Fall 2008

Steel Bridge Competition Design and Business Planning

Advisor: Chad Fischer

1.0. Abstract

The focus of this IPRO is to design and build a steel bridge to the specifications given by the AISC and by using teamwork. One of the goals of this IPRO is to win this year's ASCE/AISC Regional Steel Bridge Competition, and to place in the top ten in the National Steel Bridge Competition.

2.0. Background

A. The ASCE Steel Bridge Competition is co-sponsored by ASCE (American Society of Civil Engineers) and AISC (American Institute of Steel Construction). ASCE is an organization that is over 150 years old with a history in engineering and problem solving. The rules for the steel bridge competition are written by AISC and updated yearly.

B. The students are to design, fabricate and construct a scaled down steel bridge. The rules are based on real life build scenarios. Examples of said problems include: cost of the project, management, design, analysis, fabrication techniques, construction time, efficiency, and safety.

C. IIT has participated in this competition for many years. Our greatest success is the 2004 competition where the team went to nationals and placed in several events. Scientific issues that will be investigated are different design methods and use of analysis to find the best overall design. Ethical problems may arise in scoring of the competition.

D. All costs are absorbed by the organization involved in solving the problem. There are no costs on society. Any costs arising to businesses are by their own choice through sponsorship.

E. The solution will be implemented by splitting off tasks into sub groups. There is a

group for designing of the bridge, and to handle the business aspect. The business tasks include fundraising for expenses, keeping track of finances, marketing of the bridge to the IIT campus and the other businesses, and to complete any other administrative tasks.

F. Students will research past year experiences. Research includes the successes and failures of real life superstructure bridges, and rules of competition.

G. Attached are the bridge layout rules set by AISC and the introduction and summary of the competition provided by AISC.

3.0. Objectives

A. Marketing

The first objective of the project is twofold. The first part of this is the selling of the bridge to students and faculty and the second is the garnering of support from the local community. By gaining more student and faculty support a larger pool of resources both academic and monetary will be available. This can be done through the encouragement of school pride and something that IIT students can be proud of. Also teachers can greatly help the project by providing the valuable knowledge of marketing and design. In this way they can also actively teach students how to use the things that they are learning inside of the classroom. The bridge could also help to bring pride to the community. Local businesses that contributed to the project will be able to advertise that their materials are of a high quality and are among the best in the nation. This objective will involve mostly business majors but is able to include everyone in the project due to the fact that everyone can help to market the bridge regardless of their major.

B. Design

The second objective of the project is to design a bridge that meets the requirements specified in the ASCE rule book. Nevertheless it is an unspoken goal that the bridge should perform above and beyond the specifications in the rule book. The design of this bridge will involve architects, civil engineers, mechanical engineers, and material engineers. They will use their specialties to help meet the goals of efficiency, strength, and beauty. This is going to be done by designing a bridge that can be assembled in a quick and efficient manner. Proper materials and the dimensions of the beam that can be used to meet specifications will be strong factors of the design.

4.0. Methodology

Time Line	Deliverables/Plans	Status
September 10	**a)** Contact Companies i) Follow up with phone calls and emails ii) Find other contacts and repeat iii) Talk to companies around IIT for financial sponsorship b) Marketing	a) In Progress i) Chose to drop Decided Letters better course of action ii) Ongoing iii) Ongoing b) Ongoing
September 19	a) Figure out what we need in budget and materials i) Use previous years	a) Complete i) Approx $12,000 b) List is currently at over

