University of Michigan

Concrete Canoe 2023

Boogie Boat

Project Proposal

Date: February 17th, 2023

To: Committee on Concrete Canoe Competitions

Subject: Response to RFP – 2023 Technical Proposal, BOOGIE BOAT

Dear Committee on Concrete Canoe Competitions,

The Michigan Concrete Canoe Team declares that the proposed hull design, concrete mixture design, reinforcement scheme, and construction of the prototype canoe have been performed in full compliance with the specifications outlined in the *Request for Proposal* (RFP). The team has reviewed all Material Technical Data Sheets (MTDS) and Safety Data Sheets (SDS) for the included and experimental materials. The *Request for Information* (RFI) Summary has been reviewed by the team, and the team's submissions comply with all requirements from the responses provided in the summary. The below list of anticipated registered participants and their associated ASCE Society Member ID Numbers contains only those who are both Society Student Members of ASCE and qualified student members who meet all eligibility requirements.

University of Michigan:

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Executive Summary

In 1972, Naval Architecture and Marine Engineering students from the University of Michigan built and raced the university's first concrete canoe.[1] In footage from their class, students paddle their canoes together on the water and return to land smiling.

Figure 1. Students Paddle 1972 Concrete Canoe

Fifty years later, the Michigan Concrete Canoe Team (MCCT) contributes to the collaborative and colorful culture of the university by enabling students to work together and adapt in the face of adversity. The '70s was the time of disco fever and the MCCT wanted to honor their predecessors who poured the foundation for their canoe fever. This year, the team embodies the unique, colorful, and revolutionary spirit of the '70s through testing and incorporating vibrant colors and an experimental schedule. The 2023 team of about 40 students follows in the Class of 1972's footsteps and brings *BOOGIE BOAT*, an exceptional and well-designed canoe, to meet the 2023 Concrete Canoe Competition's Request for Proposals (RFP). The specifications for *BOOGIE BOAT* are shown below in **Table 1.**

MCCT competes in ASCE's Eastern Great Lakes Conference and demonstrates its commitment to the university's tenets with this year's submission. Recent years have been the most transformative in the team's recorded history. While unable to compete with *KEPLER* in 2020 due to the COVID-19 pandemic, MCCT made many improvements maintained up to this year. In 2021, *ROWMAINE*, while not a physical prototype, placed first in the North Central Conference and went on to place sixth at Nationals. Last year, MCCT's 2022 canoe, *STALLION,* placed second in the Eastern Great Lakes Conference. The team is proud of its evolution and success due to dedicated members engaging in multidisciplinary design and striving for technical excellence.

The 2023 team embraces the interdisciplinary nature of the Concrete Canoe Competition with the greatest diversity in majors in the team's recorded history. This includes more than ten majors, eight of which are in the College of Engineering. The team used their combined knowledge to improve the structural design and aesthetics of the canoe. Team members also persevered through supply chain issues, challenges with testing, and rescheduling Casting Day. However, the team was more adaptable and resilient than ever, undoubtedly due to the diversity of skills and dedication of MCCT's members.

Table 1. Canoe Specifications

BOOGIE BOAT					
Weight	300 lbs		Compressive Strength (28 day)	1595 psi	
Length	236 in		Split Tensile Strength (28 Day)	299 psi	
Width	28 in		Flexural Strength (28 Day)	300 psi	
Depth	14.3 in		Pressure Air Content	11.0%	
Average Hull Thickness	0.75 in		Slump	0.25 in	
Structural Concrete Unit Weight	Wet	79.3 lbs/ft^3	Finishing Concrete Unit Weight	Wet	60.3 lbs/ft^3
	Dry	73 lbs/ft^3		Dry	47 lbs/ft^3

MCCT's Hull Design subteam built off the experience of paddling from the most recent competition and took steps to improve performance by enhancing stability and maneuverability. MCCT improved stability by increasing the canoe's freeboard and beam. The team overhauled previous years' designs by choosing a shallow arch cross-section and shortening the overall length of the canoe. The team wanted to embody the values of the '70s by embracing experimentation and questioning precedent. The team has not used colored pigment in the structural mix of the canoe since 2015.[2]

It was passed down by word of mouth that pigment caused test samples to have increased density, so generations of teams have avoided pigmented concrete. However, MCCT wanted a groovy canoe that was bright and multicolored to fit the '70s aesthetic. The Mix Design subteam tested in-mix pigments and spray-on stains for the concrete, evaluating their effects on strength and buoyancy. The Mix Design subteam was agile and responsive to the needs of the team due to improvements in data collection and material storage.

Embracing the diverse skill set of MCCT members and growing from pushing boundaries, MCCT submits its canoe design, *BOOGIE BOAT*, as a response to the 2023 RFP.

Project Delivery Team

ASCE Student Chapter Profile

The ASCE Student Chapter at the University of Michigan organizes academic, social, and professional events for its members and the wider Civil and Environmental Engineering (CEE) community. The chapter has eight student officers and holds weekly executive board meetings to discuss current and future events. The first event of the year organized and hosted by the University's student chapter was the annual CEE Career Fair, which was held in person this year. This career fair is unique to the department in that all of the companies that are invited to the fair are searching for civil and/or environmental engineers. This event brings professionalism to campus by helping students in the department find internships, co-ops, and full-time positions.

The ASCE Student Chapter at Michigan also hosts a Speaker Series and luncheon occurring most Fridays. This Series has been a staple within the department for several years and attracts audiences of undergraduate and graduate students from various civil and environmental engineering concentrations. The series also provides an opportunity for companies to recruit, create a presence on campus, and build professional connections. The presentations themselves are a mix of technical engineering information and engaging networking. The chapter endeavors to create a relaxed environment where students can ask questions and learn.

Lastly, the ASCE Student Chapter at the University of Michigan hosts social events. It is very important to build lasting connections with peers and faculty, as well as to bridge the gap between environmental engineering and civil engineering disciplines. The student chapter helps build these relationships by hosting social events such as volunteering at the campus farm and the Huron River Watershed, celebrating fall with cider and donuts, and participating in intramural sports. The annual weekend in Chicago is currently being planned for early Spring, where alumni will take students for on-site tours at engineering firms around the city. This is a great opportunity for networking with alumni and faculty and for students to learn more about the industry in a hands-on manner. Collaborations between the chapter and MCCT have contributed to the ongoing success of both groups. This relationship ensures that MCCT has the support necessary for continual improvement and excellence at the annual ASCE concrete canoe competition.

Key Team Roles

Captain, *Xanthe Thomas*: The Captain creates a project plan for the year, monitors the team's progress, and acts as the liaison between the university and the project team. This position holds weekly general meetings, plans outreach events to recruit new members, and keeps subteams informed to make sure they are on track with critical path milestones. Additionally, the Captain helps any subteam when questions arise and prepares the team for competition.

Secretary, *Jenna Bonello*: The Secretary writes weekly meeting recap emails to ensure all members are involved and informed. This position keeps team member information up to date and plans social events.

Treasurer, *Stacey Zeng*: The Treasurer directs the team's finances. This includes registering for the competition and managing the cost of materials for the team's operations. This position also coordinates team fundraising.

Hull Design Lead, *Vivian Kim*: The Hull Design Lead guides the process of designing and modeling the hull of the canoe. This position also analyzes load cases and ensures design goals are met.

Structural Lead, *Patrick White*: The Structural Lead utilizes modeling software to analyze the hull of the canoe to determine performance metrics. This position supports the hull design lead and ensures the structural integrity of the canoe.

Mix Design Lead, *Erdem Ozdemir*: The Mix Design Lead designs and tests concrete mixes to determine the optimal one. This position keeps a notebook of each mix to track curing and strength.

Mix Design Assistant, *Ben Routhier*: The Mix Design Assistant works closely with the Mix Design Lead to plan and run subteam meetings. This position lessens the workload of the mix design lead and improves the efficiency of subteam meetings. The intention is that the assistant will become next year's Mix Design Lead.

Inventory Lead, *Gillian James*: The Inventory Lead works closely with the Mix Design Lead and the Mix Design Assistant to monitor material quantities and coordinate the donations, purchases, and deliveries of MCCT's materials.

Construction Lead, *Cindy Wheaton*: The Construction Lead designs the technical display, canoe stands, and other large aesthetic elements such as the cross-section.

Aesthetics Lead, *Ghassaq (Gigi) Nassir*: The Aesthetics Lead designs the overall look of the canoe, technical paper, and display. The team votes on a theme and the aesthetics lead makes this theme cohesive throughout all display elements.

Technical Submissions Lead, *Karina Otten*: The Technical Submissions Lead makes sure that the team's competition technical submissions are complete and cohesive.

Finishing Lead, *Jamie Blatnikoff*: The Finishing Lead completes the final details and finish of the canoe. This position prepares the mold, trowels the canoe during casting, and organizes the sanding process after the canoe has cured.

Quality Control (QA/QC) Manager, *Leah Riutta*: The Quality Control/Assurance Manager ensures that the team follows all rules and guidelines outlined in the RFP. The position also organizes test procedures for sample concrete, Casting Day concrete, and the canoe itself to check that these items meet MCCT's quality standards.

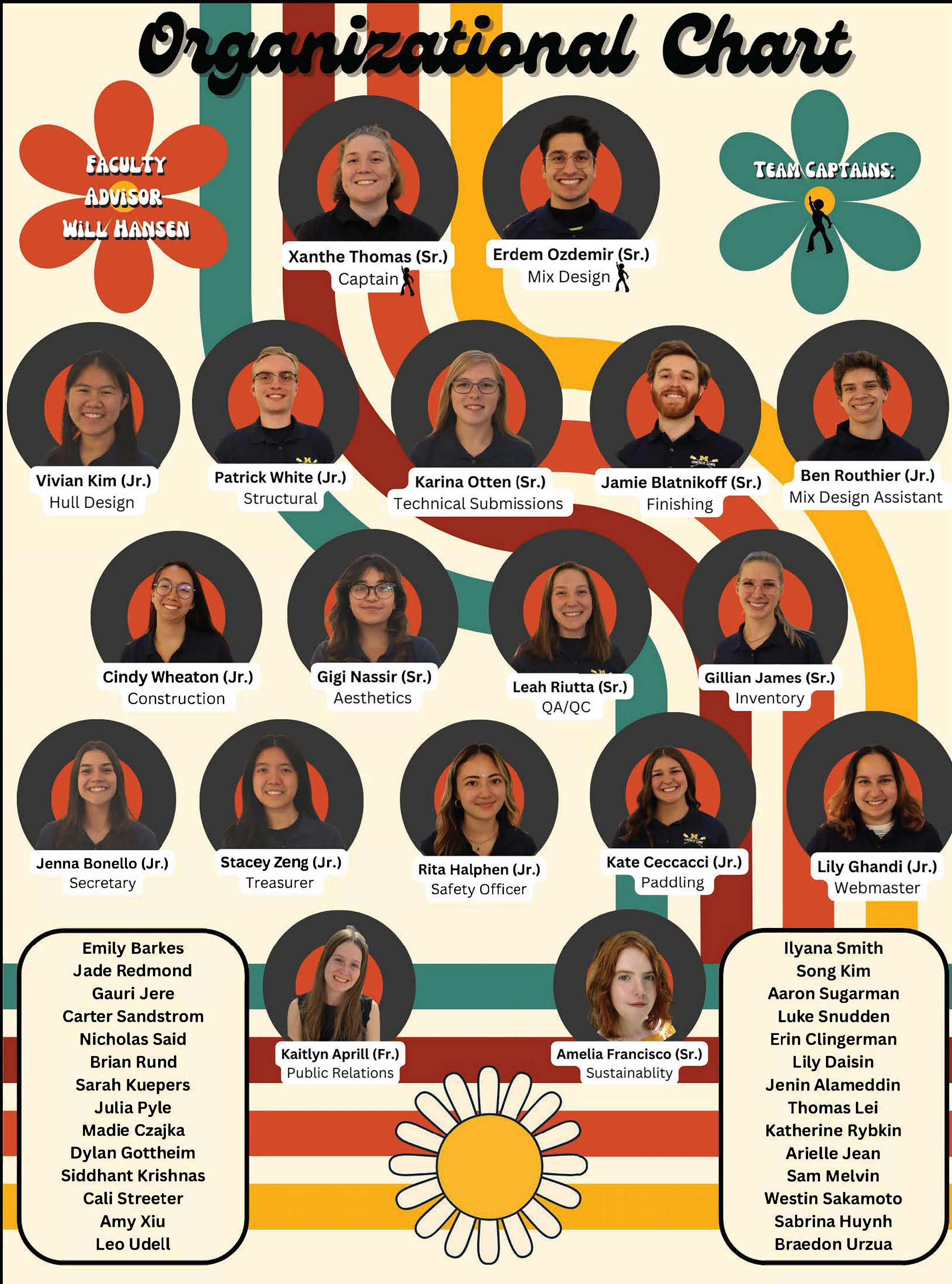
Paddling Lead, *Kate Ceccacci*: The Paddling Lead recruits the paddling subteam and organizes team workouts. This position also plans events and reserves locations to practice paddling.

