Concrete Canoe:

Final Proposal

To: Professor Mark Lamer & Technical Advisor Taylor Layland

From: Kristen Rasmussen, Carl Wilson,

Stephan Henderson, Conrad Senior, Logan Grijalva

CENE 476: Capstone Preparation

December 10th, 2019

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1 Project Understanding

1.1 Project Purpose

The National Concrete Canoe Competition (NCCC) is an annual competition that calls upon engineering students apart of American Society of Civil Engineers (ASCE) to design and build a working canoe out of concrete. The goal of the competition is to "gain hands-on, practical experience and leadership skills by working with concrete mix designs and project management [1]". This competition helps creates a strong student faculty bond as well allowing the students to ask clarifying questions to help strengthen their knowledge and understanding of concrete mix design. The 2020 Rules and Regulations break up the scoring into four different categories; Technical Proposal, Technical Presentation, Final Product Prototype and the Race Demonstration. The NCCC is broken up into 19 different regional conferences.

Table 1-1 below shows the competition scoring break down for each category. Each category is worth 25 points maxing out at 100 points. The Race Demonstration is broken up into five different events, each worth five points for a total of 25 points.

Table 1-1: Competition Scoring Breakdown

Categories	**Maximum Points**
Technical Proposal	25
Technical Presentation	25
Final Product Prototype	25
Race Demonstration (5 Events)	25
Total Possible Points	100

The top three scoring schools that compete at each of these conferences are then invited to compete at the national level against other top schools. The goals for the 2019 Northern Arizona University (NAU) Concrete Canoe team is to create a schedule that will allow enough float time between different tasks to account for various complications with the mix design or material quantities. With a strong project schedule and project deadlines, the 2019 Concrete Canoe team will be able to build a canoe that will arrive to the conference without any damages to the canoe, meet the requirements provided by the NCCC, and to create a working canoe. By achieving this goal, the team will show that NAU's engineering program can create a top-level canoe.

1.2 Project Background

NAU participates in Pacific Southwest Conference (PSWC) which will be hosted by California State University, Fullerton this year. The canoe races will be at Puddingstone Lake in Bonelli Park. Puddingstone Lake is a freshwater lake [2]. Previous canoes from NAU have placed 11th in 2019 and 9th in 2018. Northern Arizona University 2018-2019 canoe "VolCanoe", placed 11th out of 18 universities. A category that the past canoe teams have struggled with have been developing a proficient Design Paper. VolCanoe placed 13th in the design paper category. Another in-efficiency of past canoe teams have been the development of a high placing Final project. This includes the overall construction of the canoe. [3]

1.3 Technical Considerations

1.3.1 Hull Design

The hull of the concrete canoe will need to be designed for efficiency and maneuverability. Solid works will design the canoe in the initial stages because it offers an easy to learn program and can develop a symmetrical canoe in a short amount of time. The design will then be uploaded into "MaxSurf" by Bentley to determine drag coefficients and how the canoe will sit within the water. The regulations of the hull design stipulate that the canoe cannot be longer than 22 feet. When designing the shape of the hull, the width of the canoe at midspan, and the bow of the canoe, "MaxSurf" will be used to analyze each model to determine the most efficient canoe. Placement of the concrete will need to be considered when designing the walls of the canoe, due to the concrete wanting to slough off of the side walls when being placed. The keel, draft, side, bow, and stern of the canoe will be modified within the MaxSurf program so that the best efficiency and maneuverability will be achieved.

1.3.2 Concrete Mixture

The mix design according to the PSWC 2020 Rules and Regulations states that the concrete canoe can have a maximum of three mix designs; structural, patching, and finishing mix. The NCCC requires that each mix design will be at least 30% aggregate by volume of the total mix. The percent finer aggregates must account for 70% or less of the total mix design volume, this may consist of expanded glass, cenospheres, or a combination of the two. Each mix design will be limited to these requirements and will be tested throughout the mix design process to see how the strength of the concrete is affected by these changes. A slump test is required to determine the workability of the concrete for placement on the canoe. Once the concrete has cured for at least seven days the sample will be tested for compressive strength. The gradation of aggregates and type of aggregate contribute to the strength of the mix design. The strength increases as cement and other cementitious material has more surface area to bind to. Admixtures are added to the mix to improve the quality of the canoe by decreasing cracks that will occur from curing and shrinking.

