DOZER

Michigan Technological University

Design Report 2020

Compliance Certificate

Michigan Technological University's 2019-2020 Concrete Canoe team hereby certifies that the design and construction of *Dozer* has been completed in compliance with the rules and regulations of the National Concrete Canoe Competition. The ten registered participants are qualified, eligible student members and national student members of ASCE. *Dozer* was completely built within the current academic year of the competition. The team has read all of the Material Technical Data Sheets (MTDS) and Safety Data Sheets (SDS), and constructed *Dozer* in methods conducive to a high degree of safety. The team acknowledges receipt of the Request for Information (RFI) Summary, and *Dozer* complies with responses thereof.

Registered Members of the 2019-2020 Michigan Tech Concrete Canoe Team

Lauren Bowling	11851359	Karl Heindlmeyer	10765493
Lauren Cole	11855298	Danny Jones	10957008
Mary Kinney	10775654	Conner Reed	11337786
Steph Klaysmat	11927679	Derrick Sullivan	11000686
Kait Pascoe	11911054	Collin Vander Beek	11949737

Dozer Dimensions

Total Length	20 Feet
Maximum Width	28.1 Inches
Maximum Depth	15.5 Inches
Average Thickness	3/8th Inch
Overall Weight	215 lbs

Properties of the Concrete Mixture and the Composite Material

<table>
<tr><th rowspan="3">Mixture</th><th colspan="2">Unit Weight (pcf)</th><th colspan="4">Strength (psi)</th><th rowspan="3">Air Content (%)</th></tr>
<tr><th rowspan="2">Wet</th><th rowspan="2">Oven-Dry</th><th colspan="2">Compressive</th><th colspan="2">Tensile</th></tr>
<tr><th>14-Day</th><th>28-Day</th><th>14-Day</th><th>28-Day</th></tr>
<tr><td>Structural</td><td>70.05</td><td>66.8</td><td>1480</td><td>1630</td><td>350</td><td>410</td><td>-10.1</td></tr>
<tr><td>Pigmented Finishing</td><td>66.05</td><td>65.5</td><td>510</td><td>580</td><td>220</td><td>250</td><td>4.7</td></tr>
<tr><td colspan="8">Composite Flexural Strength: 1080 psi</td></tr>
</table>

We certify that the aforementioned information is valid.

Mary Kinney

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Executive Summary

From the first trans-continental railroad to modern day bustling cities, engineers have been fascinated and consumed by massive construction projects that aim to advance mankind and create a global society. The 2020 Michigan Technological University (Michigan Tech) Concrete Canoe Team was inspired by the fast-paced construction industry and introducing sustainablest solutions to unique problems. Construction innovation and techniques are rapidly evolving. In the same way, the Michigan Tech designed and refined old practices through new ideas to create a streamlined process that minimized the person-hours and resources that were exhausted in the construction of our boat *Dozer*.

Table 1. Properties of Dozer

Dozer (2020)	
Weight	215 lbs.
Colors	Black and Yellow
Maximum Length	20 feet
Maximum Width	28.4 inches
Maximum Depth	15.5 inches
Average Thickness	3/8th inch
Primary Reinforcement	GlasGrid® 8511 SpiderLath 3/16-inch Steel Cable
Secondary Reinforcement	PVA-RFS400 Enduro Prime

The team's main goal this year focused on creating the hull design that should be used as the standard in future years for the ASCE Concrete Canoe competition. The team felt confident in using last year's hull design, *Driftwood* (MTU 2019), as the basis on which to improve for the future standardized hull design. *Driftwood* was able to improve travel velocity and straight-line tracking as well as increase paddler efficiency. After the national competition, the hull design committee met with the paddlers to strategize what needed improvement. It was determined that the stability of the canoe was the most important aspect to be improved upon. The hull design committee was able to keep the benefits of the hull design from *Driftwood* while increasing stability, resulting in a well-rounded design that the team is proud to present for the standardized hull design award.

This year the Michigan Tech team implemented a new time tracker that helped track person-hours and quantify which aspects of the project needed to be made more efficient. The team made decisions based on this data throughout the year to streamline certain activities and will continue this process for future years.

The team's mix committee worked on improving the tensile strength of the boat by incorporating more fibers than have been used in previous designs. The committee also focused on reducing the water to cement ratio to a value less than 0.5 while maintaining a mix that has comparable workability to last year's mix, Sandbar (MTU 2019), with the use of admixtures.

The reinforcement committee's goal was to incorporate more testing into the decision process of determining the final reinforcement scheme, specifically a torsional test. However, the team's advisors, Dr. Tess Ahlborn and Dr. Larry Sutter, suggested the implementation of a tension tie rather than find a reinforcement scheme that also has to meet a "tension resistance" requirement. Therefore, the committee's goal changed to center around implementing tension ties into the reinforcement design.

Mixture	**Unit Weight (pcf)**		**Strength (psi)**				**Air Content (%)**
	Wet	Oven-Dry	Compressive		Tensile		
			14-Day	28-Day	14-Day	28-Day	
Structural	70.05	66.8	1480	1630	350	410	-10.1
Pigmented Finishing	66.05	65.5	510	580	220	250	4.7
Composite Flexural Strength: 1080 psi							

Table 2. Properties of the 2019-2020 Concrete Mixture

Introduction to the Project Team

ASCE Chapter Profile

Michigan Technological University is a public university located in Houghton, in the Upper Peninsula of Michigan. The university offers world-class education and cutting-edge research to its roughly 7,000 students. Michigan Tech's student chapter of ASCE has 51 active student members, and 30 national members. These student members meet monthly to plan community events, and engage with professors and industry professionals on matters concerning civil engineering. There is often an emphasis on ASCE's Code of Ethics and how it pertains to each of the chapter's students. The chapter works alongside Michigan Tech's Graduate chapter of SEI as well. A couple of the joint projects that both chapters have completed include Adopt a Highway and Make a Difference Day. The ASCE student chapter has participated in the Adopt a Highway program for over 30 years, and regularly schedules events to clean and maintain the section of highway our chapter has been assigned. The University annually organizes Make a Difference Day, which allows student organizations to have a positive impact on the community. A few of the projects that ASCE has participated in include maintaining and updating local parks, stocking and organizing the local food pantry, and raking leaves for community members. ASCE at Michigan Tech has been boasting growth in membership and involvement over the past four years and looks forward to exploring further into the benefits that come with becoming an ASCE professional member.

Recently the Upper Peninsula of Michigan branch of ASCE. This allows the student chapter to have the opportunity to meet more regularly with professionals in the industry, in turn helping individuals network with professionals. Michigan Tech's Student Chapter members were some of the first to learn about the creation of the branch and worked hand-in-hand to strengthen both the branch and student chapter as a whole. Faculty along with branch founders to not only worked to establish a strong branch core, but also showed students how to get involved. The creation of the Upper Peninsula Branch has not began working on projects with the student chapter yet, but plans for service and networking events have begun for the 2020-21 school year.

Michigan Tech's Concrete Canoe Team is made up of 31 members who each play an integral role into the success of the team. The team is led by a senior project manager and a junior project manager who each specialize in different aspects of the project. Veteran members of the team are elected to committee head positions and oversee construction, engineering, technical documentation, and paddling. Other members work under committee heads to help meet deadlines, as well as facilitate knowledge transfer and improve technical expertise.

The Michigan Tech Concrete Canoe team has competed un the North Central Student Conference since 1992, placing first in 10 of the last 11 competitions. Most recently the team placed 10th in the 2019 national competition with their boat *Driftwood*.

Figure 1. ASCE Adopt a Highway Stretch

Organization Chart

Project Managers

Mary Kinney, Sr & Lauren Bowling, Jr.

Research & Development

Derrick Sullivan, Sr.

Assisted By: Allison Dagesse, Sr., Lauren Bowling, Jr., Nicholas Kippenhan, Jr., Jason Cinader, So.

Responsible for development and testing of mix designs, as well as reinforcement schemes and canoe aesthetics.

Academics

Zeke Marchel, Sr.

Assisted By: Ryan Olsen, Sr., Conner Reed, Sr., Karl Heindlmeyer, Sr., David Castlevetere, Fr., Lauren Cole, Jr.

Presenters: Connor Reed, Sr., Lauren Cole, Jr

Responsible for structural analysis, hull design, design paper, presentation, and compliance.

Construction

Charlie Hill, Sr.

Assisted By: Matthew Fox, Sr., Caleb Schmeltzer, Sr., Lauren Bowling, Jr.

Responsible for casting day and all preparations thereof, as well as the construction of stands, cross-section, and display.

Paddling

Danny Jones, Sr. & Mary Kinney, Sr.

Paddlers: Danny Jones, Sr., Karl Heindlmeyer, Sr., Mary Kinney, Sr., Derrick Sullivan, Sr., Lauren Bowling, Jr., Lauren Cole, Jr., Steph Klaysmat, Jr., Kait Pascoe, Fr., Colin Vander Beek, Fr.

Responsible for training and preparing paddlers for competition.

Additional Members: Danielle Lautenbach, Sr., Cole Schilling, Sr., Joey Switala, Sr., Jacob Byron, So., Connor Dykehouse, So., Alex Rogers, So., Ryan Cesario, Fr., Henry Summers, Fr.

Technical Approach to the Overall Project

Hull Design

The team's primary goal for hull design was to build upon the foundation of *Driftwood*, which improved travel velocity, straight line tracking ability, and put a greater emphasis on paddler efficiency than any of its predecessors. *Dozer*'s hull geometry is relatively similar to *Driftwood's* design, featuring a long slender profile that resembles a teardrop shape in a plan view. Paddlers spoke highly of *Driftwood*, approving of the model's performance in races with modest reservations. An area of improvement that the paddlers wanted to see in this year's hull design was the secondary stability of the boat. By instituting a shallow V-shaped cross section to the canoe, the team aims to increase the stability while also maintaining the majority of the speed and straight-line tracking ability possessed by its predecessor.

Table 3. Hull Design Comparison

	Driftwood (2019)	Dozer (2020)
Length / Beam Ratio	8.715	8.460
Beam Width at Waterline (in)	27.1	27.6
Depth (in)	12.7	15.1
Freeboard (in)	0.785	0.785
Block Coefficient	0.500	0.403
Wave Drag at 6mph (N)	9.45	12.70

A cedar strip prototype was constructed throughout the year, encouraging new members to become increasingly involved in the project. There was not an emphasis put on the completion date of the prototype for hull design analysis because the hull design is similar to previous years; the completion date for the prototype has been set at roughly week 6 of the first semester. This gives the paddling team a few weeks to test the design in open water and make any considerations before the design is finalized and the mold is ordered. While this process does allow for valuable input from the paddling team, it was found that by the time the design was finalized, it was pushing the mold procurement date further back than anticipated. Thus, the increased timeline for completion was deemed the better route for the continued success of the team by maintaining our schedule and also by taking more time with the construction of the prototype, ultimately providing a more accurate product for the paddlers. The paddlers were able to test the prototype in the school's lap pool during winter paddling practices to familiarize themselves with the boat before races at competition.

Several aspects of *Dozer* make it a worthy candidate for the standardized hull design for future competitions. The aggressive hull geometry ensures that it will be competitive in every race, from sprints to endurance. *Dozer*'s V-shaped bottom and long, narrow profile provides good attributes for speed and stability as well as straight-line tracking capabilities. With a practice routine that emphasized turns, every team is capable of making impressive turns as well. The paddlers were well-experienced and capable of making a full 180-degree turn in 4 draw strokes using last year's model, and this high efficiency is expected with the new cross section as well.

Dozer's hull geometry is easily duplicated. Not every team has a CNC service available, but this boat's shape is able to be constructed using a hand-made, male mold. By simply printing out the full-scale cross sections for every one-foot increment along the boat, the mold could be shaped to match the final design of *Dozer*. This boat is also customizable in multiple ways. The reinforcement scheme can be changed to meet the needs of the structural analysis, and the different aspects of the canoe (gunwales, end-caps, aesthetics) can also be changed to meet the preferences of future teams.

