Concrete Canoe

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PONDEROSA PINECONES

CENE 486C

4/22/2022

Project Introduction

General Introduction

- Build a concrete canoe
- Follow guidelines provided by the ASCE concrete canoe competition (C4)
- Race and compete with canoe in ISWS competition
- Conference held at UNLV April 13th - 16th

Overall Team Goals

- Create strong, workable mix
- Design hull and fabricate mold
- Construct canoe with help of mentee program

Figure 1: ASCE Concrete Canoe Competition Logo [1]

Mix Design

Cementitious Materials

- Type 1 Portland Cement
- Silica Fume
- Class-C Fly Ash

Aggregates

- UL-FGA
- Expanded Perlite
- Utelite
- Recycled Concrete Canoe

Admixtures

- MasterGlenium® 7500
- Masterset® DELVO
- MasterLife® SRE-35

Secondary Reinforcement

- PVA-15 8mm Reinforcing Fibers

Table 2: Concrete Mix Properties

Concrete Properties		
Property	**Value**	**Units**
Wet Density	76.3	pcf
Dry Density	74	pcf
Compressive Strength (14-day)	1190	psi
Tensile Strength	180	psi
Slump	0.5	inches
Air Content	2.1	%

Figure 4: Steven Hand-Mixing
Photo Credit: Hunter Kassens

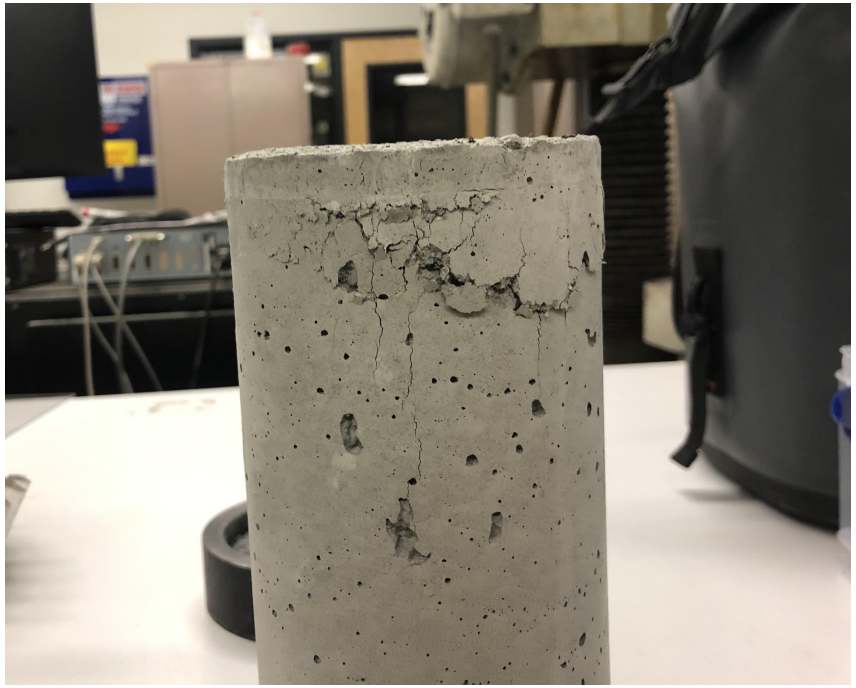


Figure 5: Mix Test Break
Photo Credit: Hunter Kassens

Hull Design

Ponderosa Pinecone Dimensions		
Property	**Value**	**Units**
Length	217	inches
Maxiumum Width	27.5	inches
Maximum Depth	14.2	inches
Thickness	0.5	inches
Weight	232.2	pounds