1.3.3 Construction

The construction of the canoe will start with either a female or male mold. The female mold is an impression of the canoe into a foam mold, and is built from the outside in. A male mold is developed by forming the inside of the canoe, and the canoe will be developed from the inside out. The placement of concrete can be done by hand placement, shotcrete, or injection molding. Mesh Fiber inlay will be formed and inserted into the canoe after the first layer of concrete to help increase the structural strength of the canoe. Once the canoe is constructed, the concrete will need to be cured for a length of time in a curing chamber. Curing the concrete can be done with humidifying a curing chamber, so that the concrete can cure with a moist environment for a length of time. A carbon dioxide chamber can be utilized, such as California Polytechnic State University San Luis Obispo "Jumanji". The canoe will be finished after the curing of the concrete is completed. The sanding of the canoe will smooth out the surface of the canoe to help the efficiency and aesthetics of the canoe. This can be done by wet sanding and utilizing different coatings that comply with the competition standards. This coating is used as a sealant for the canoe so that it doesn't allow water to enter the canoe. The sealer can only have two coats, so the first coat will be applied before the lettering, and the second layer will be applied at the end.

1.3.4 Aesthetics

The final prototype of the canoe will be evaluated based on the workmanship and aesthetics. The workmanship will be judged based on criteria of the overall characteristics of the canoe. The canoe must have consistent wall thickness and concrete coloring, to receive a favorable score. Any visible micro-cracking and reinforcement materials will result in a decreased score. A concrete canoe that is aesthetically pleasing will include a smooth finish, no visible voids or holes, and clean graphics. The canoe will also be judged based on how the canoe fits with the theme in terms of graphics and aesthetics.

1.4 Potential Challenges

1.4.1 Rule Changes

The first issue prevalent is the drastic rule change that occurred for the 2019-2020 Concrete Canoe Competition. This year, the NCCC went from supplying a rules and regulations document to a Request for Proposal (RFP). This has not been done before and is a challenge due to the unfamiliarity with the document. The RFP is driven to provide more of a proposal instead of a guideline. This style of project replicates the real world better, but poses a challenge with understanding limitations and need materials for the report.

1.4.2 Mix Design

The second issue is developing a lightweight mix design for the canoe. Developing a lightweight mix design and maintaining a relatively high compression strength is critical for the success of the canoe. This challenge will be mitigated by developing different lightweight mix designs and testing these mixes for compressive, tensile, and slump to achieve the desired values.

1.4.3 Post Tension

Post tensioning a canoe is always a very difficult task to successfully achieve but the team is determined to do it this year. The team plans to build a table/form that the post tensioning equipment can brace to so the post tension equipment can successfully fulfill the desired tension amount. Along with this, the team plans to practice post tensioning with a half size mold, this is so the team can practice the methodology required to successfully post tension.

1.4.4 Mix Placement

Consistency is key when it comes to placing the mix in the mold and because of this, the team is planning to use the Shotcrete sprayer to apply the mix in the mold. Wall thickness of the canoe is always a factor that is hard to be consistent on, but the team expects to alleviate this through spraying the mix rather than hand placing it. This creates a problem with the mix consistency. The mix must be viscous enough to be sprayed but also cannot be too wet resulting in a mix that will not adhere to the mold. The team will test and experiment with mixes until the best mix for spraying is achieved.

1.5 *Stakeholders*

There are five stakeholders in this project; Northern Arizona University, Northern Arizona University's College of Engineering, Informatics, and Applied Science (NAU CEIAS), NAU ASCE student chapter, the client, and team sponsors. The university has stake in this project because the reputation of the college is at risk depending of the team's performance at the Pacific Southwest Conference. If the team performs well it will reflect positively on the university. The

ASCE student chapter at NAU is considered a stakeholder because of the club involvement from the students in the club. Success at conference could increase attendance to club meetings and more fundraising opportunities. The success of the project will depend largely on the satisfaction of the client. The monetary donations and material supplies provided by the team sponsors gives them stake in the project. If the team performs well it will provide the sponsors more advertising to a variety of schools and students.

2 *Scope of Service*

2.1 *Task 1: Mix Design*

2.1.1 Task 1.1: Material Research

2.1.1.1 Task 1.1.1: Aggregates

The team will look at various canoes from NAU and other schools to look at what types of aggregate were used, the particle distribution and the wall thickness of the concrete. The particle size used in the concrete helps to determine the biggest particle size used in the canoe to see how small particles will affect unit weight and concrete strength.

2.1.1.2 Task 1.1.2: Cementitious Material

The team will look at various mix proportions from NAU and other schools to see what ratios of cement to cementitious materials and the strength of the concrete. These mix proportions will be retrieved through past design papers that have been submitted to NCCC. The team will use this analysis to compare the ratios and concrete strengths from each school to determine an initial ratio to use for an initial mix design.

2.1.1.3 Task 1.1.3: Admixtures

The team will look at reports from NAU and other schools to determine what admixtures were used, the amount, and the type of cementitious material used in the canoe. The team will make relationships between the type of admixture used to the amount of different types of cementitious material used. These relationships will help to establish initial ratios for the initial mix design.

