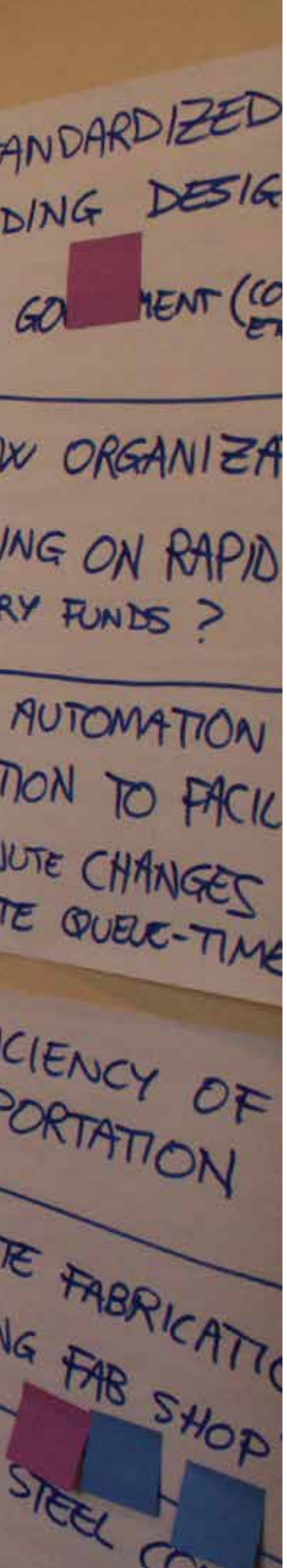
Looking Toward the Future

BY ANDREA SUROVEK, P.E., PH.D, AND JUDY LIU, PH.D.

Workshops explore potential areas for innovation in steel design and construction.



IMAGINE THIS CONSTRUCTION SITE: A robotic arm places steel box columns onto a catapult to be launched into place and bolted by workers with jetpacks. Large robotic hands shuffle panels of cladding like a deck of cards and toss them onto the steel frame.

From the top of the structure, four columns telescope toward the sky, while floor and wall panels unfold themselves to complete a section of the tower. With the help of a couple of biwing propeller planes, additional wall panels are unfurled. These panels grow their own extensions that "walk" up the building, like Slinkies defying gravity, creating duplicate wall panels as they go. A kinetic sculpture pops up with a globe that opens to reveal a crane; another globe houses the operator, who positions a purple box containing a purple, unfolding building envelope.

The building is topped out in 1 minute, 25 seconds. There are also elephants and a golden, mechanical gorilla involved in the construction. However, more significant is that this fantastical vision, created by artists and writers of dubious steel construction background, manages to embody many of the key words floated at the steel innovations workshop held earlier this year: Telescoping structures. Robotics. Self-assembling structures. Kinetic structures. Rapid construction.

The clip described, taken from the Disney Channel's Phineas and Ferb cartoon, was screened at a NASCC: The Steel Conference session summarizing some of the key outcomes from a pair of workshops on research needs in steel design and construction. In December 2010, AISC hosted practitioners, academics, fabricators, software developers and equipment providers at its "Innovations in Structural Steel" workshop. Building on ideas generated at that event, the authors, along with members of the Technical Administrative Committee on Metals of ASCE, organized the AISC- and NSF-supported workshop "Innovations in Steel Design: Research Needs for Global Competitiveness," held this past March in conjunction with the ASCE/SEI Structures Congress. The former workshop produced, among other things, a SWOT (strengths, weaknesses, opportunities and threats) analysis of steel design, fabrication and erection. The latter brought together academics, practitioners and graduate students in a brainstorming environment geared toward developing potentially transformative ideas that could move steel design and construction in new directions.

Pros and Cons

One of the stated goals of the 2010 workshop was to help AISC, and workshop participants, to form the forward-thinking vision that would enable development and change in structural steel design and construction. This fit with AISC's mission to "support and improve the ability of the structural steel industry to be both innovative and competitive in a worldwide construction market."

Identified threats to U.S. competitiveness included market issues as well as concerns related to education and training. Price instability, steel availability and foreign competition, particularly in regions with cheap labor, topped the list of threats. These factors also seem to fuel the competition with concrete, which is easier to obtain in developing countries, and may be perceived as having more innovative gains in research. Meanwhile, difficulties obtaining funding for steel research and reductions in university course requirements threaten the talent pool. In addition to presenting obstacles to innovative research, these factors could lead to less capable engineers, as well as fewer engineers knowledgeable in structural steel.

Not surprisingly, some of the same factors found their way onto the "weaknesses" list in the SWOT analysis. Price and availability of steel could present difficulties with bidding a project too far in advance; an engineer might be constrained by limited rolling sizes. Weaknesses in education and training may be responsible for communication and collaboration issues

◄ Idea generation from brainstorming at the 2012 Research Needs workshop.

Judy Liu (**jliu@purdue.edu**) is an associate professor of civil engineering at Purdue University, West Lafayette, Ind. **Andrea E. Surovek** (**surovek@sdsmt.edu**) is an associate professor of civil and environmental engineering at the South Dakota School of Mines and Technology in Rapid City, S.D. She currently chairs the ASCE/SEI Technical Administrative Committee on Metals.

Moderator Jerry Hajjar (Northeastern University) and scribe Caroline Bennett (University of Kansas) lead the brainstorming on sustainability.

between fabricators and engineers, who often do not understand each other's work. Reliability and durability issues with corrosion and fire protection were also identified as potential weaknesses.

