Mr. Abdullah Y Kassab
TPAC Kiewet Western Co.
3052 S. 19th Ave.
Phoenix, Arizona 85009

September 19, 2013
NAU PCI Big Beam Team
Northern Arizona University Department of Civil and Environmental Engineering
2212 S Huffer Ln,
Flagstaff, AZ86001

Dear Abdullah Kassab:

We appreciate your response for request of sponsorship in the PCI Big Beam Competition. Through research and analysis, an ideal beam design will be created to ensure quality results in the competition. Our team will provide you with the most advantageous design to ensure cost is low and performance is high.

As three University seniors who are involved in the PCI big beam project, we are pleased to submit our project proposal to you. Our team has done extensive research concerning the project based on the PCI website including the Official Rules for the PCI Engineering Design Competition. After reading this proposal, we believe you will find that our team already has a viable understanding of this project. The following is a list of objectives that our team has already fulfilled:

- Full knowledge of due dates including the contest design report as well as the structure and concrete mix design must be submitted before the deadline.
- The background of this project and the contest judging criteria are also mastered and are given in the attached memo.
- Meetings have been established with our specified Technical Advisor, Robin Tuchscherer, and looking forward to his and your help.
- The existing conditions of the project have been reviewed and discussed.
- All technical aspects of this project have been identified and a schedule was developed to overcome these technicalities.
- Potential challenges have been identified by all of the members of the team and we are working on completing the tasks at hand.

Our team is pleased to submit the following proposal to you for your review. The structure of the proposal is as follows:

Part 1 Project Understanding
Part 2 Scope of Service

The attached proposal has more detail on the list above. Thank you for this opportunity and your company's sponsorship. We look forward to your response and are very excited to start designing and manufacturing. If you have other questions, please feel free contact us.

Sincerely,

Chad Dietrich cd352@nau.edu

Mengxi Du md552@nau.edu

Wael Alqattan wa45@nau.edu

PCI Big Beam Competition

Proposal for Services

December 6th, 2013

(Alqattan, 2013)

Prepared for:

A Division of Kiewit Western Co.

Abdullah Y Kassab, Ph. D, P.E.
TPAC Kiewit Western Co.
3052 S 19th Ave.
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Submitted by:

ENGINEERING, INC.

CMW Engineering, Inc.
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Table of Contents

Key Staff **5**

Project Understanding **7**
Purpose 7
Eligibility 7
Background 7
Key Stakeholders 8
Existing Conditions 8
Technical Objectives 9
Potential Challenges 11

Scope of Service **13**
Task 1- Project Management/Review of Current Practice 13
Task 2 – Preliminary Analysis and Design 14
Task 3 – Final Analysis and Design 15
Task 4 – Beam Fabrication 16
Task 5 – Beam Testing 16
Task 6 – Capstone and Competition 17

Project Schedule **19**

Cost Proposal **21**

Closing Statement **23**

Appendix A **24**

Appendix B **29**

Key Staff

Staff Member	Year Experience	Project Role
Chad Dietrich	4	Project Manager
Wael Alqattan	3	Capstone Manager
Mengxi Du	3	Analysis and Design Manager

Chad Dietrich – Project Manager

Mr. Chad Dietrich is a Civil Engineering Undergraduate Student with over 4 years of education experience and over 2 years of landscaping foreman experience. He has spent 2 years as a foreman for Warner's Landscaping in Flagstaff, Arizona managing various projects ranging from residential to corporate. Led a team of 6-8 personnel coordinating with customers, contractors and supervisors to achieve accurate and outstanding landscapes. His experience with contractors and customers allow him to provide proficient communication with the client in this project. Understanding what a customer wants and needs will allow Mr. Dietrich to complete the various task to complete this project with efficiency and accuracy. His skills include: Air Force leader, creative problem solving, outgoing person, optimal performer, well organized, exceptionally timely and a tremendous team member.

Wael Alqattan – Capstone Manager

Mr. Wael Alqattan is a Civil Engineering Undergraduate Student with 3 years of education experience at Northern Arizona University. He has studied English as second language at Rice University of Houston, Texas. He is a member of Union of Kuwaiti Students where he once held a leadership position. Currently, he is the president of The Kuwaiti Students Club and Northern Arizona University. My Alqattan has been awarded with the Dean's list and is a member of The National Society of Collegiate Scholars since 2010.

Mengxi Du – Analysis and Design Manager

Ms. Mengxi Du is a Civil Engineering Undergraduate student of over 3 years. She began her education at the Xi'an University of Science and Technology in Xi'an, China. Ms. Du transferred to Northern Arizona University in 2010. She is also pursuing a minor in Mechanical Engineering. She retains effective communication skills and it fluent in English and Chinese. She has a great familiarity with Microsoft Office, AutoCAD, SOLIDWORKS, and Structural and Hydraulic programs. These skills will allow Ms. Du to be an excellent Analysis and Design Manager for this project. Her computer skills will provide the team with proficient time management and accurate calculations. She is currently an Undergraduate Research Assistant at Northern Arizona University where she has participated in research involving Thermal Snow Melting Systems in Northern Arizona and asphalt. Her accomplishments include 2nd Place in the 2013 Arizona Material/Pavement Conference Student Poster Competition, Dean's List and has been an ASCE Member since 2012.

Project Understanding

Purpose

The purpose of this project is to effectively create a design for a prestressed, precast, reinforced concrete beam. Each team will develop and submit one report to the PCI Big Beam Competition. A submittal includes the design, analysis, predicted data, and experimentally measured data. Parameters have been set by the PCI Committee and will be discussed below. The groups must collaborate with a PCI Producer member to design and manufacture the beam. Testing of the beam will be done at the Northern Arizona University campus. All design, testing and analyzed material will be submitted to PCI and awards will be given to the team that most satisfies the requirements set forth by PCI (PCI, 2013).

