MSC

MODERN **STEEL** CONSTRUCTION

September 2009

AMERICAN INSTITUTE OF STEEL CONSTRUCTION
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A New Twist on Truss Recycling

IN THIS ISSUE

Field-Bolted Steel Joists

Steel Bridge News

Parking Garages


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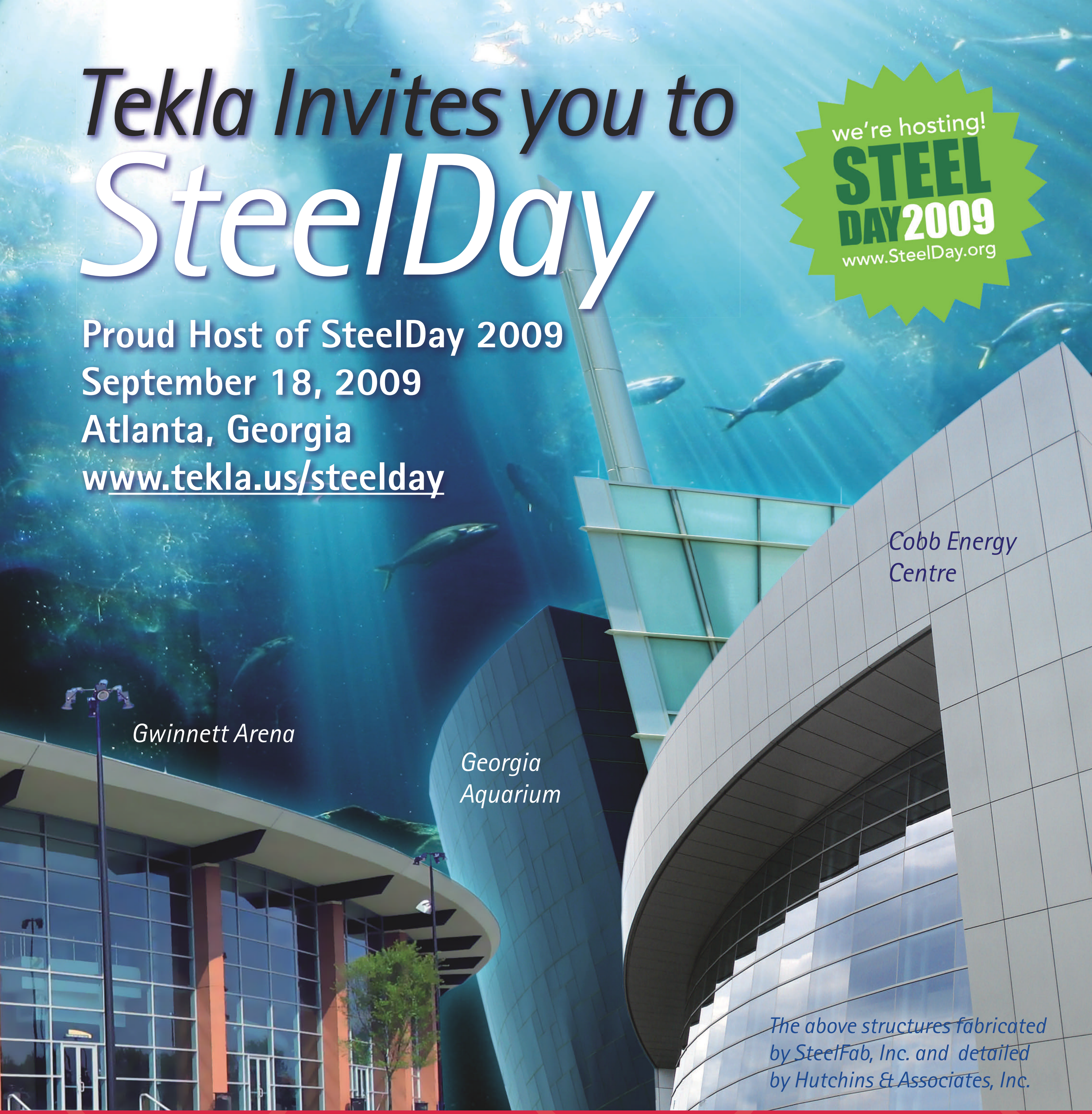
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September 2009

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MODERN **STEEL** CONSTRUCTION

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ON THE COVER: The new Black Bridge in Missoula, Mont., was reconstructed largely from the old bridge's two short trusses. (Photo: Tom Hanou, HDR)

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editor's note

I'M IN FLORIDA, IT'S 94 DEGREES OUTSIDE, AND I'M SITTING IN A MEETING ROOM WEARING A SPORTS COAT AND HUDDLING AROUND MY RAPIDLY COOLING CUP OF COFFEE IN A VAIN ATTEMPT TO STAY WARM.

I'm amazed, given all the daily talk about climate change and the green movement, that we spend so much on over-air conditioning rooms. And lest you think I'm exaggerating, let me quote from the welcome letter I received from a conference I'm attending in mid-August: "Attire for the 2009 Annual Meeting & Exposition is business casual, don't forget a light sweater for air-conditioned meeting rooms!" Why don't they just turn down the air-conditioning? (Ironically, this particular convention center bills itself as: "An environmentally responsible, 'green' convention center." It's website notes: "Long recognized as an outstanding example of a 'green' facility, our goal is to serve as a global leader within our industry in this area and to provide opportunities for our client and their events to aspire to do the same." Adding insult to injury, they particularly note their attention to energy conservation.)

A growing number of organizations, AISC included, are now offering alternatives to shivering in meeting rooms: Webinars that you can take from the comfort and convenience of your office or home. Webinars differ from online continuing education in an important manner—with a webinar you can interact with the presenter.

AISC's first webinar is scheduled for September 18, which as many of you know is SteelDay. (What's SteelDay? It's a nationwide networking and educational event for members of the design, construction, and structural steel industry. More than 150 live events—such as fabricator shop tours—are scheduled in almost every state in the U.S. Visit **www.steelday.org** to find the closest event.) And in celebration of SteelDay, AISC is offering free registration to this webinar. The 1.5-hour program, kicking off at 10:30 a.m. CST, focuses on Stability and Analysis. The speaker, Professor Louis F. Geschwindner, will emphasize the requirements for stability design and analysis under the 2005 AISC *Specification* (including how it differs from the 1999 LRFD and 1989 ASD *Specifications*). According to Geschwindner: "This live webinar is an introduction to the methods for incorporating the 2005 AISC *Specification* requirements into your design. Examples will be given." For more information on the webinar, visit **www.aisc.org/webinar**.

In the hierarchy of continuing education, there really is no substitution for in-person events. I find I often learn as much by interacting with the other attendees as I do from the formal presentation. But when budgets or time constraints interfere with attending an event in person, a webinar seems like a good compromise. If you attend this webinar, let me know what you think!

And since we started with talk of the green movement, please join me in congratulating Geoff Weisenberger who was recently promoted from MSC Senior Editor to AISC's Director of Sustainability. Please also join me in welcoming Tom Klemens as MSC's new Senior Editor. Tom started his career as an engineer but for the past two decades has worked at a variety of trade magazines.

SCOTT MELNICK
EDITOR

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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.

HSS Steel Availability

What yield strengths are typically available for HSS2×2×¼ and HSS3×3×¼?

HSS is generally supplied to the fabricator through a local service center from an inventory of common sizes. The two sizes you list are quite common and most likely available in your region. For additional information please try the Steel Availability link at **www.aisc.org/availability**, a handy resource to find manufacturers of various shapes commonly used in structural steel applications. Generally speaking, sizes with multiple manufacturers are carried by steel service centers. Should you require more information on availability, use the "Contact Information for Steel Service Centers" to find a contact in your area.

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

Installation Torque

What is the normal torque for ASTM A325 and A490 bolts used in non-slip-critical connections?

There are three types of joints: snug-tightened, pretensioned, and slip-critical. There is no "normal torque" defined for any of these cases. Rather, it is the level of installed pretension that matters.

In the first case—snug-tightened—the installation requirements are only that the connection be brought into firm contact with the full effort of an ironworker using an ordinary spud wrench. Where snug-tightened installation is permitted, the actual level of pretension that results does not matter.

In the second case—pretensioned—the AISC and RCSC *Specifications* define a required pretension that must be installed in the bolts, rather than a torque. There is no recognized uncalibrated torque/tension relationship for bolt installations, as this can be quite variable dependent on the condition of the bolts. That is why pretensioned bolt installations must be performed using one of the four permitted methods: turn-of-nut pretensioning, calibrated wrench pretensioning, TC bolt pretensioning, or DTI washer pretensioning. All of these methods require a preinstallation verification process. The calibrated wrench method is torque-based, but must be explicitly calibrated in order to define the torque-tension relationships for the particular application. See the RCSC *Specification* (a free download at **www.boltcouncil.org**) for details.

In the third case—slip-critical—installation is performed the same way as for pretensioned joints. The only differences are in the additional requirements, such as for design and faying surface preparation.

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

Axial Strength of Channels

The AISC *Manual* tables for columns do not include channels. How does one determine the axial strength of such shapes?

The axial strength of channels with webs that are not slender can be computed using the AISC *Specification*, Chapter E. Specifically, consider flexural buckling per Section E3 and flexural-torsional buckling per Section E4 (Equation E4-5). If the web is slender for compression (see Table B4.1, Case 14), see Section E7.

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

Thermal Cutting

If an oxy-acetylene torch is used to flame cut the edge of a new steel beam or plate, what impact does that have on the steel? Is the strength of the steel affected? Is the edge distance or bolt hole spacing affected by this process?

Flame cutting is a common practice in steel fabrication and erection, and the effects of this heat input are not significant in statically loaded structures. In cyclically loaded structures, there are cases when the AISC *Specification* requires that flame-cut surfaces must be ground smooth. Note that the surface finish of thermally cut surfaces, and particularly bolt holes, must comply with the requirements of Sections M2.2 and M2.5 of the 2005 AISC *Specification* [available for free at **www.aisc.org/2005spec**] for the above to be true.

Amanuel Gebremeskel, P.E.

Mill Cut or Square Cut?

What is the difference between mill cut and square cut?

The term mill cut generally implies that compressive loads will be transferred in bearing between the parts. Since this is rarely required for beams, the more general term square cut is used.

The Commentary to Section J7 of the AISC *Specification* states, "As used throughout the *Specification*, the terms "milled surface," "milled" and "milling" are intended to include surfaces that have been accurately sawed or finished to a true plane by any suitable means."

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

Puddle Welds

We have a project where we have asked the structural engineer of record to change a ⅝-in. puddle welded connection to a connection using powder-driven fasteners. He has indicated it is acceptable to use powder-driven fasteners as long as they meet or exceed the uplift resistance of the assembly when using welds. Can such fasteners provide the uplift resistance of a ⅝-in. puddle weld?

I presume that you are referring to puddle welds (arc spot welds) on sheet steel products. This subject is not covered in the AISC *Specification*, but you can find the method to calculate the uplift capacity of puddle welds in AWS D1.3, *Structural Welding Code—Sheet Steel*. This capacity will be based on the thickness and specified tensile strength of the sheet steel, and the resultant average diameter of the arc spot weld. With that information, the powder-driven fastener product manufacturer should be able to advise you which of their products will provide for the needed strength.

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

Anchor Rods

For base plate anchor rod design, why is ASTM F1554 the preferred specification? Is ASTM A449 suitable? What is the reference for torque values of base plate anchor rods?

Both ASTM F1554 and ASTM A449 are permitted for use as anchor rods in the AISC *Specification*. ASTM F1554 is preferred because it is an anchor-rod product specification. ASTM A449, like all the other common grades that have been used for anchor rods, is a material specification only with no specific requirements given for when it is used as in an anchor rod application.

Table 2-5 in the 13th edition AISC *Steel Construction Manual* shows ASTM F1554 Grade 36 as the usual grade for the general case. If you are specifically going to use a high-strength anchor rod, ASTM F1554 remains the preferred type, and has two options: Grades 55 and 105.

Regarding torque, we have two comments. First, torque is not useful in installation of fasteners in buildings, unless it is calibrated. Rather, it is the level of pretension that we specify. Second, pretensioning of anchor rods is not a requirement in the AISC *Specification*, and it is not required in usual applications. If there is a case in which pretensioned anchor rods are required, the effects of creep in the concrete and bond relaxation along the length of the rods would have to be addressed. You also will need to specify a pretensioning method, as the bolt pretensioning methods we have are for short fasteners, not long rods.

Amanuel Gebremeskel, P.E.

Increase Fillet Weld Size for Gap?

On braced-frame connections we specify a weld size from a slotted HSS to a gusset plate. The HSS are generally slotted about ⅛ in. larger than the thickness of the gusset plate, so theoretically 1⁄16 in. of weld is lost on each side. Do I need to show the increased weld size on the design drawings?

Clause 5.22 of AWS D1.1 requires the welder to increase the leg size by the gap dimension when the gap is greater than 1⁄16 in. up to a maximum allowed gap of 3⁄16 in. (with some exceptions on the maximum gap).

You should not increase the weld size shown on your design documents, since this will result in the weld size being increased twice. It is good practice, however, in obvious cases such as the slotted HSS connection you describe, to include a note in the tail of the weld symbol that states that the welder is to increase weld size to account for the gap. This precaution should be unnecessary, since as I stated it is covered in AWS, but it always made me feel better to include it.

Larry S. Muir, P.E.

Delayed Steel Erection

A delivery on a job has been delayed by eight months. Because the steel is to be fireproofed, it is not painted and has rusted. The owner has expressed concerns about the steel and the effects of the rust. Would this affect the steel as far as strength?

If there is a loss of section caused by rusting, the strength of the member could be compromised. However, except for extremely corrosive environments, deterioration due to rusting is a very long-term process, and I would be surprised if this is a factor for an eight-month exposure.

The effect of the rust on the bonding of the fireproofing might be more of a consideration. FAQ 11.1.1 on the website at www.aisc.org/faq addresses the subject of surface preparation for application of fireproofing. If the rust bloom is tightly adherent, it may not affect the adhesion. I suggest that you should check with the fireproofing applicator to review the conditions for suitability of their product application.

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

Prequalified Weld Details

In Table 8-2, the prequalified weld for a single-bevel corner joint groove weld(4), on pages 8-43 and 8-44 of the 13th edition AISC *Steel Construction Manual*, one diagram shows the bevel in the horizontal plate and no bevel in the vertical plate. Wouldn't this be a problem of lamellar tearing? If not, why isn't it? Are there some load conditions in which this geometry would be acceptable?

The figures on the right in both the TC-U4a and the TC-U4b show the bevel on the part that is perpendicular to the 'face' of the weld. This is the preferred detail to reduce the potential for lamellar tearing. That being said, the details on the left are not prohibited. They will work in many cases and are useful in many applications.

A brief discussion of lamellar tearing is in the commentary to Clause 2 of the AWS D1.1 *Code*. AISC alumnus Bill Milek wrote this information, and did a good job of listing variables that affect potential for lamellar tearing. The figures on the right are the first choice, but not the only choice.

Tom Schlafly

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. Tom Schlafly is AISC's director of research. Larry Muir is a part-time consultant to AISC.

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

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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One East Wacker Dr., Suite 700
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solutions@aisc.org

steel quiz

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

1 True/False: The 2005 AISC *Specification* ASD safety factors are calibrated to give the same structural reliability and the same component size as the LRFD method at a live-to-dead load ratio of 3.

2 What is the value of second-order amplification in Chapter C of the 2005 AISC *Specification* beyond which the Direct Analysis Method provisions of Appendix 7 must be used?
(a) 1.0 (b) 1.5
(c) 1.7 (d) 2.0

3 True/False: When considering local buckling of flanges in built-up I-shaped sections, the 2005 AISC Specification includes the effects of web-flange interaction.

4 True/False: Because of strain hardening, a ductile steel bar loaded in axial tension can resist without rupture a force greater than the product of its gross area and its specified minimum yield stress.

5 What is the difference between the web local yielding and web crippling limit states at a local concentrated force on a member?

6 When evaluating existing structures through the use of load testing, is there a need to adjust the tensile yield stress determined by standard ASTM methods of testing?

7 True/False: The location of the shear center for a single angle is at the centroid of the section.

8 What value of damping, expressed as a percentage of critical damping, is generally used when evaluating steel building motion under wind events:
(a) 1% (b) 2%
(c) 3% (d) 4%

9 When working with ASTM A6 W-shapes with flanges of thickness in excess of 2 in., what is the minimum preheat temperature that is required when thermally cutting beam copes and weld access holes?

10 True/False: Grinding of paint from surfaces adjacent to joints to be field welded is required to reduce the possibility of porosity and cracking.

TURN TO PAGE 14 FOR ANSWERS

steel quiz ANSWERS

1 True. This is explained in further detail in Section A1 of the Commentary to the 2005 AISC *Specification*.

2 (b) According to Section C2.2 of the 2005 AISC *Specification*, use of the Direct Analysis Method is required when the ratio of second-order effects to first-order effects is greater than 1.5.

3 True. According to the Commentary to Section B4, k_c is used in Table B4.1 to account for the interaction of flange and web local buckling in built-up sections.

4 True. The tension yielding limit state is still checked, however, because excessive elongation of a tension member can limit its usefulness and precipitate failure of the system.

5 Web local yielding applies to both tensile and compressive forces, and limits the extent of yielding in the web. Web crippling on the other hand applies only to compressive forces and prevents crumpling of the web into buckled waves directly beneath the load. Web crippling controls for more slender webs, while web yielding controls for stocker webs. See the Commentary to Sections J10.2 and J10.3 in the AISC *Specification*.

6 Yes. According to the Commentary to Section 5.2 of the AISC *Specification*, the static yield stress is of interest, and can be determined using Equation C-A-5-2-1.

7 False. The location of the shear center—the point through which a member can be loaded as a beam without causing twist—for a single angle is at the intersection of the mid-lines of the two legs. See Figures C-F10.3 and C-F10.4 in the Commentary to the AISC *Specification*.

8 (a) The damping level used in evaluating steel building motion under wind events is approximately 1% of critical damping, as discussed in the Commentary to Section L6 in the AISC *Specification*.

9 When the curved part of the access hole is thermally cut, a preheat temperature of not less than 150 °F is required; See Section M2.2 of the AISC *Specification*.

10 False. Wire brushing to reduce the paint film thickness adjacent to joints to be field welded minimizes weld rejection. Grinding is typically not necessary, as stated in the Commentary to Section M4.5 in the AISC *Specification*.

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

Steel Solutions Center

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news

TRADE

Chinese Policy Hurts

A study released in late July by the American Iron and Steel Institute (AISI) and the Steel Manufacturers Association (SMA) says Chinese government economic policies are continuing to wreak havoc on the U.S. economy and others around the world.