On the flip side, the SWOT analysis found strengths in steel's material properties, inherent adaptability and quick construction. The ductility and high strength-to-weight ratio of structural steel make it highly suitable for seismic applications. Steel framing is adaptable to unique and restrictive conditions and forms. Steel components and shapes may be mass produced or custom fabricated to satisfy particular project needs. Structural steel also has inherent benefits in terms of sustainability; not only is the steel itself recyclable, but steel framing has the capability to be deconstructed and reused.

Workshop participants discussed various opportunities for capitalizing upon the strengths of structural steel while addressing the weaknesses and threats. Robotics could be used to further improve and automate fabrication and erection processes. Innovative design methods or new materials could eliminate the need for fire proofing altogether. Building information modeling (BIM) was seen as an opportunity for integrating disciplines and expediting design and construction. A complete building model with consideration for non-structural components and multi-hazards may improve efficiency in both design and construction. Improvements in and the use of BIM could help to resolve fragmentation in project delivery; there was also discussion of possible integration of the mill, fabricator, designer and contracting companies.

Discussion on strengths and opportunities expanded to brainstorming on potential areas for innovation. Innovations in the material to improve fire resistance would reap benefits for steel construction; collaboration with other disciplines, such as bio- or nano-technology, may be needed. With strengths in steel for sustainability and fast construction in mind, innovations in connections and modular construction were suggested. Education and training again received attention as an area for innovation, especially as related to improvements in integration, communication and team relations.

Brainstorming

Building on this discussion, more than 50 academics, graduate students and industry practitioners joined together at the Structures Congress workshop in March to answer the question: "What innovations will help move U.S. steel design forward in the coming decade?" The intent of the workshop was to bring together both leaders and emerging talent in the academic and design communities to specifically address the following:

- What are the most promising areas of steel design innovation to increase U.S. global competitiveness?
- What fundamental questions about structural steel behavior, including response to extreme loads and resiliency, need answers?

The workshop used a brainstorming approach to develop a list of potential innovations, followed by a focused discussion to identify the overarching themes from the brainstorming. Roberto Leon, past president of ASCE/SEI, and Tom Schlafly, AISC director of research, presented their ideas to help generate discussion. Breakout sessions then allowed for brainstorming on four areas that had been identified partly based on their potential for innovation, and outcomes from the initial AISC Innovations meeting.

Four breakout areas:

- Sustainability, lead by speaker Greg Briggs of Magnusson Klemencic Associates and moderator Jerry Hajjar of Northeastern University
- Rapid Constructability, lead by speaker/moderator Ron Johnson of Skidmore Owings and Merrill
- Extreme Loads, lead by speaker Mike Engelhardt of the University of Texas and moderator Bruce Ellingwood of Georgia Tech
- Wildcard session, lead by speaker/moderator David Campbell of Geiger Engineers

As Nobel Prize winner Linus Pauling once said, "The best way to have a good idea is to have lots of ideas." The brainstorming approach allowed the participants to consider both short-term ideas as well as more far-reaching, "pie-in-the-sky" concepts.

Based on results from the four breakout sessions, five themes emerged across all areas of discussion and in all breakout sessions:

- Integration
- Modular design and construction
- Novel joining methods and connection design
- Material improvements
- Educational opportunities

The single most important and overarching theme was that of integration: of systems, of disciplines, of design and construction, of education and industry and of materials properties and function. It became evident that true integration will not be achieved through individual effort, but rather will require collaborative and diverse thinking across disciplines as well as boundaries of structural design and construction. For many steel professionals, this will necessitate a paradigm shift in how we see our professional roles, how we develop research partnerships and how we go about the day-to-day business of designing structures.

NASCC Session

In April, the outcomes of the AISC Innovations meeting and the Research Needs Workshop were presented at the Steel Conference to an audience of more than 80 attendees at the session "Steel Design and Construction Innovations." A survey was distributed to establish which of the ideas from the workshops were anticipated to have the most impact on the steel industry. More than 60 session attendees completed the survey. Of those that responded, 61% identified themselves as designers, 13% as detailers/fabricators/erectors and 6% as educators. Suppliers, contractors, architects, and personnel involved in sales and marketing rounded out the list.

Two-thirds of respondents agreed that designing for rapid constructability should be given high priority. A strong majority (70%) felt that integration should be given high priority. Modular design and construction was also high on the list of high priorities (59%).

When it came to the "Wildcard" topic with the most potential, 66% chose mechanical and structural integration. One respondent wrote that "mechanical and structural integration has opportunities both to simplify and shorten design time, but also to speed building construction." Nearly half voted for adaptable and plug-and-play connections as the Wildcard topic with the most potential.

Overall, the Steel Conference audience clearly favored ideas that would speed up construction. The survey responses also echoed the overarching theme from the workshops: the need for more integration. (You can view the PowerPoint presentation, along with audio, from this session at **www.aisc.org/nascc**.)

Moving Forward

To quote a non-engineer, chess grandmaster Garry Kasparov, "Where does our success come from? The answer is synthesis, the ability to combine creativity and calculation, art and science, into a whole that is much greater than the sum of its parts."

What has become obvious from the workshops is that innovation in steel construction, a complex arena with multiple components and constituencies, cannot happen in a vacuum. Collaboration is necessary to achieve true innovation, whether it is integration of mechanical and structural systems, of materials and structures or of engineering design, fabrication and erection. And while it is unlikely that the near-term future of structural steel design and construction will include either builders with jetpacks or mechanical gorillas, the continuing exercise of looking forward and envisioning the impossible, the improbable and the potential is useful in propelling steel design and construction into new, potentially rewarding directions. MSC

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