Proposed ASHRAE Standard Delves into Structural Issues

The structural steel industry has a long track record of success in sustainable development, consistently leading the way in implementing energy, carbon, and resource utilization improvements for the past 25 years. Today, however, the structural steel industry is faced with a significant challenge, one that originates not from a lack of accomplishment with respect to sustainability, but rather from being too successful in this area.

AISC has significant concerns with some provisions in the recently published second draft of the proposed ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 189.1, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings*. AISC's concerns with this proposed standard are that:

1. It is outside the scope and expertise for which ASHRAE is ANSI-accredited.
2. It will result in adverse environmental impacts.
3. It includes provisions that are unfair to steel, and inappropriately preferential to the interests of the concrete industry.
4. It adversely restricts the freedom of design professionals in their selection of structural framing materials.

The proposed ASHRAE standard being developed jointly with the U.S. Green Building Council and the Illuminating Engineering Society of North America is intended to provide minimum requirements for high-performance green buildings.

While addressing HVAC and lighting issues, the standard also establishes prescriptive requirements for construction materials, an area that AISC believes to be outside the scope and expertise of ASHRAE, USGBC, and IESNA. In addition, the committee responsible for the proposed 189.1 standard was not constituted in a balanced manner under appropriate ANSI consensus protocol. AISC also believes that the committee lacks expertise in the area of construction materials, particularly as they relate to structural framing systems.

This apparent lack of balance and expertise has resulted in provisions that appear to be significantly slanted toward the interests of the cement/concrete industry under the guise of encouraging less sustainable industries to become more sustainable.

For example, today a typical structural steel frame provides an 11% credit towards the overall recycled content of a building. A concrete frame may provide one to two percent. At the same time, the reinforcing steel in the concrete structure will provide an additional 5% credit. The proposed standard will limit the contribution for any material at 5%. The result: structural steel gets capped at 5%, while concrete still gets its full credit AND the 5% credit for reinforcing steel.

Similarly, the definition of recycled content is that portion of a material by mass that originates in either pre- or post-consumer waste streams. But the ASHRAE committee has decided to allow the calculation of the recycled content of concrete to violate that definition. Instead of reflecting the actual recycled content of the concrete, ASHRAE 189.1 allows the recycled content of the cementitious portion of the concrete to be used as the recycled content of the entire concrete mix.

For example, at present, substituting 25% fly ash for Portland cement in concrete with no other recycled content, results in an actual recycled content of 3%. Under ASHRAE 189.1 the cement and concrete industries are allowed to claim a 25% recycled content.

The committee's justification is that they wish to encourage the use of fly ash in concrete. In reality, they are discouraging the use of recycled aggregates, removing over 50% of the mass of a concrete building from green considerations and providing the cement/concrete industry with an unfair advantage in the marketplace.

It is not the role of a standard to provide incentives and to favor particular products. The selection of structural framing materials should be based on the merits of the materials as judged against a consistent metric.

The inclusion of this standard in building codes is being encouraged by ASHRAE as an appendix at the national level available for local adoption. Including these provisions in a local building code will significantly limit the opportunity of design professionals to select construction materials for high-performance green buildings that properly balance economic, environmental, and design issues.

The structural steel industry believes strongly in the need for high-performance green buildings. AISC also believes that standards for the selection and optimization of structural framing materials should be developed in a balanced, consensus-based ANSI process that engages design professionals, industry associations, and interested parties with the required level of expertise to develop a fair and environmentally sound standard. AISC would welcome the participation of the concrete, cement, masonry, wood, precast, light-gauge steel, per-engineered building, and any other affected industries in that process.

AISC's objection to 189.1 is not a rejection of sustainable construction practices or the need for green buildings. Much to the contrary, AISC's commitment is to continue to be the leader in sustainable construction materials and to actively pursue additional sustainable practices within our industry.

When the domestic structural steel industry experienced a rebirth 25 years ago, purposeful decisions were made to create a sustainable industry. A central decision was the transition from basic oxygen furnaces (using iron ore and coke) to electric arc furnaces (using scrap as the primary raw material and electricity and natural gas as energy sources).

