Two Decades of National Steel Bridge Competition

BY THOMAS L. KLEMENS, P.E.

What began as friendly local intercollegiate rivalry has grown to be a highly educational and impressive program.

THIS YEAR MARKS the 20th anniversary of the National Student Steel Bridge Competition. Things have come a long way since the first national competition, in 1992, when Michigan State University hosted 13 teams. This year on May 20-21 a field of 48 teams competed in the 2011 finals held at Texas A&M University's Reed Center.

Historical Perspective

It all started in 1987 when Bob Shaw, then AISC director of university programs, arranged a student steel bridge competition for three Michigan universities: Lawrence Technological University, Southfield, Mich.; Michigan Technological University, Houghton, Mich.; and Wayne State University, Detroit. The resulting bridges included a deck truss that took more than three hours to build, a chain of heavy wide-flange girders bolted at the webs, and a half-ton replica of a 19th century railroad through truss.

Over the next four years additional schools joined the Michigan competition, and other local competitions developed throughout the country. Each of the local competitions claimed to have the best bridges in the country. To settle the issue, in 1992 Michigan State challenged all bridge teams to the first national competition in East Lansing, Mich. Fromy Rosenberg, AISC director of university programs from 1990 to 2008, provided organizational, moral and monetary support for the competition. Thirteen teams competed and Michigan State won.

With the educational and financial support of AISC, schools throughout the country were encouraged to develop their own student steel bridge teams and the competition steadily grew. From 1992 through 1995, when 31 teams competed, the national competition was open to all teams. In 1996 participation in the national competition became by invitation only. By then most bridge teams were organized by the ASCE student chapters, and the top two teams from each of the then 20 ASCE student chapters were invited. As the number of student chapters grew they were organized into the 18 regional conferences that now host the qualifying round.

Throughout the 25 years of the steel bridge competition AISC has provided financial support to every team that competes at the conference and national levels, financial support to the host schools and the required equipment, and staff and organizational support.

ASCE's involvement grew over the years, particularly at the local chapter level. In 2000 AISC and ASCE entered into a formal agreement and the competition was officially named the ASCE/AISC National Student Steel Bridge Competition.

The Rules Committee conferring at the team captains' meeting May 20, 2011. Clockwise from lower left: Mike Engstrom, Ping Wei, Nancy Gavlin, John Parucki, Frank Hatfield, Jennifer Greer Steele, Bart Quimby, Jim Williams. Don Sepulveda and Renee Whittenberger are facing away from the camera.

John Parucki (center, left) and Frank Hatfield fielding questions from team captions at the 2011 Nationals Student Steel Bridge Competition.

Today approximately 200 teams compete each year in the regional competitions. They come from nearly every state, as well as the District of Columbia, Puerto Rico, Canada, Mexico and China. And, in contrast to the early days of the competition, most of today's student bridges are light and quickly constructed. In 2011 the fastest construction time was 4.74 minutes and the lightest bridge weighed just 141 lb.

Playing by the Rules

The competition is based on a substantial set of rules, which include specific design criteria that are modified each year. The nine members of the Rules Committee develop each year's challenge and attend the regional and national competitions.

- **Frank Hatfield**, the committee chair, was faculty adviser for the first Michigan State team in 1988. His students hosted the first national competition in 1992 and he has been helping to write the rules and organize the competition ever since.
- **John Parucki** serves as national head judge. His fabrication company began supporting local university bridge teams after NSBA's Bill McEleney told Parucki and others attending a 1991 New York State Steel Fabricators Association meeting about the competition. He has been the national head judge since 1995.
- **Don Sepulveda** was a member of three student steel bridge teams from 1993 to 1995 and credits participation in this student program with saving his life. (See also page 66 of this issue.) He has been on the Rules Committee since 2001.
- **Jennifer Greer Steele** was on the Texas A&M student steel bridge team from 2001 to 2003. She was a judge from 2004 to 2006 and has been a member of the Rules Committee since 2007.
- **Bart Quimby** was the faculty adviser for the University of Alaska, Anchorage student team that competed in the first national competition in 1992. A member of the Rules Committee since 2000, he developed the scoring spreadsheet, provides technical support for scoring throughout the competitions, and maintains the website **www.nssbc.info**.
- **Mike Engestrom** has been on the Rules Committee since 1995. His employer, Nucor Yamato Steel, has been a sponsor of the competition since 1999.
- **Jim Williams** is on the faculty at the University of Texas, Arlington, and in 1994 helped organize the first Texas student steel bridge competition. He joined the Rules Committee in 2003.
- **Renee Whittenberger** was a member of a student steel bridge team for four years during her college career. After graduation, she served as a regional and national judge for four years and has been on the Rules Committee since 2007.
- **Ping Wei** is the ASCE director of educational activities and has been on the Rules Committee since 1998.