Table 3: Canoe Properties

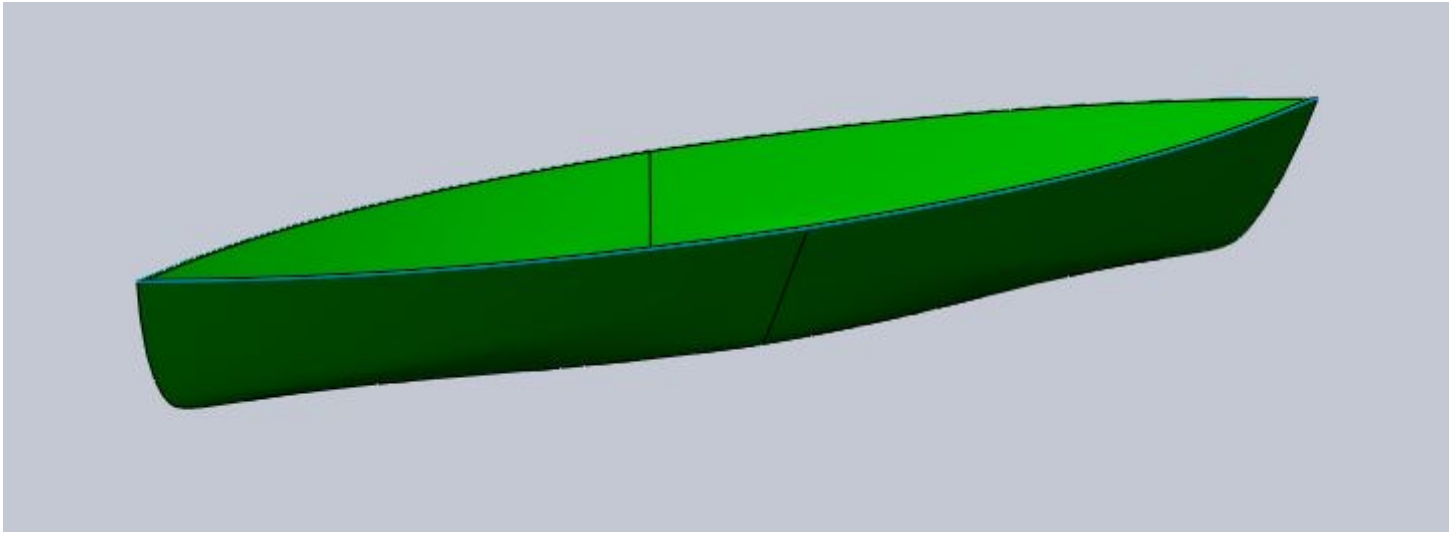


Figure 6: Isometric Image of Canoe (SolidWorks)