The gains from this transition have positively impacted sustainable construction:

- ✓ Wide-flange structural steel products average in excess of 90% recycled content.
- ✓ A 96% recycling/reuse rate for structural steel members removed from existing structures.
- ✓ An increase in mill productivity by a factor of 20 moving from 10 to 12 man-hours per ton to 0.6 man-hours per ton.
- ✓ A reduction in energy consumption per ton of product by 30%.
- ✓ A reduction in carbon emissions by 47% since 1990; by comparison, the Kyoto protocol would have mandated a 5.2% reduction by 2012.
- ✓ A recycling rate for automobiles now exceeding 100%, emptying out salvage yards.
- ✓ The elimination of all production water discharges and the minimization of water utilization.
- ✓ An increase in the strength of structural steel by 38% over the past 10 years, reducing the quantity of structural steel required in a typical building.

For more information, contact Scott Melnick, AISC's vice president of communications, at melnick@aisc.org. MSC

Keeping Up with the AISC Spec

BY MATTHEW FADDEN AND JILL RAJEK

Important changes to the AISC specification can be easy to lose track of, and often the challenge is to understand when the changes were made. *Design Guide 15: AISC Rehabilitation and Retrofit Guide* (DG 15), Appendix A1 provides a comprehensive source of historical information that references changes made to the specification.

Currently, DG 15, Appendix A1 provides a list of changes to the specification through the 1999 *LRFD Specification for Structural Steel Buildings*. An update to this list, including the changes from the 1999 LRFD specification to the 2005 specification, is now available at **www.aisc.org/crossref99**. An overview of some of the more prominent revisions is outlined below.

The 2005 specification contains numerous unifying changes, which can be seen in Chapter A, General Provisions. While this list of updates only pertains to the LRFD portion of the specification, the most noticeable change is the combination of the ASD and LRFD provisions. Additionally, the scope of the specification has been expanded to include "other structures", which are defined as "those structures designed, fabricated, and erected in a manner similar to buildings, with building-like vertical and lateral load-resisting elements." Less noticeable but equally useful to the 2005 specification is the inclusion of the specifications for single angles and HSS sections. Incorporating these specifications has mitigated the need for other provisions.

Revisions to Chapter C, Stability Analysis and Design, reveal major organizational and substantive changes; most notable is the requirement to address second-order effects in the analysis and design. A new procedure, the Direct Analysis Method, which is described in Appendix 7, will satisfy the requirements of Chapter C. Additionally, stability based on plastic design must follow Appendix 1, which also includes other provisions for inelastic analysis and design.

Chapter F, Design of Members for Flexure, has also been renamed and reorganized. The chapter is now divided into sections based on member type and the axis of bending. Table User Note F1.1, Selection Table for the Application of Chapter F Sections provides a summary of the chapter by illustrating each cross-section addressed and stating the applicable limit states for that member.

The updates to Chapter I, Design of Composite Members, reflect research results and allow the use of higher strength materials, as well as provide better consistency with ACI 318-05, *Building Code Requirements for Structural Concrete*. Shear stud strength is now dependent on the location of the stud in the flute of the metal deck, the number of studs welded within one flute, and the orientation of the metal deck with respect to the beam. Composite column design is based on new interaction formulas that better reflect behavior and strength.

Some changes have been made to Chapter J, Design of Connections, and one of the most notable organizational revisions is the inclusion of the effects of concentrated forces previously appearing in Chapter K of the 1999 LRFD specification. The 1999 LRFD specification combined concentrated forces, fatigue, and ponding into one chapter. The 2005 specification separates these sections where Design for Ponding is located in Appendix 2 and Design for Fatigue is located in Appendix 3.

The all-new Appendix 4, Structural Design for Fire Conditions, provides much-needed criteria for the design and evaluation of structural components for fire conditions. This appendix discusses the effects of elevated temperature on materials and accounts for these changes in the design.

