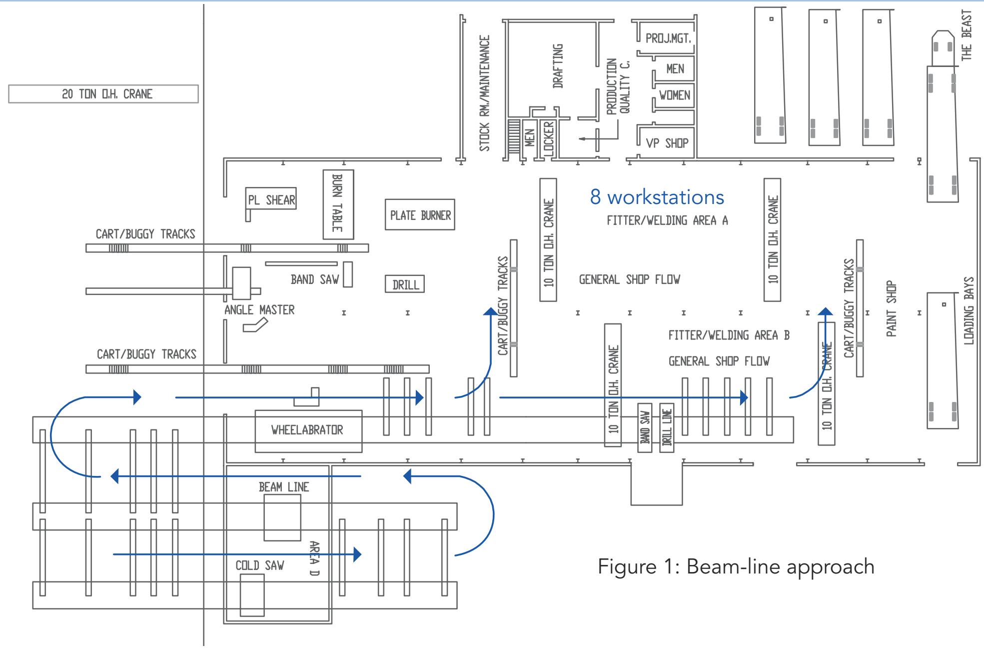


Figure 1: Beam-line approach

where connection materials are attached to them.

The infill beams represent a work level of two to three man-hours per ton, and the girders represent a work level of five to six man-hours per ton. Overall, this shop averages three to four man-hours per ton of output from the shop.

Shop B

Shop B is a high-labor, low-volume shop that is profitable based upon the value of the labor it provides. The shop's annual tonnage is approximately one third of tonnage fabricated by Shop A.

The majority of its structural work is for heavy industrial structures, like power plants or offshore drilling platforms. However, the shop does bid more traditional structural work in its vicinity. Typically, half or more of the shop's work is plate work— either for structural applications, such as plate girders and large gusset plates, or for industrial applications, such as hoppers, silos, or mechanical shafts.

The shop is set up with a basic beam line that drills—no punching. It focuses more on welded work and isn't burdened wit the need to make holes as quickly. In addition, the beam line is not the centerpiece of the shop. Rather, this shop has 20 workstations set up to accommodate welding and plate-type construction and a large plate bay with two plate-cutting tables.

The shop has a dedicated bay set up for large truss work. Because of the large sections fabricated in the shop, it employs workers who are skilled in heat cambering methods. Smaller sections are cambered with a more traditional cold cambering machine; cambered members are not easily fed through a beam line.

Shop B prefers welded connections. The welders it employs are masters of their craft and have many years of experience. The shop highlights its ability to have greater control over complex connection work while simultaneously operating with the "shop-welded, field-bolted" philosophy of constructability.

In terms of square footage, this shop is much larger than Shop A, because it has so many welding workstations, as well as a truss bay and extra plate bay. Shop B averages 10 to 12 man hours per ton of output.

Material Procurement

Regardless of shop size or the type of work preferred, all fabricators have a choice when they need to get steel for a project. They can either order steel directly, and in mill quantities, from the rolling mill, or they can purchase it from a steel service center. In fact, almost every fabricator will tell you they use a mix of these options, and there are advantages of working with each.