Safety Officer, *Rita Halphen*: The Safety Officer learns all of the requirements for the team to use a workspace at the Wilson Student Team Project Center on campus and keeps team members informed of these requirements. This position attends weekly safety meetings to make sure that the student project space is utilized safely.

Public Relations, *Kaitlyn Aprill*: The Public Relations Officer increases awareness of the team on campus. This includes all of the team's social media posts, planning social events for the team, and planning recruiting events.

Webmaster, *Lily Gandhi*: The Webmaster updates the team's website with sponsor information and team member bios.

Sustainability Lead, *Amelia Francisco*: The Sustainability Lead is responsible for overseeing that the team is prioritizing sustainability and making sustainable, environmentally conscious choices. This includes producing the team's Life Cycle Analysis.



Organizational Chart
Faculty Advisor Will Hansen
Team Captains:
Xanthe Thomas (Sr.)
Captain
Erdem Ozdemir (Sr.)
Mix Design
Vivian Kim (Jr.)
Hull Design
Patrick White (Jr.)
Structural
Karina Otten (Sr.)
Technical Submissions
Jamie Blatnikoff (Sr.)
Finishing
Ben Routhier (Jr.)
Mix Design Assistant
Cindy Wheaton (Jr.)
Construction
Gigi Nassir (Sr.)
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Leah Riutta (Sr.)
QA/QC
Gillian James (Sr.)
Inventory
Jenna Bonello (Jr.)
Secretary
Stacey Zeng (Jr.)
Treasurer
Rita Halphen (Jr.)
Safety Officer
Kate Ceccacci (Jr.)
Paddling
Lily Ghandi (Jr.)
Webmaster
Emily Barkes
Jade Redmond
Gauri Jere
Carter Sandstrom
Nicholas Said
Brian Rund
Sarah Kuepers
Julia Pyle
Madie Czajka
Dylan Gottheim
Siddhant Krishnas
Cali Streeter
Amy Xiu
Leo Udell
Kaitlyn Aprill (Fr.)
Public Relations
Amelia Francisco (Sr.)
Sustainablity
Ilyana Smith
Song Kim
Aaron Sugarman
Luke Snudden
Erin Clingerman
Lily Daisin
Jenin Alameddin
Thomas Lei
Katherine Rybkin
Arielle Jean
Sam Melvin
Westin Sakamoto
Sabrina Huynh
Braedon Urzua

Technical Approach

Hull Design

The main objective for *BOOGIE BOAT* was to prioritize paddler comfort, based on MCCT's experience at the 2022 regional competition. The Hull Design subteam achieved this by increasing stability and maneuverability. Throughout the hull design process, the subteam ensured that new members understood how to use the design software and could justify changes to the design. A collaborative design exploration and decision-making process resulted in *BOOGIE BOAT* being 236 inches long, 28 inches wide, and 14.3 inches deep.

The Hull Design subteam decided to innovate with an original hull built on naval architecture insight. The subteam also adopted a new software, Siemens NX, to design the canoe. Siemens NX supports parametric definition of the hull geometry, allowing the shape of the canoe to be rapidly modified by changing a few key input parameters.[3]

To improve the performance of the canoe, the Hull Design subteam focused on making the canoe easier to maneuver and propel forward. These changes involved choosing a smaller length-to-beam ratio and reducing the prominence of the keel line in comparison to *STALLION,* as shown in **Figure 2**.[4] The subteam used the mass moment of inertia in yaw to quantify each design's maneuverability. Holtrop Mennen's 1982 method for resistance prediction was used to quantify the straight-line speed of potential designs.[5]

Figure 2. Cross-Section Comparison of *BOOGIE BOAT* (black) and *STALLION* (red)

The Hull Design subteam also intentionally added rocker to both ends of *BOOGIE BOAT*. The deepest point of the canoe is 13 inches below the bow depth and 9 inches below the stern depth. This results in a shorter waterline length, making the canoe easier to turn. The addition of rocker also reduces the canoe's wetted surface area, resulting in less frictional drag.

Multiple performance metrics were selected to quantify stability as the canoe was analyzed using Orca3D Hydrostatics under the design displacement of the two-male load case.[6] The first stability metric was the righting moment at 20 degrees of the heel. The second stability metric was the angle of downflooding, representing the angle of the heel at which water will begin to come over the gunwale of the canoe. The subteam required a minimum downflooding angle of 30 degrees for all potential designs. The final stability metric was freeboard, having a minimum requirement of 8 inches. *BOOGIE BOAT*'s increased depth and beam meets these requirements and will provide the paddlers with more comfort and security, so they can focus on racing.

Relieving the paddlers of concerns about falling into the water or water coming into the canoe allows them to perform their best during the prototype performance demonstration. The shorter length and added rocker make the canoe easier to paddle and turn, while the greater width makes it more stable. Subteam members learned to use new software and gained an understanding of how changes to canoe parameters impacted performance. The collaborative decision on *BOOGIE BOAT*'s parameters cultivated an engaging and cooperative team environment.

Structural Analysis

For structural analysis, the Hull Design subteam evaluated the shear, bending, and punching shear for the two-male load case. The team modeled the canoe hull structure as a beam with the uniform section shown in **Figure 3**. The weight of the canoe was estimated as 300 lbs.

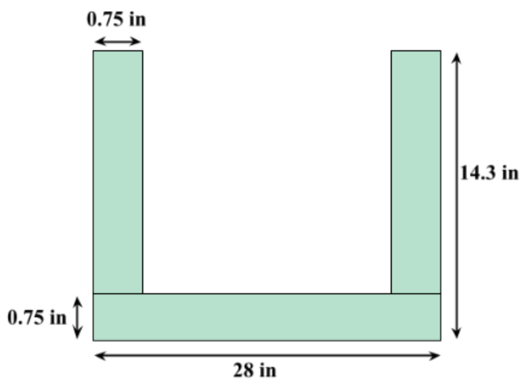


Figure 3. Cross-Section for Structural Analysis

A coordinate system was established such that positive forces act downward. The longitudinal direction along the canoe was defined as the z direction. Paddlers were treated as point loads of 175 lbs each positioned at 20% and 80% of the overall canoe length. The distributed buoyancy force was approximated by **Equation 1**. The distributed weight force was approximated by **Equation 2**.

$$b(z) = -b_1(z - b_2)^2 + b_1(b_2)^2 \quad \textbf{Eqn 1}$$

$$w(z) = -w_1(z - w_2)^4 + w_1(w_2)^4 \quad \textbf{Eqn 2}$$

Boundary conditions were imposed on the distributed buoyancy and weight functions to determine the coefficients as shown below. The integrals of the functions were set equal to the total buoyant force and total concrete weight respectively. The z intercepts of the functions were set to be at z = 0 and z = L.

$$b_1 = \frac{(Canoe + Paddler\ Weight)}{(b_2)^2 L - \frac{2(b_2)^3}{3}} = 0.513$$

$$w_1 = \frac{Canoe\ Weight}{(w_2)^4 L - \frac{2(w_2)^5}{5}} = 0.513$$

$$b_2 = w_2 = \frac{L}{2} = \frac{19.7ft}{2} = 9.83$$

The distributed loads and the paddler point loads are shown along the canoe in **Figure 4**.

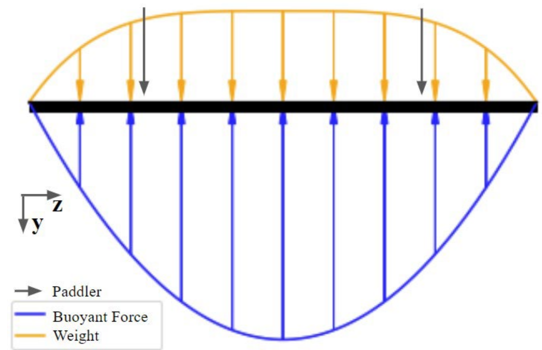


Figure 4. Free Body Diagram of Two-Male Load Case

From integrating the distributed forces, the shear force is defined as:

$$V(z_1) = -\left(\int_0^{z_1} w(z)\ dz - \int_0^{z_1} b(z)\ dz + \sum_0^{z_1}(Applied\ Point\ Loads)\right)$$

The maximum positive or negative shear force is 148 lbf as shown in **Figure 5**.

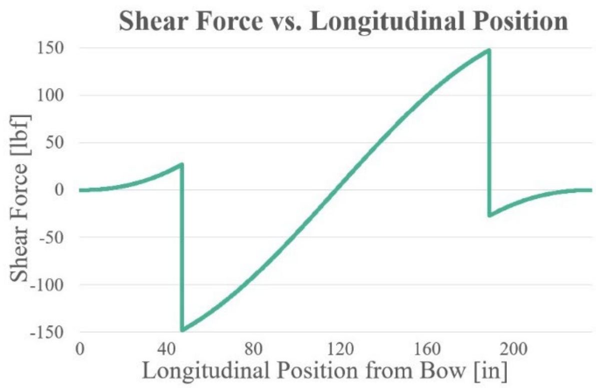


Figure 5. Shear Force Diagram of Two-Male Load Case

The bending moment was numerically approximated as follows:

$$M(z_1) = M(z_1 - \Delta z) + \frac{\Delta z}{2}\{V(z_1 - \Delta z) + V(z_1)\}$$

where Δz = 0.1 in. The maximum positive bending moment is 33 lbf-ft, and the maximum negative bending moment is -449 lbf-ft as shown in **Figure 6**.

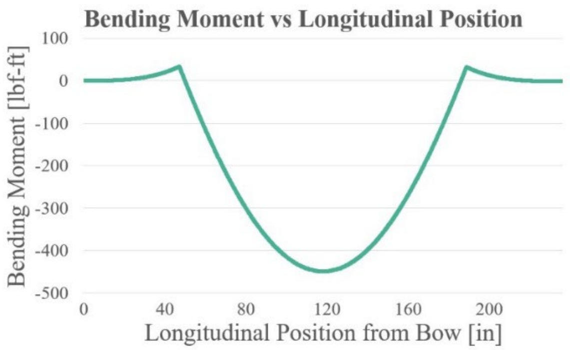


Figure 6. Bending Moment Diagram of Two-Male Load Case

The punching shear stress was calculated at the knee of a paddler using **Equation 3** based on ACI 318-05.[7] The shear force, V_u, was the design weight of a paddler (175 lbs), d was the distance from the compression face to the tensile reinforcement (0.375 in), and the punch perimeter, b_o, was 13.74 inches, calculated from a circle with a radius equal to the paddler knee radius (2 in) plus half of the distance from the compression face to the tensile reinforcement ($\frac{1}{2} \cdot$ 0.375 in). The punching shear stress was calculated to be 34 psi.

$$\tau_{punch} = \frac{V_u}{b_o d} \quad \textbf{Eqn 3}$$

The punching shear stress and bending moment are both means to quantify the internal reactions of the canoe to loading. While the bending moment represents the internal reactions to the unequal distribution of loads along the length of the canoe, the punching shear stress represents the internal reaction to the concentrated load of a paddler. The Hull Design subteam combined the results of the bending moment calculations with the results of the punching shear calculations to calculate factors of safety. These calculations involved the use of a 3-Dimensional stress tensor and can be found in the Value and Innovation section on page 14.