Entitled *Rebalancing the U.S.-China Economic Relationship: A Steel Industry Perspective*, the study examines in detail the policies China has pursued to give its exports an artificial advantage in international competition, including manipulating the value of its currency, subsidizing export-oriented industries, and failing to enforce environmental laws. The study also analyzes the effect these policies have had on the U.S., including a $300 billion annual bilateral trade deficit. The full study is available on the AISI website at **www.steel.org**, and on the SMA website at **www.steelnet.org**.

SPECIFICATIONS

Second Public Review of the 2010 AISC Seismic Provisions (AISC 341)

The 2010 draft of the AISC *Seismic Provisions for Structural Steel Buildings* is available for public review from September 11 to October 26, 2009. This is the second opportunity for the public to submit comments on the new provisions; however, only portions that have been revised since the first public review (April 2009) will be open for comment. Look for a press release announcing the public review listed under "News" on the AISC home page (**www.aisc.org**) during this time. The draft provisions and comment submittal form will also be available for downloading directly at **www.aisc.org/AISC341PR2** and **www.aisc.org/AISC341PR2Form**. Hard copies will be available (for a $12 nominal charge) by calling 312.670.5411.

Please submit comments using the form provided online to Cynthia J. Duncan, director of engineering, at **duncan@aisc.org** by October 26, 2009 for consideration.

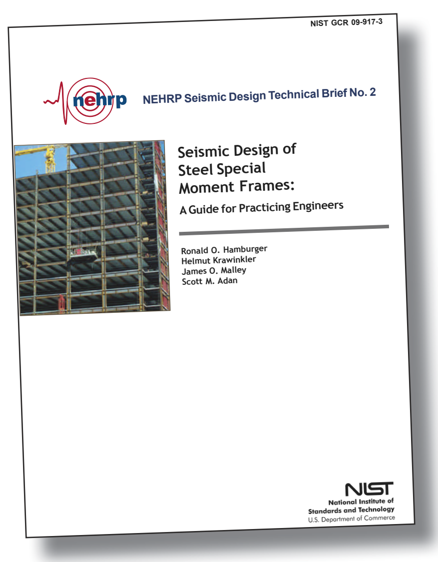
PUBLICATIONS

New Steel Deck Standards Downloadable for Free

The Steel Deck Institute (SDI) is offering its three new American National Standards (ANSI)/Steel Deck Institute (SDI) standards for Steel Roof Deck (RD1.0), Composite Steel Floor Deck (C1.0) and Non-Composite Steel Floor Deck (NC1.0) for free downloading from the SDI website, **www.sdi.org**. These three standards, which are suitable for reference use in project specifications by the design community, are the institute's latest resources. Since 1939 SDI has provided uniform industry standards for the engineering, design, manufacture and field use of steel decks.

Shake, Rattle, No Roll: Construction Guide for Earthquake-Resistant Buildings

A guide for designing buildings using steel moment frames to resist earthquakes has been published by the National Institute of Standards and Technology (NIST) as part of its support for the National Earthquake Hazards Reduction Program (NEHRP). "Seismic Design of Steel Special Moment Frames: A Guide for Practicing Engineers" is written for structural engineers, building officials, educators and students. It is the second in a series of technical briefs addressing topics of interest to earthquake professionals, primarily those in the design and construction industries.



Beams, columns and beam-column connections are specially designed in "structural steel special moment frames" to withstand building sway during the ground shaking that accompanies earthquakes. The new publication consolidates requirements of the International Building Code, which is the code generally adopted throughout the U.S., and related standards including ASCE 7, AISC 341 and AISC 358.

The guide covers code requirements and accepted approaches to their implementation, including background and sketches to illustrate the requirements. It also includes chapters on the use of special moment frames, their principles, guidance on analysis and design, additional requirements and detailing and constructability issues. The authors, professional engineers Ronald O. Hamburger, Helmut Krawinkler, James O. Malley and Scott M. Adan, also present best practice recommendations for design and construction that may not be specifically required by the codes or standards.

The free guide is available for downloading at **www.nehrp.gov/pdf/nistgcr9-917-3.pdf**.

CORRECTIONS

The architectural credit for this year's IDEAS2 award for the Pool/Ice Rink Project (May 2009 *MSC*) should have read "Handel Architects in Association with Kevin Hom + Andrew Goldman Architects, PC."

The authors of the article "Keeping the Party Going" were incorrectly identified on the July 2009 *MSC* table of contents. Robert M. Weilacher, P.E., S.E., LEEP AP and Dr.-Ing. Olaf U. Faber, P.E. wrote the article about the renovation of Atlanta's Marriott Marquis Hotel.

In the August issue of *MSC* Scott Adan's name was inadvertently included among the authors of a paper being published in the third quarter 2009 *Engineering Journal*. Mr. Adan co-authored "Experimental Evaluation of Kaiser Bolted Bracket Steel Moment-Resisting Connections," which appears in the same issue of *EJ*.

PROJECTS

Welding Delays Bridge

Welding problems at the China-based steel fabricator for the San Francisco-Oakland Bay Bridge have caused a two-month delay in shipping the pieces to the Bay Area, according to Steve Heminger, executive director of the Metropolitan Transportation Commission and a member of the panel that oversees bridge construction. The late deliveries could push back completion of the eastern span, now scheduled for 2013.

The National Steel Bridge Alliance in 2004 cautioned about circumventing the Buy America bridge provisions. The issue developed when the single American bid for the project was higher than expected. But rather than using a value engineering process to optimize the design and decrease costs, it was decided to use a China-based fabricator and Chinese-produced steel. At the time, NSBA officials said it could be redesigned more economically with a U.S.-based collaborative effort. It now appears the result of rejecting that option will increase costs and substantial delays in project completion. For more on this subject, visit the NSBA website, **www.steelbridges.org**.

IN MEMORY

Long-Time AISC Officer William W. Lanigan

William W. Lanigan, died July 14, 2009, at the age of 78. Bill joined AISC as secretary and general counsel following the retirement of Harvey Smedley in 1969 and held that position until 1988. He was made an honorary AISC member in 1989.

During Bill's early involvement he was very astute in guiding the Institute through the labyrinth of newly developing government regulations and rules pertaining to such matters as safety and OSHA. A daily mentor and facilitator to the entire membership, Board and staff, Bill helped guide AISC through the morass of moving its headquarters from New York to Chicago.

One of the many changes that Bill helped AISC work through was facilitating associate membership and the membership of individuals. He also was a strong consultant on changes made to the steel construction specification and facilitated many discussions, all of which led to a better and stronger Institute.

A fixture in all facets of the Institute for more than 20 years, Bill's attendance at most business and social events, committee meetings, and Board meetings was invaluable. He will long be remembered for his good counsel and for helping to move AISC, NSBA and the other associated organizations forward.

Leader in Steel Detailing Mario Webber-Rookes

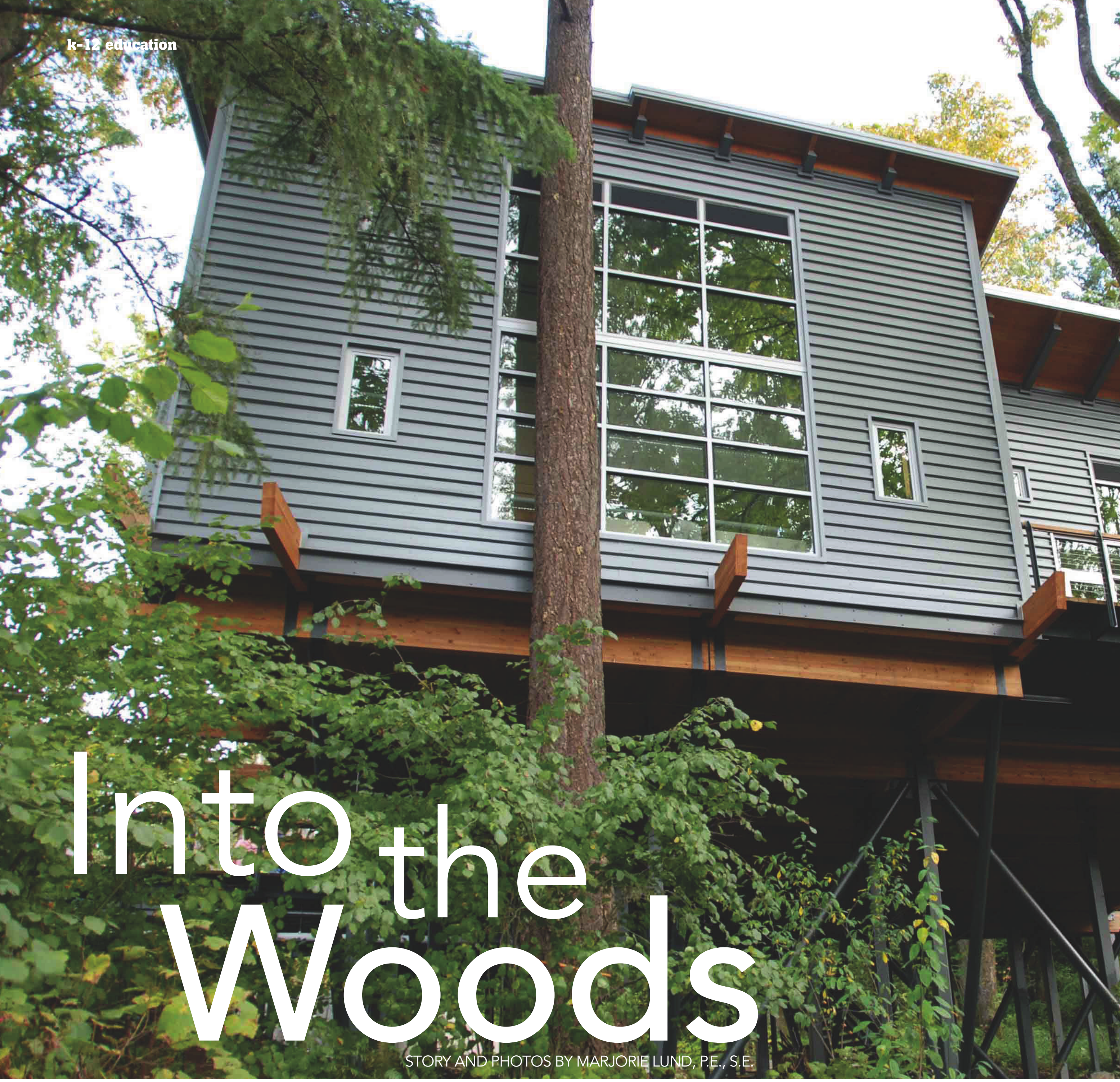
Mario Webber-Rookes, 54, of Wylie, Texas, died on July 19, 2009, in Dallas. Born Sept. 10, 1954, in Taormina, Sicily to the late Frank and Angelina Webber-Rookes, he was president of Southwestern Detailers Association and a past president of the National Institute of Steel Detailing (NISD). He was the NISD 2002 Man of the Year, and was serving as the Southwest Chapter Director and Chairperson for the AISC/NISD Joint Committee. Additionally Webber-Rookes was the owner and president of Webber-Rookes Detailers, Inc. of Plano, Texas. Memorials may be made to American Heart Association.

Progressive Structural Engineer Dov Kaminetzky

New York City structural engineer Dov Kaminetzky died July 17, 2009. He was 83. Author of the engineering text *Design and Construction Failures*, Kaminetzky was a partner in the firm Feld, Kaminetzky & Cohen where he earlier worked for the firm's founder, Jacob Feld, Ph.D., P.E. as a consulting engineer on the Guggenheim Museum.

People and Firms

- **Charles H. Thornton**, Ph.D., P.E., chairman of Charles Thornton and Company LLC and co-founder of the international engineering firm Thornton Tomasetti, has been honored by the Construction Industry Institute (CII) with the **2009 Carroll H. Dunn Award of Excellence**. The Construction Industry Institute established the award in 1985 to honor an individual for significant achievements in improving the engineering and construction industry. The award is CII's highest honor and is recognized as one of the most prestigious awards of its kind in the construction industry. Dr. Thornton is the 23rd recipient of the award.
- **The Harman Group**, consulting structural engineers, is celebrating its 25th anniversary. Kirk Harman, president, co-founded the firm 1984 as Cagley Harman & Associates. Today it has offices in King of Prussia, Pa., and Las Vegas.



Into the Woods

STORY AND PHOTOS BY MARJORIE LUND, P.E., S.E.

Mercer Slough Environmental Education Center treads lightly but provides unique vantage points.

THE BELLEVUE, WASH., DEPARTMENT OF PARKS AND COMMUNITY SERVICES, in conjunction with the Pacific Science Center, has developed a remarkable project for hands-on wetlands education. Sited on a 40° slope overlooking the largest remaining urban wetlands in Washington, the Mercer Slough Environmental Education Center embraces the beauty of the natural environment while minimizing disruption to the sensitive forest floor. Seven individual structures are tied together with elevated walkways and grand viewing platforms to overlook the forest and wetlands. The initial phase of construction includes classrooms, visitor's center, restrooms, laboratory and administration, and totals 10,000 gross sq. ft.

The learning experience is enhanced by the lightness of the structures elevated into the tree canopy. Opportunities for exploration abound in the classrooms, tree house and on the boardwalks. Green roofs instruct on the benefits of insulating value and blending to the environs. A "wet lab" was built with the expectation that countless kids in muddy boots will be welcome there, viewing "pond dips," or slough samples, through microscopes.

The project anticipates a LEED® Gold certification, owing to its reuse of existing buildings, low-impact development, natural ventilation systems, certified wood, steel as a recycled material, and on-site stormwater management. The project is designed to

Exposed glulam beams are supported in custom saddles welded to the HSS substructure bracing.

Marjorie Lund is an owner and principal of Lund and Everton Structural Engineering. The firm was recently recognized by AISC for its innovative design using structural steel in the IDEAS2 awards. See the May 2009 issue of MSC.

be light on the land through the use of a variety of low impact techniques. Steel piling and a steel substructure support the buildings, thus minimizing damage to tree roots and permitting unobstructed drainage. The use of exposed steel frames below the floors of the buildings and boardwalks minimize the disruption to the site and provides a unique lofty visual appearance.

Foundation System and Steel Substructure

The steep unstable slope required deep foundations but we needed to specify a foundation system that had the least construction area and weight of equipment because of the fragile forest soil surface. Clusters of helical anchors were augured into the soils by lightweight drilling equipment. The pile groups of mostly battered piles are capped with individual concrete pier caps supporting the steel framework. That approach minimized the placement of concrete onsite and disruption to the soil surface. A unique variation on grade beams was used to reduce damage to surface roots. The pile caps are connected with a series of galvanized pipes rather than reinforced concrete beams. This not only was less damaging to the site but also faster to construct.

The steel substructure splays upward in a manner architecturally echoing the tree branches above. This serves as lateral force resisting braced frames as well as allowing a cantilever system of floor beams that projects the buildings further into the trees and over the wetlands. The branching steel frame consists of HSS with slotted and welded gusset connections. Forces are transferred from the floor diaphragms to the braced frames by a grid of floor beams. The frames are designed as ordinary steel concentrically braced frames for seismic and for wind loads coming across the open ground in front of, and sweeping up the slope. The analysis of the

Far left: The use of steel framing for the substructures of the Mercer Slough Environmental Education Center minimized the project's impact on the sensitive forest floor and provides a light and airy feel to the entire complex.

Left: Elevated walkways, some three stories in the air, link the learning center's seven individual structures and provide viewing platforms overlooking the forest and wetlands.

three-dimensional steel and wood system was optimized by the use of RISA-3D software for gravity, wind and seismic forces. The structures are designed for Structural Occupancy Category II in Seismic Design Category D.

The floor diaphragms of the structures are structural insulating panels spanning between glulam beams. The beams, exposed from below, are supported in custom saddles welded to the steel braces. The saddles transfer the tension and compression components of the steel frames into the wood beams.

Walls above the floors are wood shear walls framed with engineered wood studs. The framing is enhanced with tubular steel frames to support out of plane wind loads in the 25-ft-tall window walls facing the slough. Steel roofing and siding were chosen for the project for their light weight, longevity, low maintenance, and recycled content.

Walls and Roof Framing

In keeping with the unusual combination of steel and wood framing, the roofs are constructed of open-web steel joists supporting structural insulated panels. The joists are exposed in the classrooms, continuing the architectural theme of lightness and openness. The joists provide the lightest roof support system with the benefit that the top chords extend out, providing graceful, slim eaves.

Again, the steel system was chosen for its ease and speed of installation and low impact on the site from weight and lack of heavy equipment. A simple connection was developed between the steel open-web joist and supporting glulam girders. The joists were pre-welded to bearing plates that were lag bolted to the tops of the girders.

A two-story "treehouse" anchors the end of the southern boardwalk. It is elevated by steel frames in a lovely compliment to the neighboring trees. On the west side an extended viewing platform, three stories above the trails, cantilevers 30 ft out toward the wetlands providing dramatic views of Mercer Slough and the city of Bellevue beyond. The beauty and airiness of this platform is enhanced with the lightness of the cantilevered steel frame.

Structural steel's exceptional light weight made erection on the difficult site less damaging to the soils and faster than conventional construction. The steel members were lifted from the street above into final positions with a mobile crane. No heavy equipment was needed on the slope for the erection. Keith Michel, project manager for contractor Berschauer Phillips Construction Co., said the project was a challenge due to the complex nature of the site. All equipment was chosen for its size, weight and maneuverability. The crew and all its equipment had to stay within five feet of the project's footprint. "This whole job was a little outside of the ordinary," Michel said. "We had to get creative in how we executed the work." That creativity led to a number of innovations to keep site impact to a minimum and reduce costs. MSC

Owner
City of Bellevue (Wash.), Department of Parks and Community Services

Architect
Jones & Jones Architects and Landscape Architects, Seattle

Structural Engineer
Lund & Everton LLC, Vashon, Wash.

General Contractor and Erector
Berschauer Phillips Construction Co., Olympia, Wash.

Garage designs have changed over the years, using this adaptable material in a variety of ways.

Steel, A Perfect Choice for PARKING STRUCTURES

BY RICHARD C. RICH, P.E.
PHOTOS BY RICH & ASSOCIATES

MANY FINE GARAGES HAVE BEEN BUILT IN STEEL since the first parking structures were built in the early 1900s. Over the years, though, technological advances in construction materials and changes in parking methods have altered the way garages are built and designed.

Many, if not all, of the transient garages built before 1950 were designed as attendant-parked structures with short spans, generally with two to three cars to the bay. Many of the earliest garages were built of structural steel with short-span beams and poured concrete floors. Customers never saw the upper floors; cars were always parked by a valet who deftly maneuvered between columns to park the automobiles.

The early 1950s saw a transition to self-service parking, which reduced labor costs and provided quicker entry and exit. Owners also discovered that self-service parking structures could serve more cars by creating a higher turnover—and generate more net revenue—than attendant-parked facilities.

