PROJECTS

From the Shipyard to the Backyard

BY JAMES FALLS

Steel containers have been a mainstay in the world's shipping industry ever since 1956, when U.S. trucking entrepreneur Malcolm McLean loaded 58 steel containers aboard the tanker Ideal-X and transported them from Newark, N.J. to Houston.

But what happens to these containers when they are "retired?" At the end of its lifespan (typically eight to 12 years), a container is traditionally sold for scrap or, when it's cost-effective, shipped back to its country of origin. But today many retired containers are finding new life as garages or spare bedrooms. Known as intermodal steel building units (ISBU), these repurposed containers are being used to build strong, sustainable, and durable structures.

Some major shipping companies are selling their used containers for approximately $1,200 each, and many containers are being sold over the Internet. A search for "shipping container" returned more than 100 advertisements for shipping containers in the U.S.; most of these are selling for around $4,000 each.

The standard dimensions of a container are 8 ft in width, 8 ft-6 in. or 9 ft-6 in. in height, and lengths of 20 ft, 40 ft, 45 ft, 48 ft, and 53 ft (for a point of reference, a 40-ft container weighs approximately 10,580 lb and can hold approximately 65,000 lb). The containers are made from high-strength weathering steel, water-resistant, and designed to resist harsh oceanic environments, making them more than acceptable for use in building construction.

Dropping Anchor

Transforming an ISBU into a useable structure is fairly straightforward. Since they are originally designed for efficient transportation, they can easily be relocated to a construction site. After delivery, holes for doors, windows, and other desired openings are cut in the sides. The ISBU is then lifted by crane onto the building foundation and securely welded to the foundation; when properly anchored, it can resist winds of up to 175 miles per hour. Commonly, several ISBUs are stacked on top of each other or placed side-by-side to form a large home or office building. The steel is insulated with a ceramic powder, making it rust-resistant and preventing mildew build-up. Exterior and interior finishes such as drywall, stucco, and wood are then attached to the steel frame as desired. At this point, the transformation from a sea-faring shipping container to a static structure is complete.

Mixed Use

ISBUs can be used to build a multitude of different structures. Architects use them to build custom homes and trendy bungalows of all sizes and shapes. The U.S. military uses them to set up temporary command centers and training facilities. ISBUs are also very useful as emergency shelters and temporary housing, as they can be delivered quickly and set up with little effort. Press boxes, concession stands, storage facilities, radar stations, and apartment buildings have also employed ISBUs.

In addition, several notable projects around the world have been constructed using these special steel boxes. Architect Peter DeMaria designed a two-story home using eight ISBUs in southern California; the 3,500-sq.-ft home was awarded the 2007 AIA Honor Award for Design Excellence/Innovation. And according to a recent article in *USA Today*, DeMaria plans to offer more of the container homes, at a starting price of $150 per square foot—a bargain considering that traditional homes in the same area typically go for $225 to $250 per square foot.

In Whistler, Canada, home of the 2010 Winter Olympic Games, 294 rooms are being constructed to provide temporary housing for workers, media, and volunteers. Also, the Nomadic Museum, built in 2005 in New York to house a photography exhibit, used 152 shipping containers for its exterior walls. (Interestingly, the museum was dismantled and then rebuilt in Santa Monica, Calif. a year later and Tokyo the following year.) And in Bishkek, Kyrgyzstan, hundreds of containers are double-stacked to create the Dordoy Bazaar, a large wholesale and retail market; an estimated 6,000 to 7,000 containers stretch for more than a kilometer to make up one of the largest commercial centers in the region.

The use of shipping containers to build structures is still in its infancy, but with a little imagination and creativity it is possible to construct almost anything. So the next time you walk by a shipyard or rail yard and see an empty shipping container, don't assume it will be crossing an ocean; it might just turn out to be your neighbor's new kitchen.

James Falls is a senior civil engineering student at the University of Florida in Gainesville and a summer intern with AISC.

This 3,500-sq.-ft home in Redondo Beach, Calif., designed by Architect Peter DeMaria, uses eight ISBUs.

ENGINEERING JOURNAL

Third Quarter 2008 Article Abstracts

The following papers appear in the third quarter 2008 issue of AISC's *Engineering Journal*. EJ is available online (free to AISC members) at **www.aisc.org/epubs**.

