Real-Life Lessons

BY THOMAS L. KLEMENS, P.E.

Students who participate in the student steel bridge contest learn far more than structural analysis and design.

FEW THINGS ROUSE the enthusiasm of young civil engineers more than the prospect of designing and building a steel bridge, and the annual AISC/ASCE-sponsored student steel bridge competition offers a great opportunity for that. Each year thousands of engineering students from across North America form teams, strategize, design and build out their dreams in this high-level simulation of a real-world bridge construction project. In the process, their hands-on learning experiences range from interpretting detailed project specifications to designing, fabricating and constructing 20-ft-plus spans that have to stand up to real loads.

The competition began in 1987 when teams from three Michigan engineering schools met for the first steel bridge contest. The event was hosted by Lawrence Technological University, Southfield, Mich., with visiting teams from nearby Wayne State University, located in Detroit, and Michigan Technological University, from Houghton, in the state's Upper Peninsula. The event originated with Bob Shaw, who was then manager of college relations for the American Institute of Steel Construction.

Additional teams entered the following years, and in 1992 Michigan State University hosted the first national student steel bridge contest on its East Lansing, Mich., campus. Also that year, AISC officially took on sponsorship of the contest under its newly appointed director of AISC college relations, Fromy Rosenberg. Thirteen teams participated that year, and MSU's zero-deflection span was victorious.

Since then teams from across the nation have gathered every spring to pit their design and construction skills in a fresh challenge guaranteed to spark the imagination and inspiration of civil and structural engineering students. Today the program is cosponsored by the American Society of Civil Engineers (ASCE) with the initial round of each year's competition based on ASCE's 18-conference organization. In 2010, the regional events included 192 teams, with 46 advancing to the finals held May 28–29 in West Lafayette, Ind., at Purdue University.

Watching the finalists compete in both the display and construction sessions, the value of the contest becomes quite clear: The challenge in the steel bridge contest very much reflects a real-world project scenario. Young engineers who participate learn key lessons that go far beyond standard class work. And in a field where experience counts, being on a college or university's steel bridge team is something worth noting.

The bridge requirements are revised each year. For 2010, the structure had to span a 13-ft, 6-in-wide river and an adjacent 5-ft floodway. The bridge piers were to be located on each end of the span, with only temporary supports permitted in the river or floodplain. Although a portion of the team could work as "barges" in the river, land access was limited to one bank, with strict limits on loads within the floodplain. The "owner" placed a premium on stiffness, light weight, and speed of construction. (For the complete project specifications, see Section 6 of the 2010 rules, which can be downloaded from the History and Results area at **www.nssbc.info**.)

Team members, as usual, had their hands full just wading through the project requirements, which itself is a lesson in the

Opposite page: The North Dakota State University team's bridge members were precisely designed and fabricated for quick and simple assembly. The mechanical joints along the various truss members do all the structural work; bolts in the web-like interstitial spaces provide stability and compliance.

reality of construction projects. But then came the question of how best to meet the challenge.

Many teams began early last summer to conceptualize their approach for this year's competition. Once the rules including the specific challenge were made public in August, the work—and the learning—began.

So, based on observations at the 2010 final round of competition, what are the lessons learned? Here are just a few.

Conception and Design

Each competing bridge must meet the specifications as described in the 38 pages of rules, which includes passing a 2,500-lb. load test. However, to be competitive, it also must be optimized for maximum strength at minimum weight—and designed for quick assembly. Team members learn they can't focus solely on any one parameter.

Members

The rules define contest bridges as consisting of two components—members and fasteners. Each bridge member must fit inside a 6-in. by 6-in. by 36-in. wooden box, precluding the use of any extra-long members. Additionally, no single member may weigh more than 20 pounds. These bridges are 1:10 scale models, so this reflects real-world limitations on fabrication, shipping and maneuverability limitations. For 2010, the rules placed an increased value on stiffness, penalizing higher deflection more than increased weight.

Connections and Tools

Making connections is one of the necessities of any construction project. But when the criteria for success include both speed of construction and the strength of the resulting structure, the importance of good connection design rises to the top of the list.

The contest rules stipulate that each member-to-member connection must have a bolt and nut, which in turn must be off-the-shelf products (standard sizes, not ground to a taper, no tapped holes, etc.). Many entries featured machined connections developed as "quick-connect" type of fittings for which fasteners were included primarily to meet contest requirements.