A review of the complete list of changes will help engineers using LRFD to become more acquainted with the 2005 specification. To get up to speed with all the changes to the specification, be sure to visit **www.aisc.org/crossref99**. MSC

Matthew Fadden is an engineering graduate student at the University of Michigan in Ann Arbor. Jill Rajek is a recent engineering graduate of the University of Wisconsin–Platteville and plans to attend graduate school in the fall. Both were summer interns at AISC in 2007.

letters

Continuing Education

I found Steve Kurtz's article "Learning by Doing" (April, p. 66) extremely interesting. We train the structural Ironworkers of New York in a 24,000-sq.-ft training school that houses nine classrooms and a 12,000-sq.-ft, 50-ft-high indoor work area. The work area includes a five-ton overhead crane, a structural steel frame, 12 burning stations for oxy-acetylene, and 33 welding booths for a variety of welding procedures (stick, automatic, pipe, and stainless).

We would be more than happy to have engineering students visit our school at any time to further showcase the complexities of structural steel erection that our students learn during their three years of training. I can be reached at director@nycironworkers.org.

Bryan Brady II, Director of Training
Ironworkers Locals 40 & 361, New York

Do they Really?

I found Anne Scarlett's article "Engineers Can—and do—Communicate Well" (April, p. 51) quite interesting, but I do not fully agree with her reasoning and her conclusion.

During their university training, engineering students write many term papers and other reports for their professors, who are senior specialist in the subject. When these students enter the industry, they continue to communicate with the assumption that the readers or listeners are also experts in their field. They fail to recognize that engineers have to communicate with other people such as workers, money managers, governmental officials, and the general public, and not only with specialists in their field. It is just as important to recognize to whom one communicates as what is communicated.

To be successful communicators, engineers must evaluate their target audience and tailor their presentations to the specific target audience.

Harry W. Ebert, P.E.
Madison, N.J.

Anne Scarlett responds:
Excellent points! It was definitely an oversight on my part to not include that factor in the article (by all means, when I'm coaching folks, we do an audience analysis first and foremost). Mainly, I wanted to be clear that engineers self-proclaiming that they are rotten communicators (and/or engineers who are just tossed aside with preconceived notions that they are ineffective at communicating) are both displaying cop-out attitudes. Rather, they can (and do) have the skill sets in them. But they need to work at it, and they need to have much confidence. (Confidence is half the battle; knowing your audience and your main message is the other half, yes?)

news & events

ENGINEERING JOURNAL

Call for EJ Papers

AISC is always looking for *Engineering Journal* articles on interesting topics pertinent to steel design, research, steel fabrication methods, or new products of significance to the uses of steel in construction. We are especially seeking technical articles with practical applications in the steel industry.

If you have a new idea or an improvement on an old idea, please submit a paper to AISC for publication in the *Engineering Journal*. All published papers are eligible for the Best EJ Paper of the Year award. The winning author of this annual award is selected by our readership and receives a free trip to the North American Steel Construction Conference as well as acknowledgment at the conference.

Please send your paper in duplicate to:

Engineering Journal
Editor, Cynthia Duncan
AISC
1 E. Wacker Dr., Suite 700
Chicago, Illinois 60601
duncan@aisc.org

Detailed information on our review process and requirements for submittals can be found on the inside back cover of each *Engineering Journal* issue.

ONLINE RESOURCES

Why Steel?

In a continuing effort to answer this seemingly simple question, AISC has recently launched a specialized web site as part of its industry mobilization program. Created exclusively for the structural steel industry, **www.WhySteel.org** is a controlled-access web site; visitors must join the site to access its content.

Users of the new site are not necessarily members of AISC; they just have to be part of the structural steel industry. The site provides access to educational articles, newsletters, discussion forums, and tools that the industry can use to learn about and promote structural steel.

Perhaps most importantly, it provides the steel industry with reasons why any project should be built with steel and includes hints, tips, and ideas for convincing those in the design and development community that "There's always a solution in steel."

Some of the sections of **www.WhySteel.org** include:

- ✓ **Industry Mobilization.** Find out how you can help your industry—and why you should. You'll also find hints and tips to get started and answers to frequently asked questions. Get started in helping your industry be even stronger than it is today.

