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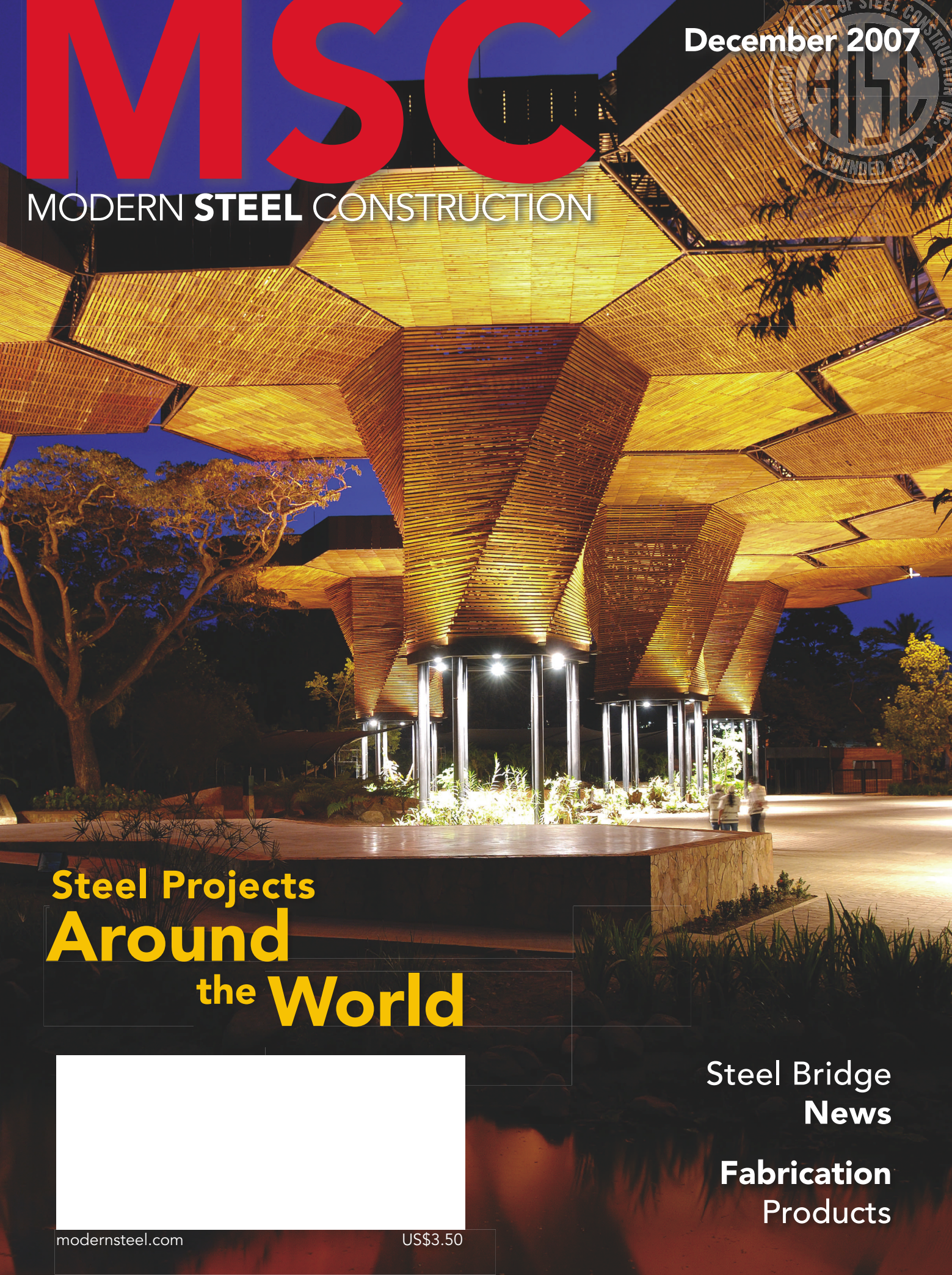
MODERN STEEL CONSTRUCTION
December 2007



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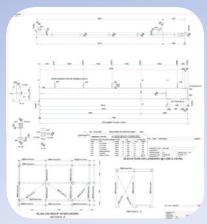

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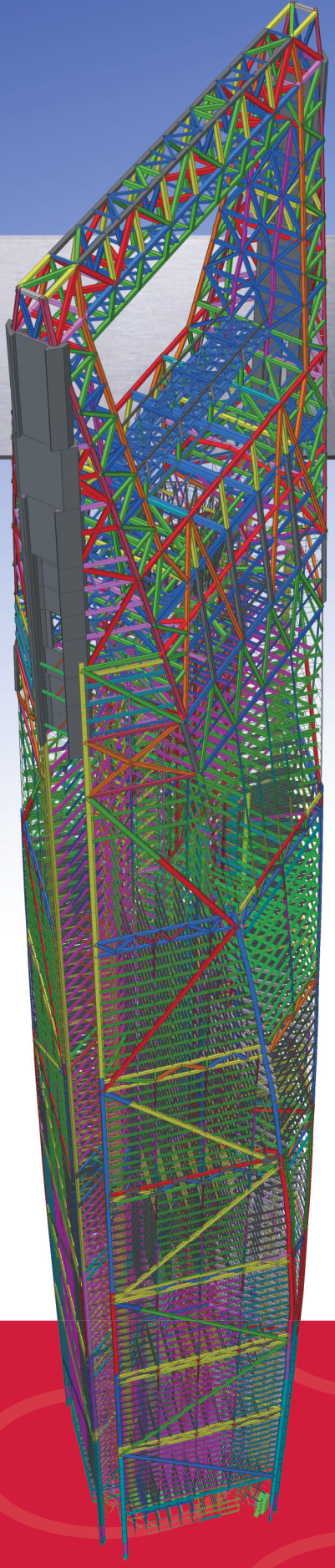

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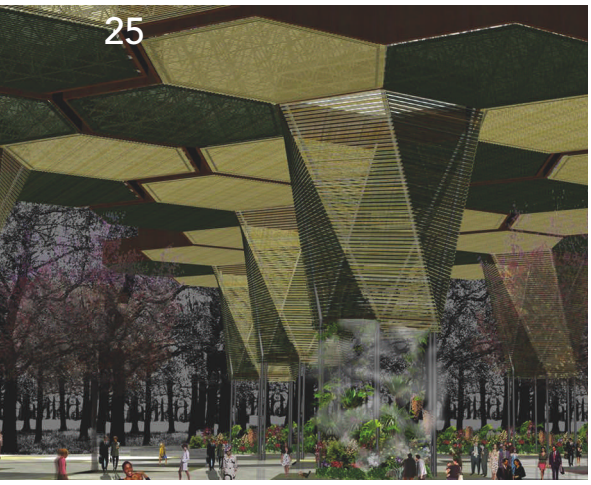

ON THE COVER: Botanical Gardens, Medellín, Colombia. Photo courtesy Dario Eusse Tobon.

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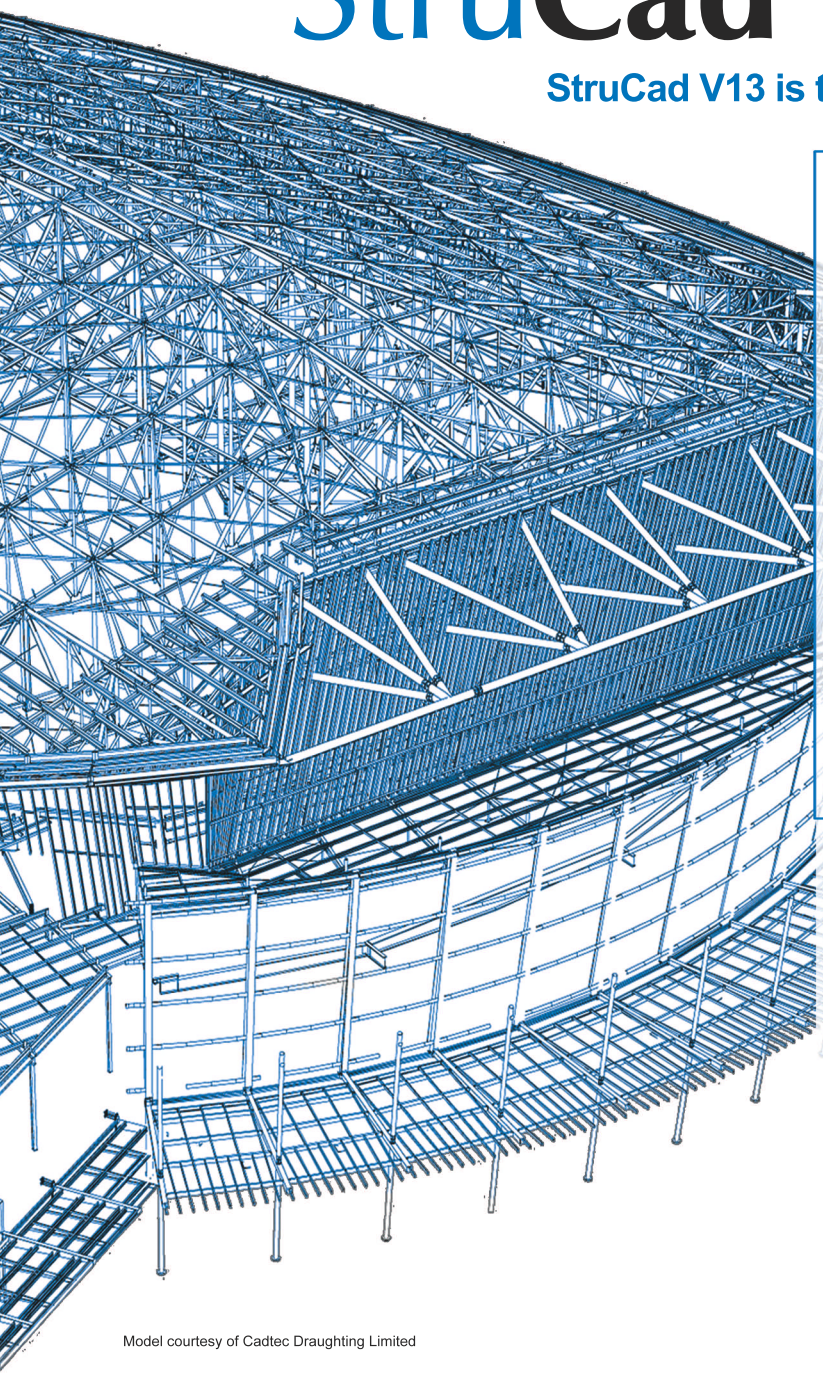

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editor's note

AS I LISTENED TO BILL CLINTON DELIVER THE KEYNOTE ADDRESS AT THE RECENT GREENBUILD CONFERENCE, I couldn't help but think about how much I could charge for tickets for a conversation between Clinton and Dan DiMicco, CEO of Nucor Steel.

While Nucor under DiMicco has been a huge proponent of a strong and sustainable environment (and has some notable green success stories), DiMicco is a huge opponent of the Kyoto Protocol. As I understand his objection, the problem with Kyoto is it has the effect of increasing the cost of U.S. manufacturing. As a result, a certain percentage of U.S. manufacturing will move offshore to places like China, where the factories produce more than nine times as much pollution. Therefore, in an interesting twist, the net result of Kyoto is not just a drain on the U.S. economy, but also a net increase in carbon emissions worldwide.

Clinton presented an opposing viewpoint during his presentation. He believes that reducing energy consumption and greenhouse gas emissions actually makes U.S. manufacturing more competitive and will have the result of bringing more business to the U.S., therefore further reducing carbon emissions worldwide. To make his case, he uses Denmark as an example of where strong environmental regulations have spurred economic growth.

Ever the pragmatist, Clinton stresses that the sustainability movement needs to be "operationalized"—that sustainability can't be presented as "a bottle of castor oil but also must have an economic benefit." As part of his "Greening America's Schools" program, his foundation is providing seed money to show that operation savings will pay for green retrofits, that the cost to make a building more energy-efficient is more than offset by the savings that result from that energy efficiency. "In 18 months, people will accept that buildings should be energy-neutral. Within five years, we'll be talking about energy-positive buildings."

During the same session in which Clinton spoke, George David, CEO of United Technologies, pointed out that "going green doesn't cost more, it saves money." I like that approach. At *Modern Steel Construction*, we've taken a similar approach. We use soy-based inks because they're not only environmentally sensitive, but also economical. We're thinking about switching to a recycled paper stock not just to help the environment, but because it's also 9% lighter, which will reduce our postage costs. We've introduced a digital edition so people who don't want a paper copy can read the entire issue (ads included) online at **www.modernsteel.com**. Likewise, the digital edition means less fossil fuel consumption from shipping the magazine.

Our parent company, AISC, has taken green even further. Our offices use energy-efficient lighting and we have occupancy sensors on the light switches. Offices all have recycling boxes. As a benefit, AISC offers its employees the opportunity purchase public transit cards with pretax dollars—and more than 96% of AISC's headquarters staff commutes by public transportation. We've moved to using eFax (where our faxes come to our Outlook inboxes) instead of paper faxes. We've introduced ePubs, where members can access *Engineering Journal*, design guides, and about 15,000 pages of technical information online rather than purchasing paper copies that need to be printed and sent through the mail. We don't print out and store membership applications and subscription renewal forms; instead we accept electronic files that we store on our servers—no paper needed (an economic benefit not just from less paper use, but also from less printer maintenance and supplies). And, of course, we're trying to make NASCC: The Steel Conference as green as possible (more on this in the coming months).

Of course, we're not alone. Steel mills have reduced energy consumption and greenhouse gas emissions by more than a third. A number of fabricators have re-lamped for energy efficiency and are looking to incorporate daylighting into their shops. Recycling is de rigueur. In fact, there's even a session at the upcoming Steel Conference (April 3–5 in Nashville) called "Greening the Shop"—visit **www.aisc.org/nascc** for more information. (And talking about recycling, steel of course is the most recycled material in the world and all of the wide-flange rolled in the U.S. uses more than 95% recycled material. Steel is recycled, recyclable, and reusable.)

What are you doing to be green at your company? Drop me an email at melnick@aisc.org or log on to **www.modernsteel.com**, click on "reader feedback" and post a comment to start a conversation.

SCOTT MELNICK
EDITOR

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Editorial Offices
One 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

MANAGING EDITOR
Keith A. Grubb, P.E., S.E.
312.670.8318
grubb@modernsteel.com

ASSOCIATE EDITOR
Geoff Weisenberger
312.670.8316
weisenberger@modernsteel.com

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Advertising Contact
Account Manager
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231.228.2274 tel
231.228.7759 fax
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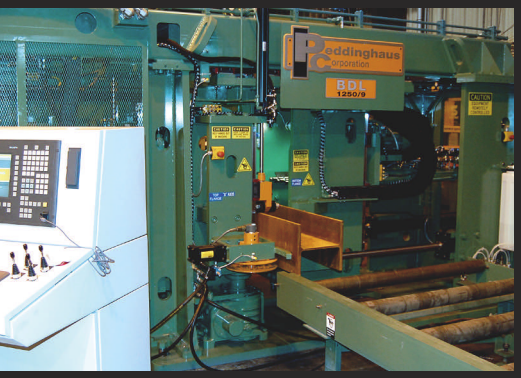

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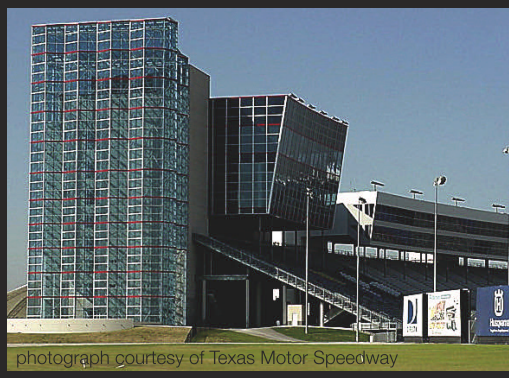

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IF YOU'VE EVER ASKED YOURSELF "WHY?" about something related to structural steel design or construction, *Modern Steel Construction*'s monthly Steel Interchange column is for you! Send your questions or comments to solutions@aisc.org.

Historic Lattice Columns

We are examining an existing building constructed roughly in 1919. The columns in the building consist of double-angle flanges with lattice steel webs. We are trying to determine allowable loading for the column but have been unable to find any documented information. Any help would be appreciated.

I am not sure what type of documented information you are looking for. You may be able to find discussions in old textbooks, but I don't think that you will find capacity tables. The design of such compression members usually started with the calculation of the basic section properties and determination of the unit compressive stress. The elements also had to be joined together to act as a unit. To act as a unit, the buckling resistance of the individual element has to be at least as great as that of the member as a whole.

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

Evaluation of an Existing Structure

I am working on an addition to a 1922 steel-framed building. When I check the columns using ASD (unreinforced concrete encased, $F_a = 18000 - 70L/R$), many are overstressed. However, the results appear to be better using LRFD.

Is there anything in the AISC specification that would require that we use ASD and not LRFD to check the existing structure? Is it reasonable to apply today's load and resistance factors to historic steel?

There is nothing in the AISC specification that defines what load approach must be used in the analysis, design, or evaluation. Either method is acceptable as long as you stay consistent in the load and capacity sides of the design equations. Current requirements are often applied to existing structures. See Appendix 5 of the 2005 AISC specification for more information on evaluating existing structures.

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

Shear Stud Requirements

Is there a minimum height requirement for studs used in the design of composite beams?

Section I1.3 of the AISC specification requires that studs shall not be less than four stud diameters in length after installation. Section I3.2c of the AISC specification requires that, when formed steel deck is used, after installation the studs shall extend not less than 1½ in. above the top of the steel deck. See Chapter I of the AISC specification for other stud requirements.

Amanuel Gebremeskel, P.E.

Crane Runway Forces

Where are "crane runway horizontal forces" addressed in the current AISC specification? This was formerly covered in Section A4.3 of the 1989 ASD specification. If it is not addressed in the new specification, where do I need to go to find these requirements?

The AISC specification no longer stipulates load requirements. Instead, loads and load combinations are now covered by the applicable building code or the ASCE 7 load standard. Crane loads are covered in Section 4.10 of ASCE 7-05.

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

Expansion Joint Location

What is the maximum length permitted between expansion joints in a steel building?

There is no one specific requirement for permitted length between expansion joints in a steel building. The determination of when expansion joints should be introduced in a building structure is dependent on many factors including the configuration of the structure, type of use, and climatic conditions, among others. You may want to look at Technical Report No. 65, *Expansion Joints in Buildings*, published by the Federal Construction Council (1974). Key points from this reference are summarized in the 13th Edition AISC *Steel Construction Manual* beginning on page 2-31. The full document can be read online and is also available for purchase at **www.nap.edu/catalog/9801.html**.

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

Reduction for Splice Length

In the 3rd Edition AISC LRFD manual, footnote "e" in Table J3.2 requires that a 20% reduction is taken on bolt patterns in tension splices where the bolt pattern length measured parallel to the line of force is greater than 50 in.

Is any tension connection considered a splice? I am evaluating diagonal tension members in a truss that connect to the top and bottom chords as well as vertical members. Does this reduction apply?

The underlying requirement is to reduce the available shear strength by 20% of an end-loaded bolt group that exceed 50 in. in length due to the uneven load distribution between such bolts. The connections you describe are likely such a case and, if the joint length exceeds 50 in., you do have to use the reduced capacity. The footnote was probably written with the term "splices" because it was rare to have connections other than splices of this length in an end-loaded configuration.

Amanuel Gebremeskel, P.E.

Seismic Retrofit of 1931 Building

I am doing a seismic retrofit for a structure designed and built in 1931. I guess it must be A7 steel. Could you let me know what values F_y, F_u, and R_y should be used?

In 1931 most structural steel for buildings was designated as ASTM A9 rather than ASTM A7, which was applicable to bridge steel at the time. The tensile strength of ASTM A9 was stipulated as 55,000 psi to 65,000 psi and the minimum yield point as ½ T.S. or not less than 30,000 psi.

steel interchange

FEMA 356, which is a prestandard and commentary for the seismic rehabilitation of buildings, defines default lower-bound material strengths for ASTM A9 as a tensile strength of 55 ksi and yield strength of 30 ksi.

There would have been no R_y (nor R_t) defined for the material at the time, as these factors were only recently developed. FEMA 356 also provides factors to translate lower-bound steel properties to expected-strength steel properties. The factor given for steel produced prior to 1961 is 1.10 for both the tensile strength and the yield strength.

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

Single Angle Design

Can you help me clarify the design of a single unequal leg angle in bending utilizing the new AISC specification? A very common situation for longer span masonry brick openings is to use an L6×3½×5⁄16 LLV. Do you have an example or some clarification on the design?

Section F10 of the 2005 AISC specification addresses the design of unequal leg angles in bending. If the angle has lateral torsional restraint, the design can be carried out using equation F10-1. If there is no such restraint, the second paragraph of page 282 in the commentary to Section F10.2 provides some guidance for how to approach that problem. Equation F10-6 is applicable with that commentary.

Amanuel Gebremeskel, P.E.

Bolt Torque/Tension Equation?

I understand that the torque required for bolt installation in a slip-critical joint depends on the bolt class, the bolt diameter, and the faying surfaces properties. Can you tell me what equation to use to determine the torque required developing the required tension in the bolt?

No. Bolt installation is defined by the tension required in the bolt, not the applied torque. There is no defined torque/tension relationship, as this can vary considerably depending on the project conditions and must be calibrated if a torque-based method is to be used to provide pretension in bolts. The RCSC *Specification for Structural Joints Using ASTM A325 or A490 Bolts* (a free download at **www.boltcouncil.org**) defines procedures for proper installation of high-strength bolts. Both the calibrated wrench method and the twist-off-type tension control bolt assembly method are torque-based methods. Note the special requirements for calibration that apply, particularly for the calibrated wrench method.

