Introduction

IPRO 315 is the steel bridge competition IPRO. The point of the IPRO is to design and build a bridge based on rules assigned by ASCE, the American Society of Civil Engineers.

Background

For the past few years, this IPRO has been done to compete in the competition. However, for last spring, there were two components, hosting and competing in the competition. Since we are not hosting the competition this year, it allows the IPRO to concentrate fully on the steel bridge.

Every year, the rules are changed for this competition. By doing so, one team cannot use the same design from year to year. For example, in this year's competition, bridge was required to take a larger load than last years. Also, the layout had a greater skew.

In previous years, Illinois Tech has had mixed results. Two years ago, the team made nationals, where they won first place in both speed and weight. However, the success did not continue last year, when the bridge was disqualified, for not meeting dimensional criteria.

Previous issues in the IPRO involved time and space. In previous years, there was no space on campus to fabricate the bridge, nor was one semester adequate time, causing previous teams to rush to complete the project.

Another issue was the actual point of the IPRO. There have been arguments that it should not be an IPRO since it is technically an ASCE event, which can be done by the organization. People who join from other majors may not have much work to do, or may participate to get an easy 'A', which is an obvious problem. However, based on prior year's results, people from other majors who participated in the IPRO did have some responsibility, such as building the website, making the poster/project deliverables, and, in some instances, helping with design (when a related engineering major). Hence, this is the least important issue.

Purpose

The purpose of the Steel Bridge IPRO 315 is to design and fabricate a steel bridge for the ASCE Regional competition. In addition to competing in the IPRO, the team was also required to work together to assign tasks and leaders to make sure everyone had an important role to play in the project. The ASCE also requires that universities with an ASCE organization compete in the competition, and the IPRO also helped meet this requirement.

The IPRO also involved completion of tasks similar to those which a business would experience. Money had to be raised and tools and steel had to be purchased. The location for working on the project also had to be acquired.

Research / Methodology

Design:

In a project like this, research is important, especially with the time constraints. For design, the first things looked at were previous designs. For this, the previous year's design (plus 2003) and designs from other schools were used. The previous year's bridge was disqualified and currently is in Morton Park, so our IPRO looked at designs and the actual bridge to note the errors that caused the disqualification. One issue with the bridge was the lack of lateral bracing, which would be important for lateral sway. Hence, our IPRO made sure to incorporate lateral bracing.

In addition, other school's bridge designs were looked at. The winner of our region, University Wisconsin – Madison, had a great idea. Instead of using bolts, they used snap in connections that connect quickly and easily. With this, they added a bolt for regulations, since the rules require bolts to be attached to connecting members. This idea was highly considered by our IPRO, however, the idea fell through with the lack of machinery or money to make these types of connections.

We also looked at our bridge from two years ago. Since half of it is in the lobby of Alumni Memorial Hall, it is easy to get up close and get ideas. This bridge was used for ideas on connections, since a lot of the connections were ingenious.

The design team incorporated all of the ideas brought up in class and eventually chose three designs to pursue further. All three designs were analyzed using SAP computer analysis to see how each design would deflect under loading. After analyzing the SAP results, the design team managed to decide on a basic bridge with similar decking to the 2003 design plus a larger upper truss.

With the basic design decided, the team then transferred the design into AutoCad to figure out all the small details such as connections. Many ideas were considered for the connections, and throughout the project the connections were constantly changed and discussed.

The type of welding to be used in fabrication was also an important topic. Eventually, the class decided to use MIG style welding because the members being welded were very thin.

Administrative:

This phase, done concurrently with the design phase, was to raise money for the project. Since time and resources were limited, raising money was done from multiple different angles. It was decided that we solicit to the administration, alumni, and companies with different methods.

To talk to administration, we scheduled an interview with the Dean of Engineering, on top of talking to numerous people about using a room to do the project. Eventually, our IPRO acquired the HUB basement for this purpose. In addition, we acquired a deal with the IPRO office to double all money raised. On top of this, Lew Collins decided to donate $1000 to ASCE, which would go directly towards the bridge.

To contact alumni (from the CAE department), letters were sent out. This aspect did not raise much money, but did involve the alumni of ongoing ASCE activities.

To solicit to area companies, we used multiple approaches. For people working for firms, we asked them to talk to their managers. We would give the manager an official letter telling them what was happening, and information for sending the money. Also, companies that donated in years past were called, to see if they were still interested. On top of this, we did go down to certain organizations personally to ask for money, as our captain spoke to the people at the Illinois Chapter of ASCE. By

doing these things, we raised as much money as necessary. We also managed to have the steel donated for free.

Fabrication:

Bridge fabrication started over spring break, when a handful of dedicated students built wood templates and forms to fit the steel pieces. Basic forms were built for the lower truss, lateral bracing, and the footings.

The steel pieces were first cut with the use of a chop saw. Complications arose when angled cuts had to be made for the lower truss. The fabrication team was able to use an angle to cut the pieces close to the correct angle, and a grinder was used to form the piece to the exact angle. Eventually, all pieces were grinded to reduce weight and make the welding process easy.

Once the pieces were cut and grinded, they were fit in their forms and welded. The MIG welding was done by three to four students, some of whom had just learned to weld. Once the pieces were welded together, holes for the connections were drilled and plugged. The lower truss was also cut into separate members, and fit with connections. Many of the connections were hand crafted with cutting tools and had to be continuously checked with the corresponding members to ensure that they fit properly.