Mechanical garages also become popular in the late 1940s. They almost always were built with structural steel frames because steel provided the lightest way of building such frames. Mechanical garages consisted of an elevator that moved along a center core and with which cars could be moved up to shelves or platforms within the structure. These were simple designs that didn't require stairs or elevators for pedestrians. All that was needed was an economical and lightweight frame, and steel satisfied these conditions.

Many of the earlier garages were configured with 60° angle parking, which required just 54- or 55-ft spans. However, the switch to self-service parking also led to the creation of garages with longer spans, going as high as 64 ft. This new approach to designing structures required new materials, and the parking industry went through a period in which steel parking became less common.

In the early 1960s, precast concrete garages started to come onto the scene. Precast concrete began to supplant structural steel as the predominant material for the construction of parking structures, followed by the twin tee garages which are prevalent today. Today, precast concrete continues to be the most common material for parking development, with about 45% of garages being built in precast concrete and 36% using cast-in-place concrete. In recent years, structural steel or some hybrid form has come to represent about 19% of the market. Although structural steel is not dominating the parking garage market today, in the right situation it can be an excellent choice.

In the early 1970s, steel parking enjoyed a mini-renaissance with the introduction of portable parking structures, which, again, were generally short-span steel parking facilities. They offered three-car bays, in the area of 28-by-30-ft grid spacing, and structural steel with flat precast concrete floor slabs. The steel elements could be bolted together, rather than welded, making it much easier to dismantle and move. Many of these garages started out as temporary structures that could be moved to other sites once they had accomplished their purpose, although some have not been moved and are still standing today.

The 1970s also saw the introduction of castellated beams, with hexagonal or round void areas in the web of the beam. This permitted the use of longer steel beams by lightening the weight of the structural element while at the same time maintaining its ability to carry the load. Although this approach is still in use, today more parking designers are using a hybrid of concrete and steel. This combination has been particularly popular for airport facilities, and has been used in at least four recently developed airport structures. For instance, JetBlue's new parking structure at John F. Kennedy International Airport in New York combines a system of a double steel center column, steel perimeter columns and long span precast twin tees spanning the beams between the columns on a shorter span. It lends itself to rapid construction, and because no shear walls are necessary within the garage, this approach offers outstanding visibility and is very secure. The JetBlue garage married the optimum floor surface with a flexible steel structure.

Before this, Portland (Maine) International Jetport built a garage of similar construction with precast twin tees and steel columns with the "H" frames. In the Portland garage, even the spiral ramp was constructed of structural steel, using the steel members as the floor supports on the columns over which the concrete slab was placed.

In addition to the design benefits steel provided in these structures, there are a number of additional advantages to steel parking, including speed of erection and the ability to add on to the structure for future expansion.

One example of this type of expansion is offered by the

This page: The JetBlue garage at the Portland (Maine) International Jetport uses a steel framework on the spiral ramp to support the floor slabs.

Opposite page: The transition to self-service parking in the 1950s led to structures that were more open and designers turned to steel to provide the longer spans this required.

Richard C. Rich, P.E., is the president of Rich and Associates. Based in Southfield, Mich., Rich and Associates is the oldest firm in North America dedicated solely to parking planning and design. The firm can be found online at www.richassoc.com.

4th and Williams garage in Ann Arbor, Mich. The facility originally was developed as a two-module, cast-in-place concrete structure. When the city needed additional parking spaces, the solution was to expand the garage by adding exterior structural steel columns. Additional steel columns were put down through the middle of the garage to create new foundations for additional floors, which were built of structural steel erected over top of the existing garage. Architectural treatment on the garage exterior enables the painted steel to blend with the original garage. Through this creative use of steel, designers were able to solve what was originally considered to be an unsolvable problem.

While it's clear that steel presents a number of advantages to parking designer, it also creates challenges. For instance, fire codes sometimes restrict floor areas unless the steel is protected by either concrete coating or expensive intumescent paint to create fireproofing on the steel columns. The cost of meeting these code requirements can be prohibitive.

Maintenance is also a key issue; all parking structures need to be properly maintained. Just as a concrete structure cannot be left for years without maintenance, steel structures also must be protected from the elements, and covering concrete must also be protected and maintained. In a steel structure, it is a simple matter to remove and replace degraded concrete areas without affecting the structural frame of the building. And in structures in which steel members are exposed, it is easy to observe where maintenance is necessary and catch problems early—a luxury that isn't available with reinforced or precast concrete.

Finally, cost can have a huge impact on whether designers choose steel when creating new parking structures. Steel has not always been available at a reasonable price because of fluctuations in market conditions. For instance, if there is a lot of office building development in the area, the demand for steel can raise the cost to unacceptable levels. This is particularly true when the garage under development is a very large building with stringent fireproofing requirements.

Of course, no two situations are alike, and the decision whether to use steel, concrete, or a hybrid approach must be based on the unique challenges and opportunities presented by the individual project. However, in the right situation, steel can be an excellent choice when developing a parking structure. MSC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Fire *Hits* the Deck

In parking garage fires, the framing system never takes the most heat.

DALE F. DENDA'S INVESTIGATORY work over the last 18 years has been both focused and unique. Denda is the director of research for Parking Market Research Co., McLean, Va. Today, after studying more than 550 fires, his findings likely constitute the largest single body of field evidence of fire behavior in open multi-level parking structures in this country. *Modern Steel Construction* editors recently spoke with Denda about this body of knowledge and the lessons it holds, especially for designers and code officials.

Q: Do we really know more today than we did a decade ago in terms of designing a better fire-safe parking structure?

DD: The short answer is yes. We now know that we don't have a huge or even significant issue, from a firefighting perspective, in terms of sustained structure-threatening fires in parking garages. Non-crash vehicle fires simply don't behave the way other combustibles do in building fires. Vehicle fires are largely contained, self-limiting events. Most garages actually are over-designed for the worst probable event.

Q: That touches on a couple of different issues. In what way do garage fires, or at least vehicle fires, represent a different type of event than found in a normal building occupancy?

DD: A non-crash vehicle fire is, in relative terms, a tame event in that it doesn't develop, or spread, quickly. Our research shows that's very significant in terms of life safety, and directly corresponds to the superior life safety record in garage fires relative to other types of structures. Vehicles also don't burn very long at exterior elevated temperatures—say above 800°—affecting exposed structural members. Very rarely does a vehicle fire burn that hot for more than 15 to 20 minutes.

Opposite page: Although fire code provisions for parking garages assume greater risk of fire damage to larger parking structures, historical information show the opposite to be true—those with larger floor areas create a relatively larger margin of safety.

Q: How rare are the longer vehicle fires? Can you be specific?

DD: Fires in larger-floor area garages show combustion to be quite limited both in relative and absolute terms. Only about 8% of events affect an area beyond the footprint of the vehicle of fire origin. Thus, 92% of the events take in a floor area of about 200 sq. ft. The maximum impact is actually a smaller area, perhaps 50 to 70 sq. ft, directly beneath the area of origin in the vehicle. We found this to be the case in several hundred single-vehicle fires. Fire incidents spreading beyond the vehicle of origin are progressively rarer and take in proportionately more, but still limited, slab areas. So considering that larger garages have on average about 70,000 sq. ft of floor area, typical fire exposure and spread are quite limited.

Q: How often does structural damage occur from vehicle fires in these structures?

DD: According to fire department records it is very rare—less than 1% of events. In terms of damage to the structural frame, it's on average negligible. As far as properly designed, built and maintained floor slabs are concerned, damage is limited to the immediate area above, and sometimes beneath, the vehicle of origin. Damage occurs in only a fraction of the larger events and, even with multiple-car fires, the damage is limited in area.

Also on average there is no difference between concrete framed- or steel-framed structures, given that steel-framed garages as a system are typically of composite (i.e. concrete deck) construction. One wouldn't expect much difference, and in fact there is none in terms of statistical significance.

Q: What do you mean by no expectation of differences between steel and concrete garages?

DD: Well, first remember that we are talking about fire events as recorded by fire departments and insurance companies. I'm a researcher and we report on what we find in the paper trail. Deck exposure to the heat of the fire is the greatest danger, and the decks are concrete regardless of whether garage framing is concrete or steel. In other words, structural damage measures in our research are in whole dollars per fire defined by the cost of repairing the damage, including both the beam and slab members. When damage does occur, it is mostly in the areas that are most exposed—the concrete slabs.

Q: But aren't beams the critical elements?

DD: Yes, fire resistance of beams, whether steel or concrete, is critical to preventing catastrophic collapse. But understand that there have been no documented situations, or even reported occurrences, where structural collapse occurred or where civilians could not be safely evacuated, firefighters inserted to combat the event, or inspectors or even repair crews sent in after the event. In short, we have seen no catastrophic failures associated with fires in parking garages. At any rate, fires in larger garages are too small and don't burn long enough for concerns of structural frame stability to come into play.

Q: Are you saying that the composite concrete deck slabs are at a greater risk in steel framed garages than the steel members?

DD: Yes, that's exactly what the evidence shows.

Q: How often does this type of slab damage occur?

DD: Again, rarely. Relatively serious damage, say in excess of $300,000, may occur once every few years.

Q: What do you see as a worst case scenario?

DD: A worst case scenario is defined in one sense by events yet to happen. Witness, for example, how the World Trade Center redefined such a scenario. However, as far as my research is concerned, we have definitively outlined the probable worst case event. We call it a probable worst case three-year event, because it likely will occur only once every three years in a single garage somewhere in the U.S.

It would be about a six-car fire load, like the one that occurred in a large airport parking structure in 2003. The total burn time there was well over 90 minutes, and probably closer to two hours due to complicating circumstances. Damage immediately above the vehicle in which the fire originated ranged from severe spalling to crazing in cast-in-place, post-tensioned slabs. That cost something less than $1 million to repair. Even under those extreme conditions, damage was limited 1,400 sq. ft in a 600,000-sq.-ft garage with parking for 1,800 cars—and there was no threat of structure failure.

In that case it's also notable that the fire investigation report was able to document how long the structure was exposed. Quoting from the report, "According to the surveillance tape

After years of studying vehicle fires in parking structures, Dale Denda says today's building fire code assesses the risk from such fires exactly opposite of what fire department reports show it to be.

there was a one-hour delay from the time cameras lost picture and the time the fire department was contacted. The time period that the fire burned freely prior to extinguishment was a significant contributing factor to the extent of fire damage to the vehicles and to the parking structure itself."

Q: Has your research resulted in any changes in garage design?

DD: None that I have heard of. Changes in the building code have been proposed, discussed and passed citing our findings. Unfortunately, those changes have been at the margins and have not, to date, addressed all issues.

Q: You raised an interesting issue when you said most garages actually are over-designed for the worst probable event. In what way is that so?

DD: Our research shows that there are several specific discrepancies between assumptions upon which the parking structure building fire codes are based and actual field experience. The findings clearly point to a typology, or categorization, of potential fire severity by garage size. Evidence shows that larger structures—those with larger floor areas—create a relatively larger margin of safety. By that I mean they militate against personal injury and conflagration-like events, which also correspond to super-heated conditions. In the first instance that is due to the limited nature of the event. Vehicle fires in large parking garages are relatively limited and relatively contained combustion in an otherwise non-combustible structure.

We not only don't see structural failure, we also don't find significant losses in larger garages due to the fact that they are over-designed for the fire events occurring in them. And by that I mean IBC Type I & Type II structures, both of which are comparable in fire resistance even without superfluous fire protection coatings, special rated assemblies or sprinklers and the like presently required in the latter. These requirements are redundant.

However, the fire code paradigm holds exactly the opposite to be true. That is, it sees larger floor area equating to greater potential combustion, translating to greater probability for structural failure due to prolonged exposure to high temperatures. Based on those unsupported assumptions, the fire codes further posit a risk at parking levels above a certain height. However the same "limited combustion" logic means these provisions are also unsupported.

That is the gap between code assumptions and real world fires. However, our data plainly show there can be complications and greatly increased risk in certain vehicle fires in smaller floor area garages. For example, consider the three-year event I mentioned earlier occurring in a 180-car, multilevel garage rather than in an 1,800-car garage. With an average floor area of only 20,000 sq. ft, the same six-car fire load could become a serious, structure-threatening fire, if given enough time. Potentially even greater risk arises if non-vehicle combustibles come into play. These are the conditions present fire codes address as if they applied to larger floor areas and heights, but they should actually be applicable only to small garages.

Q: Is over-designing really all that much of an issue? And if so, in what ways?

DD: About 35% of the garages in design or starting construction in 2008 were of a size or configuration that would trigger unnecessary fire code requirements—but only if the garages were of steel construction. And these projects are by definition the larger ones, so in 2008 code-related over-design affected as many as 195,000 spaces or the potential use of well over 200,000 tons of steel.

Q: What would you say are the most significant aspects of your work concerning parking garage fires?

DD: There are two problematic issues in terms of basic assumptions in the fire code as applied to parking garages. The flaws in the code are fundamental, not details at the margin. One, field evidence does not support any difference whatsoever in structural fire-resistance between any type of larger concrete parking structure and any kind of steel-framed parking structure. And the evidence is pretty straightforward—the fires are too limited in extent and duration, and therefore degrees of exposure and temperature in that area are below any threshold where there are differences between steel and concrete. The fire code recognizes garages as a low fire hazard building type, creating, ironically, an internal contradiction in applying higher standards for heat resistance for steel in an environment that, as I just said, it also classifies as low hazard.

But, again, the bigger issue is a more fundamental flaw concerning the assumed relationship between area, or size, and structural risks. The present building fire code posits risk assessment exactly opposite of what fire department reports show it to be, namely, that large steel or concrete garages are more risk prone to collapse than smaller ones. The evidence to support this proposition does not exist. MSC

When damage does occur as a result of a vehicle fire in a parking garage, Denda says, it is mostly in the areas that are most exposed—the concrete slabs.

Photos by Bill Pascoli, AISC, in the offices of AISC Member Kinsley Manufacturing, York, Pa.

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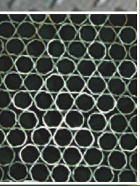

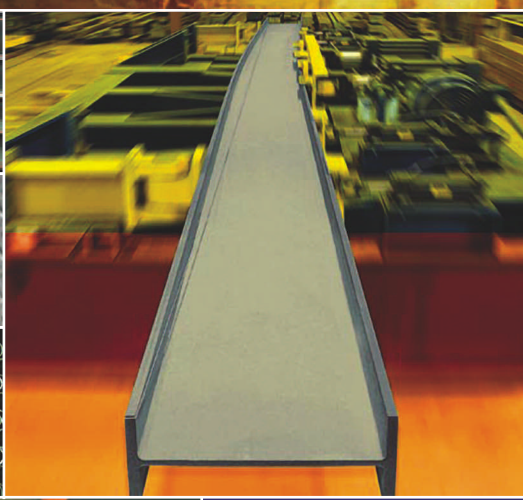

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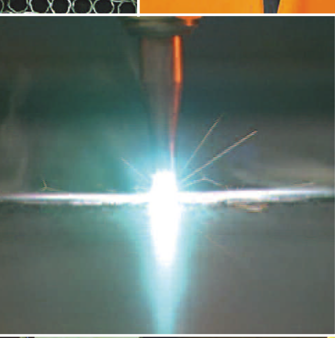

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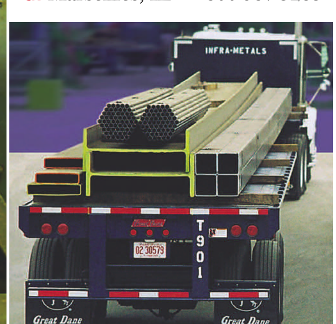

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BY PETER MARXHAUSEN, M.S., P.E.
AND DAVE HENLEY, P.E.

Field-bolted spliced open-web steel joists offer a lightweight and easy-to-install upgrade.

FOR THE PRACTICING STRUCTURAL ENGINEER, open-web steel joists can present a challenge when modifying an existing building to accommodate increased loads, floor performance enhancements, and new floor/roof openings. One common reason for modifying an open-web steel joist is the need to install new rooftop equipment that exceeds the original design capacity of the supporting structure. When the existing open-web steel joists are not capable of safely supporting the new loads, it is far preferable to install additional joists to provide the required capacity. However, new full-length joists often cannot be inserted due to the lack of clearance needed to insert the new joist into the existing cavity.

Historically, some structural engineers have turned to their own engineering creativity to modify an open-web steel joist framing system. Modifications have included welding steel plates, angles, channels, and rounds to the joist chords in an effort to increase the gross section modulus of the joist. While that approach has merit, it often does not adequately address the fact that the weak point may be the web members or their attachment to the joist chords. Similarly, welded attachments may not be successful due to difficulties with welding access at the top chord and quality concerns associated with field welding.

Another approach seen in existing buildings is the installation of new steel wide-flange beams adjacent to an existing open-web steel joist. Where this type of modification has been implemented, the end of the steel beam is coped to a depth of 2½ in. and the web is reinforced with steel angles. This installation can present problems similar to the installation of full-length open-web steel joists because a wide-flange beam is often too long and cumbersome to fit into an existing opening. Sometimes the beam may be designed as two pieces with a moment connection near midspan. Although this approach also has merit, the steel beam is often too heavy to match the relative stiffness of the adjacent joists. Such a match is necessary to ensure that the beam will evenly support the proposed loading without overloading and/or causing a premature failure of the existing adjacent open-web steel joists.

Although not widely known, a better approach to strengthening an existing open-web steel joist framing system is to install new field-bolted spliced open-web steel joists supplied by the joist manufacturer. Field-bolted spliced open-web joists are relatively lightweight, they do not require modification of the existing bracing/bridging regime, and may be able to accommodate existing electrical/plumbing/mechanical installations with little modification.

Opposite page: Interior of the Grand Prix Motorsports showroom, illustrating the difficulty of doing retrofit construction overhead while allowing the business to remain open.

Case Study

The two-story Grand Prix Motorsports building is a 34,691-sq.-ft commercial structure in Littleton, Colo. Completed in early 2004, the building has a motorcraft and motorcraft accessories showroom on the first floor and a mezzanine level located on the east side of the building. The west end of the building has a mechanic/repair area on the first floor and a storage warehouse on the second floor. The roof structure was economically designed with open-web steel joists to accommodate the locally prescribed snow load of 30 psf.