Fracture Modeling of Rectangular Hollow Section Steel Braces

XIANG DING, DOUGLAS FOUTCH, AND SANG-WHAN HAN

Steel braced frames are widely used in all regions of the U.S. including those with high levels of seismicity. Rectangular hollow sections (RHS) are popular because of good section properties and ease of construction. A refined beam model has been developed which is efficient for use in finite element models of buildings. It accounts for local buckling and fracture in the brace and is shown to have good accuracy for nonlinear seismic analyses.

Topics: Seismic Design, Hollow Structural Sections, Stability and Bracing

Design Aid for Triangular Bracket Plates Using AISC Specifications

SHILAK SHAKYA AND SRIRAMULU VINNAKOTA

This paper presents a model to determine the nominal strength of a triangular steel bracket plate using the column strength equations in the AISC *Specification*. Also included are two design tables for such bracket plates for two grades of steel. The nominal strengths obtained by using the relations developed by the authors are compared with the available experimental results and results from other available theoretical approaches. The authors' approach predicts results closer to the experimental results than the other theoretical approaches. Two example problems are worked to illustrate the use of the design tables.

Topics: Connections-Simple Shear, Columns and Compression Members, Steel

A Comparison of Frame Stability Analysis Methods in ANSI/AISC 360-05

CHARLES J. CARTER AND LOUIS F. GESCHWINDNER

Two simple unbraced frames are used to illustrate the application of the following four frame stability analysis methods:

- The Second-Order Analysis Method (ANSI/AISC 360-05, Section C2.2a)
- The First-Order Analysis Method (ANSI/AISC 360-05, Section C2.2b)
- The Direct Analysis Method (ANSI/AISC 360-05, Appendix 7)
- The Simplified Method (13th Ed. *Steel Construction Manual*, page 2-12; AISC *Basic Design Values* cards)

Topics: Analysis, Specifications, Stability and Bracing

Effects of Slab Post-Tensioning on Supporting Steel Beams in Steel-Framed Parking Deck Structures

BHAVNA SHARMA AND KENT A. HARRIES

AISC Design Guide 18, *Steel-Framed Open-Deck Parking Structures*, discusses the use of cast-in-place post tensioned concrete slabs in steel framed parking structures. In Section 3.3.2.1 of Design Guide 18, the authors reflect on the manner in which the post-tensioning force is resisted by and affects the supporting beam: in a non-composite or composite manner. They conclude that the post-tensioning force is carried almost entirely in a composite manner (minus effects of shrinkage and elastic shortening). This conclusion is based on results of unpublished research and is corroborated by earlier design guidance. The objective of this field study is to quantitatively assess the effect that slab post-tensioning forces have on their supporting steel members.

Topics: Beams and Flexural Members, Composite Construction

Current Steel Structures Research

REIDAR BJORHOVDE

This regular feature of the *Engineering Journal* provides information on new and ongoing research around the world. Research projects are summarized on the following topics: structural behavior and strength under seismic loads, including special concentrically braced frames and energy dissipation characteristics of semi-rigid connections; cross-sectional stability of hot-rolled shapes; behavior and strength of steel columns with partial damage of the fire retardant coating; composite beams with precast hollowcore slabs; and plate girder research in Spain, including hybrid and stainless steel girders.

Topic: Research

INDUSTRY EVENTS

May the Best Welder Win

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For more on FABTECH International and AWS Welding Show and the AWS Skills Competition Weld-Off, visit **www.fmafabtech.com**.

UNIVERSITY RELATIONS

Student Bridges Shine in the Sunshine State

The University of Florida's Stephen C. O'Connell Center was full of students this past May 23-24, but the majority of them weren't Gators.

Civil engineering students from around the country, as far away as Hawaii, traveled to the Gainesville campus, as the school played host to the 17th annual AISC/ASCE National Student Steel Bridge Competition. This year's contest ended with the University of California, Berkeley taking first place. Cal's win ended North Dakota State University's bid for a three-peat; that school had won in 2006 and 2007. The University of Florida (UF) and the University of California, Davis took second and third place, respectively.

For the 42 participating universities, the goal of the competition was to design, fabricate, and build the most efficient 21-ft steel bridge that could support a vertical load of 2,500 lbs. Each bridge was ranked in six categories: construction speed, lightness, aesthetics, stiffness, economy, and efficiency. Teams spent the entire year and countless hours preparing for the competition.

Beyond the Bridge

For Florida students, however, designing an award-winning bridge was only part of the goal. As the host school, the larger feat was figuring out how 42 bridges were going to be assembled and tested in only eight hours.