Concrete Setting at TPAC (Alqattan, 2013)

Eligibility

Any team of students enrolled in an Associates, Baccalaureate or Graduate Degree Program of Civil Engineering, Construction Engineering, Construction Management, Architecture, Architectural Engineering or Building Sciences (PCI, 2013). Our team meets all of the eligibility requirements for this project.

Background

Since 2005, the PCI Student Education Committee has invited engineering students to participate in the PCI's Engineering Design Competition (PCI, 2013). The competition calls for a local PCI certified manufacturer to sponsor each group. As a sponsor, the company will produce and give professional advice regarding the design of the beam. Teams from various universities will design, analyze and test a precast/prestressed concrete beam. Sika Corp. has provided various rewards, including cash, for the team that submits an outstanding and accurate report (Burgess & Stephens, 2013). This report is one of many deliverables for this project.

The main deliverables for the competition include the precast/prestressed concrete design, material testing, a full engineering report summarizing predictions, results and processes taken to produce a successful beam.

Prestressed concrete is any concrete that has an initial stress when it is released from its forms. One method of prestressing concrete is to apply tension to a steel cable within the concrete form. The concrete is then pour into the form and it will settle around the cable. Once the concrete sets, the forms are broken and the steel cable cut. The tension in the cable will create an initial compressive stress on the concrete which will increase load capacity at which the concrete cracks. Once the concrete has cracked due to compression the force will be transferred to the tension steel. Steel has a higher tension capacity than concrete. As stated above, the advantage of prestressed concrete is that the concrete has a higher cracking capacity. The advantages of precast concrete is the improvement of manufacturing conditions. A precast manufacturer has the ideal tools and resources to produce a quality concrete structure. The concrete is released quickly and this is due to the economic advantage.

Key Stakeholders

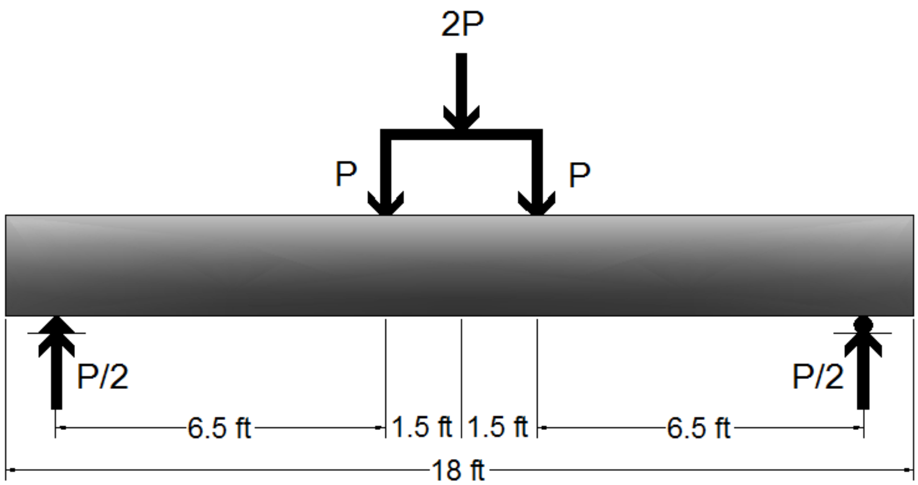
This project includes three major stakeholders; a technical advisor, a sponsor and the PCI Student Education Committee. The team's technical advisor is Dr. Robin Tuchscherer of Northern Arizona University. Dr. Tuchscherer's role is to help the team with any technical aspects of the design and help avoid any critical mistakes that can be make during the design process. He can also offer a higher insight on the development of prestressed concrete design. The next key stakeholder is the team's sponsor for the competition, TPAC. TPAC Precast is a PCI Certified manufacturer located in Phoenix, AZ. Our point of contact and TPAC's representative is Mr. Abdullah Kassab. TPAC's role is to donate and manufacture the beam, as well as offer professional advice pertaining to prestressed/precast concrete. The final stakeholder for this project is the PCI Student Education Committee. Members of the committee produce the rules and parameters for the competition and will judge the team's final submittal. These key stakeholders rely on the team to achieve the best possible ranking in the competition. Also, each one of the stakeholders contributes their personal time so the team can be as innovative and successful as possible. It is the team's responsibility to ensure that all objectives and deliverables are achieved.

Mr. Kassab on Far Right (Alqattan, 2013)

Existing Conditions

The following is an overview of the parameters given by PCI, a full copy of the rules is provided on page 25 of the Appendix. A short overview of the parameters are described in this section.

The PCI Competition calls for a prestressed, reinforced concrete design and testing for a beam simply supported at 16 feet. The beam must undertake a simulated live load of 22 kips (22,000 pounds) without crack and fail between 35 kips and 42 kips (PCI, 2013). A diagram is provided below displaying the location of the two point loads. To clarify, the simulated live loads will be equal to “2P,” thus providing two individual point loads of half the quantity of the live loads given. For example, the maximum ultimate live load is 42 kips. This will render two point loads of 21 kips each.



The beam is simply supported over a 16 foot span and will undertake to point loads. The diagram above shows the specific locations of loads, supports and their dimensions. (PCI, 2013)

A submittal containing design, predicted values and actual values will be developed and judged on a point system. Material cost and weight is given on page 28. The team must account for materials cost and beam weight for there are point reductions given for excessive weight and cost. The specific point system is located on page 27 (PCI, 2013).