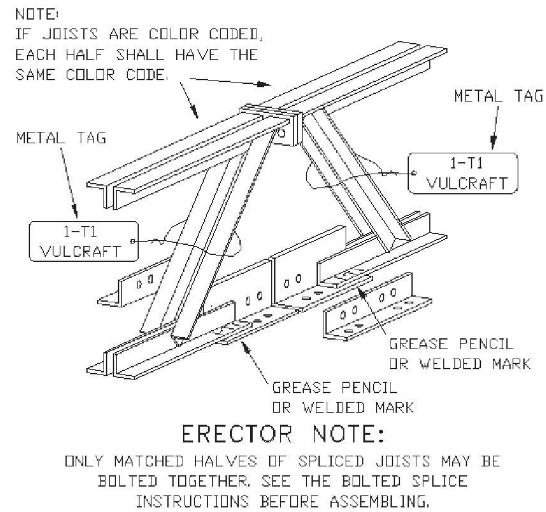
The height of the rooftop mechanical screen walls and parapet walls combined with the open nature of the adjacent roof created a condition that could develop significant snow drift loads. In some roof areas the calculated effect of the potential snow drift loads was nearly 100% more than the minimum roof snow load. Unfortunately this was not adequately communicated between the architect and structural engineer of record during the project design phase. As a result, several of the specified roof joists were appreciably underdesigned for the anticipated loading.

As a precautionary measure, the owner of the facility elected to shovel snow off the roof if it accumulated more than 6 in. Although 6 in. of snow would not overload the joists, the concern was that blowing snow could create drifts at the parapets and screen walls that could overload the roof joists at those areas.

Several options were investigated to strengthen the roof structure including installing wide-flange beams and removing the roof to install new full-length open-web joists. Opening the roof raised concerns with the impact to the existing electrical/mechanical/plumbing installations as well as concerns over the financial impact to the business associated with the disruption. As a result, the roof strengthening repairs were delayed for nearly four years. After investigating several options to strengthen the roof, the original joist manufacturer, Vulcraft, suggested field-bolted spliced open-web steel joists might be an appropriate solution.

Field-bolted spliced open-web steel joists can be manufactured to any standard joist size and are shipped from the manufacturer in two segments. The joists are field-bolted with a moment splice that can be designed to be almost anywhere along the joist. Adjusting the splice location can help accommodate an existing duct or fire suppression line that otherwise would have to be temporarily disconnected or rerouted to install a standard joist.

Field-bolted open web joists were delivered to the job site in two sections with the red oxide primer paint already applied.



MATCHED HALVES OF SPLICED JOISTS

The completed joist installation with angle braces welded into place.

Peter Marxhausen (left) is a forensic structural engineer with Higgins & Associates, Inc. in Morrison, Colo., and an adjunct faculty member with the University of Colorado at Denver Civil Engineering Department. Dave Henley is the Denver district manager for Vulcraft Sales Corporation. He has more than 27 years of experience in the design and construction of open-web steel joists, joist girders, and metal deck.

The 2¼-in. joist seat depth required a ¼-in.-thick shim be welded into place after the joist was erected.

Another benefit of field-bolted joists is that the joist seats can be manufactured with a 2¼-in. height versus the standard 2½-in. height. The reduced seat height provides easier insertion of the joists between the bearing surface and the metal deck. Similarly, the ¼-in. tolerance accommodates some angular movement as the joists are installed. After installation, ¼-in.-thick steel plates are installed beneath the joist seats to provide a tight connection against the metal deck.

In new construction, the top/compression chord of open-web steel joists is laterally braced to resist lateral buckling using screw and/or welded connections to the metal roof deck. When a new flexural member is installed in an existing building, bracing of the top chord is a significant concern. One option is to remove the roofing and screw the metal roof deck to the new joists. Although that is a possibility, the top chord of field-bolted spliced joists can be braced by welding standard steel angle braces to both the new joist and the existing open-web joists.

In the example of Grand Prix Motorsports, existing continuous bridging was installed at the quarter points of the existing open-web joists. To minimize field welding of additional bridging or braces, the new field-bolted steel joists were designed to be braced at the quarter points only. The end result was that the roofing system was not penetrated and the appearance from below was relatively unchanged.

Repair of the Grand Prix Motorsports facility, including the installation of 20 new field-bolted joists, was completed in approximately two weeks. The repair contractor, The Deer Creek Corporation, indicated that all 20 joists could have been installed in two days; however, the project was sequenced such that only one area at a time would be affected by the construction. All repairs were completed during normal business hours without interruption to the business operations.

Design Requirements

Design of field-bolted open-web steel joists is similar to new construction with some minor modifications. The structural engineer of record for the design should provide the following:

1. Existing and new joist layout with joist sizes and layout dimensions.
2. Existing/available bearing widths with clear construction span dimensions.
3. Preferred splice location.
4. Details for the attachment of the new joists to the supporting structure.
5. Specifications regarding the permanent bracing of the top chords.

Conclusion

There are several methods to strengthen an existing roof structure. Structural engineers are encouraged not to modify open-web steel joists in a manner not accepted by the open-web steel joist manufacturer or the Steel Joist Institute (SJI). As outlined above, one economical way to increase the load capacity of an existing open-web joist roof is to install field-bolted open-web steel joists manufactured by the original joist manufacturer. Although field-bolted spliced joists will strengthen the structure in a localized area, additional calculations are required by the structural engineer of record to ensure the metal roof deck and support girders are adequate to support the proposed loading. MSC

A Little Joist History

The Massillon Open-Web Joist, which was developed in 1923, was the first open-web steel joist system. It consisted of a single continuous web in a Warren-type truss configuration and incorporated two top chord bars and two bottom chord bars. The unobstructed nature of the first open-web joist provided a weight-efficient design that could also easily accommodate electrical/mechanical features within the plane of the roof framing.

The Steel Joist Institute (SJI) was formed five years after the first open-web steel joist was manufactured. In 1929, one year after SJI's founding, the first open-web steel joist load table was developed. That original load table helped unify design standards and eliminate product confusion among architects, engineers, fabricators, and builders. Although modern open-web steel joists consist of either steel angles and rods or just steel angles, the term "bar joist" developed from the early use of continuous round bars is still used as the common nomenclature.

Since SJI's creation, open-web steel joists have been a dominant construction feature in the industry offering weight- and material-efficient designs, long spans, simplified erection, and an unobstructed design that allows for electrical and mechanical conduits. Currently, there are billions of square feet of both roof and floor structures in the United States that have been constructed using open-web steel joists.


TEREX
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A student team proposes a unique way to make Olympic athletes feel right at home.

Thinking **Inside** the BOX

BY EILEEN BURKE AND RUSTY KUCHER

AS THE DAY APPROACHES when the International Olympic Committee (IOC) will announce its decision for the 2016 Summer Olympics host city, many Chicagoans are making plans to prepare for the potential influx of thousands of people into their already crowded city. More than 17,000 athletes and coaches from all over the world may make Chicago their home for the six weeks of training and competition, yet as quickly as they may descend upon the city, they will leave it to return to their home countries around the world. The Chicago 2016 Bid Committee has offered viable solutions to the Olympic housing challenge, but a team of students participating in the Interprofessional Projects (IPRO) Program at Illinois Institute of Technology (IIT) in Chicago has developed an innovative solution of their own in steel.

The IPRO project team has been working for four semesters to explore the concept of adapting steel shipping containers to create affordable housing. The multidisciplinary team includes students from architecture; civil, architectural, electrical, mechanical and materials engineering; political science; psychology and other fields. As part of this investigation, the team has created a sustainable and affordable housing plan designed to serve the temporary needs of thousands of Olympic athletes throughout the course of the games, while at the same time providing the city with affordable housing unit options after the Olympic Games conclude.

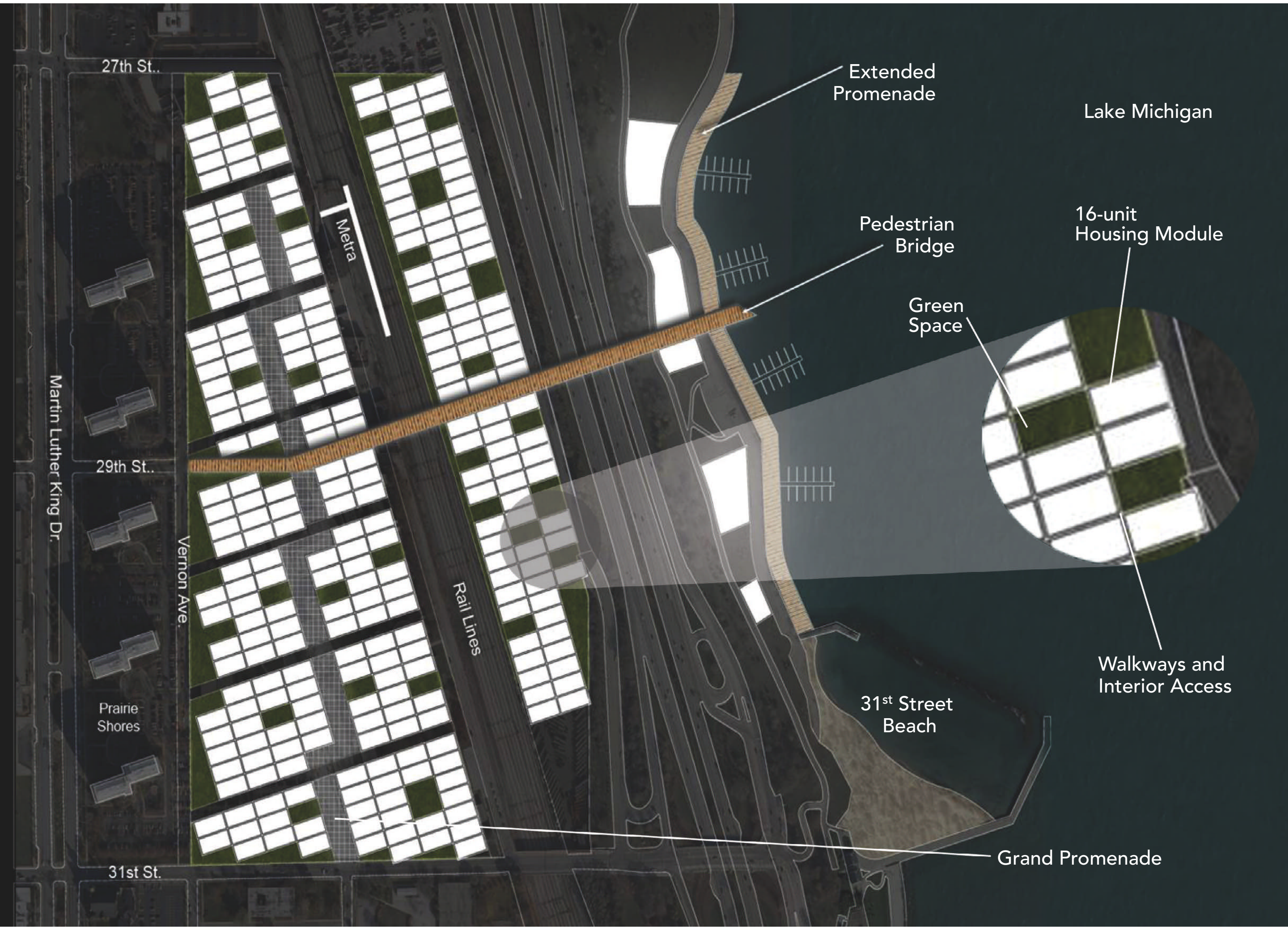
Eileen Burke is an architecture graduate student at the University of Illinois at Urbana Champaign and Rusty Kucher is a structural engineering graduate student at the Illinois Institute of Technology in Chicago. Both are summer interns with AISC.

The team of students has developed a design that uses intermodal steel building units (ISBUs), i.e., steel shipping containers, as the core structural module for the housing complex. These units will be integrated as a cohesive, small village just south of Chicago's Loop near McCormick Place and on the site that is already proposed for Olympic housing. Ultimately, these units can be disassembled and repurposed to provide a unique affordable housing solution for several Chicago-area communities. ISBUs are an extremely economic and viable solution, as there is a surplus of them in the United States that can be acquired at a cost that is compatible with the plans for 2016 Olympic housing and subsequent market-rate housing in the Chicago area.

As with any project, there are many design requirements and restrictions, including minimum requirements set forth by the IOC that an Olympic Village must satisfy. The Village must accommodate approximately 17,000 athletes, technicians and other Olympic staff. Each occupant must have at least 153 sq. ft of gross living space, and there cannot be more than two beds per room, although there must be 600 single bed rooms. Half of the units must comply with the accessibility requirements of the Americans with Disabilities Act (ADA) to accommodate Paralympic athletes. Aside from these Olympic Village-specific design limitations, the local building code also must be satisfied. Given that each standard shipping container has an internal clearance of 8 ft, it is also a design challenge to meet the minimum 7.5-ft interior height clearance requirement. Shipping containers come in several larger heights, but the budget and scale of the project has limited the design to 8 ft.

Taking all of these design requirements and integrating them within an established plot of land is another obstacle that has faced the IIT IPRO team. The land set aside for the Olympic Village is on the site of the former Michael Reese Hospital near Chicago's lakefront and McCormick Place. The site is an ideal location with easy access to the city, the lake, and the core of the Olympic venues; however, its size and configuration pose an additional challenge for the IPRO team.

One of the IPRO team's initial concepts represented a high-rise temporary structure on the site with units in an octagonal pattern. This design, however, required the use of elevators and the team decided that erecting elevator shafts in the units for the short six-week Olympic period could not be justified. Instead, the IPRO



team's conceptual design for 2016 Olympic housing consists of a low-rise community solution without elevators, ranging four floors high, distributed across the expanse of the site. Lower-cost external ADA-compliant modular lifts would provide access to upper floors.

From an engineering standpoint, the use of steel containers poses its own challenges. A shipping container is used to safely and securely transport goods from one place to another. Using these containers for housing causes some concern as they are much lighter than typical structural systems. Nonetheless, the containers and the connections between them must satisfy the dead, live, wind, and other loading requirements. Because two containers make up one unit, one long wall must be cut out completely from each container so that they may be joined. A standard metal-stud wall will be used for room partitions within each unit.

From a mechanical point-of-view, the container must be properly insulated to maintain a cool interior environment during a hot Chicago summer, and keep out the cold in the winter. A rigid foam board, R-16 insulation will be used on the interior of exposed walls for the temporary setting. In the subsequent permanent housing scenario, insulation also will be added to the exterior of the container along with a façade of the owner's choice.

Because the temporary Olympic housing is going to be disassembled, relocated, and reused for permanent housing after the 2016 Olympics, plumbing, HVAC and electrical connections must be

Above: The proposed site plan for the Olympic Village features a variety of common spaces including lakefront access and recreational areas.

Below: For the Olympic Village, a typical four-level housing module will consist of 32 steel containers transformed into 16 housing units.

Images by IPRO Program at Illinois Institute of Technology

Above: It's difficult to distinguish the kitchen/dining area of a permanently installed ISBU dwelling from a traditional residence.

Right: Athletes will experience all the comforts of home in their temporary housing at the Olympic Village.

Images by IPRO Program at Illinois Institute of Technology

designed for easy and reliable assembly and disassembly. A forced air, heating/cooling system will be installed in each unit to satisfy the individual needs of each residence. The whole system must be designed in a way that achieves the short-term goals associated with Olympic housing, while not compromising the long-term needs associated with subsequent use as affordable housing. The system must offer a strong value proposition for its intended long-term occupants and assure a fair resale value in the marketplace.

Using intermodal steel building units as the primary building blocks of a temporary Olympic Village has the potential to be an extremely sustainable and affordable solution. Recycling the ISBUs to create affordable housing not only reduces their surplus within the United States, but their original function as shipping containers permits easy relocation to areas where they can be converted into permanent, affordable housing.

As Olympians from around the globe prepare for the next Olympic Games, many are also anticipating the announcement of the host city for the 2016 Summer Olympics. Little do they know, however, that they may be staying in a housing structure that has traveled as far as they have. MSC

The Steel Challenge: Collegiate Sports Facilities

BY THOMAS L. SCOTT, P.E., LEED AP, STEPHEN H. LUCY, P.E. AND JOHN HOENIG, P.E., LEED AP

These projects can present both structural challenges and opportunities in which structural steel excels as a solution.

IN RECENT YEARS, COLLEGIATE SPORTS FACILITIES and the extensive activities, equipment and programming that go along with them have become the heartbeat of campus health and wellness. Given the huge recruiting potential associated with these buildings and the trend toward integrating multiple campus functions under one roof, it is no surprise that the project size for new facilities, once averaging 40,000 sq. ft, continues to grow. Among the largest, for example, the Recreational and Physical Activity Center at Ohio State University, completed in 2007, offers more than half a million sq. ft of recreation, meeting, fitness and aquatic space.

In the past 20 years, the average cost to build these state-of-the-art recreational facilities has increased from $2 million to more than $50 million. Moreover, according to Kerr & Downs Research, the growth in recreational facilities construction is expected to continue, despite the slowdown in the economy. Today many university officials view their sports facilities as economic drivers within the surrounding community and among their alumni/donor base.

For the structural engineer, the size and complexity of these facilities can present both structural challenges and opportunities in which structural steel excels as a solution. Many of the challenges in designing large student sports and recreation centers are unique to these structures. One of the most unique is accommodating the sheer number of different activities housed under one roof.

Every recreation center will likely house a multi-purpose gymnasium, weight training area, cardio area, aerobic rooms, indoor jogging track, locker rooms and offices. In addition, many also will include more specialized areas for racquetball/handball/squash courts, rock climbing walls, outdoor pursuits, indoor and outdoor pools, and hockey rinks. To complicate things further, smaller universities also often put other departments into the same building. It is not uncommon to see athletic, kinesiology, biomechanical/anatomy labs and even nursing programs sharing a building.

With each of these functions and services come special needs and design issues. The most obvious to the structural engineer is the need for large open spaces. With gymnasiums, minimum spans of 100 ft should be expected, with much larger spans for competition gyms with bleacher seating. In addition, most designs call for expanses of 60 ft or more in the main workout areas that house cardio machines and weights. Steel, whether as fabricated trusses or long-span joists, offers an economical solution. Combining that with acoustical steel roof deck can provide an appealing open space with good sound qualities.

Another major issue is support of jogging tracks. Students want the ability to exercise indoors in a climate-controlled and secure area, regardless of weather or location. And as recreation centers have grown, so has the complexity of the jogging tracks, and you can be assured that at some point the track will be cantilevered. We have tried most methods of accomplishing this including concrete systems, composite systems, steel systems hung from the roof structure and steel cantilevered systems. Each has its benefits, but steel systems that are cantilevered from support columns are our preference. Even though vibration may be more of an issue when designing with steel, the ease of fabrication and construction make this the most economical system.