Materials Selection and Testing Protocol

The primary goals of the Mix Design subteam were to design a lightweight concrete mix stronger than *STALLION*'s mix and to explore new aggregates. The team increased the strength of the concrete mix; however, this came with the trade-off of having a higher density than *STALLION*.[4] This density increase was largely due to the aggregate gradation requirements restricting the amount of fine particulate, low-specific gravity aggregate. Unfortunately, the Mix Design subteam did not fully consider the gradation requirements until shortly before the originally scheduled Casting Day, when the team learned that all the designed mixes were noncompliant. However, the team quickly formulated new mixes to be tested the following semester that were compliant by following ASTM C136.[8]

As in previous mix designs, the pozzolans VCAS 160 and Class C Fly Ash were used as lightweight substitutes for a large portion of Portland Cement because they have a lower specific gravity.[9][10] The cementitious materials also continued to include Komponent, a type K cement, in the same proportion as in previous years to prevent shrinkage cracking.[4][11] Due to the continued unavailability of GGBFS 120, the subteam continued to use GGBFS 100 as a cementitious material.[12] To improve upon the workability lost from this change, the subteam looked into using K37 to replace K20, but ultimately chose to use K20.[13] The K37, while increasing the strength and workability of the mix, also increased the density. To improve the slurry, Type I Portland Cement, which the team began using last year, was replaced with White Portland Cement.[14][15] This reduced the amount of natural pigment in the mix, making the added pigments more vibrant. To further aid color saturation, the team also replaced the previously used pumice with Poraver, making all the aggregates white, rather than gray. The Poraver also improved the workability of the slurry, allowing it to be more easily applied in patterns.

This year, significant changes were made to the proportions of aggregate used, largely to comply with the new gradation requirements in the RFP. For this requirement, the gradation of each aggregate was measured in accordance with ASTM C136.[8] Once the subteam had gradation data for each aggregate, the total gradation of all aggregates was calculated and weighted by volume. The final aggregate properties are shown below in **Table 2**.

Table 2. Aggregate Properties

Aggregate	Composition	Specific Gravity	Absorption (%)	Particle Size (mm)
Poraver 2-4	Glass Microsphere	0.35	19	2.0 - 4.0
Poraver 0.5-1		0.50	18	0.50 - 1.0
Poraver 0.25-0.5		0.70	21	0.25 - 0.50
SG 300	Cenosphere	0.72	1	0.01 - 0.30
K20		0.20	1	0.03 - 0.09
Norlite	Ceramic Shale	1.55	7	0 - 4.76

An early decision to no longer use Buildex was made as its relatively large particle size reduced the workability and visual smoothness of the mix. To comply with the finest sieve requirement, the volume percent of K20 was reduced. To offset the loss of low-density aggregate, the proportions of Poraver were increased. Additionally, during the design season, Poraver 1-2 became unavailable from the team's suppliers, leading to its replacement with the larger Poraver 2-4.[16] This change helped minimize the density increase due to Poraver 2-4's lower specific gravity. This also helped maintain the gradation of mixes as in previous years. A smoother gradation minimizes the total volume of voids between aggregates, improving the workability of the mix.[17] Having both the larger Poraver and the very fine aggregates, SG300 and K20, allowed for control of the overall gradation of the mix.

The team continued to implement internal curing by iterating on the process begun with *KEPLER* for all test mixes and the canoe itself.[18] This was accomplished by soaking the natural aggregate, Norlite, prior to mixing so that it would release water during the curing process. Soaking the aggregates aided in the hydration reaction and increased the strength of the mix. Internal curing can also prevent early shrinkage.[19] To ensure consistency, a measured amount of water was added to the aggregate such that it was completely submerged. The aggregate was allowed to soak for a minimum of 24 hours, and then the remaining water was poured through a sieve so that aggregate was not lost. To control the true quantity of water that goes into the mix, the weight of the water removed from the bucket was subtracted from the original weight of added water. The weight of water remaining in the aggregate was then subtracted from the total water designed to be added to the mix.

The mix used two admixtures, an air entrainer and a high-range water reducer, in the same proportions as *STALLION*, including the increased dosage of water reducer implemented to increase workability.[4] To prevent shrinkage and cracking, *BOOGIE BOAT* continued to use the same amount of Polyvinyl Alcohol (PVA) fibers in its mix as in previous years.[4] These fibers are equally divided by dosage between ¼-in, ⅓-in, and ½-in lengths.[20][21][22]

The team performed tensile and compressive tests at 7, 14, and 28-days on the Casting Day concrete, resulting in a curve of strength over time and can be seen in **Figure 7**. The team disqualified cylinders as poorly made when they had a lower strength value than the average value for a shorter time span. Most of the 14-day samples fell into this category, likely due to inadequate cylinder formation and quality control for that batch.

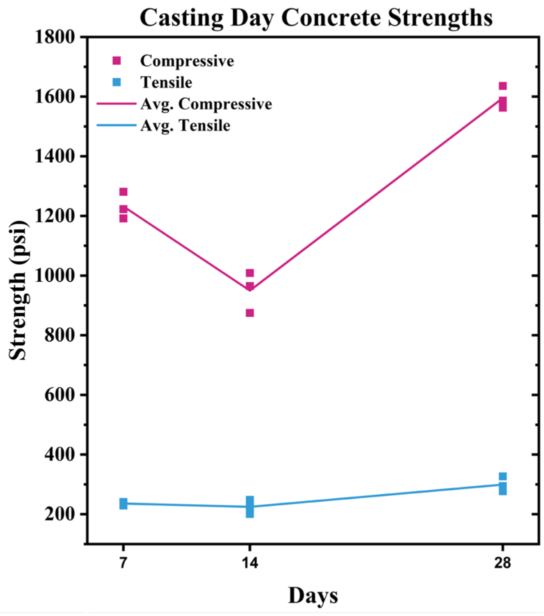


Figure 7. 7, 14, and 28 day Compressive and Tensile Strengths of Casting Day Structural Concrete Mix

The team discontinued flexural beam tests, as it was material consuming and ultimately did not yield notable results.[4] However, MCCT did use a pressure air test and compared it to the calculated theoretical air content. This comparison, **Table 3**, shows that the tests did not align with MCCT's theoretical calculated values. This is likely due to performing the air last with less fresh concrete to conserve material for the canoe.

Table 3. Comparison of experimental and calculated results for air content

Pressure Air Content	Experimental	11.0%
Gravimetric Air Content	Calculated	17.6%

Overall, the Mix Design subteam met their goals for the 2023 mix and learned from their challenges. While the average density of the structural mix was higher than preferred at 72.9-lbs/ft^3, the team improved strength to nearly double that of *STALLION's*.[4] Additionally, the subteam tested K37 as a possible aggregate to use in future years.

Construction Process

Form Material Selection and Construction

The canoe's form material was three-pound polystyrene foam made of scrap pieces donated by one of MCCT's sponsors. Using scrap foam offered budget flexibility for other expenses. The Hull Design subteam used Siemens NX to produce a file for a male mold to be fabricated on a CNC milling machine. The supplier manufactured the mold in two pieces with a rectangular base. The mold was picked up in late December due to supply chain delays which impacted the team schedule.

After receiving the foam mold, the team started by joining the halves using two-foot long dowels. Next, a thin layer of automotive body filler was applied over the entire mold and cured. The same process was repeated for a second layer. Then, the team applied a water-based primer followed by an oil-based release agent to create an impermeable surface. These layers were crucial in preventing the mold from absorbing water while the concrete was curing. If the mold absorbed water, the foam would expand within the canoe, making it difficult to remove.

Methodology of Mixing

The Mix Design subteam measured the cementitious materials, aggregates, and fibers into separate labeled batches prior to Casting Day to ensure batch consistency and mix efficiency. K20 was added first to the Hobart D300 mixer. The cementitious materials and non-natural aggregates were added second. The natural aggregates were added third since they were pre-soaked, and the cementitious materials should remain dry for as long as possible. The air entrainer was added next and then mixing began. The mixer was covered by a cloth that prevented the loss of material into the air during mixing. About 75% of the total water and all fibers were added within thirty seconds. The water reducer was added directly after the water and fibers. Lastly, the rest of the water was added to the mixture.

Placement of Concrete and Reinforcement

The concrete was placed in two layers using the chasing method; the first ⅜-in layer of concrete was placed on the foam mold starting at the stern. Once the concrete was applied a few feet in from the stern, the team began placing a layer of SpiderLath fiberglass mesh over the first layer of concrete from stern to bow with each piece of mesh overlapping the preceding piece by two inches.[23] As the mesh was applied, MCCT members massaged concrete into the mesh in order to have a strong and seamless transition. Then members began adding the second ⅜-in layer of concrete at the stern and continued until the tip of the bow.

Curing

This year, the curing process of the canoe occurred in a sealed tent within the project workspace. Based on results from 2022's Enhanced Focus Area, the curing process involved covering the canoe in damp burlap, plastic sheeting, and an insulating concrete-curing blanket. The burlap was sprayed with water at least once every three days.[24] A team member checked on and reported on the dampness of the burlap, humidity levels, and temperature of the tent each day. This method kept free water maintained on the entire surface of the canoe for the duration of the curing process, as required by ASTM C192, to prevent cracking due to cyclic drying and rewetting of the concrete.[25] The curing process took place over 28 days. Internal curing was facilitated by pre-soaking the natural aggregates for 24 hours, which limited the risk of shrinkage and improved concrete workability.

Form Removal and Canoe Finishing
The team began the finishing process by sanding the outside of the canoe with sandpaper ranging from 60 to 400 grit. After the outside of the canoe was smooth, the team removed the mold using a combination of picks and manpower. After the mold was removed, MCCT sanded the gunwales. Then, the team applied concrete stain to the outside of the canoe and let the stain set. Finally, the canoe was coated in two thin layers of SILRES BS 6920, a clear, non-pigmented, siloxane-based sealer.[26]

Aesthetics
MCCT's theme revolves around the groovy decade of the 1970s. MCCT originally considered using pigment in the structural mix to match the theme's vibrant palette. Unfortunately, it was found that the pigmented concrete colors were not as vibrant as desired, and the pigment negatively affected the density and strength of the concrete. The team decided that a pigmented structural mix would not be a viable option to achieve a colorful canoe, so the Aesthetics subteam explored concrete stains for a similar effect. The stain colors were sampled for color and the Mix subteam performed additional concrete testing to ensure acceptable visual and physical properties. Multi-color flower designs were stenciled on the interior of the canoe using a pigmented slurry, to achieve a unique and groovy pattern. The slurry flowers were strategically placed in the interior of the canoe to avoid contact with paddlers during racing to ensure the longevity of the design.

The stands for the canoe were designed as stacks of records on top of a turntable based on the '70s theme of music media. The arms of the stand show a library of vinyl. MCCT originally planned on reusing the stands presented with *STALLION* with modifications for structural stability and thematic design, so the Aesthetics subteam dismantled the stands from last year and assessed their condition in collaboration with the Michigan Steel Bridge Team.[4] It was concluded that the stands needed adaptations to be structurally sound enough to hold the increased weight of *BOOGIE BOAT*.

The display is a wood panel designed to resemble the rear end of a '70s caravan with shelving. The materials information will be displayed as bumper stickers, the cylinders will sit in roller skates, the materials will be enclosed in lava lamps, and the physical copies of MCCT's Project Proposal and MTDS Addendum will sit on a tailgate shelf with cover art inspired by '70s design elements and patterns.

Scope, Schedule, and Fee
To be awarded a design contract by the CCCC, MCCT considered how to arrange the budget, schedule, project scope, and risk management to fulfill the requirements of the RFP and guide the team to be a quality canoe supplier.

Critical path items in the team's project schedule, in order of occurrence, included: recruiting, release of the RFP, choosing a theme, choosing a Hull Design, choosing a Mix Design, Casting Day, weighing the canoe, the Technical Proposal due date, flotation testing, and Regional Competition. The schedule was arranged such that internal deadlines were before competition deadlines or physical constraints of the design process. MCCT experienced disruptions to the schedule due to supply chain issues and unsatisfactory final mix compositions. This resulted in postponing Casting Day until January, one month later than originally scheduled. While Casting Day is a critical path activity, this delay did not impact consecutive critical path activities because MCCT previously followed a timeline where Casting Day was scheduled in December, over a month earlier than necessary to cure and sand the canoe with adequate precision. While the old project timeline has traditionally helped the team by providing time to focus on the Technical Proposal and Presentation, it was determined to be excessively early and a hindrance to the team's ability to test new hull and mix designs. The new timeline was successful because of additional flexibility for risk management, greater availability of team members, and subteam deadlines being more evenly distributed throughout the second semester. MCCT intends to use the new schedule structure with Casting Day in January in the future due to its positive impact on innovation and allowance for student work-life balance. To avoid future difficulties, more emphasis will be placed on proactive material acquisition and completing required testing.