2.1.2 Task 1.2: Material Acquisition

Gathering all the materials needed requires coordinating with suppliers and manufacturers on how the material will be delivered and the quantity that will be available to be picked up. The team will also coordinate with a construction company to crush any material that is too large to be used in the canoe as its original size. Ensuring enough material is available for the duration of the project is critical to ensure the project stays on task.

2.1.3 Task 1.3: Initial Mix Design

The team will create a mix table with all of the proposed aggregates, cementitious materials, and admixtures along with the initial ratios and specific gravity of each material found from material research. The mix table will ensure that the concrete meets all the requirements from NCCC of at least 30% of concrete is natural aggregate by total volume and no more than 70% of expanded glass, cenosphere, or a combination of the two by total concrete volume.

2.1.4 Task 1.4: Initial Mix Testing

2.1.4.1 Task 1.4.1: Compressive Strength

To find the compressive strength of each concrete mix design the team will use ASTM C39 to find the compressive strength of each concrete mix. Compressive strength will be used to determine if the concrete mix design has enough strength to be used in the construction of the canoe.

2.1.4.2 Task 1.4.2: Tensile Strength

Each concrete mix design will be tested for tensile strength using ASTM C496. Using the tensile strength from each mix will help to determine how the quantities and ratios of materials in each concrete mix affect the tensile strength.

2.1.4.3 Task 1.4.3: Slump and Application of Concrete

Each concrete mix design will be tested for slump using ASTM C143. Slump will help to determine the workability of the concrete. The team will also spray the concrete mix onto a foam mold of the canoe to see how well the concrete sprays and how it sticks to the mold. Seeing how the concrete sprays will help to determine the max particle size that can be in the concrete and how much water needs to be in the concrete mix to allow for application on the concrete during and after spraying.

2.1.4.4 Task 1.4.4: Unit Weight

Each concrete mix design will be tested for unit weight following ASTM C138. Unit weight will be tested before each compressive strength and tensile strength test. Unit weight will be conducted to ensure that the mix design table is accurate and how the unit weight is changing for each concrete sample.

2.1.5 Task 1.5: Alternative Mix Design Testing

Due to the different amount of different aggregates, admixtures, and cementitious materials used within each mix, multiple test for each mix is needed to determine what ratios of what materials give the concrete the greatest strength without increasing the unit weight. The physical characteristics from the four tests from the above section helps to decide how each mix should be changed to improve strength and unit weight.

2.1.6 Task 1.6: Final Mix

The final mix will be designed by looking at all of the data from previous concrete mixes and deciding what mixes can be used to build the canoe without making the canoe excessive heavy. The final mix will also take into consideration the workability of the concrete mix to be placed. NCCC allows up to three mixes that can be used to make the canoe, even if color is the only thing changed within the mix, it counts as one mix.

2.2 Task 2: Hull Design

The canoe will be modeled and designed from a software called “MaxSurf”. This software will help determine performance measures of the canoe to increase efficiency and to ease the construction of the concrete canoe by minimizing design time between each hull concept. Redesigning the canoe will be based on the analysis from “MaxSurf” and construction of the practice canoe on practice pour day.

2.3 *Task 3: Structural Design*

2.3.1 Task 3.1: Calculation

Calculations will be made to determine various values that are crucial when designing the mix and hull. These calculations are made to ensure structural integrity of the canoe which will increase the performance and overall strength. An excel spreadsheet will be utilized when doing these calculations so that all the variables are linked, and changes can be made easily and quickly. This excel sheet will improve the accuracy and precision of the design criteria.

2.3.2 Task 3.2: Mesh

Mesh lining will be placed in the canoe to increase the rigidity of the structure. This mesh requires calculations to ensure productivity of the material. These calculations are done to analyze the flexural capacity as well as the ductility. Like the general design calcs above, these calculations will be done in excel and will reference various support sources such as textbooks, journals, and professional engineers.

2.3.3 Task 3.3: Testing

Testing the mesh will ensure that the mix and mesh together provide a high enough tensile strength based on the design calculations. This testing will be done by placing a piece of mesh in the center of a square of concrete that will then be pulled to test the tensile strength. This test will be performed by applying an axial force that will pull the mess apart. The stress will be measured with a pressure gauge and will be considered successful once the desired tensile strength based on calculations has been exceeded.

2.3.4 Task 3.4: Post Tensioning

Agassiz plans to utilize post tensioning in the canoe this year for a variety of reasons. The main reason in to increase the overall strength of the canoe and to help minimize cracking. Post tensioning will put the canoe in compression which increases its ductility and durability in harsh conditions. The team plans to achieve this goal by placing six cables in the canoe and then utilizing a table and custom-built equipment to withstand the stress of post tensioning.