Above, right: The University of Wyoming bridge used a split truss approach, joining top and bottom members with goof-proof connections. The bolts hold them together while additional pairs of pins and holes carry member forces. At the supports, a similarly simple connection was used.

Below: The Université Laval (ESUL) team designed its deck support as an integral part of the main bridge members. Judges use the wooden box in the background to check that all members are within the maximum size limits.

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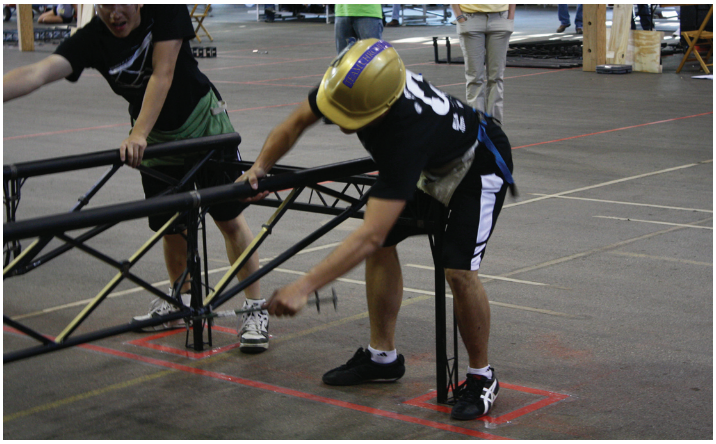
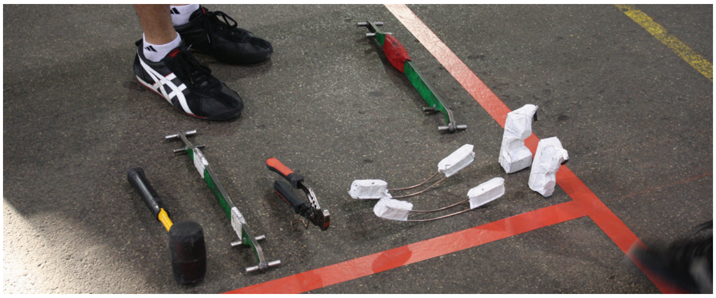
Left: The New Jersey Institute of Technology's highly fabricated bridge members, officially staged and ready for the competition, with groups of fasteners in the forward staging area. The construction site begins 30 ft beyond where the fasteners are.

Clemson University team members learned TIG and MIG welding in the process of fabricating their bridge. Team members several years ago used their newly acquired skills to produce these team mascots.



Above, below: The University of California at Davis design included several custom tools for holding members in place and making connections, shown below in the staging area and above in use during construction.



The University of Wyoming's bridge identification plate includes the school trademark, a cowboy on horseback, in a style matching the member fabrication.

Also, dropped fasteners incur penalties, so teams find clever ways to avoid that. (To see examples of this and other ideas discussed in this article, go to **www.modernsteel.com/photos**.)

In practice, straightforward moment connections seemed to be the best performers this year, but require careful fabrication to facilitate construction. The difference between good and not-so-good connections often could be gauged by whether the team kept a rubber mallet "persuader" close by.

Lessons Learned

Through participating in this very real design and construction project, students learned first hand that:

- Planning, constructibility and practice are *all* required for success.
- Rules, and by extension real-world specs and drawings, can have varying interpretations. The Rules Committee each year handles dozens of questions, and students learn the importance of asking for clarification.
- Devising a solution includes choosing among several good proposals, often melding the best parts of each.
- Achieving team motivation and coordination is not easy, but as competitive teams know, it isn't just about the bridge, it's about the bridge builders, too. Success depends upon the ability to plan and work as a group.
- Given the complex interactions of many parameters, there's nothing simple about designing and constructing a steel bridge.

Wrapping Up

Photos of the 2010 competition and a list of winners is available at **www.aisc.org/steelbridge**, where the rules for the 2011 National Student Steel Bridge Competition will be posted in late summer. A detailed spreadsheet of each national finalist team's category-by-category scores is at **www.nssbc.info**, in the History and Results section. That site also offers a participant guide, the official rules dating back to 2001, and results from 2003 to date. MSC