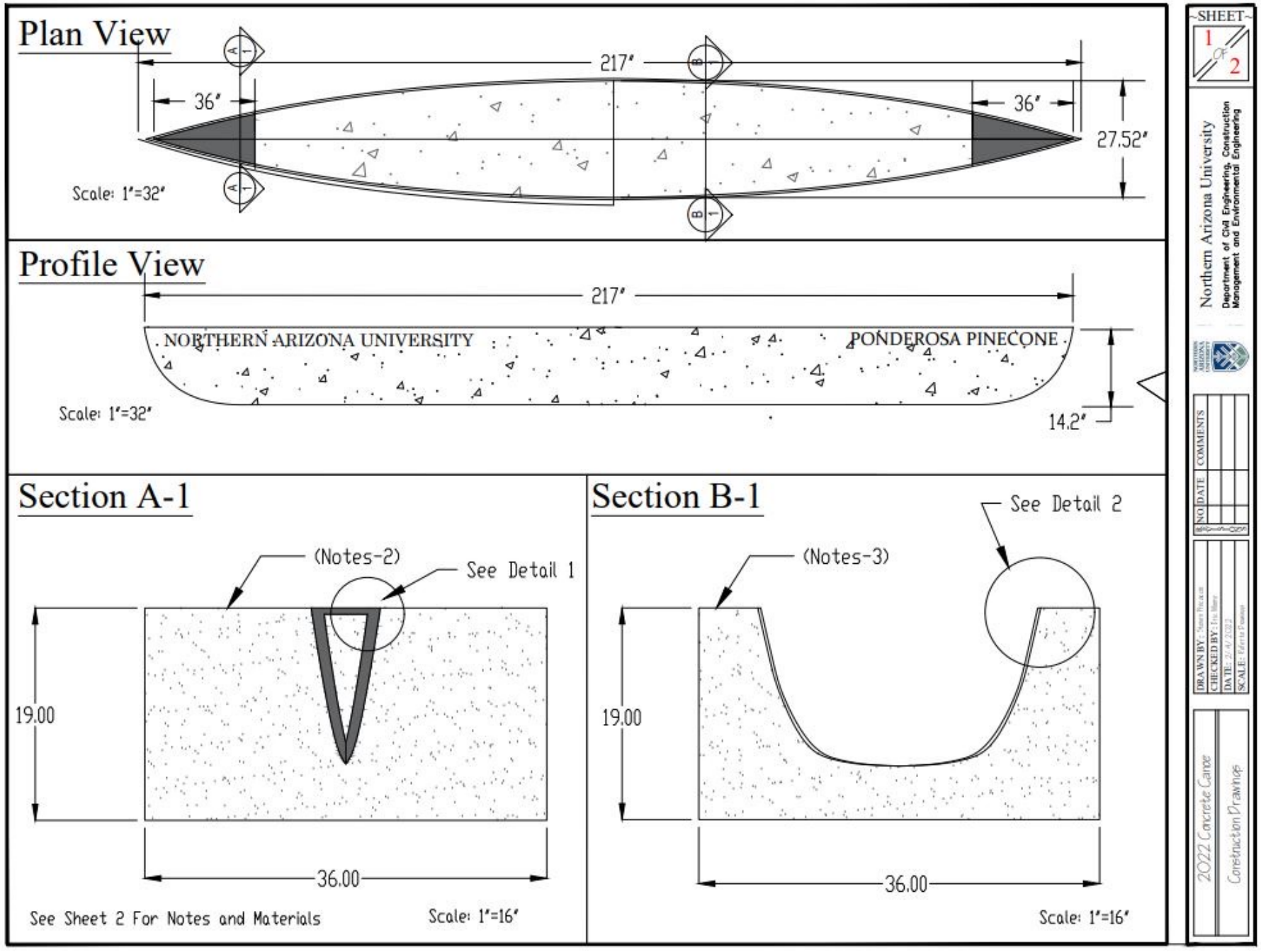
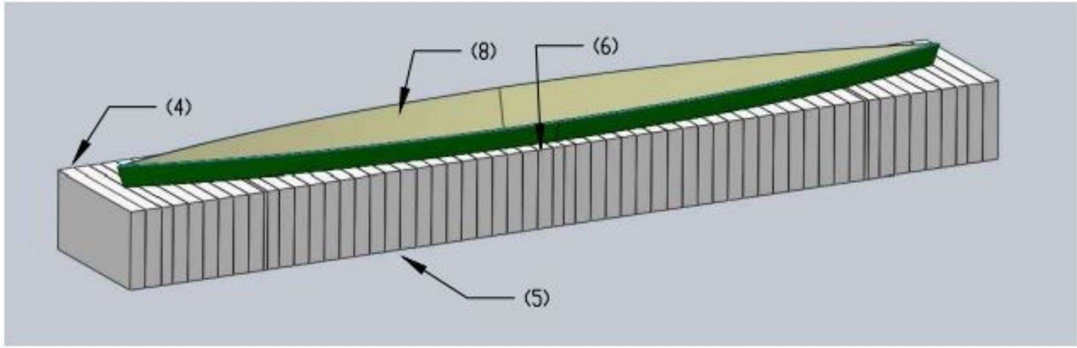


Figure 7: Final Canoe Construction Drawings

Isometric View

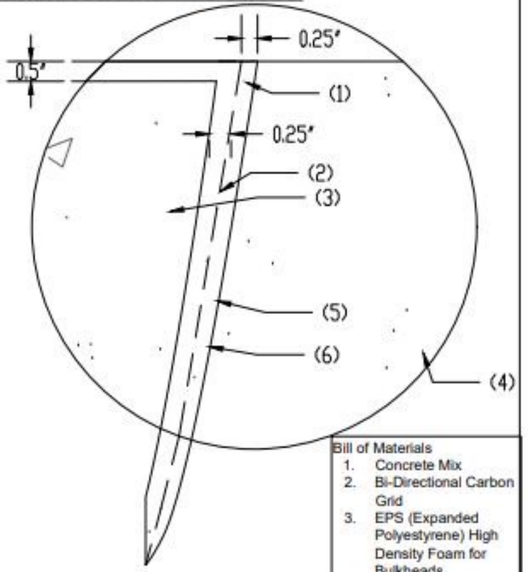


Not to Scale

Notes

1. A two-level layering scheme will be utilized for concrete. placement, with two layers of concrete mix at a thickness of ¼" each, with bi-directional carbon grid in between.
2. Section A-1 represents the first 36" of the canoe on the bow and stern.
3. Section B-1 represents the interior of the canoe between the bulkheads.
4. Mold is displayed with section cuts to display construction methods.
5. Mold is split into 4" sections for constructability purposes.
6. Liquidized rubber is applied to the mold for protection.
7. Retarder Admixture is added to the concrete mix to decrease set time and reduce risk of delaminating in between layers.
8. Canoe is raised from the mold to show finished product inside of mold.