2.4 *Task 4: Construction*

2.4.1 Task 4.1: Setup

2.4.1.1 Task 4.1.1: Transportation Stand

The canoe stand will be utilized to help safely transport the canoe to the PSWC conference location. A steel stand will be erected utilizing 1" square tubing, and casters. Everything will be welded in place to ensure that the stand will hold up to the traveling strain. This stand will need to protect the canoe from any strains and stress it may experience as it is being trailered to the conference location.

2.4.1.2 Task 4.1.2: Pour Table

A pour table will help ensure a level surface to work on while also allowing team members to maneuver around the canoe with ease, especially when the time comes to pour the whole canoe. Post-Tensioning equipment will be built into the pour stand to allow for a streamline and efficient use of the pour table. The pour table will be constructed out of wood due to cheap material cost and ease of construction. The post-tensioning equipment will be constructed out of wood, and will hold the cables in place while a horizontal force in applied to the canoe.

2.4.1.3 Task 4.1.3: Mold Preparation

Acquiring the canoe mold is essential to the construction of the canoe because it will provide a surface to shape once the mold is acquired the pieces that it will come in will have to be glued together. The mold will be shadow sanded to see the various bumps and cracks that have formed within the mold. Butcher paper will be used instead of a release agent to help cover the gaps between mold pieces to provide a smoother exterior canoe finish.

2.4.1.4 Task 4.1.5: Cure Chamber

Building a curing chamber that will utilize a PVC frame and plastic cover will help keep the humidity as high as possible. This will ensure the correct humidity levels for proper curing of the concrete. The curing chamber will be developed by construction of a PVC frame, with a heavy plastic wrap that will encase the PVC frame. This plastic wrap will be tapped together to help contain the humidity created for curing the canoe.

2.4.2 Task 4.2: Practice Pour

2.4.2.1 Task 4.2.1: Practicing Mixing and Placing

Practice pour day will consist of making the structural and finishing mixes to be placed on the canoe mold. The post tensioning strands, and fiber meshes will be placed in the mold with concrete placed on top. The concrete mixtures will be sprayed onto the mold to develop an Standard Operating Procedure (SOP). This will ensure consistency throughout the design.

2.4.2.2 Task 4.2.2: Wet Curing

The concrete canoe will be wet cured with a curing chamber. This curing process will help ensure that the concrete will reach its maximum 28-day compressive strength by making the humidity inside the curing chamber as close to 100% as possible. The curing chamber will be erected for this process, and humidifiers will be plumed into the chamber to create the humid environment.

2.4.2.3 Task 4.2.3: Removal

Removal of the canoe from the mold is very important for the whole canoe to cure properly. The removal of the canoe will be determined by the type of release agent used or other methods. It is important to remove the canoe with as little effort as possible to help reduce the risk of cracking or breaking the canoe.

2.4.2.4 Task 4.2.4: Post Tensioning

After approximately two weeks of allowing the canoe to curing in the curing chamber, post tensioning cables will be pulled adding more compressive strength to the canoe. Cylinders that were collected during the construction of the practice canoe will help determine the optimum time to utilize post-tensioning.

2.4.3 Task 4.3: Final Pour

2.4.3.1 Task 4.3.1: Mixing and Placing

Final pour day will consist of making the final structural and finishing mixes to be placed on the canoe mold. The post tensioning strands, and fiber meshes will be placed in the mold with concrete placed on top. The concrete mix will be sprayed onto the mold utilizing Shot-Crete spray guns.

2.4.3.2 Task 4.3.2: Wet Curing
The concrete canoe will be wet cured with a curing chamber. This curing process will help ensure that the concrete will reach its maximum 28-day compressive strength by making the humidity inside the curing chamber as close to 100% as possible. The curing chamber will be erected for this process, and humidifiers will be plumed into the chamber to create the humid environment.

2.4.3.3 Task 4.3.3: Removal
Removal of the canoe from the mold is very important for the whole canoe to cure properly. The removal of the canoe will be determined by the type of release agent used or other methods. It is important to remove the canoe with as little effort as possible to help reduce the risk of cracking or breaking the canoe. The mold will be removed by applying pressure to the foam mold and slowly removing sections of the mold from the canoe.

2.4.3.4 Task 4.3.4: Post Tensioning
After two weeks of allowing the canoe to curing in the curing chamber, post tensioning cables will be pulled adding more compressive strength to the canoe. The post-tensioning equipment will be set up, and the cables will be pulled to the desired tension. In line strain gauges will be used to determine the amount of force within the cable.