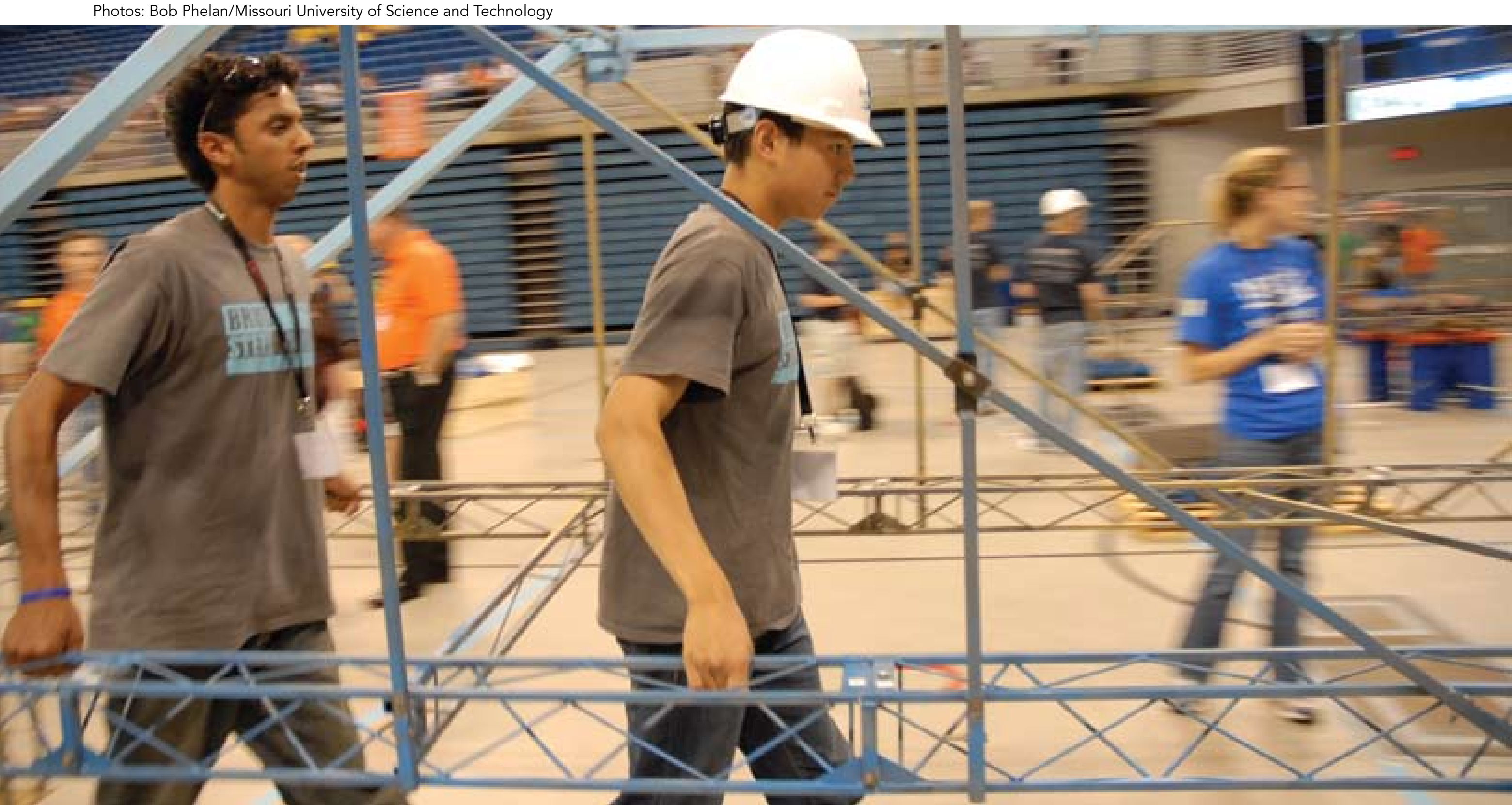
Nearly 650 students, professors, and professionals attended the competition expecting the competition to run smoothly and efficiently. What many of them didn't realize is that well before the rules were released in August of 2007—and before many students knew they would even be on a steel bridge team—UF students were already preparing for the 2008 competition. In fact, Dr. Tom Sputo, UF ASCE Faculty Advisor, began the long process in 2006 when he requested that UF be considered as the host of the 2008 NSSBC.

A small committee of dedicated students was assembled to plan, coordinate, and execute the competition. The students, with already busy schedules—juggling homework and oftentimes a job, as well as other responsibilities—added another demanding item to their plate, spending countless hours making hotel arrangements, setting up contracts with vendors, contacting professionals to be judges, and coordinating with the qualifying universities to make sure they were ready for the competition. Many of the venues, including the O'Connell Center and the Reitz Union Grand Ballroom, were reserved two years in advance—even before the 2007 NSSBC, hosted by California State University, Northridge, took place.