Structural Analysis

The goal of the structural analysis committee was to provide the material development committees with the maximum stress values that the canoe will experience. Structural analysis began by looking at last year's boat, *Driftwood*, to figure out what could be improved upon. After inspection, it was observed that *Driftwood* failed in the middle at the gunwales due to shear stress when turning. Cracks developed due to shear stress caused by the paddlers leaning into the side of the canoe. A conservative 240 lbs. for men and 170 lbs. for women were used as the paddler weights and the force of the paddlers leaning into the canoe was equal to half their weight. In order to solve this issue, the location of the cracks was measured as 120 in from the front of the canoe on average. From there, a shear stress calculation was performed to figure out the maximum shear stress experienced by the canoe during races. A buoyant force equal to the weight of the paddlers and canoe was also factored in as shown in figure 2. It was found that the maximum shear stress occurred during the men's sprint race and was 872 psi (tension) at the gunwales. An iterative excel sheet was used to calculate the moment of inertia for the applicable cross section in order to calculate this stress value. The maximum tensile stress of the canoe at the gunwales is 280 psi. To make up for the difference between the applied shear stress and shear strength of the concrete, a 3/16" steel cable was laid in the gunwales and tied together at each end of the canoe. The shear strength of the cable is 30,422 psi which fills the gap between the canoe's tensile strength and the applied tensile strength as well as accounts for a safety factor and dynamic loading.

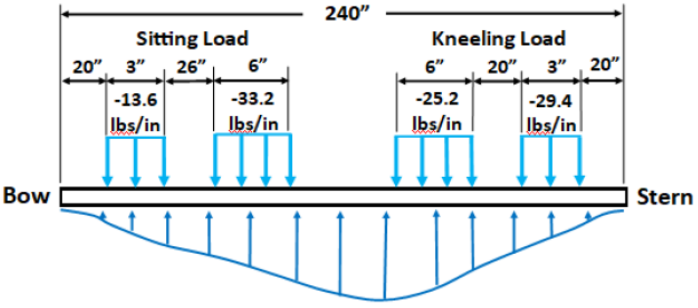


Figure 2. Buoyant Force and Paddler Loads

Development and Testing

The mixture committee established multiple goals to keep testing on schedule and to continuously improve the mix design. Goals include improving the tensile strength of concrete with the use of secondary reinforcement, incorporating sustainable cementitious materials, and reducing the water to cement ratio to less than 0.50 while maintaining a mix with comparable workability to mix designs of previous years. Predominant attributes from *Sandbar* (MTU 2019) were used to provide a strong basis for this year's testing procedures. Materials such as Class C Fly Ash, Slag Cement, Nycon fibers, Poraver® glass spheres and 3M™ K-series glass bubbles continued to be a staple in a highly competitive structural mix design.

To begin testing for the 2020 season, the committee decided to do away with utilizing white Portland cement in exchange for a more commercially available grey Portland cement. The team also incorporated a new supplementary cementitious material, added new fibers, and new aggregates.

The implementation of silica fume in the structural mixture employs advantages by increasing the strength to weight ratio, as well as meeting the goals of the aesthetic committee for a black canoe. Silica Fume, an industrial byproduct of silicon metal production, is more sustainable than typical production methods of Portland Cement. Silica Fume requires 85% less CO2 emissions than Type F Portland Cement, making it environmentally friendly as well. The fiber blend exchanged the previously used Nycon- PVA RF4000 fibers for new Sika Enduro Prime macro-synthetic fibers. Sika macro-synthetic fibers provide unparalleled performance in ductility and pull-out strength compared to those previously used in Michigan Tech's mixes. The Enduro Prime / RFS400 blend exceeded the committee's goals for improving tensile strength without influencing workability in the structural mix.

Figure 3: Backfill Fiber Blend.
Enduro Prime (Top),
PVA RFS400 (Bottom)

The Michigan Tech Structural Mix Committee tested various new aggregates and found success in most. Elemix, a material left behind by teams of the past, was introduced in small quantities to the mixture. Elemix decreased the specific gravity and offset some of the cenosphere aggregate volume in the mix, without dramatically decreasing in strength. The most innovative solution in for aggregates was implementing crushed concrete that was recycled from previous testing cylinders. Recycled Concrete Aggregate was processed and refined by team members. The recycled concrete reduced costs, CO2 emissions and time as it was a waste product of previous testing. The crushed concrete was responsible for a 12% increase in strength and a 4% decrease in weight of the mix when compared to previously used Haydite. Due to limited supply and time constraints the mix committee was only able to replace a portion of Haydite in the mix. Concrete that was recycled required periodic testing to ensure that specific gravity, absorption, and moisture content remained constant throughout testing and casting of *Dozer*.

Figure 4: Recycled Concrete Aggregate - Passing #8 Sieve, Retained in #16

The most difficult goal for the Michigan Tech team this year was decreasing the water- cement ratio without sacrificing workability. New rules which prohibit the use of latex modifiers made the solution even more rigorous. The team increased superplasticizer dosages and soaked aggregates in batch water for 30 seconds before conditions to prevent absorption after mixing, thus maintaining a constant workability at a longer duration after mixing.

Table 4. Properties of the Aggregates in the Final Concrete Mixture

Aggregate	Specific Gravity	Absorption (%)	Particle Size	% Retained in #200 Sieve
Poraver® 1-2 mm	0.39	20.0	1-2 mm	100%
Poraver® 0.5-1 mm	0.47	25.0	0.5-1 mm	100%
K1	0.125	0.0	≤ 120μm	55%
K37	0.37	0.0	≤ 85μm	10%
Shale	1.22	36.0	≤ 2.38 mm	100%

This year's finishing mix aimed to reduce the total amount of material used, cost, and mix density, while maintaining a workability that promoted easy placement on the canoe. Similar to last year's boat, *Dozer*'s structural mix was pigmented allowing for less need for aesthetic mix. *Dozer*'s finishing mix implements K-37 aggregate in place of Poraver 0.25-0.5 mm as used in *Driftwood's* finishing mix. This decision was made in order to produce a finishing mix that was easier to work with and had a less grainy texture. The finishing mix also recorded a lower density due to a new mix design utilizing Recycled Concrete Aggregate. Fines from the Recycled Concrete Aggregate (passing No. 16 sieve, retained in No. 200 sieve) were added to the finishing mix adding strength and decreasing unit weight, while also serving as a sustainable alternative to previous finishing mixes.

The reinforcement committee started the year by consulting the team's advisors about ways to test a torsional reinforcement scheme because in previous years the team's boats have always had large cracks in the middle due to tension. Previously the team has used gunnels in an attempt to do tension ties but it has not proven to be sufficient. This prompted the team to explore the use of tension ties in our reinforcement scheme. The team had to start from scratch and create a database that would show the effects of pre- and post-tensioned ties and how they would react to forces in different situations along with the use of different bars in each force scenario.

This task was going to be more than the reinforcement committee could take on in a single year. Therefore, the team's advisor suggested placing bars in the gunnels of the boat. The bars work in conjunction with the gunnels to act as tension ties to prevent the large cracking that has been observed in the middle of the boats in past years. 3/16-gauge wire was placed in the gunnels and then the layers of reinforcement were folded over them.

The committee strived to match last year's reinforcement scheme in terms of weight, while surpassing it in maximum load and strength at the seams. The team overall had positive feedback on the reinforcement scheme used for *Driftwood*; it was workable while also contributing the necessary strength required. This is why GlasGrid® 8511 (GG) and SpiderLath (SL) were considered as meshes to be used this year. The team decided that Panzer® 15 would be a material that was worth testing with GlasGrid® 8511 as well as SpiderLath in an effort to have a stronger maximum load and have better seam strength. Through testing it was discovered that when the Panzer® 15 was bent horizontally it was more resistive (R) than when bent vertically. Panzer® 15 was tested in both orientations in all possible combinations along with SpiderLath and GlassGrid® 8511. It was noticed that when the non-resistive (NR) orientation was on the top layer, peak loads were generally larger than when the resistive orientation was on the top layer. The strongest schemes after testing all of the possible schemes and observing that the non-resistive orientation is better on top, were NR/NR, NR/R, and SL/GG.

The team noticed that all beams made with Panzer® 15 delaminated; extra time and care was put into making new sets of beams with Panzer® 15 to see if this problem could be resolved. It was determined that Panzer® 15 would not delaminate if it was ensured that it engaged with the matrix, but because the casting of the boat is time dependent it would take too much time for the QC/QA team to assure that it was engaged with the matrix.

Panzer® 15 was used during a mock cast for the trowelers and QC/QA team to determine the workability of the reinforcement. The trowelers' feedback was negative overall toward the use of Panzer® 15. It was too difficult to make sure it was in the correct orientation and didn't inhibit the desired workable qualities.

Due to all of the testing and troweler feedback, the team decided to go with a reinforcement scheme that did not include Panzer® 15. GlasGrid® 8511 was chosen for the outer layer and SpiderLath for the inner layer. This scheme had overall better peak loads and flexural strength than the combinations of reinforcement that included Panzer® 15. This combination of reinforcement is lightweight and met the trowelers' desired workability standards.

Figure 5: Beam Delamination Testing Results

Approach to Scope, Schedule, & Fee

The schedule was developed from the outline of previously successful projects, with most of the research and development happening during the fall semester, and aesthetics along with competition display elements being completed in the spring semester. Some of the major milestones occurring during the length of the project include selection of the final structural mix, finishing mix, and reinforcement scheme, along with the completion of the technical proposal and presentation. These milestones, along with the completion of the final display elements, are crucial in providing a high-quality final product for competition. This year, the Michigan Tech Concrete Canoe team has a dual critical path on the final schedule. This is due to the importance of the structural mix and reinforcement scheme development during the fall semester. The critical path continues with casting, curing, and applying the aesthetics to the canoe. These aspects must be completed on time in order for the project to continue without delay. One risk to the schedule included material procurement during the research and development phase. This risk was mitigated by having meetings with committee heads early on to determine quantities needed in order to successfully develop a mix with the desired qualities. Through this scheduling process, the Michigan Tech Concrete Canoe team was able to achieve their goals without any major delays in the project.

The Michigan Tech team implemented a new time-tracking app to not only ensure that critical work was being completed, but to also maintain work efficiency. The application allowed each team member to clock in as the labor role that they were expected be for the time period and to categorize hours by the task they were working to achieve. The time-tracking app allowed the team to get an exact count and breakdown on hours in an effort to keep the cost of the project low.

The team found that replicating a boat in the same conditions would cost just over $120 for materials that went into the canoe and an additional $18,600 for labor hours that were invested into the competition of the project. Without having a comparison for cost, the team feels as though the price is reasonable for a large team focused on completing a high-quality product for competition.

Approach to Health & Safety

The Michigan Technological University Concrete Canoe Team has a health and safety plan in place which centers around proper training for personnel and the use of proper PPE in the lab environment and during paddling practices. Prior to being allowed into the lab area, members are required to complete online safety training courses about general safety awareness, hazard communication and the university chemical hygiene plan. Members who complete this training then tour the lab with the lab supervisor to become familiarized with resources as well as explain the rules and potential hazards of the area. To mitigate risk of injury in the lab, there is a required dress code of pants and closed toed shoes; safety goggles are required PPE for all work done in the lab, and dust masks and gloves are used as needed for handling potentially hazardous materials safely. As for paddling practices, all boats are equipped with enough life-vests for everyone in the boat and meet campus water activity safety monitoring standards for practices.

Approach to Quality Control and Quality Assurance

Michigan Tech's approach to Quality Control/Quality Assurance (herein referred to as QC/QA) applies methodologies and policies to ensure the success of the product by considering the totality of the design process. Programs that the team specifically focuses on which encompass the totality of our design process include: material procurement, training, document tracking and review, and compliance review. Each of these will be discussed further individually.

The materials that Michigan Tech uses in its mix design are all carefully analyzed and prepared prior to being mixed for casting day. A primary focus for the mix team concerns the quality of aggregates used in the final mix. As such, the mix committee sieves and separates each aggregate (Shale, Portland Cement, recycled aggregates, etc.) in order to achieve repeatable results from the testing environment to implementation on casting day. If the team plans on including the same aggregate in the following years mix as was in the previous year, the aggregates are ordered from the same supplier in order to ensure the desired results.

Individual and group training sessions have proven to be a vital part to the continued success of the team. This year, the team held four troweling practices prior to casting day to prepare new and experienced trowelers for the construction of the final product. Practices consisted of the mix committee providing one to two batches of the current iteration of the mix while the trowelers practiced troweling the first 1/8-inch-thick layer on an old mold section from a previous year. As well as members improving upon their mechanics of applying the concrete, the troweling practices also served as an important tool for the mix committee. While practicing, the troweling members provided feedback to the mix committee on the workability of the mix. In one instance, the PVA fibers that were currently being used for the mix were proving difficult to trowel and with the feedback provided, the mix committee and trowelers came to the decision to shorten the length of the fibers which was ultimately used in the final design. Similar recommendations happened routinely, eventually leading to a mix design that was both appealing to the trowelers and satisfied the strength requirements determined by structural analysis.