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

Required Bolt Length

I am relocating a structure where there is not proper documentation of existing conditions, and I am unable to determine the required length of the structural bolts.

We have the connection drawings of the columns and beams, and the thickness of the splice plate. I want to know what should be the length of the bolt and length of the threaded portion, taking into consideration the height of the nut and the thickness of the washer.

In addition to the information you summarized, you will also need to assess what loads the connections are required to transfer, that appropriate use of washers and nuts is followed, and whether the threads are required to be excluded from the shear plane. The length of bolt used must, at a minimum, allow for the end of the bolt to be flush with the outside face of the nut so as to have the threads adequately engaged. Furthermore, the washer requirements will depend on the bolt, hole, and base material types, as well as the method of installation.

The RCSC *Specification for Structural Joints Using ASTM A325 or A490 Bolts* (a free download at **www.boltcouncil.org**) provides a good source of information on these subjects. The Commentary to Section 2.3 provides general guidance on proper selection of bolt length. An AISC *Engineering Journal* paper by Carter (second quarter, 1996) provides a more detailed treatment of the subject. This paper is available at **www.aisc.org/epubs**.

Amanuel Gebremeskel, P.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 and Amanuel Gebremeskel is a senior engineer in AISC's Steel Solutions Center. Charlie Carter is AISC's chief structural engineer, and Lou Geschwindner is AISC's vice president of engineering and research.

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:

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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.

It's all about the AISC *Seismic Provisions* in this month's Steel Quiz, developed by AISC's Steel Solutions Center. Sharpen your pencils and go! You can download a copy of the AISC Seismic Provisions at no charge at www.aisc.org/2005seismic.

1 What limiting width-thickness ratio should be used for a member subjected to axial compression plus flexure?

2 What area is used to check for shear yielding and shear buckling on a round HSS?

3 What is the difference between nominal strength, design strength, and allowable strength?

4 **True/False**: When evaluating an existing steel structure, the available strength of the structural members and connections must be assessed based on the AISC specification that was in effect at the time of the original construction.

5 **True/False:** If a steel building structure is classified as Seismic Design Category C and an *R*-Factor of 3 is used, the design need not comply with the detailing requirements of the AISC *Seismic Provisions*.

6 Can finger shims be used in slip-critical connections?

7 **True/False:** When considering flexural yielding on a W-shape, the available strength is based upon the plastic section modulus (Z_x).

8 Is it permitted to use thermal cutting to make bolt holes?

9 When checking the bearing strength at bolt holes, how are the various bolts in the connection required to be checked, given that edge distances vary?

10 Is a pipe the same thing as a round HSS?

TURN PAGE FOR ANSWERS

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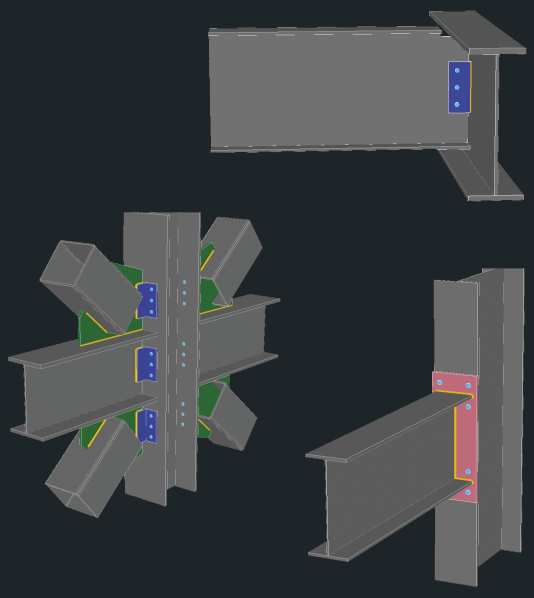

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steel quiz

ANSWERS

1 Design of members for combined forces is covered by Chapter H of the 2005 AISC specification. The axial and flexural design parameters are considered independently and combined per the applicable equation. Thus the applicable limiting width-thickness ratio for uniform compression from Table B4.1 is used in determining P_c , and the applicable limiting width-thickness ratio for flexure from Table B4.1 is used in determining M_c.

2 One-half of the gross area of the round HSS based on the design wall thickness is used in the shear check, which also includes parameters for shear buckling based on the diameter of the HSS. See Section G6 of the 2005 AISC specification for details.

3 Nominal strength is the unreduced strength of a structure or component (without the resistance factor or safety factor applied) determined in accordance with the AISC specification. This is an estimate of the load that would be achieved in laboratory testing. Design strength is the nominal strength multiplied by the resistance factor, used with the LRFD load approach. Allowable strength is the nominal strength divided by the safety factor, used with the ASD load approach.

4 **False**. The available strength of members and connections can be determined from applicable provisions of the current AISC specification. See Appendix 5 of the 2005 specification for evaluation of existing structures.

5 **True**. Table 12.2-1 of ASCE 7-05 permits structural steel buildings in seismic design categories A, B, and C to not be specifically detailed for seismic resistance if an *R*-factor of 3 is used in the design. Steel building structures classified as seismic design category D, E, or F are required by ASCE 7-05 to be detailed per the AISC *Seismic Provisions*. Note also that if *R* is taken greater than 3 in categoires A, B, or C, the structure must be detailed per the AISC *Seismic Provisions*.

6 **Yes.** However, the shims must also meet the faying surface requirements. For finger shims up to ¼ in. in slip-critical connections with standard holes, no reduction is necessary. Above ¼ in. thickness, the slip resistance is reduced to that for short-slotted holes. See Section J3.2 and J3.8 of the 2005 AISC specification for details.

7 **True**. As defined in Section F2.1 of the 2005 AISC specification, the nominal flexural strength for yielding is $M_n = M_p = F_yZ_x$. For those familiar with previous versions of the ASD approach, note that this similar concept of plastic distribution was hidden in the specification, which permitted a 10% increase for compact shapes ($F_b = 0.66F_y$ in lieu of $F_b = 0.60F_y$). This increase was provided assuming that the lower-bound shape factor (Z_x/S_x) for a W-shape is 1.1 (the range is from 1.1 to 1.4, approximately). The 2005 AISC specification permits the use of the actual Z_x for the specific shape.

8 **Yes.** Section M2.5 of the 2005 AISC specification states that "thermally cut holes shall be permitted with a surface roughness profile not exceeding 1,000 µin. (25 µm) as defined in ASME B46.1. Gouges shall not exceed a depth of 1⁄16 in. (2 mm)." Thermally cut is defined as cut with gas, plasma, or laser.

9 For connections, the total bearing resistance is taken as the sum of the bearing resistances of the individual bolts. In other words, the bearing resistance at each individual bolt hole is determined, and the sum of these is used to determine the available strength of the connection for this limit state.

10 As defined in the 2005 AISC specification, an HSS is a hollow structural section, which includes square, rectangular or round shapes produced in accordance with a pipe or tubing product specification. Don't confuse this definition with the actual ASTM specifications for the particular material types. Pipe used for structural steelwork, as defined in Section A3 of the 2005 AISC specification, is ASTM A53 Grade B (F_y = 35 ksi); round HSS is ASTM A500 Grade B (F_y = 42 ksi) or Grade C (F_y = 46 ksi).

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**.

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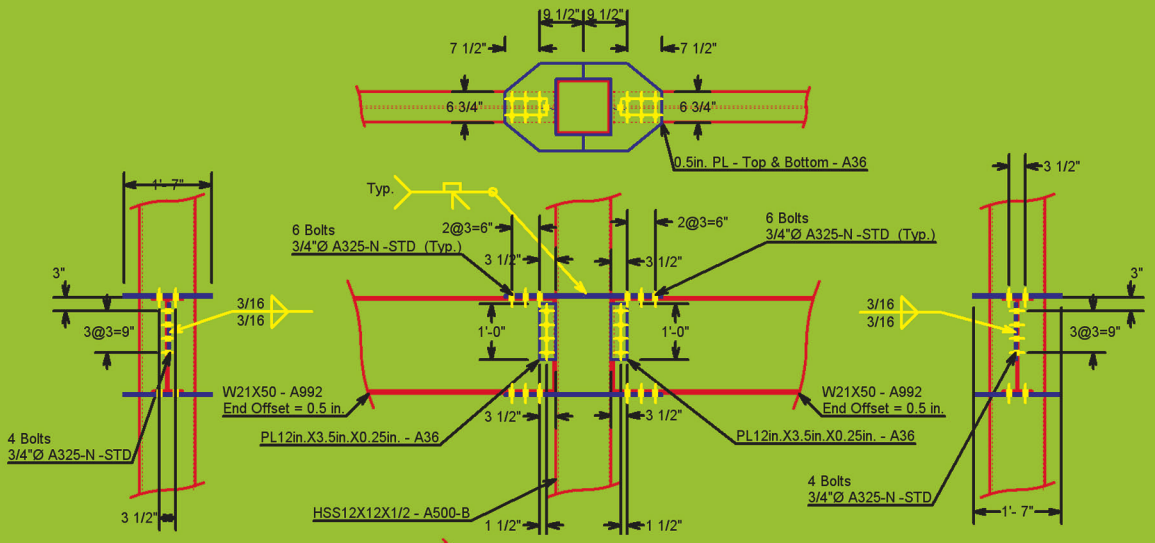

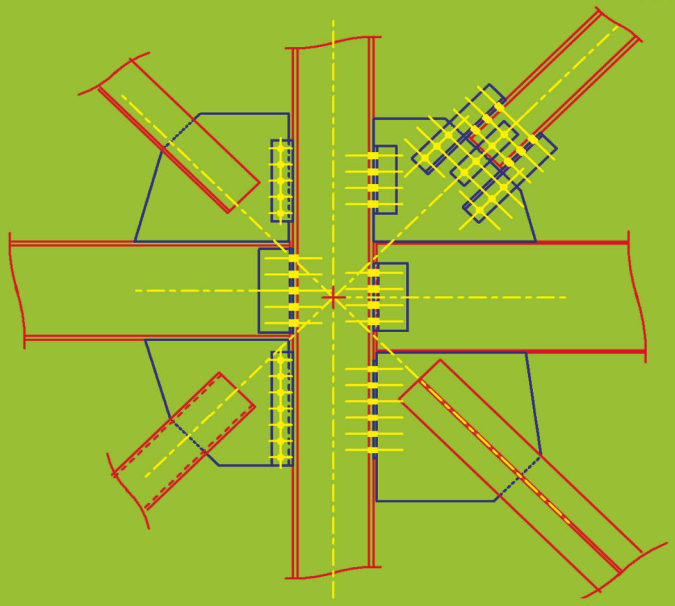

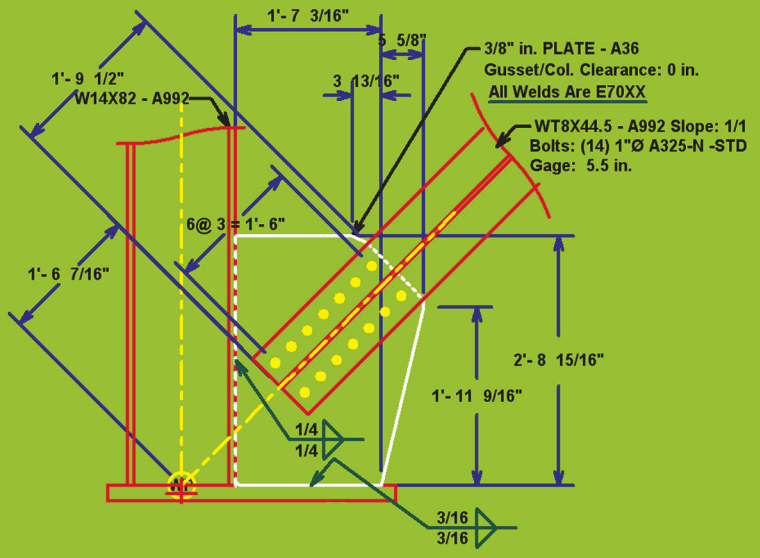

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CERTIFICATION

AISC to End Sponsorship of Metal Building Certification Program

The American Institute of Steel Construction (AISC) and the Metal Building Manufacturers Association (MBMA) have jointly decided to end AISC's sponsorship of the Metal Building Certification Program effective December 31, 2008, or 12 months from the date of the final participant's 2008 audit, whichever comes later.

"AISC is focusing its certification efforts on its revitalized fabrication, erection, and bridge certification programs," explained Roger Ferch, president of AISC. The termination of this program is not a reflection its quality or importance, but rather reflects a concentration by AISC on its core market and participants. "The timing of the transition is designed to give MBMA time to transition to a new sponsor," Ferch explained.

"MBMA is currently in the process of selecting a new sponsor/administrator for the program, and anticipates that the transition to the revised metal building certification program under this new sponsor will be seamless, and that there will be no interruption in a company's certification," explained Bill Savitz, chairman of MBMA.

The Metal Building Certification Program began in 1989. The program is often referenced in project specifications and is designed to assure that certified companies have the manufacturing and engineering capabilities necessary to design and fabricate a quality metal building system.

Both Ferch and Savitz stressed that the two organizations have valued their relationship and expect to continue working together on a variety of future projects. Currently, the two organizations are working jointly on a tapered member design guide as well as seismic research.

For more information on the current program and a list of participants, please visit **www.aisc.org/metalbuilding**. For more information on metal buildings, please visit **www.mbma.com**.

BOOKS

New Handbook for Civil and Environmental Engineers Addresses Risk and Reliability Analysis

When it comes to the planning, design, construction, and management of engineering systems, risk and uncertainty are unavoidable. The consideration of the risk involved in any situation, project, or plan becomes an integral part of the decision-making process. *Risk and Reliability Analysis: A Handbook for Civil and Environmental Engineers* presents key concepts of risk and reliability that apply to a wide array of problems in civil and environmental engineering.

The authors begin with an overview of the art of making decisions in the presence of uncertainty and then explain the fundamentals of probability that will be applied throughout the book. In the second part of the book, the authors discuss various techniques used in probability distributions and parameter estimation. A third section of the book considers different aspects of uncertainty analysis, especially risk analysis and risk management, providing instructive examples. The final group of chapters addresses reliability analysis and design, focusing particularly on the important area of water distribution networks.

Ample illustrations and detailed real-life examples make *Risk and Reliability Analysis* essential reading for present and future engineers in the fields of civil, environmental, biological, and agricultural engineering, as well as the watershed sciences.

To order, call 800.548.ASCE (2723) or visit **www.pubs.asce.org**. The ASCE member price is $120.00.

Correction

The detailer for the Springwater Trail (McLoughlin Blvd.) Pedestrian Bridge in Portland, Ore. (November, p. 75) was AISC Member Graphics for Steel Structures, Inc. AISC Member Fought & Company, Inc. was the fabricator for the project. We regret any confusion caused by the error.

CONFERENCES

Register Now for The Steel Conference!

Register now for the 2008 North American Steel Construction Conference! More than 3,000 engineers, fabricators, erectors, and detailers are expected to register for The Steel Conference, which will take place April 2-5 in Nashville, Tenn. See the advance program in this issue or visit **www.aisc.org/nascc** for a complete schedule of conference events and instructions for preregistration.

With nearly 90 technical sessions, The Steel Conference is the industry's premier education event. It provides structural engineers, steel fabricators, erectors, and detailers with practical information and the latest design and construction techniques. The conference is a key networking opportunity. Its extensive trade show features products and services ranging from fabrication machinery, galvanizing, and connection products to detailing and engineering software. The conference also incorporates the Structural Stability Research Council's Annual Stability Conference. Online registration is available through March 27, 2008. After March 27, registrations will be taken on-site, but at higher rates.

ONLINE RESOURCES

Annual Meeting Presentations Online

In response to a large number of requests by attendees, the speaker presentations from the 2007 AISC Annual Meeting are now available for download by AISC members. The presentations include:

- ✓ *Attracting and Retaining A Quality Workforce* (Andrew Patron from FMI Management)
- ✓ *Immigration Reform Update* (Patrick Cont from Strum & Cont)
- ✓ *Four Generations* (Cam Marston from Marston Communications)
- ✓ *Moving Your Business a Generation Ahead* (Wayne Rivers from the Family Business Institute)

The downloads are only available to members. To access the files, visit **www.aisc.org** and click on the Membership tab, then click on the Annual Meeting Sessions link.

AWARDS

Walterio Lopez and Rafael Sabelli Win 2008 T.R. Higgins Award

Buckling-restrained braced frames (BRBFs) are an increasingly popular new steel seismic load resisting system that has demonstrated efficiency and exceptional seismic performance. Based on their groundbreaking paper "Seismic Design of Buckling-Restrained Braced Frames," Walterio Lopez and Rafael Sabelli are being honored with the T.R. Higgins Lectureship Award. "BRBFs have the potential to significantly impact the structural steel market in seismic regions," explained Louis F. Geschwindner, AISC's vice president of Engineering and Research.

A new paper based on the work will be presented for the first time at the 2008 NASCC: The Steel Conference in Nashville April 2-5, 2008. For more information on the conference, visit **www.aisc.org/nascc**.

Their work has already been published by the Structural Steel Education Council and has helped BRBFs to be accepted in ANSI/AISC 341-05 Seismic Provisions for Structural Steel Buildings and in the International Building Code. Included in their paper is a detailed component design of two typical BRFB configurations and the development of testing protocols. In addition, a discussion of gusset-plate design and its influence on acceptable frame behavior is provided.

The T.R. Higgins Lectureship Award, which includes a $10,000 cash prize, is presented annually to an outstanding lecturer(s) and author(s) whose technical paper or papers are considered an outstanding contribution to the engineering literature on fabricated structural steel. For more information on the T.R. Higgins Award, visit **www.aisc.org/higgins**.

letters

Weight vs. Cost

Scott Melnick's recent comments about weight vs. cost invoke a long-standing sore point with me. It has often taken hours of discussion and many design alternatives to prove the point.

One argument that I have not been able to get much traction with is the concept of pounds per *cubic* foot of building volume: As floor-to-floor heights increase, whether they are trading floors in high-rises or roofs over warehouses, weight per square foot will increase since the columns are longer with no increased floor area to compensate. In very tall buildings this can easily add one pound per square foot.

Now that I am on the developer's side of the table, I have been able to defend the consultant when he/she gets beaten up on the pounds per square foot numbers.

It would be interesting to learn whether others have considered this concept. Maybe we can start something. Keep up the good work.

Irwin Cantor
Tishman Speyer

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A Royal Addition

BY SHAHÉ SAGHARIAN, P. ENG.

A modern, angular addition to Toronto's Royal Ontario Museum uses steel to augment the existing historic structure.

IN 2001, THE ROYAL ONTARIO MUSEUM (ROM) IN TORONTO EMBARKED ON A MISSION TO REJUVENATE AND EXPAND ITS HISTORIC FACILITY. The first order of business was to establish an international design competition, one that would attract renowned architects from around the globe. Studio Daniel Libeskind (SDL) was eventually selected to design the project, and six years later, ROM's Michael Lee-Chin Crystal addition has come to fruition. The new angular structure is adjacent to, and also overlaps, ROM's classic façade.

From the onset, it was clear that structural steel was the right material for the job, as it was the only solution that could make the vision conceived on the famous "Libeskind napkin sketch" a reality. The engineering team recognized that the irregularity of the structure would amplify gravity forces and needed to be as light as possible. The site limitation also required minimum construction staging space and quick erection. Arup and SDL team members who had already experienced SDL's Denver Art Museum, a project with similar structural demands (April 2007, p.30), shared the lessons learned with the rest of our group, including the owner and construction manager.

Design Stage

Early in design, a process was implemented between the architects and the structural engineers that provided a virtual space where the steel members had to "live" and established "no-fly zones" for the rest of the building systems to work around. The architectural modeling work was carried out using Form-Z software, and then the plans were imported into AutoCAD where individual floor and diagrid elements were modeled by the structural engineers. The architects used this line work to review the structure and coordinate with their design.

Once the geometry was finalized, the line work was imported into finite element design and analysis programs. At the preliminary stages, GSA (a structural analysis software package developed by Arup) was used for its capability to provide a better graphic interface with other software being used. In the final production stage, SAP 2000 was used for its compatibility with X-steel (now Tekla Structures), which the team predicted would be implemented during detailing. After ironing out a few translation and communication issues between the different software

products used, this process proved to be extremely valuable.

At the preliminary stages, custom-built skewed tube sections were specified at various locations, including the corners where the diagrid planes met. By collaborating with the fabricators, we learned that the fabrication of these custom sections was not going to be economical and timely. Although it was the correct response to provide box sections that were torsionally stiff and achieved concentric corner details, it was evident that the local market demanded the use of sections that were readily available. It was obvious that the custom-made box sections had to be redesigned to allow the use of readily available wide-flange sections.

Detailing Stage

The file transfer protocol that was adopted during the design stage was complementary to the protocol adopted during detailing and fabrication stages. The team added one more step to the file exchange process. Once the structural steel elements were designed in SAP, the geometry and the section properties were forwarded to the detailer. The detailer then imported the line work into Tekla Structures, where the single-line work was converted to actual extruded sections. The extrusions were rendered and then exported into Form-Z for compliance review. Once the geometry was coordinated, the changes were fed back into the structural design and analysis program in order to revise the design and load paths. The extra efforts made during the detailing stage eliminated almost all problems during fabrication.