When ordering steel from a rolling mill, the unit cost is typically lower, but there is usually a minimum order that must be placed. This is called a "bundle" and might amount to, say, five to 20 W18x35s.

For smaller fabricators who order steel on a job-to-job basis rather than an inventory basis, this quantity might be too large. Steel service centers, however, make it possible to order the exact number of members you need. They also offer delivery within a matter of days rather than based on a mill rolling schedule, which can take quite a bit longer.

A typical truck delivery from a service center might include several types of steel at once—wide-flange beams, HSS, angles, and plate material—and, again, all in smaller quantities than could be ordered directly from the mill. Also, service centers can can cut members to length so that fabricators end up with less "drop" or scrap length. And most will provide staged delivery so that the material doesn't have to wait out in the fabricator's yard for extended periods of time until it can be run through the line.

Cash flow is also a factor. Ordering from a service centers allows the fabricator to get a firm price quote at the time of order, while mill pricing can be more fluid. Service centers do charge a premium on top of mill prices for providing these services. This premium is based upon the individual client's relationship and past business with the service center. (For more on service centers, see "A Wide Range of Wide-Flange," 1%8 at **www.modernsteel.com**.)

Many large fabricators work with mills almost exclusively because they have a large backlog of work and don't need to worry whether a full bundle of material will be used. In addition, one domestic mill is now rolling larger "jumbo" shapes that were previously only available abroad.

Recommendations

The two shop examples given here are fairly extreme, and most fabricators will fall somewhere in the middle. A shop that tends to take on work that can be done with a beam line might suggest bolted connections with angles from time to time, and a shop that tends to pursue the workstation approach might suggest welded connections.

So what is the designer to do given that each fabricator is different than the next? Regardless of a fabricator's work methods, you can be an advocate for constructability by involving the fabricator early in the design process. As explained in AISC Design Guide No. 23, *Constructability of Structural Steel Buildings*, the fabricator can provide suggestions and advice that even the most experienced structural engineer might not have considered—and steer the project to maximum shop and field efficiency.

What about the cost? It seems that many general contractors and owners are convinced that design-bid-build generates the lowest-cost job. Yet there are many who have learned that a teamwork approach can mean higher quality at a lower cost. Steel fabrication is a specialty, and the expertise gained from all participants in a team approach using early involvement can, in the end, save much more money than hard bidding.

The best way to appreciate and better understand how fab shops operate is to visit one in your area. Shops across the country will be opening their doors to the public on SteelDay on September 18 (see SteelDay coverage on page 22—and visit **www.steelday.org**). If you're not available for a tour that day, contact a fabricator and set up a personal tour for another day. See what they do and how they do it. Take the time to get to know them, and let them get to know you. Consider how you might work together as a team and make each other more successful and profitable. You'll be very glad you did! **MSC**

Real Shops

While we focused on two fictional fab shops, two very real ones—Garbe Iron Works in Aurora, Ill. and Hillsdale Fabrication (Alberici Construction) in St. Louis, both of them AISC members and Certified—generously shared their experiences and shop layouts for this article. Garbe is more of a conventional shop that is centered on a beam line, with a 45,000-sq.-ft facility (30,000 sq. ft of which is dedicated to steel fabrication). Hillsdale takes the workstation approach, with main production areas totaling around 220,000 sq. ft.