The large size of Michigan Tech's team allows for many subdivided committees that are all working in concert. With this large number of committees also comes the creation of many documents from everyone's work within their committee. To ensure that all documents are organized and easily accessible from every committee, the team uses a shared drive on the campus network in which every member on the team is able to access and edit. This provides an open platform for sharing information and aids in both the knowledge transfer process as well as progress updates within committees that routinely work together when information is needed between the weekly meetings updates.

Every major submittal that Michigan Tech's team submitted to the NCCC is first reviewed and supervised by the team's designated compliance officer. This committee is responsible for understanding the rules to the best of their ability and ensuring that the team stays within the parameters provided by the rules. This process covers the entire design process and is integral to limiting deductions at competition.

Approach to Sustainability

Current societal trends place a growing emphasis on sustainability. In the effort of ensuring a healthy future, Michigan Tech strives to contribute to global sustainability efforts through social, economic, and environmental methods. In recent years, research and design committees have collaborated to develop test plans that would evaluate multiple mix and reinforcement parameters at once, reducing the number of mixes required, and thus the amount of materials used for what can be a lengthy process. Not only is the team reducing the quantity of materials, but using more sustainable materials from the start. This year the team incorporated sieved recycled concrete, crushed from cylinders used during the research and design test process. Recycled concrete decreased material costs and any further CO_2 emissions that would have incurred during material refining and transporting, proving as the most sustainable effort for the team this year. The team also found ways to include supplementary cementitious materials including blast furnace slag, fly ash, and silica fume, which are byproducts of iron, coal, and silicon metal productions respectively, creating a use for a material that would have become environmental waste. Silica fume, for example, also contributes to 85% less CO_2 emissions than Type F Portland Cement, reducing Michigan Tech's carbon footprint. The team is lucky enough to have many of these materials donated in bulk, eliminating those costs from the yearly budget, allowing funds to be reallocated elsewhere in the project. Economic sustainability also stems from our relations with alumni, faculty, family/friends and industry partners who are gracious enough to donate and support the project. The team also fundraises through volunteering in the community events such as bagging groceries at a local grocery store where customers can donate a portion of their receipt total toward the team. This not only supports the team financially, but allows the team to interact with community members and build meaningful relationships in a close-knit community.

Economic and environmental aspects are only part of sustaining a successful team. People are required to carry out the project and it is important that the team stays enthusiastic and knowledgeable about the final goal. Emphasis was stressed knowledge transfer as many members are graduating in the spring. Ideas and processes are passed down through captains and committee heads to establish the transfer of knowledge. Younger contributors are always encouraged to get involved early and often and processes are documented so transitions year-to year run smoothly. To aid this, a universal document was distributed to each committee head to outline details of crucial steps, advice, contacts etc. to communicate lessons learned to future teams.

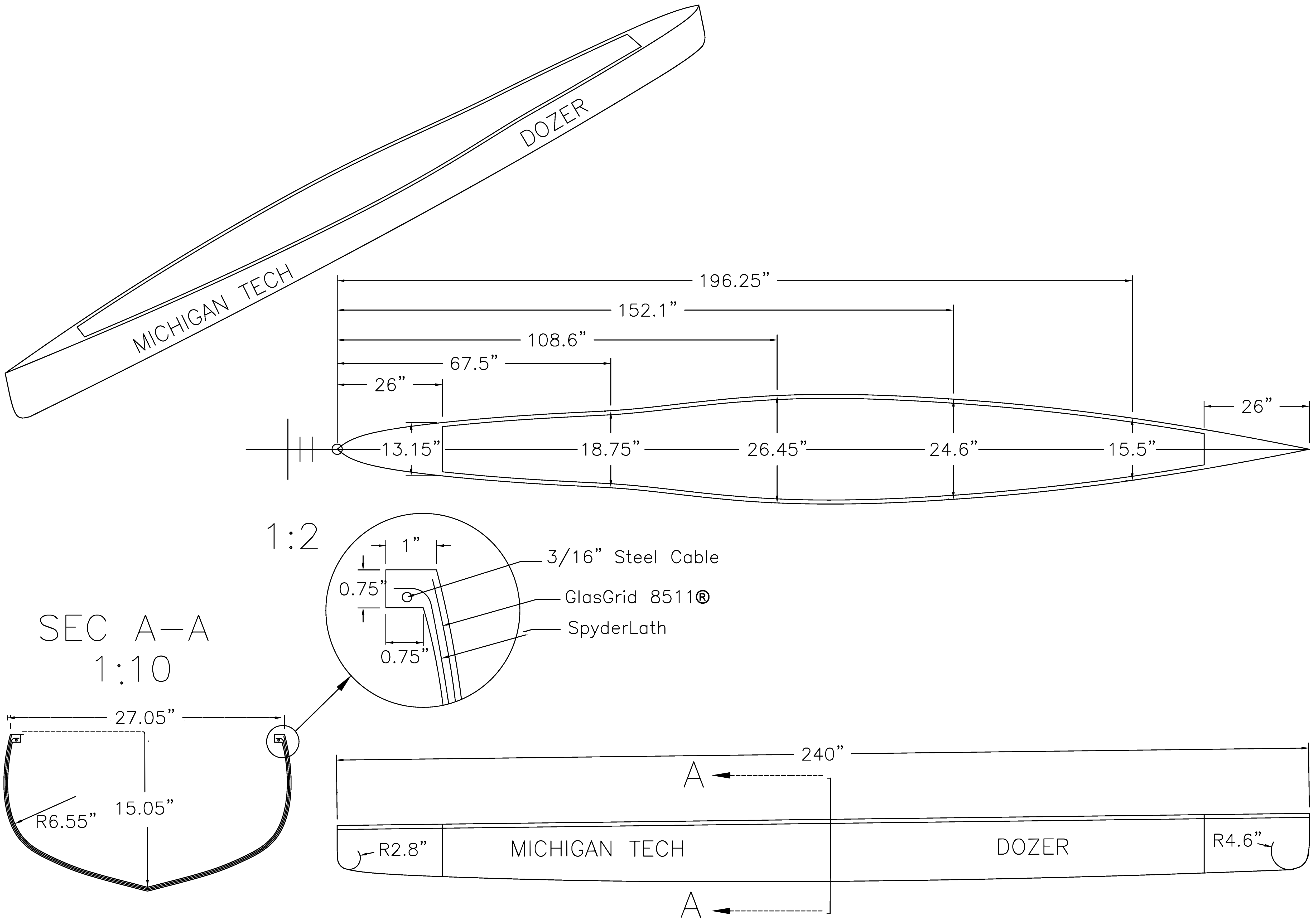
Itemized Fee Summary

Table 5. Material Cost for One (1) Canoe

Bill of Materials	Cost
Lafarge Portland Cement C-150	$ 1.67
Blast Furnace Slag	$ 0.52
Class C Fly Ash	$ 0.53
NORCHEM Undensified Silica Fume	$ 1.12
NYCON RFS400 PVA	$ 0.58
SIKA ENDURO PRIME	$ 0.77
GlasGrid 8511	$ 7.89
SpiderLath	$ 7.89
3/16" Steel Cable	$ 1.36
Trinity Haydite	$ 1.21
DOW Extruded Polystyrene Foam	$ 42.50
3M Glass Bubbles K1	$ 0.92
3M Glass Bubbles K37	$ 1.01
Poraver 1-2 mm	$ 1.86
Poraver 0.5-1 mm	$ 0.99
Poraver 0.25-0.5 mm	$ 0.47
Poraver 0.1-0.3 mm	$ 0.29
Elemix	$ 2.05
Recycled Concrete Aggregate	$ 0.55
Direct Colors Concrete Pigments	$ 9.39
Distilled Water	$ 1.81
BASF Glenium 3030 NS	$ 0.46
Sealkrete Clear-Seal	$ 32.89
Silhouette Glossy Permanent Vinyl	$ 1.50
TOTAL COST PER CANOE	**$ 120.23**

Table 6. Detailed Cost Assessment

Activity	Projected Total Person-Hours	Associated Cost
Project Management	18	$ 860.00
Hull Design	20	$ 500.00
Structural Analysis	20	$ 400.00
Mixture Design Development	153	$ 4,732.50
Mold Construction	32	$ 991.75
Canoe Construction	69	$ 1,819.75
Preparation of Technical Proposal	50	$ 1,000.00
Presentation	336	$ 6,720.00
Display	50	$ 1,550.00
Shipping Costs - Trailer	N/A	$ 80.00
TOTAL		**$ 18,654.00**
TOTAL COST PER CANOE		**$ 120.23**
GRAND TOTAL		**$ 18,774.23**



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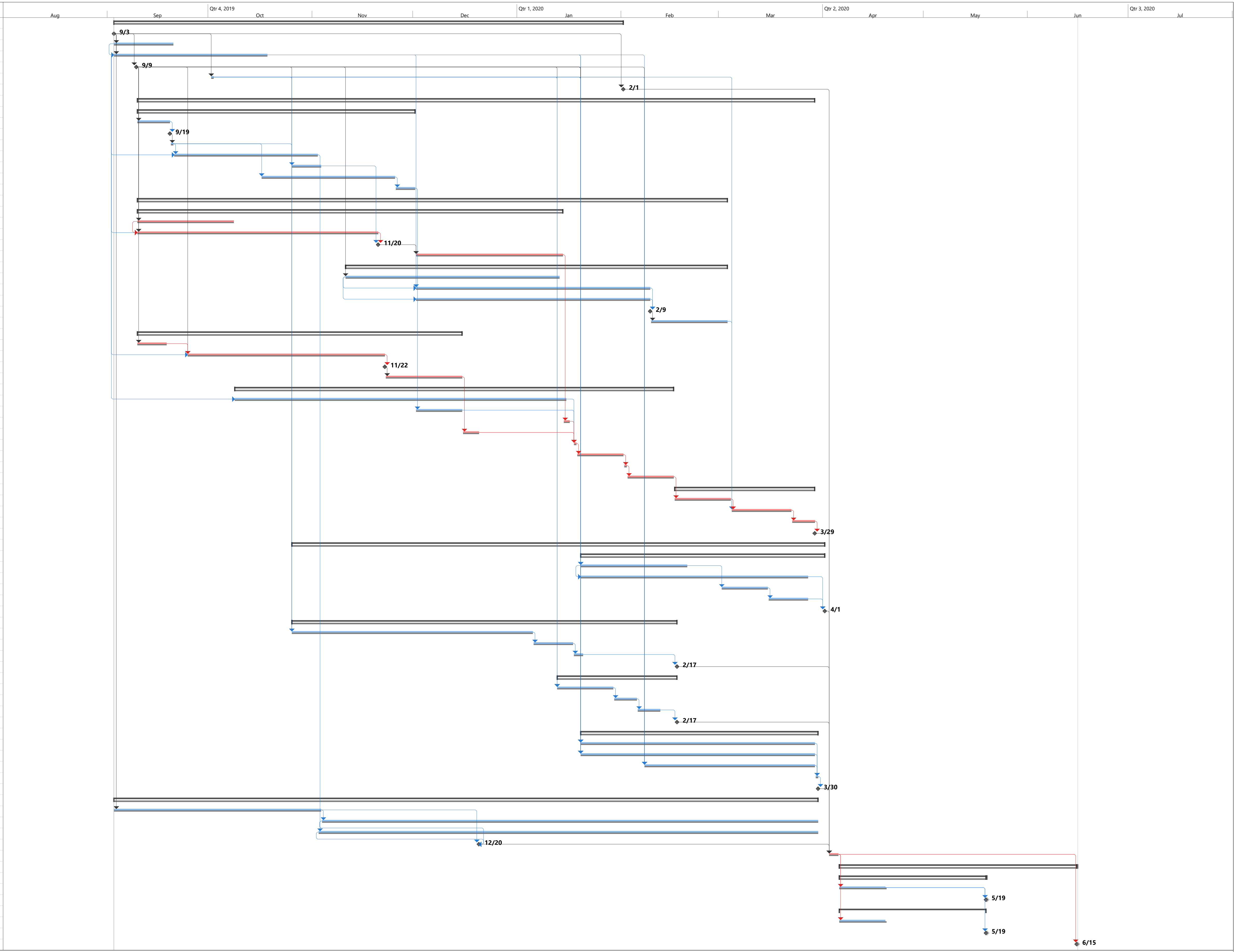
1885