Royal Ontario Museum © 2007

Fabrication

The fabrication process was, in a word, intriguing. The complex geometry required that many members be framed into a single node from many different directions. Shop personnel had to be equipped with laptops in order to visualize the 3D models of the nodes and execute their work. One of the more complex nodes required a shop drawing that was 5 ft wide by 8 ft long with more than forty views of the node. This process proved yet again that extra time spent in the shop pays off during erection.

Since the structure was irregular, a conventional grid system could not be established. A general grid system was in place that identified the diagrid and floor planes with their corresponding crystal form. However, an unconventional naming system was also adopted to identify the various connection locations that could not be referenced to the grids. Metaphoric names such as "Owl's head," "Thore's brother's broken leg," (named for an SDL team member), "Stair of wonder," and the "Pinnacle" were used to reference these locations.

Construction Engineering

The construction managers identified the proper construction sequence to enable other trades to move into the building and start their work while the steel structure was partially erected. But the team was concerned that the partially erected steel structure might not behave as modeled and designed, and hired Halsall to carry out the construction engineering and to provide the necessary staging sequence to reflect the schedule needs.

Halsall's job was to ensure that the partially erected structure did not experience overstressing due to locked-in forces, as well as to predict the behavior of the partially erected sections to avoid misalignments for later erection. Roughly fourteen different partially built analysis models were created that addressed the partially erected structure and the sequencing of shoring installation and removal. Additional steel elements had to be introduced to compensate for the missing floor diaphragms, and shoring had to be added to maintain the geometry of the partially erected sections. It was crucial to maintain the building's geometry due to the proximity of the new structure to the ROM's existing 1914 and 1933 buildings on three sides of the site, as well as to accommodate the cladding that had already started the detailing process.

The extra efforts made during the detailing stage eliminated almost all problems during fabrication.

This process worked flawlessly. A number of monitoring targets were added all around the structure and checked at various stages of erection and after each concrete floor was constructed. The building structure behaved as predicted at all different stages of construction. The erection

Royal Ontario Museum © 2007

Aerial view of the Royal Ontario Museum.

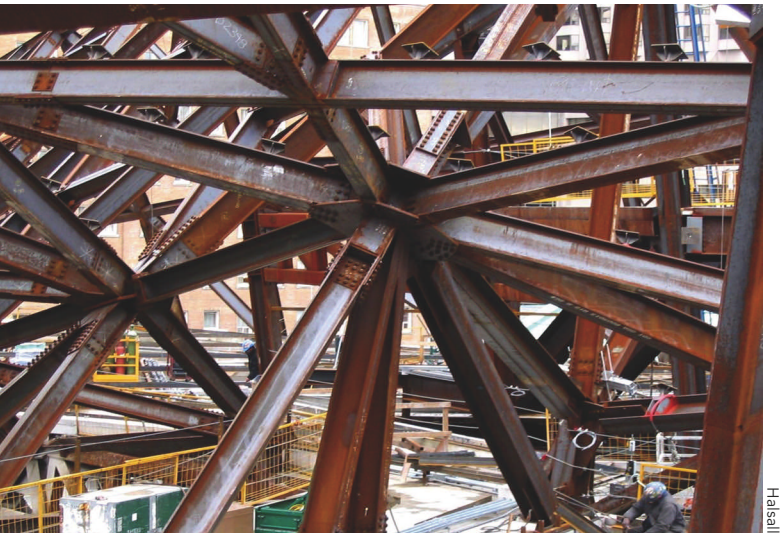
Fabrication Bidding

At the design development stage, the team visited several local steel fabricators to understand their capacities and capabilities. It was evident that close interaction was needed between the steel fabricators and the design team, so employing a fabricator that was geographically close to the team and the project was a very important consideration.

With this knowledge in hand, the team tendered the project to four pre-qualified steel fabricators. The bidders were tasked with providing a guaranteed maximum price, ideas on fabrication and erection, and a detailed schedule of deliverables to expedite the steel work.

All four bids demonstrated excellent understanding of the work and had various approaches to detailing and building this structure, but only one firm could be chosen. Immediately after awarding the steel contract, the A/E/C team and the fabricator began the design interaction and implementation process. The challenge was to detail and fabricate the steel in order to have it ready for erection as soon as the sub-grade work was complete.

Royal Ontario Museum © 2007



Halsall

Left, top: Interior spaces prominently feature the structure's unusual geometry.

Left, bottom: Due to the complexity of the structural nodes like this one, shop personnel had to be equipped with laptops in order to visualize their work in 3D.

was completed with minimum modification on-site, and few coordination issues arose.

At times, the challenges appeared overwhelming. Despite this, the building team was able to create the landmark architectural icon that the ROM envisioned. And given the effort that went into the steel work, some of the complex steel structures were left exposed, giving museum patrons a glimpse of the skeleton. MSC

Shahé Sagharian was Halsall's project principal for the ROM Michael Lee-Chin Crystal addition.

Owner
Royal Ontario Museum, Toronto

Architect
Studio Daniel Libeskind, New York/B+H Architects, Toronto – Joint Venture

Structural Engineer
Arup, London
Halsall Associates Ltd., Toronto

Construction Manager
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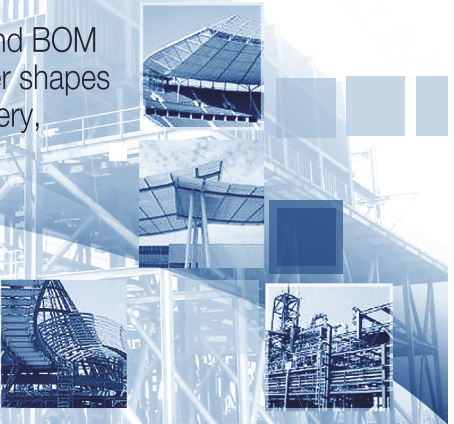

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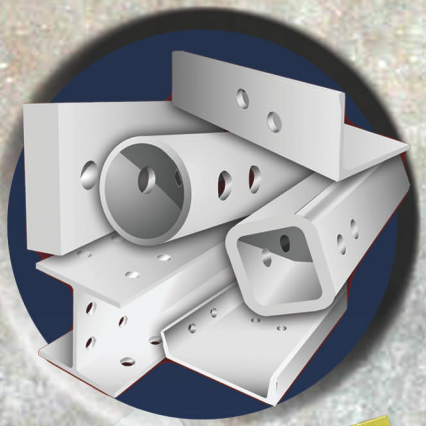

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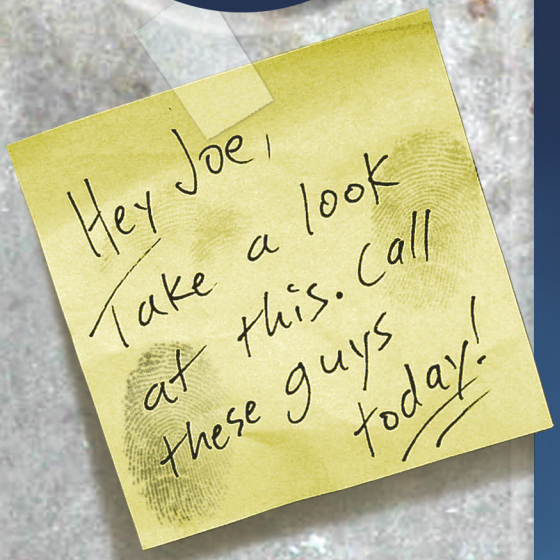

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A Garden of Steel Flowers

BY MAURICIO GUTIÉRREZ VILLA

Hollow structural shapes help Medellín's Botanical Gardens blossom into a new icon for the city.

IT USED TO BE THAT WHEN YOU THOUGHT OF MEDELLÍN, COLOMBIA, YOU THOUGHT OF CRIME. But the twenty-first century version of Colombia's second-largest city paints a different picture. For the last decade or so, local administrators have focused on boosting the city's image and have poured significant funding into public parks, convention centers, libraries, and public transportation. In the process, Medellín has also become a city of avant-garde architecture—much of it using structural steel.

A new canopy shelter at Medellín's Botanical Gardens is perhaps one of the most representative icons of the city's recent improvement. Set on a small piece of native jungle in the heart of the city, the old Botanical Gardens were practically abandoned, with old enclosures that didn't attract local or foreign visitors and were deemed not worth restoring. However, the current local government—particularly in response to increased environmental awareness and conservation efforts—decided to transform the place into one of the most important landmarks of the city, one that would bring in tourists and also provide a base for scientific research.

In Harmony with Nature

With the new $2.2 million (USD) canopy enclosure (part of an overall renovation of the Botanical Gardens), the architects created a monument to nature, harmonizing the design with local natural symbols; bee hives and orchids—Colombia's national flower—served as inspiration for the project. The new enclosure covers an open plaza area and is constructed in the form of 10 huge steel "flowers," each made up of multiple hexagons. From the sky, the structure appears as a giant honeycomb in the middle of the jungle.

The enclosure is 59,000 sq. ft (5,900 sq. ft per flower), making it suitable for large outdoor events, and the flower structures are modular, allowing for future expansion. Each flower is 50 ft tall and weighs 62,000 lb.

The flower structures were fabricated with round HSS of diameters between 2 in. and 12¾ in. in ASTM A500 Grade C steel. Each flower was composed of more than 700 steel elements of various sections, diameters, lengths, and directions, creating a very intricate detailing process in terms of the welded connections.

The roof of the enclosure was made from standing seam tile, galvanized and pre-painted, and modified polycarbonate. On the inside, each flower was covered with immunized cypress wood slats with large

Above: From the air, the steel canopy appears as a giant honeycomb.

Left: Constructed of round HSS of varying sizes, the steel flowers consist of more than 700 members each.

gaps between the slats, allowing visitors to view the steel structure. Due to Medellín's humid, tropical climate, the coating used for the structure was an epoxy base with finished epoxy paint.

The project's most significant challenge was that of time; it was necessary to complete the project within five months. And of course, construction took place during the most brutal rainy season of the last several years. The schedule was impossible to modify, as the structure had to be completed in time for the Feria de las Flores (Flower Festival), where the Botanical Gardens play an significant role.

Already a Winner

In April, the Botanical Gardens project was awarded the Colombian design prize Lápiz de Acero (Steel Pencil) for the best project of the year in terms of quality, aesthetics, and harmony with its surroundings, as well as for its practicality, environmental friendliness, and functionality.

With the Botanical Gardens and other projects over the past few years, Medellín has gone a long way in changing its late 20th century image and aims to present itself to the world as a city full of dynamic, architecturally significant—and steel-framed—buildings. MSC

Mauricio Gutiérrez Villa is a mechanical engineer with ESTACO S.A. in Medellín, Colombia.

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City of Medellín

Architect
Plan B and JPRCR

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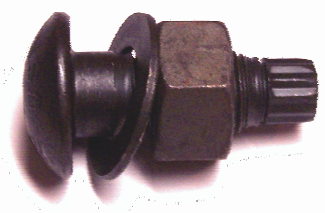

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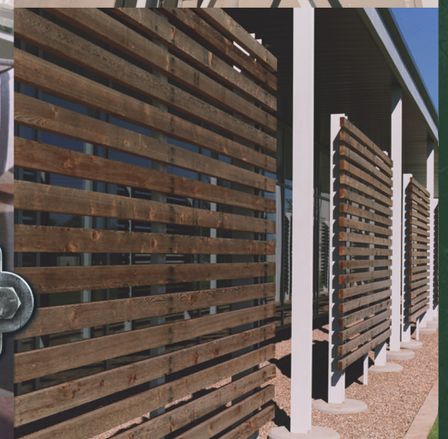

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Building in Beijing

BY MARK SARKISIAN, P.E., S.E., NEVILLE MATHIAS, P.E., S.E., AND AARON MAZEIKA, P.E.

Steel provides the support for two new high-profile atriums in China's capital.

IT'S NO SECRET THAT CHINA'S ECONOMY HAS BEEN ON THE RISE IN RECENT YEARS, AND PROMINENT STRUCTURES HAVE BEEN GOING UP AT A RAPID PACE. And as expected, this construction surge has provided some unique structural design opportunities, especially in the country's larger cities. Two recently completed projects in Beijing, both designed by Skidmore, Owings & Merrill LLP, illustrate this phenomenon. The first, the New Beijing Poly Plaza, is a composite office tower incorporating the world's largest steel cable net-supported glass façade. The second is Beijing Finance Street, a mixed-use development consisting of 700,000 m^2 (7.5 million sq. ft) of framed office, retail, and residential space. The centerpiece of this development is a retail mall enclosed by a 300-m (980 ft) skylight supported by architecturally exposed steel trusses.

New Beijing Poly Plaza

Taking a look at the New Beijing Poly Plaza, the project is prominently located at a major intersection along Beijing's second ring road, northeast of the Forbidden City. The site's primary orientation is northeast towards the intersection and beyond to the client's existing headquarters building. The triangular form minimizes the perimeter surface area exposed to the elements, while a series of atria provide additional interior surface area to give office areas maximum access to daylight. The result is a simple "L" shaped office plan that cradles a large atrium. The exterior walls of the atrium are comprised of minimal glass membranes supported on two-way cable nets in order to maximize visual and solar transparency. In order to accelerate the construction schedule—and to accommodate the complex geometry of the building form—SOM selected a composite structural system employing both reinforced concrete and structural steel. The base building structural system consists of three reinforced concrete cores acting compositely with structural steel moment resisting frames. Floor framing consists of structural steel trusses at 13.5-m (44.2 ft) spans and rolled sections at 9-m (30 ft) spans. Moment resisting frame beams and columns used ASTM A913 grade 65 steel imported from Europe, while locally produced steel was used in gravity framing.

Tim Griffith

An Exotic Solution?

While conceptually simple, cable-net systems may still be considered an exotic solution for the structural support of glass curtain walls. However, the completion of several major walls around the world has established a proven track record of an achievable scale and level of transparency. Planar two-way cable systems support and stabilize glass façades through the resistance to deformation of the two-way prestressed net. Gravitational loads from the glass elements are carried through the attachment nodes to the vertical cables, and up to a transfer structure in the base building above. Lateral deformations due to wind and seismic loadings are resisted by the tendency of each of the horizontal and vertical cables to return to its straight line configuration between supports, while being subject to a perpendicular force. The flexible nature of a planar cable-net under lateral loading means

that the critical design goal is limiting deflection through adjusting axial stiffness of the cables, as well as the cable pre-stress. Deflection limits of L/40 to L/50 are generally set for the design loading condition (typically, a 50-year wind event) to protect the integrity of the glass and sealants and to minimize a perception of weakness by the building's occupants.

For more on cable-net walls, please see "Getting Started with Cable-net Walls" from the April 2007 issue (available in the Archives section at **www.modernsteel.com**).

The Challenge

The New Beijing Poly Plaza project is 110 m (360 ft) tall with a 90-m-tall (300 ft) atrium enclosed by a cable-net glass wall, 90 m high by 60 m wide (300 ft by 200 ft). The scale of this wall greatly exceeds those that have been built before, introducing specific challenges that are not critical in smaller walls. SOM's preliminary analysis showed that the cable-net spans were too large to be economically achieved using a simple two-way cable-net design. We determined, however, that the cable-net could be achieved by subdividing the large cable-net area into three smaller zones by folding the cable-net into a faceted surface, and introducing a relatively stiff element along the fold lines. The faceted cable-net solution allows the individual sections of the cable-net to span to a virtual boundary condition at the fold line, effectively shortening the spans. Rather than introduce a beam or truss element to stiffen the fold line, a large-diameter cable under significant pre-stress was used. The largest of these primary cables is 275 mm (11 in.) in diameter and consists of a parallel-strand cable bundle of 199 individual 1x7 strands (a strand consisting of six wires twisting around a single straight wire), each strand being 15.2 mm (0.60 in.) in diameter. The largest cable is pre-stressed to 17,000 kN (3,800 kips) and experiences a maximum in service loading of 18,300 kN (4100 kips) during a 100-year wind event. Using the faceted design solution, the typical horizontal and vertical cables are limited in diameter to 34 mm and 26 mm (1.3 in. and 1.0 in.) respectively. The composite base building structure proved well-suited to the cable-net installation, as two of the three reinforced concrete cores were located at the sides of the cable-net to act as stiff boundary conditions resisting the cable pretension forces, and also providing an ideal location to access the cable anchorage points and to facilitate tensioning operations. The remaining boundary conditions were provided at the bottom of the net by the concrete structure at ground level, and at the top by a three-story-tall structural steel truss spanning 60 m (200 ft) between the top of the two cores.

Tim Griffith

"Rocker Mechanisms"

By introducing the large-diameter diagonal cables, one problem is created while another is solved. As the base building structure is subject to seismic and wind loads and experiences inter-story drifts, connecting a point on one floor slab to another point 45 m (150 ft) higher up the structure with an axially stiff element, the diagonal cable behaves as a brace and tries to resist the base building drift. Thus analyzed, the brace forces were too great to be resisted by the main cables or the attachments to the base building structure. However, when the base building drifts in a direction that causes one diagonal cable to go into tension (tries to lengthen), the other cable that forms part of the "V" con-

figuration goes in compression (tries to shorten). A pulley analogy was developed that allowed the "V" cables to be considered as a single element, with rotation at the base of the V allowing the length increase of one cable to be offset against the length decrease of the other cable. This allows the base building to drift without significantly increasing or decreasing the level of prestress in the main cables. The pulley analogy was realized in a buildable form as a cast "Rocker Mechanism." By crossing the cables and connecting to the rocker casting arms, the need to provide curved pulley surfaces and curved sections of the main cable were eliminated. Each of the two rocker mechanisms consisted of six unique steel castings, each weighing up to 8 tonnes (18,000 lb), with solid material thicknesses of up to 800 mm (32 in.).

Construction

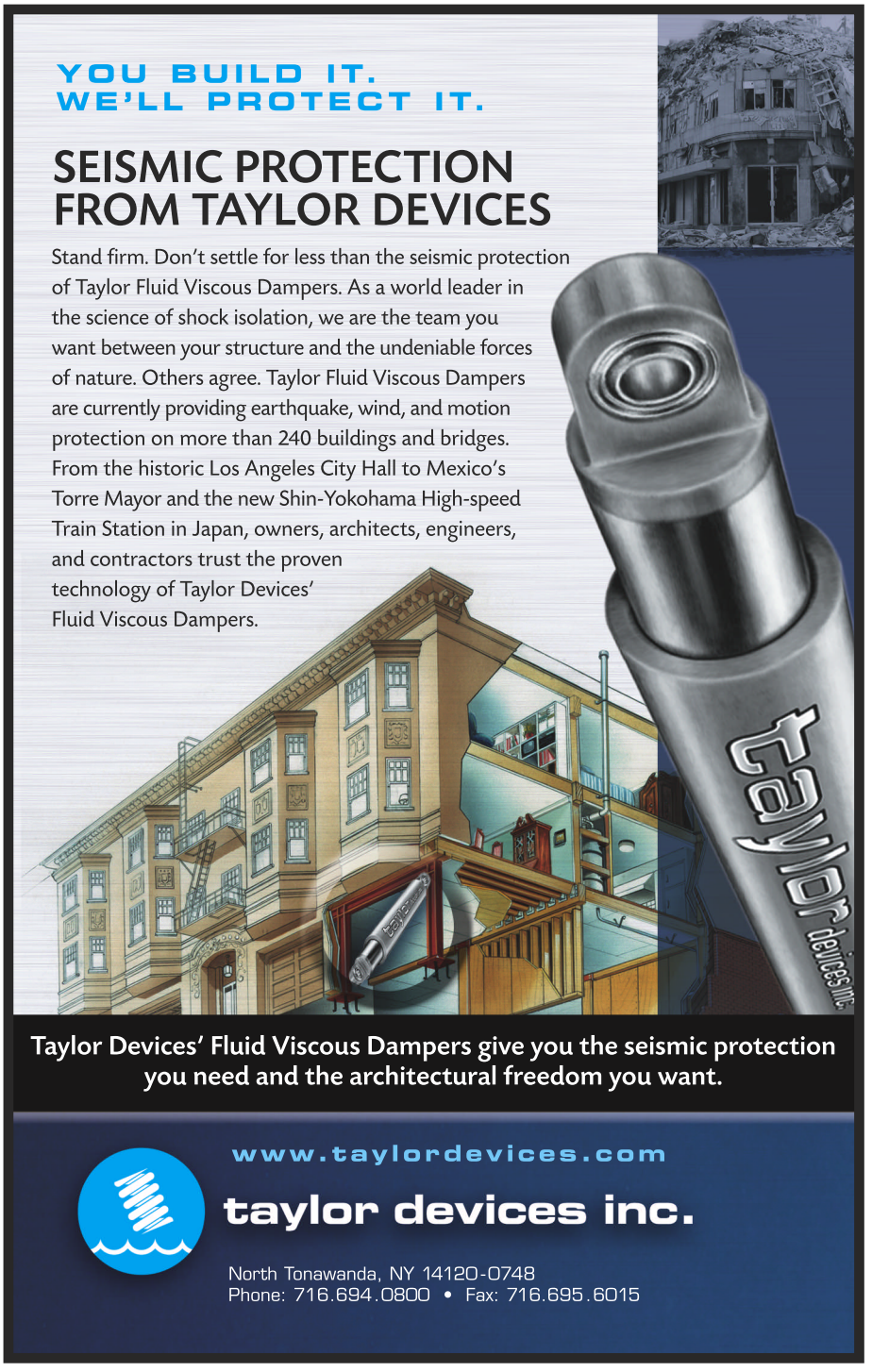
The installation of the cable-net wall required that the base building structure be topped out before any cable installation operations could occur. The base structure was constructed with the structural steel floor framing following several stories behind the concrete cores. Once the boundary elements were in place, the installation of the rocker mechanisms began. Each of the castings were hoisted into place, then connected together to form the mechanism. With the rocker mechanisms temporarily shored in place, the main V cables were installed and tensioned. Using technologies developed for the installation of cable-stayed bridge cables, each of the 199 strands were tensioned in a carefully planned sequence to result in an even distribution of force in the final condition. With the V cables installed and tensioned, the smaller cable-net cables were then loosely located in place and incrementally tensioned up to the design pretension level, then the glass support nodes were tightened and the glass was installed and sealed.

