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Bridging the Gap: Classroom Learning to Hands-On Experience

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A new competition between Student Chapters of the American Society of Civil Engineers is now underway. This large-scale bridge-building contest gives students a hands-on experience that teaches them about steel construction, at the same time offering them a challenging, educational and fun project. The popularity of balsa wood structures contests in the laboratory and the popularity of other Student Chapter competitions led to the development of this form of program.

A pilot program was conducted of this contest to test its feasibility, format and rules. Initiated in December, 1986, the competition culminated in the erection of three bridges in late March, 1987. Lawrence Institute of Technology, Southfield, Michigan, served as the host school. Based upon the success of the pilot, AISC and the ASCE has undertaken the program for use at the 1988 Spring Regional Conferences for ASCE Student Chapters.

THE COMPETITION

The basic competition was to design, fabricate and erect a 20' long 3'-6" wide simple-span steel bridge. An opening scenario was provided the Student Chapters to make the contest into a "real-world" design-build competition. Contest rules were formulated to simulate common construction situations. Dimensions were scaled downward from the scenario at a ratio of 1:10. The weights were scaled at a ratio of 1:1000. The 20' bridge was representative of a 200' long, two-lane replacement bridge to be placed on existing abutments and spanning a valley with a 50' wide river bank, a 70' wide swift-flowing and environmentally sensitive river and an 80' wide river bank on the other side. The model bridge site then had a 5' north bank, a 7' river and an 8' south bank. The largest individual piece the students could use was 5'-6" long, 7.5" deep and 60# in weight, representative of a 55' long, 6'-3" deep, 30 ton member. The design and construction challenges become obvious at this point.

Any form of steel construction was permitted, but the abutments were simple and no cable anchorages or backstays were available. For erection, temporary shoring and hand tools were permitted, but not field welding or power tools. Storage yards were provided at either end of the bridge construction site. Yard assembly was permitted to allow units as long as 11', as wide as 3'-6" and as heavy as 100# provided at least 2 students handled these pieces.

Four minimum design loads for the bridge were given. The bridge had to support a single 150# moving cart, simulating a 75 ton truck, at any point rolling along the bridge. Two 100# carts, or 50 ton trucks, were also placed on the bridge at possible worst-case locations. A 500# static load was applied at the center of the bridge, and to ensure some consideration for lateral stability, a 100# lateral pull was applied at the center of the bridge. When these four tests were completed, the bridge was tested for ultimate capacity by incrementally loading the center of the bridge up to 2500# while measuring the deflection using a surveying instrument.

The Student Chapters competed in six different areas:

Lightest bridge
Fastest team construction time
Lowest "cost" - combining time and weight
Highest capacity
Best capacity/weight ratio, and
Most esthetic.

The students had to interplay the first five categories of competition to determine their best chance of winning the overall competition, a contract with the State, according to the scenario. Should a tie occur, esthetics would serve as the tie-breaker.

CONTEST DAY

Four of Michigan's six Civil Engineering schools entered the contest, but one dropped out the week prior to the contest date. One of the schools not competing was hosting its own balsa wood contest for high school students that day, and the other was heavily involved in organizing a pasta bridge contest for high school students in late April. Three different types of bridges were designed and constructed by the three ASCE Student Chapters. They employed three entirely different erection methods.

On contest day, construction was done on an asphalt parking lot, not a real river valley. Three pairs of steel workhorses were used as the abutments. 2500 pounds of steel punches and scrap in burlap bags, measured out in 50# units, were used for the load testing. Precut 1" grating served as the bridge deck. The bridges were erected one at a time to allow the students to observe their competition and to learn from the experience. Erection was done in the morning and load-testing was done in the afternoon.

THE BRIDGES

By luck of the draw, Wayne State University's Student Chapter was the first to build their bridge. Their design was an elaborate parallel chord thru-truss, complete with horizontal bracing at top and bottom chords. The students first assembled the 11' section that would span across the river. They lowered it across the river using rope, then set it on temporary shores on both river banks. End truss units were added at both ends, then the lateral bracing and grating units were installed.