The team is limited to the rules set forth and certain specifications that must be followed to place high in the competition.

Technical Objectives

Many technical objectives are present in this competition. The major objective is to design a beam with a cracking capacity larger than 22 kips and an ultimate load between 35 kips and 42 kips. An excel spreadsheet will be produced by the team to develop design alternatives. The excel spreadsheet allows the team to input different variables pertaining to the beam design. These variables include change in shape/size, amount of prestressed strains used, amount of compression steel used and the type of concrete used. Once an ideal alternative is chosen, predictions for cracking capacity, ultimate load and ultimate deflection will be more accurately estimated by a fully sectional computer software analysis called Reponses 2000. A fully sectional analysis software will break up the beam into very small sections and determine the moment and curvature of each. The program will then accumulate all the sectional data and produce a moment-curvature curve. With further analysis of this curve, the deflection, cracking load, and ultimate load can be determined. The data estimated by the Response 2000 will be used as the official predicted values in the submittal to PCI. Once the beam is manufactured and has reached the team's specified strength it will be shipped to Northern Arizona University for testing. The testing will occur in the Engineering Building. The actual test will document the cracking load, ultimate load and deflection. These measurements will be compared to the predicted values (PCI, 2013). In addition to PCI submittal dates, deliverable deadlines will be established by the CENE 476 instructors, as well as additional research and understanding.

Prestressed concrete design requires additional seminars with our technical advisor and additional personal understanding. The seminars began on October 12th and continued during the team's weekly technical advisor meetings. The seminars offer a greater understanding of prestressed concrete properties. In accordance to the parameters set by PCI, the seminars focus on the concrete strength at release, ultimate concrete strength, moments of steel yielding, appropriate placement of compression and tension steel, moments of concrete cracking and failure, flexural analysis, live load placement, ACI code requirements, types of concrete conditions during loading, etc.

In addition to the seminars, time must be taken to obtain an ideal concrete mixture. TPAC will provide information pertaining to their lightweight and normal weight concrete. Each mix has its advantages and disadvantages. For example, lightweight concrete will cost $10.00 more per cubic yard (PCI, 2013). However, lightweight concrete will weigh less. Also, light weight concrete has a lower ultimate stress capacity than that of normal weight concrete. These are the types of factors that must be taken into account when designing this beam. The team will develop alternatives including the different types of concrete. The team will discuss the reasoning for choosing the mix and will include any modifications to the mix if applicable (PCI, 2013).

Further Technical Objectives given by the PCI Competition Rules are the requirements for the final report. Below is a list, provided in the rules, regarding the minimum necessities for the final report, this list can also be found in the Appendix A:

- A cover page with name of school, team members, sponsoring producer member, and faculty advisor according with the report.
- A completed summary/judging form and the total load/midspan deflection graph.

- Certification that the calculations were performed before beam testing. The calculations may be certified by the producer member, a regional director or a neutral third party.
- Drawings of the cross sections and elevation of the beam, showing reinforcement.
- A one to two page narrative about the concrete mix used, including proportions, measured unit weight, slump, air content and 28 day compressive and tensile strengths. A discussion of the reasoning for choosing the mix, any modifications to the mix and a discussion of how the chosen mix performed with respect to the team's design requirements is required.
- A one to two page discussion of the structural design. In addition, the design calculations along with a prediction of the cracking load, maximum applied load and a prediction of the midspan deflection (due to applied load only) at maximum load shall be provided as an appendix.
- A narrative of not more than 8 pages (including any pictures) describing the beam fabrication and testing. This must include the load/midspan deflection graph showing peak load and cracking load.
- A statement by the team members explaining what they learned from the contest.
- DVD of the test showing at least the highlights of the test and the failure for verification purposes. There shall be a visible scale showing the beam deflection (Precast/Prestressed Concrete Institute, 2013).

Potential Challenges

Many potential challenges may occur during the design, manufacturing and testing of the beam. Communication is key for the success of this project and always posed a potential challenge. Choosing the ideal alternative for this design is expected to be a major challenge during the design phase. Also, the transportation, testing and specified deadlines are also additional challenges. Potential challenges and avoidance procedures are discussed below.

Communication is the driving factor for any project. A solid line of communication must be established throughout the designing and manufacturing phases. Each member of this team will ensure they have an open line of communication with each other. Timely responses and meetings will eliminate any chances for communication errors. Our sponsor and PCI Producer Member is TPAC Kiewit Western Co., located in Phoenix, Arizona, approximately 145 miles south of the Northern Arizona University campus. The distance between the production plant and the design team can pose a potential challenge that may influence the project in many ways. The conveyance of ideas and designs is a critical part for success in this project. If there are any conflicts in the design plans or delays with production, it is important that the team is notified. To overcome this potential challenge, frequent and accurate communication will occur between the two parties. Early design submittals will be utilized in case there are any questions of concerns by the manufacturer. The team has met with its sponsor, Mr. Kassab, and has established a solid line of communication. Expectations of the team and shop drawings have been created to ensure an ideal beam is manufactured without any faults or discrepancies.

Another potential challenge is the safety and set up accuracy of the testing apparatus, "The Hulk." "The Hulk" will provide a load of 42,000 pounds to the beam. Since, the beam is to be tested to failure, a large amount of energy will be released. When this energy is released, it is essential that the team and all other spectators are safe. To address this challenge, constant communication will be established during testing and the proper safety equipment will be worn. Also, it is important that the instrumentation used to measure load and displacement are accurate because there is only one beam being tested. To overcome this challenge, the team will program and set up the necessary equipment so that an accurate test can occur. Various testing tools will include a hydraulic cylinder, linear potentiometers, load cells and video camera.