Vibrations of the structure are an important design consideration in these facilities. Jogging tracks that can have anywhere from one to more than 50 people at a time can experience significant vibrations if not addressed in the design. Additional mass helps, but this same mass can significantly affect the beam and column sizes. This has to be considered in conjunction with the actual track width (cantilever length), support spacing and the natural frequency of the structure. Unfortunately there is no magical answer; the final solution will likely vary with each individual case. Similarly, these same design criteria need to be considered for other areas of the

Texas A&M University–Corpus Christi
Corpus Christi, Texas
Area: 67,000 sq. ft
Cost: $20.5 million
Completion: January 2009

68-in.-deep steel joists span 123 ft over the Dugan Wellness Center gymnasium. A drag truss at the end of the gym is designed to carry hurricane wind forces from the high roof level to the braced frames.

building such as dance and martial arts rooms that may have an entire class bouncing at exactly the same rhythm, as well as aerobic areas set up with treadmills.

Sports and recreation centers also require coordination with specialized manufacturers, equipment providers and sub-consultants. Specialized manufacturers include flooring (sport courts, wood flooring, and rubberized or composite track flooring), aerobic equipment, basketball goals (to be hung from the roof structure) and prefabricated racquetball courts. In addition, it is common to have specialized sub-consultants designing pools, rock climbing walls, food vending areas and hockey rinks, all of which require coordination with the structure.

The following four projects completed for the University of Texas and Texas A&M systems demonstrate the steel requirements behind this burgeoning and competitive niche business.

Dugan Wellness Center

The Dugan Wellness Center represents Phase I of a multiple-phase project that will ultimately meet the needs of several campus departments: Recreational Sports, Athletics, Kinesiology and Nursing. The three-story facility contains a gymnasium with two regulation NCAA Division II basketball courts and seating for 1,500 spectators, weight and cardio areas, locker rooms, and group exercise rooms. In addition, the university opted to incorporate its new Emergency Operations Center (EOC) into this project to save the cost of constructing a separate structure. Located on the Texas coast, the structure was designed to withstand hurricane force winds of 120 mph.

Both concrete and steel systems were considered for this project. Several factors influenced the choice of structural steel, including the 123-ft span over the gymnasium, greater versatility, the ability to accommodate a shortened construction schedule with the release of an early steel package, and sustainability goals.

The upper level floors consist of a composite steel framing system with 3½-in. of lightweight concrete over a 3-in. composite steel deck. Prefabricated steel joists supported on wide-flange girders provide the roof level framing, along with 68-in.-deep joists spanning the gymnasium. Roof framing over the EOC uses composite steel framing to meet hurricane design standards. The lateral system consists of a combination of steel braced frames and concrete masonry unit (CMU) shear walls.

Final steel quantities included 392 tons of structural steel and 62 tons of joists, all of which was recycled.

Owner/Developer The Texas A&M University System
Architect F&S Partners Inc., Dallas
Structural Engineer Jaster-Quintanilla, Dallas
Engineering and Steel Detailing Software
RAM Structural System
Contractor
Fulton-CoastCon Construction, Corpus Christi, Texas

From left: John Hoenig, P.E. LEED AP; associate/senior project manager; Thomas L. Scott, P.E., LEED AP, principal; and Stephen H. Lucy, P.E., principal, Jaster-Quintanilla (www.jqeng.com).

Texas A&M University–Commerce
Commerce, Texas
Area: 51,442 sq. ft
Cost: $9.99 million
Completion: June 2003

Above: Composite steel cantilevered running track in the Jerry D. Morris Recreation Center gymnasium is supported by composite steel columns.

Above and center: Interior and exterior views of the architecturally exposed steel supporting the curtain wall around the climbing wall at the Jerry D. Morris Recreation Center.

Jerry D. Morris Recreation Center

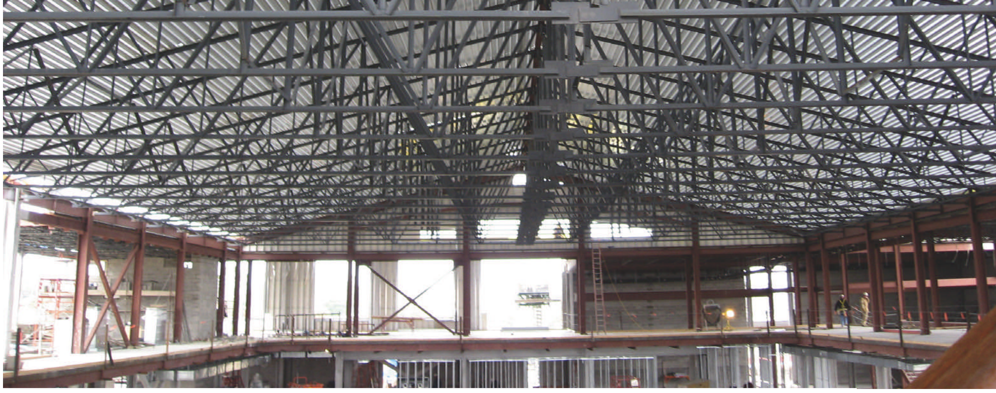
The Jerry D. Morris Recreation Center houses a multi-court gymnasium, 45-ft climbing rock, a cantilevered three-lane jogging track, four racquetball courts, a large fitness room with cardiovascular and weight equipment, an aerobics room, snack area, locker rooms and co-located kinesiology classrooms. One of its unique architectural design features is an elliptical tower of exposed steel and curtain wall around the climbing wall.

Steel was the structural material of choice for the 102-ft spans over the gymnasium and racquetball courts. Architectural aesthetics and the flexibility required for the complex architectural forms also were factors in this selection.

The upper level floors consist of a composite steel framing system with 3½-in. of lightweight concrete over a 3-in. composite steel deck. Prefabricated steel joists supported on wide-flange girders were used for the five different levels of roof framing. The lateral system consists of a combination of steel braced frames and CMU shear walls. Composite steel beams and columns provide additional strength and stiffness for the cantilevered running track.

Final quantities included 225 tons of structural steel and 120 tons of steel joists, all recycled.

Owner/Developer The Texas A&M University System
Architect F&S Partners Inc., Dallas
Structural Engineer
Jaster-Quintanilla, Dallas
Engineering and Steel Detailing Software RAM Structural System and RISA-3D
Contractor Lee Lewis Construction, Inc., Dallas



Double-pitched top chord trusses span the TSU Recreation Sports Center gymnasium, where the jogging track is cantilevered from the W14x99 columns.

Recreation Sports Center

The Recreation Sports Center at Tarleton State was designed to interface with the university's main campus via a plaza and sweeping curvilinear curtain wall at the cardio theater and strength training areas. The facility consists of a three-court multi-purpose gymnasium, four racquetball courts, strength training, a rock climbing wall, cardio theatre, aerobics and martial arts rooms, locker rooms, two classrooms and administrative offices.

Both the 106-ft roof span over the gymnasium and the cantilevered, upper level jogging track posed structural challenges. Additionally, the second floor had aerobic and dance rooms that created vibration and in-floor ducting issues. Steel was chosen for its ability to satisfy all these needs and still meet the architectural aesthetics.

The upper level floors consist of a composite steel framing system, typically spanning approximately 35 ft, with 3½ in. of lightweight concrete over a 3-in. composite steel deck. Prefabricated steel joists supported on wide-flange girders were used for the roof framing, with double-pitched top chord trusses spanning the gymnasium. The lateral system consists of a combination of steel braced frames, moment frames and CMU shear walls. The upper level jogging track is cantilevered from W14×99 columns.

All recycled steel was used for this project—373 tons of structural steel and 215 tons of joists.

Owner/Developer The Texas A&M University System
Architect(s) Randall Scott Architects, Inc., Dallas
Associate Hastings & Chivetta Architects, St. Louis
Structural Engineer Jaster-Quintanilla, Dallas
Steel Fabricator and Detailer Basden Steel & Erection Inc., Burleson, Texas (AISC Member)
Engineering and Steel Detailing Software Used RAM Structural System
Contractor Satterfield & Pontikes Construction, Inc., Irving, Texas

Tarleton State University
Stephenville, Texas
Area: 72,000 sq. ft
Cost: $12.2 million
Completion: November 2007

University of Texas at Tyler
Tyler, Texas
Area: 127,000 sq. ft
Cost: $19.3 million
Completion: August 2003

Left and above: The serpentine track in the Herrington Patriot Center is hung from the castellated steel roof beams used to accommodate the long span over the weight room.

Herrington Patriot Center

At 127,000 sq. ft, the Herrington Patriot Center is one of Jaster-Quintanilla's largest and most comprehensive collegiate sports facilities. It is a multi-functional educational facility with offices and labs for the health and kinesiology faculty. Research and teaching labs include a biomechanical/anatomy lab and an exercise physiology lab. The complex also includes a 30,000-sq.-ft convocation center with three full basketball and volleyball courts and chairback seating for 2,000 spectators. In addition, the center houses a recreation and therapy heated pool and spa with sundeck, a student lounge, and a 6,340-sq.-ft fitness center. Two racquetball courts, dance studios, and an overhead suspended walking/jogging track complete the center's offerings.

Steel accommodated the versatility required by the facility, and met the aesthetic desires of the architect for an exposed articulated structure. Typical floor framing, including the elevated track, consists of a composite steel system with a 3-in. composite deck and beams spaced at 10 ft. Typical roof framing used open web steel joists at approximate 6 ft spacing with wide-flange steel girders and 1½-in. steel decking.

The roof at the competition gymnasium/convocation center consisted of 152-ft span, double pitched open-web steel joists at 15 ft spacing, supporting 3-in. acoustical steel decking. The joists were 96 in. deep at mid-span and designed to support a suspended score board and rigging for light and sound grids used for musical performances.

The roof over the fitness area and supporting the walking/running track consists of 40-in.-deep castellated steel beams spanning approximately 64 ft and spaced at 12 ft supporting 3-in. acoustical metal decking. Because the serpentine jogging track was suspended from the roof, the use of castellated beams allowed greater flexibility in track configuration. Hanger location was not as critical as it would have been with open web joists or other truss options. All framing in this area was architecturally exposed.

All stairs within the facility are architecturally exposed with steel tube framing cantilevered from one central column at each landing supporting steel channel stringers. Lateral stability is provided by steel braced frames.

The project used 610 tons of steel.

Owner/Developer
The University of Texas System
Primary Architect
Hastings & Chivetta, Inc., St. Louis
Associate Architect Wiginton Hooker Jeffry Architects, Dallas
Structural Engineer
Jaster-Quintanilla, Dallas
Engineering and Steel Detailing Software Used RAM Structural System, RISA 3-D
Contractor C Construction Co. Inc., Tyler, Texas

For today's collegiate sports facilities, which have become the centerpieces of campus life, steel provides a structural solution for even the most ambitious multi-purpose facility. It is versatile to accommodate building next to existing conditions, drops in floor slabs, long spans and special conditions such as hanging or cantilevered jogging tracks. Steel also works well with projects on a tight schedule when early release packages can be incorporated, and helps to meet sustainability goals that are set by many major universities and colleges now. In short, steel ensures not only the integrity and performance of the structure itself but also enables the fulfillment of the architect's aesthetic vision. MSC

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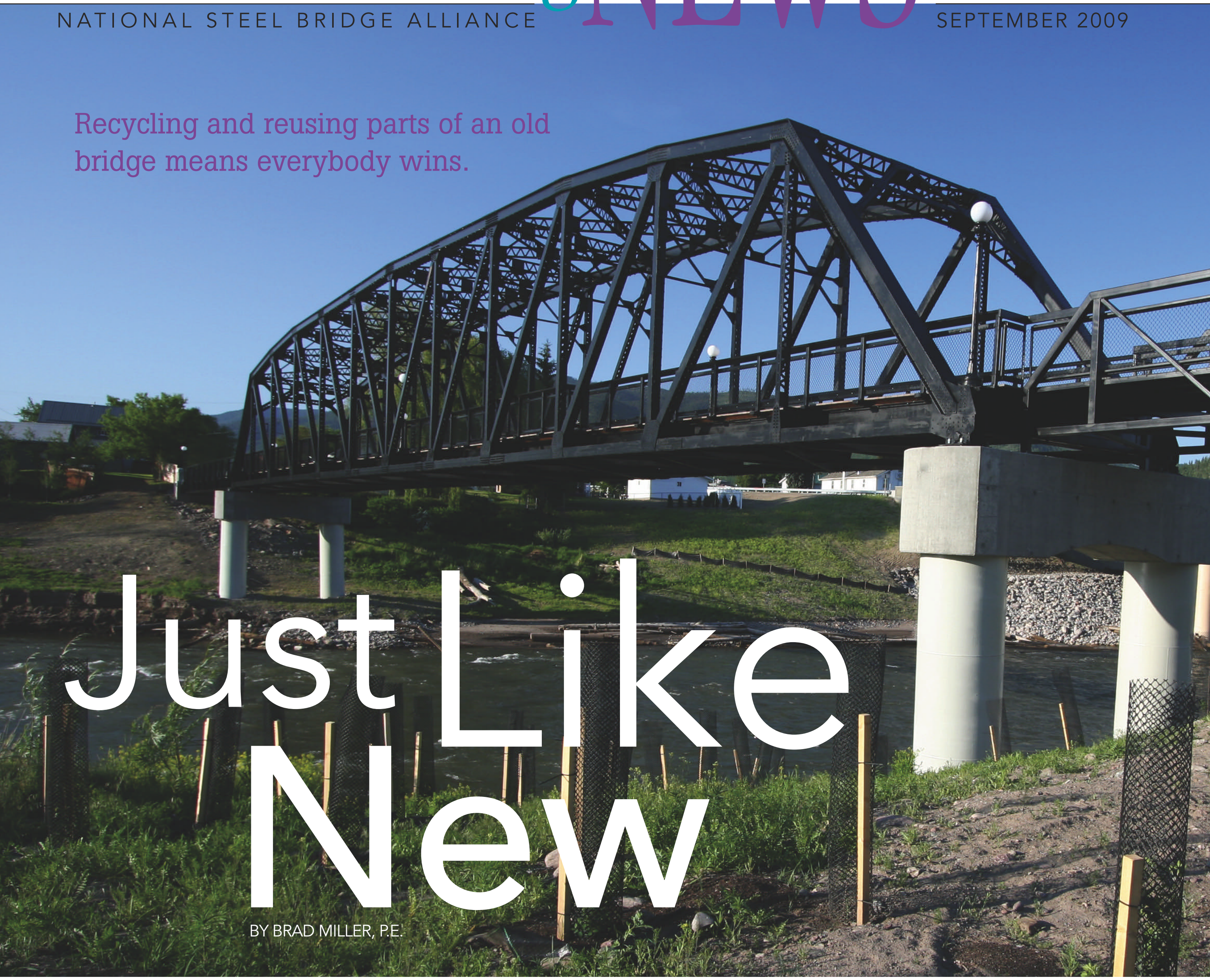


Recycling and reusing parts of an old bridge means everybody wins.

Just Like New

BY BRAD MILLER, P.E.

THE BLACK BRIDGE near Milltown and Bonner, Mont., was reconstructed in 2008, but not in the ordinary way. The old bridge was a four-span pedestrian bridge with two steel Pratt truss spans and a short concrete approach span on each end. The new bridge has all new foundations, a much longer center span and new prefabricated steel approach spans. Splitting one old truss span near mid-span and adding new truss bays enabled lengthening the center span and avoided impending foundation problems. The truss lengthening was made possible, from an engineering standpoint, by removing the heavy, old concrete deck and installing a new lightweight timber deck.

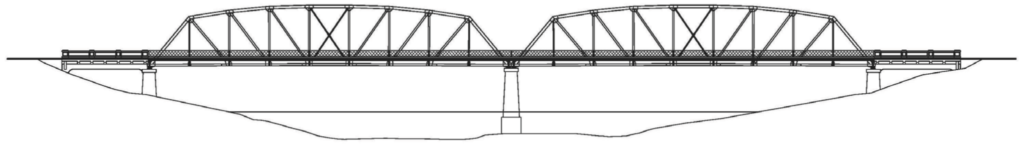
Project Development and Engineering

The old Black Bridge, located five miles east of Missoula, Mont., was constructed in 1921 over the Milltown Reservoir, part of the Blackfoot River near its confluence with the Clark Fork River. In recent years it has been open to only pedestrian traffic. With the removal of the 100-year-old Milltown Dam as part of a superfund clean-up site, and the loss of the reservoir behind it, the 85-year-old Black Bridge, would be subjected to swifter stream action and scour than it was originally designed for. The Blackfoot River channel was expected to degrade 12 ft or more in the area of the bridge, undermining the center pier that was founded on relatively shallow spread footings. There also were two old piers from a previous bridge that obstructed the channel contributing even more to potential scour. An alternate study was performed and the decision was made to replace the structure with a new pedestrian bridge.

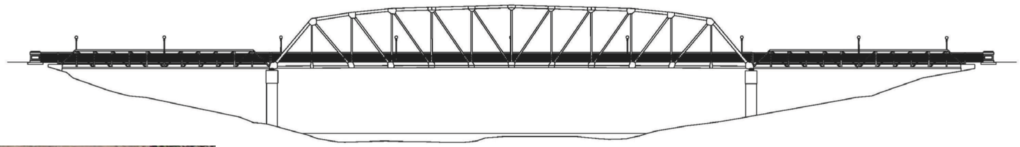
The citizens of nearby Milltown and Bonner, already sore from

Above: Before, two 166.5-ft spans and four piers in the water.

Left: After, one 222-ft span on new piers on the banks.



The original bridge built in 1921 had two 166-ft-long truss spans with short approach spans.



In 2008 the bridge was reconstructed. One truss span was lengthened to 222 ft using parts from the second truss as well as new components, and new approach spans were added.

losing their historic dam and other significant structures, formed a Save Our Bridge (SOB) committee and won support from Missoula County to save a significant portion of the existing truss spans. Tim Elsea, Missoula County Engineer, worked closely with HDR Engineering to achieve this goal while satisfying the roughly 230-ft main span length dictated by environmental constraints. HDR determined that it could incorporate one of the truss spans into the new bridge by lengthening it to 222 ft, sufficiently close to the environmental requirement for the main span, by reducing the dead load imposed on the truss. This was done by replacing the heavy concrete deck with a lightweight timber deck.

HDR bridge engineers analyzed the lengthened truss model and determined that this was a viable option but would cost significantly more than an all-new bridge. Missoula County opted to

Brad Miller, P.E., is a senior bridge project manager and professional associate with HDR Engineering Inc., Missoula, Mont.

New HSS2×2×3⁄16 supports running longitudinally between the stringers stiffen the new wooden deck, enabling multiple 2-in. by 8-in. planks to carry the single-wheel loads from emergency and maintenance vehicles.

go with the lengthened salvaged truss span and the final bridge design was modified to include this concept. Pleased by the outcome, the citizens of Milltown and Bonner amended the "Save Our Bridge" sign that had been installed on the old bridge to read "Saved Our Bridge."