MCCT started the year with a comfortable amount of funds but still actively sought out and grew company sponsorships. MCCT doubled company sponsors, with nine returning and nine new sponsors, and partnered with the university to procure funds for the competition season. MCCT primarily invested capital goods in funding the renovation of past projects, such as repairing the fiberglass practice canoe, *JAMES POND*, made in 2018, to be safer and more usable. MCCT's capital goods expenses decreased by 85% from last year due to using the previous year's capital goods investments. MCCT purchases focused on canoe and team developments. Canoe developments included purchases like K37, various gradations of Poraver, white Portland Cement, and high-density foam for bulkheads. Team developments included the rental of a community pool to practice paddling. Norlite, GGBFS 100, Komponent, Fly Ash, and SikaColor Stain, and SILRES BS 6920 were all donated from suppliers to MCCT. Other materials were bought or received from sponsors in previous years. Overall, 30% of the canoe material costs were not direct expenses this year. Intentional investments and strategic sponsor partnerships gave MCCT the tools and experience necessary to offer a competitive proposal for a high-quality canoe.

Quality Control and Quality Assurance

Mix Testing Quality Assurance

MCCT continued its testing procedures on wet and cured concrete from last year. This included the use of a pressure air meter to take physical air content measurements to compare with theoretical gravimetric calculations. MCCT continued teaching members how to calibrate and use the air meter appropriately according to ASTM C231.[27] This addition benefited the design process by ensuring concrete mix designs consistently meet the desired air content.

This year, the team produced more concrete than in past years due to increased experimentation with materials, pigments, and stains. The QA/QC Manager taught and guided the team in following ASTM C31 standards to produce cylinders that had representative compressive and tensile strength values.[28] MCCT has continued to thoroughly test concrete using 7-day and 14-day cures to identify invalid test results.

Casting Day Quality Assurance

Several quality assurance devices were prepared and utilized on Casting Day. Firstly, 3⁄8-inch thick, flexible foam tape, generally used for window insulation, was used to indicate the desired thickness of each layer of concrete. The Quality Control Manager placed the tape along the canoe mold in one-foot intervals as a guide for uniform concrete thickness during placement and then painted two ⅜-in colored stripes on construction nails. The nails were intermittently placed into the concrete throughout casting to confirm that layers were the correct thickness. Finally, to guide the keel line, a string was attached to dowels that were placed through the mold on each end of the canoe and strung taught from bow to stern, which can be seen in **Figure 8**. Many new members learned how to properly cast the canoe and conduct slump tests to ensure the transfer of knowledge about procedures and techniques.

Figure 8. Mesh Being Incorporated into the First Layer of Concrete with the QA/QC Devices of Foam Tape and Keel Line String (Credit to Brenda Ahearn)

Quality Control

MCCT will conduct a flotation test in March to confirm that the foam bulkheads sufficiently improve the canoe's buoyancy. The flotation test is an important quality control measure that will demonstrate the design and implementation strategy as a viable final product that meets design specifications.

Non-Construction Quality Control and Assurance
The Quality Control and Assurance Manager had the additional responsibility to ensure that all subteams understood and followed all competition guidelines. The team elected a Technical Submissions Lead who reviewed technical documents and ensured RFP requirements were being met. This position monitored the quality of reports and delegated responsibilities for project deliverables. This year, the lead prioritized subteams editing each other's work and this process was rotated several times to ensure clear communication.

Sustainability
This year, MCCT focused on the pillars of environmental and social sustainability. To increase focus on environmental sustainability and ecologically sound decisions, MCCT implemented a Sustainability Lead who prioritized awareness of the team's waste streams, material choices, and carbon footprint.

Concrete wash water can be damaging to municipal water infrastructure and the surrounding environment by affecting soil chemistry, inhibiting plant growth, contaminating groundwater, and polluting waters and habitats.[29] This year, MCCT handled its concrete wash water as a hazardous liquid under guidance of the University's Environment Health and Safety (EHS) Department to ensure appropriate disposal. The concrete wash water was transferred to five-gallon containers, labeled, and sent to hazardous disposal, thereby reducing harmful environmental impacts.

Using the lifecycle analysis methodology developed in the MCCT 2021 EFA, the CO_2 emissions of the gate-to-grave production process of one metric ton of *BOOGIE BOAT*'s concrete was calculated to be 783 lbs of CO_2.[30] This is an significant decrease from *STALLION*, which had 888 lbs CO_2 equivalent per metric ton of concrete.[4] For the material phase, CO_2 emissions were 700 lbs for *STALLION* and 533 lbs for *BOOGIE BOAT*, shown in **Figure 9**. The decrease in emissions was partly due to modifying the aggregate ratios to use more Poraver in the place of Buildex and K20. Another source of emission reductions was the increased use of Fly Ash and GGBFS 100, which are more sustainable alternatives to Portland cement as they are byproducts of industrial processes. As a further improvement, research into local concrete recyclers that will accept the team's excess concrete is in process.

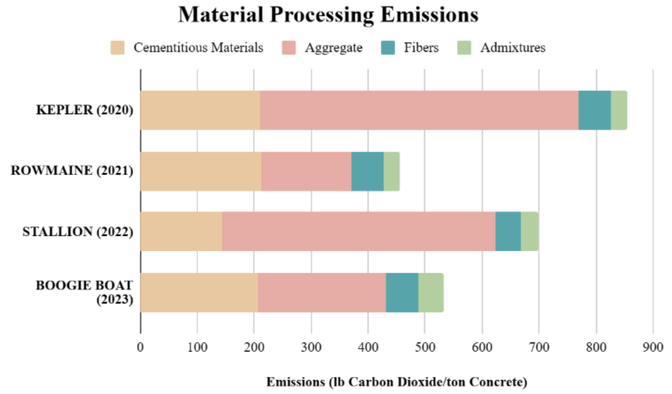


Figure 9. Material Processing Emissions of 1 Metric Ton of Concrete for the past 4 years of Mix Design

MCCT furthered the pillar of social impact by concentrating on inclusion and breaking down misconceptions about joining project teams. Students often hesitate to join MCCT because of concerns about their inexperience or the impression that the project team is only for civil engineering majors. A core belief of MCCT is that a multidisciplinary approach with a diverse group of people and perspectives builds a strong team culture and creative results. This year, MCCT increased focus on recruiting both engineering and non-engineering students by engaging with various organizations, including the Architecture and Art and Design schools. MCCT created new member onboarding information consolidated in an accessible location and distributed weekly. This included detailed explanations of sub teams, logistics, training opportunities, and boat vocabulary. The team began to utilize anonymous feedback forms to identify areas in need of improvement. The team believes offering instruction to every member empowers old and new members to feel comfortable and included. This year, MCCT expanded team education with interactive, educational presentations and hands-on experiences, such as CAD learning days, as ways for members to engage and grow together as a team.

Health & Safety

Health and safety has always been a core value of MCCT. Over the course of the project, all team members were required to follow the University of Michigan's COVID-19 regulations, which included following all vaccination policies and exposure guidelines. To ensure that safety standards under the Occupational Safety and Health Administration, the EHS Department, and the University of Michigan were rigorously met, a Health and Safety Officer was present at all university-led safety meetings. Safety protocols were approved by the faculty advisor and director of university's project team design facility. MCCT members were required to complete a safety module and evaluation and an in-person safety training to work in the facility and the team work area.

During all activities in the design space, team members were required to wear protective eyewear, gloves (when necessary), closed-toed shoes, and long pants. The Mix Design subteam participated in a structural laboratory training to be able to test the mechanical properties of molded cylinders. To protect against the inhalation of particulate matter and harmful gases, team members received university-led respirator training. Members were required to wear a half-facepiece respirator with cartridges that protected against organic vapors, acid gases, and particulates during activities that had hazardous particulate components and/or fumes.[31] MCCT followed an additional, required protocol from the design facility for hazardous gases by using the facility's downdraft paint booth which had a ventilation, filtration, and fan system that safely diverts fumes.

MCCT used concrete stains for the first time, which contained small amounts (98 g/L) of volatile organic compounds (VOCs).[32] Therefore, the team wore respirators and followed the required protocol for hazardous fumes and aerosols. To evenly coat the canoe with stain, a high-pressure, low-volume gravity feed spray device was attached to the central pressurized air system in the facility's paint booth. After staining, the Captain reported the amount of product used to the director of the design space in order for the EHS Department to determine the amount of VOCs released.

Value and Innovation

Project Proposal

MCCT's Hull Design subteam validated the structural integrity of *BOOGIE BOAT's* design by calculating factors of safety for twelve critical locations across three load cases as shown in **Table 4**.

Table 4. Factors of Safety at Critical Locations

Load Case	Stress Location	Factor of Safety
Coed	Inner Paddler, Side Edge of Knee Punch Perimeter	8.8
	Inner Paddler, Front Edge of Knee Punch Perimeter	9.0
	Outside Paddler, Side Edge of Knee Punch Perimeter	8.8
	Outside Paddler, Front Edge of Knee Punch Perimeter	8.2
	Midship Gunwale	13.5
	Midship Keel	192.5
Two-Male	Paddler, Side Edge of Knee Punch Perimeter	8.8
	Paddler, Front Edge of Knee Punch Perimeter	8.6
	Midship Gunwale	4.5
	Midship Keel	63.8
Stands	Midship Gunwale	39.4
	Midship Keel	19.8

The team used the Modified Mohr-Coulomb Failure Criterion from Barber's Intermediate Mechanics of Materials which is stated in **Equations 4** and **5**.[33] Lambda represents the factor of safety to failure.

$$\sigma_1 \lambda = S_t;\ (\sigma_1 + \sigma_3) > 0 \quad \textbf{Eqn 4}$$

$$\left(\frac{S_c}{S_t} - 1\right)\sigma_1 \lambda - \sigma_3 \lambda = S_c;\ (\sigma_1 + \sigma_3) < 0 \quad \textbf{Eqn 5}$$

The subteam calculated the punching shear and normal stress due to bending at each of the critical locations. To determine the highest tensile and compressive principal stresses (1 and 3) at each of the locations, the subteam constructed 3-Dimensional stress tensors to combine the shear and normal stresses. The team used WolframAlpha to calculate the eigenvalues for each of these stress tensors which were then plugged into **Equations 4** and **5**.[34] The lowest factor of safety was 4.5 in the Two-Male load case at the midship gunwale, which was greater than the minimum factor of safety of 3.0; therefore, the hull structure was validated for paddling.

This year was the first year that the Project Proposal development and editing process was standardized. MCCT identified that more involvement was necessary for the Project Proposal and that there needed to be a process in place to ensure the quality control of proposal development and editing. MCCT thus developed a system to ensure all sections of the technical paper had equal attention and outlined digestible segments where members could easily participate in the writing and editing process. Initial drafts were developed before the second semester to ensure the timeliness of meeting deadlines.

Every section and subsection of the Project Proposal was organized into a comprehensive spreadsheet divided into two stages. The spreadsheet acted both as a log and checklist to track what sections needed editing and who completed them. In the first stage, members looked for grammatical, syntactical, and wording errors and added suggestions to the content. Each section was read and edited five times by a different member of the team who did not write the section. In between the first and second stages, the Technical Submissions lead and the Captain reviewed the proposal draft for compliance errors with the RFP. In the second stage, members commented on wording and cohesiveness following the same process as the first stage. Finally, all edits and suggestions were reviewed by the Technical Submissions lead. In addition, as a separate element, alums were able to read through the proposal and provide edits and suggestions at their leisure. With this newly implemented method, all members who wanted to provide input on the various sections within the technical paper were easily able to do so while maintaining strict quality control of each section and the overall proposal.

