2024 ASCE CONCRETE CANOE COMPETITION

CENE 486C

MAY 3RD

DYLAN CONDRA

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PROJECT BACKGROUND

- Design and construct a prototype canoe for the client
  - Prototype will be used to design 100 canoes
- Location: Utah State University, Logan, UT
  - Intermountain Southwest Symposium
- Created to give technical civil engineering skills

Figure 3: ISWS 2024 Logo.

Figure 1: Location map.

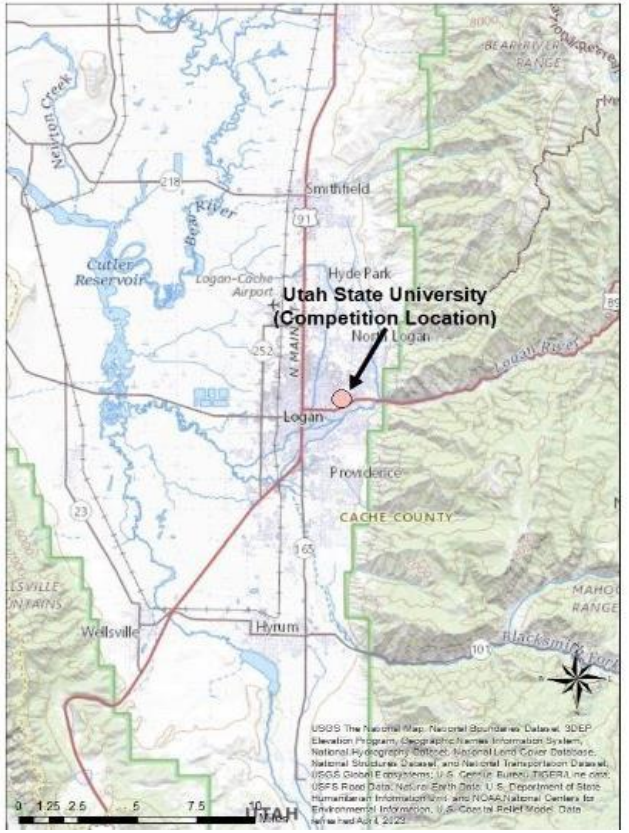

Figure 2: Vicinity map.

PROJECT MANAGEMENT

Dylan Condra (Sr.)
Project Manager

Declan Geltmacher (Sr.)
Mixture Design Lead

Derek Vecchia (Sr.)
(QA/QC) lead

Kevin Tautimer (Sr.) Hull
Design and Structural Design
Lead

ASCE FACULTY ADVISOR:
Mark Lamer, P.E.

2023-2024 Mentees:
Jessica Hillman
Kylie Hanson
Trevion Booker

MIX DESIGN

- Aggregates
  - Aero aggregate ½”
  - K1 glass bubbles
  - Red Cinder Sand
- Fibrous Materials
  - PC4
- Secondary Reinforcement
  - MasterFiber MAC Matrix
- Density of water
  - 62.4 pcf

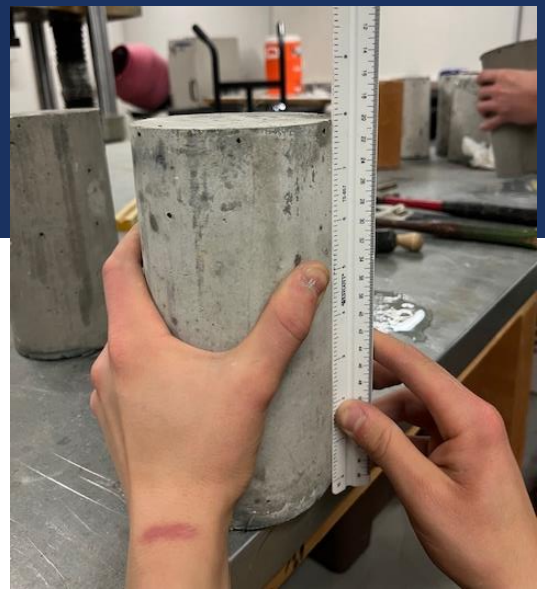

Figure 5: Concrete cylinder

Figure 6: Slump test

Table 1: Mix Design Proportions

Materials	Specific Gravity	Mix 1 (lb/cu. yd)	Mix 2 (lbs/cu. yd)	Mix 3 (lb/cu. yd)
Calport Type 1 Cement	3.2	150	150	150
Fly Ash Class F	2.8	122	122	122
Slag Grade 120	3	214	214	214
ChemStar Type S Lime	0.6	125	125	125
MasterFiber M35	2.6	6	6	6
Aero Aggregate	0.4	223	223	223
Crushed Carpet (PC4)	1.3	45	33	33
Red Ciner Sand (3/16)	2	200	0	0
K1 Glass Bubbles	0.4	51	67	0
Poraver Glass Bubbles	0.06	0	0	22
Water	1	414	408	415
Total		1610	1451	1421

Table 2: Mix Design Results

Properties	Mix 1	Mix 2	Mix 3
Compression Strength (psi)	1010	660	1890
Tension Strength (psi)	140	100	220
Dry Density (pcf)	47.6	41.7	54.2
Slump (in)	2	1.9	3
Air Content (%)	1	1.4	0.25

FINAL MIX DESIGN

Table 3: Concrete Mixture Decision Matrix.