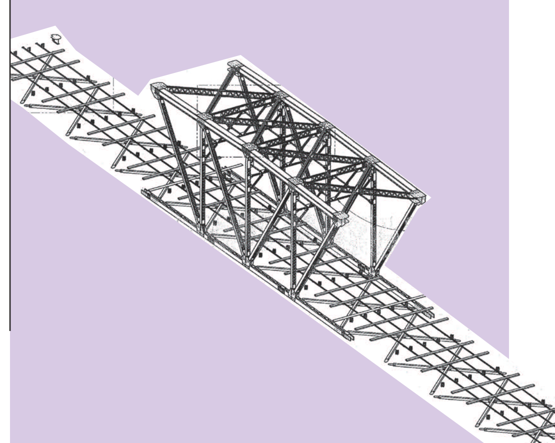
The original Pratt truss consisted of nine 18.5-ft truss panels with an 8- to 10-in.-thick concrete deck. By replacing the heavy concrete with a lightweight wood deck, three additional truss panels could be inserted into the center of the bridge, lengthening it from 166.5 ft to 222 ft. The lengthened truss was completely re-evaluated for pedestrian, emergency, and maintenance loads as well as seismic and wind loads.

Reducing the dead load was done primarily by replacing the concrete deck with a 1.5-in. timber deck using long-lasting Ipe hardwood, also referred to as ironwood.

Returning to the Scene

Roscoe Steel had its beginnings in the Minneapolis-based Security Bridge Company, the general contractor for the Black Bridge in 1921. The area manager for security was W.P. Roscoe, Sr. who went on to found W.P. Roscoe Co. (a bridge contracting firm whose history spanned from 1923 to 1974). His son W.P. Roscoe, Jr. started Roscoe Steel & Culvert Company, Inc. in 1953 and subsequently his grandson, Jim Roscoe, bought control of that company in 1975.

For the Black Bridge reconstruction project, Roscoe Steel developed a 3D CAD model of the lengthened portion of the truss along with other new members in order to ensure the correct dimensions of new truss elements and bolted connections.



One old truss span was removed to the river bank for reconstruction, where it was split apart and new steel added to lengthen the span. Steel from the second truss span was used to replace damaged parts and steel stringers were used in the added truss bays.

The old steel of the existing truss was cleaned by 5,000-psi water jetting with a roto-tip nozzle. Cleaning water and paint debris were collected, filtered and recycled. The reconstructed truss, along with the new approach spans, were painted semi-gloss black using a three-coat moisture cure urethane paint system supplied by Wasser.

Eliminating the cantilevered sidewalk on the downstream side of the bridge, which was used when the bridge served as a highway bridge, and narrowing the deck width inside the truss from 19.5 ft to 16 ft reduced the dead load even more. The net reduction in dead load was about 2,500 lb/ft of truss after taking into account the weight of lateral bracing added due to the increase in truss span and to offset the bracing component lost in removing the concrete deck, as well as miscellaneous steel added in the deck and rail system.

An ironwood deck, which does not require chemical preservative treatment, was selected instead of a treated wood deck because this bridge reconstruction project was part of a large superfund clean-up effort and the agencies involved were very sensitive to possible environmental concerns resulting from the use of treated wood over water. This was more of a preference than a real issue since treated wood over water is still acceptable if properly designed and installed.

The final bridge configuration consists of a new 98-ft-long prefabricated steel truss approach span at each end of the refurbished center truss span. The main truss span is wider than the approach spans and offers special overlooks for fishing and recreation. Portions of the unused second span were used to replace damaged parts on the reconstructed span and old steel stringers were incorporated into the new center portion. All the steel was painted black to match the original color of the bridge.

The final structure has an entirely new substructure consisting of concrete drilled shafts at the abutments and piers. Each pier consists of two 5-ft diameter drilled shafts extending approximately 43 ft below the ground line. Each abutment has two 2-ft diameter drilled shafts extending 22 ft below the base of concrete cap. The old truss span was removed and re-installed using a work bridge and heavy moving equipment. MSC

Owner
Missoula County, Mont.

Structural Engineer
HDR Engineering Inc., Missoula, Mont.

Steel Fabricator
Roscoe Steel, Missoula, Mont. (AISC Member)

Steel Fabricator – Approach Spans
CONTECH Bridge Solutions Inc., Fort Payne, Ala. (AISC/NSBA Member)

General Contractor
Frontier West LLC, Missoula, Mont.


ONE SOURCE
FOR ALL STEEL COMPONENTS
NECESSARY TO CONSTRUCT
YOUR GREEN BRIDGE.
WHAT A CONCEPT.

A New Era for Short-Span Bridges

BY ATOROD AZIZINAMINI, PH.D.

Steel provides a simple and economical solution.

ALMOST 45% OF THE BRIDGES in U.S. bridge inventory are less than 60 ft in length. Most are simple spans located on county roads. Many of these short-span bridges are either structurally deficient or functionally obsolete and need to be replaced. It is essential to develop alternatives that are economical, can be constructed using light construction equipment and have long service life with minimal maintenance.

A new solution, referred to as the Folded Plate Bridge System, offers an economical and exciting solution for many of the nation's bridges with maximum span lengths up to 60 ft. The system consists of a series of standard shapes that are built by bending flat plates into inverted tub sections using a break press (see Fig. 1) and has many advantages for both steel fabricators and bridge owners. The maximum span length for this system is currently limited to about 60 ft, reflecting the longest press breaks that are available in the industry.

Folded plate girders suitable for different span lengths differ only by their cross-sectional dimensions. More specifically, varying the width of the top and bottom flanges and the depth of the web while keeping the plate thicknesses to either ⅜ in. or ½ in. can accommodate span length requirements. The different top and bottom flange widths and web depth can easily be accommodated by changing the bend locations, so fabricators can build folded girders very quickly while only stocking two plate thicknesses. That is important because delivery of steel bridge girders in a timely manner is an important issue for the bridge owners.

The shape of the cross section for the Folded Plate Bridge System has several key advantages in its design and construction:

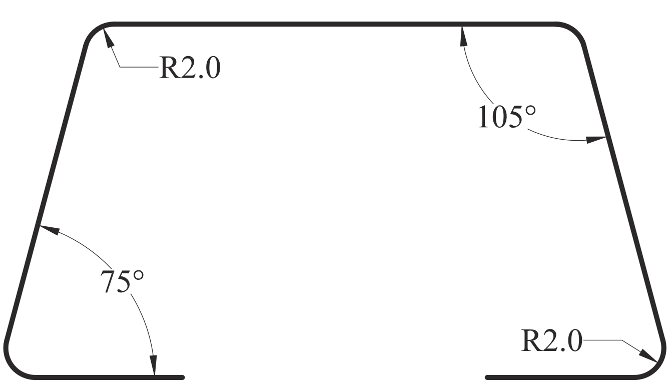


Fig. 1 Typical cross section for the Folded Plate Bridge System. Dimensions vary based on span length.

- The inverted tub shape produces a very stable bridge girder configuration that does not require internal or external cross frames for either local or global stability. A single cross frame could cost as much as $1,000, so eliminating cross frames helps reduce cost. It also eliminates a major factor responsible for fatigue and fracture observed in old steel bridges. Further, the Folded Plate Bridge System is very user friendly during the construction phase. For example, the formwork for casting concrete can be accomplished using conventional equipment and practices.
- The top flange of the Folded Plate Bridge System is wide enough (about 25 in. to 35 in.) to serve as a work platform. That itself can reduce many construction hazards associated with workers walking on girders during construction.
- Box or tub girder bridges are very efficient bridge systems but usually are used only for longer span bridges (longer than about 300 ft). That is in part because of the inspection issue. Longer span lengths result in tub sections that are deep enough to allow internal inspection. However, for short-span bridges (less than 60 ft) the depth of the box needed is so small that it prohibits crawling inside the box for inspection. This is one of the reasons for not using box girder bridges for short-span bridges. The cross section of the Folded Plate Bridge System, however, is open on the bottom side, making inspection very easy.

Fabrication and Construction

One of the advantages of the Folded Plate Bridge System is its promise for rapid delivery. The concept uses only two plate thicknesses—⅜ in. and ½ in.—and bending the plate to specified shapes is

Atorod Azizinamini, Ph.D., is a professor of structural engineering at the University of Nebraska–Lincoln. He also serves as director of the university's National Bridge Research Organization. For further information about the Folded Plate Girder Bridge System, contact Professor Azizinamini at 402.770.6210.

Photos provided by Atorod Azizinamini.

Fig. 2 Conventional forming materials and methods can be used to form the concrete deck on the folded plate girder.

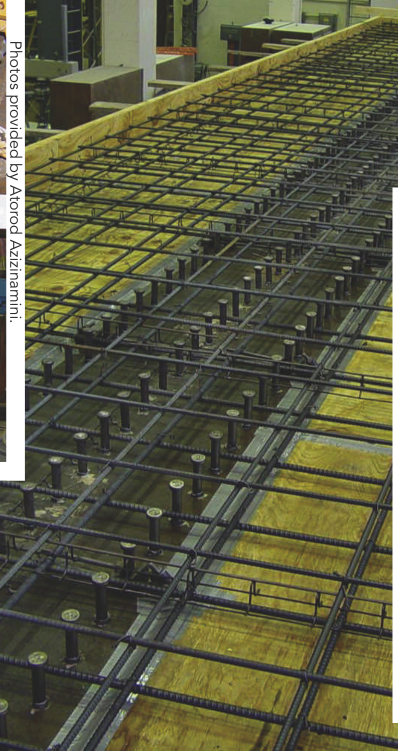


Fig. 4 With the concrete deck in place, several sections of a folded plate girder bridge can be stacked and shipped to the site on one trailer.

Fig. 3 A folded plate girder with deck forms and reinforcing steel in place. Note the studs on the girder and the sizable work platform it provides.

not time consuming. These attributes combined allow rapid fabrication and delivery. For example, many U.S. electrical utility pole manufacturers have the capability of building one folded plate girder in less than a minute.

Recently, the trend within the bridge construction industry has been toward reducing construction activities on the bridge site and eliminating the interruption to traffic. The Folded Plate Bridge System can be constructed using conventional construction techniques as well as using principles of Accelerated Bridge Construction. In the case of conventional construction procedures, readily available construction equipment could be used to build the formwork for casting the concrete deck (see Fig. 2 and Fig. 3).

An alternate and perhaps better approach when using the Folded Plate Girder system to construct short-span bridges is to use prefabricated elements. The tributary width of concrete deck for each folded plate girder could be cast on the girder prior to shipping to the site. In this scenario each prefabricated bridge element would be in the form of a folded plate with a precast top deck (see Fig. 4).

A typical two-lane county type bridge will require three such folded girder sections placed side by side and connected longitudinally. A number of approaches can be used to connect pre-decked girders in the longitudinal direction. A 40-ft.-long folded plate girder with precast deck will weigh about 24,000 lb, allowing use of a relatively lightweight crane on the construction site.

The development of the folded plate bridge system is a result of research at the University of Nebraska-Lincoln. Ongoing research and development work is nearing completion and the new bridge system will be available for field application by December 2009. MSC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Over the River and More

BY CRAIG A. MATTOX, P.E.

Using various styles of steel beams and girders helped engineers avoid conflicts with existing streets and buried utilities as well as maintain clearances.

Photos by Craig Mattox.

The new Topeka Boulevard Bridge spans a river, a railroad, a flood protection levee system, and local streets.

PRELIMINARY DESIGN STUDIES for this bridge replacement looked at composite steel girder spans and precast prestressed girder spans. The final structure needed to carry 23,000 vehicles per day on a viaduct spanning a number of different obstacles: the Kansas River, four side streets, the U.S. Corps of Engineers Kansas River levee system and three tracks of the Union Pacific's mainline carrying 120+ trains per day.

The design was to be flexible enough to be readily widened in the foreseeable future should traffic growth continue at its current pace. In addition, the design would have to be able to accommodate carrying two 24-in. water mains and a 10-in. high pressure gas line supplying the metropolitan area north of the river. The result of the design study was for a steel superstructure 3,209.56 ft long on a substructure widened to accommodate future expansion. The new bridge is four lanes wide with room for an additional lane to be added to each side. Both sides of the roadway have a 6-ft-wide sidewalk that meets ADA requirements.

Aesthetic improvements were added to the structure based on public comments. A steel sign truss spans gateway towers located at each river levee. At this same location, an observation deck extension on a simple span welded girder was added to the bridge to offset the widened substructure. The exterior girders and exposed bearing devices were painted for aesthetic reasons. The red color was selected and presented to the public in a series of public meetings.

Steel erection took place over an eight-month period, including several delays due to flooding. The project required 22 months to construct and was opened to traffic in August 2008.

This bridge illustrates the flexibility offered by structural steel. The structure used three types of steel spans. Composite rolled (40-in.) beam sections were used for Units 1 and 3, each with five spans ranging from 70 ft to 95 ft. Composite uniform depth welded plate girders were used for Unit 4, where the five spans were between 103 ft and 141 ft. The composite haunched welded plate girders used for the nine spans in Unit 2 ranged from 146 ft to 215 ft. The use of each these different solutions allowed flexibility in avoiding

Craig A. Mattox, P.E., is managing partner/owner of Finney & Turnipseed Transportation & Civil Engineering, Topeka, Kan.

Divided into four units for planning purposes, the 3,210-ft Topeka Boulevard Bridge includes 24 spans ranging from as little as 70.5 ft to as much as 215 ft.

At least partly to maintain good aesthetics, observation deck extensions were added to the bridge at the gateway tower piers at the levee on each side of the river to harmonize with the widened substructure.

Although the bridge is constructed of weathering steel, the exterior girders and exposed bearing devices were painted for aesthetic reasons.

conflict with existing streets and buried underground obstructions. Their use also helped in maintaining vertical and horizontal clearance requirements set forth by the Corps of Engineers for the levee and by the railroad for its mainline tracks. This, in turn, equated to structural economy. MSC

Owner
City of Topeka, Kan.

Designer
Finney & Turnipseed, Transportation and Civil Engineering, Topeka, Kan.

General Contractor
Joint Venture of United Contractors, Johnston, Ia., and Hawkins Construction Co. Inc., Omaha, Neb.

Steel Detailer & Fabricator
AFCO Steel, Little Rock, Ark. (AISC/NSBA Member)

Delicate & Desolate Bridge Replacement

BY IN-TAE LEE, P.E., S.E. AND MELISSA MONCADA, P.E.
PHOTOS BY OTAK INC.

Combining an innovative approach and high-strength steel results in a picturesque and functional upgrade.

THE DIAMOND CREEK BRIDGE REPLACEMENT PROJECT in Oregon's Douglas County presented unusual challenges involving site access, geological and topographical variability, and traffic control limitations. The bridge is located along a remote and extremely windy stretch of Oregon highway near Crater Lake National Park in an environmentally sensitive watershed in Umpqua National Forest. The sharp curves on the road to the site limited construction equipment availability and the transport of bridge elements, in particular the steel girders.

Because the bridge is a main transportation link for area residents and is also used for commercial purposes, it could not be closed during the replacement. Therefore the new bridge was constructed adjacent to the existing structure.

The site includes steep rock formations at each end of the bridge. At one end a vertically fractured rock cliff created a significant test in designing the foundation elements. Furthermore, the steepness of the natural slopes at the bridge site posed serious challenges in accessing the area underneath the bridge. The existing Diamond Creek Bridge's main span, a 100-ft-long steel truss, prevented any type of staged construction and created the necessity to design a new alignment. In addition, the old truss was coated with lead-based paint. To minimize the associated environmental hazards, the old truss was to be removed in one piece and placed on the new bridge, from which it could be driven away for dismantlement.

In close coordination with Douglas County staff, the new bridge was designed from foundation to superstructure to optimally address the site challenges while assembling an aesthetically pleasing and balanced structure that blends well with its natural surroundings. Abutment footings were designed to follow the natural rock line at each end of the bridge and were placed strategically to avoid vertical fractures in the rock while minimizing span lengths.

The interior pier was placed at the center of the bridge not only to create a bridge with two balanced 135-ft spans, but also to avoid proximity to the environmentally-sensitive area within the ordinary high water mark, minimizing environmental impacts. Environmental impacts were further reduced at the interior pier by using small-diameter drilled shafts rather than a spread footing, significantly reducing the excavation required during construction. Designing for balanced spans also allowed a smaller column to be used.

The need for intermediate splice towers for erecting the steel girder superstructure was eliminated through the use of a creative

Opposite page: Although based on a technically challenging design, the new Diamond Creek Bridge is a simple and elegant blend of technical innovation and context-sensitive problem solving.

design technique. The steel girders were designed as simple spans with regard to the self-weight of the structure and as continuous spans under live load.

The structural steel beams were designed specifically to make site access possible. Due to the shipping restrictions on their size and length, the beams also were designed with the fewest structural components possible and were assembled at the site.

High-performance and high-strength weathering steels (ASTM A709 Grade HPS 70W) were implemented for the design of the structural steel beams. Using these progressive materials allowed the structural steel to be relatively light and easy to assemble during construction.

Recently bridge decks constructed in Oregon have been developing an increasingly greater number of cracks immediately after construction. To reduce the immediate and long-term cracking due to the shrinkage and seasonal freeze-thaw fluctuations, the client and the design team jointly decided to add plastic fiber reinforcement to the concrete mix design.

Although a technically challenging design, the result was a simple, original, and elegant structure. The Diamond Creek Bridge is an exceptional blend of technical innovation and context-sensitive problem solving, as well as an elegant structure that will serve the client and community for decades. MSC

Owner
Douglas County, Ore., Public Works

Designer / Project Manager
Otak, Inc., Lake Oswego, Ore.

General Contractor / Steel Erector
Holm II Inc., Stayton, Ore.

Steel Fabricator
Oregon Iron Works, Inc. (OIW), Vancouver, Wash. (AISC/NSBA Member)

Above: To minimize disruption to its lead-based paint, the 100-ft truss from the old bridge was removed in one piece.

Below: Located along a remote and extremely windy stretch of Oregon highway, the Diamond Creek Bridge site required tight clearances to minimize environmental disturbance.

In-Tae Lee, P.E., S.E. is a senior project manager and Melissa Moncada, P.E. is a bridge engineer. Both are with Otak Inc., Lake Oswego, Ore.

World Steel Bridge Symposium Convening in TEXAS

Bridge experts from around the globe gather to learn and to share.

THE NATIONAL STEEL BRIDGE ASSOCIATION'S 2009 World Steel Bridge Symposium & Workshops (WSBS) will be held at the Henry B. Gonzalez Convention Center in San Antonio, Texas, on November 17–20. Held every two years, the conference features a series of workshops, technical sessions, and networking activities.

The WSBS gathers steel bridge owners, designers and contractors from around the world to discuss all aspects of steel bridge design and construction. The exhibit hall, which this year includes more than 75 exhibitors, includes products and services to advance the state of the art of the steel bridge industry. Attendance this year is expected to top 600 bridge policy makers, engineers, and industry guests.