Performance

The critical service level load condition (the 50-year wind event) was determined through careful wind engineering studies performed by Beijing University. The wind studies included a traditional rigid model of the building massing, as well as that of the surrounding building fabric, and an aero-elastic wind tunnel study performed on a flexible model of the actual cable-net configuration. This latter study used wires and a membrane to replicate the anticipated dynamic response of the cable-net system. This study, likely the first of its kind to be performed on a cable-net curtain wall system, was used to verify and modify, where appropriate, the results of the rigid model. Analysis and testing shows that the New Beijing Poly cable-net wall behaves very much as conceived. The results from the static non-linear (large displacement) analysis clearly show that the strategy of subdividing the wall into facets with shorter individual spans was indeed successful. This strategy allows the overall displacements to meet the L/45 deflection limit between hard boundary conditions established for the project, while maintaining the economic viability of the project. MSC

Architect and Structural Engineer
Skidmore, Owings & Merrill LLP, San Francisco

Local Design Institute
Beijing Special Engineering Design & Research Institute, Beijing, China



Beijing Finance Street – F9 Retail Project

Tim Griffith

The buildings in this carefully planned development are decidedly modern, reflecting Beijing's strong position in international commerce. Beijing Finance Street's many architectural and landscape elements are all clustered around a park, which is the project's core. Opening onto the park is the Great Urban Atrium. This crescent-shaped building—the most engaging component of the project, with a sharply slanting roof and exposed diagonal trusses—provides a vibrant indoor urban space and, being adjacent to the park, enhances the complex's role as a gathering place.

"Butterfly Trusses"

The roof of the cavernous 300-m-long (980 ft) atrium retail space is intended to establish a theme of transparency that is present throughout the development. Exposed structural steel "butterfly trusses" are key components. Each is formed by tipping two planar single-kingpost trusses towards each other, resulting in a three-dimensional "V" kingpost butterfly truss. Spanning up to 30 m (100 ft), the single-kingpost trusses provide a long-span solution using a minimum number of structural elements. As the top chord of each truss is effectively point-supported at its ends and at one point within the span (at the ⅔ point along the length of the truss when viewed in plan), bending forces on the top chord are significant. Large-diameter steel circular hollow sections, specified per American Petroleum Institute standards for pipe sections, were used to resist the combined axial and bending forces resulting from this truss configuration. The lack of bracing elements between the top and bottom chord, as well as the visual weight of the 457-mm-diameter (18 in.) pipe truss top chords relative to the 25-mm- to 37-mm-diameter (1 in. to 1.5 in.) cable bottom chords, results in the appearance of slender parallel beam elements spanning the atrium.

The reinforced concrete retail buildings that support the retail roof are subdivided into independent structures with a maximum dimension of 90 m (300 ft). The structures were also subdivided by the natural building break that occurs at the atrium. As a result the roof needs to span between six independent structures. A typical solution to this type of relative movement issue is to provide sliding supports at one end of each of the trusses. However, due to the slope of the roof trusses, the high end of the trusses are supported atop free-standing columns that extend up to 11 m (36 ft) above the roof of the supporting concrete structure. This condition reduces the applicability of a sliding detail.

Ultimately, the high-end columns were also the source of the design solution to the "dynamic" support issue. By providing articulated ball-and-socket joints at the top and bottom of the high-end columns, the columns and trusses become components in a three-pinned arch roof system. Relative move-

Tim Griffith

ment between the supporting structures is accommodated by the articulation of the joints. When the supporting buildings move closer together and further apart along the axis of the roof trusses, the enclosed angle at the apex of the roof closes and opens. The glazing system is jointed to allow this rotation without damage. When the relative movement between supports is perpendicular to the axis of the truss, the top of the high-end columns effectively moves with the low-end support point due to the diaphragm bracing in the plane of the sloped skylight. The bottom of the high-end columns conversely moves with the high-end support point. This causes the south wall of the roof system to rack in-plane.

The glazing for the south wall is supported in horizontal courses that are allowed to slide relative to each other as the columns rack. Due in part to the dynamic nature of the support conditions, the kingpost truss arrangement was developed to result in the three-dimensional truss configuration that has additional out-of-plane stiffness. Lateral forces induced in each of the roof sections are transferred to one of the supporting structures (through the low-end columns) by the use of diaphragm bracing rods.

Construction

Originally designed to allow for the fabrication and tensioning of each of the butterfly trusses at ground level, the truss design could accommodate the lifting and installation of each three-dimensional truss without any requirement for shoring. However, after construction of the reinforced concrete supporting structures was completed, the contractor elected to install a scaffolding system filling the full volume of the retail atrium, allowing each of the truss top chords to be installed independently with continuous gravity support along its length. The truss elements were then connected together, and the steel cable bottom chords were installed and tensioned in-situ. MSC

Architect and Structural Engineer
Skidmore, Owings & Merrill LLP, San Francisco

Local Design Institute
China Academy of Building Research, Beijing

Mark Sarkisian is a partner, Neville Mathias is associate director, and Aaron Mazeika is an associate with Skidmore, Owings & Merrill LLP in San Francisco.

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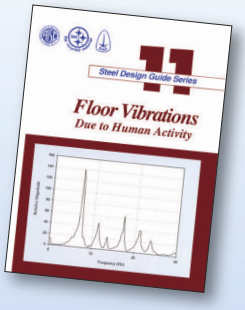

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Essential Elements

BY KEN JONES

London's new O_2 Arena uses a steel roof, erected with an innovative lifting operation, to top what was designed to be Europe's most acoustically advanced concert venue.

THERE'S BEAUTIFUL MUSIC COMING FROM GREENWICH, LONDON. More specifically, it's coming from the new O_2 Arena. Built within London's existing Millennium Dome structure, the recently opened arena provides London with a 22,000-seat state-of-the-art entertainment venue. Designed to be the most technically and acoustically advanced concert arena in Europe, it also plays host to multiple sporting events.

Geometry and Design

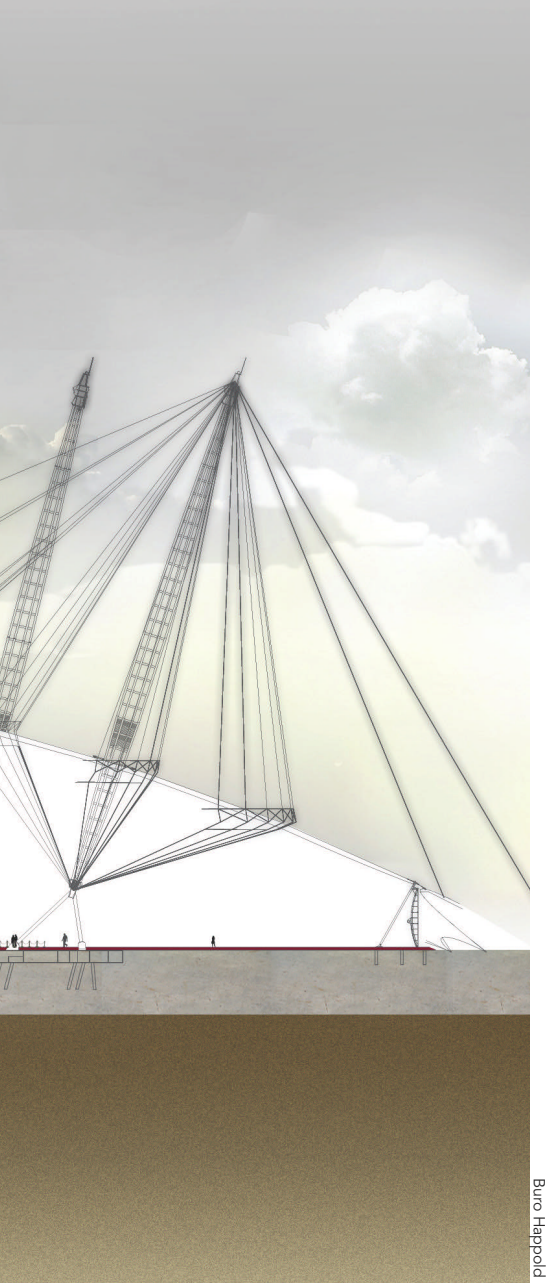
The spherical surface of O_2 Arena's roof has a radius of 1,145 ft and is exactly parallel to the surface of the dome canopy above. (The project's structural engineer, Buro Happold, also designed the original award-winning cable-net structure of the Millennium Dome itself, now called The O_2.) The structure comprises intersecting planar trusses of depths varying between 13 ft and 36 ft. The radial trusses cantilever by up to 72 ft beyond perimeter trusses that form a ring inside the roof support bearings and cores. The slender roof edge is dressed with a smooth "bullnose" cladding detail that undulates and seemingly floats in space over the upper concourse.

Buro Happold created a three-dimensional structural model of the project using Microstation, and Structural design analysis was carried out using STAAD.Pro. The ductwork and catwalk systems were fully integrated and coordinated into the design from the outset. The fabricator, Watsons Steel, then progressed with the steelwork production drawings using the 3D model as a starting point. During the initial stages of connection design, Watsons seconded an engineer to work in the Buro Happold offices, which aided the full understanding of the critical joint issues from the project's early stages.

The Roof

Constructing a building within a building created many challenges. For starters, the seating bowl design limited the space available for the new roof construction beneath the existing dome canopy; a minimum 16.5 ft of clearance between the new arena roof and the existing structure was required for building environment and smoke management considerations. The use of standard cranes was clearly not an option because of the proximity of the existing dome structure.

The whole roof was built at ground level, including all catwalks, services containment, ductwork, gondola winch platform, perimeter bullnose, gutters, fall-arrest systems, and acoustic cladding. It was built on



Buro Happold

a series of temporary trestles and then lifted by the strand-jacking method in a virtually completed condition. Working at this low vertical level maximized access and speed of construction and also improved safety.

Roof support was accomplished using only eight bearing points; the roof "floats" above the upper seating bowl and upper circulation concourse. It was lifted by strand jacks acting on the eight permanent support bearing points. The contractor chose to lift the roof in one piece, although the original concept allowed for raising it in several discrete, independently stable pieces, thereby enabling the progressive construction of the building frame below.

Each of the concrete cores at the eight points was designed so that the roof "slotted" into a gap in the core, allowing the roof to be lifted from directly above the bearing point. In two of the cores, several sections of floor slab were eliminated so that the roof steel could move vertically up past the floor edges. These were added at a later date. At four of the cores, quadruped support frames fitted into a free gap. They were hung from the end of the primary truss nodes as a means of lifting them to the top of the cores. Once the roof was positioned at the correct level, the quadrupeds were rotated and dropped onto the top of the core to support the roof.

The Lift Operation

Temporary steel lifting frames, with strand-climbing jacks, were positioned at the head of each core and used to lift the roof. All the jacks were controlled from a central computer, enabling them to be operated individually or simultaneously. Due to a lack of space above the temporary lifting frames, climbing jacks, rather than top-mounted jacks, were used.

Buro Happold worked closely with Watsons Steel and specialist lifter PSC Fagioli on the design of the lifting frames, the lift sequences, monitoring, and method statements. Some of the concrete cores were slender, with tall temporary steel frames mounted on them. Detailed non-linear buckling analysis of the combined roof, lifting frame, and core assemblies was carried out, together with independent checks on the design of the frames themselves, using the analysis results. Developments to the design of the lifting frames were made to ensure a rigorously checked and safe overall build sequence.

Lifting the roof safely required tight dimensional control and monitoring during the operation. The strands needed to remain within only 1 in. of vertical in order to avoid excessive lateral loads to the lifting frames, especially as the strands shortened at the top of the lift. In addition, the roof needed to remain almost perfectly horizontal, within a band of 1.2 in., so that the trusses and connections were not overstressed by a temporary condition in the process.

The lift operation was split into two stages—an 36-ft lift and a 52-ft lift—giving a total roof elevation of 88 ft. Each stage took three night shifts to complete, allowing other construction work to continue throughout the day. Particular care was taken on "lift-off" when the temporary frames rapidly picked up their full load and the roof swung free. During this step, a swing of only 0.40 in. to the north was experienced, which was testament to the accuracy of the construction, positioning, and robustness of the temporary lifting frames. In the three weeks between the two lift operations, the strand jacks were locked off and packs inserted as a precaution to control any tendency toward lateral movement. The roof hung on its strands while work continued to complete the final cladding envelope work, such as movement joint in-fill sections.

The lift progress was hampered by the need to constantly correct for level after every few jack strokes, in order to remain within the required tolerances. Problems with survey monitoring points and survey equipment were encountered periodically, but were overcome. Maintaining a balanced force within a pair of jacks at a single suspension point caused consternation at times. To combat this, movements were surveyed, plotted, and monitored for all core lift points (using survey targets mounted near the top and bottom position of the strands), as well as for some of the slender concrete cores. An automated surveying system was used so that measurements could be taken regularly, allowing the lift to proceed as quickly as possible.

Building the temporary lifting frames was a feat in and of itself, involving smaller jacking processes to push the 12-ton lift beams to within 5 ft of the underside of the existing cable net.

By the Numbers

Arena roof steel: 2,800 tons
Main span: 421 ft
Approx. roof area: 186,000 sq. ft
Seating capacity: 22,000
Primary truss depth: 36 ft (max.)
Primary truss chord: 30-in.-diameter by 2.2-in.-thick tubes
Building height: 154 ft
Roof lift weight: 4,400 tons

Design Features

As predicted and expected, large vertical structural deflections occurred at the time of lift-off from the ground level trestles. This formed an important and unique challenge for the structural design, one that is not often encountered in this way. To accommodate this movement, an extensive network of joints in the steelwork and cladding was incorporated. Steelwork joint movements were monitored before, dur-

Buro Happold/Adam Wilson

Above: The roof structure was built at ground level on a series of temporary trestles.

Below: The roof structure in its final postion.

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Each of the concrete cores at the eight points was designed so that the roof "slotted" into a gap in the core, allowing the roof to be lifted from directly above the bearing point.

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ing, and after the initial lift, and this work showed the structure to have behaved as planned, with joints opening or closing by the predicted amount.

The catwalks and network of rigging beams at the level of the truss bottom chords are configured to support the complex sports lighting requirements and concert rigging demands. A maximum rigging load of 110 tons plus 22 tons of center-hung scoreboard can be suspended in the roof. In addition, the roof is "future-proofed" for possible external conditions, such as wind and snow, in the event that the dome canopy is removed.

The scoreboard can be fully retracted into the roof volume using the winch platform at the center of the roof to make way for in-the-round event configurations. Buro Happold continues to work with and advise the client on specific concert rigging requirements.

Roof Cladding

The cladding is tuned for optimum acoustic performance for break-out, break-in, and reverberation time. It is designed to be the most acoustically advanced venue in Europe. The cladding is also used as a "stressed skin" structure, in order to economize on the steel weight in the purlin members.

Cladding build-up options were tested against prescribed acoustic performance requirements, and the resulting deck weighs a hefty 14 psf, including an 8-in.-deep steel profile decking with acoustic absorption panels fixed to the soffit of each trough.

A large (approximately 52 ft by 46 ft) cladding and purlin trial panel was built, which proved to be extremely useful for many reasons:

- ✓ To check buildability of warped cladding fixed to spherical-faceted purlins
- ✓ As a physical fit-up test for complex purlin-to-truss steelwork bracket connections (also a function of spherical geometry)
- ✓ As an aid to test options for the cladding movement joints and edge support trim
- ✓ To develop and hone a safe method of cladding installation
- ✓ To force coordination and collaboration between all parties in advance of the main fast-track build (cladding contractor, steelwork contractor, main contractor, cladding designer, acoustics engineer, structural engineer, and procurement parties)

Buro Happold

The end result is the O_2 Arena, Europe's most acoustically advanced concert venue.

✓ To "de-risk" the construction process (faster, safer, etc.)

The panel, although large, is certain to have paid for itself many times over in terms of improved overall project performance and product quality.

Tight Space, Tight Schedule

All told, the O_2 Arena is a stunning venue with a special and unique design. The construction and lifting of the roof by controlled strand jacking of the whole 4,400-ton assembly was skillfully and safely achieved to a tight schedule, despite the challenges of construction within an existing building. MSC

Ken Jones is Structures Group Director with Buro Happold's Bath, UK, office.

Owner
Anschutz Entertainment Group, London

Architect
HOK Sport, London

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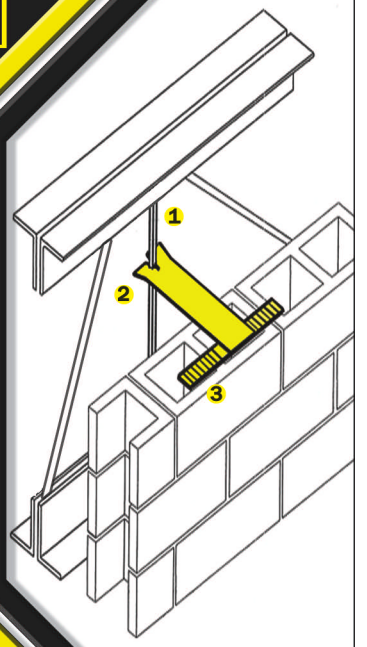

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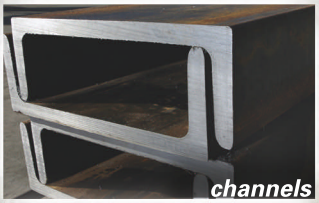

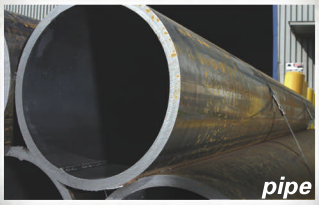

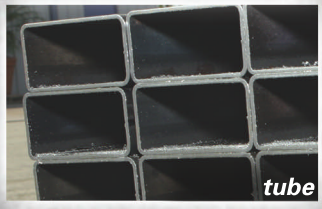

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Pushing the Envelope

BY JAMES C. PARKER, P.E., ALEC S. ZIMMER, P.E., AND CHRISTOPHER M. HEWITT

Careful attention to façade attachment details pays off in the long run.

ONE OF THE MOST CHALLENGING DETAILS FACING STRUCTURAL DESIGNERS IS THE SUPPORT OF A BUILDING FAÇADE. The complexity of this attachment is not to be overlooked, and the entire design team should be engaged in developing a strategy for supporting the façade system in order to prevent unplanned changes and problems in the field. The structural designer should then strive to develop slab edge and spandrel beam designs that are consistent with this strategy.

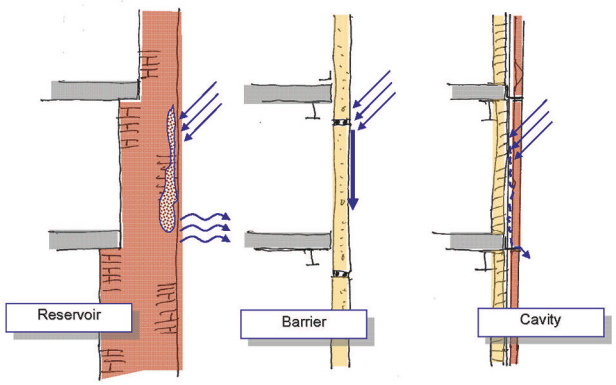
Building Envelope Systems

Before devising a support strategy, it is important to understand the function of the façade system. There are three basic concepts for exterior walls to mitigate water infiltration: reservoir walls, barrier walls, and cavity wall systems. While each system is designed to keep water out of a building, each approaches the problem differently. Understanding the type of system that the structural frame is supporting is important for determining appropriate goals for the structural support.

Older masonry bearing wall buildings employ the reservoir system. In traditional thick stone and brick bearing wall buildings, the walls act as reservoirs and allow a certain amount of water infiltration into the wall. The walls are thick enough to prevent an unacceptable amount of water from entering the interior space, and the water later escapes by weeping and evaporation. Though good in its day, this system is heavy and is no longer considered to be cost-effective.

Most modern commercial walls are constructed as either barrier or cavity systems. Barrier wall systems are just that—barriers designed to keep water out of the wall and to rely on the exterior surface and joint seals to prevent (or mitigate) water infiltration into the building.

Alternatively, cavity walls have a drainage plane and waterproofing barrier behind the exterior cladding and a means to divert water out of the wall. Water that makes it past the cladding runs down the drainage plane and out of the wall through weep holes at the base or at flashing joints. AISC's Design Guide 22 and its seminar on façade attachments to steel frames give attachment strategies to accommodate the challenges of each of these wall systems.



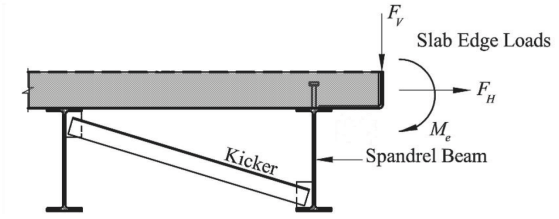
Exterior wall systems for mitigating water infiltration.