- ✓ **Structural Steel Benefits.** Learn about the advantages and benefits of building with steel. One area of this section is devoted to understanding the benefits of steel as it relates to different types of projects, enabling you to talk sensibly to the local design community about steel and provide them with handouts and case studies of specific project types.
- ✓ **Education/Learning.** Access talking points about the industry and learn about the other players in the steel supply chain. Gain an understanding of terms and terminology, and increase your knowledge of steel's competition.

Guitars and Girders

BY GEOFF WEISENBERGER

The information-packed 2008 Steel Conference in Nashville breaks NASCC attendance records.

FOR A LONG TIME NOW, NASHVILLE HAS BEEN KNOWN AS THE PLACE WHERE COUNTRY MUSICIANS GO TO MAKE IT BIG. This year, the same can be said of the North American Steel Construction Conference. The show brought nearly 3,800 people to the Music City, making it the best-attended Steel Conference ever.

While Nashville received a substantial amount of rain during the show (April showers…), it certainly didn't dampen the spirits of those in attendance. This year's Steel Conference took place at the Nashville Convention Center in the heart of downtown. The compact, more vertical layout of the show created a hive of activity, as attendees seamlessly moved between the sessions and the exhibit floor, greeting fellow colleagues and old acquaintances along the way.

In addition, many of the show's 90+ sessions and short courses were very well-attended, some of them even reaching standing-room-only status—as was the case with the Erector track session "Sporting Opportunities: Design, Fabrication, and Erection Issues on the New Dallas Cowboys Stadium." Perhaps it was because of the two world-record longest single-span trusses (1,225 ft each) that the will support the stadium's new roof, or maybe there are just a lot of Cowboys fans out there, but the session was packed to the gills, with several attendees standing in the back or near the front.

The exhibit hall was equally busy, hosting more than 220 exhibitors. In a setup that was part Cracker Barrel and part Old West, AISC's booth welcomed visitors with candy sticks, rocking chairs, and iced tea (and yes, it was sweet tea).

Away from the booth, AISC made a couple of major announcements. One focused on the findings of a full-scale blast test of a steel wide-flange column that was conducted for and funded by AISC. The test investigated the behavior of a W14×233 column of ASTM A992, Gr. 50 structural steel subjected to an explosive charge similar to that experienced during the terrorist attack on the Alfred P. Murrah Federal Building in Oklahoma City in 1995. The result showed that while the column suffered plastic deformation, the use of a steel column—as opposed to the concrete column that was destroyed in the Murrah Building attack—would have resulted in much less structural damage to the building. (Go to **www.aisc.org/blast** for the full report.)

AISC also announced its response to the recently published second draft of the proposed ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 189.1, *Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings* (see page 18 for more information).

The exhibit hall at the Nashville Convention Center boasted more than 220 exhibitors, showcasing everything from software to services to fabrication machinery.

Pushing Green

The idea of sustainability echoed throughout the conference and also served as one of AISC's top priorities for the show. Conference bags were made from 51% post-consumer recycled content, the final program was printed on recycled paper with soy-based inks, and attendees were presented with reusable water bottles, which they were able to fill at one of the many water coolers throughout the center. A number of sessions, including "Greening the Shop: Strategies for Managing Your Environmental Footprint" and "Green Design: Beyond Material Issues", also focused on sustainable building practices and material recycling.

While not focusing directly on environmental friendliness, many other sessions did put an emphasis on efficiency. "Designing Low-Cost Steel Structures" provided dozens of tips on efficient steel design. One of the speakers, John Rolfes, P.E., S.E., of Computerized Structural Design, pointed out that while not all of the tips were new, it's important to push the old ones until people really start following them. Suggestions ranged from using joist girders only where appropriate to considering cantilevered columns for the top story of a multi-story frame to practicing timely service. "Don't let shop drawings sit in your office for three weeks," he stressed. Co-speaker Jay Ruby, P.E., of Ruby and Associates, compared construction documents to confusing assembly instructions for items such as bicycles and grills, saying, "As designers, we need to make it easier for the builders."

Wednesday's keynote speaker, Stephen Kieran, AIA, a partner at KieranTimberlake Associates LLP, also touched upon sustainability in his address, noting that the concept is becoming more desired in the construction industry. "Our clients are starting to demand the same performance from us as is taking place everywhere else," he said.