I.D.	DESCRIPTION	QTY.
1	Lafarge Portland Cement C–150	55.62 lb
2	Blast Furnace Slag	25.84 lb
3	Class C Fly Ash	26.39 lb
4	NORCHEM Undensified Silica Fume	2.54 lb
5	NYCON RFS400(19mm) PVA	0.55 lb
6	SIKA Enduro Prime	0.83 lb
7	GlasGrid 8511®	65.78 ft^2
8	SpyderLath	65.78 ft^2
9	$\frac{3}{16}$" Steel Cable	9.04 lb
10	Trinity Haydite	24.16 lb
11	DOW Extruded Polystyrene Foam	1.70 ft^3
12	3M Glass Bubbles K1	5.11 lb
13	3M Glass Bubbles K37	5.64 lb
14	Poraver 1–2 mm	7.44 lb
15	Poraver 0.5–1 mm	3.96 lb
16	Poraver 0.25–0.5 mm	1.89 lb
17	Poraver 0.1–0.3 mm	1.16 lb
18	Elemix	0.74 lb
19	Recycled Concrete Aggregate	11.08 lb
20	Direct Colors Concrete Pigments	1.88 lb
21	Distilled Water	60.40 lb
22	BASF Glenium 3030 NS	0.05 gal
23	Sealkrete Clear–Seal	0.75 gal
24	Silhouette Glossy Permanent Vinyl	3.00 ft^2

Construction Drawing

DRAWN BY: CONNER REED	CHECKED BY: Karl Heindlmeyer
DATE: 2/4/2020	SHEET: 11
SCALE: 1:25 OR AS NOTED	

ID	ℹ	Task Mode	Task Name	Baseline Start	Baseline Finish	Duration
1			**Project Management**	**Tue 9/3/19**	**Sat 2/1/20**	**152 days**
2	▦		Start of Academic Year	Tue 9/3/19	Tue 9/3/19	0 days
3			Recruitment	Tue 9/3/19	Fri 9/20/19	18 days
4			Lab Safety Training	Tue 9/3/19	Fri 10/18/19	46 days
5			Rules Released & Reviewed	Mon 9/9/19	Mon 9/9/19	1 day
6			Theme Decision	Wed 10/2/19	Wed 10/2/19	1 day
7			ASCE Annual Report Submission	Sat 2/1/20	Sat 2/1/20	0 days
8			**Canoe Development**	**Tue 9/10/19**	**Sun 3/29/20**	**202 days**
9			**Hull Design**	**Tue 9/10/19**	**Sun 12/1/19**	**83 days**
10			Draft Hull Design	Tue 9/10/19	Thu 9/19/19	10 days
11			Final Hull Design Selection	Thu 9/19/19	Thu 9/19/19	0 days
12			Release Hull Dimensions	Fri 9/20/19	Fri 9/20/19	1 day
13			Prototype Construction	Sat 9/21/19	Sat 11/2/19	43 days
14			Structural Analysis	Sat 10/26/19	Sun 11/3/19	9 days
15			Foam Sized and CNC Milled	Thu 10/17/19	Mon 11/25/19	40 days
16			Mold Pick-up and Delivery	Tue 11/26/19	Sun 12/1/19	6 days
17			**Concrete Mix Design**	**Tue 9/10/19**	**Tue 3/3/20**	**176 days**
18			**Structural Mix**	**Tue 9/10/19**	**Tue 1/14/20**	**127 days**
19			Material Procurement for Testing (Structural)	Tue 9/10/19	Tue 10/8/19	29 days
20			Binder, Aggregate, and Fiber Testing	Tue 9/10/19	Wed 11/20/19	72 days
21			Final Structural Mix Selection	Wed 11/20/19	Wed 11/20/19	0 days
22			Final Structural Mix Material Procurement	Mon 12/2/19	Tue 1/14/20	44 days
23			**Finishing Mix**	**Mon 11/11/19**	**Tue 3/3/20**	**114 days**
24			Material Procurement for Testing (Finishing)	Mon 11/11/19	Mon 1/13/20	64 days
25			Finishing Mix Design & Testing	Mon 12/2/19	Sun 2/9/20	70 days
26			Application Technique Testing	Mon 12/2/19	Sun 2/9/20	70 days
27			Final Finishing Mix Selection	Sun 2/9/20	Sun 2/9/20	0 days
28			Final Finishing Mix Material Procurement	Mon 2/10/20	Tue 3/3/20	23 days
29			**Reinforcement**	**Tue 9/10/19**	**Sun 12/15/19**	**97 days**
30			Material Procurement for Testing	Tue 9/10/19	Wed 9/18/19	9 days
31			Reinforcement Testing	Wed 9/25/19	Fri 11/22/19	59 days
32			Final Reinforcement Selection	Fri 11/22/19	Fri 11/22/19	0 days
33			Final Reinforcement Material Procurement	Sat 11/23/19	Sun 12/15/19	23 days
34			**Canoe Construction**	**Wed 10/9/19**	**Sun 2/16/20**	**131 days**
35			Casting Practices	Wed 10/9/19	Wed 1/15/20	99 days
36			Mold Assembly	Mon 12/2/19	Sun 12/15/19	14 days
37			Pre-Batch Final Structural Mix	Wed 1/15/20	Thu 1/16/20	2 days
38			Pre-Cut Reinforcement	Mon 12/16/19	Fri 12/20/19	5 days
39			Concrete Placement	Sat 1/18/20	Sat 1/18/20	1 day
40			Initial Cure with Mold	Sun 1/19/20	Sat 2/1/20	14 days
41			Mold Removal	Sun 2/2/20	Sun 2/2/20	1 day
42			Final Curing	Mon 2/3/20	Sun 2/16/20	14 days
43			**Finishing & Aesthetics**	**Mon 2/17/20**	**Sun 3/29/20**	**42 days**
44			Sanding	Mon 2/17/20	Wed 3/4/20	17 days
45			Interior & Exterior Design	Thu 3/5/20	Sun 3/22/20	18 days
46			Sealing	Mon 3/23/20	Sun 3/29/20	7 days
47			Finishing Complete	Sun 3/29/20	Sun 3/29/20	0 days
48			**Communications**	**Sat 10/26/19**	**Wed 4/1/20**	**159 days**
49			**Technical Presentation**	**Mon 1/20/20**	**Wed 4/1/20**	**73 days**
50			Create Presentation	Mon 1/20/20	Thu 2/20/20	32 days
51			Presentation Practice	Mon 1/20/20	Fri 3/27/20	68 days
52			Professional Reviews	Mon 3/2/20	Sun 3/15/20	14 days
53			Final Revision	Mon 3/16/20	Fri 3/27/20	12 days
54			Presentation Complete	Wed 4/1/20	Wed 4/1/20	0 days
55			**Technical Proposal**	**Sat 10/26/19**	**Mon 2/17/20**	**115 days**
56			Proposal Outline & Draft	Sat 10/26/19	Sun 1/5/20	72 days
57			Professional Reviews	Mon 1/6/20	Fri 1/17/20	12 days
58			Final Revision	Sat 1/18/20	Mon 1/20/20	3 days
59			Technical Proposal Submission	Mon 2/17/20	Mon 2/17/20	0 days
60			**Material Technical Data Sheets Addendum**	**Mon 1/13/20**	**Mon 2/17/20**	**36 days**
61			MTDS Outline & Draft	Mon 1/13/20	Wed 1/29/20	17 days
62			Professional Reviews	Thu 1/30/20	Wed 2/5/20	7 days
63			Final Revision	Thu 2/6/20	Wed 2/12/20	7 days
64			MTDS Addendum Submission	Mon 2/17/20	Mon 2/17/20	0 days
65			**Final Product Display**	**Mon 1/20/20**	**Mon 3/30/20**	**71 days**
66			Table Top Display Design & Construction	Mon 1/20/20	Sun 3/29/20	70 days
67			Display Stands Design & Construction	Mon 1/20/20	Sun 3/29/20	70 days
68			Cross Section Design & Construction	Sat 2/8/20	Sun 3/29/20	51 days
69			Compliance Check	Mon 3/30/20	Mon 3/30/20	1 day
70			Final Product Display Complete	Mon 3/30/20	Mon 3/30/20	0 days
71			**Paddler Training**	**Tue 9/3/19**	**Mon 3/30/20**	**210 days**
72			Outdoor Paddling Practice	Tue 9/3/19	Sun 11/3/19	62 days
73			Indoor Paddling Practice	Mon 11/4/19	Mon 3/30/20	148 days
74			Prototype Testing	Sun 11/3/19	Mon 3/30/20	149 days
75			Selection of Competition Paddlers	Fri 12/20/19	Fri 12/20/19	0 days
76			**North Central Student Conference**	Fri 4/3/20	Sun 4/5/20	3 days
77			**National Competition**	**Mon 4/6/20**	**Mon 6/15/20**	**71 days**
78			**Technical Proposal**	**Mon 4/6/20**	**Tue 5/19/20**	**44 days**
79			Final Revision	Mon 4/6/20	Sun 4/19/20	14 days
80			Technical Proposal Submission	Tue 5/19/20	Tue 5/19/20	0 days
81			**Material Technical Data Sheets Addendum**	**Mon 4/6/20**	**Mon 2/17/20**	**44 days**
82			Final Revision	Mon 4/6/20	Sun 4/19/20	14 days
83			MTDS Addendum Submission	Tue 5/19/20	Tue 5/19/20	0 days
84	▦		**National Concrete Canoe Competition**	Sat 6/13/20	Mon 6/15/20	3 days



Michigan Technological University
Concrete Canoe
2019-2020 Preliminary Schedule

Baseline Milestone ◇	Baseline Summary	Task	Milestone ◆	Summary	Critical	Critical Split	Baseline

Appendix A-Mixture Proportions and Calculations

MIXTURE: Structural, Backfill

CEMENTITIOUS MATERIALS

Component	*Specific Gravity*	*Volume ft³*	*Amount of CM lb/yd³*	
Type 1 Portland Cement, ASTM C150	3.15	1.998	392.7	Total cm (includes c) 811.4 lb/yd³ c/cm ratio, by mass 0.484
Blast Furnace Slag	2.99	0.87	162.3	
Fly Ash – Class C	2.65	1.413	233.7	
Silica Fume	2.22	0.164	22.7	

FIBERS

Component	*Specific Gravity*	*Volume*	*Amount of Fibers lb/yd³*	
PVA RFS400	1.3	0.06	4.9	Total Amount of Fibers 12.2 lb/yd³
Endura Prime	0.91	0.129	7.3	

AGGREGATES (EXCLUDING MINERAL FILLERS PASSING NO. 200 SIEVE)

Aggregates	*Expanded Glass (EG) or Cenosphere (C)*[1]	*Abs (%)*	*SG$_{OD}$*	*SG$_{SSD}$*	*Base Quantity, W*		*Volume, $V_{agg,SSD}$ ft³*
					W_{OD} lb/yd³	*W_{SSD} lb/yd³*	
Poraver 1-2 mm	Yes	0.20	0.39	0.468	65.82	78.99	2.71
Poraver 0.5-1 mm	Yes	0.25	0.47	0.587	35.11	43.88	1.20
Poraver 0.25-0.5 mm	Yes	0.30	0.59	0.767	16.68	21.68	0.45
K1	Yes	0	0.125	0.125	32.91	32.91	2.11
K37	Yes	0	0.37	0.37	41.69	41.69	0.18
Elemix	No	0.055	0.042	0.044	6.58	6.94	2.51
Trinity Haydite (#8 Sieve)	No	0.122	1.17	1.313	152.27	170.85	2.09
RCA (#8 Sieve)	No	0.22	1.10	1.342	87.76	107.07	1.28

LIQUID ADMIXTURES

Admixture	*lb/ US gal*	*Dosage (fl. oz / cwt)*	*% Solids*	*Amount of Water in Admixture*	
BASF GLENIUM 3030NS	9.009	6.00	0.2027	2.66 lb/yd³	Total Water from Liquid Admixtures, $\sum w_{admx}$ 2.66 lb/yd³

SOLIDS (DYES, POWDERED ADMIXTURES, AND MINERAL FILLERS)

Component	*Specific Gravity*	*Volume (ft³)*	*Amount (lb/yd³)*	
K1	0.125	2.11	16.46	Total Solids, S_{total} 68.88 lb/yd³
K37	0.37	1.63	37.52	
DCI Concrete Pigments – various colors	2.25	0.11	14.90	