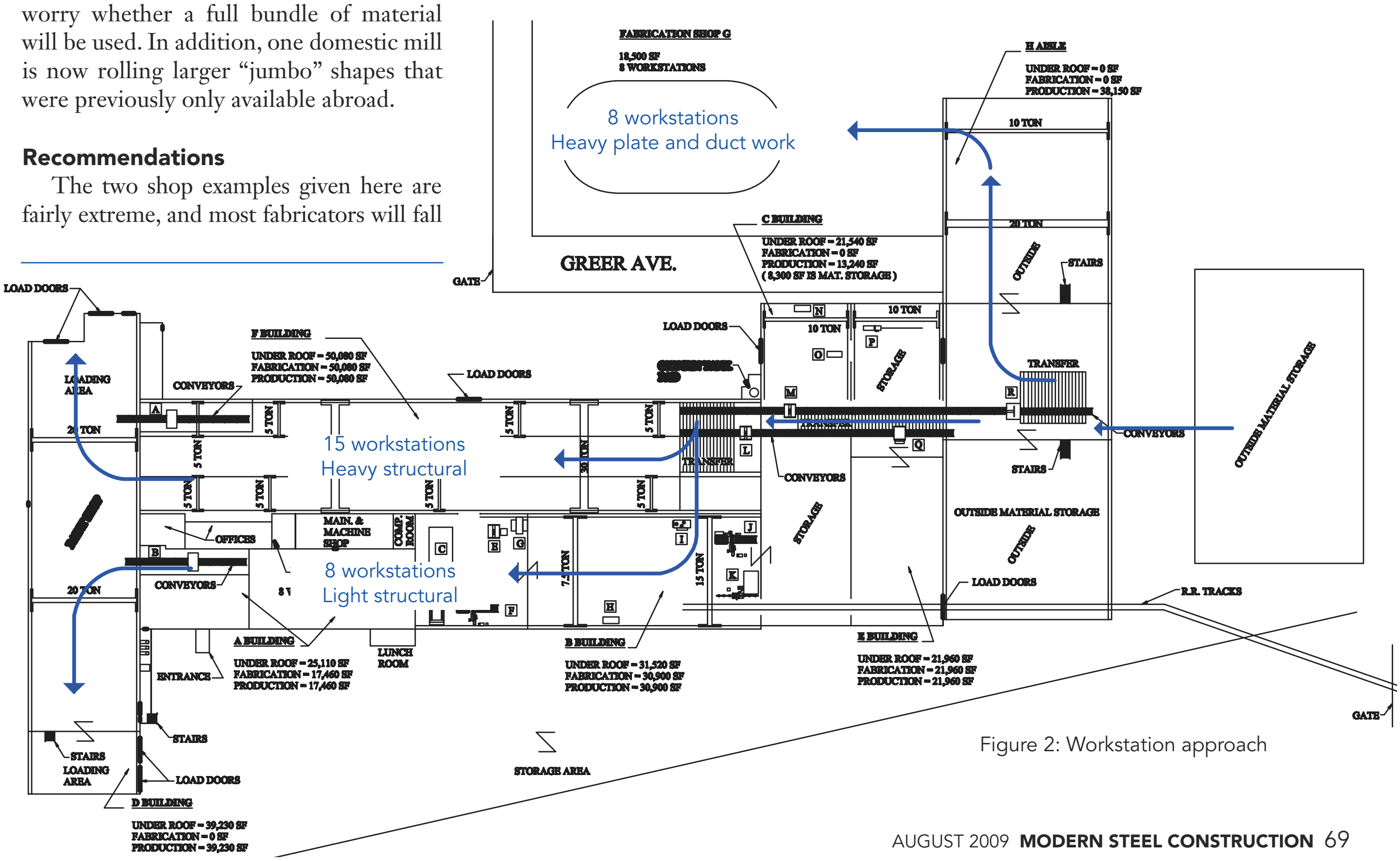


Figure 2: Workstation approach

Selling Quality

BY BRIAN W. MILLER

Sales and estimating excellence: home-grown in your AISC Certified quality management system!

WORK BACKLOGS HAVE SHRUNK drastically for many firms as a result of the recent economic downturn. You may find that your firm, like many fabricators and erectors, is looking to increase prospecting and sales activity to secure work.

When times are lean as they are now, your company's regular sales and estimating force will need additional support. Opportunities are fewer in number and securing work from the projects that are available requires greater effort and skill. It's critical that sales representatives use estimating resources to the maximum result.

Of course, increasing sales and estimating efforts quickly is a tough challenge for management. Hiring additional staff in a downturn adds overhead cost at a time when being lean is important to your ability to offer the best pricing possible. It is also not easy to identify and hire individuals qualified to do this work without training. A new hire with strong sales experience will still need time and training to get to know your company's market focus and customer base, and be able to represent your firm effectively.