2.4.3.5 Task 4.3.5: Aesthetic (Sealing/Sanding/Stickers/Lettering)
Adding aesthetics to the finish product of the canoe will added to the presentation on the day of conference. The aesthetics involve wet sanding and sealing the canoe to get a nice smooth look and adding lettering to present the school and canoe names. Wet sanders will be used with different variations of grit sand paper to achieve a smooth finish. Sealant will be applied by brushing it on with paint brushes or a pressurized sprayer.

2.5 Task 5: Conference

2.5.1 Task 5.1: Presentation
A presentation will be created and practiced showing the results of the concrete canoe within the requirements of the PSWC rules. This will be presented to the judges of the PSWC conference. “PowerPoint” will be used to develop the presentation.

2.5.2 Task 5.2: Report
The final report will be completed and submitted with the research and findings that were finalized for the concrete canoe. These finding will include the data from the final concrete mix, construction drawings, structural calculations, a finalized budget, and a project schedule. This report will be reviewed by the judges of PSWC for accuracy and completeness. A report will be developed utilizing “Word” processors.

2.5.3 Task 5.3: Races/Rowing
Training Paddlers to practice racing based on the courses for conference as fast and efficiently as possible to score as much points as possible. An older canoe will be used to help the paddlers train. The canoe will go through multiple different races that will illustrate different performance measures of the canoe.

2.5.4 Task 5.4: Display

For conference a display stand is needed to convey the team's theme for their canoe and helps promote the school that is competing in the conference. This stand will also serve as transporting the canoe to and from conference by allowing the team to roll the canoe into the lake without lifting the canoe. The display will utilize decorated wood pieces to illustrate the theme of the canoe. These wood pieces

2.6 Task 6: Capstone Deliverables

2.6.1 Task 6.1: 30% Report and Presentation

An initial report will be developed to provide an initial update on the findings and the progress of the project. The presentation will give a visual update for the project. The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint".

2.6.2 Task 6.2: 60% Report and Presentation

A report will be developed to provide an update on the findings and the progress of the project since the 30% submittal. The presentation will give a visual update for the project. The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint".

2.6.3 Task 6.3: 90% Report and Presentation

A rough draft of the final report will be developed to provide a final update on the findings and the progress of the project. The presentation will give a visual update for the completion of the project. The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint".

2.6.4 Task 6.4: Final Report, Presentation, Website

The final report will be developed to provide the final findings and the completion of the project. The presentation will give a visual update for the project. The report and the presentation will incorporate any redlines changes that have been identified in the 90% submittal. The report will be developed in "Word" processors and the presentation will be developed in "PowerPoint". A final website will also be developed to illustrate the timeline if the project and the completed canoe itself. This website will be developed on an online platform.

2.7 Task 7: Project Impacts

The project impacts will be analyzed throughout the project. These impacts are: regulatory, health/environmental, economic, and social. These analyses will be analyzed on an as needed basis.

2.8 Task 8: Project Management

2.8.1 Task 8.1: Scheduling

A project schedule will be developed with Microsoft "Project". This schedule will ensure the project stays on task and deliverables are met.

2.8.2 Task 8.2: Meetings (GI/TA/Team)

Regular Team, Grading Instructor, and Technical Advisor meetings are necessary to ensure the project stays on track and that everyone involved within the project is up to date. Meetings will be formed over email, with an agenda and to follow 24 hours before the meeting time. Meeting minutes will be taken and distributed to all involved parties within 24 hours after the meeting has taken place.

2.8.3 Task 8.3: Fundraising

Funding for this project is needed to help buy materials for the mix design of the canoe, post tensioning cables, material for the canoe stand, mold and any other supplies that will contribute to the completion of the project.

2.9 Exclusions

An exclusion that this project has is the actual creation of the mold. The mold for the canoe will be made by an outside source and shipped to Northern Arizona University for the team to begin construction.

3 Project Schedule

3.1 Schedule

The schedule consists of a 209-day duration. The major tasks consist of; mix design, hull design, structural, construction, final pour, conference, capstone deliverables and project management. The capstone deliverables will include a 30%, 60% and 90% report and presentation and a final presentation, report, and website.

3.2 Critical Path

The critical path includes the mix design tasks, the practice pour, final pour tasks, and the conference presentation and report. The mix design is included in the critical path because the canoe cannot be completed without a final mix. These tasks take up a large portion of the schedule for this project which makes them critical tasks. The practice pour and final pour is in the critical path because they are next areas that will take up a majority of the team's time. The set up for these days and time investment they will require causes them to become part of the critical path. The team will use the critical path to keep the project on schedule. The tasks included in the critical path will be monitored closely a d the team will regularly evaluate the schedule during team meetings. This will ensure that the critical tasks are being completed on time and the necessary resources can be acquired

4 Staffing Plan

4.1 Staff Positions

The staffing positions are shown below in Table 4-1. The staff titles for the project are Project Manager (PM), Structural Engineer (SE), Design Engineer (DE), Materials Engineer (ME), Project Engineer (PE), Engineer in Training (EIT), Sub-Consultant (SUB), and Lab Technician (TECH).