WATER

	Amount		*Volume ft³*
Water, w [$=\sum (w_{free} + w_{admx} + w_{batch})$]	w/c ratio, by mass 0.93 w/cm ratio, by mass 0.45	365.13	5.85
Total Free Water from All Aggregates, $\sum w_{free}$		-62.20	
Total Water from All Admixtures, $\sum w_{admx}$		2.66	
Batch Water, w_{batch}		424.68	

DENSITIES, AIR CONTENT, RATIOS, AND SLUMP

Values for 1 cy of concrete	*cm*	*Fibers*	*Aggregate (SSD)*	*Solids, S_{total}*	*Water, w*	*Total*
Mass, M	811.4	12.2	450.04	68.88	365.13	$\sum M$: 1707.6 lb.
Absolute Volume, V	4.45	0.189	12.52	3.84	5.85	$\sum V$: 26.85 ft³
Theoretical Density, T, ($=\sum M / \sum V$)	63.61 lb/ft³		*Air Content, Air, [= (T – D)/T x 100%]*			-10.1 %
Measured Density, D	70.05 lb/ft³		*Air Content, Air, [= (27 – $\sum V$))/27 x 100%]*			0.56 %
Total Aggregate Ratio[2] *($=V_{agg,SSD}$ / 27)*	46.4 %		*Slump, Slump flow, Spread (as applicable)*			0.5 in.
EG+C Ratio[3] *($=V_{EG+C}$ / $V_{agg,SSD}$)*	46.9 %					

MIXTURE: FINISHING

CEMENTITIOUS MATERIALS

Component	*Specific Gravity*	*Volume*	*Amount of CM*	
Type 1 Portland Cement, ASTM C150	3.15	2.622	515.3	Total cm (includes c) 811.4 lb/yd^3 c/cm ratio, by mass 0.6
Blast Furnace Slag	2.99	1.842	343.6	

FIBERS

Component	*Specific Gravity*	*Volume*	*Amount of Fibers*	
PVA RFS400	1.3	0	0	Total Amount of Fibers 0 lb/yd^3
Enduro Prime	0.91	0	0	

AGGREGATES (EXCLUDING MINERAL FILLERS PASSING NO. 200 SIEVE)

Aggregates	*Expanded Glass (EG) or Cenosphere (C)*[1]	*Abs (%)*	SG_{OD}	SG_{SSD}	*Base Quantity, W*		*Volume,* $V_{agg,SSD}$
					W_{OD}	W_{SSD}	
Poraver 0.1-0.3 mm	Yes	35	0.90	1.22	53.019	71.576	0.94
K1	Yes	0	0.125	0.125	31.811	31.811	4.08
K37	Yes	0	0.37	0.37	4.242	4.242	0.18
Trinity Haydite (#16 Sieve)	No	36	1.17	1.59	318.112	432.632	4.36
RCA (#16 Sieve)	No	22	1.10	1.34	53.019	64.683	0.77

LIQUID ADMIXTURES

Admixture	*lb/ US gal*	*Dosage (fL oz / cwt)*	*% Solids*	*Amount of Water in Admixture*	
BASF GLENIUM 3030NS	9.009	9	20.27	3.99	Total Water from Liquid Admixtures, $\sum w_{admx}$ 3.99 lb/yd^3

SOLIDS (DYES, POWDERED ADMIXTURES, AND MINERAL FILLERS)

Component	*Specific Gravity*	*Volume (ft^3)*	*Amount (lb/yd^3)*	
K1	**0.125**	4.08	31.81	Total Solids. S_{total} 84.89 lb/yd^3
K37	**0.37**	1.66	38.17	
DCI Concrete Pigments-various colors	**1.19**	0.20	14.90	

WATER

	Amount lb/yd^3		*Volume ft^3*
Water, w, $[=\sum (w_{free} + w_{admx} + w_{batch})]$	w/c ratio, by mass 0.75 w/cm ratio, by mass 0.45	386.51	6.19
Total Free Water from All Aggregates, $\sum w_{free}$		-65.05	
Total Water from All Admixtures, $\sum w_{admx}$		3.99	
Batch Water, w_{batch}		447.57	

DENSITIES, AIR CONTENT, RATIOS, AND SLUMP

Values for 1 cy of concrete	*cm*	*Fibers*	*Aggregate (SSD)*	*Solids,* S_{total}	*Water, w*	*Total*
Mass, M lb	858.90	0	529.22	84.89	386.51	$\sum M$:1859.5 lb
Absolute Volume, V ft^3	4.46	0	10.34	5.84	6.19	$\sum V$: 26.83 ft^3
Theoretical Density, T, (=$\sum M / \sum V$)	69.31 lb/ft^3		*Air Content, Air, [= (T – D)/T x 100%]*			4.70 %
Measured Density, D	66.05 lb/ft^3		*Air Content, Air, [= (27 – $\sum V$))/27 x 100%]*			0.63 %
Total Aggregate Ratio[2] (=$V_{agg,SSD}$/ 27)	38.3 %		*Slump, Slump flow, Spread* (as applicable)			4 in.
EG+C Ratio[3] (=V_{EG+C} / $V_{agg,SSD}$)	49.6 %					

Cementitious Material

$Mass_{Portland} = 392.7lb$ $SG_{Portland} = 3.15$

$Mass_{BlastSlag} = 162.3lb$ $SG_{BlastSlag} = 2.99$

$Mass_{FlyAsh} = 233.7lb$ $SG_{FlyAsh} = 2.65$

$Mass_{SilicaFume} = 22.7lb$ $SG_{SilicaFume} = 2.22$

$$Volume_{Portland} = \frac{Mass_{Portland}}{SG_{Portland} \cdot 62.4 \frac{lb}{ft^3}} = 1.998 \cdot ft^3$$

$$Volume_{BlastSlag} = \frac{Mass_{BlastSlag}}{SG_{BlastSlag} \cdot 62.4 \frac{lb}{ft^3}} = 0.87 \cdot ft^3$$

$$Volume_{FlyAsh} = \frac{Mass_{FlyAsh}}{SG_{FlyAsh} \cdot 62.4 \frac{lb}{ft^3}} = 1.413 \cdot ft^3$$

$$Volume_{SilicaFume} = \frac{Mass_{SilicaFume}}{SG_{SilicaFume} \cdot 62.4 \frac{lb}{ft^3}} = 0.164 \cdot ft^3$$

$$\Sigma Mass_{CM} = Mass_{Portland} + Mass_{BlastSlag} + Mass_{FlyAsh} + Mass_{SilicaFume} = 811.4 \cdot lb$$

$$\Sigma Volume_{CM} = Volume_{Portland} + Volume_{BlastSlag} + Volume_{FlyAsh} + Volume_{SilicaFume} = 4.445 \cdot ft^3$$

$$C\_CM\_Ratio = \frac{Mass_{Portland}}{\Sigma Mass_{CM}} = 0.484$$

Fibers

$Mass_{RFS400} = 4.9lb$ $SG_{RFS400} = 1.3$

$Mass_{EnduroPrime} = 7.3lb$ $SG_{EnduroPrime} = 0.91$

$$Volume_{RFS400} = \frac{Mass_{RFS400}}{SG_{RFS400} \cdot 62.4 \frac{lb}{ft^3}} = 0.06 \cdot ft^3$$

$$Volume_{EnduroPrime} = \frac{Mass_{EnduroPrime}}{SG_{EnduroPrime} \cdot 62.4 \frac{lb}{ft^3}} = 0.129 \cdot ft^3$$

$$\Sigma Mass_{Fibers} = Mass_{RFS400} + Mass_{EnduroPrime} = 12.2 \cdot lb$$

$$\Sigma Volume_{Fibers} = Volume_{RFS400} + Volume_{EnduroPrime} = 0.189 \cdot ft^3$$

Aggregates (50% of K1 and 90% of K37 are to be recorded as Mineral Filler)

$\text{MassOD}_{\text{Poraver1}} = 65.8231\,\text{lb}$ $\quad \text{Abs}_{\text{Poraver1}} = .20$ $\quad \text{SGOD}_{\text{Poraver1}} = 0.39$

$\text{MassOD}_{\text{Poraver0.5}} = 35.1057\,\text{lb}$ $\quad \text{Abs}_{\text{Poraver0.5}} = .25$ $\quad \text{SGOD}_{\text{Poraver0.5}} = 0.47$

$\text{MassOD}_{\text{Poraver0.25}} = 16.6752\,\text{lb}$ $\quad \text{Abs}_{\text{Poraver0.25}} = .30$ $\quad \text{SGOD}_{\text{Poraver0.25}} = 0.59$

$\text{MassOD}_{\text{K1}} = 32.9116\,\text{lb}$ $\quad \text{Abs}_{\text{K1}} = 0$ $\quad \text{SGOD}_{\text{K1}} = 0.125$

$\text{MassOD}_{\text{K37}} = 41.6880\,\text{lb}$ $\quad \text{Abs}_{\text{K37}} = 0$ $\quad \text{SGOD}_{\text{K37}} = 0.37$

$\text{MassOD}_{\text{Elemix}} = 6.5823\,\text{lb}$ $\quad \text{Abs}_{\text{Elemix}} = 0.055$ $\quad \text{SGOD}_{\text{Elemix}} = 0.042$

$\text{MassOD}_{\text{Haydite}} = 152.2708\,\text{lb}$ $\quad \text{Abs}_{\text{Haydite}} = .122$ $\quad \text{SGOD}_{\text{Haydite}} = 1.17$

$\text{MassOD}_{\text{RCA}} = 87.7642\,\text{lb}$ $\quad \text{Abs}_{\text{RCA}} = .22$ $\quad \text{SGOD}_{\text{RCA}} = 1.10$

$\text{MSSD}_{\text{Poraver1}} = \text{Abs}_{\text{Poraver1}} \cdot \text{MassOD}_{\text{Poraver1}} + \text{MassOD}_{\text{Poraver1}} = 78.988\,\text{lb}$

$\text{MSSD}_{\text{Poraver0.5}} = \text{Abs}_{\text{Poraver0.5}} \cdot \text{MassOD}_{\text{Poraver0.5}} + \text{MassOD}_{\text{Poraver0.5}} = 43.882\,\text{lb}$

$\text{MSSD}_{\text{Poraver0.25}} = \text{Abs}_{\text{Poraver0.25}} \cdot \text{MassOD}_{\text{Poraver0.25}} + \text{MassOD}_{\text{Poraver0.25}} = 21.678\,\text{lb}$

$\text{MSSD}_{\text{K1}} = \text{Abs}_{\text{K1}} \cdot \text{MassOD}_{\text{K1}} + \text{MassOD}_{\text{K1}} = 32.912\,\text{lb}$

$\text{MSSD}_{\text{K37}} = \text{Abs}_{\text{K37}} \cdot \text{MassOD}_{\text{K37}} + \text{MassOD}_{\text{K37}} = 41.688\,\text{lb}$

$\text{MSSD}_{\text{Elemix}} = \text{Abs}_{\text{Elemix}} \cdot \text{MassOD}_{\text{Elemix}} + \text{MassOD}_{\text{Elemix}} = 6.944\,\text{lb}$

$\text{MSSD}_{\text{Haydite}} = \text{Abs}_{\text{Haydite}} \cdot \text{MassOD}_{\text{Haydite}} + \text{MassOD}_{\text{Haydite}} = 170.848\,\text{lb}$

$\text{MSSD}_{\text{RCA}} = \text{Abs}_{\text{RCA}} \cdot \text{MassOD}_{\text{RCA}} + \text{MassOD}_{\text{RCA}} = 107.072\,\text{lb}$

$\text{SGSSD}_{\text{Poraver1}} = \text{Abs}_{\text{Poraver1}} \cdot \text{SGOD}_{\text{Poraver1}} + \text{SGOD}_{\text{Poraver1}} = 0.468$

$\text{SGSSD}_{\text{Poraver0.5}} = \text{Abs}_{\text{Poraver0.5}} \cdot \text{SGOD}_{\text{Poraver0.5}} + \text{SGOD}_{\text{Poraver0.5}} = 0.587$

$\text{SGSSD}_{\text{Poraver0.25}} = \text{Abs}_{\text{Poraver0.25}} \cdot \text{SGOD}_{\text{Poraver0.25}} + \text{SGOD}_{\text{Poraver0.25}} = 0.767$

$\text{SGSSD}_{\text{K1}} = \text{Abs}_{\text{K1}} \cdot \text{SGOD}_{\text{K1}} + \text{SGOD}_{\text{K1}} = 0.125$

$\text{SGSSD}_{\text{K37}} = \text{Abs}_{\text{K37}} \cdot \text{SGOD}_{\text{K37}} + \text{SGOD}_{\text{K37}} = 0.37$