Student Director of the competition and AISC summer intern James Falls described his experience: "You have to be dedicated and proud to host the best student engineering competition in the country. It was a tremendous amount of work but extremely rewarding when two years of hard work all comes together." Without question, he explained, the students in charge from year to year are the unsung heroes that make the competition possible.

Fromy Rosenberg, AISC's Director of University Relations, commented, "This is the premier competition for student engineers. It brings together everything students have learned in the classroom. Participating students practice basic steel

Photos: Bob Phelan/Missouri University of Science and Technology



design and fabrication and project scheduling and management, and gain hands-on appreciation for the strength and versatility of structural steel."

In order to reach the national competition, student teams nationwide competed in 18 regional competitions. The winners in those competitions were invited to compete in the national event. This year a total of 182 universities competed in the regional competitions.

The 2009 NSSBC competition will be hosted by the University of Nevada, Las Vegas, May 22-23, 2009—and yes, UNLV has already been preparing for months.

2008 NSSBC Winners

Overall

University of California, Berkeley
University of Florida
University of California, Davis

Construction Speed

SUNY College of Technology at Canton
University of California, Berkeley
University of Wyoming

Lightness

University of California, Berkeley
Virginia Polytechnic Institute
University of Florida

Aesthetics

Iowa State University
South Dakota School of Mines
University of Wisconsin, Madison

Stiffness

University of Missouri, Kansas City
University of Wisconsin, Madison
Seattle University

Economy

SUNY College of Technology at Canton
University of California, Berkeley
University of Florida

Efficiency

University of California, Berkeley
University of California, Davis
University of Florida

Full results of the overall competition and each category are posted on the official 2008 NSSBC web site, **www.2008steelbridge.com.**

PROJECTS

Covering the Colts

On September, 7 the Indianapolis Colts will play their first game at brand-new Lucas Oil Stadium. Designed by architect HKS, Inc., the stadium seats 63,000 (and can be expanded to 70,000 when it hosts the Super Bowl in 2012). The playing field is 25 ft below street level, allowing fans unobstructed views from their easily accessed seats.

At the Colts' first game in its new home—against the Chicago Bears—fans will be sitting beneath an engineering milestone. The stadium's steel roof, designed by structural engineer Walter P Moore, is the first ever to divide lengthwise into two retractable panels—160 ft long × 600 ft wide and 2.9 million lb each—with each half sliding down the steep, gabled roof of the stadium into the open position. A 960-hp cable drum drive system moves the retractable roof panels up and down the sloped track in 9 to 11 minutes depending on wind conditions. (Structural steel was fabricated by AISC Member Hillsdale Fabricators/Alberici Constructors.)

The project also features a retractable end wall consisting of six glass panels that move to create an 85-ft-tall × 210-ft-wide opening. Each panel rides on a steel rail while the wall opens and closes, and is supported by two hardened steel wheels.

Walter P Moore

HKS, Inc.

QUALITY NEWS

Indiana Fabricator Wins Free Audit

Indiana Steel and Engineering Corp., a fabricator in Bedford, Ind., has won Quality Management Company's drawing for a free audit.

Since October 2006, QMC has been administering a voluntary Customer Satisfaction Survey of AISC Certified Fabricators and Erectors upon receipt of their certificate. The objective of the survey is to improve the certification process from invoicing to the audit to issuing the certificate, and companies that complete the survey are automatically entered into the drawing. QMC will draw for another free audit in six months, so keep those surveys coming in!

STEEL SHEET PILING

Best Practices for Installing Steel Sheet Piling

The North American Steel Sheet Piling Association (NASSPA) earlier this year announced the publication of its *Best Practices Steel Sheet Piling Installation Guide*. This updated and revised manual provides an authoritative guide to the methods of installing steel sheet piling.

The goal is to describe practices that ensure proper steel wall installation, and convey the importance of predicting the "driveability" of sheet piling sections following a thorough evaluation of all ground conditions. The manual presents an inventory of the existing driving systems, from impact hammers to vibratory piling drivers and special systems, and also provides a description of driving methods, ancillary equipment (including guide frames), and all necessary procedures to follow when installing sheet pilings. Finally, some common installation problems are illustrated and several special aspects of driving are briefly outlined.

The guide can be downloaded from the NASSPA web site, **www.nasspa.com**. A hard copy is available upon request; call 866.658.8667.