Lastly, a potential challenge will be to meet all of the deadlines established by PCI, TPAC and the CENE 476 Engineering Design class. It is important that all deadlines are met to ensure success in the competition and the class. To overcome this potential challenge, the team will produce a Scope of Service and Gantt Chart. Ample amount of time will be given for each task and the team will strive to stay ahead of schedule. Additional time will be given in case there are any setbacks in the design, manufacturing and testing of the beam. Subtasks will be established to ensure the team is on schedule. If all subtasks are completed by the given date then all major tasks and milestones will be met, ensuring success in this project.

All of the potential challenges pose a threat to the success of the project. It is the team's responsibility to manage each challenge, address them and promptly overcome them to produce an ideal and accurate report for the PCI Big Beam Competition.

Scope of Service

This section will discuss all of the necessary tasks and their subtasks that must be completed to ensure all deadlines and deliverables are met.

Task 1 – Project Management/Review Existing Projects
Task 2 – Preliminary Analysis and Design
Task 3 – Final Design and Analysis
Task 4 – Beam Fabrication
Task 5 – Beam Testing
Task 6 – Capstone and Competition Deliverables

Task 1 - Project Management/Review of Current Practice

This task enables the team to ensure quality and allows the team to keep track of project updates. The following tasks will allow the team to avoid costly mistakes and reduce the risk of missing project deliverable dates. Review of Current Practice research is an important aspect of this project because it allows the team to gather knowledge on existing designs. With knowledge of existing designs the team will be able to produce a beam and counter potential problems. This task will be continued throughout the duration of the design. PCI encourages students to develop new alternatives and ideas (PCI, 2013).

1.1 Precast/Prestressed Seminar Lectures

This project requires additional seminars with the team's technical advisor regarding the details pertaining to prestressed/precast design. These meetings are ideal because they offer greater knowledge and understanding of the project. These lectures began on October 12th, 2013 at 8:00 am and additional seminars have occurred during the technical advisor meetings. The first lecture was a milestone because it allowed the team to begin the design excel.

1.2 Weekly Team Meetings

These meetings will take place to ensure the entire team is on the same page regarding details of the project. Meeting times are tentative due to team member's schedules and are limited to one per week. The meetings will allow the team to constantly coordinate ideas and task completions for the project.

1.3 Technical Advisor Meetings

This task is important because it gives the team the opportunity to report, ask questions and get advice from our technical advisor on a weekly basis. Any potential challenges or problems with the project will be discussed at this time. These meeting take place every Friday at 3:15 pm and end at approximately 4:00 pm.

1.4 Review Existing Projects

The team must review previous precast/prestressed beam designs. This can be done by reaching out to our technical advisor and sponsor. With prior knowledge of this project, our technical advisor has the ability to express to the team what works and what will not work. The team will continue to be innovative but this task will allows us to develop a beam design that is practical. This research will occur throughout the majority of the project beginning on September 9th and ending on November 1st, 2013. A visit to the TPAC manufacturing facility will offer a look at existing projects and will occur on October 29th.

Set Prestressed Concrete Members at TPAC (Alqattan, 2013)

Task 2 - Preliminary Analysis and Design

This task will include the analyzation of different options which will lead to an ideal beam design. Factors including concrete type, dimensions, area of prestressed steel and area of compression steel will warrant different results.

2.1 Concrete Mix Analysis

To obtain the ultimate design, the team must first ensure the concrete is acceptable for this design. Lightweight and normal weight concrete provided by TPAC will be analyzed. If the concrete mixes do not meet the qualification required for this project then the team will develop a unique mix. Cylinders will be tested in the Northern Arizona University lab and a strength data will be collected. This task will occur from November 1st to November 18th, 2013. Choosing the concrete mix will be a milestone for this project.

TPAC Has Many Mixes but Can Accommodate for Any Unique Mix (Alqattan, 2013)

2.2 Beam Design Analysis

An excel spreadsheet containing all of the required parameters will be produced. The spreadsheet will allow the team to develop alternatives. The differences in each alternative include, but are not limited to: dimensions, properties of concrete mix, flexural steel area and location, prestressed steel area and location, etc. The duration of the development of this excel is November 1st to November 29th, 2013.

2.3 Design Decision Matrix

A decision matrix will be developed to choose the ideal alternative design. The matrix will include advantages and disadvantages of each alternative. A point system will be developed in regards to the scoring system given by the PCI Committee. A minimum of four alternatives will be produced. This task will occur after Task 2.2 is completed and a minimum of four alternatives will be submitted by December 6th, 2013.

Hollow Core Designs Offer a Light Weight Alternative (Alqattan, 2013)

Task 3 - Final Analysis and Design

This task will include the subtasks required to choose a final design. Final dimensions and steel areas will be determined during this task. The final design will be run through a simulation program and the resulting values will be used as predicted values in the submittal to PCI.

3.1 Choose One Alternative

In this task, the final design will be chosen. By utilizing the decision matrix, all alternatives will be analyzed and one ideal design will be chosen. This task will only take one day and will occur on December 6th, 2013.

3.2 Shop Drawing Using AutoCAD

An example shop drawing will be obtained from TPAC to ensure the design specifications are accurately portrayed. A detailed model will be drawn, revised and looked over by the team's technical advisor before being shipped off the TPAC for manufacturing. This task will occur from December 7th, 2013 to January 17th, 2014.

3.3 Final Calculations Using Response 2000 and Excel

The final design will be analyzed using Response 2000. The required inputs will be inserted into the program and the software will output the moment-curvature response of the team's beam's cross-section. These values will be used to predict the cracking capacity, ultimate capacity and ultimate deflection of the specimen. The information gathered during this simulation will be used in the final report to PCI. This task will be done between January 13th and January 17th, 2013.