Design of Slab Edge Conditions

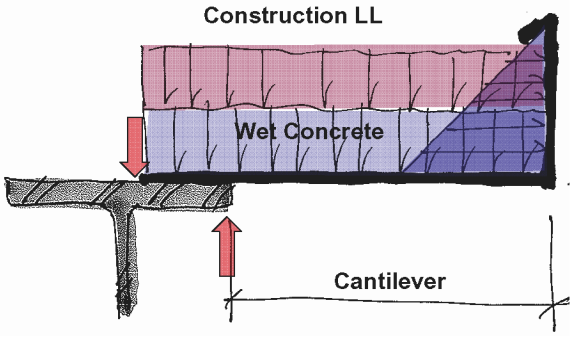
In designing slab edge conditions, there are two fundamental approaches: Either the slab cantilevers over the spandrel beam to carry any loads applied to the overhang, or the designer does not count on the slab as a cantilever, and loads applied to the overhang are carried by a structural steel plate or assembly attached to the spandrel beam. Generally, using the slab to carry the loads as a cantilever will be more economical than relying on the spandrel beam alone, but the slab must have sufficient strength to carry the load without increasing the thickness of the floor slab system. Otherwise, a bent plate or other steel assembly must be designed to transfer façade loads to the spandrel beam. Several examples of these appropriate details are included in the design guide and seminar.

Pour Stops and Bent Plate Edge Details

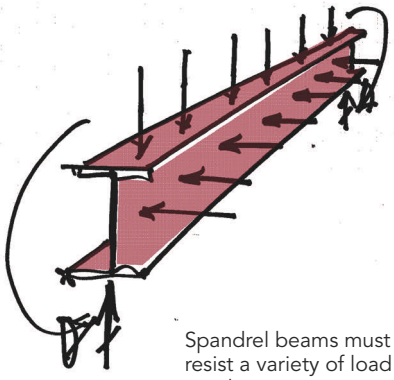
The use of a light-gage metal pour stop as part of the façade support system is generally limited to slabs that have a clear overhang less than 12 in. and slabs that have sufficient strength to sup-



Typical forces at slab edge conditions.



Design loads on light-gage metal pour stops or bent plates.



Spandrel beams must resist a variety of load conditions.

port superimposed loads. Typically, in this type of slab edge, the façade attachment will be made directly into the slab or spandrel beam and will not engage the pour stop. Accommodating such an approach may become difficult at corners and column joints. When used, the light-gage metal pour stop should be designed for the wet weight of concrete, concrete fluid pressure on the vertical leg, and 20 psf of live load. When these conditions are such that a light-gage element can not accommodate the loads, the designer must employ the use of a bent plate at the slab edge. The bent plate may be designed to be a pour stop, a means to attach the façade, and a means to transfer the façade loads to the primary structure.

Design of Spandrel Beams

As one might suspect, spandrels must have sufficient strength and stiffness to resist the applied loads, but must also be designed to accommodate architectural and practical limitations of the system. For strength, the spandrel design must consider:

- superimposed floor loads
- loads arising from weak-axis bending
- torsion on the member and its connections
- offsets between the centerline spandrel and of the column
- eccentric façade loads

For serviceability, the spandrel design must consider:

- deflection due to superimposed dead loads and live loads
- rotation of spandrel beams and façade supports
- long-term creep of composite sections
- relative displacements of the structural frame with respect to the façade
- tolerances of the façade and structural frame

And, for practical reasons, the spandrel design must consider:

- overall depth and flange width
- the interferences with the slab edge and the connections
- interferences with window heads
- interferences with mechanical systems such as ducts and piping
- interferences with shade pockets or other architectural features
- flange interferences with the façade system
- clearances for fireproofing and façade elements
- constructability of the spandrel

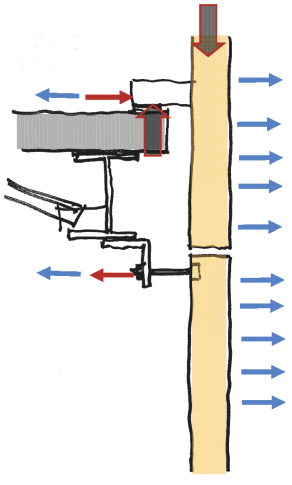
Because composite spandrel beam sizes are often controlled by post-composite deflections, cambering composite spandrel beams does not tend to reduce the beam weights for most façade systems. Cambering adds to the tolerances that the design of the façade system must accommodate, and it should typically be avoided for spandrel beams.

Wind and Seismic Loads

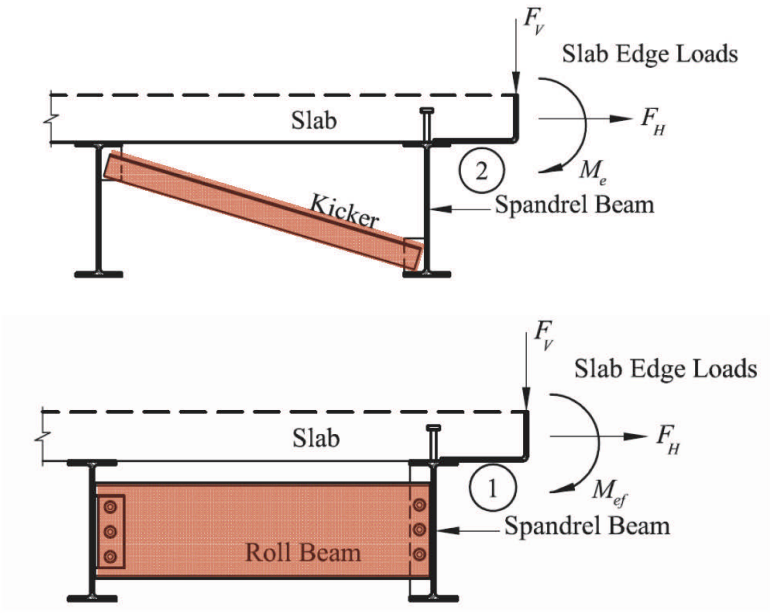
For the base building components, the structural engineer of record can often use a simple and conservative design when planning for façade wind and seismic loads without adding undue cost. Negative wind pressures on the wall, combined with gravity load eccentricities, will often control the design of the façade attachment, particularly those attachments made to the bottom flange of the spandrel beam as shown in the below figure. The IBC requires components and cladding to be designed for seismic forces and the attachments to accommodate relative seismic displacements, which can be large. These requirements should not be overlooked and can control wind loading for heavy wall systems.

Kickers and Roll Beams

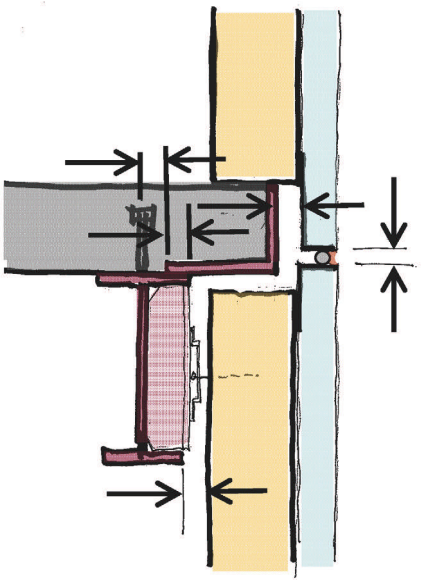
When façade loads are eccentric to the supporting spandrel beams, significant eccentricity exists on a cantilevered slab. There are a number of strategies that the designer can use to help to resist the torsional moments imposed on the spandrel beam. Commonly, either a roll beam or a kicker is provided to restrain the beam against rotation. Each system has advantages and disadvantages. In addition to their role as a torsional brace, kickers can also be used as an effective solution for resisting façade forces applied between floor levels; however, they require coordination with the architectural and mechanical systems, which can limit their use. Roll beams ensure a rectangular grid of girders and beams, but designers must be sure to design their connections to the spandrel beams to have some level of moment resistance. Both approaches, however, are effective ways to restrain torsion on spandrel beams and thereby reduce spandrel beam rotations.



Façade attachments must be designed to resist lateral and gravity loads.



Eccentric loads on spandrel beams can be resisted by kickers (top) or roll beams (bottom).



Façade systems and related details must account for fabrication and erection tolerances.

Accommodating Tolerances and Adjustments

Every façade attachment design must allow for adjustment to accommodate tolerances and deflections. Steel framing tolerances are generally larger than façade tolerances, and the designer must be careful to provide sufficient adjustability in the design to accommodate these tolerances, which may accumulate. A good attachment detail will provide the means to:

- adjust the slab edge in or out relative to the spandrel beam,
- adjust the location of the façade system in or out relative to the slab edge,
- adjust the location of the façade system up or down relative to the slab edge,
- and adjust the location of the attachments both vertically and horizontally.

Designers must also provide sufficient clearances between the steel frame and the façade that accommodate tolerances, relative movements and rotations, thermal insulation, fireproofing, and access to install the façade component.

Forces from Restraint

The façade system must be designed to accommodate relative movement between stories, and when that movement is restrained the restraining element is highly loaded. When possible, it is best to avoid restraint altogether. When it can not be avoided, restraint forces can be difficult to predict because of cracking, creep, and attachment stiffness. It is also important to be cautious of the potential for inadvertent restraint caused by friction, movement, or other sources, which can have dire consequences when not accounted for.

Conclusions

Designing façade systems can be a challenging effort. The process should be approached with an earnest understanding of its complexity, and by initiating a dialogue among the structural engineer, architect, façade system designer, and contractor to arrive at the most practical and economical solution for a project. With open communication and the appropriate degree of care, most façade attachment problems can be avoided from the start, making the project successful for the entire construction team. MSC

James Parker is a senior principal and Alec Zimmer is a senior staff engineer at Simpson Gumpertz & Heger, Inc. Chris Hewitt is a senior engineer wtih AISC.

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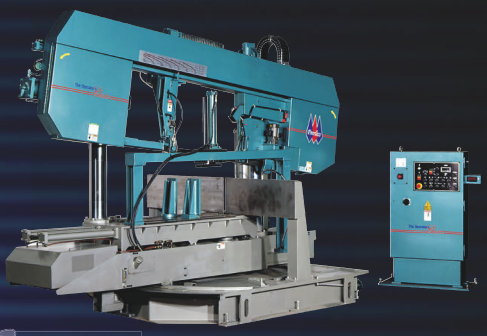

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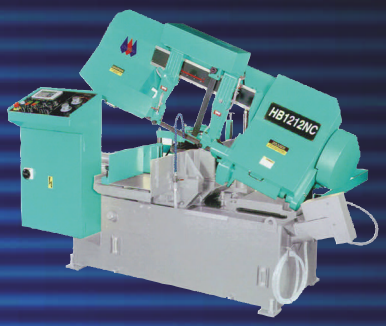

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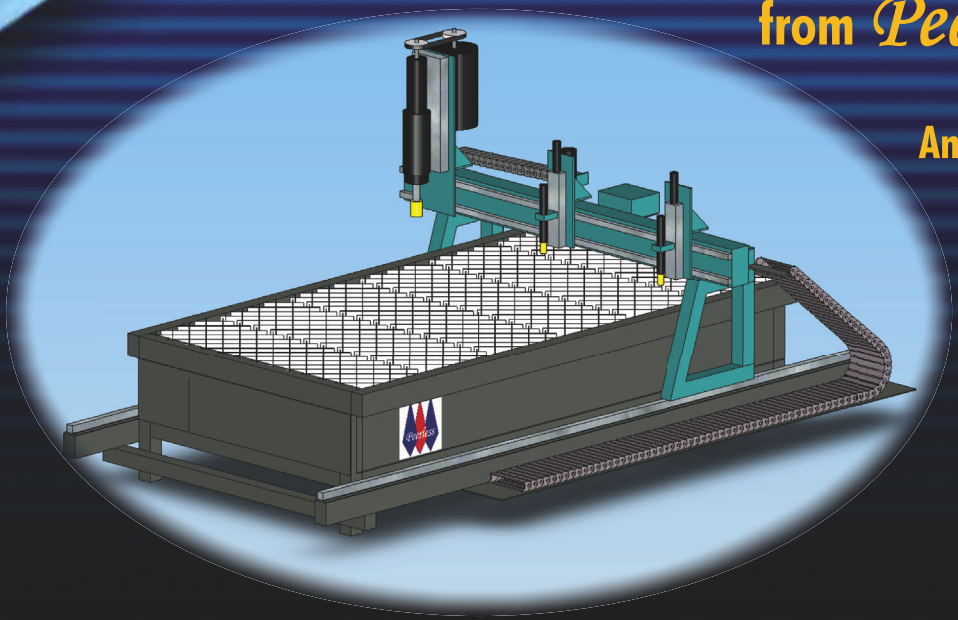

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Listening to the Customer

BY SHEILA ALEGRIA, KIM SWISS, AND BOBBI MARSTELLAR, P.E.

Feedback from AISC Certified companies is making a difference in daily operations for AISC's independent auditing company.

IN OCTOBER 2006, QUALITY MANAGEMENT COMPANY (QMC) DID SOMETHING THAT MANY COMPANIES ARE TOO AFRAID TO DO: We started asking our customers (fabricators and erectors) for feedback. Early in 2006, our team set a goal to improve the level of service we provide to our program participants. Since customer satisfaction is often described as the gap between what the customer expects and what they get, we knew we first had to make understanding their expectations a priority.

Program participants are mailed a survey annually with their certificate. The survey is designed to measure customer satisfaction related to the audit, the on-site auditor, and the QMC staff. In the first year of the program, QMC received more than 400 completed surveys (a response rate of more than 50%!) containing extremely substantive and thoughtful comments. From them, we have gained valuable insight into how our customers think, and more importantly, what they expect of us.

The surveys have become an integral part of our continuous improvement process. As an ISO 9001:2000 certified company, QMC is required to monitor and measure the performance of our quality management system. One of those measurements pertains to customer satisfaction. How do we know that we are meeting our customer's requirements and expectations? We review each and every survey comment—more than 600 through the end of September 2007. Then we look for trends and determine which ones are actionable. (For a more detailed look at our survey process, see the figure at right.)

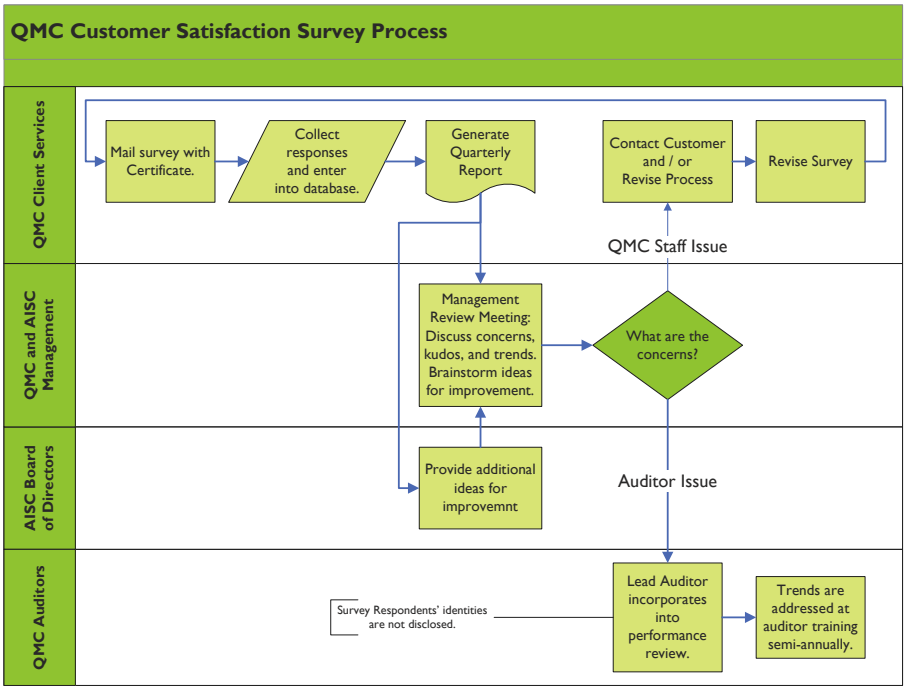
Areas for Improvement

The majority of concerns we've received to date have to do with communication, auditor issues, or audit scheduling. (For a complete breakdown of the topics, see the pie chart on the next page.) We can't deny the fact that our clients would like to hear from us more often. There are times in the certification process that participants have felt ignored or concerned that their materials were lost in cyberspace.

We have also received a lot of comments regarding the differences among auditors, in particular that an auditor observed or commented on something within a company's quality system that the previous year's auditor did not. We do our best to keep these variations to a minimum by providing individual and group training for our auditors. However, we consider the uniqueness of our auditors to be an asset. They have different strengths and areas of expertise and can provide our program participants with a fresh perspective each year.

Other comments relate to the pace of the audit, some indicating that it went too slow, while others felt rushed. With so much to cover in just one or two days, it can be difficult to get the pace just right while still making sure that the experience is a beneficial one. Our auditors can adjust their pace almost immediately, so be sure to speak up during the audit if you are concerned.

Material submission requirements made the list as well. Many of the program participants felt it was unnecessary to resubmit their quality documentation every year, and we couldn't agree more! Beginning in October 2007, participants are only asked to submit their materials every third year, when a full audit is scheduled. Material submission requirements are outlined in the renewal packets.



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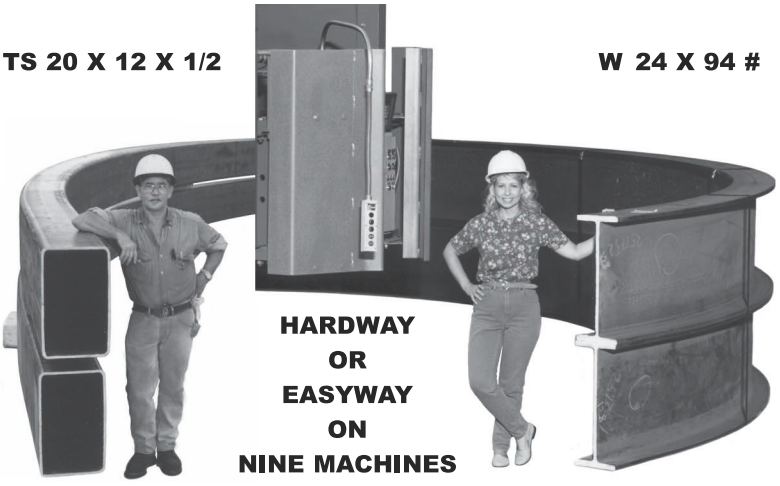

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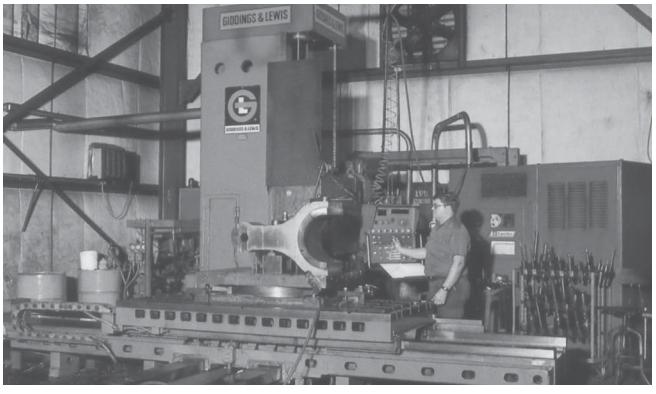

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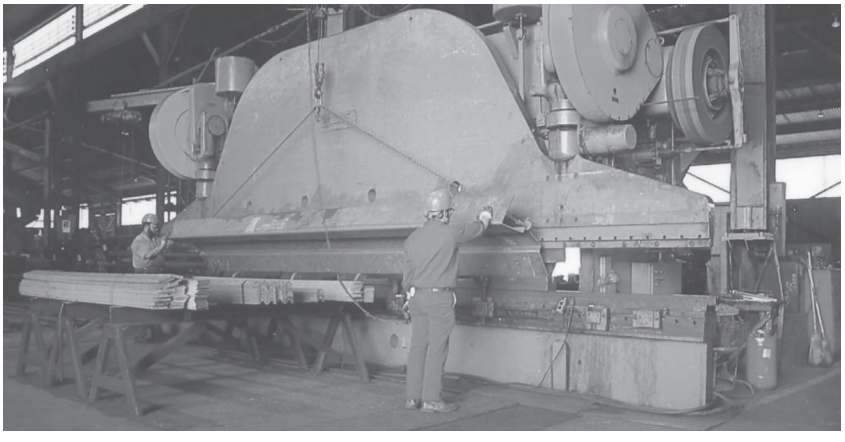

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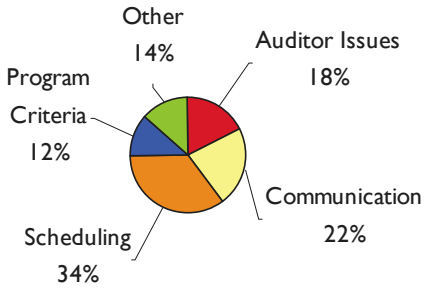

Survey comments by category.

Audit scheduling received a significant amount of feedback, specifically how clients would prefer to pick their audit date. We agree that this would be ideal; however, attempts at this in the past have proven more costly and time consuming and still we had unhappy customers. We currently schedule the audits for the fabricator program four months ahead of time, which we hope can give ample time to prepare for the audit. (For more information on audit scheduling, please see the September 2007 Quality Corner at **www.aisc.org/qualitycorner**.)

Taking Action

As it turns out, collecting the data is the easy part. It's taking action that presents the real challenge. We knew when we implemented the program that we couldn't ask for feedback unless we were prepared to act on it. We react to the comments we receive and trends we identify in the following ways:

- Call or e-mail to the program participant to further discuss their comments.
- Implement a new process.
- Modify an existing process.
- Incorporate feedback anonymously into auditor performance evaluations.
- Include as an agenda item at auditor training.