	Dry Weight		Compression		Tension		Workability		Cracking		Green		Weighted Total
Weight	30%		25%		25%		10%		10%		5%		
	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	
Mix #1	2	0.6	2	0.5	2	0.5	3	0.3	3	0.3	2	0.1	2.3
Mix #2	3	0.9	1	0.25	1	0.25	2	0.2	1	0.1	3	0.15	1.85
Mix#3	1	0.3	3	0.75	3	0.75	1	0.1	2	0.2	1	0.05	2.15

Figure 7: Concrete Testing Cylinders

Figure 8: Concrete Tensile Testing

Figure 9: Flexural Testing Bricks

REINFORCEMENT DESIGN

Table 4: Reinforcement Decision Matrix

Reinforcement Decision Matrix							
Reinforcement	Weight		Tensile Strength		Availably		Total
	30%		50%		20%		
	Value	Weighted Score	Value	Weighted Score	Value	Weighted Score	
Carbon Mesh	3	0.9	2	1	3	0.6	2.5
1/2" Galvanized Mesh	1	0.3	3	1.5	2	0.4	2.2
FG50 Alkali Mesh	2	0.6	1	0.5	1	0.2	1.3

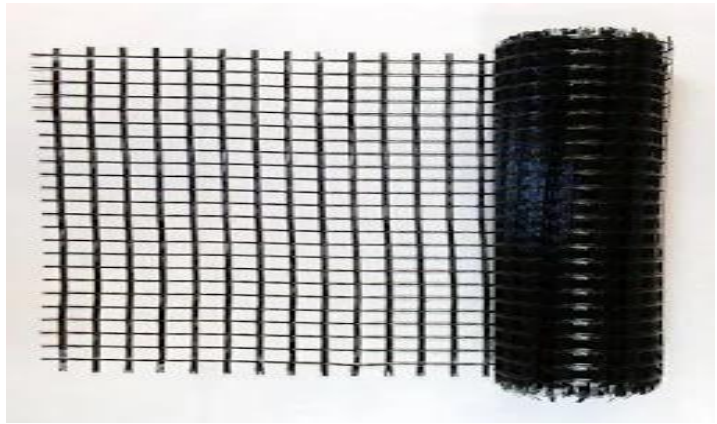

Figure 10: FG50 Alkali Mesh

Figure 11: Carbon Mesh

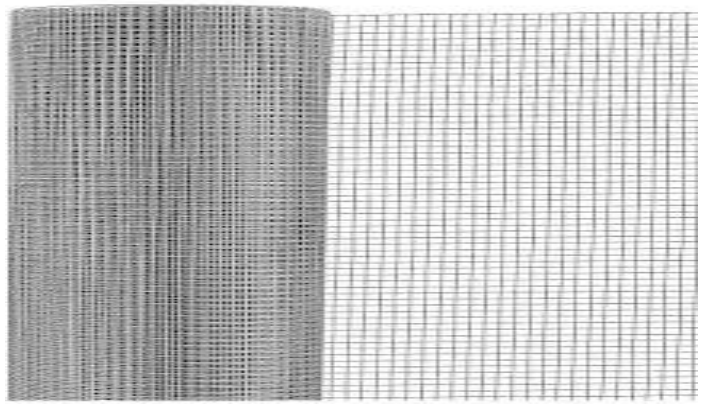

Figure 12: Galvanized Mesh

HULL DESIGN

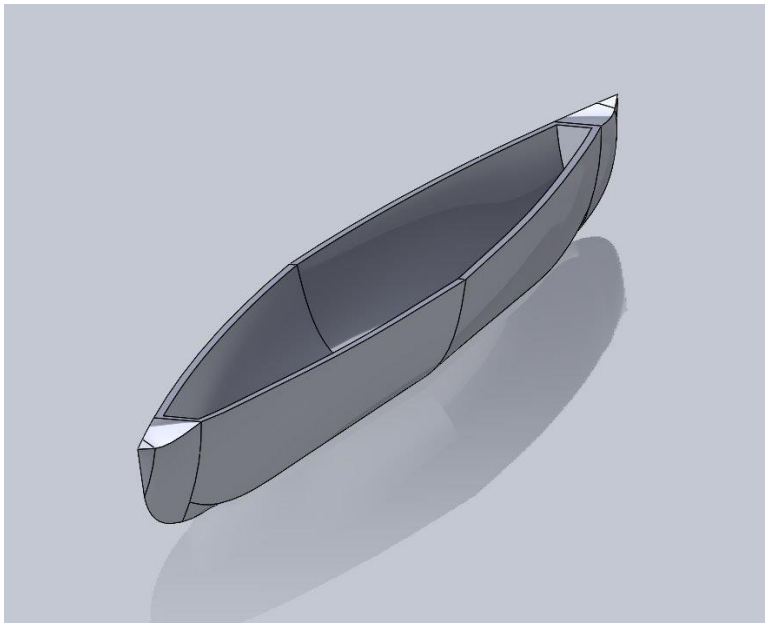

Figure 13: Canoe Design 1 [1]