Task 4 - Beam Fabrication

This task will include the sending of shop drawings the TPAC and their review of the drawings. If the drawings contain the proper information then the beam will began fabrication. Transportation of beam is also included in this task.

4.1 Sending of Shop Drawings to TPAC

Once the shop drawings are finalized and reviewed by the team's technical advisor then they will be sent to TPAC via email or mail. A confirmation of retrieval and quality will be given by TPAC and manufacturing will begin. This task will occur on January 18th, 2014. This task will be a milestone for the project.

4.2 Beam Manufacturing

Once designs are approved, manufacturing will begin. Forms and concrete mixes will need to be produced. The project is applicable to TPAC's project schedule and the time of manufacturing can be tentative. The potential dates of manufacturing are January 30th to February 26th, 2014.

4.3 Beam Transportation

This task will occur when the beam manufacturing is complete and the concrete has reached its ideal 28 day strength. As stated in 2.5.2 the beam's transportation is also reliant on TPAC's schedule. The potential date of transportation is February 27th, 2014.

Task 5 - Beam Testing

This task contains subtask that will ensure the proper and accurate testing of the beam. All final testing analysis and data will occur during this task.

5.1 Predicted Calculations in Response 2000

Once the beam is transported the team will have actual weight and dimensions. Cylinders will be tested to determine the properties of the concrete in the beam. The Response 2000 outputs the moment-curvature behavior of the beam from release to failure. The team will interpret and analysis the moment-curvature cure to attain the values that will be used in the submittal to PCI. This task will be completed on February 28th, 2014. This is a milestone because this data will be used in the final submittal report.

5.2 Preparation of Testing Apparatus

This task will include all of the preliminary tasks required to ensure an accurate test. Safety concerns will be regarded during this task. All measurement devices must be calibrated and attached to the beam where applicable. The team must ensure all equipment is accurate for there is only one beam being testing. Also, a video camera will be set up to document the testing. The test preparation is dependent on task 2.5.0 but is scheduled to take place between March 1st and March 13th, 2014.

5.3 Testing and Gathering Data

The beam will be placed in the testing apparatus and the point loads will be applied. The beam will be tested until failure with a constantly increasing load. The rate of load is still to be determined. All measurements will be monitored to ensure accuracy and all data will be recorded. The duration of the test will be videotaped and all data stored for later analysis. Again, this task is dependent on the completion of previous tasks but currently the testing will occur on March 14th, 2014. The testing and data gathering of the beam will be a milestone for the project.

5.4 Analysis of Results

All of the data obtained during tested will be compared to the predicted results in task 2.6.1. Differences in actual and predicted results will be analyzed and documented for the PCI submittal. This task will occur after testing is done between March 15th and March 30th, 2014.

Task 6 - Capstone and Competition Deliverables

This task will include all of the deliverables required by the PCI Competition Committee and the Capstone class.

6.1 Project Website

The project website is to be completed by April 10th, 2014 but a preliminary check will be conducted on December 6th, 2013. The website must include a populated homepage and a documents page. Details pertaining to content are given by the capstone instructors. The completion of the website will occur in the spring. The duration of this task is from November 1st, 2013 to April 25th, 2014.

6.2 Proposal Report & Presentation

This task includes the preparation of the proposal and proposal presentation to the client. This task will be completed between November 15th and December 6th. This task is a milestone because it marks the completion and submittal of all deliverables required by the CENE 486 class.

6.3 50% Design Report & Presentation

This task will include half of the total design report. This will allow the team to obtain valuable information and feedback regarding the progress of the project. This task will occur from December 7th, 2013 to March 13th, 2014.

6.4 Final Project Report & Presentation

This task include the finalization of the design report. This task will be completed between April 16th and May 1st, 2014. This task is a milestone due to its importance regarding the completion of the project.

6.5 Final Submittal to PCI

The final submittal to PCI will include a full report, video recordings of test, test analysis and other objectives specified by PCI. This report will be completed between Mat 1st and June 15th, 2014.

Project Schedule

A detailed project schedule is provide on the next page. Major milestones for the project are displayed below:

Milestone	Date
Precast/Prestressed Seminars Begin	October 10th, 2013
CENE 476 Deliverables Submitted	December, 6th, 2013
Shop Drawings to Client	January 1st, 2014
Prediction Analysis - Response 2000	February 28th, 2014
Testing	March 14th, 2014
Final Project Report Submitted to CENE 486 Instructors	May 1st, 2014
Final Report Submitted to PCI	June 15th, 2014

This schedule is over a total duration of 205 days from preliminary design and report of testing. Due to TPAC's tentative schedule some adjustments will be made accordingly. The team will modify and monitor the schedule to ensure all task are completed.

Insert Project Schedule

Cost Proposal

Services needed to accomplish all tasks stated in the schedule in the previous section is described in the section below. The maximum cost for this project will be approximately $57,105.40.