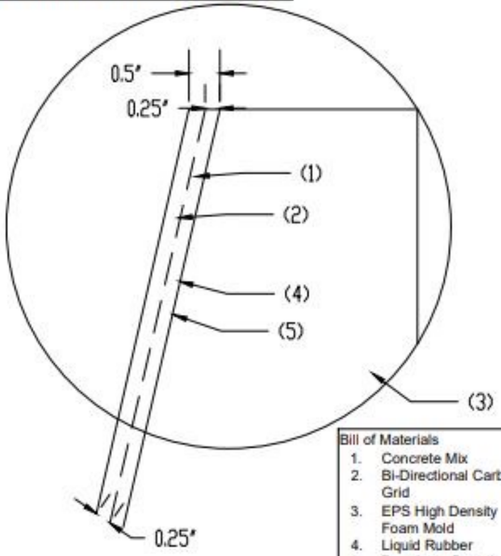
Section A-1 -Detail 1



Bill of Materials
1. Concrete Mix
2. Bi-Directional Carbon Grid
3. EPS (Expanded Polyestyrene) High Density Foam for Bulkheads
4. EPS High Density Foam Mold
5. Liquid Rubber
6. Petroleum Based Releasing Agent

Scale: 1"=4"

Section B-1 -Detail 2



Bill of Materials
1. Concrete Mix
2. Bi-Directional Carbon Grid
3. EPS High Density Foam Mold
4. Liquid Rubber
5. Petroleum Based Releasing Agent

Scale: 1"=4"

Bill of Materials

Material	Weight
Utelite Crushed Fines	15.57 lbs.
Utelite 10mesh	15.57 lbs.
Recycled Aggregate	41.35 lbs.
UL-FGA	20.41 lbs.
No. 6- Expanded Perlite	10.2 lbs.
Delvo	0.16 lbs.
Type I/II/V Cement	46.19 lbs.
Class C Fly Ash	12.89 lbs.
Silica Fume	4.3 lbs.
Glenium 7500	0.49 lbs.
SRA-35	0.04 lbs.
SSD Water	24.17 lbs.
Water for CM Hydration	25.35 lbs.
Fiber Mesh	0.11 lbs.

SHEET 2 OF 2

Northern Arizona University
Department of Civil Engineering, Construction Management and Environmental Engineering

NO. | DATE | COMMENTS

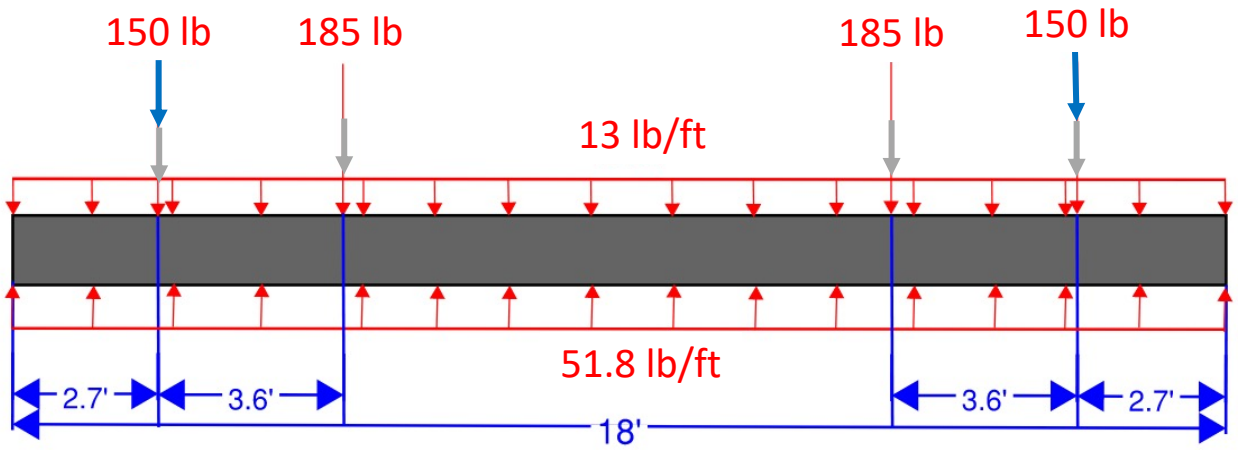
DRAWN BY: | CHECKED BY: | DATE: | SCALE:

