

STUDENT TEAM COMPETITIONS: A PATH TO CREATIVITY and PROBLEM SOLVING in CIVIL ENGINEERING TECHNOLOGY

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Abstract

Members of the American Society of Civil Engineers (ASCE) Student Club at Southern Polytechnic State University (SPSU) have participated in numerous team competitions. These competitions are held each year at the ASCE regional student chapter conference. The two most notable competitions are the STEEL BRIDGE and CONCRETE CANOE. However, SPSU students have competed (and performed well) in other competitions such as Surveying, Environmental, Geotechnical, and even the Concrete Bowling Ball. The learning process offered by these competitions cannot be duplicated in the classroom. At SPSU some companies have asked specifically to interview *competition students* at graduation. This paper will bring together the *learning, creativity, and problem solving* that evolves through team competitions. Discussion will concentrate on the experiences of the *SPSU Steel Bridge Team*. Recommendations will be given as to how any ASCE Chapter can successfully compete and offer this experience to the students.

Introduction

The value of student design competitions is well recognized in various disciplines of engineering and engineering technology. For example, manufacturing engineering ¹, computer science and electrical engineering ², and mechanical engineering ³. In design competitions, students gain in-depth experience in teamwork, creativity, problem solving, and the technical discipline. SPSU students majoring in the *B.S. Civil Engineering Technology Program* or *B.S. Surveying and Mapping Program* are given the opportunity to compete in regional and national competitions. Each year students from approximately 200 Civil Engineering and Civil Engineering Technology programs compete among 20 regional competitions. These competitions are held annually at the ASCE Regional Student Conferences. For example, in 2002 the SPSU teams will compete at the 2002 ASCE Southeast Regional Student Conference hosted by Florida A&M and Florida State Universities.

Two highly publicized competitions are the Steel Bridge and Concrete Canoe competitions which are held at both the regional and national levels. The first and second place Steel Bridge teams from each regional competition are invited to compete in the annual national competition. Thus, a total of 40 bridge teams are invited to compete

nationally from the 20 regional competitions. Additional teams may also be invited to the national competition at the discretion of *The American Institute for Steel Construction* (AISC) which co-sponsors the Steel Bridge competitions.

The SPSU Steel Bridge teams have achieved a national reputation for *excellence*. SPSU Steel Bridge teams have competed in all national competitions (total of 10) since inception of the *national steel bridge competition* in 1992. SPSU teams have placed in the top 5 in eight of the ten national competitions including twice tying for first place. The SPSU team's success is largely due to the commitment ingrained in the team by their faculty advisor, Professor Mike Orlandella. The competitions require students to excel in *teamwork, creativity, and problem solving*. As these students have not normally worked together these skills must be learned "on-the-job". The learning comes quickly as the students *raise funds, search literature, create designs, seek vendors, order materials, write reports, fabricate, and conduct virtual and physical tests*. The complete process is conducted in about a five-month period which enhances one more skill learned by team members: coping with stress and deadlines.

Team Management

The steel bridge competition is a total package. The team (of students) completes the bridge project from concept to construction. The students design (and re-design), test (and re-test), fabricate (and re-fabricate), construct (and practice construction), and finally compete with other teams. In addition, students must seek project finances. There are problems, successes, and failures in the process. The key to maintaining the teams focus and desire is *management*. Students must learn to manage themselves while at the same time being *managed* by a faculty advisor.

SPSU is fortunate to have a dedicated and committed faculty advisor for the steel bridge team. The faculty advisor must guide and encourage the team through every aspect of the project. To compete at a high level, students must devote long hours to the project, while carrying a regular course load. At SPSU students do not receive university credit for their participation in the competition. The faculty advisor must instill team commitment, cohesiveness and pride. At SPSU the faculty advisor has daily contact with the team captain(s) and joins the team in meetings and work sessions (including weekends).