Looking Within

So how can you quickly ramp up sales and estimating effort and effectiveness? A team approach using current employees who support your company's AISC Certified quality management system may be the answer. The folks who maintain the day-to-day focus and discipline needed to understand and consistently meet your customer's requirements are a deep and rich pool of talent waiting to be tapped. Although initially perhaps obvious, a closer look will show that many of these individuals possess the skills and enthusiasm needed to be effective in sales and estimating.

Brian Miller is AISC's director of certification.

Quality-focused individuals are goal-oriented, creative problem-solvers likely to welcome the challenge of a cross-functional assignment in the face of a shrinking work load. They have been a large part of the success your company has achieved to date and will likely be eager to pitch in and continue the progress. The skills that individuals gain supporting AISC Certified quality align very well with the skills and expertise needed for effective sales and estimating, skills such as being:

Customer-focused. A commitment to understand and consistently meet customer requirements is fundamental to AISC Certified quality management. This focus provides individuals involved in quality management with regular practice in observing and evaluating what customers value and what they find objectionable. Quality-focused individuals who interact with your customers—from project managers to accounting representatives to delivery truck drivers—are key candidates for providing additional support to sales and estimating.

Management-driven. In an AISC Certified company, management drives communication and commitment to established company values, policies, strategies, and goals with respect to quality. Individuals involved gain a strong understanding of the solutions that can be offered to customers and are confident in management support and commitment for those solutions. Management also actively supports continual improvement. Individuals involved in quality know that past failures to fully meet customer requirements are actively addressed and they are confident in telling customers that appropriate action is being taken to make changes and prevent recurrence.

Process-based. Sales and estimating can benefit greatly from the experience and skill in process-based methods ingrained in individuals engaged in AISC Certified quality management. Individuals gain appreciation for the importance of understanding and managing variability to make progress toward an objective; they build a commitment to a consistent process approach that includes established and recorded goals and performance metrics. Regular work with the corrective action process and quality tools helps to equip individuals with the ability to identify and overcome obstacles as well as recognize and exploit opportunity.

You can see the potential, so now you'd probably like to have a way to become more confident that this idea will succeed. Try this: Select new sales and estimating recruits from your quality management system and engage them in a proof-of-concept exercise with internal customers. Your internal audit process, required for AISC Certification, provides a way for individuals to further increase understanding of your organization's processes and capabilities—critical to success in preparing proposals and estimates. The internal audit also offers an excellent way

Quality Corner is a monthly feature that covers topics ranging from how to specify a certified company to how long it takes to become a certified company. If you are interested in browsing our electronic archive, please visit **www.aisc.org/QualityCorner**.

to sharpen the confidence and people skills needed to be effective in sales.

Individuals may be anxious about participating in sales based on negative stereotypes and apprehension about having to make a pitch. Fears are reduced with recognition that an effective sales approach relies on a defined process and is more about listening than presenting. Effective sales professionals may not close a sale with each customer contact, but they use a process approach to draw the sale closer with each customer meeting. Each step in the following five-step sales process can be applied to an internal quality audit:

1. Lower resistance. As in sales, participants in internal audits are likely to encounter and need to overcome resistance. Effective ways of overcoming resistance focus on providing a safe and constructive forum for exchanging ideas. This takes practice, but inviting someone to share a success or best practices story often goes a long way toward lowering resistance.

2. Ask questions. With resistance lowered, asking questions paves a way to learn more about your customer's business and identify their needs. Customers in an internal audit are encouraged to describe both what improves and impedes their productivity and effectiveness. The acquired knowledge is then used by your management to make decisions and allocate resources. The goal is similar in a sales call with particular attention given to assigning value to factors related to the customer's needs and confirmation that the individual representing the customer in the sales call is authorized to make purchasing decisions.

3. Present solutions. In an internal audit, individuals combine understanding of quality goals with problem-solving tools to develop solutions. A sales call is similar in that solutions are offered that match customer needs with the capability of your company. Interaction is important here, encourage and address reaction as you proceed to gain the customer's full engagement and support for the solution.

4. Close. Confirm with your customer the value and acceptance of your solution. The close of an internal audit may lead to a commitment to a corrective action or improvement initiative. Ideally, a sales call results in purchase agreement. Avoid high-pressure tactics, but don't be afraid to ask for the sale!