Table 4-1: Staffing Position Abbreviations

Staff Positions	
Title	Abbreviation
Project Manager	PM
Structural Engineer	SE
Design Engineer	DE
Materials Engineer	ME
Project Engineer	PE
Engineer in Training	EIT
Sub-Consultant	SUB
Lab Technician	TECH

4.2 Senior Personnel Qualifications

The senior personnel qualifications are courses that directly pertain to the design of the concrete canoe. All senior personnel must have taken or be currently enrolled in the following courses to be sufficiently qualified. These courses are listed below:

- Waters Resources
- Reinforced Concrete Design
- Structural Analysis
- Mechanic of Materials
- Geotechnical Engineering Lab

4.3 Staffing Matrix

The staffing matrix was created to show the specific number of hours each role is expected to spend on each scope item. This is shown in Attachment D. The total amount of hours for each staff position was totaled and is shown below in Table 4-2. From this table a total of 1039 hours is expected to be spent on this project.

Table 4-2: Staffing Hours Summary

Staffing Summary	
Title	Hours
PM	112
SE	125
DE	162
ME	160
PE	193
EIT	87
SUB	139
LAB	61
Total	1039

5 Cost of Engineering Services

The total cost of the project was calculates using the hours from the staffing summary. This cost also includes travel for meetings and the conference, supplies for the concrete canoe, and the use of lab facilities. The quantities and rates for these are shown in Table 5-1. The total cost for this project is $147,476.

Table 5-1: Engineering Services Cost Estimate

Engineering Services Cost Estimate					
	Classification	Quantity	UM	Rate ($/UM)	Cost
1.0 Personnel					
	PM	112	HR	175	$ 19,600
	SE	125	HR	150	$ 18,750
	DE	162	HR	150	$ 24,300
	ME	160	HR	150	$ 24,000
	PE	193	HR	150	$ 28,950
	EIT	87	HR	110	$ 9,570
	SUB	139	HR	85	$ 11,815
	TECH	61	HR	75	$ 4,575
Sub-Total					$ 141,560
2.0 Travel					
	Conference Travel	453	MI	0.58	$ 263
	Conference Regristration	5	EA	125	$ 625
	Conference Lodging (2 Roon	3	Nights	450	$ 1,350
Sub-Total					$ 2,238
3.0 Lab Facilites					
	Concrete Laboratory	20	HR	30	$ 600
	Field Station	30	HR	25	$ 750
Sub-Total					$ 1,350
4.0 Supplies					
	Cementitious Material	10	CF	5	$ 50
	Aggregates	12	CF	6	$ 72
	Admixtures	3	GAL	10	$ 30
	Basalt Mesh	13	SY	10	$ 130
	1/8" Inch Cable	108	LF	0.32	$ 35
	Cable Sleeve	108	LF	0.11	$ 12
	Transportation Device	1	LS	75	$ 75
	Display	1	LS	125	$ 125
Sub-Total					$ 528
5.0 Sub-Contract					
	Mold	2	EA	900	$ 1,800
Sub-Total					$ 1,800
6.0 Total					$ 147,476

6 *Resources*

[1] "National Concrete Canoe Competition," ASCE, [Online]. Available: https://www.asce.org/event/2020/concrete-canoe/. [Accessed 25 September 2019].

[2] "Frank G. Bonelli Regional Park Headquarters," [Online]. Available: https://www.bonellipark.org/about-the-park.html. [Accessed 25 September 2019].

[3] J. C. T. M. A. M. a. E. M. Virgilio Bareng, "2019 Concrete Canoe Team," 2019. [Online]. Available: https://www.cefns.nau.edu/capstone/projects/CENE/2019/ASCEConcreteCanoe/U-Grads%20Final%20Presentation.pdf. [Accessed 8 10 2019].

Attachment A: Grading Instructor Cover Letter

NAU NORTHERN ARIZONA UNIVERSITY
College of Engineering, Informatics, and Applied Sciences
Civil Engineering, Construction Management, and Environmental Engineering Department

Concrete Canoe 2019-2020

Project Manager: Kristen Rasmussen | Phone: (520)-971-9006 | Email: klr374@nau.edu

Thursday 26, 2019

Mark Lamer, P.E.
Northern Arizona University Professor
2112 S. Huffer Lane, Office 122M
Flagstaff, AZ 86011

Dear Mark Lamer P.E.,

Attached to this letter is the Project Understanding from the 2019-2020 Concrete Canoe Team. This document introduces and discusses the project's purpose, background information, technical considerations, potential challenges, and stakeholders. The technical considerations consist of hull design, concrete mixtures, structural reinforcement, construction, and aesthetics.