Some concerns and ideas can be addressed or implemented immediately, while others take time. As a direct result of the survey responses, we've made the following changes over the past year:

- When Corrective Action Requests (CARs) are closed, an e-mail is sent to the program participant.
- When materials are received, a postcard is sent to the program participant.
- Auditors are required to send their audit agendas and introduction letters to QMC.
- Auditors are required to obtain confirmation from program participants that their audit agenda has been received.
- Audit materials are no longer required for Annual audits (AR1/2), only Initial and Full audits.

- A new, comprehensive list of documentation required for certification has been created. This list is mailed annually with the renewal packet and is also available in the Resources section of the QMC website at **www.qmconline.com**.
- We revised our customer appreciation survey for surveys mailed after October 1, 2007.
- QMC has increased the number of days that auditor training takes place to allow more time for "calibration."
- An "Auditors Forum" now exists where auditors can post messages, ask questions, and share their thoughts with one another.
- We have redesigned our audit report so our auditors can communicate their findings more efficiently.

Some of these points can be considered the proverbial low-hanging fruit, but we never underestimate the significance that a small change can make. As for our long-term goals, we are currently exploring our customer service program in its entirety, from mailing the invoice to mailing the certificate, in an effort to close the remaining cracks and ultimately improve our overall satisfaction scores. Plans are also underway for revamping both the QMC web site and the AISC web site (**www.aisc.org**).

In October 2007, we began mailing a new version of the survey to our customers. Please look for it in the mail with your certificate. It's a little shorter than the first version and concentrates more on the specifics of how and when we communicate with our program participants. For those of you that have taken the time to submit a survey to QMC: Thank you! We hope that you will continue to take the time to do so each year, not only because it enters you in a drawing to win a free audit, but also because what you say is essential to our continuous improvement. If you have an idea or concern, please don't wait for the annual survey. You can contact us at any time: certinfo@QMConline.com or 312.670.7520. We look forward to hearing from you! MSC

Sheila Alegria is client services coordinator, Kimberly Swiss is manager of certification administration, and Bobbi Marstellar is vice president with Quality Management Company.

% "completely" and "mostly" satisfied	2006	2007		
	4Q	1Q	2Q	3Q
Total # of respondents	76	105	104	115
Overall satisfaction with your AUDIT this year	96%	99%	99%	100%
Overall satisfaction with QMC	93%	95%	94%	97%
How satisfied are you with QMC staff with regard to:				
courteousness	95%	100%	98%	100%
program knowledge	96%	97%	96%	97%
explanation of deadlines and requirements	95%	96%	95%	92%
ability to resolve problems	86%	95%	92%	89%
how quickly your call was answered	83%	88%	85%	83%
how quickly you received a reply to your e-mail	76%	85%	79%	80%
frequency of phone and e-mail communication	82%	88%	85%	88%

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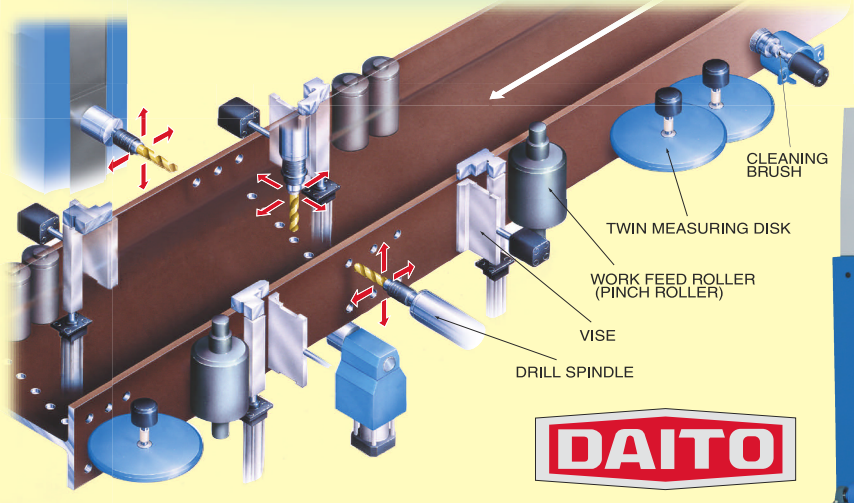

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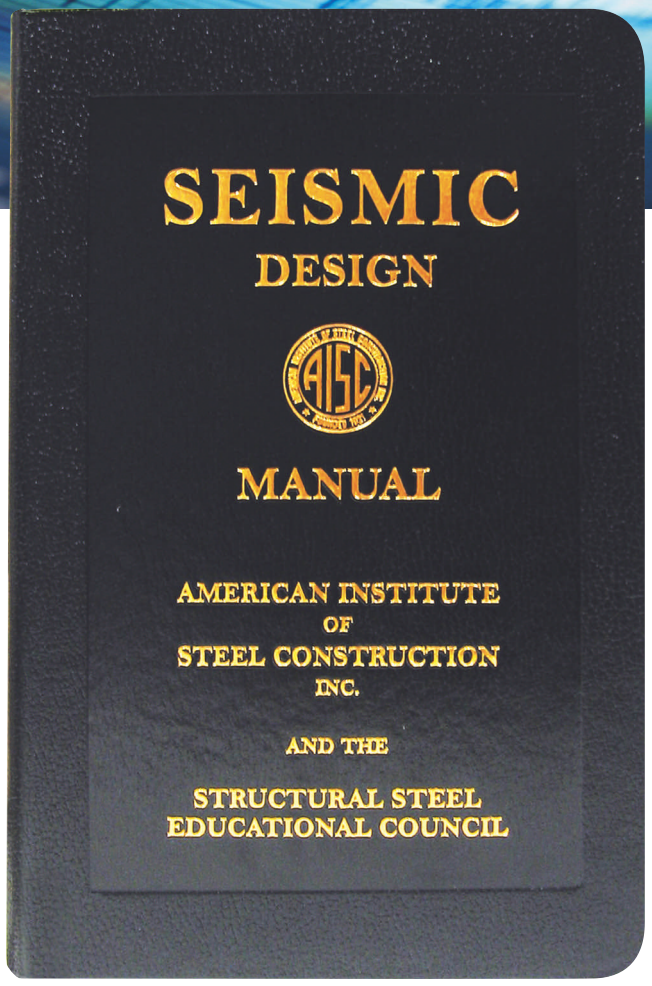

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Steel Bridge NEWS
NATIONAL STEEL BRIDGE ALLIANCE DECEMBER 2007

Quick Response

BY AARON FRANKLIN, P.E., MAZEN WAHBEH, PH.D., P.E., DANIEL SPEER, P.E., AND MARTIN POHLL, P.E., S.E.

A Caltrans-led construction team was able to quickly repair a damaged Bay Area interchange following a major explosion.

THE MACARTHUR MAZE ISN'T AS FUN AS IT SOUNDS. It's a nickname for a network of major interchanges east of the San Francisco-Oakland Bay Bridge that distributes traffic to East Bay freeways. The Maze connects Oakland, Berkeley, and San Francisco via five major highways, whose combined average daily traffic is approximately 80,000 vehicles.

Earlier this year, the Maze was the site of a major accident that made national headlines. At 3:41 a.m. on April 29, 2007, a tanker truck, carrying 8,600 gallons of fuel and traveling southbound from I-80 to I-880, overturned and exploded. According to police reports, the accident occurred when the driver changed lanes and the fuel shifted from one side to the other, tipping the truck. The explosion and fire occurred on the bridge deck of southbound I-880 and beneath the connector ramp from the Bay Bridge to eastbound I-580. The heat from the free-burning gas fire caused the steel box beam bent cap at Bent MB19, as well as spans 18 and 19 on I-580, to buckle and collapse onto the I-880 connector ramp directly below. The estimated high temperatures were in excess of 1,500 °F, which caused the steel to soften and forge under its own weight. This collapse closed both the southbound I-880 and eastbound I-580 connectors, interrupting San Francisco-Oakland Bay Bridge traffic.

Two spans of I-580 collapsed onto the I-880 connector ramp directly below.

The collapsed portion of I-580—a total of 160 ft long and 51 ft wide—encompassed the steel girders on both sides of the bent (MB19) as well as the bent cap itself. The failed spans had six steel girders with a 45-ft-wide concrete deck. Luckily, the I-880 connector sustained less damage.

The California Department of Transportation (Caltrans) management and government officials reacted immediately and decisively to prioritize reconstruction. Within hours, senior bridge officials were meeting to set priorities, and engineers were on-site assessing damage. By the end of the first day, Governor Arnold Schwarzenegger declared a State of Emergency and procured federal support for emergency reconstruction funds.

Immediately after removal of debris and stabilization of the structure, steel and concrete samples were obtained. After testing, Caltrans engineers determined that the I-580 superstructure, which remained standing, was not heat damaged, with exceptions at the upper columns. Caltrans engineers also determined that the I-880 structure had suffered minimal damage.

Eight days later, after shoring from below and minor repairs were completed on the I-880 connector, Caltrans reopened it to traffic. As a result, the primary items of work required to replace the collapsed section were the girders, bent cap, and deck. Caltrans engineers realized that rebuilding quickly would hinge on the availability of materials and obtaining the right contractors. On the day of the accident, Caltrans officials mobilized a worldwide search to assess steel availability and fabrication capabilities. This information, gathered within two days, became a critical guide for engineers selecting the reconstruction alternatives.

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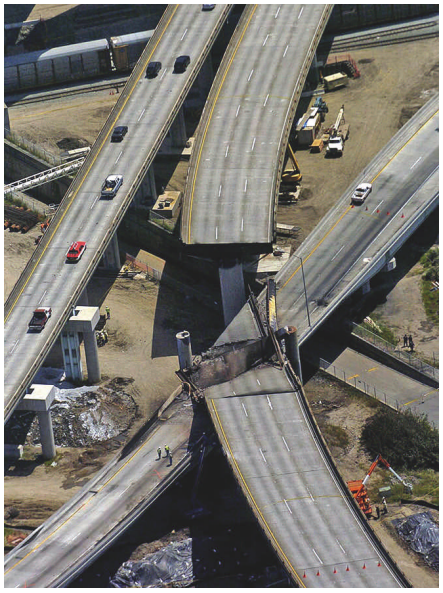
The steel box beam bent cap spanning the I-880 connector collapsed in the estimated 1,500 °F fire.

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A MESSAGE FROM THE

Executive Director

On October 31, the House Transportation and Infrastructure Committee approved legislation to authorize $2 billion in spending for repairs and reconstruction to the most structurally unsound bridges in the U.S. The bill was drafted by committee chairman Congressman Jim Oberstar (D-MN) in response to the I-35 bridge collapse in Minnesota that killed 13 people and injured at least 140. Chairman Oberstar originally proposed a $25 billion initiative, partially funded by a five-cent fuel tax for automobiles over three years. However, that amount has been scaled back to $2 billion in light of political opposition from the Senate and White House, both of which are fearful that the new tax would contribute to the highly politicized issue of growing fuel prices. The approved $2 billion amount is a fraction of the Department of Transportation's estimate that $65 billion is needed to address all critical bridge deficiencies.

The bill now waits to be considered and voted upon by the full House of Representatives and has yet to be introduced in the Senate.

Best Regards,
Conn Abnee
NSBA Executive Director

National Steel Bridge Alliance
One East Wacker Drive, Suite 700
Chicago, IL 60601-1802
www.nsbaweb.org
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Conn Abnee
Executive Director
Phone: 606.724.2347
Cell: 312.804.1524
abnee@nsbaweb.org

Mike Moffitt
Director of Engineering Services
1228 S. 4th Street
St. Charles, IL 60174-4019
Phone: 630.443.8090
moffitt@nsbaweb.org

Jody Lovsness
Marketing and Membership Coordinator
11708 Jackson Road
Omaha, NE 68154
Phone: 402.758.9099
Fax: 402.778.9499
lovsness@nsbaweb.org

Calvin R. Schrage
Regional Director (west)
5620 Harding Drive
Lincoln, NE 68521
Phone: 402.466.1007
Fax: 402.466.1027
schrage@nsbaweb.org

William F. McEleney
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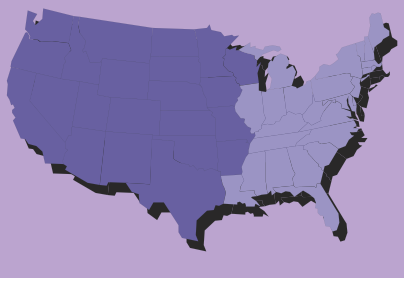

continued from p. 49

Caltrans determined steel girders like those in the original design would be the preferred option—if the steel could be located quickly. They initially considered precast concrete girders, but decided against this idea because it would require foundation enhancement to support the additional weight.

From the time of the collapse on Sunday until the following Thursday, damage to the bridge structures was evaluated, a design was developed, and contract documents and plans were developed. To meet this schedule, designers had to make quick decisions, taking into consideration several factors. These included:

- Quick design that could be easily fabricated with currently available materials.
- Fast fabrication time to minimize structure closure.
- Shoring design of the lower structure to provide a platform for reconstructing the upper structures.
- Two different designs, with both concrete and structural steel bent caps, providing alternatives to further speed-up the reconstruction.

The engineers anticipated that the contractor would need a straightforward and simple design to complete the project in the time frame required, and made several engineering judgments during the design phase with assistance of fabrication experts, allowing delivery of a fast and safe design. The design team investigated prefabricated rolled shapes versus built-up sections; however, the required rolled shape sizes were not known to be readily available and would have required several weeks for fabrication. Hence the team decided to proceed with built-up sections. In addition, to reduce the number of stiffeners required for local buckling checks and to reduce the amount of welding required on built-up girders, the web thickness was increased. The flange plates were kept to one size only to simplify fabrication. The web depth was adjusted to ensure that the overall depth would not require adjustment of the existing bearings that were to be reused.

Constant communication played a large role in the success of this project. Daily status meetings with project managers and key Caltrans management cleared hurdles that would have caused costly delays. On the shop floor, Caltrans maintained a constant presence of quality assurance inspectors, which proved to be critical to the success of steel girder fabrication. Designer availability at all hours of the day allowed ma-

Quick Turnaround

The implementation of significant changes to typical construction contracts contributed to the MacArthur Maze project's success. Caltrans, the owner, was motivated to complete the project safely and in record time. It issued a construction contract specifying that its engineers would have only 24 hours to respond to all submittals and requests from the contractor (typical response times range from several days to several weeks, depending on the submittal type). To provide a comprehensive yet expedited review, Caltrans significantly increased the manpower of the review teams. Reducing response time to a single day clearly demonstrated Caltrans' commitment to be responsive.

Within two hours of awarding the general contract award, the steel fabricator was also determined. Caltrans immediately initiated contact to begin discussing the fabricator's first critical path item before fabrication could start: approval of welding and shop plans. Within 24 hours of contract award, Caltrans had placed a senior reviewer full-time at the fabricator to provide immediate guidance for welding and shop plans. In order for Caltrans to meet the one-day review times, Caltrans engineers directly solicited draft copies of all welding submittals. In this way, Caltrans provided the fabricator immediate feedback, often before the official copy was even submitted.

On May 10th, three days after the contract was awarded, Caltrans and the general contractor conducted a pre-welding meeting with the fabricator. During this meeting, Caltrans provided Stinger Welding with review comments on their Welding Quality Control Plan, to which the fabricator was able to respond immediately. By the end of this meeting, Caltrans officials were satisfied with the fabricator's plan; that same evening, fabrication began.

Built-up sections were fabricated with thicker web plates to minimize the number of stiffeners required. Flange plates were kept constant to simplify fabrication. The bridge reopend to traffic in only 25 days.

terials engineers to quickly work through any issues that came up. On-site, Caltrans inspectors quickly elevated and addressed any issue that could potentially delay fabrication. At the height of fabrication, there were several QA inspectors covering fabrication and quality around the clock.

Another key factor to the project's success was a new Caltrans process that was recently implemented where "fit-for-purpose" decisions could be made. This process is managed by a materials engineer who is dedicated to the project and charged with seeking proposals from the fabricator and contractor, making a fit-for-purpose determination on the contractor's proposal and gathering input and concurrence from the appropriate authorities. With this process, when it is in the best interest of Caltrans to accept the contractor's proposal, a decision can be rapidly made and documented. Thanks to this new program, Caltrans was able to use material with minor deviations, but that were nonetheless acceptable to all parties.

Governor Schwarzenegger had described the Maze collapse as "the worst damage to our transportation infrastructure since the Loma Prieta Earthquake." However, in just 25 days, traffic was reopened in time for the Memorial Day weekend. In less than a month, the design and construction team was able to erect a bridge that met current stringent guidelines. MSC

Aaron Franklin is a senior engineer and Mazen Wahbeh is a senior principal with Mactec Engineering. Daniel Speer is a supervising bridge engineer and Martin Pohll is a senior bridge engineer (seismic specialist) with the California Department of Transportation.

Owner/Designer
California Department of Transportation (Caltrans)

General Contractor
C.C. Myers, Rancho Cordova, Calif.

Fabricator
Stinger Welding, Coolidge, Ariz. (AISC/NSBA Member)

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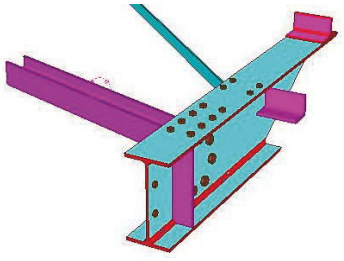

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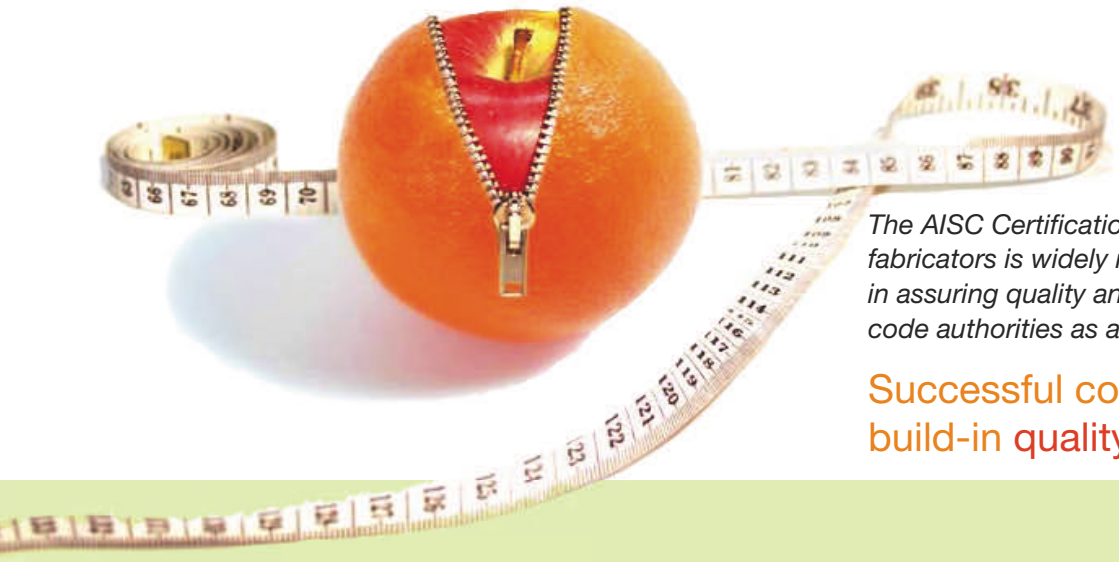

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Beauty and the Beast

BY DENNIS GOWINS, P.E.

In taming congestion, Orlando's Lake Underhill Bridge widening project will be beautiful—and beautifully effective.

CONGESTION CAN BE A BEAST ON ORLANDO'S STATE ROAD 408. Just ask any of the more than 150,000 daily commuters who pay a toll to use the major artery to and from downtown. Increased demand, backups at toll plazas, and a general lack of mainline capacity create 55 hours of delays per motorist annually.

To sooth the bottleneck, the Orlando-Orange County Expressway Authority has undertaken a $450 million improvement program to widen 12 miles of S.R. 408 from Hiawassee Road to Goldenrod Road. Program improvements include the reconstruction of the Holland East and Holland West main toll plazas and the installation of express E-PASS lanes, so that customers may travel at the posted highway speed instead of creeping along. Once complete, the overhaul is expected to significantly condense commute times and increase the corridor's overall capacity by 50%. S.R. 408 will be well-positioned to handle the more than 215,000 daily commuters projected by 2025.

The final leg of the current S.R. 408 improvement program calls for widening the Lake Underhill Bridge from eight to 12 lanes, increasing the bridge's traffic capacity by 50%. The Expressway Authority, which plans, builds, maintains and operates a network of five tolled expressways in the Orlando metropolitan area, is funded completely by tolls. It has taken extra steps to respect the surrounding neighborhoods of its customers by ensuring the mile-long project will be both highly functional and highly attractive.

Beauty Comes at a Price

Lake Underhill Bridge is punctuated with two pylons with faux cable stays resembling a cable-stayed bridge. Dramatic nighttime lighting will be added to spotlight the structure, which has been dubbed Orlando's new eastern gateway. Complementing this structure to the east will be the Conway Road Bridge. This highly curved steel box girder structure will be framed by four pylons in combination with highly landscaped planter walls.