5. Agree to your next contact. Internal audits and sales calls are steps in an ongoing relationship and establishing a plan for the next step communicates positive direction and commitment to that relationship. Subsequent internal audits may target advancement in improvement objectives and include evaluation of methods, metrics, and timetables for achievement. Agreement to the next sales contact cultivates critical customer relations and provides the sales representative with further opportunity to position your company for future work.

Challenge the quality-focused, creative problem-solvers in your company with the goal of improving your work backlog. The individuals who support your AISC Certified quality management offer a pool of talent, expertise, and enthusiasm well matched to the needs of an effective sales and estimating effort. You may find this decision a key to prosperity in this economic downturn. MSC

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Detailing and BIM: Are You Ready?

BY BRIAN COBB, P.E.

If the answer is yes, there are a few things you should know to make sure that you're *really* ready.

STEEL DETAILING AND DESIGN SOFTWARE packages have paved the way for much of today's building information modeling (BIM) world. Despite this fact, detailers who work with 3D models are often not equipped to work in a BIM environment. Are you ready to work on a BIM job? If not, here are some tips that may help you get started.

Prepare for BIM—Now

Chances are you will soon get a call midway through a job, asking you to provide a model for BIM coordination. As a 3D detailer, the best way to be ready for a BIM project is to prepare your office now. Establish procedures to ensure your model is accurate. Eliminate obstacles to an accurate model, such as modeling repetitive material only once and adjusting the quantity recap at a later stage. Better to be prepared now than to admit later that your 3D model is not detailed sufficiently enough to share.

Know Your Software

What file types does my software export? What file types can I import? What is the best way to export my software to program X? What are the limitations on my software? Find out what your software can do. Ask a sales representative, call a technical support representative, or call another detailer using the software. Once you have some guidelines, test them out. You will be surprised at the capability and knowledge you already have.

Brian Cobb is operations manager and co-owner of Structural Detailing, LLC, a detailing and engineering company located in Brentwood, Tenn. He currently serves as president of the SDS/2 Users Group.

Know the Other Software

No, I'm not talking about your detailing competition. I'm talking about the software used by the design team and/or the contractor. What is their software? What type of file imports can it accept? Some software packages offer free viewers. Use these free options to test your software's export and see how it interacts. If you cannot get a free viewer, take some time to discuss BIM with an architect, engineer, or contractor. Test the software with them, either through e-mail exchanges or a scheduled meeting. You will both benefit from seeing what the other can do.

Once you know the basics, dig a little deeper. Assume the contractor's software can accept three to four different formats that you, as a detailer, can create. Which one works best? Again, test this yourself or use another detailer's experience. On more than one occasion, a contractor has asked me to provide a certain type of file. The file I am asked to provide is often not the most intelligent file type or the file type that translates best. The credibility you can establish by providing a better file type can go a long way in a project—and in getting the next project!

What does BIM Mean to the Project?

Establish a definition for BIM that's specific to each project. Does BIM mean the engineer will provide a CIS/2 file from the analytical model to import into detailing software? Does BIM mean providing a model to the general contractor? BIM, for any given job, may be a one-time process, or it may be a collaborative effort throughout the job.

I've got a BIM Job—Now what?

Much like a detailing scope list or setup sheet, it is a good idea to create a BIM setup sheet. Find out what software will be used for the master model, what file type will be provided for detailing use, and what file type will be required to come back into the master model. Find out how often the steel model must be provided and if coordination meetings (or conference calls) will be required to resolve conflicts between models of different disciplines.

If you receive a model from another source (such as the engineer's analytical model), don't be afraid to ask specific questions about their software and modeling practices. These questions might include: "What is the starting XYZ reference being used?" and "What tolerance is being used in the architect's master model?" Once the guidelines are set, kick the tires. Ask for a test run through the process. This will ensure that your software interacts as it should, and will hopefully expose any other problems in the line that may be corrected before it is late in the project.

It is worth reiterating that BIM is a *process*, not a software package. Defining that process and knowing your ability to work within that process will go a long way toward a successful experience on your next BIM job. MSC

Have an opinion you'd like to share in "Topping Out"? Send your feedback to Geoff Weisenberger, senior editor, at weisenberger@modernsteel.com.

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