What It Takes to Compete

Although many teams begin planning as soon as the new rules are issued each August, this year's all-around winner from Lakehead

The Lakehead University team's bridge components in the staging area.

University, Thunder Bay, Ontario, began in January with the start of the new semester. Although the school has been fielding steel bridge teams since 1989, this was the first time any of the five senior structural engineering students on this year's team had participated.

The team first considered three different truss types using Bentley's STAAD analysis and design software. "We had a competition amongst ourselves to see who could get the lowest score with some approximated values," said team member Chris Kukkee.

"That's one of the things that pushed the team to do more than what was really required," said Damien Ch'ng. "We all have a competitive nature, and we just kept pushing until we were down to $500 or so between bridge designs." To put that level of nickel and diming into perspective, consider this: The competition rules include formulas that combine the scores in various categories to provide an overall cost for the structure. This year Lakehead's

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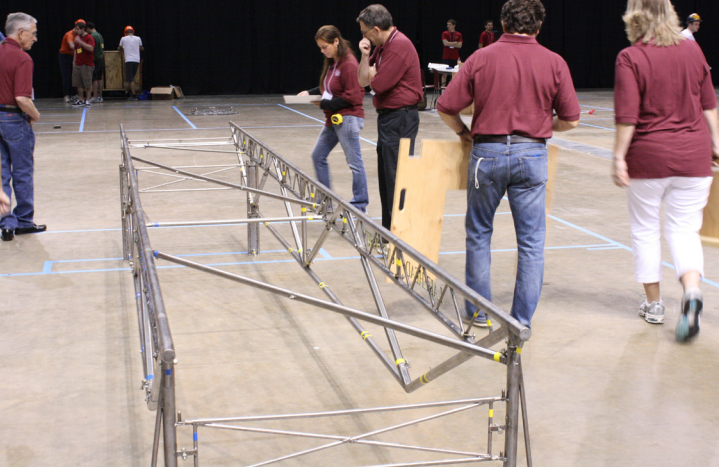

The judges check the completed Lakehead University steel bridge.

Measuring the Lakehead University bridge's horizontal deflection.

bridge came in first with a "cost" of $2,024,822, so a theoretical $500 difference between possible bridge designs was not significant enough upon which to base a decision.

"At the point of the students deciding which design to go with, there's also the element of the roll of the die," said Antony Gillies, one of the team's faculty advisers. On the day of the competition, the position where the load will be placed in the backspan is decided by rolling a die. A table in the rules lists the six possible locations, which teams can consider in developing their designs.

"We knew we could make any of the designs work," said Dave Enns. "There were different elements to consider, like a double stack with fewer members would give us the speed advantage but we'd lose the stiffness. An undertruss would give us stiffness and less speed. Ultimately we went with the deeper truss system to minimize the effect of the roll of the die… it would give the best weight-to-deflection ratio overall."

"We also knew that once we built the bridge, we couldn't change the deflection," Ch'ng said. "But the build time was different—with practice we could get faster." So the team went with the option that gave them more control over the variables.

"We didn't focus on being the fastest bridge only," said Kukkee, "or the stiffest bridge only, or the lightest bridge only. We wanted to be all of those." To do that, the team knew, would require good connections that could be assembled quickly. Kukkee came up with a double stud system that would twist and lock in place. "It was a three-prong keyhole concept," he said. "But with 1¼-in. tube there wasn't enough space to make it work."

Next Enns drew up a twist lock with protruding L-shaped teeth, but that design also had clearance and fabrication issues.

"As soon as I saw Dave's design I realized it looked like the way you connect a lens to a camera body," Ch'ng said. "So I took what Dave had and modified it a little bit." After some additional analysis to work out the detailed design, he handed over his CAD drawings to team member Cory Goulet for machining.

"That's when the connection design once again got changed," Goulet said. The school had recently acquired a CNC metal working machine and was in the process of getting up to speed on its use. "Once we began to fabricate we realized we didn't have the proper tools to make many of the required cuts, so we decided to change tool diameters and cut sizes in the software. We had to figure it out on the fly because we had a very limited amount of time to make these parts." In the process Goulet became quite adept at CNC programming with Mastercam.

"There were some who thought the parts couldn't be cut using this equipment," said Timo Tikka, who with Gillies has been a Lakehead faculty adviser for many years. "Cory managed to figure out a way to fool the computer software to do anything he wanted."

Once the team started fabrication, there was a continual effort to improve various aspects of the bridge. However, maintaining balance—between lightness and stiffness, for example—was also a continual challenge. One such episode occurred shortly before the regional competition when the bridge's lateral deflection increased. The rules limit lateral deflection to ½ in., which this year was tested by sequentially applying a 75-lb side pull at two points on the structure.