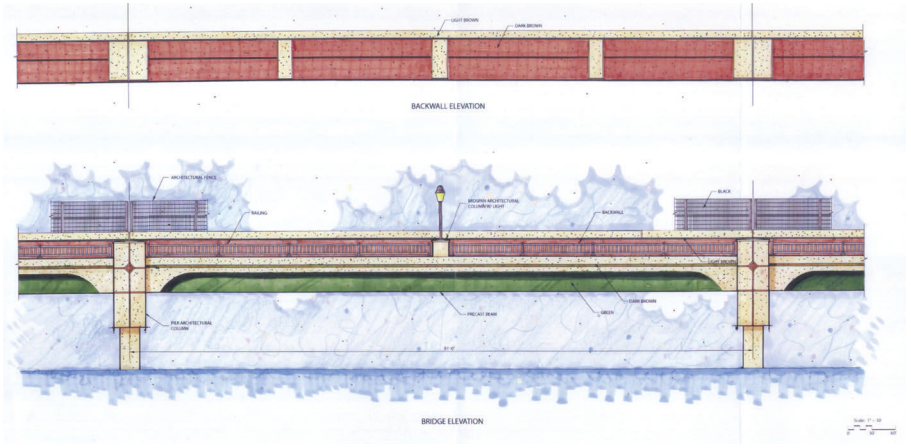
HNTB was selected as the prime consultant to provide final engineering and construction plans for the Lake Underhill widening project, which runs from Crystal Lake Drive to Conway Road. At the request of the Expressway Authority, the original design featured two "braided ramp" bridges, each more than 2,400 ft long. They were to be a combination of steel plate girders and AASHTO prestressed girders. The steel plate girders were to span the ramps below and yield a braided ramp configuration. The braiding concept was intended to eliminate traffic weaving between the Crystal Lake Drive and Conway Drive ramps.

The low bid for the project came in at $105 million—too much, according to the Expressway Authority. It rejected the bids and directed HNTB to redesign the project without the braided ramp bridges.

Because it impacted other aspects of the adjacent projects currently under construction, completion of the Conway Road Bridge was the only milestone built into the new design. The Expressway Authority's request for a new design could have jeopardized the project's schedule, but HNTB established an aggressive one-year schedule for the redesign and hoped for a better bidding environment than the original project bid, which occurred just a few weeks after Hurricane Katrina. When the firm delivered the redesign, bidding was tight with the low bid being within 1% of the engineer's estimate.

Scrapping the initial design proved to be a very cost-effective decision for the Expressway Authority. Less than 18 months later, HNTB presented a new design with a new price tag: $77.9 million—more than $25 million less than the original bid. This past March, designs for the Lake Underhill widening project were completed. The project includes:

- Expanding one mile of S.R. 408 from six to 10 lanes.



At least $10 million of the project's budget will be spent on aesthetic elements to integrate the bridges into the surrounding communities.

- Widening Lake Underhill Bridge to 12 lanes.
- Modifying the ramps at Crystal Lake Drive and Conway Road Interchanges.
- Widening the mainline bridges at Crystal Lake Drive and Lake Underhill Road.
- Creating a parallel 1,700-ft pedestrian bridge spanning the lake that will be the missing link in connecting a series of trails in the area.

Bids for the redesign were opened on May 8, 2007, and construction began this summer. The project is scheduled for completion in early 2010. More than 290 tons of steel will be used in the fabrication of the structure.

Putting it into Context

At least $10 million of the project's budget will be spent on aesthetics and to preserve the fiber of the surrounding community. As such, the Expressway Authority was at liberty to incorporate design elements that might not have been considered on a tighter aesthetics budget. For example, in lieu of curved plate girders for the Conway Road Bridge, they chose curved steel box girders, which traditionally are more expensive.

The Authority also approved the additional expense of enclosing the area beneath the deck between the steel box girders to give the appearance of a single steel box. This will provide a smooth appearance to motorists traveling below.

The bridge is a highly curved two-span structure with an overall length of 270 ft. The curvature's tight 280-ft radius and spiral transitions presented a complex geometrical challenge. The use of two steel trapezoidal box girders yielded both a technical and aesthetically pleasing solution.

The Expressway Authority's decision to put the Lake Underhill project in a context-sensitive design is part of a national and statewide trend in transportation planning. It requires the input of all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic, and environmental resources, while also improving mobility and safety.

Throughout the entire S.R. 408 widening project, the Expressway Authority has incorporated sound walls, eye-pleasing retaining walls, tiered landscaped planter walls, improved lighting, decorative bridge treatments, colored concrete, and extensive landscaping. Architects even borrowed design elements from Orlando's downtown neighborhoods. For example, the battered pylons featured at each bridge in the program reflect the battered columns found on the front porches of bungalows throughout downtown neighborhoods. Sedate colors, aesthetic wall treatments, and high-quality lighting fixtures follow the community's standards.

The Expressway Authority used the Florida Department of Transportation's Interstate 4 urban design criteria as a foundation for the S.R. 408 improvements. Criteria include:

- Placing emphasis on adjacent properties and cross streets.
- Reflecting the character of the surrounding neighborhood in the design of retaining and sound walls.
- Providing good lighting for pedestrian safety under bridges.
- Landscaping, so the focus is on the veg-

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Finley's redesign replaces twin, cast-in-place concrete box girders with a single, four-steel box girder design. This solution provides significant economic benefits with the elimination of a large falsework support system, reduced construction time, reduced foundation design requirements, and simplified construction.

The new Estero Parkway Flyover, 561 ft long with spans of 340 ft and 221 ft and approximately 116 ft wide, will alleviate traffic on the parkway and nearby I-75 in the Estero community, which is southeast of Fort Myers. It will complement the widening of Corkscrew Road while providing a link to areas east and west of I-75. It will also provide an alternate east-west route for travelers using the Tamiami Trail and I-75.

"By using shallower steel girders, it allows for the use of smaller grades, so it won't require as much fill on each approach," said Robert Clark, Jr., president of steel fabricator Tampa Steel. "The contractor can also erect the bridge in longer sections, which means fewer obstructions in the roadway."

The redesign also calls for a staged temporary tower support scheme to optimize the efficiency of the steel section, which allowed the steel bridge solution to be competitive against the initial cast-in-place concrete design.

In addition, the driving public benefits from the redesign through reduced traffic maintenance requirements. The redesign also enhances overall project safety with the elimination of falsework over the Interstate and reduces risks associated with a constrained traffic pattern through the falsework system.

The $1.85 million refund to the county is significant because the county is responsible for funding the flyover, and in the wake of a tax cut passed down by the state, the money will help the county meet its budgetary commitments.

"We're obviously pleased," said Donald Deberry, P.E., public works operations manager for Lee County. "We always appreciate working with engineers and contractors who are willing to take a second look at projects and find ways to give the public more bang for their buck."

"We see this as a great example of what can happen with value engineering when the owner, contractor, and engineer come together to create a design that takes the contractor's strengths into account and utilizes the best material for the challenges of the project," says Craig Finley, president of Finley. "In this case, the redesign from concrete to steel had an overall positive effect on the cost, schedule, and efficiency of the bridge. With construction budgets as tight as they are, there's no room for waste in any of these areas." MSC

etation, not the walls.

- Minimizing the use of chain-link fence.

The design of the S.R. 408 expansion program also follows the vision of the Downtown Orlando Community Redevelopment Agency (CRA). As part of its Downtown Orlando 2020 Vision plan, the CRA touched on downtown gateways that announce: "You have arrived."

The Lake Underhill project is symbolic of the entire city. In planning the project, the Expressway Authority obviously thought well beyond the scope of its right-of-way. By considering the community along its corridor, the design moves far beyond asphalt and concrete to respect the people who live and work along this road, as well as those who drive on it. The entire community will benefit. MSC

Dennis Gowins is structures leader for HNTB Corp. and structural project manager for the State Route 408 Lake Underhill widening project.

Designer
HNTB, Orlando, Fla.

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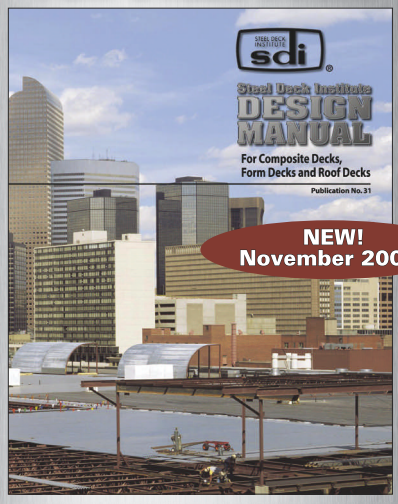

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A Tale of Two Yanktons

BY DAN SHARP

A new steel span over the Missouri River replaces a National Historic Register bridge to route auto traffic between South Dakota and Nebraska.

PRETTY SOON, THERE WILL BE A NEW WAY TO GET FROM NEBRASKA TO SOUTH DAKOTA—AND VICE VERSA, OF COURSE. Construction began this summer on a new, 1,590-ft, welded steel-plate girder bridge over the Missouri River between Yankton, S.D. and South Yankton, Neb. It is the first bridge over the Missouri River to be designed in-house by the Nebraska Department of Roads (NDOR).

The bridge is being constructed approximately 900 ft west of the Meridian Bridge, the current span between the two towns. The 84-year-old, two-level, steel truss bridge carries U.S. Route 81 motorists via a single lane on the top level. Northbound traffic is underneath, on a single lane orginally intended for a railroad line that was never built.

Constructability was the primary concern when preliminary design began, and the added attention to that aspect resulted in a very efficient, cost-effective design. With assistance from National Steel Bridge Alliance, NDOR was able to evaluate the capabilities of fabricating shops in the surrounding states to determine the maximum length and height of girder sections to use. It was determined that the maximum-depth girder that area shops could handle was 10 ft, and the maximum length for a girder section was 160 ft. With a six-span, haunched girder design, using 280 ft for the four interior spans and 235 ft for the two end spans, a 166-ft girder section was needed in the end span from the abutment to the first field splice. All of the other girder sections could be 130 ft, 140 ft, or 150 ft. An optional field splice in the 166-ft section was provided to reduce the section length to less than 130 ft, if the contractor chooses to use it.

The superstructure is made up of seven lines of girders spaced at 11-ft 4-in. centers. The hybrid girders, which incorporate ASTM A709 Grade HPS70W steel for the flanges and Grade 50W steel for the webs, are 10 ft deep at the piers and 6.5 ft deep at midspan. The maximum flange plate thickness used was 2 in. to take advantage of increased market competition in the supply of Grade HPS70W 2 in. thick and under. These limits helped determine the best span arrangement to use for the bridge.

Preliminary plans were sent to the steel fabricating shops for review and comment. The only comment received was that it was a very clean and efficient design and should be very competitive with any other girder option.

Common practice in Nebraska is to design both concrete and steel options for girder bridges with spans greater than 50 ft, unless site conditions or other restrictions prohibit it. In the case of the Meridian Bridge replacement, the state prepared both sets of plans and received three bids—all for the steel option; no bids were received for a concrete girder option.

Once completed, the bridge deck will provide for two traffic lanes in each direction on a 74-ft clear roadway with an 18-ft painted median. The anticipated completion date is November 2009; however, the contractor expects to finish almost a year early because of the steel design.

The old bridge, meanwhile, is on the National Historic Register and will be maintained for use as a pedestrian bridge, connecting existing and planned foot and bike trails. MSC

Dan Sharp is a bridge engineer with the Nebraska Department of Roads.

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Nebraska Department of Roads

Fabricator
PDM Bridge, Eau Claire, Wisc. (AISC/NSBA Member)

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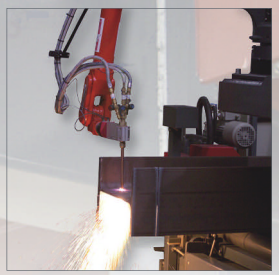

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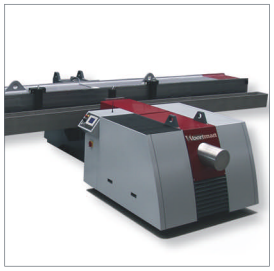

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FABRICATION PRODUCTS

Company	Products Offered	Product Description
Advanced Fabricating Machinery www.advancedfab.com 603.642.4906	**Tube fabrication equipment**	Advanced Fabricating Machinery provides tube/pipe bending and beam cambering equipment.
Anchor Lamina, Inc. www.anchorlamina.com 800.652.6462	**Heavy-duty drills**	Lamina hydraulic drills are powerful and portable. Quick-change heads drill and tap up, down, or sideways from 13/16 in. to 4 in. They are reliable and low-maintenance, and meet U.S. and global standards.
Behringer Saws, Inc. www.behringersaws.com 888.234.7464	**Automatic bandsawing systems**	Bandsaw machines and material handling systems deliver 50% faster average cutting times for higher productivity and throughput.
Bug-O Systems, Inc. www.bugo.com 800.245.3186	**Components for hand-held tools**	BUG-O Systems, Inc., a division of Weld Tooling Corporation, manufacturers ofa system of drives, carriages, rails, and attachments designed to automate welding guns, cutting torches, and other hand-held tools.
Cambco, Inc. www.cambcoinc.com 713.781.9702	**The Original Cambering Machine**	Structural steel beam cambering machines that camber beams as large as a W44x285, W40x397, or W36x441. Eight basic models plus six conveyor-fed versions are available to meet any cambering need. Totally self-contained, they may be moved or stored when not in use.
CMLUSA, Inc. - Ercolina www.ercolina-usa.com 563.391.7700	**Megabender 030**	Ercolina's patented mandrel system adapts easily to the Rotary Draw Bender Model MegaBender 030, without modification, to produce high-quality bends on tubes and hollow profiles.
	050KD Economy Top Bender	Ercolina 050KD is ideal for bending pipe, tube, squares, rectangles, solids, and other profiles. Hex mount patented tooling system tooling allows rapid changeover.
	CE35 Angle Roll	Ercolina angle rolls are capable of bending a wide range of profiles and materials to centerline radii as small as four times the diameter of the work piece.
COMEQ, Inc. www.comeq.com 410.933.8500	**ROUNDO, AMERICOR, GEKA, and PRIMELINE**	Distributor of metal fabricating machinery including ROUNDO angle, section, beam, 3-roll, and 4-roll plate bending rolls; AMERICOR angle, 3-roll, and 4-roll plate bending rolls; GEKA ironworkers and automated punching systems; PRIMELINE press brakes and shears; and more.
CS Unitec, Inc. www.csunitec.com 800.700.5919	**LKF-450 multi-purpose beveling machine**	Bevels, deburrs, and chamfers steel, stainless steel, nonferrous metals, brass, and plastic. Faster and cleaner than angle grinders, the unit has a fine adjustment feature for the preparation of weld seams.
	ECO 50-AK portable magnetic drill	Lightweight, portable, 2-speed, high-performance magnetic drill has a hole-cutting capacity of 2-in.-diam. and a twist drill capacity of 7/8-in.-diam. An automatic cooling/lubrication system is built into the arbor. Ideal for structural steel and other metals.
	ARMOR-PLATED Unibroach	Ideal for drilling applications in structural steel and other hard metals. These cutters allow drilling at high operating temperatures with more power and RPM. Available in 1-in., 2-in., and 3-in. depths with diameters from 7/16 in. to 5 in.
	PL50 air-reciprocating saw	Pneumatic reciprocating saw for demanding applications, including cutting metal, timber, and fiberglass. Accepts either ½-in. or ¾-in. hand or machine hacksaw blades with nosepiece change. Rugged construction and built-in lubrication system for long life.
Daito USA www.daito-seiki.com 847.437.6788	**Band saws and miter saws**	Band saws and miter saws for industrial and structural steel. Our band saws and miter saws come in a variety of sizes up to 20-in. capacity.
	Drill presses	Drills designed for structural steel use.
Design Data www.dsndata.com 800.443.0782	**SDS/2**	Design Data's SDS/2 is a 3D computer modeling software product designed for the structural steel industry. SDS/2 allows steel detailers, fabricators, engineers, and erectors to access the same 3D model from anywhere in the world simultaneously.
DoALL Sawing Products www.doallsawing.com 888 DoALLSAW	**General purpose saws**	Cut-off, contour, and miter band saws are available for sawing a variety of materials with capacities to 17-in. x 17-in. rectangles. They are an economical solution for low volume operations.
	Vertical contour saws	Vertical band saws have a throat depth up to 36 in. and a maximum work height to 20 in., depending on the model. They are for mitering, contour cutting, disk cutting and more.
	Miter cutting saws	Available in tilt-frame or swivel head configuations, miter cutting saws feature rectangluar capacities to 26 in. x 39½ in. with angle cutting capacities to 60°.
	Product power saws	Horizontal saws for production sawing have automatic operation and numeric control and feature solid, heavy-duty construction. This provides more rigidity and reduces vibration for superior finishes and exceptional accuracy.
E.J.E. Industries, Inc. www.ejeindustries.com 724.228.8841 800.321.3955	**Structural Material Manager**	The system manages material lists by providing weights, surface areas, paint/primer requirements, bolt counts, shipping tickets, and estimating reports. Its Nesting Module optimizes cut-lists, and the CAD interface eliminates re-typing.
ESAB Welding & Cutting Products www.esabna.com 800.ESAB.123	**Coreshield self-shielding flux cored wires**	Combining outstanding strength, superior weld characteristics, high deposition rates, low spatter, easily removable slag, and low fume production, Coreshield wires consistently rate the highest welder appeal in their class.
	Atom arc covered electrodes	The original iron powder low-hydrogen electrode still sets standards for high-production radiographic quality welds in mild and low alloy steel with its smooth metal transfer and excellent mechanical properties.
	ESAB 653cvcc power source	This multi-process, three-phase power source is designed for heavy-duty industrial DC welding applications. Ideal for Mig, flux cored wire, submerged arc, and stick electrode welding or carbon arc gouging.
	Mobilefeed wire feeder	This arc voltage wire feeder for use with DC, CC, or CV power supplies features a permanent magnet drive motor and a totally enclosed, impact-resistant case that protects against contaminants
FabCAD, Inc. www.fabcad.com 866.427.2454	**FabCAD Premium**	An AutoDesk-powered ornamental/miscellaneous detailing system. The program automatically draws railings, fences, and gates with complete dimensions and bill of materials. FabCAD Premium also includes a 10,000-part design library of ornamental castings and forgings from nine industry suppliers.
FabSuite LLC www.fabsuite.com 757.645.0842	**FabSuite**	A package of fabrication management programs that includes: estimating, combining (mult/nest), inventory, production control, project management, purchasing, order entry, and bar coding interface.
	FabSuite – Project Management	A stand-alone program, packaged for independent steel detailers. It includes: project contacts, design and detail drawing logs, transmittals, RFIs, change orders, journal entries, check list, and task list.
FabTrol Systems, Inc. www.fabtrol.com 541.485.4719	**Fabrication software**	FabTrol MRP is the global leading steel fabrication software for managing estimating, drawings, materials, production, and shipping.