At the center of his address was a call for innovation, and he noted the building industry's tendency to shun liability—and risk. "We have been marginalized because we haven't assumed risk," he said, stressing that playing it too safe squelches innovation and doesn't allow the industry to reap its benefits.

He also suggested a more proactive, long-term approach to buildings. Instead of planning, designing, and building a structure, then walking away from it, architects and engineers should monitor a building to learn how to make the next project better.

Bringing the discussion back to sustainability, Kieran predicted that within 10 years, we will no longer be able to construct "throwaway" buildings. They will be built with full life cycle in mind, and when they reach the end of their useful lives, they will have to be disassembled and "taken back"—

More than 1,400 attendees enjoyed networking at the conference dinner, held on Nashville's Honky Tonk Highway.

Both the exhibit hall and technical sessions were packed throughout the conference. More than 90 technical sessions provided ample opportunities for attendees to earn continuing education credits.

much like BMW does with its "retired" automobiles.

Recognizing Excellence

Also at the Wednesday keynote session, Joseph Burns, P.E., S.E., FAIA, LEED AP, managing principal in the Chicago office of Thornton Tomasetti, Inc., was presented with the Special Achievement Award for notable accomplishments in structural steel design, research and education. Specifically, he was honored for his significant efforts in promoting and advancing the use of building information modeling (BIM) and interoperability in the design and construction of major steel structures.

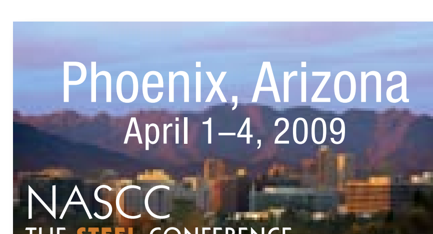
At the Friday keynote address, Walterio Lopez, S.E., a senior associate with Rutherford & Chekene in San Francisco, and Rafael Sabelli, a senior project manager with Walter P Moore in Los Angeles, were honored with the T.R. Higgins Lectureship Award for their paper "Seismic Design of Buckling-Restrained Braced Frames." Their work on BFRBs—an increasingly popular new steel seismic load resisting system—has already been published by the Structural Steel Education Council and has helped BRBFs be accepted in ANSI/AISC 341-05 Seismic Provisions for Structural Steel Buildings and in the International Building Code.

Nashville at Night

A hard day's work at the Steel Conference warranted a relaxing night on the town. This year's conference dinner gave attendees a taste of two things that Nashville does best: barbeque and country music. Guests were given exclusive use of six adjacent country music bars that comprise the well-known Honky Tonk Highway, just steps away from the convention center. Guests could amble from one music venue to the next with relative ease, networking in the laid-back, fun, and friendly atmosphere.

Of course, plenty of barbeque, from local favorite Jack's, was on hand too, and everyone was able to dig into their hickory-smoked meat of choice, topping it off with one of several BBQ sauce options and complementing it with delicious and BBQ-appropriate, if not exactly healthy, sides. (This editor opted for brisket, the hottest sauce available, homemade macaroni and cheese, iced tea, and Shiner Bock; I call it the "Honky Tonk Diet".)

Next year, NASSC leaves the country behind but keeps the western, as the 2009 show will take place April 1-4 in Phoenix. Information for the 2009 Steel Conference will be posted soon at **www.aisg.org/nascc**. MSC



ENGINEERING JOURNAL

Second Quarter 2008 Article Abstracts

The following papers appear in the first quarter 2008 issue of AISC's *Engineering Journal*. EJ is available online to AISC members and ePubs subscribers at www.aisc.org/epubs.

Reduced Beam Section Spring Constants

BART MORTENSEN, JANICE J. CHAMBERS, AND TONY C. BARTLEY

A moment connection that includes a wide-flange beam with trimmed flanges is commonly known as a reduced beam section (RBS) connection. Accurate analysis of frames incorporating RBS beams requires knowledge of the elastic stiffness matrix of RBS beams. In lieu of using this stiffness matrix, an RBS beam can be modeled as an Euler-Bernoulli frame element with rotational springs at each end, which can be easily implemented in structural analysis software. This paper presents the derivation of the formula for the spring constants of an RBS beam, and validates it. From a study of the spring constants for a plethora of RBS beams, it was found that a strong linear relationship exists between the minimum plastic section modulus of RBS beams and their spring constants. This paper has direct applicability to the practical and accurate determination of the elastic drift of a moment frame with RBS connections.