Once the main superstructure was complete, the bridge was fully assembled and checked for possible ASCE rule violations in the member and superstructure set up.

Competition Setup:

The bridge was painted once the fabrication and design team agreed that the bridge was ready for competition. Spray paint was used to paint the bridge silver and red. Each side of the bridge was painted a different color to color code the pieces for simplified construction during the competition.

Testing was also done on the bridge before the competition to make sure there wouldn't be any outstanding errors. The bridge was loaded to a fraction of the loading it would experience in competition and the actual deflected was negligible. The bridge was also tested under lateral loading and passed the lateral test.

In Madison, a bridge setup team was chosen, and the team worked for an entire day to practice building the bridge from the completely separated members. Ultimately, it was decided that four people should be used to construct the bridge on the day of competition.

Assignments

Administrative Team:

During the first meeting IPRO meeting, the class decided on an administrative team which included an IPRO team leader, an IPRO office correspondent, and 2-3 students to help with fundraising, paperwork, and general administrative tasks. The role of the IPRO team leader and her workers was to organize the entire project, keep everyone on task, contact businesses for fundraising, and make sure deadlines for the project were met. The IPRO office correspondent was in constant communication with the IPRO office and worked to initiate the fundraising of money and matching of funds by the IPRO office.

Design Team:

At the beginning of the semester, all students were suggested to create a bridge design and present the idea in class. After ideas were presents, the class ruled out bad designs and assigned 6-8 students who had design experience to work exclusively on creating a bridge. The design team worked to create and test the design on SAP, and draw the connections and members on Auto Cad. The team also used outside sources such as professors to consult with ideas. Bridge design ended up being a continuous process that constantly needed to be modified even while the bridge was being fabricated. In the end, the design team completed all drawings for the bridge and handed them over to the fabrication team for construction.

Fabrication Team:

A Fabrication team leader stepped up so that the fabrication process would be more streamlined and simplified. His task was to review Auto Cad drawings and assign tasks for bridge construction. The fabrication leader also worked with the design team to make sure all forms and pieces were constructed to exact specifications. The leader also separated the fabrication team into a welding group and a helper group.

The welding group was comprised of IPRO members who had welding experience. Since only a few members were proficient welders, welding was limited to the times when they were available. Welders also had to have basic knowledge of the bridge design and Auto Cad drawings.

The helpers group did all of the cutting, grinding, and fitting of pieces. All of the steel for the project was prepared by these members. The helpers group also completed other miscellaneous tasks associated with fabrication, including traveling to the hardware store to buy equipment.

Competition Team:

The competition team practiced assembly procedures before constructing the bridge. It was there job to know where all the connections and members of the bridge fit for proper assembly. Ultimately, the bridge's fate for the competition would be in the hands of these members.

Obstacles

Throughout the semester, many obstacles had to be overcome to complete the bridge. The main obstacles the team confronted were time constraints, finances, communication, and equipment and facilities.

Time Constraints:

The IPRO is only a one semester project, and many students have a hard time finding enough free time to dedicate to the bridge. This created a delay in fabrication and bridge design. Many students found themselves dedicating most of their final month of the semester to fabrication. A solution would be to make the IPRO a two semester ordeal. This would allow students time to raise funds, create a sufficient design, and fabricate the bridge.

Finances:

To create a steel bridge requires money to purchase steel and equipment. Money was brought in from outside companies and all donations were matched by the IPRO office. However, it was hard to start fabrication of the bridge until fundraising was complete. The fact that the class managed to raise enough money to purchase all the equipment necessary for fabrication will definitely help for future steel bridge IPROs. One solution to ease the financial difficulty incorporated in the IPRO would be to create a regular budget so the fabrication process can be started much earlier in the semester.

Equipment and Facilities:

To start the semester, students had no equipment or location to fabricate the bridge. Eventually, we were able to use the HUB basement to work on the bridge. However, safety concerns over welding forced us to leave the HUB and move to the crowded soils lab in Alumni Hall. The students also had problems keeping their equipment a safe distance from the equipment used in the soils lab. A solution to this problem would be a student workshop on campus for all IPROs.

Software restrictions also limited the group. Many programs are available for design and drawing, but students were limited to using the software provided by the school only when the labs were available. Added software, even in just a single lab would of helped the students complete the IPRO design without limitations.

Communication:

As with any project, some students are going to dedicate more time to the projects than others. IPRO 315 wasn't any different, as some students dedicated all of their free time to the IPRO and others put the IPRO on the bottom of their priority list. Some students were completing their final semester and had higher priorities, such as searching for a job or taking the FE exam. The lack of help on part of unreliable, distracted students puts unnecessary strain on those dedicated to completing the bridge. The solution for this problem requires better communication between all students, and more awareness by those attempting to sneak by without participating.

Results

A successful design was produced and fabricated on time. Students learned a lot of about design, design modification and fabrication. As for the competition, our bridge earned 3rd in lightness and 3rd in aesthetics, placing 5th overall in the competition. Other awards included 4th in stiffness and 5th in efficiency. The main reason for the bridge's low overall score is because it couldn't take the entire required load. The load it was designed to take was 2500 pounds; however the competition team could only put 2375 pounds before the bridge started to sway excessively.

Recommendations

Making the IPRO a two semester project would definitely solve many of the problems experienced and eliminate many obstacles. Future steel bridge teams can definitely learn from the previous competitions, and should take their designs, accomplishments, and failures into account. Learning from the past definitely makes the IPRO experience easier and more successful.

References

http://www.ascegreatlakes2005.org/

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