Prototype Display

With a nearly 100-lb increase in weight from *STALLION*, the Aesthetics subteam found that the previously used stands required additional attention to securely hold *BOOGIE BOAT*.[4] MCCT consulted the University of Michigan Steel Bridge Team for the stand design, as they are experts in creating structures that experience increased loads. MCCT and the Steel Bridge Team first analyzed last year's stands and determined that the most significant area of instability were the arms. The Aesthetics and Steel Bridge teams collaborated to design a reinforced U-shaped steel structure for the arms of the stands and decided the base of the stand would benefit from the additional support of wood braces. The new professional relationship with the Steel Bridge team promotes collaboration between the teams in future years.

The display of *BOOGIE BOAT* honored *STALLION*'s display by repurposing the doors of the western saloon as the tailgate of this year's groovy caravan. Finding new life in existing materials reduced costs while showcasing the team's creativity and skills. The design elements and information for *BOOGIE BOAT* presented on the display are a way for members' artistic creativity to be used in a technically creative competition.

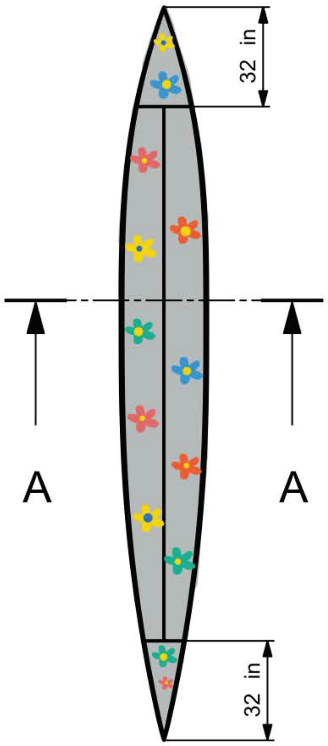
Technical Presentation

Developing the technical presentation was a collaborative effort, where all subteams created and edited the presentation together so that the presenters had knowledge all content. The team primarily focused on presenting internally to the general body and recent alumni. MCCT realized that it needed to grow its pitch and delivery to effectively deliver the information. MCCT believed that peer-to-peer and professional feedback were critical. As a result, the team invited older MCCT alumni and sponsors for feedback to improve the effectiveness of the presentation delivery. Peer feedback from alumni was extremely valuable. The alumni's point of view was unique in that they had familiarity with the team, could give peer-to-peer critiques, and could give insight into presenting as a young professional. MCCT's partnerships and sponsorships were also an enormous resource for mentorship and guidance in the engineering world. In asking for their feedback, they offered a valuable outside perspective. These individuals are established engineering professionals and can provide guidance on technical delivery and impact.

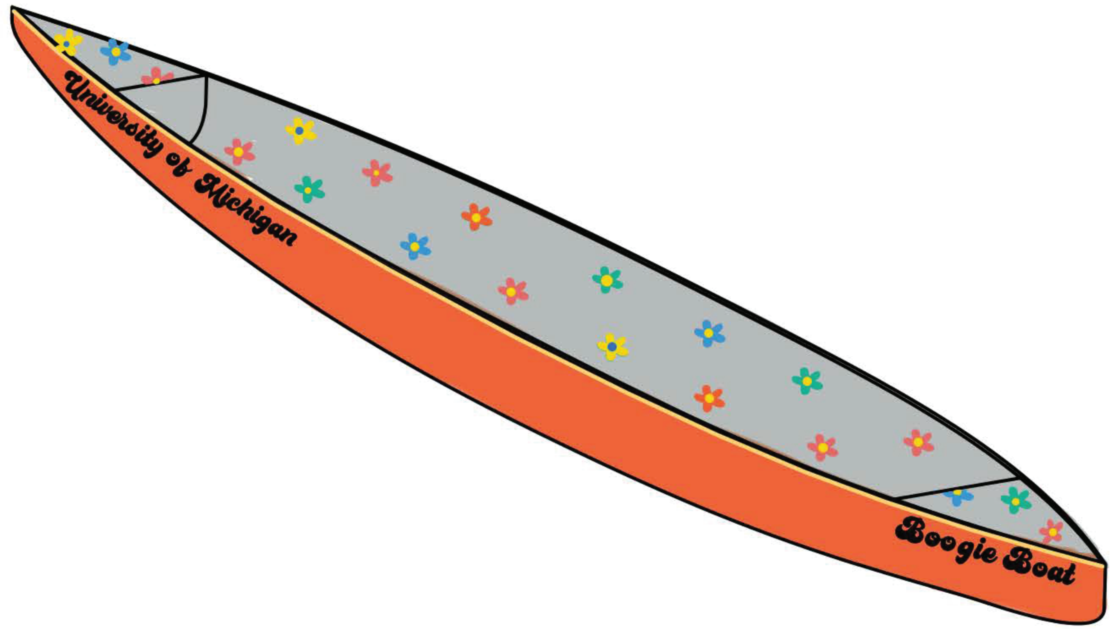
Canoe Prototype Performance Demonstration

Paddling and racing have not been MCCT's strong suit due to the lack of in-water practice and strength training. The team utilized the warmer weather in the fall to introduce paddling techniques and practice long-distance paddling in a nearby river. Last year, the team began practicing in the university's Marine Hydrodynamics Lab in the colder months to paddle straight-aways. MCCT organized weight training with a push/pull approach to strengthen paddlers' upper bodies for more forceful strokes.

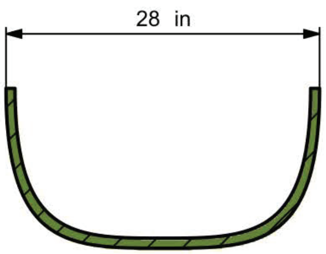
In-water practice beyond practicing straight-aways was critical to improving paddling control and turning. The Paddling Lead conducted outreach to seek access to public aquatic facilities to hold practices because the university's recreational pools have not been accessible due to construction and COVID-19. The team secured space in Eastern Michigan University's club pool to practice at the start of the winter semester to focus on turning. The team had difficulty in the slalom races last year due to a lack of skill in changing direction. A turning method was honed this year that used "J" strokes at the stern for efficient turns. Prior to indoor paddling, safety renovations were made to the practice canoe, *JAMES POND*. These improvements included sealing the fiberglass and wood beams and adding a protective rubber seal to the gunwales for paddler safety.



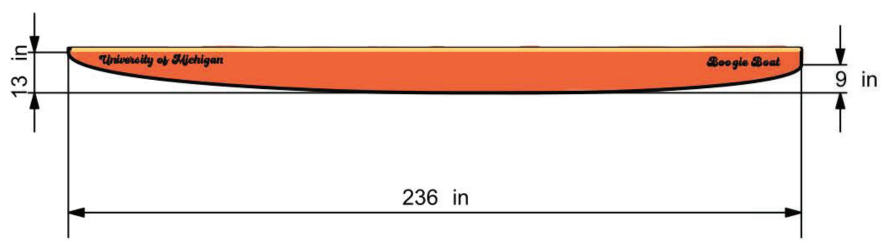
PLAN VIEW



ISOMETRIC VIEW

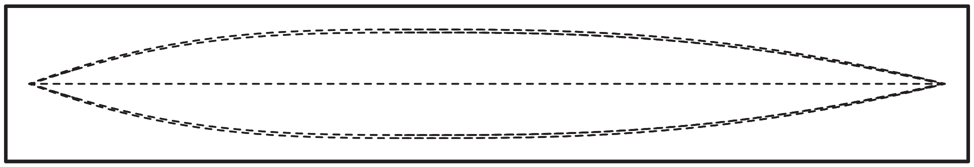


SECTION A-A

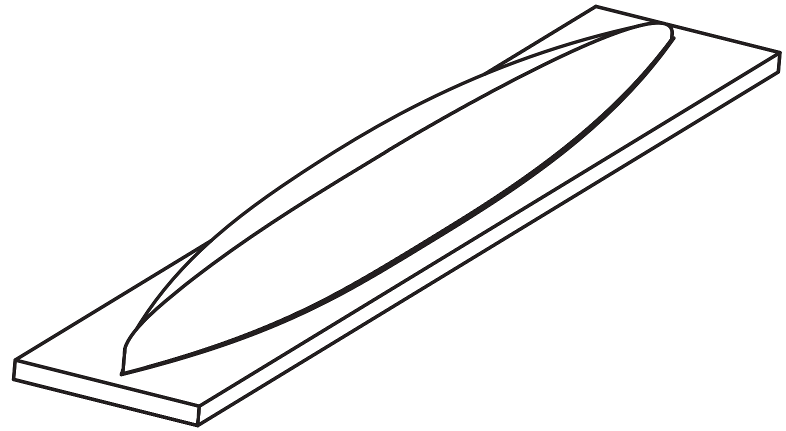


ELEVATION VIEW

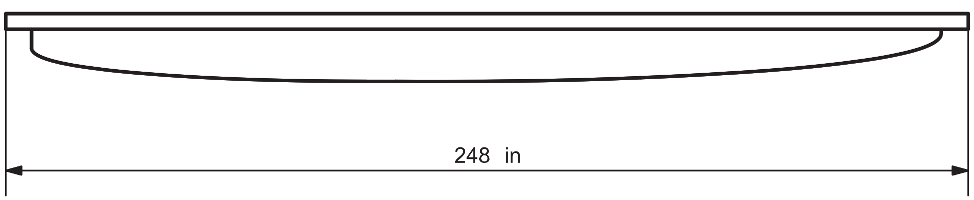
MICHIGAN CONCRETE CANOE TEAM	
TITLE	BOOGIE BOAT
DESCRIPTION	CANOE DRAWING
DRAWN BY	JADE REDMOND AND THOMAS LEI
DATE	11/17/2022



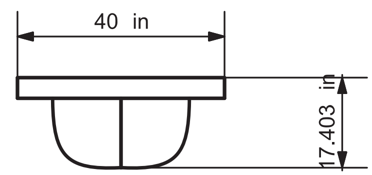
PLAN VIEW



ISOMETRIC VIEW

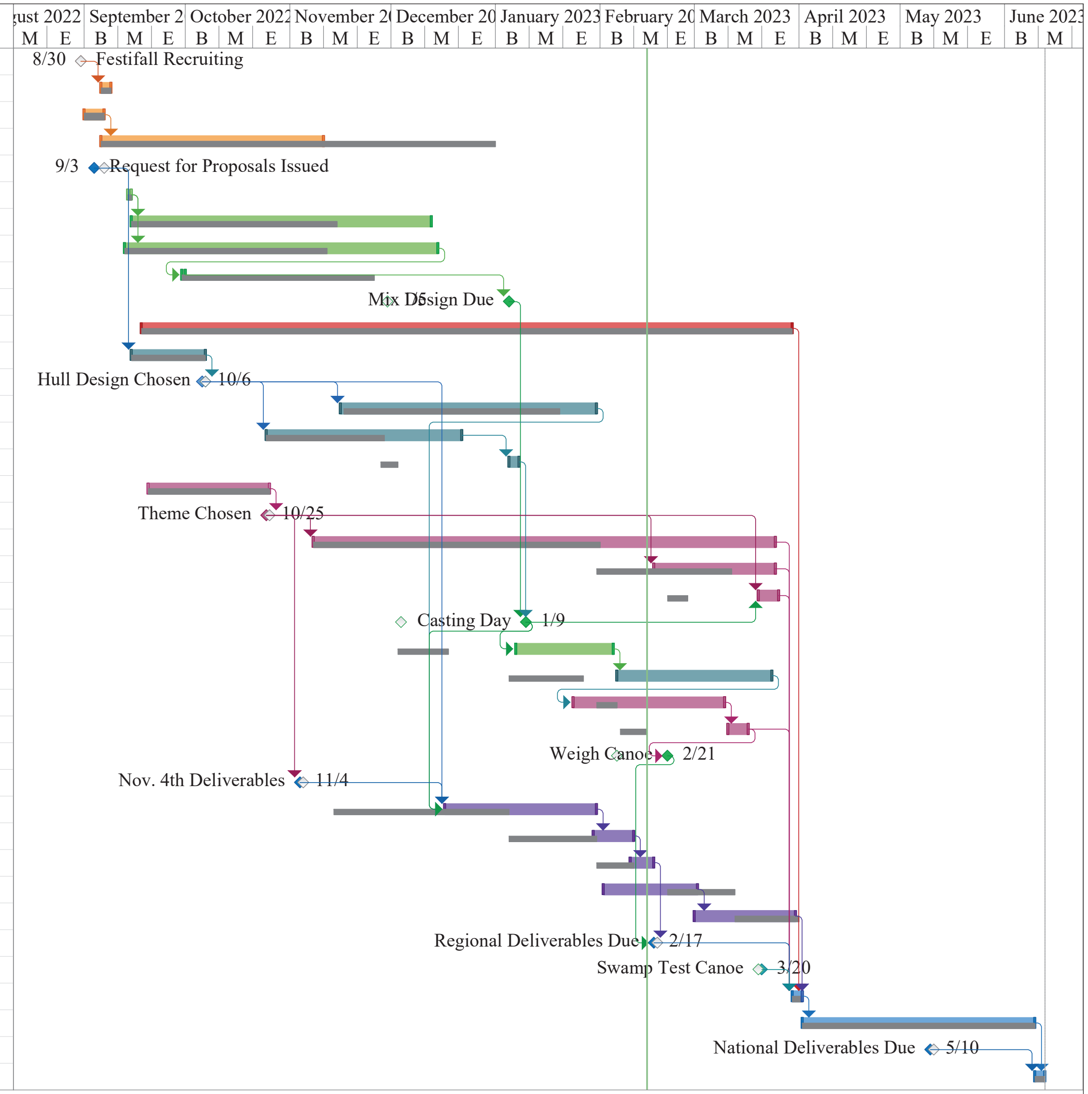


ELEVATION VIEW



MICHIGAN CONCRETE CANOE TEAM	
TITLE	BOOGIE BOAT MOLD
DESCRIPTION	MOLD DRAWING
DRAWN BY	JADE REDMOND AND THOMAS LEI
DATE	12/1/2022