Design and Production Cost Estimation

Task Name	Overhead ($150/hr)	Project Engineer ($218/hr)	Engineer 1 ($135/hr)	Data/Analyzation Technichian ($86/hr)	Cost Per Task
Task 1: Project Management/SOTA					
Precast/Prestressed Seminars	2	4	4	1	$1,786.00
Decision Matrix Spreedsheet	2	4	4	1	$1,786.00
TPAC Manufacturing Plant Visit	1	1	1	1	$586.00
Select mix/Design Own Mix	1	2	2	4	$1,194.00
ACI 318-11 Code Regulation	1			2	$322.00
Task 2: Preliminary Analysis and Design					
Concrete Analysis/ Cylinder Testing		2	2	4	$1,044.00
Concrete Samples Analyzed		1	1	6	$866.00
Beam Design Analysis		2	2	8	$1,388.00
Design Decision Matrix	1	4	5	12	$2,717.00
Task 3: Final Design and Analysis					
Choose Alternative		1	1	2	$522.00
Develop Shop Drawing	1	4	6	10	$2,680.00
Response 2000 Report				12	$1,032.00
Task 4: Beam Fabrication					
Shop Drawings Sent to Client		1			$215.00
Beam Manufacturing					$0.00
Beam Transportation					$0.00
Task 5: Beam Testing					
Predition Analysis (Response 2000)	1	4	6	10	$2,680.00
"Hulk" Preperation		2	4	12	$2,002.00
Testing		1	2	4	$829.00
Analyze Results	1	4	2	12	$2,312.00
Task 6: Capstone & Contest Deliverables					
Project Website	2	1	15		$2,543.00
Completion of Project Website	2	1	15		$2,543.00
Proposal Report/Presentation	1	10	6	2	$3,312.00
50% Design Report/Presentation	1	10	6	2	$3,312.00
Final Project Presentation	1	4	4	4	$1,906.00
First Draft	1	8	5	3	$2,827.00
Final Project Report	1	12	6	2	$3,748.00
Final Report to PCI	2	12	8	6	$4,512.00
Total Estimated Labor Hours	22	95	107	120	$48,775.00
				Total Labor Cost	$48,664.00

Cost Proposal

Staff Position	Base Pay ($/hr	Benefits (%)	Actual Pay ($/hr	Profit (%)	Billable Rate ($/hr)
Project Engineer	150	30	195	10	215
Engineer 1	90	36	122.4	10	135
Data/Analyzation Technician	65	20	78	10	86

Labor & Materials Costs	
Tasks 1 - 3 Design Phase	
Project Management/Sota	$5,674.00
Preliminary Analysis and Design	$6,015.00
Final Design and Analysis	$4,234.00
Computer Costs	$250.00
Design Phase Subtotal	$16,173.00
Tasks 4-6 Testing/Analysis Phase	
Beam Fabrication	$215.00
Beam Testing	$7,823.00
Capstone & Contest Deliverables	$24,703.00
Beam Materials	$3,000.00
Testing/Analysis Phase Subtotal	$35,741.00
Project Total Cost	
	$51,914.00
Total + Profit	
Profit of 10%	$57,105.40
Total Cost	$57,105.40

Closing Statement

Thank you for your consideration of our team for this project. This proposal contained all of the information pertaining to project understanding, design, analysis, schedule and budget. Our team is dedicated to quality, timeliness and professionalism. We will strive to provide you with excellent results and leave you completely satisfied with your whole experience.

Appendix A

Rules Given by PCI

FACULTY ADVISOR

Each team must have a faculty advisor. A single advisor may work with multiple teams. The advisor provides advice and assistance to the student teams. Advisors are expected to provide for supervision of the beam test. Advisors are also responsible for assuring students wear proper safety equipment and for the safe conduct of the test.

PRODUCER MEMBER PARTICIPATION

Each team must work with a PCI Producer Member. A Producer Member may work with more than one team and may work with teams from different schools. There is no limit to the number of teams a given Producer Member may support. Producers who are members of PCI chapters, partners, affiliates or allied organizations meet this requirement.

A Producer Member is expected to provide: advice and expertise to aid the student teams, all materials, beam fabrication, beam transportation to the testing facility (or provide for testing at the plant) and disposal. The actual design must be done by the students, but the faculty advisor and the producer member are encouraged to assist in this phase. Students are expected to participate in the fabrication of the beam to the extent deemed safe and practical by the Producer Member. If a team cannot find a Producer Member who will work with them or if there is no Producer Member within a reasonable driving distance, a team may obtain a waiver of this requirement from the Chair of the Student Education Committee or the PCI Staff Liaison to the Student Education Committee.

GENERAL RULES

All entries must be accompanied by a hard copy and a PDF version of a report containing all the following elements in the order listed. Entries submitted with an insufficient report may be disqualified by the judges.

1) A cover page with the name of the school, the team members, the sponsoring producer member, the faculty advisor and the regional director, as applicable. If a school submits more than one entry, the teams shall be numbered.

2) A completed summary/judging form and the total load/midspan deflection graph.

3) Certification that the calculations were performed before testing the beam. The calculations may be certified by the producer member, a regional director or a neutral 3rd party.

4) Drawings of the cross section(s) and elevation of the beam, showing reinforcement.

5) A one to two page narrative about the concrete mix used, including proportions, measured unit weight, slump, air content and 28 day compressive and tensile strengths. A discussion of the reasoning for choosing the mix, any modifications to the mix and a discussion of how the chosen mix performed with respect to the team's design requirements is required.

6) A one to two page discussion of the structural design. In addition, the design calculations along with a prediction of the cracking load, maximum applied load and a prediction of the midspan deflection (due to applied load only) at maximum load shall be provided as an appendix.

7) A narrative of not more than 8 pages (including any pictures) describing the beam fabrication and testing. This must include the load/midspan deflection graph showing peak load and cracking load (from the bend over point).

8) A statement by the team members explaining what they learned from the contest.

9) A DVD of the test showing at least the highlights of the test and the failure for verification purposes. There shall be a visible scale showing the beam deflection.

(PCI, 2013)

DEFINITIONS, SPECIFICATIONS, AND INTERPRETATIONS FOR THE BIG BEAM CONTEST

For the standards listed below, contestants may use either the listed English unit standard or the equivalent metric standard.