At SPSU, a team captain and co-captain are assigned by the faculty advisor. The team captains gain experience in managing people, funds, materials, equipment, and time. Most of the work begins in January to meet the regional competition scheduled in April. Deadlines must be set (and met). Students quickly learn teamwork skills and the meaning of commitment. If something goes wrong (and it always does) the tendency to direct blame is strong. These situations provide excellent opportunities for students to recover and pull together as a team.

Students learn to make decisions among alternative choices with no guarantee of success. For example, the 1998 SPSU Steel Bridge team was trying to improve the bridge's performance (under-load) for the National competition. Adding 4 new steel members

would improve the bridge's performance, but at the expense of adding construction time. The new members were not added and the team placed 6th which was the lowest finish for an SPSU team at a national competition. Another critical management decision occurred in 1997 at the national competition. The SPSU team had locked up 2nd place, but due to a judging error were given the opportunity to "go again" at the end of the competition. They could compete again but would not be guaranteed 2nd place. The team chose to "go again" but nerves and stress took their toll. With hundreds of other student team members, faculty and friends watching, they were slower (than the first time) at constructing their bridge and dropped to 4th place.

Design

The design process is new to most team members. Their design experience is mostly limited to coursework problems. Guidance from the faculty advisor is crucial. All design alternatives must conform to the competition rules. Although rules change each year, the competition assigns points (through specific mathematical equations) based on bridge weight, deflection combinations (under specific loads), economy and efficiency of construction, number of builders and aesthetics. Factors to consider in design are type of bridge (truss, arch, girder, etc), steel properties, connections, overall weight, fabrication, speed of construction, and efficiency of performance (deflection under load). The team is rapidly confronted with choices and deadlines for decisions. The faculty advisor helps by presenting past experiences and noting key factors affecting cost, fabrication, construction time in competition, and effects on performance. Students will have many design ideas (most not feasible). It is the job of the faculty advisor to encourage the students to keep thinking and learning.

Structural analysis (and computer modeling) of alternative designs must begin early in the process. Many hours of computer analysis are needed to optimize design. This process must be completed early to allow for procuring materials and bridge fabrication and testing. Teams often get consumed in the analysis and modeling which delays beginning the fabrication process.

During the design stage, students learn another important fact. Bridges cost money and SPSU resources provide only a portion of the cost. At SPSU, the steel bridge competition is supported with funding from the Student Government Association and the Alumni Association. This funding totals about \$6,500 for the Steel Bridge team. However, SPSU teams raise additional funds through industry supporters. Students make phone calls, send letters, and at times meet with industry supporters to request funding. The faculty advisor also meets with industry personnel to develop new supporters and maintain existing supporters.

Fabrication

SPSU students are responsible for procuring materials for steel members and connections, then fabricating the bridge to meet design specifications. Steel members are cut to length, trimmed and shaped for minimal weight and smooth connections. During

competition, the bridge is laid out in pieces which must be assembled (constructed) as quickly as possible. How the bridge is laid out is a crucial factor in competition. Basically, the design process (and student creativity) continues during fabrication. The team learns that their bridge design will always require changes to facilitate fabrication. The fabrication process brings the team together as they see their bridge take shape. Teamwork and communication skills are learned and improved in the process. The team learns that if one member does not do their job, the whole project suffers. They learn to communicate very clearly and demonstrate shop procedures as even the simplest of tasks can be misunderstood.

SPSU is fortunate to have strong industry support for the steel bridge competition. One company opens their fabrication shop to the team. Safety is the NUMBER ONE consideration during fabrication. At SPSU each team member must have individual health insurance. Students working in the shop must be skilled with the operation and safety features of all tools and machinery and are required to wear safety glasses, goggles, and a full-face shield. Typical shop work will include cutting, drilling, grinding, and welding. Experience level of the team members will vary, thus all students are checked out on equipment by the faculty advisor. Always be ready for an accident. Have a first aid kit handy and know exactly how a major accident will be handled. Minor accidents such as cuts and burns will happen. In 14 years, SPSU teams have had only one serious accident. The student injured was very familiar with the equipment, but investigation, after the accident, showed that the tool was being operated outside its safe range. Fortunately, the injured student was treated promptly and the student is now fine.