2022 Concrete Canoe
Construction Drawings

Figure 8: Final Canoe Construction Drawings, pt. 2

Structural Analysis

- Assumptions
  - Symmetrical U-Shaped Beam
  - Load cases:
    - Female Tandem
    - Male Tandem
    - Four Person
    - Simply Supported
  - Uniform loading creates a uniformly distributed buoyancy force acting upwards



- Analysis
  - Dependent on the weight of the mix design and the length of the canoe
  - Conducted in Microsoft Excel

Structural Analysis

Moment Summary Table

Table 4: Moment Summary

Load Case	Positive Moment Magnitude (lb*ft)	Positive Moment Location (ft)	Negative Moment Magnitude (lb*ft)	Negative Moment Location (ft)
Female Tandem	60.7	2.7, 15.3	-269.6	9
Male Tandem	74.1	2.7, 15.4	-329.3	9
4-Person	206.8	6.3, 11.7	N/A	N/A
Simply Supported (right side up)	607.5	9	N/A	N/A
Simply Supported (upside down)	607.5	9	N/A	N/A

Freeboard Summary Table

Table 5: Freeboard Summary

Load Case	Freeboard (in.)
Female Tandem	9.7
Male Tandem	9.4
4-Person	7
Self-Weight	12.3

Shear & Moment

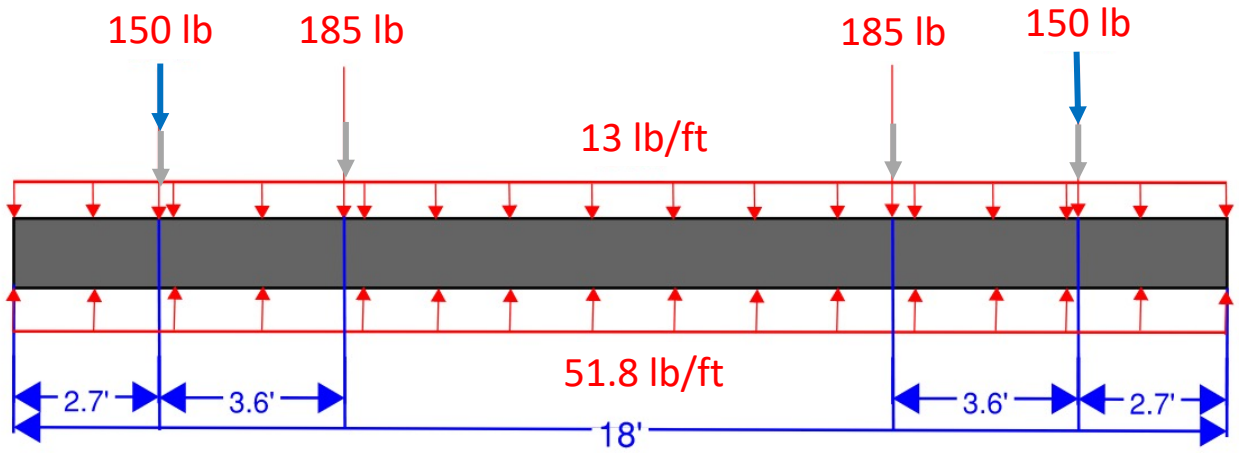
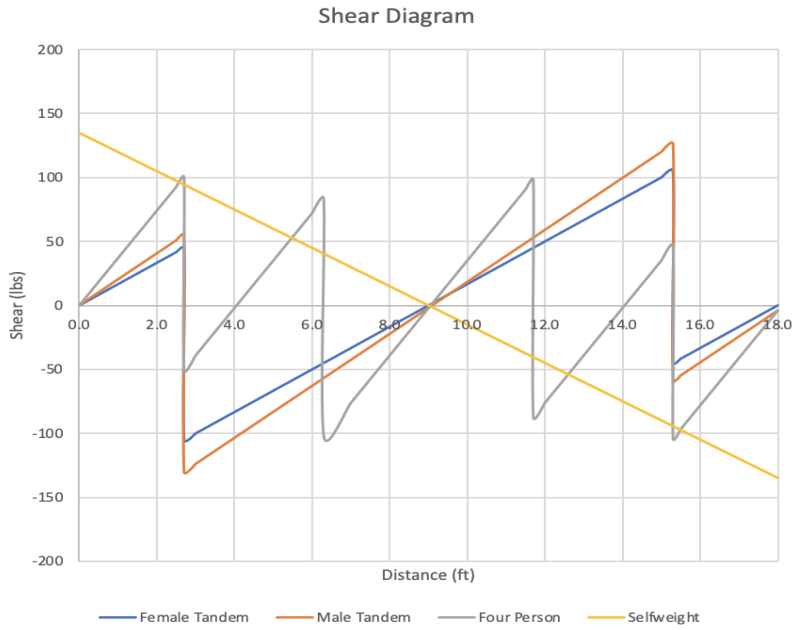