Several pre-conference workshops are also being offered as an official part of the 2009 symposium.

SSPC Workshop: Bridge Coatings: Today's Systems, Tomorrow's Performance

Tuesday, November 17, 1:30 p.m. – 5:00 p.m.

Get an overview of today's corrosion protection systems (paint, galvanizing, metalizing, weathering steel), including case studies detailing the proper application of the systems and also describing their successful performance after many years in service.

PreFabricated Bridge Elements and Systems Workshop

Tuesday, November 17, 1:30 p.m. – 5:00 p.m.

Prefabricated bridge elements and systems (PFBES) are becoming an increasingly important tool to facilitate accelerated bridge construction. This workshop will present various PFBES and feature examples of successful application of PFBES in steel bridge projects.

Accelerated Construction Technologies Workshop

Wednesday, November 18, 8:00 a.m. – 11:30 a.m.

Presentations will address various contracting strategies, staging techniques, construction methods and the use of prefabricated bridge elements to achieve accelerated bridge construction.

Kicking off the symposium on Wednesday afternoon will be Per Tviet, whose keynote address is titled "Genesis and Development of the Network Bridge Concept." Tveit is professor emeritus of Agder University in Norway and the world's leading expert on network arches. The network tied arch, with sloping hangers, improves on the traditional tied arch (with vertical hangers) by reducing demand in the arch by up to 75% resulting in a significant savings in structural steel and providing an improved redundancy.

Multiple sessions are offered each day of the symposium. Wednesday afternoon, following the opening session and keynote address, one session will focus on erection while a second session deals with analysis. The Thursday morning sessions include the headings of Texas, Security, Signature Bridges, and Practical Design.

Thursday afternoon sessions include Skew, Fabricator Interest, Curved Girders, and Cost Effective. Three of the symposium's final four sessions, on Friday morning, cover a variety of topics and so have been labeled "Potpourri." The fourth is, simply, Fatigue/Fracture.

For more detailed information including listing of specific papers and authors for each session, visit **www.steelbridges.org/wsbs**.

The symposium also will highlight the NSBA's Prize Bridge Awards, which bi-annually honor the most innovative steel bridges. More information on the competition, including a list of winning entries going back to the 1920s, can be found at **www.steelbridges.org/prizebridge**.

The WSBS exhibit hall will open Wednesday afternoon at 3 p.m. with a reception from 5:00 p.m.–7:00 p.m. Thursday the exhibits will be open all day, beginning at 7:30 a.m. The Thursday evening reception begins at 6:00 p.m.

Online registration for the 2009 WSBS is now open. For more information on the symposium, call 312.670.5402 or visit **www.steelbridges.org/wsbs**.

MSC

Who is the NSBA?

The National Steel Bridge Alliance (NSBA) is organized as a unified voice for the steel bridge industry. The NSBA seeks to facilitate/coordinate the industry efforts to enhance the deployment of steel bridge design and construction in the U.S. through technology confidence building, infrastructure strengthening and market awareness. The NSBA maintains a committed focus on assisting its membership with their bridge design needs and technical information associated with steel bridge construction. For more information visit **www.steelbridges.org**.

Fire Protection Basics

BY MONICA STOCKMANN, LEED AP

A variety of good options are available.

MINIMIZING THE POTENTIAL FOR A fire to occur, and protecting life and minimizing the extent of destruction if one does, are important goals for the design of any building. Fire loss mitigation in buildings can be achieved through a number of measures, such as fire prevention strategies, control of combustible and hazardous contents, provision of alarm systems, means of safe evacuation, fire-fighting access routes, adequate water supplies, active fire-fighting systems, building separations, compartmentation of premises, and structural fire resistance. The specific combination of fire mitigation measures in a building depends on the size and severity of associated risks and hazards. Structural fire resistance requirements often are prescribed in the applicable building code based on building occupancies, height, area, and other building characteristics. When fire resistance is prescribed for the structure, the associated objective can be described as a succinct inequality: Fire Resistance ≥ Fire Severity. To achieve this condition, the structure must resist collapse or failure during a fire of a specified severity.

Fire resistant materials and systems are designed to prevent or delay the temperature rise in structural steel so that the steel members can maintain adequate strength for the required duration. Ideally, this time allows for safe evacuation of the affected areas and fire-fighting operations, including search and rescue.

Figure 1: Steel framing with SFRM in place at Children's Memorial Hospital under construction in Chicago. Inset shows the hospital's signature handprint rendered in SFRM.

Many technologies are available for protecting structural steel during a fire, and they use a variety of methods to achieve specified fire resistance ratings. This article provides a brief overview of different fire protection systems. For a more detailed look at this topic, see AISC Design Guide No. 19 *Fire Resistance of Structural Steel Framing*. That publication also provides references to common assemblies used in fire-resistant designs, such as the Underwriters Laboratories Inc. (UL) Fire Resistance Directory (**www.ul.com**).

Sprayed-On Protection

Spray-applied fire-resistant materials (SFRM) are most commonly used to protect structural steel. SFRM products are commonly classified by their in-place density as standard-density (13-18 psf), medium-density (22-30 psf), and high-density (40 psf and over).

Most SFRMs are of the "wet-mix" product type (often referred to as "cementitious fire protection"). The proprietary dry factory-premixed combination of gypsum or portland cement binders and lightweight mineral or synthetic aggregates is mixed with water on-site to form a slurry that is pumped and sprayed on the steel substrate. Some SFRM products are "dry-mix" products (often referred to as "fiber fire protection"). The proprietary dry factory-premixed combination of portland cement and inorganic binders combined with mineral wool is pneumatically pumped in a dry state on-site and mixed with water at the spray nozzle immediately before the application of the resulting slurry on the steel substrate.

Because SFRMs have proprietary formulations, it is imperative to closely follow the manufacturer's recommendations for mixing and application. Thicknesses required to achieve various ratings are typically provided by the manufacturer as well.

The biggest advantages of using SFRM are speed, efficiency, and cost-effectiveness. Surface preparation time is minimal for steel that

Monica Stockmann (stockmann@aisc.org) is an AISC Steel Solutions Center advisor.

is to receive a field-applied contact-type SFRM—the steel need only be shop cleaned of dirt, oil, grease, and loose mill scale. The application of SFRM is relatively easy and fast; however, because it is a wet process, it can impact other trades. Also, protecting on-site areas from overspray is typically required.

It is important to avoid accidental or intentional removal of SFRM as other trades perform their work on or near the steel structure subsequent to the application of SFRM. It is ideal for attachments to be in place before the application of the SFRM. However, if SFRM does need to be removed for attachment purposes, the removed material needs to be replaced. Quality control for the SFRM should be a designated responsibility assigned to a member of the construction team.

Gypsum Board

Gypsum-based board products protect the steel by absorbing energy. Gypsum is a naturally-occurring mineral that consists of calcium sulfate chemically combined with water. When exposed to fire, gypsum-based materials undergo "calcination"—they release the entrapped water in the form of steam, providing a thermal barrier. After calcination, gypsum-based materials retain a relatively dense core, providing a physical barrier to fire in addition to the thermal barrier.

Gypsum board typically is provided with "regular" or "Type X" designations. The "Type X" sheets are special fire-resistant products that ensure the required fire-resistance ratings for specified benchmark wall assemblies. Some manufacturers also produce a "Type C" or "Improved Type X" board that exhibits superior fire performance. Most fire resistant gypsum board includes glass fibers and other additives that reduce shrinkage and cracking under fire exposure.

Gypsum board enclosures are relatively cost-effective when compared with other fire resistant products. Gypsum board walls and ceilings are commonly used in building projects for interior finishes; thus, upgrading to a fire-resistive gypsum assembly achieves two goals simultaneously—interior finish and fire protection.

Several considerations in the design and construction of gypsum board wall and floor assemblies should be addressed to achieve the desired fire ratings in the field.

- Gypsum board enclosures should be designed and specified as an assembly, based upon a tested system. Fire-resistance testing is conducted on assemblies made up of specific materials put together in a specified manner. For example, the mixed selection of individual products each with appropriate fire ratings will not compensate for deficiencies in the size of studs or number of fasteners when compared to a tested assembly.
- The assembly built in the field must be representative of the one tested because construction detail variations from the tested assembly can impact performance. If a product substitution occurs, for example, the designer should be notified and should verify the new assembly. The size and spacing of framing and fasteners should be the same as, or more conservative than, the enclosure assembly test. The intersection of the partition wall with the ceiling or floor should correspond to the tested assembly as well, which typically requires extra attention in the field.

Intumescent Paint Systems

Intumescent paints are multi-layer coating systems that char and expand rapidly in a fire to insulate the steel, as shown in Figure 2. Proprietary intumescent paint formulas typically include a

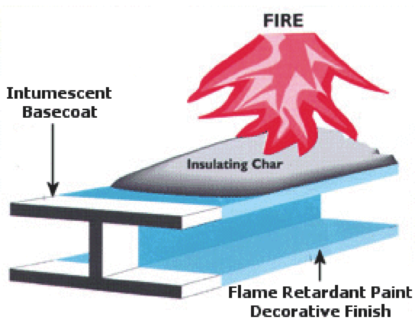

Figure 2: How intumescent paints perform. Courtesy of **www.astroflame.com**.

mixture of resin binders and chemicals that react under high temperatures to expand to a thickness up to about 100 times the original thickness of the film, creating a thick char that insulates the steel from fire. Intumescent paints are commonly spray-applied at thicknesses less than 100 mils (1⁄10 of an inch). The appropriate paint thickness is dependent on the size of the structural element to which it is applied and the fire resistance rating required.

Intumescent paints provide many benefits, including reduced weight per surface area protected, durability, aesthetic appeal, and good adhesion. Aesthetics is typically the main driver for selecting this system—steel members protected with intumescent paint often are used in architecturally exposed structural steel (AESS) applications with a colored finish if desired. Intumescent paints can be applied off-site to save valuable construction time on-site. Maintenance of intumescent paint systems—cleaning the protected members and post installation repairs—is relatively easy.

With these advantages comes a relatively high cost compared to other systems, particularly for higher fire ratings. One way to bring down that cost is to up-size the steel and thus decrease the required thickness of intumescent paint, which not only reduces intumescent paint material costs but also decreases the workmanship and the lengthy drying times involved with the application process. Additionally, suitable environments are required for the application of these paints. Adjacent areas must be protected from overspray. If off-site application is used, areas with mechanical damage to the paint during transport and erection will need to be repainted. Quality control is very important with intumescent paints—the steel surface should be appropriately prepared according to the paint manufacturer's recommendations and proper thicknesses should be applied and verified. Additionally, there should be enough room around the steel member for the intumescent paint to expand, should a fire make that necessary.

Concrete-filled HSS and Pipe

Round, rectangular and square hollow structural sections (HSS) and pipe can be filled with concrete to increase their fire resistance. The HSS serves as permanent formwork for the concrete, which can be reinforced by standard bars, or by adding steel fibers to the wet concrete mix. The HSS can be filled off-site or erected and filled on-site. During a fire, heat passes through the steel to the concrete, which serves as a heat sink. As the yield strength of the steel decreases, the load is transferred to the concrete. The steel encasement and reinforcement helps limit the heat effects on the concrete, such as spalling and strength degradation. Ventilation holes in the steel encasement allow for steam to release when the concrete is heated, relieving pressure. This method is frequently used in exposed steel applications because the steel can be easily painted.

Fire-Trol System

Fire-Trol columns are prefabricated members that consist of a load-bearing steel column (labeled A in Figure 3) encased in a special proprietary insulating material (B). An outer non-load-bearing steel shell (C) permanently encloses and protects the insulating material. Fire-Trol columns are shipped to the job site ready to erect and can be specified to achieve up to a four-hour fire rating.

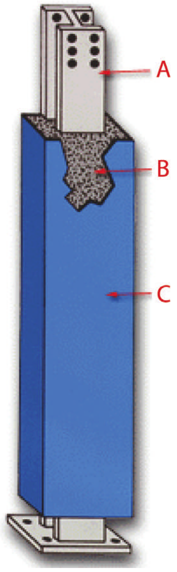

Figure 3: Fire-Trol column elements. Courtesy of Dean Lally, L.P. **www.dean-lally.com**.

Other Systems

There are a variety of other fire protection systems and products on the market, such as:

- Mineral fiber board enclosures, which can be cut and placed to form a tight seal around structural steel members.
- Ceramic wool wraps that insulate steel.
- Gypsum-based plaster applied directly to steel surface or to metal lathe fixed around the member.
- Plaster, clay tile, concrete, and masonry enclosures.

Improving Economics

Regardless of the fire protection system chosen, there is likely an opportunity to improve the economics of the design. Because the rate of temperature change in a body is a function of its mass and the area of its surface exposed to the temperature difference, the amount of fire protection required is dependent on the steel section selected. The *W/D* ratio (weight per unit length over heated perimeter of the steel member) is critical for the selection of wide flange shapes, and the *A/P* ratio (steel section area over heated perimeter) is used for HSS selection. The larger the *W/D* or *A/P* ratio, the slower the rate of temperature change. Thus, a steel beam with a large heavy cross section may require less fire protection than its lightweight counterpart. Design Guide No. 19 provides tables of *W/D* and *A/P* values for respective wide-flange sections and HSS, as well as design examples for determining thicknesses required for various fire protection systems.

Further References

For more information, please refer to:

- AISC *Facts for Steel Buildings: Fire Facts* (free download at **www.aisc.org/freepubs**).
- AISC Steel Design Guide 19, *Fire Resistance of Structural Steel Framing* (download at **www.aisc.org/epubs**—free for AISC members; fee for non-members). MSC

Business Velocity: Part Two

BY LARRY MARTOF

A structured approach to looking for and eliminating waste.

IN PART ONE OF THIS ARTICLE (February 2009 *MSC*, **http://www.modernsteel.com/Uploads/Issues/February_2009/022009_qc_web.pdf**) we examined what "Business Velocity" means—having a business with speed and direction—and how it uses the methodologies of Lean Six Sigma (LSS). We were introduced to some of the tools and approaches to achieving breakthrough improvements that can lower costs, increase profits, increase customer satisfaction and create a sustainable business environment. We learned that Business Velocity provides an organization with the speed of Lean—focusing on the reduction of waste—and the direction of Six Sigma, which provides a keen focus on the customer. In this installment we will further explore the deployment of Lean Six Sigma tools.

Lean uses the acronym **DOWNTIME** to explain the many forms that waste can take. Each of these can be seen in the steel construction industry.

- ➜ **D**efects that result in rework and scrap. Defects are an interesting animal. Acceptable defects have resulted in tolerances, limits and acceptance criteria. Unacceptable defects result in nonconformances that require dispositioning and often rework, resulting in wasted money and time. They can occur in the field, the fabrication shop, purchasing, accounting, project management, estimating or any other process. They can be caused by equipment/machinery, detailers, suppliers, employees, environmental conditions, process methods, measuring devices and materials. Identifying defects is the first step in controlling and reducing them. A simple log provides for the tracking and categorization of defects. It also enables the creation of trend charts, bar charts and pareto analysis. Pareto charts give a visual portrayal of which defects are occurring most often or which defect category is causing the most rework or highest costs.
- ➜ **O**verproduction results in cost and space burden of excess inventory. Often stacks of clips, tabs and other pieces are made in advance and held in inventory for later use. Sometimes parts are made in advance to avoid lengthy changeovers, but that is just avoiding the real issue. Instead of avoiding changeovers, fix the changeover process. Dig into SMED (Single Minute Exchange of Die), a methodical attack at eliminating waste in changeovers. Another tool to fix overproduction is PULL. Keeping inventory is a PUSH practice in which we make parts in advance and then try to push them out the door hoping a project will come along that needs them. In a PULL practice we allow the customer order or project to pull the parts from the shop as they are made according to demand. Don't we invest in automation in order to speed our production process? So why do we resort back to the old PUSH thinking? Another tool that comes to mind is One Piece Flow or Single Piece Flow. Many folks think that this doesn't work in the fabrication shop because we can't flow one piece at a time. The key to using this tool with success is how we define "One Piece." One Piece can be a sequence or a truckload or another grouping that makes sense to our workflow.
- ➜ **W**aiting is observed as one process waits for another process to complete before it can begin. Waiting indicates a constraint or chokepoint in the process or workflow. We often create wait in our processes by how we deploy equipment. A "one machine does it all" can be a blessing or a curse. If we can use this multi-function capability for the majority of our work then it is good, but it also means each piece that has to wait for the use of only one function is wasting time. Think of it this way: The saw and drill are closely connected so that each piece passes through the saw and drill versus having a separation between the saw and drill that allows each piece to pass through the saw and then choose if it needs drilling. Then while it moves to the drill other pieces that only need cutting can move through to other processing. Keep in mind that we have to weigh things such as space and budget when making these decisions. Understanding how work flows and where waiting occurs can help us overcome waste time and keep product moving.
- ➜ **N**on-utilized talent is the waste caused by having the wrong person in the wrong position. This is easy waste to overcome. The key lies in understanding who is qualified in what processes. This can be accomplished by creating a training matrix listing personnel down the rows and equipment and/or processes across the columns. Color coding can be used to show the level of competency each person possesses for each process. The resulting

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

tool can be used to determine who can be on vacation at the same time, who needs training, where more resources are needed or even who is qualified to be a trainer in a process. It also can be used to define the development path for new hires and as a method for advancement.

- ➜ Transportation waste is probably the biggest form of waste in any shop or jobsite. It occurs when product is moved around without any value-added activities. Every time someone stops an operation to move a piece of steel wastes time and motion. A Spaghetti Diagram provides a simple tool for understanding transportation waste. This is created by observing product flow and handling points and documenting this as an overlay on a facility layout plan. The best way to do this is to find an elevated vantage point that gives you a bird's-eye view. It is called a Spaghetti Diagram because when we first do this exercise it typically looks like a bowl of spaghetti as the material wanders to and fro as it moves from the delivery truck to the shipping trailer. Another good tool is Value Stream Mapping, which shows movement, time and flow in one map. Both of these tools help in targeting activities that are not adding value, including transportation waste.
- ➜ Inventory waste refers to excess raw materials that are not being processed. Reducing inventory reduces cost burdens. Understanding the supply chain is key to success in eliminating waste here. A common tool for this is the Just In Time (JIT) approach. But as with Single Piece Flow, where we redefine what single piece means, we must determine what Just In Time is and how much burden and inventory risk we want to assume. The key is to maintain the desired level without over burdening and creating transportation or waiting waste.
- ➜ Motion waste is the extra human movement resulting from not having what is needed where it is needed. This is a great starting point for deploying LSS. It starts with understanding what we do and making it a standard practice. Then we take this baseline and improve it. If you have documented a quality management system that reflects what you do and this system has been revised, then you have deployed the standardization tool of LSS. Another invaluable tool is 5S. This tool takes housekeeping, organization and safety to the next level. The 5S's are:
  1. Sort–getting the clutter out.
  2. Straighten–organizing what is needed; a place for everything and everything in its place.
  3. Shine–cleanliness breeds safety and good housekeeping habits.
  4. Standardize–instill the first 3S's and use checklists for audits and improvements.
  5. Sustain–keep the good habits; train, reward, recognize.
- ➜ Extra processing is seen in redundant steps, duplicated work or data and energy waste. This form of waste often is found in the administrative tasks where multiple people are entering or recording the same information or data. Process Mapping overlays the process flow on the functions or people involved in each step of the process. The flow should be continuous but often is hindered by repeated steps or redundant data entry. This waste brings LSS into the front office and reveals elements of the waste-laden "Hidden Factory" lurking outside of the shop floor.