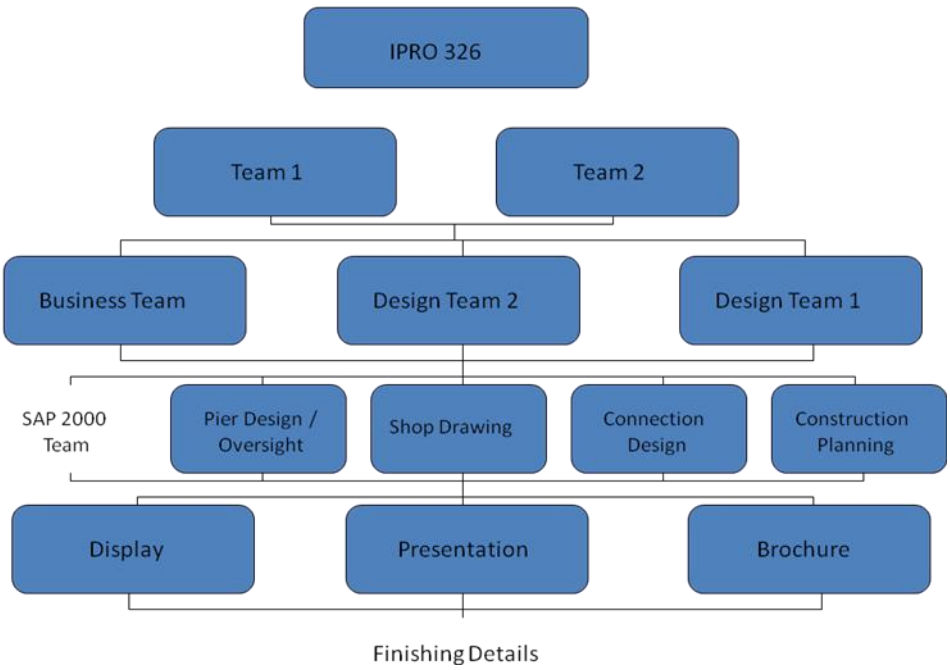
	budgets and receipts as a reference and work with design team to project a final cost b) Find major companies for possible donations and ask for local distributor/contact info c) Design i) Real life experiences with bridge design competition ii) Previous successes and failures iii) Different connections (1) IIT past connections (2) Photos from Nationals (3) School websites iv) Ways to build v) Fastest times	75 companies and friends of ASCE @ IIT c) Complete the rest of section d) Website dropped , decided not crucial to design and marketing. ASCE site to platform off of hacked
September 26	a) Write letter and make package i) Explain	a) Awaiting Mail b) Dropped c) Complete

	opportunity ii) Past awards iii) Past sponsors iv) Pictures/info of past and present national competitions b) Website i) Informational Section ii) Info for donors iii) Info about competition iv) Blog and pictures of status updates v) Info about IIT vi) Pictures/drawings as they become available c) SAP2000 – how to model and analyze? d) Rules / Concept i) Read and understand rules (1) Understand the	d) Complete

	problem (2) Know scoring requirements ii) Determine bridge shape	
September 30	**a)** Shape b) From researching, finalize bridge shape and layout to prepare for analysis	a) Complete b) Complete
October 7	**a)** Computer Modeling **i)** Build the bridge model in SAP2000 ii) Analyze system to acquire design loads b) Sizing Members c) Design members for the loads acquired from the computer modeling	a) Complete b) Complete c) Complete
October 21	**a)** Review-revise b) Look at current design and analyze possible problems and modifications	a) Ongoing b) Ongoing
November 4	a) Determine how to split the bridge in order to meet the	a) Complete b) Ongoing

	criteria from the rules 2) Connections a) Design connections for all of the joints in the bridge	
November 11	a) Draw shop drawings in Auto-CAD detailing connections as they are designed	a) In Progress

5.0. Team Structure and Assignments



Explanation:

The group was initially split into two groups to come up with preliminary designs. From there the group joined back together and split into three groups, Design team 1, Design team 2, and Business team. These groups were tasked with further design ideas, collecting sponsor information, and creating mailers. The whole team split again into five more groups to work on the finishing details of design, calcs, and construction. The final separation of the team was to prepare for the presentation.