Please contact the project manager, Kristen Rasmussen, if there are any questions or comments.

Sincerely,

2019-2020 Concrete Canoe Team
Logan Grijalva (QA/QC)
Stephan Henderson (Hull Design Captain)
Kristen Rasmussen (Project Manager)
Conrad Senior (Mix Design Captain)
Carl Wilson (Structural Design Captain)

Attachment B: Technical Advisor Cover Letter

NAU NORTHERN ARIZONA UNIVERSITY
College of Engineering, Informatics, and Applied Sciences
Civil Engineering, Construction Management, and Environmental Engineering Department

Concrete Canoe 2019-2020

Project Manager: Kristen Rasmussen | Phone: (520) 971 9006 | Email: klr374@nau.edu

Thursday 26, 2019

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Sincerely,

2019-2020 Concrete Canoe Team
Logan Grijalva (QA/QC)
Stephan Henderson (Hull Design Captain)
Kristen Rasmussen (Project Manager)
Conrad Senior (Mix Design Captain)
Carl Wilson (Structural Design Captain)

Attachment C: Technical Advisor Contract

CENE 476/486C Technical Advising Contract

An essential element in the education of engineering students is their culminating senior design experience, also known as capstone. In Civil and Environmental Engineering, students work in teams with a client, usually external to the department, to develop a real-world engineered design. The PRIMARY role of the technical adviser (TA), as a practicing engineer, is to advise the students with technical and practical advice to avoid critical mistakes (incorrect assumptions, analyses methods, missing work, etc.) that have the potential to derail the project.

Each student team will work with their TA to identify and direct the team to technical content necessary to develop a proposal for the project due at the end of CENE476 and the final design report due at the end of CENE486C. This may include help with codes/standards, scoping items, methods/approaches, time commitment for tasks, equipment/material/software resource identification, experimental design and data collection, data analysis, engineering analysis, decision making, and overall advising.

Student Team Terms and Conditions:

- Provide TA with all necessary capstone documents (this document, deliverables, grading rubrics), and applicable communications
- Interact with their technical adviser in a professional manner at all times.
- Request meetings via a calendar appointment request according to TA preferred time. **Meeting request must include meeting agenda and any items the TA could review prior to the meeting**
- Use the adviser's time efficiently and effectively by providing agendas as well as being prepared for consultation and meaningful discussion
- Keep detailed meeting minutes from meetings and **provide to advisor (with CC to all team members and the grading instructor) within 48 hours of meeting**
- Students are not to ask for meetings individually or without the entire team present
- Follow all reasonable recommendations made by the tech adviser.
    - Where a team does not adhere to their adviser's advice, they must justify and document reasons why they chose not to follow the TA input

TA Terms and Conditions:

- Provide four meetings:
    - 476: one prior to submission for the Project Introduction (1st), Scope and Schedule (2nd), Staffing and Cost (3rd), and Final Presentation (4th)
    - 486C: one each prior to submission of 30% and 60% reports, and two prior to 90%
- Interact with their student team in a professional manner at all times.
- Be available to the student team, approximately one (1) hour per week on average
- Prepare for meetings with their team in advance by reviewing meeting agenda and provided documents
- Provide honest and constructive feedback with respect to the technical approaches used on their project
- Provide an evaluation of each individual team member at the end of the semester to the grading instructor with assessments of various team activities including meetings (preparedness, agendas, minutes, review documents, engagement, attitude), quality technical work provided in documents reviewed, and ability for the team to follow provided recommendations.
    - The TA evaluation will adjust the individual's grades via a final grade multiplier applied at the end of the semester

UNDER NO CIRCUMSTANCES IS IT EXPECTED THAT THE TA WILL:

- Track down the students for meetings or contact
- Do any of the research/analysis/design/document prep
- Provide financial support
- Be forced to meet or advise without proper notice
- Contact the client for the capstone team
- Supervise field/lab work
- Provide reviews of submittals for grammar, punctuation, spelling, etc.

1 TA Initials_________

CENE 476/486C Technical Advising Contract

General information for TA communication and interaction (to be filled out by technical advisor):

- Provide your contact information: TLAYLAND272@GMAIL.COM 928.890.7212
- Preferred means of contact: TEXT, EMAIL, CALL
- Minimum number of days needed to have a meeting scheduled: 7 MIN
- Preferred meeting location: FARM
- Preferred meeting days and/or timeframe: MON OR WED.
- Are you willing to be contacted via phone (YES or NO) and/or email (YES or NO) for quick questions from individual team members
- Are you willing to meet more the identified minimum of four times (YES or NO)
- Any other comments: SEND ME AGENDA PRIOR TO MTG. MEETING MINS. AFTER MTG.