ID	Task Name	Baseline Start	Baseline Finish	Actual Start	Actual Finish
1	**Festifall Recruiting**	Tue 8/30/22	Tue 8/30/22	Tue 8/30/22	Tue 8/30/22
2	**Mass Meetings**	Tue 9/6/22	Thu 9/8/22	Tue 9/6/22	Thu 9/8/22
3	**Draft Sponsor Letters**	Thu 9/1/22	Tue 9/6/22	Thu 9/1/22	Tue 9/6/22
4	**Send Sponsor Letters**	Tue 9/6/22	Sat 12/31/22	Tue 9/6/22	Thu 11/10/22
5	**Request for Proposals Issued**	Tue 9/6/22	Tue 9/6/22	Sat 9/3/22	Sat 9/3/22
6	**Inventory**	Wed 9/14/22	Wed 9/14/22	Wed 9/14/22	Wed 9/14/22
7	**Research and Order Materials**	Thu 9/15/22	Mon 11/14/22	Thu 9/15/22	Mon 12/12/22
8	**Mix Testing**	Tue 9/13/22	Fri 11/11/22	Tue 9/13/22	Wed 12/14/22
9	**Strength Testing**	Fri 9/30/22	Fri 11/25/22	Fri 9/30/22	Fri 9/30/22
10	**Mix Design Due**	Tue 11/29/22	Tue 11/29/22	Thu 1/5/23	Thu 1/5/23
11	**Paddling Practice**	Sun 9/18/22	Wed 3/29/23	Sun 9/18/22	Wed 3/29/23
12	**Hull Design and Prototyping**	Thu 9/15/22	Thu 10/6/22	Thu 9/15/22	Thu 10/6/22
13	**Hull Design Chosen**	Thu 10/6/22	Thu 10/6/22	Thu 10/6/22	Thu 10/6/22
14	**Structural Calculations**	Thu 11/17/22	Thu 1/19/23	Wed 11/16/22	Mon 1/30/23
15	**Mill Mold**	Tue 10/25/22	Mon 11/28/22	Tue 10/25/22	Wed 12/21/22
16	**Assemble Mold**	Mon 11/28/22	Fri 12/2/22	Thu 1/5/23	Sat 1/7/23
17	**Theme Brainstorming**	Tue 9/20/22	Tue 10/25/22	Tue 9/20/22	Tue 10/25/22
18	**Theme Chosen**	Tue 10/25/22	Tue 10/25/22	Tue 10/25/22	Tue 10/25/22
19	**Stand Construction**	Tue 11/8/22	Tue 1/31/23	Tue 11/8/22	Fri 3/24/23
20	**Poster Construction**	Tue 1/31/23	Sat 3/11/23	Fri 2/17/23	Fri 3/24/23
21	**Make Cross Section**	Tue 2/21/23	Sun 2/26/23	Mon 3/20/23	Sat 3/25/23
22	**Casting Day**	Sat 12/3/22	Sat 12/3/22	Mon 1/9/23	Mon 1/9/23
23	**Canoe Curing**	Sat 12/3/22	Sat 12/17/22	Sat 1/7/23	Sat 2/4/23
24	**Sanding**	Thu 1/5/23	Thu 1/26/23	Mon 2/6/23	Thu 3/23/23
25	**Concrete Aesthetics**	Tue 1/31/23	Sun 2/5/23	Tue 1/24/23	Thu 3/9/23
26	**Apply Lettering and Sealer**	Tue 2/7/23	Tue 2/14/23	Sat 3/11/23	Thu 3/16/23
27	**Weigh Canoe**	Sun 2/5/23	Sun 2/5/23	Tue 2/21/23	Tue 2/21/23
28	**Nov. 4th Deliverables**	Fri 11/4/22	Fri 11/4/22	Fri 11/4/22	Fri 11/4/22
29	**Write Technical Proposal**	Mon 11/14/22	Wed 1/4/23	Sat 12/17/22	Mon 1/30/23
30	**Edit Technical Proposal**	Thu 1/5/23	Mon 1/30/23	Mon 1/30/23	Fri 2/10/23
31	**Format Technical Proposal**	Tue 1/31/23	Fri 2/10/23	Fri 2/10/23	Thu 2/16/23
32	**Make Presentation**	Tue 2/21/23	Sun 3/12/23	Wed 2/1/23	Wed 3/1/23
33	**Practice Presentation**	Mon 3/13/23	Fri 3/31/23	Wed 3/1/23	Thu 3/30/23
34	**Regional Deliverables Due**	Fri 2/17/23	Fri 2/17/23	Fri 2/17/23	Fri 2/17/23
35	**Swamp Test Canoe**	Sun 3/19/23	Sun 3/19/23	Mon 3/20/23	Mon 3/20/23
36	**Regional Conference**	Thu 3/30/23	Sat 4/1/23	Thu 3/30/23	Sat 4/1/23
37	**Prepare for National Conference**	Sun 4/2/23	Fri 6/9/23	Sun 4/2/23	Fri 6/9/23
38	**National Deliverables Due**	Wed 5/10/23	Wed 5/10/23	Wed 5/10/23	Wed 5/10/23
39	**National Conference**	Sat 6/10/23	Mon 6/12/23	Sat 6/10/23	Mon 6/12/23



Appendices

Appendix A – Bibliography

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Appendix B – Mixture Proportions and Primary Mixture Calculations
Structural Mixture

CEMENTITIOUS MATERIALS				
Component	***Specific Gravity***	***Volume***	***Amount of CM***	
Portland Cement Type I (Respirator)	*3.15*	*0.49 ft^3*	*96.05 lb/yd^3*	*Total cm (includes c) 504.09 lb/yd^3 c/cm ratio, by mass 0.19*
GGBFS 100	*3.08*	*0.37 ft^3*	*71.82 lb/yd^3*	
Komponent	*3.10*	*0.26 ft^3*	*50.04 lb/yd^3*	
VCAS	*2.60*	*1.06 ft^3*	*172.54 lb/yd^3*	
Fly Ash Class C (Respirator)	*2.64*	*0.69 ft^3*	*113.64 lb/yd^3*	

FIBERS				
Component	***Specific Gravity***	***Volume***	***Amount of Fibers***	
PVA 6mm	*1.3*	*0.03 ft^3*	*2.13 lb/yd^3*	*Total Amount of Fibers 6.39 lb/yd^3*
PVA 8mm	*1.3*	*0.03 ft^3*	*2.13 lb/yd^3*	
PVA 12mm	*1.3*	*0.03 ft^3*	*2.13 lb/yd^3*	

AGGREGATES (EXCLUDING MINERAL FILLERS PASSING NO. 200 SIEVE)						
Aggregates	***Abs (%)***	***SG_{OD}***	***SG_{SSD}***	***Base Quantity, W***		***Volume, $V_{agg, SSD}$***
				W_{OD}	***W_{SSD}***	
Poraver 2.0 - 4.0	*23%*	*0.28*	*0.35*	*52.74 lb/yd^3*	*64.86 lb/yd^3*	*2.97 ft^3*
Poraver 0.5 - 1.0	*18%*	*0.42*	*0.50*	*78.53 lb/yd^3*	*92.66 lb/yd^3*	*2.97 ft^3*
Poraver 0.25 - 0.5	*21%*	*0.58*	*0.70*	*101.85 lb/yd^3*	*123.24 lb/yd^3*	*2.82 ft^3*
SG 300 (Respirator)	*1%*	*0.71*	*0.72*	*33.03 lb/yd^3*	*33.36 lb/yd^3*	*0.74 ft^3*
K20 (Respirator)	*1%*	*0.20*	*0.20*	*11.01 lb/yd^3*	*11.12 lb/yd^3*	*0.89 ft^3*
Norlite	*7%*	*1.45*	*1.55*	*402.70 lb/yd^3*	*430.89 lb/yd^3*	*4.46 ft^3*

LIQUID ADMIXTURES					
Admixture	***lb/ US gal***	***Dosage (fl. oz/cwt)***	***% Solids***	***Amount of Water in Admixture***	
Water Reducer	*8.9*	*40*	*5%*	*13.32 lb/yd^3*	*Total Water from Liquid Admixtures, $\sum$wadmx 23.08 lb/yd^3*
Air Entrainer	*8.7*	*30*	*5%*	*9.76 lb/yd^3*	

SOLIDS (DYES, POWDERED ADMIXTURES)				
Component	***Specific Gravity***	***Volume (ft^3)***	***Amount (lb/yd^3)***	
Pigment	*5.24*	*0.00*	*0.00*	*Total Solids. S_{total} 4.56 lb/yd^3*
SG-300 (mineral filler)	*0.72*	*0.05*	*2.18*	
K20 (mineral filler)	*0.20*	*0.19*	*2.38*	

WATER			
	Amount		Volume
Water, *w, [=∑ (wfree + wadmx + wbatch)]*	*w/c ratio, by mass 2.62 w/cm ratio, by mass 0.50*	*252.05 lb/yd³*	*4.04 ft³*
Total Free Water from All Aggregates, *∑wfree*		*-48.09 lb/yd³*	
Total Water from All Admixtures, *∑wadmx*		*23.08 lb/yd³*	
Batch Water, *wbatch*		*277.06 lb/yd³*	

DENSITIES, AIR CONTENT, RATIOS, AND SLUMP						
Values for 1 cy of concrete	***cm***	***Fibers***	***Aggregate (SSD)***	***Solids, Stotal***	***Water, w***	***Total***
Mass, *M*	*504.09 lb*	*6.39 lb*	*756.14 lb*	*0.00 lb*	*277.06 lb*	*∑M: 1548.23 lb*
Absolute Volume, *V*	*2.87 ft³*	*0.08 ft³*	*14.85 ft³*	*0.00 ft³*	*4.44 ft³*	*∑V: 22.24 ft³*
Theoretical Density, *T, (=∑M / ∑V)*	*69.61 lb/ft³*		***Air Content, Air,*** *[= (T – D)/T x 100%]*			*-4.79%*
Measured Density, *D*	*72.94 lb/ft³*		***Air Content, Air,*** *[= (27 – ∑V))/27 x 100%]*			*17.62%*
Total Aggregate Ratio *(=V_{agg} / 27)*	*55.00%*		***Slump, Slump flow, Spread*** *(as applicable)*			*0.25 in.*