Figure 9: Load Distribution



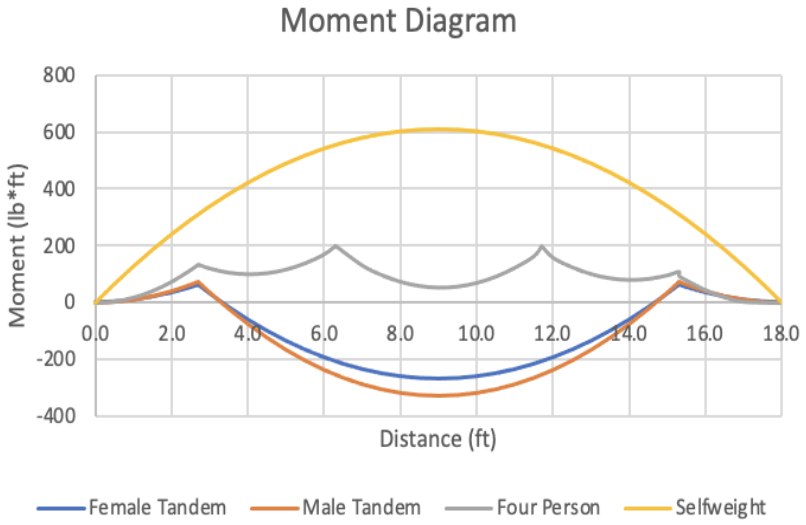


Figure 10: Shear & Moment Diagrams

Construction

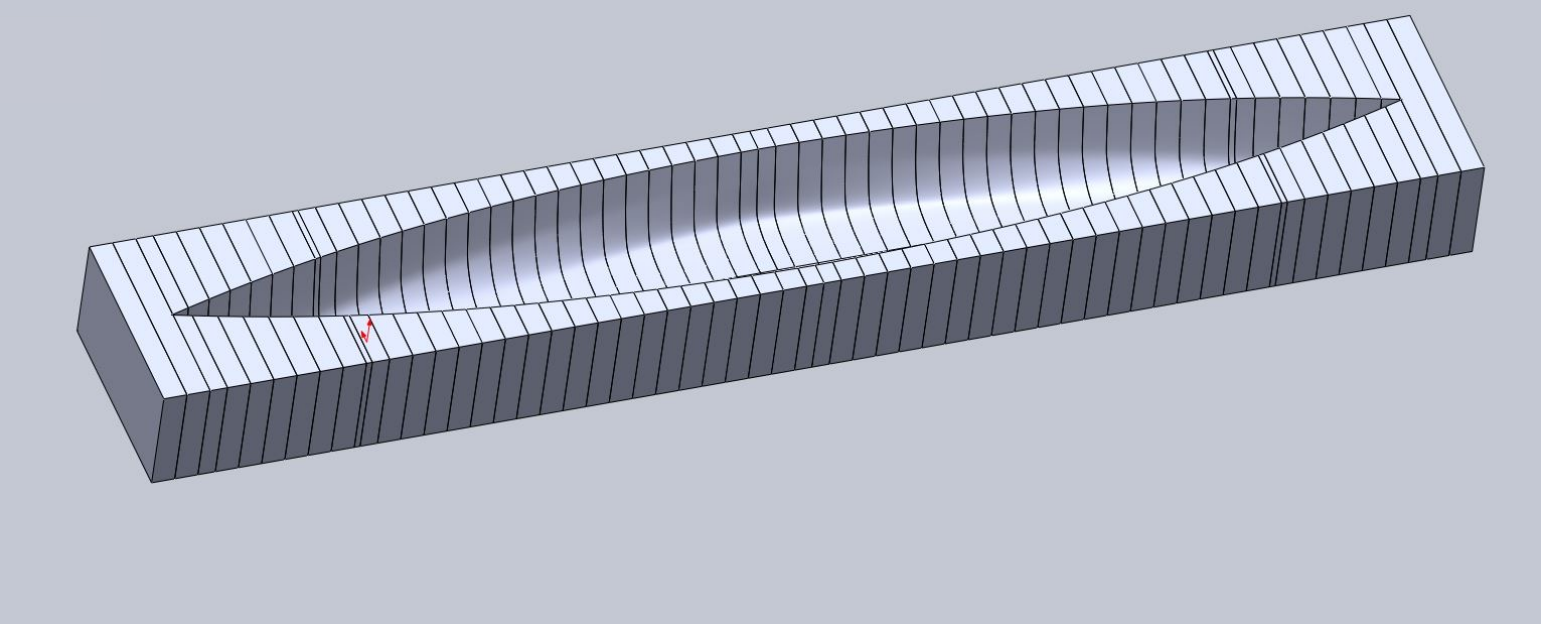


Figure 11: Isolated Image of Mold from SolidWorks

Table 6: Mold Procurement Details

Full Size Mold Procurement	
Cross Sections	60
Cross Section Thickness	Varies from 4", 3" & 1"
Foam Density	1.5 lb/ft^3
Material	EPS (Expanded Polystyrene)
Manufacturer	F3 Online (Palm Springs)

Mold Procurement

Figure 12: Gluing Mold Pieces Together
Picture Credit: Steven Procaccio

Figure 13: Mold After Sanding
Picture Credit: Hunter Kassens

Figure 14: Flex Seal Applied onto Mold
Picture Credit: Hunter Kassens

Concrete Pour

Figure 15: Placing Reinforcement
Picture Credit: Hunter Kassens

Figure 16: Team Hand-Mixing
Picture Credit: Hunter Kassens

Figure 17: Working with Mentee
Picture Credit: Alexa Rosenthal

Cure Chamber Fabrication

- Made up of PVC piping and tarp
- Frame recycled from previous teams
- Designed to keep Canoe above 95% humidity for first 14 days
- Used in conjunction with humidifiers

Figure 18: Curing Chamber
Picture Credit: Hannah Thelen

Conference Deliverables

Table 7: Summary of Important Dates/Deadlines [1]

ITEM	DATE
Issuance of 2022 Request for Proposal Solicitation	September 7, 2021