Aggregates	Shall meet ASTM C33 or ASTM C330 (Lightweight Aggregates)
Chemical Admixtures	Shall meet ASTM specifications D98, C494, C260, or C1017.
Compressive Strength of Concrete	Shall be determined according to ASTM C39.
Concrete	Concrete is a mixture of Portland cement, water, and aggregate. Mineral and chemical admixtures may be included. The material must have both coarse and fine aggregate. Fiber-reinforced concrete is permitted.
Concrete Beam	A concrete beam resists load through flexure and the primary load-resisting system is made of concrete and reinforcing steel. Composite systems, trusses, and arches do not qualify under this definition.
Enclosed Reinforcement	The reinforcement must be completely enclosed within the concrete with adequate cover as stated by ACI 318.
Mineral Admixtures	Shall meet indicated ASTM specifications and be silica fume (C1240), class C or F fly ash (C618), class N metakaolin (C618), or Grade 100 or 120 ground granulated blast-furnace slag (C989).
Portland Cement	Conforms to ASTM C150.
Proprietary Materials	Any material whose contents are not available to the public. These materials are banned, as the judges cannot verify compliance with the rules.
Reinforcing Steel	All reinforcing steel must meet one of the following ASTM specifications: A615, A616, A617, A706, A775, A934, A185, A497, A184, A884, A416, A886, A910, A722, or A1035. Structural steel plates or shapes are not allowed as primary or confining reinforcement. Fiber-reinforced plastics are not allowed.
Steel Plates	Steel plates are permitted as bearing plates or as anchorage plates for mild or prestressing steel.
Tensile Strength of Concrete	Determined using either ASTM C78 or C496.

International entries may use the equivalent specifications from their countries.

(PCI, 2013)

1) The beam must be tested as a simply supported span of 16 feet, center to center of bearing. It cannot be longer than 18 feet overall. It may have any cross sectional shape but the top surface must be flat and horizontal along the entire span.

2) The beam shall be designed for dead load plus TWO applied service (UNFACTORED) live loads of 11 kips (i.e in equations 9-1 through 9-7 in ACI 318-08 LL = 11 kips each). This translates to factored live loads of 17.6 k at each loading point. The beam must not crack under service live load of 11 kips at each point (22 kips total service live load).

3) The beam shall be loaded by applying two point loads, symmetrically, 6.5 feet from the center of each support (= 1.5 ft on either side of midspan) as shown. The loading mechanism must apply the loads equally at both points. Use of a single jack and a spreader beam to create two loads is permitted.

PERMITTED LOAD CONFIGURATIONS

4) Bearing pads and/or bearing plates, not exceeding 6" in length (along the span) may be used at supports and/or under the load.

5) The load may be measured at each point or, if a spreader beam is used, the total load applied to the spreader beam may be measured. Report load as the TOTAL applied load (sum of two point loads). Midspan deflection must be measured.

6) The beam must resist load primarily through flexure. Trusses, arches and other non-flexural members are prohibited.

7) The beam must be made primarily of concrete – cement, coarse aggregates, fine aggregates and water. Pozzolans, fibers, lightweight aggregates and admixtures are permitted. UHPC is permitted.

8) The beam must be longitudinally reinforced with steel bar and/or strand. Reinforcing shall be pretensioned and/or post-tensioned. Embedded or partially embedded steel sections are not allowed. Bar or mesh may be used for shear reinforcement. Reinforcement must be completely embedded in the beam and meet applicable spacing and cover requirements.

9) All materials must be commercially available. No experimental materials. Steel plates may be used as bearing plates and/or as anchorage plates for post-tensioning steel only. Steel plate may not be used as any type of reinforcement or for confinement.

10) All entries must meet the provisions of ACI-318-11 or the 7th Edition of the PCI Design Handbook for a precast/prestressed beam, interior exposure. International entries must meet the equivalent specifications for their country and must state which specification was used.

11) Entries which, in the opinion of the judges, are obviously impractical, an attempt to circumvent the rules or are of very poor quality may be disqualified.

12) If an entry fails to meet some aspect of the rules, the judges may, at their option:

a. Disqualify the entry entirely

b. Allow the entry to stand, but award "0" points in the categories where the violation occurred

NOTE: Students must submit a hard copy AND a PDF version of the final report.

The Big Beam Competition will consist of a zone competition and a national competition. Each entry will judged in relationship to the other entries in the zone. The winner of each zone be entered into the national competition. In the national competition, the zone winners will be re-judged against each other to determine the national champion. International entries will be considered as a zone.

The judging categories shall be:

1) Design accuracy. The beam must to carry at least a total factored live load of 35.2 kips and must not have a total peak applied load of more than 42 kips. The beam shall not crack under the total applied service load of 22 kips. Total applied load is defined as the sum of the two applied point loads. Beams meeting these criteria receive 20 points.

A. Beams which do NOT hold a total applied load of 35.2 kips shall be penalized 2 points for each kip, or part of a kip, below 35.2.

B. Beams which hold a total applied load of more than 42 kips shall be penalized 1 point for each kip, or part of a kip, above 42.

C. Beams which crack before a total applied load of 22 kips receive a 5 point penalty.

The load/midspan deflection graph must show a peak load either by post-peak softening or by collapse of the beam. Stopping the test to avoid the overstrength penalty will result in a score of 0 for this category.

2) Lowest cost.

3) Lowest weight.

4) Largest measured deflection at maximum total applied load.

5) Most accurate prediction of maximum total applied load, total applied cracking load and midspan deflection at maximum total applied load. Total applied load is the sum of the two applied point loads.