Finishing Mixture

CEMENTITIOUS MATERIALS				
Component	**Specific Gravity**	**Volume**	**Amount of CM**	
Portland Cement Type I (Respirator)	*3.15*	*1.82 ft^3*	*358.30 lb/yd^3*	*Total cm (includes c) 358.30 lb/yd^3 c/cm ratio, by mass 1.00*
GGBFS 100	*3.08*	*0.00 ft3*	*0.00 lb/yd^3*	
Komponent	*3.10*	*0.00 ft3*	*0.00 lb/yd^3*	
VCAS	*2.60*	*0.00 ft3*	*0.00 lb/yd^3*	
Fly Ash Class C (Respirator)	*2.64*	*0.00 ft3*	*0.00 lb/yd^3*	

FIBERS				
Component	**Specific Gravity**	**Volume**	**Amount of Fibers**	
N/A	*N/A*	*N/A*	*N/A*	*Total Amount of Fibers 0.00 lb/yd^3*

AGGREGATES (EXCLUDING MINERAL FILLERS PASSING NO. 200 SIEVE)						
Aggregates	**Abs (%)**	**SG_{OD}**	**SG_{SSD}**	**Base Quantity, W**		**Volume, $V_{agg,SSD}$**
				W_{OD}	**W_{SSD}**	
Poraver 2.0 - 4.0	*23%*	*0.28*	*0.35*	*52.74 lb/yd^3*	*64.86 lb/yd^3*	*2.97 ft^3*
Poraver 0.5 - 1.0	*18%*	*0.42*	*0.50*	*98.16 lb/yd^3*	*115.83 lb/yd^3*	*3.71 ft^3*
Poraver 0.25 - 0.5	*21%*	*0.58*	*0.70*	*294.84 lb/yd^3*	*356.76 lb/yd^3*	*8.17 ft^3*

LIQUID ADMIXTURES					
Admixture	**lb/ US gal**	**Dosage (fl. oz/cwt)**	**% Solids**	**Amount of Water in Admixture**	
N/A	*N/A*	*N/A*	*N/A*	*N/A*	*Total Water from Liquid Admixtures, $\sum w_{admx}$* ***0.00 lb/yd^3***

SOLIDS (DYES, POWDERED ADMIXTURES)				
Amount	**Specific Gravity**	**Volume (ft^3)**	**Amount (lb/yd^3)**	
Pigment	5.24	0.06	19.83	Total Solids. S_{total}

WATER			
	Amount		**Volume**
Water, *w, [=∑ (wfree + wadmx + wbatch)]*	*w/c ratio, by mass 0.50 w/cm ratio, by mass 0.50*	*179.15 lb/yd^3*	*2.87 ft^3*
Total Free Water from All Aggregates, $\sum w_{free}$		*-91.71 lb/yd^3*	
Total Water from All Admixtures, $\sum w_{admx}$		*0.00 lb/yd^3*	
Batch Water, *w_{batch}*		*270.86 lb/yd^3*	

DENSITIES, AIR CONTENT, RATIOS, AND SLUMP						
Values for 1 cy of concrete	***cm***	***Fibers***	***Aggregate (SSD)***	***Solids, S_{total}***	***Water, w***	***Total***
***Mass**, M*	*358.30 lb*	*0.00 lb*	*537.45 lb*	*0.00 lb*	*270.86 lb*	*∑M: 1166.62 lb*
***Absolute Volume**, V*	*1.82 ft^3*	*0.00 ft^3*	*14.85 ft^3*	*0.00 ft^3*	*4.34 ft^3*	*∑V: 21.01 ft^3*
***Theoretical Density**, T, (=∑M / ∑V)*	*55.52 lb/ft^3*	***Air Content, Air,** [= (T – D)/T x 100%]*			*15.32%*	
***Measured Density,** D*	*47.27 lb/ft^3*	***Air Content, Air,** [= (27 – ∑V))/27 x 100%]*			*22.17%*	
***Total Aggregate Ratio** (=V_{agg} / 27)*	*55.00%*	***Slump, Slump flow, Spread** (as applicable)*			*0.25 in.*	

Detailed Step by Step Calculations

Design Parameters:

Cementitious Material	Mass (lb/yd³)	SG
Portland Cement Type I	*96.05*	*3.15*
Komponent	*50.04*	*3.10*
VCAS 160	*172.54*	*2.60*
Fly Ash Class C	*11.64*	*2.64*
NewCem GGBFS Gr. 100	*71.82*	*3.08*
Total	*504.09*	

Fibers	Mass (lb/yd³)	SG
PVA (6mm)	*2.13*	*1.30*
PVA (8mm)	*2.13*	*1.30*
PVA (12mm)	*2.13*	*1.30*

Admixture	Dosage	Solids (%)
HRWR (8.9 lb/gal)	*40 fl oz/cwt*	*5*
Air Entrainer (8.7 lb/gal)	*30 fl oz/cwt*	*5*

w/cm ratio	*0.50*

Aggregate	SG_{OD}	SG_{SSD}	W_{OD} (lb)	W_{SSD} (lb)	W_{stk} (lb)	Abs (%)	MC_{stk} (%)
Poraver (2-4mm)	*0.28*	*0.35*	*52.74*	*64.86*	*52.74*	*23%*	*-23%*
Poraver (0.5-1mm)	*0.42*	*0.50*	*78.53*	*92.66*	*78.53*	*18%*	*-18%*
Poraver (0.25-0.5mm)	*0.58*	*0.70*	*101.85*	*123.24*	*101.85*	*21%*	*-21%*
SG 300	*0.71*	*0.72*	*33.05*	*33.36*	*33.03*	*1%*	*-1%*
K20	*0.20*	*0.20*	*11.01*	*11.12*	*11.01*	*1%*	*-1%*
Norlite	*1.45*	*1.55*	*402.70*	*430.89*	*430.89*	*7%*	*0%*

Cementitious Materials/Fibers:

$$\text{Absolute Volume} = \frac{mass\ (lb)}{SG*62.4\left(\frac{lb}{ft^3}\right)}$$

$$V_{portland} = \frac{96.05}{3.15*62.4} = \mathbf{0.49\ ft^3}$$

$$V_{komponent} = \frac{50.04}{3.10*62.4} = \mathbf{0.26\ ft^3}$$

$$V_{VCAS} = \frac{172.54}{2.60*62.4} = \mathbf{1.06\ ft^3}$$

$$V_{fly\ ash} = \frac{113.64}{2.64*62.4} = \mathbf{0.69\ ft^3}$$

$$V_{GGBFS} = \frac{71.82}{3.08*62.4} = \mathbf{0.37 ft^3}$$

$$V_{fibers\ 6mm} = \frac{2.13}{1.30*62.4} = \mathbf{0.03\ ft^3}$$

$$V_{fibers\ 8mm} = \frac{2.13}{1.30*62.4} = \mathbf{0.03\ ft^3}$$

$$V_{fibers\ 12mm} = \frac{2.13}{1.30*62.}4 = \mathbf{0.03\ ft^3}$$

$$Total_{CM} = \mathbf{2.87\ ft^3}$$

$$Total_{fiber} = \mathbf{0.09\ ft^3}$$

Aggregates:

$$\text{Absorption} = \text{Abs} = \frac{W_{SSD}(lb) - W_{OD}(lb)}{W_{OD}(lb)}*100\%$$

$$Poraver\ (2\text{-}4mm) = \frac{64.86-52.74}{52.74}*100\% = \mathbf{23.0\%}$$

$$Poraver\ (0.5\text{-}1mm) = \frac{92.66-78.53}{78.53}*100\% = \mathbf{18.0\%}$$

$$Poraver\ (0.25\text{-}0.5mm) = \frac{123.24-101.85}{101.85}*100\% = \mathbf{21.0\%}$$

$$SG\ 300 = \frac{33.36-33.03}{33.03}*100\% = \mathbf{1.0\%}$$

$$K20 = \frac{11.12-11.01}{11.01}*100\% = \mathbf{1.0\%}$$

$$Norlite = \frac{430.89-402.70}{402.70}*100\% = \mathbf{7.0\%}$$

Aggregate Absolute Volume (ft^3) $== \frac{W_{SSD}(lb)}{SG_{SSD}*62.4\left(\frac{lb}{ft^3}\right)}$
$V_{Poraver\ (2\text{-}4)} = \frac{64.86}{0.35*62.4} =$ ***2.97 ft³***
$V_{Poraver\ (0.5\text{-}1))} = \frac{92.66}{0.5*62.4} =$ ***2.97 ft³***
$V_{Poraver\ (0.25\text{-}0.5)} = \frac{123.24}{0.7*62.4} =$ ***2.82 ft³***
$V_{SG\ 300} = \frac{33.36}{0.72*62.4} =$ ***0.74 ft³***
$V_{K20} = \frac{11.12}{0.2*62.4} =$ ***0.89 ft³***
$V_{Norlite} = \frac{430.89}{1.55*62.4} =$ ***4.45 ft³***
Total = ***14.84 ft³***

Water: Moisture content of and Norlite takes into account the conditioning of the aggregate to the saturated, surface dry (SSD) condition. In the equation below (0)/W_{OD} x 100% = 0.

Water:

Water = w/cm * cm
*w = 0.5 * 504.09 lb =* ***252.04 lb***
$MCtotal = \frac{W_{stk}(lb) - W_{OD}(lb)}{W_{OD}(lb)} * 100\%$
$MC_{total,\ Poraver\ 2\text{-}4} = 0.0\%$
$MC_{total,\ Poraver\ 0.5\text{-}1} = 0.0\%$
$MC_{total,\ Poraver\ 0.25\text{-}0.5} = 0.0\%$
$MC_{total,\ SG300} = 0.0\%$
$MC_{total,\ K20} = 0.0\%$
$MC_{total,\ Norlite} = 7.0\%$
$MC_{free} = MC_{total} - Abs$
$MC_{free,\ Poraver\ 2\text{-}4}$ = 0.0% - 23.0% = -23.0%
$MC_{free,\ Poraver\ 0.5\text{-}1}$ = 0.0% - 18.0% = -18.0%
$MC_{free,\ Poraver\ 0.25\text{-}0.5}$ = 0.0% - 21.0% = -21.0%
$MC_{free,\ SG300}$ = 0.0% - 1.0% = -1.0%
$MC_{free,\ K20}$ = 0.0% - 1.0% = -1.0%
$MC_{free,\ Norlite}$ = 7.0% - 7.0% = 0.0%
$w_{free} = W_{OD} * \frac{MC_{free}}{100\%}$
$w_{free,\ Poraver\ 2\text{-}4}$ = 52.74*-23.0100% = **-12.13 lb**
$w_{free,\ Poraver\ 0.5\text{-}1}$ = 78.53*-18.0100% = **-14.14 lb**
$w_{free,\ Poraver\ 0.25\text{-}0.5}$ = 101.85*-21.0100% = **-21.39 lb**
$w_{free,\ SG300}$ = 33.03*-1.0100% = **-0.33 lb**
$w_{free,\ K20}$ = 11.01*-1.0100% = **-0.11 lb**
$w_{free,\ Norlite}$ = 402.70*0.0100% = **0 lb**
Combined free water = $\sum(w_{free})$ = **-48.10 lb**

$Water\ in\ admixture = dosage\left(\frac{fl\ oz}{cwt}\right) * cwt\ of\ cm\ \left(\frac{lb}{yd^3}\right) * \left(\frac{\%\ water}{100}\right) * \left(\frac{1\ gal}{128\ fl\ oz}\right) * \left(\frac{lb}{gal}\right)\ of\ admixture$
$w_{HRWR} = 40.0 * \left(\frac{504.09}{100}\right) * \left(\frac{100-5}{100}\right) * \left(\frac{1\ gal}{128\ fl\ oz}\right) * 8.90\left(\frac{lb}{gal}\right)$ = **13.32 lb**
$w_{AEA} = 30.0 * \left(\frac{504.09}{100}\right) * \left(\frac{100-5}{100}\right) * \left(\frac{1\ gal}{128\ fl\ oz}\right) * 8.90\left(\frac{lb}{gal}\right)$ = **9.76 lb**
Total Water from admixtures = 13.32 + 9.76 = ***23.08 lb***

$w_{batch} = w - (w_{free} + ©w_{admx})$
w_{batch} = 252.04 lb – (- 48.10 lb + 23.08 lb) = **277.06 lb**
$V_{water} = \left(\frac{Mass_{water}(lb)}{62.4\left(\frac{lb}{ft^3}\right)}\right)$
$V_{water} = \left(\frac{277.06}{62.4}\right) = \mathbf{4.44\ ft^3}$

Appendix C – Hull Thickness, Reinforcement, and Percent Open Area Calculations

Hull Thickness and Reinforcement

MCCT used a consistent overall thickness of ¾ inches for the bilge and sidewalls of the canoe. MCCT used a 1/16th inch Spiderlath fiberglass reinforcement for the canoe. The mesh is applied in sections that overlap. The calculations below confirm that the mesh reinforcement does not exceed 50% of the thickness of the canoe at any point.