The student leading the project for the Chapter had prepared four sheets of complete detail drawings and supervised the fabrication of the bridge by the students. Unfortunately for WSU, the erection crew made a few mistakes. Several pieces were installed in chord, and it was necessary to disassemble and reconnect parts of the bridge to make it fit together. With 76 pieces and 216 field bolts, and the above problems, it took 2 hours and 23 minutes for their 7-person team to finish their bridge. The WSU bridge was designed targeting the lightest weight, highest capacity and best capacity/weight ratio categories, and they were not necessarily concerned with construction time or cost. The bridge weighed 556# and deflected 3/8" under the 2500# load. It also rated a 6 out of 8 possible points for esthetics.

The Lawrence Institute of Technology Student Chapter designed their bridge targeting speed of construction and lowest cost. They built a rolled-beam bridge, actually a plate-girder bridge considering scale, made up of 6" deep M-sections. The two parallel rows of beams were connected with three sets of angle cross-bracing, with one set in the middle and one set at each end. The erection method employed by Lawrence Tech proved to be one of the highlights of the day, and it took just 18 minutes and 40 seconds for their 8-person team to complete their bridge. The 11' sections that would span over the 8' bank were yard-assembled, then placed on the abutment and a temporary wood shore. Two students then walked to the end of the beams, cantilevering over the river and counterbalanced by a student sitting on the opposite end of the beam at the abutment. The next 5'-6" section was bolted into place, handed to them by the crew working from the 5' bank, and then the final 5'-6" section was placed at the end. The bracing was added and the grating placed on top of the beams.

The 12-piece bridge weighed 515#, and proved to be lighter than the truss of WSU. It was also the fastest to construct and lowest in cost. Because they were concerned with interference with the grating bridge deck, the students did not provide connections across the flanges and used only simple web shear plates. The situation was worsened by the use of oversized holes in the beam webs to ease erection fit-up. Under the bridge's own weight, the web joints slipped and allowed the bridge to sag 5", just within the 6" sag permitted under the rules (to accommodate the students' potential lack of fabrication skills). Under load testing, the joints continued to slip until the load test was terminated with an 8" additional sag under 2000# of load.

The students of Michigan Technological University built a bridge not only for the contest but for a future use as well. Their bridge would be put into use after the contest as a pedestrian bridge in a nearby town's park. This meant that they needed a stringer bridge than required, perhaps, but also limited their choice of bridge design. The Chapter designed and constructed a type of bowstring truss, or arch truss, that employed outrigger bracing to keep the walkway clear of obstruction. The students yard-assembled 10'-6" truss sections at each end of the bridge, then set the trusses over the 8' bank on temporary steel shoring. The trusses over the 5' bank and river were then slid into place and joined at the bottom chord by a student on the bridge reaching out into the cantilever region. The connecting top chord members were added to complete the trusses, the lateral bracing at the bottom chord level was installed and the outriggers were put in place. The grating was installed and construction was complete. One design flaw was noted that proved to be of concern. The students did not realize that grating spanned in one direction only and failed to provide support under the main bearing bars. Instead, the grating was supported only along its side edges. Fortunately for MTU, the loading carts did not fail the grating, although deflections in the grating were definitely noticeable. Cross-bracing was located under the grating at mid-span where the static loading was conducted, and hence, the grating had adequate support and did not fail.

The 57-piece MTU bridge took 50 minutes for their 8-person team to build. They reported that their best time in the laboratory was close to 20 minutes, but they experienced some fit-up problems with tight-fitting bolts. It was the heaviest bridge at 642#. Under the 2500# static load, the bridge deflected only 1/16". Upon completion of the load test, the team climbed atop the pile of loading material and another 1/16" deflection was measured. The bridge won both the capacity and capacity/weight ratio categories.

Under the point system used, Lawrence Institute of Technology and Michigan Technological University tied for first place, and the category of esthetics determined that Michigan Tech was the overall winner with an esthetics score of 7 out of a possible 8. The Wayne State team was recognized with the Chairman's Award of Excellence for its outstanding quality of design and workmanship.

CONCLUSIONS

The pilot test of the competition did prove to be successful. Some guidelines and rules did show need for adjustment. The bridges came in heavier than anticipated at the conception of the program, but the learning curve for the competition has just begun. The students indicated that the competition was a tremendous learning experience not attainable in the classroom, and that their extra effort outside classroom studies was well spent. They also showed their competitive spirit, and suggested ways to make the competition fairer and even closer to real life.

With this input, the guidelines for the competition have been revised and are available to ASCE Student Chapters. AISC offered this program for use at the 20 ASCE Spring Regional Conferences scheduled around the country for the Spring of 1988.

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