6) Report quality. Reports MUST contain a discussion of the concrete mix design and the beam structural design.

7) Practicality, innovation and conformance with code.

For judging categories 2 -4, the entries in each zone will be ranked from best to worst in that category. The best entry receives 10 points in that category; the 2nd best receives 9 points and so on. If there are more than 10 entries in a zone, places 11 and below receive 0 points.

In category 5 (most accurate calculations) receive points based on the following scale:

<10% = 10 points; deduct 1 point for each 10% increment above 10% rounded UP to the nearest 10% (e.g. 25% is rounded to 30% and receives 8 points). Above 110% receives 0 points.

In category 6, the judges will award 0-5 points for the quality of the report. In category 7, the judges will award 0-5 points for practicality, innovation, compliance with the applicable code and demonstration of good engineering judgment. For any category, no entry can receive less than "0".

In case of a tie in a category, the tied teams will be awarded the points for the tied places and a subsequent number of places eliminated (e.g. if two teams tie for 2nd, each will be awarded 2nd place points; 3rd place is eliminated, 4th place is awarded)

Prizes shall be awarded based on total points. In the event of a tie in total score, the value of the load closest to, but exceeding, the target total load (35.2 k) shall be used to break the tie. If the tie is not broken by this method, the prizes for the tied positions shall be combined and split equally.

(PCI, 2013)

MATERIAL COSTS AND BEAM WEIGHT

The following unit cost shall be used to determine the beam cost. Concrete cost is based on actual strength, not design strength.

Material	Cost	Notes/Instructions
Concrete	$100/cu yd	Using gross section geometry.
High-Strength Concrete	$120/cu yd	Defined as $f_c' \geq 10$ ksi.
Fiber-Reinforced Concrete	$110/cu yd	
UHPC	$400/CU YD	
Lightweight Concrete		Add $10/cu yd to the concrete cost.
Prestressing Strand:		Use estimated lengths used in the beam.
⅜ in. diameter	$0.17/ft	
½ in. diameter	$0.30/ft	
½ in. special	$0.32/ft	
0.6 in. diameter	$0.42/ft	
0.7 in. diameter	$0.55/ft	
Steel:		Use estimated lengths and nominal unit weights in this calculation as provided in the PCI Design Handbook
A615/A706	$0.45/lb	
Welded wire (deformed or smooth; for shear)	$0.50/lb	
A1035	$0.70/lb	
Plate steel	$.055/lb	
Forming	$1.25/ square foot of formwork	

There is no need to include cost of steel fabrication, concrete fabrication, curing, inserts, etc. Concrete cost is based on actual strength.

The beam weight shall be estimated by using the measured unit weight of the concrete or by actually weighing the beam. If the beam weight is estimated, it is estimated based on the gross concrete cross section only, ignoring reinforcing, bearing plates, etc.

REPORT COMPETITION

The judges shall select a beam report for the "Best Report". The criteria shall be that report which best demonstrates student learning, application of sound engineering judgment and excellence in presentation. The judges may elect not to award a prize if there are no suitable entries or to award multiple prizes if there is more than one worthy report.

BEST VIDEO

Students are encouraged to submit a video (in addition to the test video required in General Rule 9) which details the design, fabrication and testing of the beam, along with statements of what the students learned. A prize may be awarded for the most creative and entertaining video. The judges may elect not to award a prize if there are no suitable entries or to award multiple prizes if there is more than one worthy entry. The winning video may be presented at the 2014 PCI Convention.

PRIZES:
SIKA AWARDS PROGRAM SPONSORSHIP

SIKA Corporation is providing prize money. Prizes will be awarded in each of the 6 Zones and an international zone. The Zone winners will compete for the national title. Prizes may be offered for the best report and best video.

DISCLAIMER:

This contest is sponsored by the Precast/Prestressed Concrete Institute (PCI). The PCI Student Education Committee shall be the final judge of the contest and all decisions/interpretations made by that Committee and/or the panel of judges shall be final. Entries received by PCI by 6/15/2014 will be accepted; entries received after this date but before the contest is judged may be accepted at the discretion of the judges and PCI.

All entries become property of PCI and will not be returned. PCI reserves the right to publish any entry, in whole or in part, without compensation. By entering, contestants agree to allow their photographs/videos to be used by PCI without compensation.

PCI reserves the right to disqualify an entry if any part of it does not meet these rules. PCI and/or the judges may revise submitted calculations or quantities to correct errors or inconsistencies as an alternative to disqualification. If there are not enough acceptable entries, not all prizes will be awarded. PCI reserves the right to award additional prizes.

Sponsored by PCI and Sika

(PCI, 2013)

Appendix B

References

References

PCI Institute. "History." *PCI.* 2013 Web. http://www.psi.org/about_pci/history. Acquired on 18 Sept. 2013.

Sika Group. "Sika U.S. Since 1937…" *About Us.* 2013. Web. http://usa.sika.com/en/group/Aboutus.html. Acquired on 18 Sept. 2013.

TPAC. "Making History Since 1954." *Tpac.* TPAC Kiewet Western Co. 2012. Web. http://www.tpacaz.com/index.php?option=come_content&view=article&id=122&Itemid=156. Acquired on 18 Sept. 2013.

Burgess, K. M. & Stephens, W. "PCI Journal". *PCI Headquarters.* 2013. Print. Acquired on 15 Sept. 2013.

PCI. "Official Rules for the PCI Engineering Design Competition: Academic Year 2013-2014." Chicago, IL. Acquired on 14-18 Sept. 2013.

Alqattan, Wael. "TPAC Visit." 2013. Flagstaff, AZ. JPEG file. Acquired on 4 Dec. 2013.