Name	Major, Year	Skills and Strengths	Experience and Academic Interest	Team
Keenan Gottschall	Business, 3rd Year	Have planned and executed many group projects academically, and with organizations. Proficient in MS Office, Quicken accounting software, and AutoCAD	President, officer, or chairman of several project-driven organizations. Currently a Business Administration major with a focus on Finance.	Business Development
Michael McCarthy	Architecture 5th year	AutoCAD, 3d Studio Max, Adobe Photoshop and Illustrator, presentation development and layout	Worked on numerous academic team projects, strong interest in structural engineering	Team Leader Design Team 2
Peter Olney	Civil Engineering – Structural, 3rd Year	AutoCAD, MathCAD 14, SAP2000, steel bridge fabrication experience from previous years competition	Experience as an intern at a structural engineering firm doing timber and steel design. Currently a Civil Engineering major with a focus on Structures.	Design Team 2
Mike Hartwig	Civil Engineering, 3rd Year	Drafting/AutoCAD experience, welding & other mechanical skills currently enrolled in	Eagle Scout, ASCE member. Currently focused in general Civil Engineering.	Design Team 2

		Structural Design courses.		
Josh Gross	Architecture, 4th Year	Design	Drawing	Design Team 1
Marcus Choy	Aerospace Mechanical Engineering	Experience arc welding, mat lab, currently enrolled in materials and design,	Member of Tau Beta Pi, experience in estimating, used to working in groups to complete projects.	Design Team 2
Randall Weyhe	Architecture	Many rendering skills in 2d and 3d, AutoCAD, some fabrication exp, as well as laser-cutter exp.	Experience at an architecture firm for 1.5 years and dealt with all aspects of design as well as shop drawings	Design Team 1
Tracy Korbus	Architectural Engineering, 4th Year	Design	Structural analysis and steel design	Design Team 2
Jelena Milkic	Architecture Minor: Construction Management	Design, 3D modeling, AutoCAD, drafting, Adobe Photoshop and Illustrator, multitasking and organizational skills.	Experience in architectural firm as drafter, measuring and inputting drawings, interested in construction management.	Team Leader- Design Team 1
Kevin O'Leary	Business Construction Management	Quicken, AutoCAD, fabricating, previous year competition/construction experience	ASCE Pumpkin launch, ASCE Steel Bridge Captain '08, Member of CMAA, Interned as Construction Engineer.	Business Development
Michael Krueger	Civil Engineering, 3rd Year	Drafting/AutoCAD, currently in Structural Analysis and Structural Design, Adobe Photoshop and Illustrator	ASCE Member, SGA Vice President, UB VP of Publicity, Leadership Academy Scholar, marketing background	Design Team 1
Lucian Muresan	Civil Engineering, 4th Year	Management and design	Construction planning	Design Team 1
Justin Van Eaton	Civil Engineering, 3rd Year	Steel design, web design, structural analysis	Steel design, web design, structural analysis	Design Team 1

Trevor Dickson	Architecture, 5th Year	Conceptual design, computer graphics	Architecture structures and steel design	Design Team 2
Kaitlyn Conley	Civil and Structural Engineering, 5th Year	Structures, design, web communications, graphics	ASCE Webmaster	Student Advisor
Heather Grace	Architecture, 5th Year	Design, business administration	Classes in architecture and structure, professional experience in offices and fundraising	Business Development
Krzysztof Olszowy	Information Technology and Management	MS Office, Customer Relations, and organizational skills	Experience in technical drawing, blueprint reading, interested in network systems and management	Business Development

6. Budget

A.

IPRO Budget

	Approved for	Used	Final Remaining	
Supplies	$200.00	$199.12	$0.88	
Equipment	$250.00	0	$250.00	
Travel	$50.00	$24.41	$25.59	($8.50 Tolls, 27.2 miles)
Totals	$500.00	$223.53	$276.47	

B. As mentioned, the only expenses incurred by the IPRO included the travel expenses for our field trip and manufacturing a model of the members to display on IPRO day. This includes supplies such as welding wire, files, saw blades, dremel accessories, grinder discs, nuts, and bolts that will also be used for the fabrication of the bridge in the spring. In addition, there were costs for fabrication of a miniature "plastic" model of the bridge

for $10 and other office expenses. The supplies in total included $199.12 and approximately $24.41 in travel expenses.

7. Results

A. A computer model of the bridge was created to determine the structural capabilities and characteristics of the bridge. The software employed for this purpose was SAP2000, an industry standard for structural engineering. The software was able to provide such information as how much the bridge would deflect, how much the bridge would weigh, and if the individual members of the bridge would keep their integrity.