$\text{SGSSD}_{\text{Elemix}} = \text{Abs}_{\text{Elemix}} \cdot \text{SGOD}_{\text{Elemix}} + \text{SGOD}_{\text{Elemix}} = 0.044$

$\text{SGSSD}_{\text{Haydite}} = \text{Abs}_{\text{Haydite}} \cdot \text{SGOD}_{\text{Haydite}} + \text{SGOD}_{\text{Haydite}} = 1.313$

$\text{SGSSD}_{\text{RCA}} = \text{Abs}_{\text{RCA}} \cdot \text{SGOD}_{\text{RCA}} + \text{SGOD}_{\text{RCA}} = 1.342$

$$V_{\text{Poraver1}} = \frac{\text{MSSD}_{\text{Poraver1}}}{\text{SGSSD}_{\text{Poraver1}} \cdot 62.4 \frac{\text{lb}}{\text{ft}^3}} = 2.705\,\text{ft}^3 \qquad V_{\text{K37}} = \frac{\text{MSSD}_{\text{K37}}}{\text{SGSSD}_{\text{K37}} \cdot 62.4 \frac{\text{lb}}{\text{ft}^3}} = 1.806\,\text{ft}^3$$

$$V_{\text{Poraver0.5}} = \frac{\text{MSSD}_{\text{Poraver0.5}}}{\text{SGSSD}_{\text{Poraver0.5}} \cdot 62.4 \frac{\text{lb}}{\text{ft}^3}} = 1.197\,\text{ft}^3 \qquad V_{\text{K1}} = \frac{\text{MSSD}_{\text{K1}}}{\text{SGSSD}_{\text{K1}} \cdot 62.4 \frac{\text{lb}}{\text{ft}^3}} = 4.219\,\text{ft}^3$$

$$V_{\text{Poraver0.25}} = \frac{\text{MSSD}_{\text{Poraver0.25}}}{\text{SGSSD}_{\text{Poraver0.25}} \cdot 62.4 \frac{\text{lb}}{\text{ft}^3}} = 0.453\,\text{ft}^3 \qquad V_{\text{Elemix}} = \frac{\text{MSSD}_{\text{Elemix}}}{\text{SGSSD}_{\text{Elemix}} \cdot 62.4 \frac{\text{lb}}{\text{ft}^3}} = 2.512\,\text{ft}^3$$

$$V_{Haydite} = \frac{MSSD_{Haydite}}{SGSSD_{Haydite} \cdot 62.4 \frac{lb}{ft^3}} = 2.086 \cdot ft^3 \qquad V_{RCA} = \frac{MSSD_{RCA}}{SGSSD_{RCA} \cdot 62.4 \frac{lb}{ft^3}} = 1.279 \cdot ft^3$$

$$\Sigma MSSD_{non\_EG\_C\_aggs} = MSSD_{Elemix} + MSSD_{Haydite} + MSSD_{RCA} = 284.864 \cdot lb$$

$$\Sigma MassSSD_{aggs} = MSSD_{Poraver1} + MSSD_{Poraver0.5} + MSSD_{Poraver0.25} + 0.5MSSD_{K1} + 0.1MSSD_{K37} + \Sigma MSSD_{non\_EG\_C\_aggs} = 450.037 \cdot lb$$

$$\Sigma Volume_{aggs} = V_{Poraver1} + V_{Poraver0.5} + V_{Poraver0.25} + 0.5V_{K1} + 0.1V_{K37} + V_{Elemix} + V_{Haydite} + V_{RCA} = 12.521 \cdot ft^3$$

Admixtures

$$Dosage_{BASF3030} = 6.00 \frac{fl\_oz}{100lb} \qquad \%Solids_{BASF3030} = 0.2027 \qquad Density_{BASF3030} = 9.009 \frac{lb}{gal}$$

$$WC_{BASF3030} = 1 - \%Solids_{BASF3030} = 0.797$$

$$Water_{BASF3030} = Dosage_{BASF3030} \cdot 7.8930 \cdot 100lb \cdot WC_{BASF3030} \cdot Density_{BASF3030} = 2.658 \cdot lb$$

$$\Sigma Water_{admix} = Water_{BASF3030} = 2.658 \cdot lb$$

Solids (50% of K1 and 90% of K37 are to be recorded as Mineral Filler)

$$Mass_{DCIPigments} = 14.90lb \qquad SGOD_{DCIPigments} = 2.25$$

$$MassOD_{K1} = 32.912 \cdot lb \qquad SGOD_{K1} = 0.125$$

$$MassOD_{K37} = 41.688 \cdot lb \qquad SGOD_{K37} = 0.37$$

$$V_{DCIPigments} = \frac{Mass_{DCIPigments}}{SGOD_{DCIPigments} \cdot 62.4 \frac{lb}{ft^3}} = 0.106 \cdot ft^3$$

$$V_{K1} = 4.219 \cdot ft^3$$

$$V_{K37} = 1.806 \cdot ft^3$$

$$\Sigma Mass_{solids} = Mass_{DCIPigments} + 0.9 \cdot MassOD_{K37} + 0.5 \cdot MassOD_{K1} = 68.875 \cdot lb$$

$$\Sigma Volume_{solids} = V_{DCIPigments} + 0.9 \cdot V_{K37} + 0.5 \cdot V_{K1} = 3.841 \cdot ft^3$$

Free Water

$$MC_{Poraver1} = 0.005$$

$$MC_{Poraver0.5} = 0.005$$

$$MC_{Poraver0.25} = 0.005$$

$$MC_{K1} = 0$$

$$MC_{K37} = 0$$

$$MC_{Elemix} = 0$$

$$MC_{Haydite} = 0.01$$

$$MC_{RCA} = 0.01$$

$$WF_{Poraver1} = MassOD_{Poraver1} \cdot \left(MC_{Poraver1} - Abs_{Poraver1}\right) = -12.836 \cdot \mathrm{lb}$$

$$WF_{Poraver0.5} = MassOD_{Poraver0.5} \cdot \left(MC_{Poraver0.5} - Abs_{Poraver0.5}\right) = -8.601 \cdot \mathrm{lb}$$

$$WF_{Poraver0.25} = MassOD_{Poraver0.25} \cdot \left(MC_{Poraver0.25} - Abs_{Poraver0.25}\right) = -4.919 \cdot \mathrm{lb}$$

$$WF_{K1} = MassOD_{K1} \cdot \left(MC_{K1} - Abs_{K1}\right) = 0 \cdot \mathrm{lb}$$

$$WF_{K37} = MassOD_{K37} \cdot \left(MC_{K37} - Abs_{K37}\right) = 0 \cdot \mathrm{lb}$$

$$WF_{Elemix} = MassOD_{Elemix} \cdot \left(MC_{Elemix} - Abs_{Elemix}\right) = -0.362 \cdot \mathrm{lb}$$

$$WF_{Haydite} = MassOD_{Haydite} \cdot \left(MC_{Haydite} - Abs_{Haydite}\right) = -17.054 \cdot \mathrm{lb}$$

$$WF_{RCA} = MassOD_{RCA} \cdot \left(MC_{RCA} - Abs_{RCA}\right) = -18.43 \cdot \mathrm{lb}$$

$$\Sigma WFree = WF_{Poraver1} + WF_{Poraver0.5} + WF_{Poraver0.25} + WF_{K1} + WF_{K37} + WF_{Elemix} + WF_{Haydite} + WF_{RCA} = -62.202 \cdot \mathrm{lb}$$

Water

$$\mathrm{W\_CM\_ratio} = 0.45$$

$$W = \mathrm{W\_CM\_ratio} \cdot \Sigma Mass_{CM} = 365.13 \cdot \mathrm{lb}$$

$$W_{batch} = W - \left(\Sigma WFree + \Sigma Water_{admix}\right) = 424.675 \cdot \mathrm{lb}$$

$$Volume_{batch} = \frac{W}{62.4 \frac{\mathrm{lb}}{\mathrm{ft}^3}} = 5.851 \cdot \mathrm{ft}^3$$

Concrete Analysis

$$\Sigma Masses = \Sigma Mass_{CM} + \Sigma Mass_{Fibers} + \Sigma MassSSD_{aggs} + \Sigma Mass_{solids} + W = 1.708 \times 10^3 \cdot \mathrm{lb}$$

$$\Sigma Volumes = \Sigma Volume_{CM} + \Sigma Volume_{Fibers} + \Sigma Volume_{aggs} + \Sigma Volume_{solids} + Volume_{batch} = 26.847 \cdot \mathrm{ft}^3$$

$$Density_{Theor} = \frac{\Sigma Masses}{\Sigma Volumes} = 63.606 \cdot \frac{\mathrm{lb}}{\mathrm{ft}^3} \qquad Density_{Meas} = 70.05 \frac{\mathrm{lb}}{\mathrm{ft}^3}$$

$$\mathrm{Air\_Content\%} = \frac{Density_{Theor} - Density_{Meas}}{Density_{Theor}} \cdot 100 = -10.13$$

Important Ratios

$$\mathrm{Water\_Cement\_Ratio} = \frac{W}{Mass_{Portland}} = 0.93 \qquad \mathrm{Aggregate\_Ratio} = \frac{\Sigma Volume_{aggs}}{27 \mathrm{ft}^3} = 0.464$$

$$\mathrm{Water\_CM\_Ratio} = \frac{W}{\Sigma Mass_{CM}} = 0.45 \qquad \mathrm{EG\_C\_Ratio} = \frac{V_{Elemix} + V_{Haydite} + V_{RCA}}{\Sigma Volume_{aggs}} = 0.469$$

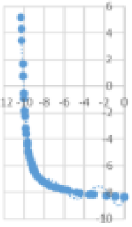
Appendix B- Structural Calculations

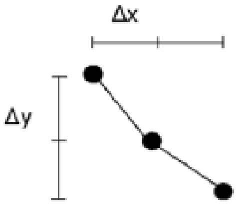
Cross Sectional Properties (needed to find canoe self-weight)

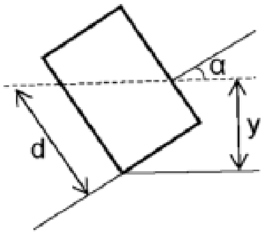
- The process used to obtain cross section properties involves breaking each cross-section into pieces, based on the number of control points for the profile curve. The sample calculations below are for the cross-section 118 inches from the bow, which is the midpoint of the canoe. Cross-section 118 has 48 control points. Properties were calculated for one side, and doubled if necessary.

Control Points

Point	x (in)	y (in)
1	-11.01	-5.03
2	-10.88	-5.03
3	-10.84	-5.47







Gunwale y location =5.129 in

Keel y location = -8.744

$$I = \frac{bd}{12}(d^2\cos^2(\alpha) + b^2\sin(\alpha))$$

$$A = b * d$$

$$\bar{y} = \frac{1}{2}(d * \cos(\alpha) + b * \sin(\alpha))$$

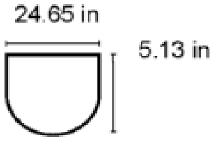
$$\alpha = \pi - \left|\tan^{-1}\left(\frac{\Delta y}{\Delta x}\right)\right|$$

$$d = \sqrt{(\Delta x)^2 + (\Delta y)^2}$$

$$b = 0.375 in$$

Piece	Δx (in)	Δy (in)	α (rad)	d (in)	A (in^2)	I_c (about piece centroid) (in^4)	$\bar{y}$ (from bottom point) (in)	$\bar{y}$ from coor. Axis (in)
1	0.123	-0.331	-0.36	0.35	0.13	.0014	.0015	-5.26
2	.0463	-0.109	-0.40	0.04	0.04	.0001	.0004	-5.48

Cross Section 118" dimensions



After all properties are calculated for each piece, section properties can be found:

Area A: Sum of all areas, multiplying by two → A= 18.03 in^2

Location of neutral axis, $\bar{y}$ using A and centroids, location of neutral axis can be found: $\bar{y} = \frac{\sum A * c}{\sum A}$ = -1.75 in

I_x: Given I_c, A, $\bar{y}$ and location of neutral axis, I_x about the x-axis can be found using parallel axis theorem. $I_x = \sum I + \sum(a * d^2)$
= 659.27in

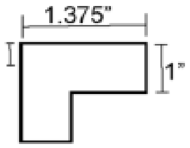
Gaps and overlaps

Using angles between pieces; areas, centroids, and moment of inertia for gaps and overlaps were calculated. In depth examples of this procedure, which relies on breaking each gap/overlap into pieces, would exceed the page limit of this appendix.