products

Company	Products Offered	Product Description
Faccin USA, Inc. www.faccin.com 813.664.8884 905.407.4606	**Bending rolls**	Faccin is the world leader in the production of heavy-duty bending rolls for plate, angle, and structural shapes. Special options automate the rolling of wind tower structures and offer maximum output. Also a manufacturer of heavy-duty flange rolls and dished head equipment.
Ficep Corporation www.ficepcorp.com 410.588.5800	**CNC plate processing systems**	The Ficep plate processing systems address the operations of drilling, punching, milling, tapping, countersinking, marking, and final part cutting without manual intermediate material-handling processes.
	CNC angle processing lines	The current Ficep product line of CNC angle fabrication systems comprises 12 different models. Typical operations include punching, drilling, marking, and notching (on not only angles, but also flats and channels).
	CNC drilling lines	The Ficep lines incorporate drilling and scribing on all surfaces. The scribing capability interfaces with Tekla Structures for downloading of the scribing data required for fitting from their 3D model.
	CNC robotic coping	The Ficep robotic coping systems feature both oxy-fuel and plasma. The full robotic torch motion features full motion even for such tasks as weld prep on the web and flanges.
Franklin Manufacturing, Inc. www.fmi-solutions.com 256.332.6654	**Model AFC5108-12FB × 196 Angle Fabricator**	Three-axis angle fabricator (6 × 6 × ½ – 8 × 8 × 1-in. maximum angle, 12 × 1-in. flat bar, C12 at 20.7 channel capacity). Triple gag tooling and optional plasma cutting. Punching capacity: 100-130 tons. Maximum: 1½-in.-diameter hole.
	Model HD-145 × 44 Drill System	CNC three spindle drill system with 300-750 lb/ft conveyor system. High-speed spindles. DVST file compatible with Windows XP. Saw integration. Engineered material handling.
	Model PF196 × 72G Plasma/ Punch Plate Fabricator	With triple gag tooling and plasma cutting. Optional conveyor and gantry systems. Multi-grade ASTM A36. 60-72 psi maximum shear strength. Maximum tonnage is 196 tons. Maximum hole diameter is 2 in. 400 amp plasma. Various nesting options. Windows XP.
	Heavy-Duty F5-2 Series Hydraulic Punch Presses and Power Units	Sixteen standard web/flange models from 30-275 tons, eight standard models from 30-100 tons. With coupling nuts, wrenches, and handlebars. Hardened replacement die pockets.
Hougen Manufacturing, Inc. www.hougen.com 810.635.7111	**Portable mag drills**	Lightweight and easy to use on the job site. Fifteen models make holes from 7/16 in. to 3-1/16 in. diameter and up to 3 in. deep.
	Rotabroach annular cutters	Require less horsepower, last longer, and drill cleaner holes than conventional methods. Available in diameters from 7/16 in. to 4 in., and up to 6 in. depth of cut.
	Sheet metal hole cutters	Two series of sheet metal hole cutters make clean, burr-free holes in sheet metal and thin materials. Heat-treated, precision ground geometry makes them last longer than hole saws.
	Punch-Pro portable electro-hydraulic hole punchers	Completely self-contained. No external hoses or hydraulic pumps to carry. Plug into any 120v outlet and punch holes in seconds.
Jesse Engineering Company www.JesseEngineering.com 253.922.7433	**Pipe benders**	Simple and rugged hydraulic pipe benders for pipe fabrication from 2-in. to 10-in. pipe.
	Pipe saddle and hole cutters	Heavy-duty roller bed-style pipe cutting machine for cut to length, bevel, and Y, T and K joints in 2-in. to 36-in. pipe.
JLG Industries, Inc. www.jlg.com 877.JLG.LIFT	**SkyWelder**	The JLG SkyWelder for boom lifts consists of a 7,500-watt generator installed in the engine compartment with leads running through the boom to the platform where a 280-AMP Miller is installed.
	Ultra boom lifts	JLG Ultra boom lifts have platform heights ranging from 120 ft to 135 ft. They have 1,000 lb of restricted platform capacity, 500 lb of unrestricted capacity, and the largest work envelope in the industry.
	JLG scissor lifts	JLG rough terrain scissor lifts feature standard 4-wheel drive, proportional lift up and lift down, and a 4-ft manual extension deck as standard equipment. Maximum capacities are up to 2,250 lb.
	JLG telehandlers	JLG telehandlers have lifting capacities up to 12,000 lb. and lifting height to 55 ft. There are four brands, each with unique features. They include JLG, SkyTrak, Lull, and Gradall.
Kaltenbach, Inc. www.kaltenbachusa.com 800.TALK.SAW	**Sawing, drilling, and coping machinery**	Manufacturer/supplier of machinery for the structural steel fabricator and steel service center, specifically: band and circular sawing machinery; 3-axis CNC drilling lines; structural plate processing machinery; 8-axis fully robotic coping cells; fully CNC punch and shear lines; plus associated material measuring and handling systems.
Lista International Corp. www.listaintl.com 800.722.3020	**Storage systems**	Lista International Corp. designs and manufactures innovative, efficient, modular storage and workspace systems: drawer storage cabinets, industrial and technical electronic workbenches, Storage Wall Systems, accessory systems, and other unique solutions. With custom solutions that exactly suit the user's specific storage needs and free design services, we maximize space to make businesses more productive
Mazak Optonics Corporation www.mazaklaser.com 847.252.4500	**FabriGear**	Automatically loads, feeds, lasercuts, and unloads round and rectangular pipe as well as I-beam and other structural shapes. Can handle pipe up to 11.8 in. in diameter and over 49 ft long.
	SpaceGear	Triple-mode laser. Fabricates sheetmetal and plate up to 7/8 in. thick. Cuts pre-formed parts—stamped, hydroformed, and spun. Processes round and rectangular pipe as well as I-beam and other structural shapes.
	HyperGear	Processes up to 1-in. mild steel using patented intelligent features designed to automatically provide optimum setup, maintenance notification, and fastest cutting speeds for every material type and thickness—all without operator intervention.
	SG-U44	Compact triple-mode production laser. Performs high-speed 2D processing of sheet metal and plate up to 7/8 in. thick, 3D cutting of pre-formed parts, and 3D-rotary cutting of tube, pipe, and structural.
MG Systems & Welding, Inc. www.mg-systems-welding.com 262.255.5520	**MPC2000**	The MPC2000 is a large-gantry, precision multi-process cutting machine enhanced with programmable PL-1 lifters. Powerful AC drives provide high performance and productivity. Heavy-duty construction allows 24/7 operation.
	EdgeMax	The EdgeMax sports a rugged unitized steel table/frame, full-capture bearing assemblies, and a low-mass aluminum beam driven by dual brushless AC motors, which provides fast acceleration, precise motion, and a very stable cutting platform. It meets the needs of various fabrication markets from HVAC, general fabrication, and precision Hy-Definition cutting.
Mobilis Systems, Inc. www.smsteel.com 866.618.3878	**Mobilis modular software suite for steel fabricators**	Software suite covering estimating, nesting, production follow-up, shipping, material management, and job costing. Modules can be implemented at your own pace, as your needs evolve, to step toward greater profitability
Multiquip, Inc. www.multiquip.com 800.421.1244	**DLW-300ES welder/generator**	A mid-size 300-amp welder/10kW generator with a 100% duty cycle at 280 amps. The arc force dial lets the operator fine-tune the arc to the desired quality.
	Moonlight balloon lights	Portable lighting systems that emit glare-free 360° white light up to 100 ft from the light source. The balloons don't require a fan to maintain inflation
	GA Series generators	Outputs from 2.5 to 9.7 kW and they power a wide variety of jobsite tools. Each utilizes 100% copper windings and brushless alternator designs for superior voltage regulation

FABRICATION PRODUCTS

Company	Products Offered	Product Description
Ocean Machinery www.oceanmachinery.com 800.286.3624	**One-stop shopping for structural fabricating machinery**	Major importer and distributor of steel fabricating machinery, including CNC beam lines, press brakes, ironworkers, plasma cutters, waterjets, hydraulic punches, etc.
	Ocean Avenger CNC Beam Drill Line	Processes all steel profiles, including beams, channel, angle, tube, pipe, and plates. It drills the heaviest/thickest steel profiles, eliminates manual layout of holes and marks, and drills holes at over 200 holes per hour.
	Ocean Liberator CNC Beam Coping Machine	Cuts and copes all steel profiles, including, beams, channel, tube, angle, plate, etc. Up to 44-in. beams, 6-in. thickness.
	Ocean Terminator Dual Column Dual Miter Band Saw	The terminator band saws are designed to cut structural steel profiles up to 42 in. They feature dual column construction and miter cutting both ways, with large 2-in. saw blades, ensuring fast accurate cutting.
Peddinghaus Corporation www.peddinghaus.com 815.937.3800	**Drill, plate processing, saw, and material handling equipment**	Peddinghaus manufactures the following products in the U.S.: three models of structural steel drilling machines; seven models of heavy plate processing systems; four models of heavy-duty production band saws; three models of Anglemaster machines for angle iron and flat stock detail production; and automated material handling systems.
Scotchman Industries, Inc. www.scotchman.com 800.843.8844	**ShearMaster 610**	Designed to shear 1-in. x 12-in. base plates and up to ¾-in. x 16-in. and ½-in. x 24-in. flat stock. This shear can be used in small-run applications or a high production environment.
	Scotchman Advanced Feed System	Comes complete with a powerful, user-friendly control panel, which allows you to set up to 99 different programs using fractions, decimals, inches, or metric. The system automatically moves your material to position and cycles the machine.
Peerless Industrial Equipment Corp. www.peerlessusa.com 920.231.4100	**Daito CNC Drill Lines**	Daito offers the most automated drill line systems in the world including drilling, marking, sawing, coping, and beveling in an integrated system with one operator.
	Daito CNC Robot/Plate Coping	Daito's innovative coping robot can be placed in-line with other machines or can stand alone. The flexible system employs both plasma and oxy-fuel. The robotic arm is motioned for all tasks including weld-prep and plate processing for plate up to 48 in. wide.
	Peerless Band Saws	Peerless began manufacturing saws in 1901 and now offers a full line of cut-off saws, contour saws, miter cutting saws, and power hacksaws.
	Peerless Ultra-Fab Plate Processors	Plasma, oxy-fuel, drilling, tapping, and plasma piece marking with tables of virtually any size.
Simonds International www.simondsinternational.com 800.343.1616	**Bandsaw blades**	Professional grade carbide-tipped, bi-metal, and carbon bandsaw blades enhance faster cutting and increased production through the toughest materials
SteelCad Consulting Corp. www.steelcad.com 800.456.7875	**SteelCad**	SteelCad offers a variety of steel detailing modules, starting at the basic structural package—which offers beams, columns, and bracing along with built-in connection design—to the fabricator package, which offers CNC and production control capability. You are free to build a package that is right for you at a price you can afford.
Steelware, Inc. www.steelware.com 864.294.1206	**Steel detailing package**	Steelware is a complete steel detailing package for both miscellaneous and structural steel. The miscellaneous section includes a very extensive and versatile stair and railing element. Also included are the cage ladders, plain ladders, angle frames, embedded angles, and considerably more. The structural section contains beams, columns, horizontal bracing, vertical bracing, and their associated components (i.e., end clips, auto coping, web holes, shear tabs, base and cap plate, etc.).
StrucSoft Ltd. www.strucsoftsolutions.com 877.810.7575	**ProSteel 3D**	Intelligent steel modeling within AutoCAD offers connection design capability and interface to popular analysis applications and CNC machines.
Tru-Weld www.truweldstudwelding.com 800.321.5588	**Concrete anchors and shear connectors**	Headed weld studs are available in low carbon or stainless steel. Ranging in diameters from ¼ in. to 1 in. diameter. Used in composite construction and embedment plates in reinforced concrete. Conforms to AWS, AISC, and AASHTO specifications
	Deformed bar	Deformed bar anchors are available in mild and stainless steel. Ranging in diameters from 3/8 in. to ¾ in. diameter with lengths up to 60 in. configured straight or bent.
	Threaded studs	Fully threaded, partially threaded, and collar studs are available in low carbon plain finish, copper plated, zinc plated, nickel plated, and stainless steel
	Stud welding equipment	Stud welding machines and accessories. New and used equipment along with a large rental fleet. Parts and service for all brands of stud welding equipment
UNIST, Inc. www.unist.com 616.949.0853	**UNIST Thru-The-Tool Micro-Fluidization Systems**	UNIST Thru-The-Tool Micro-Fluidization Systems are positive displacement lubrication systems designed to apply lubricants small amounts to the tool-work interface in structural steel drilling applications. UNIST Thru-The-Tool systems are designed for use both in portable and CNC drilling for steel fabrication. The systems employ a "low air-pressure drop" technology, which maintains a consistent amount of air and fluid flowing to the tool tip throughout the entire duration of the cut to keep materials cool and evacuate chips.
Vernon Tool Company www.vernontool.com 760.433.5860	**Pipe cutting machines**	An oxy-fuel and plasma cutting machine for 2-in. to 84-in. OD structural members.
	MasterTube Plasma Profiler	Cutting machine for 1 in. to 6 in. round and rectangular structural tubing for ornamental and miscellaneous steel construction.
Voortman Corporation www.voortmancorp.com 815.935.3010	**CNC pipe cutting systems**	Plasma and gas cutting systems for pipe, square, and rectangular tubing from 2 in. to 84 in.
	CNC drilling lines	Up to 50 in., all with high-speed drilling using carbide tooling. Spindle speed up to 2,500 rpm and 30 ipm feed rate. Layout/detail marking from 3D detailing to the material can now be included with the standard system. These machines can be incorporated into the Voortman FMS system to run unmanned as required.
	CNC band saws	Many models up to 50 in. wide with mitering capability up to +/- 60°. Stand-alone systems or in combination with a CNC drill line. Saw measuring system that includes the measuring stop and also rollerfeed can be added to the system. The systems can be driven directly from DSTV to provide automation and a paperless cut list.
	CNC plate processing	High-speed carbide plate drilling systems, combination punch, and high-speed plate drilling systems. Punching and shearing systems with miter shear capability. Automated plate systems that can run unmanned with stock loading systems. Plate plasma/gas cutting and drilling systems up 8 ft in width with automated load unload.
Wheelabrator Group www.wheelabratorgroup.com 800.845.8508	**Wheel blast equipment, automated air blast equipment, and equipment modernization programs**	Wheelabrator Group manufactures a full range of wheel-type shot blast machines, mass finishing equipment dedicated to the demands of the industry, and automated airblast solutions. Technically advanced and designed for ease of maintenance, Wheelabrator Group machines range from standard versions to fully customized and integrated systems. Wheelabrator Plus professionals will inspect your current blasting equipment and conduct a thorough assessment that includes reviewing the latest modernization options to determine if any productivity, cost savings, safety, or environmental improvements could be realized as a result of upgrading to newer technology.

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QUALITY-CONSCIOUS, GOAL-ORIENTED, AND PROACTIVE STRUCTURAL STEEL FABRICATORS COMMITTED TO QUALITY WANTED FOR AISC QUALITY CERTIFICATION PROGRAM. AISC is looking for capable fabricators of any size interested in reinforcing their positive reputation within their local market by implementing a quality management system addressing all aspects of their business processes. Candidates must be willing to subject themselves to a rigorous annual third-party independent audit. Successful candidates will become AISC Certified, proving to specifiers, contractors and owners that they have the personnel, experience, equipment and knowledge to deliver a quality product. All interested applicants please contact AISC at 312.670.7520 or certinfo@aisc.org.

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- Presenting Company, Software and Solution Services
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Candidates will require excellent written and verbal communication skills, with the ability to multi-task. Attention to detail, enthusiasm and the will to succeed are necessary to fulfill this demanding role, but knowledge of the Structural Steel Industry is essential.

2-3 years experience using fabrication software for the steel industry is required.

Equal opportunity employer.

Please apply in writing with an up-to-date resume to **sales@strucad.com**

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ProCounsel, a member of AISC, can market your skills and achievements (without identifying you) to any city or state in the United States. We communicate with over 3,000 steel fabricators nationwide. The employer pays the employment fee and the interviewing and relocation expenses. If you've been thinking of making a change, now is the time to do it. Our target, for you, is the right job, in the right location, at the right money.

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TEKLA STRUCTURES DETAILING MANAGER

CAL WEST STEEL DETAILING is looking for an experienced Tekla Structures Detailer/Checker to run our Tekla Structures Department.

Ideal Candidate would have multiple years of Detailing and Checking Experience with several years of Tekla Structures Experience. Cal West offers Excellent Pay, Great Benefits including 401K and a Relocation Allowance. A Starting Bonus will be paid to the right candidate.

Cal West Steel Detailing
4495 Stoneridge Drive, Pleasanton, CA 94588
Or email to: **bobs@cwsteeldetailing.com**

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Top 25 ENR General Contractor is seeking an experienced Structural Steel Division Manager. Qualified candidates must have 15 years experience in structural steel erection in commercial building and or heavy highway, preferably both. Must have the capability to develop new business, estimate, project manage, and recruit key personnel. Ideal candidate will provide leadership, team building, develop talent, and create a successful atmosphere.

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Our organization has been recruiting for the Structural and Misc. Steel Fabricating industry for over 20 years. Current positions include:

- Project Manager
- Plant Superintendents
- Chief Draftsman
- General Manager
- Estimators
- Quality Control
- Detailers
- Checkers

Please send resume to:
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Staff Engineer

If you are looking for an entry-level position, have good people skills, and like new challenges, AISC has an opportunity available. AISC is now seeking applicants for a Staff Engineer position in the AISC Engineering & Research Dept. This is a unique opportunity to work with issues in structural research as well as steel fabrication. You will work with the top educators in the North American steel design and construction industry and will be in a position to establish yourself as an expert in steel design. The position will allow you to use your technical training to develop and promote research and industry issues that benefit the entire structural engineering community and structural steel industry.

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Ramar STEEL ERECTORS INC.

Ramar Steel, a member of AISC, is one of western New York State's most reputable structural steel fabricators and erectors. Ramar is located in Rochester—on the shores of Lake Ontario and within the Finger Lakes region of the state. We are seeking experienced, talented and motivated steel industry professionals to support our plant expansion and sales growth. We are currently seeking:

- **Detailer** – minimum 2-3 years structural steel detailing experience (Tekla / XSteel preferred)
- **Project Managers** – to manage multiple fabrication and erection projects
- **Fabrication Manager** – Hands-on professional to oversee shop operation of 15-20 employees
- **Estimators** – Minimum 5 years structural steel estimating experience required

Ramar Steel offers excellent pay, generous medical, dental and life insurance benefits, 401K, profit sharing and bonuses.

Send resumes to **mar@ramarsteel.com** or fax to **585.263.2734**.

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Progressive structural engineering firm seeks a structural 3-D Building Information Modeler interested in an opportunity to join an innovative team involved with adopting a more advanced technological approach to designing, documenting and constructing building facilities across the country.

Responsibilities will include working with design and construction teams in a 3D environment to design and coordinate multi-discipline building design projects and assist the interoperable flow and use of 3D models to the construction team. Qualifications include 3-5 years Tekla detailing or Revit modeling experience and fluency in Autocad.

Submit resume and project biography to Structural Consultants, 3400 E. Bayaud Ave. #300, Denver, CO 80209, fax 303-333-9501. Email: joe@sci-denver.com.

Project Manager/Detailers/Checkers

SteelStar Corporation is an aggressively growing detailer/fabricator/erector (16-20 Million/Annually) in the Denver Metro area along the beautiful Front Range of Colorado.

Project Manager ($65-95K Annually)
We are currently seeking an aggressive and skilled project manager with experience in low to mid rise commercial/industrial, miscellaneous and architectural/ornamental metals projects from 500-2000 Tons.

The successful candidate must have a minimum of five years experience in construction project management. Requirements to include, but are not limited to; excellent computer/technical skills, organizational skills, scheduling skills and documentation skills as well as great communication and customer service skills. Most important of all, the successful candidate must have a great attitude! An Associates or Bachelors degree is required; this may be waived in lieu of experience. Relocation to Colorado Required. Must have excellent references and project track record.

Detailers/Checkers ($15-$35 Per/Hour)
We are currently seeking (3) skilled Tekla (Xsteel) and (4) AutoCAD/AutoSD detailers & checkers with experience in low to mid rise commercial/industrial, miscellaneous and architectural/ornamental metals projects up to 2000 Tons.

The successful candidate must have a minimum of (3) year's structural and/or miscellaneous steel detailing experience. Requirements include, but are not limited to; excellent computer/technical skills and Tekla or AutoCAD experience. Most important of all, the successful candidate must have a great attitude! Relocation to Colorado Required. Candidate must be able to provide excellent references and drawing examples. All candidates must be currently eligible to work in the United States.

We offer the security of a financially stable company, profit sharing, competitive wages, relocation reimbursement, medical benefits, 401K, paid holidays and paid leave time, and most of all, a fun place to work with opportunity for advancement. Please send resume to: SteelStar Corporation, P.O. Box 218 - Dacono, CO 80514 Attn: Employment - Fax 303.828.4092 or email employment@steelstar.com. Visit us @ www.steelstar.com.

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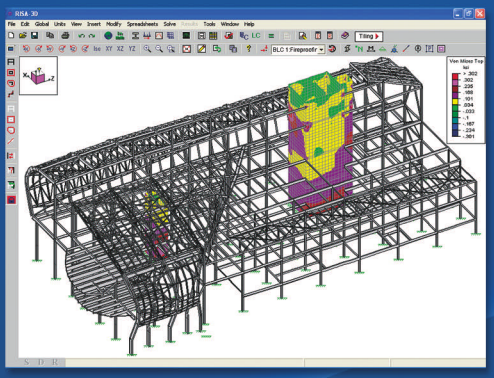

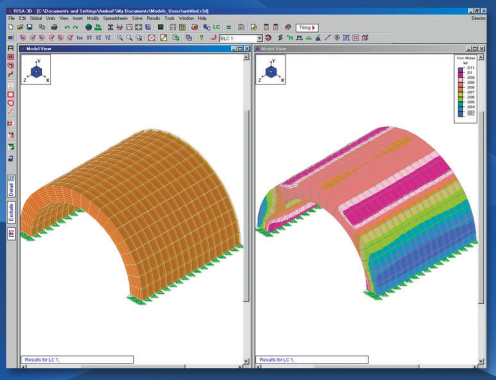

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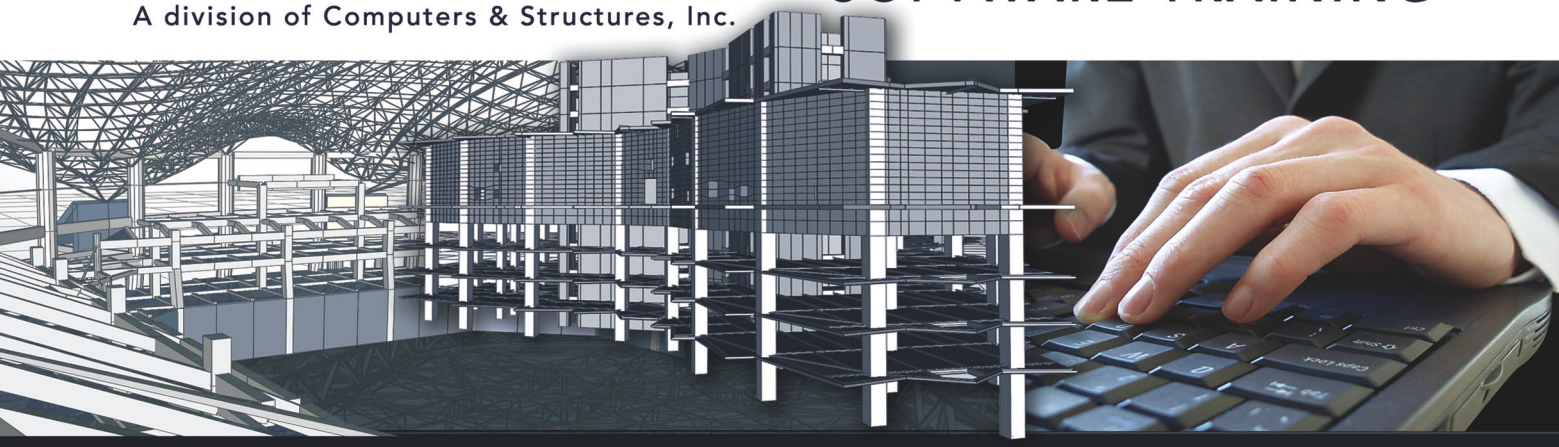

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