Deadline for Submission of *Preliminary Project Delivery Schedule, Letter of Intent, and RFQ Pre-Qualification Form*	November 5, 2021
Last Day to Submit RFI's to the C4	January 21, 2022
ASCE Student Chapter Annual Reports/Dues Deadline	February 1, 2022
Issuance of RFI Summary	February 1, 2022
Project Proposal, Enhanced Focus Area Report, and MTDS Addendum Deadline (Symposia Competition)	February 18, 2022
ASCE Student Regional Symposia Competitions	April 13-16, 2022
Project Proposal, Enhanced Focus Area Report, and MTDS Addendum Deadline (Society-Wide Finals)	May 10, 2022
2022 ASCE Concrete Canoe Competition, hosted by Louisiana Tech University, Ruston, LA	June 3-5, 2022

Figure 19: Conference Proposal Cover

Enhanced Focus Areas

Table 8: Enhanced Focus Areas Design Matrix

Enhanced Focus Areas: Decision Matrix						
	Criteria	Innovation	Sustainability	Cost	Practicality	Total Score
Alternatives	Weight	0.40	0.20	0.15	0.25	100%
Advanced Reinforcing	Raw Score	6	3	2	3	4.05
	Weighted	2.4	0.6	0.3	0.75	
Construction Techniques	Raw Score	5	5	2	6	4.8
	Weighted	2	1	0.3	1.5	
Website for Future Teams	Raw Score	5	8	9	7	6.7
	Weighted	2	1.6	1.35	1.75	
Fluid Dynamic Analysis	Raw Score	7	6	4	2	5.1
	Weighted	2.8	1.2	0.6	0.5	
Mentee Training	Raw Score	4	9	7	8	6.45
	Weighted	1.6	1.8	1.05	2	
Full Scale Construction Plans	Raw Score	6	4	7	4	5.25
	Weighted	2.4	0.8	1.05	1	