B. For SAP2000 to give meaningful results, the bridge must be properly modeled. As the placements of the vertical loads on the bridge during actual contest are variable, the extreme limits were applied for modeling purposes. That is, the load placements that would provide the maximum stresses and deflections in the bridge were used.

C. Each section of the bridge was designed to provide maximum strength while keeping the weight minimal. When it came to strength requirements, there were two areas of focus. One was on the stress forces that the bridge could withstand and the other was the bending forces the bridge could withstand. The maximum amount of cross sectional area (the more area the more weight) was determined to satisfy the stress needs from the loads being applied to the bridge. From the cross sectional area that was found, the shape of the cross section was designed. The deeper the cross section, the more bending force the bridge can withstand. Keeping in mind the size requirements for the bridge, the deepest cross section was selected.

8. Obstacles

A. The business development portion of this IPRO encountered problems with creating a plan to market and publicize this project to the campus in order to gain interest, and potentially additional help, with the fabrication of the steel bridge that will take place during the spring semester. As for the construction method that was being put together some trouble was brought on by the fact that this team had to create a process of construction based on 3-D models, and shop drawings, which is somewhat less than ideal in this case due to the fact that it would be more efficient to have the actual structure on-hand in-order to account for the various factors that play into the construction of the bridge. Some of the various factors that play into the construction method include weights of individual members, as well as, fabrication of the members, and the practice of constructing the bridge before the competition.

B. To resolve the business development issue the team that was assigned to marketing brainstormed a variety of methods, such as, competitions, t-shirts, and other methods, that will help to gain interest from students and faculty on the IIT campus. Either all of these methods or some of these methods can be used by the ASCE or a spring semester steel bridge IPRO team to get more help with the construction of the bridge which will be the final, and most essential, section of the bridge project. To resolve the construction method issue this team developed a series of plans that can be tested when the actual structure is on-hand, and this series combines various steps that take into account different methods of construction, such as, counter-weights and temporary piers. The team will not be sure which methods of construction work, if any, until the bridge can be constructed in the spring.

C. There was no way to avoid or reduce the impact of the business development and construction method problems because they depend on outside factors that cannot be controlled by this team.

D. The remaining barriers that need to be addressed by a continuing team are the matter of building the actual structure so that all of the construction issues can be addressed. Also the solution to the business problems will need to be addressed by testing the various methods on campus to see which help to gain the most outside interest in the project.

E. This additional section will utilize a more technical discussion in order to explore an important design issue that was encountered during the course of the semester. This problem encountered during the design of the bridge dealt with the possible local buckling of the top chord. The top chord was designed to take an axial compressive load. The strength of the desired top chord section is dependent upon the un-braced length of the top chord. The total bridge length is 19'-2" which becomes the un-braced length of the top chord with no lateral bracing. This means the section has a greater chance of buckling and thus drastically reduces the axial capacity of the member. The rules for the bridge competition state that both sides of the bridge must be 3 feet apart and a member can be no longer than 3.5 feet. There is no question that our bridge needed lateral bracing in order to reduce the required size of the top chord section and thus decrease the overall weight of the bridge. We decided to use lateral bracing which spans straight across the bridge perpendicular to each top chord. This bracing works fine for transferring the applied lateral load, however, it is questionable whether or not it provides adequate lateral bracing for the top chord under the maximum gravity live load. The question becomes does the perpendicular bracing adequately prevent local buckling. There is a possibility

that with this type of bracing, both top chords could buckle together in the same direction. In a real bridge design, this fact could not be ignored and some sort of x-bracing would be required. However, for the steel bridge competition we decided that it would be ok to brace it in this way. The alternative would be to add long x-braces consisting of 2 members each. This would add weight to the bridge as well as construction time due to the added connection. After fabrication, the bridge must be load tested in order to confirm that our assumption is ok for the stability of the bridge.