The foregoing CONTRACT with its identified **Terms and Conditions** has been has been read, is understood, and is hereby accepted.

EXECUTED BY:

		Date
[signature] Technical Advisor Signature	TAYLOR LAYLAND Technical Advisor Typed or Printed Name	9/14/19 Date
[signature] Student Signature	Conrod Senior Student Typed or Printed Name	9-14-19 Date
[signature] Student Signature	Stephon Henderson Student Typed or Printed Name	9-14-19 Date
[signature] Student Signature	Kristen Rasmussen Student Typed or Printed Name	9/14/19 Date
[signature] Student Signature	Carl Wilson Student Typed or Printed Name	9-14-19 Date
[signature] Student Signature	Logan Grijalva Student Typed or Printed Name	9-14-19 Date
Student Signature	Student Typed or Printed Name	Date

2 TA Initials________

Attachment D: Staffing Matrix

Staff Positions	Structural Engineer	Design Engineer	Materials Engineer	Project Manager	Lab Technician	Project Engineer	Engineer in Training	Sub-Contractor
Task 1: Mix Design	0	13	78	19	49	45	39	0
Task 1.1: Material Research	0	12	24	3	0	16	16	0
Task 1.1.1: Aggregates		4	8	1		8	8	
Task 1.1.2: Cementitious Material		4	8	1		4	4	
Task 1.1.3: Admixtures		4	8	1		4	4	
Task 1.2: Material Acquisition	0	0	10	10	0	0	0	0
Task 1.3: Initial Mix Design	0	1	12	0	0	5	3	0
Task 1.4: Initial Mix Testing	0	0	2	2	4	4	0	0
Task 1.4.1: Compressive Strength			0.5	0.5	1	1		
Task 1.4.2: Tensile Strength			0.5	0.5	1	1		
Task 1.4.3: Slump and Application of Concrete			0.5	0.5	1	1		
Task 1.4.4: Unit Weight			0.5	0.5	1	1		
Task 1.5: Alternative Mix Design Testing			10	2	40	10	10	
Task 1.6: Final Mix			20	2	5	10	10	
Task 2: Hull Design	10	30	0	2	0	10	0	0
Task 3: Structural Design	55	15	5	2	10	35	10	2
Task 3.1: Calculation	30	10	0	0	0	10	0	0
Task 3.2: Mesh	10	0	0	0	0	10	0	0
Task 3.3: Testing	5	0	0	1	10	10	5	0
Task 3.4: Post Tensioning	10	5	5	1	0	5	5	2
Task 4: Construction	21	65	48	18	0	44	5	92
Task 4.1: Setup	5	28	18	8	0	5	5	50
Task 4.1.1: Transportation Stand		5		2				20
Task 4.1.2: Pour Table		3	3	2				10
Task 4.1.3: Mold Preparation		10	5	2		5	5	10
Task 4.1.4: Cure Chamber	5	10	10	2				10
Task 4.2: Practice Pour	8	18	15	4	0	20	0	20
Task 4.2.1: Practicing Mixing and Placing		10	10	1		10		10
Task 4.2.2: Wet Curing			2	1		2		2
Task 4.2.3: Removal	3	3	3	1		3		3
Task 4.2.4: Post Tensioning	5	5		1		5		5
Task 4.3: Final Pour	8	19	15	6	0	19	0	22
Task 4.3.1: Mixing and Placing		10	10	1		10		10
Task 4.3.2: Wet Curing			2	1		2		2
Task 4.3.3: Removal	3	3	3	1		1		3
Task 4.3.4: Post Tensioning	5	5		1		5		5
Task 4.3.5: Aesthetic (Sealing/Sanding/Stickers/Lettering)		1		2		1		2
Task 5: Conference	15	15	5	25	0	25	25	40
Task 5.1: Presentation	10	10		5		5	5	
Task 5.2: Report	5	5	5	5		10	10	
Task 5.3: Races/Rowing				10				30
Task 5.4: Display/Decoration				5		10	10	10
Task 6: Capstone Deliverables	16	16	16	8	0	16	8	0
Task 6.1: 30% Report and Presentation	4	4	4	2		4	2	
Task 6.2: 60% Report and Presentation	4	4	4	2		4	2	
Task 6.3: 90% Report and Presentation	4	4	4	2		4	2	
Task 6.4: Final Report, Presentation, Website	4	4	4	2		4	2	
Task 8: Project Management	8	8	8	38	2	18	0	5
Task 8.1: Scheduling				10				
Task 8.2: Meetings (GI/TA/Team)	8	8	8	8	2	8		5
Task 8.3: Fundraising				20		10		