First layer of concrete: 0.375 inches

Mesh reinforcement: 0.0625 inches

Second layer of concrete for the areas with overlapping mesh: 0.25 inches

Net thickness: 0.375 + 2(0.0625) + 0.25 = 0.75 inches

Percent of mesh reinforcement by thickness: 0.125/0.75 = **16.7% Mesh by Thickness**

16.7% < 50% → Compliant

Percent Open Area

One layer of SpiderLath fiberglass mesh was used in the layering scheme chosen for *BOOGIE BOAT*. Calculations are presented below.

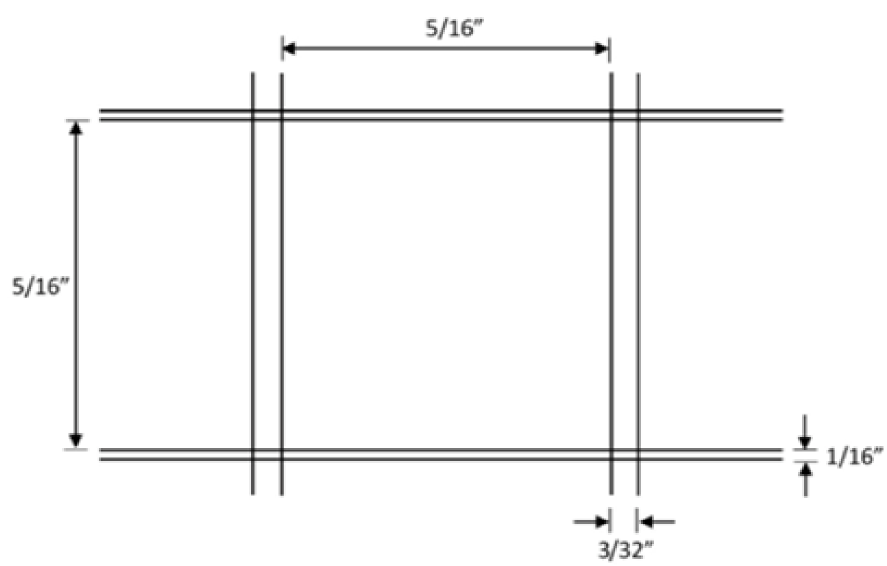

Figure C-1. Detailed view of the mesh reinforcement

Number of apertures along sample width = 20

Number of apertures along sample length = 20

Open Area = $20 * 20 * \frac{5}{16} * \frac{5}{16} = 39.06\ in^2$

Aperture Area (considering half of strand thickness) W = $\frac{5}{16}" + \frac{1}{2}\left(2 * \frac{3}{32}"\right) = \frac{13}{32}"$

$$L = \frac{5}{16}" + \frac{1}{2}\left(2 * \frac{1}{16}"\right) = \frac{6}{16}"$$

Width of sample = $20 * \frac{13}{32}" = 8.13\ in$

Length of sample = $20 * \frac{6}{16}" = 7.50\ in$

Total Sample Area = $8.13" * 7.50" = 60.98\ in^2$

Percent Open Area = $\frac{39.06\ in^2}{60.98\ in^2} * 100\% = \mathbf{49.3}\%$

49.3% > 40% → Compliant

Appendix D – Detailed Fee Estimate

Table D-1. Labor Costs

PROJECTED TOTAL MANHOURS AND DIRECT LABOR COSTS		
POSITION	**RAW LABOR RATES (RLR)**	**LABOR HOURS (HRS)**
Project Management		
Principal Design Engineer	$50/hr	31
Laborer/Technician	$25/hr	347
Clerk/Office Admin	$15/hr	21
Hull Design		
Design Manager	$45/hr	36.5
Construction Superintendent	$40/hr	81
Laborer/Technician	$25/hr	56.5
Structural Analysis		
Design Manager	$45/hr	8
Project Construction Manager	$40/hr	10
Laborer/Technician	$25/hr	55
Mixture Design Development		
Design Manager	$45/hr	28
Construction Superintendent	$40/hr	35.5
Laborer/Technician	$25/hr	182
Mold Construction and Canoe Construction		
Design Manager	$45/hr	36
Quality Manager	$35/hr	30
Laborer/Technician	$25/hr	236
Outside Consultant	$200/hr	5
Preparation of Technical Proposal, Presentation, and Display		
Design Manager	$45/hr	34.25
Technician/Drafter	$20/hr	105
Outside Consultant	$200/hr	3
TOTAL		
Direct Labor DL = [∑(RLR*HRS)]*(1.50 + 1.30)*(1 + 0.18)		**$132,197.17**

Table D-2. Cost to Produce One Canoe

MATERIALS	TOTAL USED	UNIT COSTS	SOURCES	MATERIAL COSTS (MC)
Portland Cement Type I	28.45 lb	$ 0.17/lb	Redford Building Supply Co.	$4.84
GGBFS 100	21.17 lb	$0.02/lb	MDPI	$0.42
Komponent	14.7 lb	$0.04/lb	Virginia Transportation Research Council	$0.59
VCAS	50.94 lb	$0.92/lb	VitroMaterials.com	$46.86
Fly Ash Class C (Resp)	33.45 lb	$0.20/lb	Aberdeen Group	$6.69
PVA 6 mm	0.599 lb	$15.00/lb	Fishstone Studio, Inc.	$8.99
PVA 8mm	0.5993 lb	$13.90/lb	Fishstone Studio, Inc.	$8.33
PVA 12 mm	0.5993 lb	$15.00/lb	Fishstone Studio, Inc.	$8.99
Poraver 2.0 - 4.0	15.5 lb	$1.23/lb	Concrete Texturing Tool & Supply	$19.07
Poraver 0.5 - 1.0	23.18 lb	$1.13/lb	Concrete Texturing Tool & Supply	$26.19
Poraver 0.25 - 0.5	29.87 lb	$0.99/lb	Concrete Texturing Tool & Supply	$29.57
SG 300 (Respirator)	10.26 lb	$0.18/lb	Sphere One, Inc.	$1.85
K20 (Respirator)	3.96 lb	$7.51/lb	3M	$29.74
Norlite	126.66 lb	$0.01/lb	Norlite, LLC	$1.27
Water Reducer	0.1893 lb	$18.51/lb	GCP Applied Technologies Inc.	$3.50
Air Entrainer	0.1388 lb	$25.09/lb	GCP Applied Technologies Inc.	$3.48
Pigment	0.0086 lb	$7.59/lb	Direct Colors	$0.07
Fiberglass Mesh	25 ft^2	$0.57/$ft^2$	The Home Depot	$15.39
Water	3.91 gal	$0.01/gal	City of Ann Arbor	$0.04
SILRES BS 6920	16 lb	$2.71/lb	WACKER	$43.36
Vinyl Lettering	60 letters	$5.13/letter	BoatUS.com	$307.80
TOTAL				
Expenses E = (ΣMC + ΣDE) * (1 + 0.10)				**$6,123.74**

Table D-3. Mold and Shipping Costs

Mold Construction and Lump Sum Fee	$5,000.00
Estimated Shipping Cost Roundtrip to Platteville, WI from Ann Arbor, MI by U-Haul Truck and Trailer	$881.94

Appendix E-Supporting Documentation

Pre-Qualification Form (Page 1 of 3) *2023 ASCE Concrete Canoe Competition™ Request for Proposals*

University of Michigan

We acknowledge that we have read the 2023 ASCE Society-wide 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 ASCE Student Symposium and Society-wide Competitions as outlined in Section 3.0 and Exhibit 3.	HE	XT
The eligibility requirements of registered participants (Section 3.0 and Exhibit 3)	HE	XT
The deadline for the submission of *Letter of Intent*, *Preliminary Project Delivery Schedule* and *Pre-Qualification Form* (uploaded to ASCE server) is November 4, 2022; 5:00 p.m. Eastern.	HE	XT
The last day to submit *ASCE Student Chapter Annual Reports* to be eligible for qualifying (so that they may be graded) is February 1, 2023.	HE	XT
The last day to submit *Request for Information* (RFI) to the C4 is January 27, 2023.	HE	XT
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.	HE	XT
The submission date of *Project Proposal* and *MTDS Addendum* for the Student Symposium Competition (uploading of electronic copies to ASCE server) is Friday, February 17, 2023.	HE	XT
The submission date of *Project Proposal*, and *MTDS Addendum* for the Society-wide Final Competition (hard copies postmarked to ASCE and uploading of electronic copies to ASCE server) is May 10, 2023; 5:00 p.m. Eastern.	HE	XT

Xanthe Thomas 11/1/22

Team Captain *(date)*

Xanthe Thomas

(signature)

Will Hansen 11/1/22

A ASCE Student Chapter Faculty Advisor *(date)*

W. HANSEN

(signature)

University of Michigan

As of the date of issuance of this Request for Proposal, what is the status of your school / university's 2022-23 classroom instruction (in-person, remote, hybrid)? What is anticipated after Thanksgiving and winter holiday break? If in-person or hybrid, do you have access to laboratory space or other facilities outside of classes?

Classes are offered entirely in-person. Many of the in-person classes include options to attend remotely and/or asynchronously. This will be unaffected by Thanksgiving and winter holiday break. The team has access to laboratory spaces and facilities to mix and test concrete and construct the canoe. Some facilities for paddling practice are unavailable, but most facilities' hours remain accessible. The team's business is primarily conducted in person, and meetings are rarely virtual.

In 250 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? Include a discussion on the impact of COVID-19 on the team's ability to perform work and what plans would be implemented assuming work could be performed.

Michigan Concrete Canoe Team (MCCT) is operating under the public health plans of the state of Michigan, City of Ann Arbor, University of Michigan, College of Engineering (CoE), and the facilities in which it operates, including the Wilson Student Team Project Center (WSTPC). MCCT also adheres to personal health requirements in all facilities, requiring proper PPE, training, and safe work environments. The team is continually working with the WSTPC and Office of Student Affairs to ensure safe in-person events to prevent the spread of COVID-19. The University of Michigan has mandated vaccination against COVID-19 for all students, faculty, and staff. Masks are optional in indoor spaces inside university buildings that are not patient care centers, but free high-quality masks are always provided and encouraged. COVID-19 testing is free and accessible to all students.

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?

The Michigan Concrete Canoe Team's current QA/QC program is headed by the QA/QC Lead, who is responsible for monitoring whether the team is following ASCE's official Request for Proposals and MCCT's internal quality standards. If other leads are confused by the guidelines, the QA/QC officer clarifies the guidelines, so that each sub-team knows what is expected of them, while also having a leader who is available if they are any problems. This lead also monitors the QA/QC of concrete mixing, concrete testing, and the construction of the canoe on pour day. Technical Submissions QA/QC is headed by the Technical Submissions Lead and they are the primary lead on communications and editing of the technical paper. Both positions are voted in at the end of the second semester through an election and the previous leads leave them with guidelines for how to operate for their term.

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?

MCCT has reviewed and complies with all policies regarding material research, testing, and construction and is in continuous contact with the proper groups and heads of the facilities (i.e. Wilson Center, College

University of Michigan

of Engineering, Department of Civil-Environmental Engineering) that MCCT uses to maintain a safe environment for students.

The anticipated canoe name and overall theme is – *(please provide a brief description of the anticipated 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.)*

We have selected our theme to be "70s decade" and we anticipate our canoe name to be "Boogie Boat". We intend to connect our theme to the University of Michigan with the Naval Architecture and Marine Engineering class of 1972 which was the first team to fabricate a concrete canoe on the University of Michigan campus.

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

Yes, the theme has been discussed with the team's Faculty Advisor and no Trademark or Copyright issues are anticipated.

The core project team is made up of 38 people.