Looking at DOWNTIME helps us to identify opportunities for improvement, but what tools help to drive improvement? This is where we reach into the Six Sigma side of the toolbox. In difficult economic markets we all need to be more efficient and more cost conscience and Lean Six Sigma provides the tools that add value to the organization. The best place to start is with standardized processes, driven by a quality management system. Then identify the Hidden Factory and reveal the Visual Factory through 5S, process mapping and spaghetti diagrams. At that point, you will be able to see the waste as well as the improvement opportunities, and can systematically make breakthrough improvements to gain speed and direction and increase your Business Velocity.

Stay tuned to MSC Quality Corner for Part Three where we will explore a case study of Business Velocity improvements.

MSC

Demystifying Social Media, Part One

What is it, and what makes sense for the AEC profession?

BY ANNE SCARLETT

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SCARLETT CONSULTING

WHEN IT COMES TO TECHNOLOGY, the architectural/engineering/construction industry often seems to trail behind. We tentatively (even skeptically) watch as other professionals in similar industries delve into social media, hoping to learn vicariously from their lessons. Yet despite our slow start, the AEC industry has finally begun to increase its social media presence.

Based on a survey funded by the SMPS Foundation and published on enr.com, the white paper "Social Networking for Competitive Advantage" reports AEC's biggest hesitancy to jump into social media is a lack of understanding of what it is, how it works, and how to measure results. Confusion case in point: survey respondents did not consistently distinguish between two very different forms of networking: electronic social networking as opposed to conferences and other offline networking events. According to the study, the AEC firms that do use blogs, LinkedIn (linkedin.com), Facebook (facebook.com) and Twitter (twitter.com) use them for specific purposes: marketing individual professionals (62%), marketing the firm (50%) and, to a lesser degree, for employee recruitment (20%) and retention (7%).

The buzz about social media and how much it will honestly help companies to grow their businesses can be mind-boggling at best, downright frustrating at worst!

I know those of you AEC professionals who are introverts (like me) may feel a little shy about connecting, exposing, and building relationships online. But what you'll discover is that social media participants are enthusiastic about trading ideas, discussing, and giving/getting feedback. Further, the entire premise is around engaging with people, so they will welcome you with open arms. It is said that social media channels increase one's direct access to individuals who might otherwise be highly inaccessible. Believe it or not, one might have better luck "touching" a C-level person or a key decision maker through social media as compared to calling or trying to meet in person. It's all in the name—social media is truly social!

So, before you throw up your hands and close the door on social media for your firm or for yourself—and before you say that you are too experienced (don't need it), too busy, or too old—please reconsider. Reconsider for the sake of your professional and personal success. And reconsider for the sake of your future.

It may help you to see an AEC firm that's doing it well. The best example I've seen thus far is HOK (www.hok.com), a global architectural/engineering/planning firm headquartered in St. Louis. Not only do they have a head start, but they actually have a strong foothold in social media. HOK is consistently active and visible in LinkedIn, Facebook, Twitter, YouTube, Flickr, Delicious and VisualCV, along with 30 active in-house bloggers publishing from across the globe.

You may agree that your firm needs to get involved (or formalize and increase its involvement) in social media. But perhaps you're not sure about how it makes sense for you personally to be socially active, either on behalf of your firm or as an individual. Here are some initial thoughts to consider:

Owners and leaders: Do you recall in the late 1990s when some AEC firms took forever to launch a website? Today, the notion of having no website is unthinkable for a business-to-business professional services firm. (We won't even talk about the problem of having a non-functioning, non-user-friendly, non-interactive website.)

Social media has been around for several years now. It's reached the mainstream and has proved itself to be an excellent form of marketing and business development. There is still a lot to learn for all of us, but why be on the tail end of this? There is still time to get active relatively early compared to your industry competitors. And remember, even if your firm's target markets are not yet highly active in social media, they will be. Wouldn't it be better for them to see that you already have it together when they finally start dabbling in it themselves?

As a firm owner, you really want to make sure that your firm establishes both a *social media program* and a *social media policy*. The *social media program* will involve some level of consistent, active involvement. Perhaps key staff—studio heads, marketing, discipline directors, etc.—are formally assigned to participate in online "conversations" on a regular basis. You also could select in-house ghostwriters to interview technical leaders for their insight and expertise, and then craft the content into an articulate, reader-friendly piece. The bottom line is for the online audience to view your firm as an authority, an expert, a leader—just like how we attempt to position our firms within all other marketing, promotional, and proposal materials.

Your *social media policy* will state the firm's expectations on what is and is not shared about your firm by staff members; branding language and issues; specific social media venues that are "approved" to be used on company time for company benefit, etc. The policy can be tricky, because the beauty of social media revolves around transparency and helping others. Nonetheless, you need to view this professionally, and prepare a serious policy in advance of something going awry in cyberland.

Mid-level professionals: If you are looking to grow your career, you want to solidify a personal brand for yourself…right now. Do an online vanity search (search for your own name) and see your personal brand on top pages in the search. Further, your online image needs to reflect the image that you want to reflect for years to come. Take special care to carve out your place, and know that this is a way in which you can exponentially create your brand, solidify your reputation, increase your network, and position yourself as a talented industry player.

Entry-level professionals: *You* are the group with the most savvy and comfort in social media! Step up to the plate and help your leadership to create solid brands for themselves and for the firm as a whole. Study up on this stuff and offer to host an in-house lunch-and-learn (or even a series) to walk them through the basics using a projector and hands-on learning (with each in front of their own laptop). Take it to the next level and work with them individually to be their ghost-blogger or blog co-author, if they need it.

Another area where you could assist the firm is through community outreach and involvement. There is a plethora of ways that social media creates social good/change. (Google it; you'll see what I mean). You have the means to increase your own value as far more than "just a technical person" if you help. As I've said in many prior articles, technical people who actively partake in the firm's marketing/business development effort will ultimately elevate their careers to new heights.

Getting started.

Please do these things as a start:

1. **Join LinkedIn** (but don't just join!) Make it a goal to do searches to link with any and all relevant colleagues in your industry.
2. **Locate at least five relevant blogs** written by your clients, prospects, industry experts, or competitors. Bookmark and subscribe to their RSS feeds. Need an example? Try **www.annescarlett.com/feed**. Technorati is a reliable source for blog searches.
3. **Sign up for a free RSS reader** (I use Google reader). Set it up so that you are not just receiving blog subscriptions, but you are also receiving Google alerts on subjects of interest. Review these feeds daily, just like you would review the news. And when possible, switch over your newsletter subscriptions to RSS feeds to get you in the habit of using the tool.
4. **Set up a Twitter account** (but don't just set it up!) Use a tool like Tweetdeck to create at least eight relevant searches that you can watch and evaluate for a couple of weeks as a quiet listener. In addition to client and competitor names, make sure you also create hashtag searches (#construction, for example).
5. **Sign up** for AISC's new file sharing and social networking site*: **www.steeltools.org**.

Remember, the unknown is intimidating for all of us until we actually become familiar and versed. Whenever we learn anything new—whether it's structural engineering, a new language, or a new computer language—the foreign aspect is scary. Yet, think about how, as you slowly but surely become more versed, it suddenly starts to become recognizable, interesting, and dare I say…exciting?

Part Two of this article will address more tactical steps, resources and opportunities for you and your firm to get involved in social media. MSC

** AISC is launching a new file sharing and social networking site on SteelDay, September 18, at **www.steeltools.org**. The site will be open to all interested parties and will give individuals the ability to share files, contribute to web forums and discussions, and set up custom user profiles.*

Each month MSC's product section features items from all areas of the steel construction industry. In general, these products have been introduced within the past six months. If you're looking for a specific product, visit MSC's online product directory at **www.modernsteel.com/products**. You can browse by product category or search on any term to help find the products you need, fast.

Blazing Welding Trails

The Trailblazer 302 Air Pak from Miller Electric Mfg. Co. is the industry's first gasoline-engine-driven welder, generator, and air compressor that meets job site reliability standards. The unit is designed to provide construction, structural steel, and equipment repair professionals with a self-contained power source that welds at up to 350 amps, provides 13,000 watts of Accu-Rated generator power, and 26 CFM at 100% duty cycle. The rotary screw air compressor delivers 70 to 160 psi of air with no storage tank required. It runs most air impact wrenches at idle and provides 100% deliverable air, which allows contractors to work continuously without worrying about air pressure. It substantially improves air carbon arc cutting and gouging, and is capable of working with ¼-in. carbons (rated: 3⁄16-in.) for most applications. It also provides more than enough power and air pressure to run Miller's full line of portable Spectrum plasma cutters with a rated cut of 5⁄8-in. The unit's 30-hp gas engine weighs 771 lbs. and occupies up to 50% less truck space and up to 25% less axle weight compared to using a separate engine-driven air compressor. It also lowers fuel use and simplifies equipment management.

For more information visit www.millerwelds.com or call 800.426.4553.

Free from Falling

Kee Safety, Inc.'s WEIGHTANKA, part of its new line of Kee Anchor modular deadweight fall protection products, is a non-penetrating, portable, deadweight anchor device designed for use on roofs with up to a 5° pitch where the installation of passive or collective protection, such as guardrails, or permanent anchor devices is not viable because of restricted means of safe access. WEIGHTANKA uses a central pedestal (attachment point) to raise the height at which the arrest force is applied, thus reducing the distance the anchor device moves during a fall-arrest event. A basic system weighs 550 lb, with no single item weighing more than 55 lb, and provides fall protection for one or two workers that remain at least 20 in. away from the roof edge. It is designed for use with personal protection equipment such as harnesses. The system conforms to Class E EN 795, BS7883, and ISO 14567 standards and is the first Class "E" anchor device approved for use on all roof surfaces, including single-ply membrane, asphalt, concrete, stone chippings (brushed), and mineral felt. The metal components are galvanized to BS EN ISO 1461 for corrosion resistance and long life.

For more information visit www.keesafety.com or call 800.851.5181.

All products submitted are considered for publication, and we encourage submittals related to all segments of the steel industry: engineering, detailing, fabrication, and erection. Submit product information via e-mail to Tom Klemens (klemens@modernsteel.com). To be included in MSC's online products directory, contact Louis Gurthet (gurthet@modernsteel.com).

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Tracking and Managing

The Steel Tracking System (STS) can provide fabricators, galvanizers, and job sites with the feedback they need to control and manage their operations with a return on investment in less than a year's time, according to the maker, P2 Programs. The software provides accurate shipping and receiving data and saw-to-job-site erection tracking. Companies can now know where a piece mark is in the fabrication process, which employee is working on it, when it has shipped, and when it has been received at the job site—no more lost inventory, no more guessing where a job is at any given moment, and, best of all, minimal paperwork. In addition, the system interfaces with several third-party modules such as FabSuite, FabTrol, Romac, SDS/2 and Tekla.

For more information visit www.p2programs.com or call 512.858.2007.

Gouge Away

The Bug-O Systems AGS-3000 Arc Gouger metal removal system is designed to provide the highest possible level of control, uniformity, and productivity in automated gouging of steels and other materials with the air carbon-arc process. Groove depth is maintained within a tolerance of + 0.025 in. The system is ideally suited for metal fabrication, particularly in weld joint preparation, where it is used to prepare uniform "U" or "J" grooves, and can also been used for back-gouging of seams and for removing defective welds. The Bug-O Tractor provides precise and consistent travel in all positions by means of rack and pinion drive on rigid and flexible rails. A unique contact shoe assembly in the torch head accepts the entire range of gouging electrodes for 5⁄16 in. to ¾ in. via a simple adjustment.

For more information visit www.bugo.com or call 800.245.3186.

is for profit. Do you consistently pursue progressively higher/larger/longer and more complex projects?

6. Decline every request to "bid" your services. Sell only on the basis of value. Clients that choose their professional consultants based on price are almost always lousy clients. If they do not value your participation, they do not deserve your time and effort. I have not knowingly quoted a fee to anyone in a competitive environment in more than 15 years. Why bother? If you are selling your services based on price, somebody else will always be cheaper. Embracing that mindset takes some time, but without it you will never be satisfied with your compensation. Do you have the discipline to stop bidding?
7. Last, but not least, routinely "fire" your bad clients. This includes your clients that have unreasonable expectations, those that are litigious, and those that repeatedly find excuses to dodge your invoices for as long as possible. Other, higher quality clients will eventually replace any void that the bad clients leave behind. Life is too short to put up with bad business. Do you have the courage to upgrade your clientele?

Now think about these techniques. If you like everything about structural engineering except for the compensation, you will need to make some changes in order to build wealth. As Albert Einstein famously pointed out, doing the same thing over and over again and expecting a different result each time is futile (he actually wrote "insane"). Your career is what it is, based almost entirely on your performance and your decisions. Nobody else is to blame. If you do not want to make any changes, that is just fine, as long as you also accept your current reality. MSC

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Quality Systems Auditor Wanted

Contract Auditor wanted to audit Quality Management systems, to AISC steel fabrication and erection certification criteria for Quality Management Company. Applicant must be willing to travel. Typical workload is 10-14 audit days per month, not including travel time. Audits are mostly in North America (90%), but also throughout the world (Asia, South America, Europe, Middle East). Prefer applicant with background in steel construction (fabrication or erection) and Quality system auditing, ASQ/CWA/CWI certifications a plus. International travel experience and multi-lingual abilities preferred but not required. Auditors must be fiscally responsible.

**Please send cover letter and resume to:
Pat Thomashefsky, patt@qmconline.com. No phone calls please.**

Marketing Director – NSBA

Are you a strategic and innovative marketer looking for an exciting challenge? AISC is looking to hire an accomplished marketing professional to take charge of its bridge division: the National Steel Bridge Alliance (NSBA). NSBA is the technical and marketing arm of the steel bridge community and is dedicated to increasing the market share of steel bridges.

The successful candidate will work with an oversight committee to develop and implement a strategic plan, including success metrics, incorporating three key areas: marketing, technical activities, and governmental action.

A degree in marketing plus a minimum of 10 years of experience with engineering or construction companies is preferred. Excellent presentation and management skills are critical. This position is based in our Chicago office. The ability to travel is required.

We offer an excellent salary and benefits package and numerous professional development opportunities. If you are interested in applying for this position, please forward your resume and cover letter, including your desired salary requirements, to Cathy Becker at: HR@aisc.org

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Please e-mail Brian Quinn, P.E., and Lisa Willard, P.E. from SE Solutions (Brian.Quinn@FindYourEngineer.com; Lisa.Willard@FindYourEngineer.com) with why you would be interested in either one of these positions. All inquiries are kept confidential. For more information on **SE Solutions**, please visit **www.FindYourEngineer.com**.

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The Myth of Inadequate Structural Engineering Compensation

BY STAN R. CALDWELL, P.E., SECB

Seven tips for making the most of your chosen career.

LET ME START WITH AN admission. I make a very good living. I always have. It is probably more money than I need and more than I can reasonably spend, although my wife would certainly disagree. I am not unique. All of the licensed professional engineers that I associate with make more than $100K, and I know dozens of structural engineers around the country that make more than $200K. The idea that structural engineers are not well-compensated is simply a myth. Any structural engineer who puts his/her mind to it and focuses his/her efforts should be able to achieve annual compensation in the range of three times your age in thousands of dollars.

How about your compensation? Is it where you expected it to be? Is it where you want it to be? If not, go take a long look in the mirror. You are probably looking at the primary problem. The person you are looking at will need to make some changes. The changes might be uncomfortable, they might be difficult, and they might be unproductive. However, to quote an old saying, "nothing ventured, nothing gained." You will never achieve what you do not attempt. If you really want to build wealth as a structural engineer, here are a few techniques that have worked for others, in no particular order:

1. Force yourself to become a rainmaker. Like it or not, sales people are the folks that keep the world turning. Learn to network far beyond your engineering comfort zone. Nurture friendship and respect with the people that make engineering procurement decisions. You will find them at church, at your kid's soccer game, or at a charity event. They are far more receptive in those settings than during a cold call in their office. Once a friendship develops, you can eventually "talk shop." Then, be prepared to offer something beyond your structural engineering expertise. Perhaps you know others who could help them put a project together. Perhaps you have dreamed up an original idea for a new project. All of this is unnatural behavior for most design engineers. Are you willing to humble yourself and earnestly seek out new projects before others become aware of them?
2. Force yourself to take calculated business risks. The old saying remains valid, "risk and rewards go hand in hand." Have you ever considered being a part of a design-build team? I never liked design-build work very much and hoped that it would be a temporary phenomenon, but it is here to stay. My firm recently won its first big design-build award. Our part of the job is worth several million dollars, so my views are now changing. However, this was not our first or second design-build pursuit. Don't be discouraged by failure, as it is an unavoidable stepping stone toward success. Are you willing to increase your risk tolerance and try new things?
3. Develop expertise in something that matters (not, for example, the optimal size of a fillet weld). Begin practicing a specialty that will distinguish you from the crowd. Niche markets will be a growth area in the future. You do not need to have a Ph.D. to become recognized as an expert, but once you are an expert you can name your price. In order to succeed, be sure to specialize in something that you really enjoy doing. Have you found a rewarding structural engineering specialty?
4. Stop working for architects! No one has ever built any real wealth doing that. Instead, swim upstream and work directly for the owner whenever possible. On many types of structures, no architect is required. Those projects are preferred. On building projects, strive to serve as the prime professional and have the architect work as your subcontractor. This is entirely legal, it is immensely satisfying, and it probably is what God intended. Are you ready to be the prime?
5. Aim high and aim long. Big fees generally result from large, complex projects. If you mostly design single family residences or strip retail centers, you should not expect big fees. However, much of what a structural engineer spends his/her time on is relatively fixed for every project and is more-or-less unrelated to size or complexity. Thus, the bigger the job is, the greater the opportunity

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Stan R. Caldwell, P.E., SECB, is vice president and manager of the structures group of Halff Associates, Inc., Richardson, Texas, and an AISC Professional Member.

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