For cross section 118:

A_{gap}= 0.21 in^2 $\bar{y}$ from coor. Axis= -3.57 I_x about x-axis = 5.27

Gunwale Caps



A_{cap}= 1.37 in^2 $\bar{y}$ from coor. Axis= 4.42in

I_x about x axis= 43.03 in^4

Total cross section properties (adding together appropriately)

A= 19.03 in^2 I_x= 680.79 in^4

$\bar{y}$= 5.1294 in I about neutral axis= 586 in^4

Internal Stresses

$\sigma = \frac{My}{I}$ y gunwale = 5.129 in

y keel = -8.7439

$\sigma_{gunwale}$ = 11842.9 in-LB * 5.129in/588in^4 = **102.65 psi**

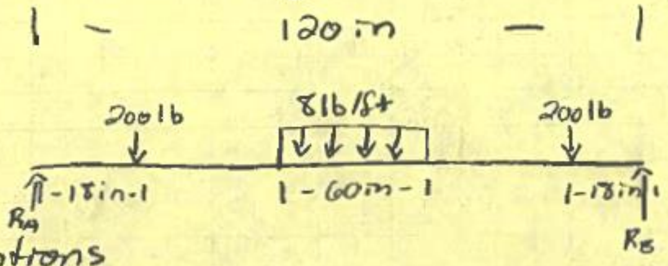
σ_{keel} = 11842.9 in-LB * -8.7439in/588in^4 = **176.71 psi**

Total Length of Canoe = 20ft = 120in

Paddler locations : 0.15(120in) = 18in

0.85(120in) = 102in

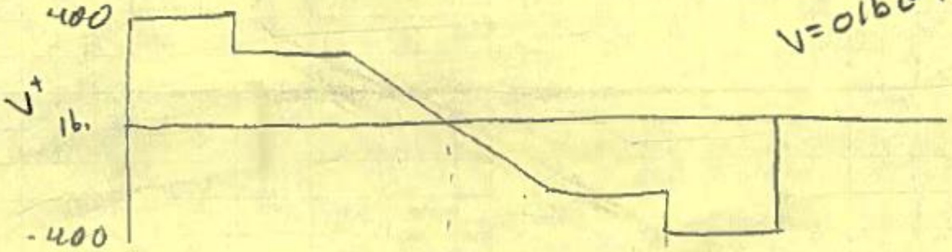
Free Body Diagram



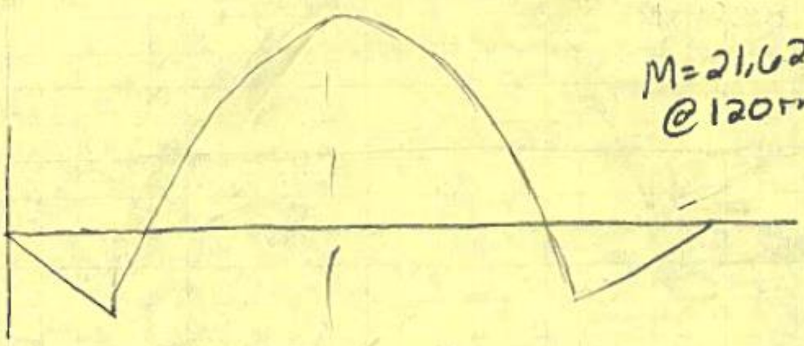
$R_A = R_B = \frac{2(200)+(80)(5)}{2}$

$= 400\text{lb}$

- Assumptions
- Canoe weighs 200lb
- Material is homogeneous
- Cargo load is evenly distributed



V = 0lb @ 120in



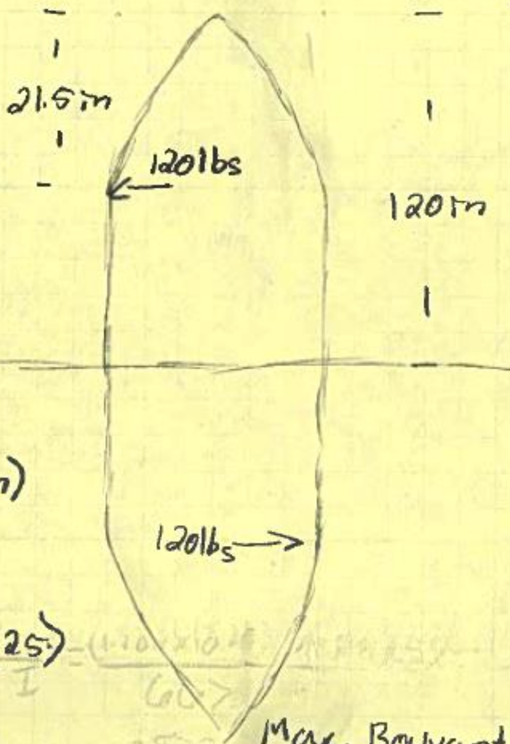
M = 21,620lb·in @120in

$\sigma = \frac{Mc}{I}$

$I = 667.49\,in^4$
(Excel)

$C = \frac{120in - 21.5in}{2}$

$= 49.25in$



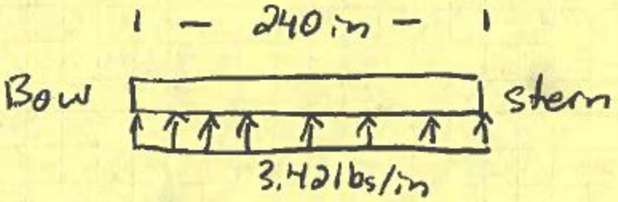
$M = F\Delta d$
$= (120lbs)(120in - 21.5in)$
$= 1.182 \times 10^4\,lb\text{-}in$

$\sigma = \frac{Mc}{I} = \frac{(1.182 \times 10^4)(49.25)}{667.49}$
$= 872.13\,psi$

Max. Bouyant force $= 2(240lbs) + 2(170l$
$= 820lbs$

$\sigma_{cable} = \frac{840lbs}{\frac{\pi}{4}(3/16)^2} = 30,422\,psi$

$\frac{820lbs}{240in} = 3.42\frac{lbs}{in}$ avg



Appendix C

PERCENT OPEN AREA CALCULATIONS

Calculations per Attachment 3

Samples: SpiderLath and GlasGrid®8511 Mesh

Given

$n_{1,SL}$ = 34

$n_{1,GG}$ = 9 Number of apertures along length

$n_{2,SL}$ = 35

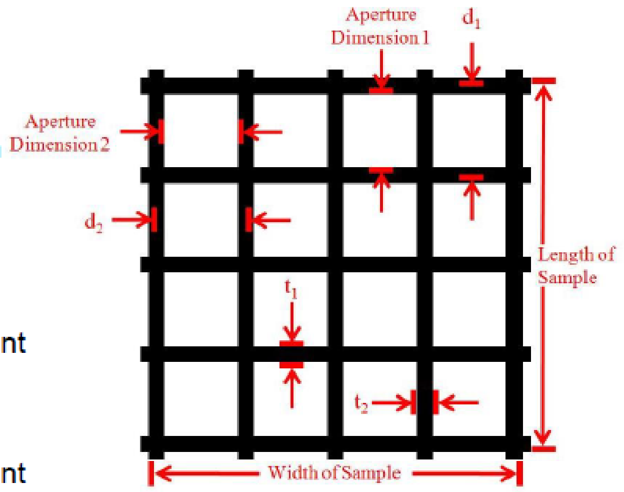
$n_{2,GG}$ = 5 Number of apertures along width

$t_{1,SL}$ = 0.103 in Average thickness of reinforcement along length

$t_{1,GG}$ = 0.262 in

$t_{2,SL}$ = 0.051 in Average thickness of reinforcement

t = 0.170 i



Sample of Reinforcement

Aperture_Dimension_1_SL = 0.312 in

Aperture_Dimension_1 _GG= 0.737 in

Aperture_Dimension_2 _SL= 0.288 in

Aperture_Dimension_2 _GG= 0.808 in

d_1 = Aperture_Dimension_1 + 2*(t_1/2)

$d_{1,SL}$ = 0.42 in

$d_{1,GG}$ = 0.99 in

Average spacing of reinforcement (center-to-center) along the sample length

d_2 = Aperture_Dimension_2 + 2*(t_2/2)

$d_{2,SL}$= 0.34 in

$d_{2,GG}$= 0.98 in

Average spacing of reinforcement (center-to-center) along the sample width

Determine Solution Percent Open Area (POA) for the GlasGrid®8511 Mesh

$Length_{Sample} = n_1 * d_1$

$Length_{SL}$ = 14.09 in

$Length_{GG}$ = 8.98 in

$Width_{Sample} = n_2 * d_2$

$Width_{SL}$ = 11.85 in

$Width_{GG}$ = 4.91 in

$Area_{Open} = n_1 * n_2 *$ Aperture_Dimension_1*Aperture_Dimension_2

$Area_{Open,SL}$ = 106.76 in^2

$Area_{Open,GG}$ = 680 in^2

$Area_{Total} = Length_{Sample} * Width_{Sample}$

$Area_{Tota,SL}$ = 167.05 in^2

$Area_{Total,GG}$ = 1120 in^2

POA = ($Area_{Open}$/$Area_{Total}$)*100

POA _SL= 63.9%

The POAs are greater than the 40% minimum required, demonstrating compliance.

HULL THICKNESS CALCULATIONS

Calculations per Attachment 3

Annotation

T_G = 0.045 in	Average thickness of first layer of reinforcement, GlasGrid®8511 Mesh
T_S = 0.050 in	Average thickness of second layer of reinforcement, SpiderLath Mesh
T_H = 0.375 in	Nominal thickness of the canoe hull

Determine that the reinforcement at any point in the canoe will not exceed 50% of the total hull thickness.

Solution

Within the canoe, a maximum of one layer of GlasGrid®8511 and two layers of SpiderLath were used along the bottom of the canoe.

$$\frac{T_G + 2T_S}{T_H} * 100 = 38.7$$

The two layers of reinforcement make up approximately 38.7% of the hull. This value is less than the maximum value of 50% outlined in Attachment 3, demonstrating compliance.

GUNNEL CAP THICKNESS CALCULATIONS

Calculations per Section 4.3.1

Annotation

T_S = 0.050 in	Average thickness of the layer of reinforcement, SpiderLath Mesh
T_C = 0.1875 in	Diameter of the steel cable
T_W = 1 in	Nominal thickness of the gunwale cap

Determine that the reinforcement at any point in the canoe will not exceed 50% of the total hull thickness.

Solution

One layer of SpiderLath Mesh was used throughout the gunnel cap.

$$\frac{T_S + T_C}{T_W} * 100 = 23.75$$

The layer of reinforcement makes up approximately 23.75% of the gunnel cap. This value is less than the maximum value of 50% outlined in Attachment 3, demonstrating compliance.

Appendix D- References

ASCE/NCCC. (2020). 2020 ASCE National Concrete Canoe Competition™ Request for Proposals. ASCE. (September 25, 2019).

ASTM International. (2013). “Standard Test Method for Flexural Properties of Continuous Fiber-Reinforced Advanced Ceramic Composites”. C1341-13. West Conshohocken, PA.

ASTM International. (2013). “Standard Specification for Mixing Rooms, Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cements and Concretes”. C511-13. West Conshohocken, PA.

ASTM International. (2014). “Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete”. C138/C138M-17a. West Conshohocken, PA.

ASTM International. (2015). “Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens”. C39/C39M-15a. West Conshohocken, PA.

ASTM International. (2017). “Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens”. C496/C496M-17. West Conshohocken, PA.

ASTM International. (2017). “Standard Specification for Lightweight Aggregates for Structural Concrete”. C330/C330M-17. West Conshohocken, PA.

AutoCAD 2018. Computer Software. Autodesk, Inc., San Rafael, CA.

Gopalaratnam, V., and Shah, S. (1984). “Instrumented Impact Testing of Brittle Materials.” Engineering Mechanics in Civil Engineering: Proceedings of the Fifth Engineering Mechanics Division Specialty Conference, 1, 635–639.

Michigan Tech Concrete Canoe Team. (2019). Driftwood: Michigan Technological University Design Report. Houghton, MI.

Microsoft Excel. Computer Software. Microsoft, Redmond, WA.

NX. Computer Software. Siemens PLM Software, Plano, TX.

PROLINES 98. Computer Software. Vacanti Yacht Design LLC, Anacortes, WA.