The Competition

Despite the many hours of practice constructing the bridge, load testing, design and re-design, the actual competition will reveal every possible flaw. The team experiences intense stress during competition. Bridge construction is “on the clock”. The number of team members needed to construct the bridge and time of construction are critical in earning points during competition. Team members can become very emotional as students, other teams, friends, and family crowd around each team during bridge construction. There are strict rules to follow during construction, and penalties are applied when those rules are broken (often by accident such as dropping tools or parts). Team members must learn to maintain composure during and after bridge construction, especially when there are penalties and potential disagreements with the judges.

SPSU team members have learned to observe all the other teams to see how they solved familiar design and construction problems. Teams respect each other and learn from each other. The creativity is amazing. One time a team put a 6-foot long socket extension on a battery powered hand drill. The drill was used to reach distant joint connections, plus served to temporarily support bridge members. This procedure was clever, but it is now against the rules.

Reports and Presentations

The SPSU Steel Bridge team is required by their faculty advisor to prepare a comprehensive report which is distributed to all the team members, faculty, and industrial sponsors. Each team member is assigned at least one section of the report. The report preparation provides excellent experience in technical writing. All past reports are available to each year's new steel bridge team members.

SPSU has been fortunate in that teams have been invited to give local and national presentations. Examples are:

- National Steel Construction Conference (AISC), May 2001, Ft. Lauderdale, Florida
- ASCE National Conference, October 2000, Seattle, Washington
- International Bridge Symposium, 1994, Atlanta, Georgia

The talks provide team members with public speaking experience. SPSU team members have also visited local grade, middle, and high schools to give presentations and/or assist with various bridge building contests.

Key Recommendations

- New schools considering forming a team should attend a regional competition to observe and ask questions before entering a competition.
- Choose a team of 8 to 11 members. Less than 8 is too much work on each person. More than 11 leads to idle time for some members.
- With guidance from the faculty advisor, the team should set a reasonable goal as to how high to finish in the competition.
- Teams should meet a minimum of once per week for a 2-hour period. Other meetings should be called when needed. The faculty advisor should attend all meetings. These meetings build *open communication* and *a cohesive team*.
- The faculty advisor should divide duties fairly among the team members.
- Begin fund raising at least 2 to 3 months before beginning the design process, as funds must be available to purchase materials. A steel bridge team from any college entering the competition will likely need from \$5,000 to \$8,000 to cover costs of materials and travel. Of course, costs can vary considerably among the different college teams entering the competition. For example, some teams (at other schools) do not fabricate their own bridge. Fabrication is done by a private company or shop technicians at their college. There are also many companies that will donate steel for the bridge. Always thank industry supporters over and over again.

- The faculty advisor must be committed and should strive to:
 1. Stimulate ideas for new bridge designs.
 2. Make new industry contacts for support and supervise all fund raising activities.
 3. Supervise fabrication and continually stress safety.
 4. Supervise all load tests and again emphasize safety.
 5. Assist in teaching students fabrication processes and use of tools and equipment. Continuously remind the team of safety issues.
 6. Contact fabrication experts to learn new processes. For example, the SPSU team sometimes visits local fabricators to learn techniques. The 2001 team learned the process of “Plasma Cutting”.

Conclusions

The authors sincerely hope that the suggestions and experiences presented in this paper will excite and encourage students and faculty (from any school) to enter the steel bridge competition (or other ASCE competitions). The SPSU first Steel Bridge team started out with a “hack saw” and a “hand drill”, and a “determination” to succeed. SPSU has succeeded and the students have benefited greatly. The authors welcome further inquiries from schools presently or planning to compete in the Steel Bridge and other ASCE competitions.

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