Topics: Analysis, Connections-Moment, Lateral Systems, Seismic Design

Bending Strength of Steel Bracket and Splice Plates

BENJAMIN A. MOHR AND THOMAS M. MURRAY

The primary purpose of this study was to determine the ultimate behavior of bracket and splice plates. The study consisted of experimental testing and comparison of test results with various design methods. The experimental testing consisted of connecting two beams together with web splice plates to form a simple span, then loading the span symmetrically to induce pure moment at the location of the splice, with the goal of achieving plate flexural rupture. This study indicates that design models used prior to the publication of the 13th Edition AISC *Steel Construction Manual* for determining bracket plate and web splice nominal moment strength are overly conservative.

Topics: Connections-Simple Shear, Research, Splices

A Modified Equation for Expected Maximum Shear Strength of the Special Segment for Design of Special Truss Moment Frames

SHIH-HO CHAO AND SUBHASH C. GOEL

Special truss moment frame (STMF) is a relatively new type of steel structural system that was developed for resisting forces and deformations induced by severe earthquake ground motions. The system dissipates earthquake energy through ductile special segments located near the mid-span of the truss girders. The other elements outside the special segments, such as truss members, girder-to-column connections, and columns, are designed based on the expected vertical shear strength (V_{ne}) of the special segment and are expected to remain elastic during a major earthquake. As a consequence, overestimation of V_{ne} in the special segment can result in significant over-design of the elements outside the special segment. This study shows that the equation for expected shear strength in the current AISC seismic provisions can be quite conservative, thereby leading to considerable over-design of members outside the special segment. Based on more realistic assumptions, a modified expression for V_{ne} is proposed in this paper, which results in a better estimation of the expected shear strength while maintaining an adequate safety margin. The proposed expression was validated by using previous experimental results as well as nonlinear static and dynamic analyses (to determine the seismic demand in the special segment). A design equation of V_{ne} for STMF using multiple Vierendeel panels in the special segment is also proposed.

Topics: Seismic Design, Structural and Building Systems

Performance-Based Plastic Design of Special Truss Moment Frames

SHIH-HO CHAO AND SUBHASH C. GOEL

This paper presents the results of a study in which a recently developed performance-based plastic design (PBPD) methodology was used to design the special truss moment frame (STMF) system rather than conventional elastic method. This newly developed performance-based method has been successfully applied to moment frames and also extended to eccentrically braced frames, buckling-restrained braced frames, and concentrically braced frames. The procedure begins by selecting a desired yield mechanism for the frame. Design base shear and lateral forces are determined from input spectral energy for a given hazard level needed to monotonically push the structure in the yielded state up to a pre-selected target drift. The frame members are then designed by following the plastic design method in order to develop the needed strength and the intended yield mechanism. A new seismic design lateral force distribution based on nonlinear dynamic behavior is also presented. The proposed design procedure was validated by extensive nonlinear dynamic analyses for a number of ground motion records. The results confirm the validity of the proposed method for the study STMFs in terms of meeting all the performance design objectives, such as target drifts and intended yield mechanism. An important advantage of the PBPD method is that, generally, no nonlinear analysis is needed to check the structural performance after the initial design.

Topics: Seismic Design, Structural and Building Systems, Plastic Design

Current Steel Structures Research

REIDAR BJORHOVDE

This regular feature of the *Engineering Journal* provides information on new and ongoing research around the world. In the 14th installment, research projects are summarized on the following topics: three-dimensional behavior of semi-rigid connections, behavior of longitudinal double plates-to-rectangular hollow section connections, welded steel beam design using particle swarm analysis, modeling of micro- and macro-structural size effects for fatigue of welded tubular structures, advanced engineering for orthotropic bridge decks and surfacing solutions, and ponding of roof structures.

Topics: Research