9. Recommendations

Ways to optimize bridge:

In order to further optimize the bridge, it needs to be fabricated and assembled. The construction process must be practiced to determine any complications or areas that negatively affect the overall build time. From the constructed bridge, these problems can be resolved. In addition to the assembly process, the load tests must be done on the bridge. The gravity load test can determine whether or not the bridge adequately carriers the load and what can be optimized for counteracting the problems that arise. The end members of the bottom chord may not be necessary to keep the bridge stable; a load test without them would help determine their usefulness. Removing them would decrease construction time and overall weight. The lateral load test needs to be done in order to check the efficiency of the lateral bracing members. It might be necessary to use x-bracing in order to decrease the overall lateral deflection and increase the lateral stability of the bridge.

10. References

AISC - ASD/LRFD Steel Construction Manual, 13th Edition

SAP2000

ASCE 2009 Steel Bridge Competition Rules

11. Resources

Due to the nature of the project there was a great deal of team work and brainstorming involved. The project began as two teams set out to design alternatives to meet the ASCE guidelines for the steel bridge competition. Each team was assigned the task of creating a profile for the bridge; determine the members to be used and to determine a project plan for the remainder of the semester. The teams collaborated on their ideas and finalized two designs and one project plan. From that point, the class was reorganized into three teams, a business team and two design teams which applied each team mates major to a more specific cause. The business team with comprised of architects, business majors and construction managers who were assigned the task of finalizing a budget plan and working on the ongoing task of obtaining donations for the project in the spring. The two design teams were assigned the task to finalize an idea for web members and connections. At the end of the two weeks, each team reported and collaborated. At this time we evaluated our progress against our initial project plan and reorganized the class again into five teams: SAP 2000 structural analysis group, pier design/ oversight, shop drawing design group, connection design group, and construction planning group. Each group had two weeks to use their skills to finalize the project. Once the project was finished, there were two weeks to reassign the class into three groups dedicated to finishing the deliverables required by the IPRO Office. A list of each team member in this IPRO and their skills are listed below.

Throughout the project there was little need for expenses. Our project focused mainly on research and brainstorming. As an educational experience, we had the opportunity to visit a steel fabrication plant in Indiana. The only expense throughout that field trip was the travel expenses as explained in the budget.

12. Acknowledgements

A. Steel bridge IPRO has been an immense educational experience for all its participants. The students of IPRO 326 would like to give a special thanks to IITs' very own American Society of Civil Engineers (ASCE). The members of ASCE put their own time in, so the bridge can be brought to life and assembled. A few of the ASCE members will be the people competing in the Steel Bridge Competition. We wish them the best of luck, and are sure they will be a great success.

We would like to thank the volunteers from the CAE department Stan Johnson and Jorge Cobo. Stan is our helpful handyman who works on the fabrication and detail of the bridge. Jorge helps out a lot with the design development. He has a vast knowledge of structural. We are very appreciative of the involvement of these two individuals. They have seen this project come along way.

We would like to thank the companies that will sponsor the fabrication. The steel bridge could not be possible without their generosity. Specifically thanks to a few companies who have been donating several years in a row:

American institute of steel construction AISC

Garbe Iron Works

FH Paschen, SN Nielsen

ASCE Illinois section

Students of IPRO 326 are not all work though. We have fun too! We visited a steel fabrication company in Gary, Indiana. It was very interesting to see how steel was manufactured. We would like to thank Industrial Steel Construction, Inc (ISC) for their hospitality and letting us behind the curtain.

IPRO 326 also owes a big thank you to Kaitlyn Conley, for her efforts. The school board was not considering steel bridge for an IPRO, but because of Ms. Conley's persistence and determination it was reconsidered and made into an IPRO. Now, she is still involved by giving a helping hand when it is needed and has been overseeing that is a success. Fortunately, her job has been an easy one because of the outstanding instructor that we've had to lead us through the semester.

Our greatest thank you goes to Chad Fischer for all his time spent with us and his influential guidance and instruction. Chad could not have been more cheerful, patient, and willing to assist us whenever we had questions. He was great to work with and we appreciated the energy and ideas he brought to this project. We hope to see him in the steel bridge IPRO future.