2011 National Student Steel Bridge Competition Winners

The top three national winners overall are:

Overall Winners
1. Lakehead University
2. Michigan Technological University
3. SUNY College of Technology at Canton

The top three winners of the following six categories the students competed in are:

Construction Speed
1. Lakehead University
2. Michigan Technological University
3. SUNY College of Technology at Canton

Lightness
1. Lakehead University
2. University of Hawaii at Manoa
3. Georgia Institute of Technology

Display
1. Georgia Institute of Technology
2. University of Hawaii at Manoa
3. California State University, Long Beach

Stiffness
1. University of Hawaii at Manoa
2. Arkansas State University
3. SUNY College of Technology at Canton

Economy
1. University of Alaska Fairbanks
2. Lakehead University
3. Michigan Technological University

Efficiency
1. Lakehead University
2. University of Hawaii at Manoa
3. Michigan Technological University

"We had built a bridge that was working very well," Ch'ng said. "We ran multiple practices and filed some pieces down to make them connect more smoothly. Then, after running more practices, we did another lateral load test and because of putting everything together and the filing we did, everything had loosened up quite substantially and we failed lateral. And this was the night before leaving for the regional competition."

The team discovered that it wasn't the superstructure itself deflecting, but that the legs were rocking and causing too much sway. "We spent the night and most of the next day trying to stiffen up the legs," Ch'ng said."Chris came up with a unique sort of clamp system that would tighten everything up. So we fabricated it all up, put it together, and we managed to pass the lateral test. As soon as we had it working, we packed it up and drove down to the regional competition."

"I don't think I've ever made it to the welcoming ceremony at that regional conference," said adviser Gillies. "It's become a tradition for the team to have a last minute crisis."

After qualifying at the regional conference, the team continued with structural modifications and to improve their construction time. "We had removed three pieces from the bridge in our lateral system to make it faster and lighter, and we were just on the border line at ½ inch," Kukkee said, referring to the limit of lateral deflection. "On our final test just before we left we were really pushing the limit, and not comfortably below half an inch, so we ended up putting a small ⅜-in.-diameter tubing on one of the lateral braces on the cantilever. That gave us an extra 0.1 inch margin and we felt comfortable with that. That piece was welded on just before it went in the box."

At the national competition, Lakehead was one of five teams in the first heat, and it was clear they had practiced and were very much working as a team. "We decided to use two runners just so we wouldn't tire out too quickly," said Kristen Myles, "even though that extra 'builder' added to the construction cost." The cost figures heavily in the construction economy and overall categories, with the largest component being that each builder-minute adds $50,000 to the cost.

Faculty adviser Tikka said the team's performance also hinged on coordinated interaction. "Our team's communications were second to none. There was only one other team that was communicating in a similar manner." To see the Lakehead team in action and hear the two runners calling out part identifications and other information in an otherwise quiet arena, go to **http://bit.ly/jLQvFc**.

"The troubleshooting experiences on this project were really valuable," Enns said. "It's a prime example of showing up on a job site and site conditions aren't exactly what you anticipated and making corrections on the fly. The fabrication was also an eye opener, like how much movement there was on a thin piece of steel when you welded it."

One additional benefit accruing from the student steel bridge competition, Gillies observed, is the connection it is building to the local community. "The students do the whole package, including the fundraising," Gillies said. "Almost all the money is raised from outside of the university. This program really opens up a relationship with the local community, from structural engineers down to parts suppliers—the company that gives us bolts, for example. You realize the power of communication from the day you are actually speaking to people and these people get as enthused as the students."

Of course, hosting the competition is also a substantial undertaking. Beyond the details of the competition itself, arrangements for this year's event included providing two lunches and a banquet for nearly 800 people; setting up blocks of rooms in nine area hotels; contracting with two facilities—one for the bridge construction and another for the display and banquet; and communicating with all involved. Jenna Kromann, a junior civil engineering student at Texas A&M, was this year's host committee director.

The biggest hurdle they faced, Kromann said, was taping off the floor for the competition. The taping group could only get access after a Friday evening event. "We had people there until three in the morning," Kromann said.

The spring semester was a busy one for Kromann. "I would get so many emails in my inbox—sometimes eight in an hour!" But the pace obviously suited her, because she ended the semester with a 4.0 grade average. "I guess when you're busiest is when you do your best," she said. MSC

The "camera connection" developed by the Lakehead University steel bridge team was both very efficient in transferring loads and quick to assemble.

The 2011 Lakehead University student steel bridge team, in hardhats from left: Chris Kukkee, Kristen Myles, Damien Ch'ng, Dave Enns, Cory Goulet. Faculty advisers Timo Tikka (left) and Antony Gillies stand at either end. Machinist adviser Kailash Bhatia is not in the photo but was an important part of the team.