Silica Fume & Sustainability. (n.d.). In *NORCHEM*. Retrieved from https://www.norchem.com/applications-sustainability.html

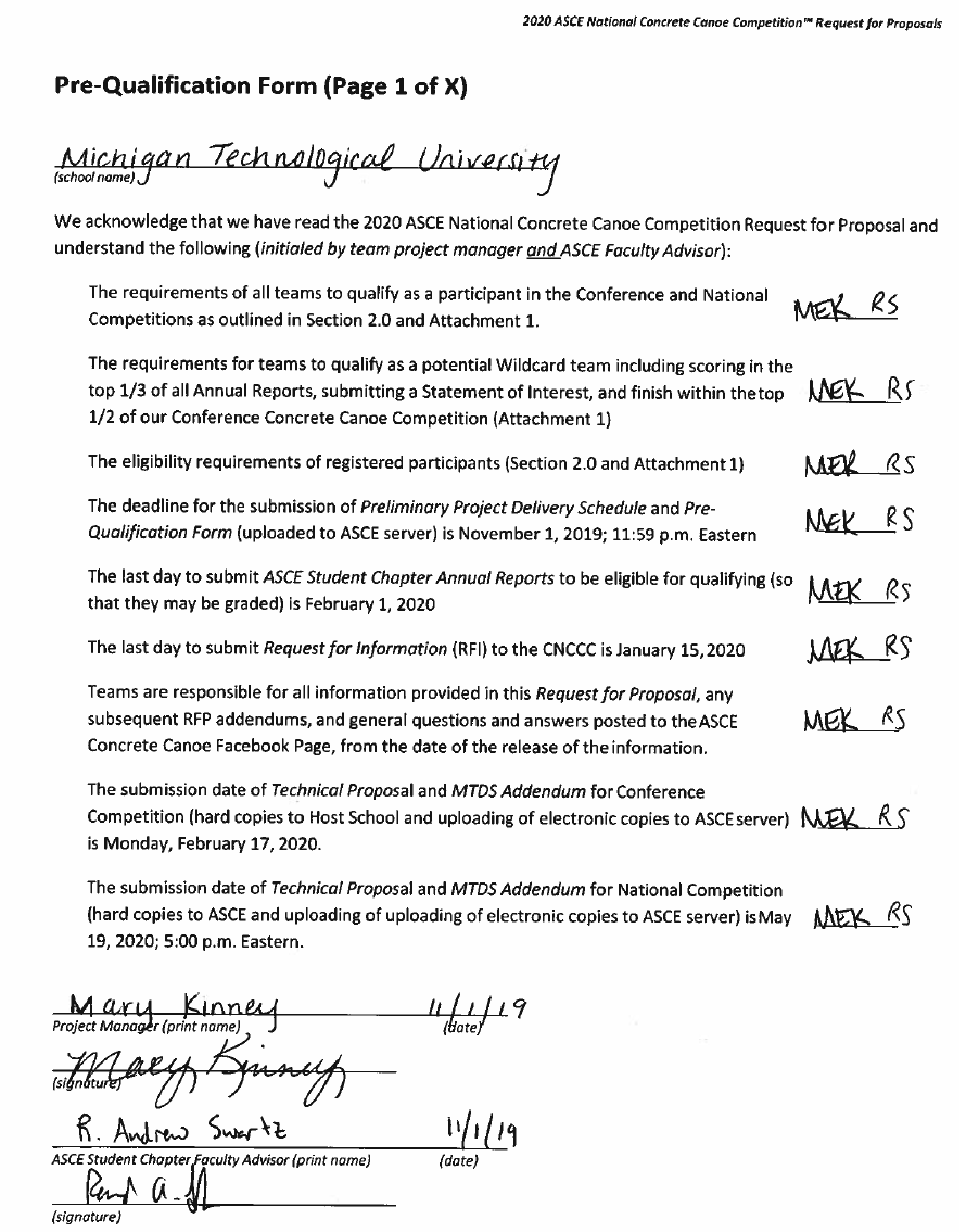
Zastrau, B., Richter, M., and Lepenies, I. (2002). “On the Analytical Solution of Pullout Phenomena in Textile Reinforced Concrete.” Journal of Engineering Materials and Technology, 125(1), 38–43.

Cover Photo and Organization Chart shot at Hudson’s Site, Detroit, Michigan, courtesy of John Mayer

Header Graphic courtesy of Touchplan

Footer Graphic courtesy of Valley Driving School

Appendix E- Supporting Documentation



2020 ASCE National Concrete Canoe Competition™ Request for Proposals

Pre-Qualification Form (Page 1 of X)

Michigan Technological University
(school name)

We acknowledge that we have read the 2020 ASCE National Concrete Canoe Competition Request for Proposal and understand the following (*initialed by team project manager* *and* *ASCE Faculty Advisor*):

The requirements of all teams to qualify as a participant in the Conference and National Competitions as outlined in Section 2.0 and Attachment 1. MEK RS

The requirements for teams to qualify as a potential Wildcard team including scoring in the top 1/3 of all Annual Reports, submitting a Statement of Interest, and finish within the top 1/2 of our Conference Concrete Canoe Competition (Attachment 1) MEK RS

The eligibility requirements of registered participants (Section 2.0 and Attachment 1) MEK RS

The deadline for the submission of *Preliminary Project Delivery Schedule* and *Pre-Qualification Form* (uploaded to ASCE server) is November 1, 2019; 11:59 p.m. Eastern MEK RS

The last day to submit *ASCE Student Chapter Annual Reports* to be eligible for qualifying (so that they may be graded) is February 1, 2020 MEK RS

The last day to submit *Request for Information* (RFI) to the CNCCC is January 15, 2020 MEK RS

Teams are responsible for all information provided in this *Request for Proposal*, any subsequent RFP addendums, and general questions and answers posted to the ASCE Concrete Canoe Facebook Page, from the date of the release of the information. MEK RS

The submission date of *Technical Proposal* and *MTDS Addendum* for Conference Competition (hard copies to Host School and uploading of electronic copies to ASCE server) is Monday, February 17, 2020. MEK RS

The submission date of *Technical Proposal* and *MTDS Addendum* for National Competition (hard copies to ASCE and uploading of uploading of electronic copies to ASCE server) is May 19, 2020; 5:00 p.m. Eastern. MEK RS

Mary Kinney 11/1/19
Project Manager (print name) (date)

Mary Kinney
(signature)

R. Andrew Swartz 11/1/19
ASCE Student Chapter Faculty Advisor (print name) (date)

(signature)

Pre-Qualification Form (Page 2 of X)

Michigan Technological University
(school name)

In 150 words or less, provide a high-level overview of the team's Health & Safety (H&S) Program. If there is currently not one in place, what does the team envision their H&S program will entail?

Our team has a health and safety plan in place which centers around proper training for personal and the use of proper PPE in the lab environment and during paddling practices. Prior to being allowed into the on-campus lab area, members are required to complete online safety training courses about general safety awareness, hazard communication, and the university chemical hygiene plan. Members who complete these training tour the lab with the lab supervisor to familiarize them with our resources, as well as explain the rules and potential hazards of the work area. To mitigate risk of injury in the lab, there is a required dress code of pants and closed toed shoes, safety goggles are a required PPE for all work done in the lab, and dust masks and gloves are used as needed. At paddling practices, all boats are equipped with enough life-vests for everyone in the boat.

In 150 words or less, provide a high-level overview of the team's current QA/QC Program. If there is currently not one in place, what does the team envision their QA/QC program will entail?

Our team's QC/QA plan consists of three separate sectors: schedule control, compliance control, and knowledge control. Under the umbrella of schedule control, we have other areas of focus such as material procurement, communications, and budget. Within compliance control, the focus remains on documentation and technical review. Within knowledge control, the emphasis is on training, recruitment, and knowledge transfer. The team has one QC/QA committee head that oversees the implementation of the various sectors, however, each committee head is also responsible to maintain knowledge transfer to less tenured members within their own areas of expertise.

Has the team reviewed the Department and/or University safety policies regarding material research, material lab testing, construction, or other applicable areas for the project?

Yes, our team has reviewed the Department and University safety policies relevant to our work.

The anticipated canoe name and overall theme is – *(please provide a brief description of the theme. The intent is to allow ASCE to follow up to determine if there may be copyright or trademark issues to contend with, as well as to provide insight)*

This year our anticipated canoe name is Dozer, correlating to the theme Construction. With this theme, we will utilize the use of barrels and other barricades, signs, safety, and emphasize the cross-sectional area of a road (subgrade/base layers/pavement/etc.).

Has this theme been discussed with the team's Faculty Advisor about potential Trademark or Copywrite issues?

Yes, we anticipate no Trademark or Copywrite issues.

The core project team is made up of_____number of people.

Our team this year is made up of 31 members.

Provide an estimated project budget for the year (including materials, transportation, etc.). Base this on real costs (not costs provided in the Detailed Cost Assessment). List and approximate (percentage (%) of overall) anticipated financial sources for the upcoming year (University, material donations, sponsors, monetary donations, etc.)

Committee	Costs	Commentary
Mix Design		
Cement	donated	
Aggregates	$ 900.00	
Cementitious Material	$ 200.00	
Supplies (gloves, masks, etc.)	$ 50.00	
Reinforcement		
Material	donated	
Material	$ 250.00	
Construction		
Prototype (wood)	$ 300.00	
Prototype (other supplies)	$ 100.00	
Foam	donated	* For mold
Mold	donated	
Mold: Shipping	$ 2,615.60	* Gas cost
Mold: Preparation	$ 100.00	
Other Miscellaneous Supplies	$ 150.00	
Paddling		
Indoor Pool Paddling (per hr)	$ 160.00	
2 hr ~ 14 weeks	$ 4,480.00	
Buoys / Life Jackets	$ 100.00	
Admin		
Newsletter Printing / Shipping	$ 50.00	
Paper Printing / Shipping	$ 50.00	
Recruitment Supplies	$ 75.00	
Travel		
Truck Rental (1)	donated	* For trailer
Van Rental (2)	$ 450.00	* $45 per day (5 days)
Gas Cost	$ 858.00	* For 3 vehicles (1320 miles roundtrip)
Regional Conference		
School Registration	$ 250.00	
Individuals Registration	$ 25.00	
Banquet	$ 25.00	
~ 20 Members	$ 1,000.00	
Hotel	$ 3,200.00	* $160 per night (5 rooms)
National Conference		
Costs	$ 6,000.00	* Estimated (registration/travel)
Total	**$ 21,178.60**	
Financial Sources		
Monetary Donations	35%	* Alum/Family/Companies
USG	15%	* Undergrad student government
Sponsors		* Material donations
Departmental	50%	* Civil, Material Sci, Electrical, & Mechanical

RFP Addendum Acknowledgment Form

Michigan Technological University
(school name)

We acknowledge that we have received and acknowledge the following Addendums to the 2020 ASCE National Concrete Canoe Competition Request for Proposal (*initialed by team project manager and ASCE Faculty Advisor*):

Addendum No. 1: Presentation Q&A

This Addendum provides the Technical Presentation score card and a list of questions that the Judges can use during the 10-minute Judge's question & answer period. In addition, a scorecard was provided.

Per Section 8.0 of the Request for Proposals (RFP), the presentation is limited to 3 minutes and will be cutoff at precisely 3 minutes by a signal. Also, per Section 8.0 of the RFP, the technical presentation "...should focus on the primary aspects of the design, construction, and technical capabilities. Briefly summarize the major aspects of the project, with the intent of demonstrating why your team, design, and prototype should be selected by the panel of judges for the standardized design (recall this is a hypothetical scenario to provide an end goal for the RFP and the competition)."

MEK
RAS

Addendum No. 2: Durability & Repairs

This Addendum provides information regarding how the durability of the canoe prototype is to be assessed, allowable repairs and materials, and forms including *Damage / Accident Report*, *Repair Procedure Report*, and *Reconstruction Request*.

MEK
RAS

Addendum No. 3: Detailed Cost Assessment

This Addendum provided a list of material costs for a variety of cementitious materials, pozzolans, admixtures, fibers, aggregates, and other constituents that were not presented in *Attachment 4: Detailed Cost Assessment* of the Request for Proposal. Teams were also advised that if they have products that were not given a specific price for, they should use their best judgement to use a price for a similar material in their Material Cost Estimate.

MEK
RAS

Mary Kinney 2/10/20
Project Manager (print name) *(date)*

Mary Kinney
(signature)

R. Andrew Swartz 2/12/20
ASCE Student Chapter Faculty Advisor (print name) *(date)*

(signature)