Enhanced Focus Areas

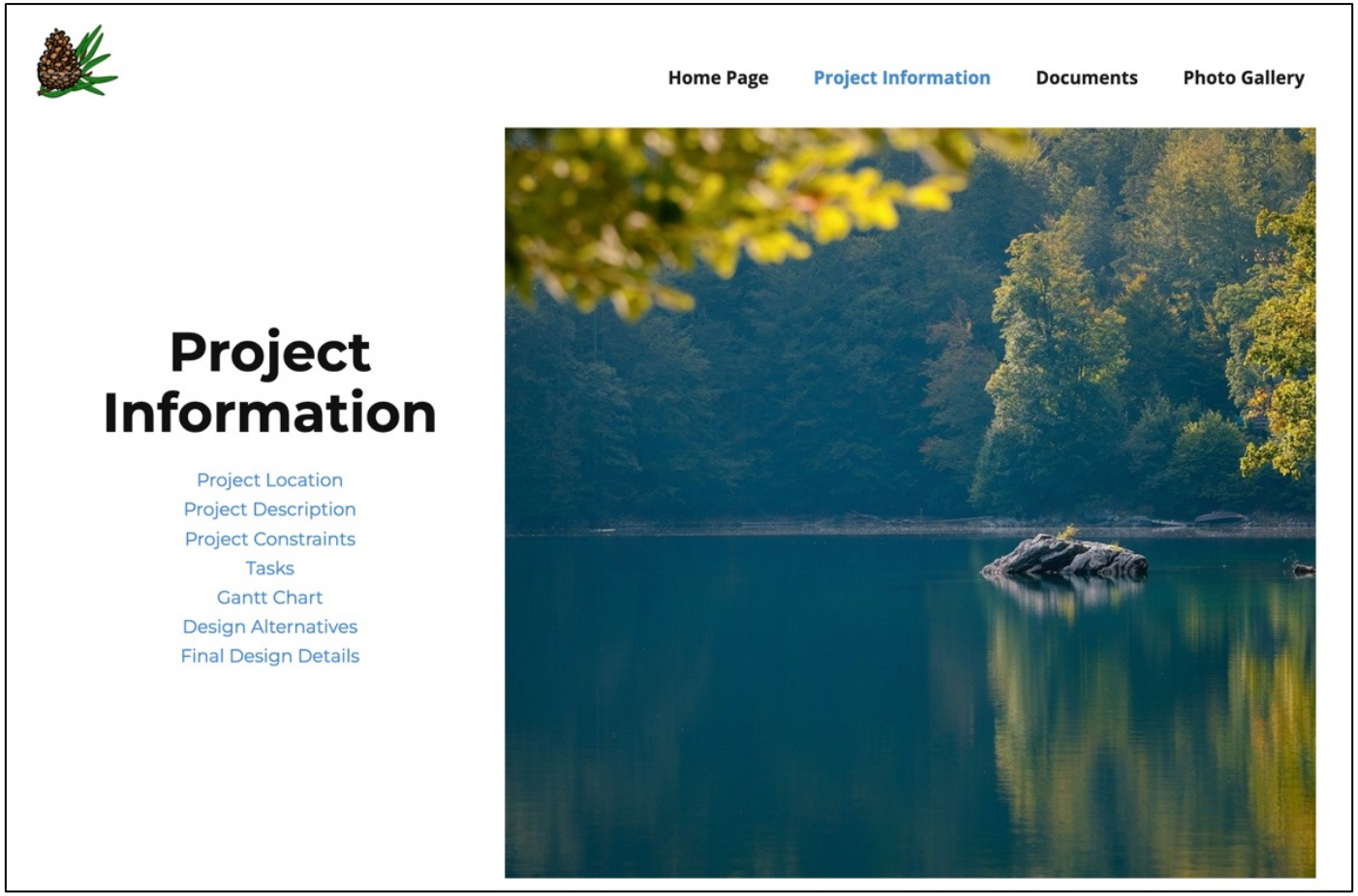


Figure 21: Concrete Canoe Website

Figure 22: Mentee Program

Conference Results

- Presentation – 1st Place
- Final Product – 1st Place
- Project Proposal – 3rd Place
- EFA Report – 3rd Place
- Paddling – 4th Place
- **Overall – 2nd Place**

Figure 23: Conference Display
Photo Credit: Hannah Thelen

Figure 24: Races Photo Credit: Alexa Rosenthal

Figure 25: Conference Presentation
Photo Credit: Frankie Martinez

Impacts

- Societal
- Environmental
- Economic

Figure 26: Canoe during Sanding
Photo Credit: Cole Robertson

References

[1] Committee on Concrete Canoe Competitions, "Concrete Canoe Competition - Request for Proposals," ASCE, Reston, 2021.

Questions?