Design 1:

Length = 19 ft
Bow = Traditional
Bottom= V- Hull
Sides = Straight

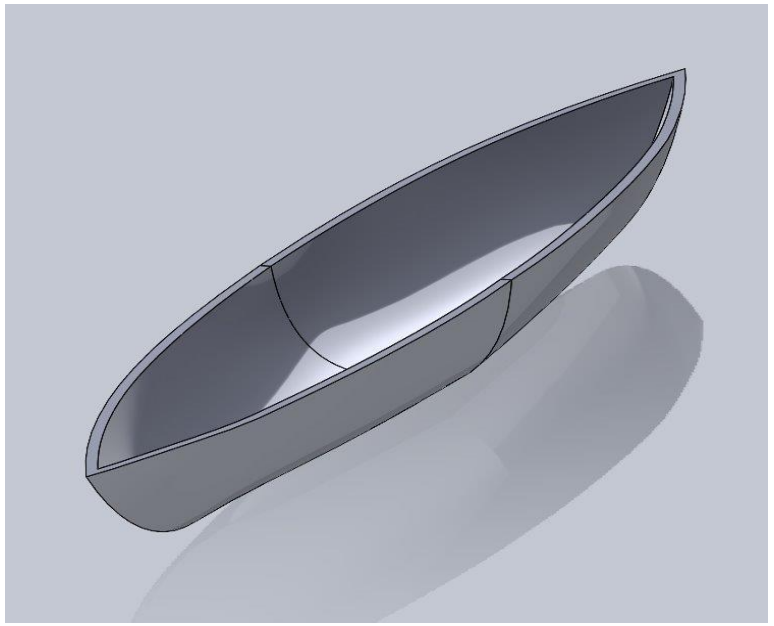

Figure 14: Canoe Design 2 [1]

Design 2:

Length = 16.5 ft
Bow = Moderate Recurve
Bottom = Rounded
Sides = Flared

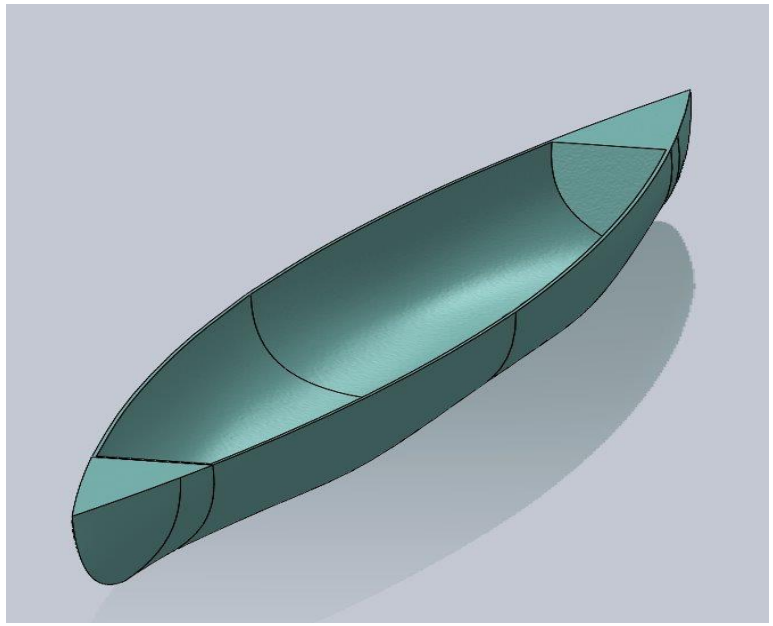

Figure 15: Canoe Design 3 [1]

Design 3:

Length = 18 ft
Bow = Moderate Recurve
Bottom = Shallow Arch
Sides = Flared

FINAL HULL DESIGN

Table 5: Hull Design Decision Matrix

Design	Aesthetics		Speed		Buoyancy		Maneuverability		Stability		Total
Weight	15%		15%		20%		20%		30%		
	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	
Design #1	2	0.3	3	0.45	1	0.2	1	0.2	1	0.3	1.45
Design #2	1	0.15	1	0.15	2	0.4	3	0.6	2	0.6	1.9
Design #3	3	0.45	2	0.3	3	0.6	2	0.4	3	0.9	2.65

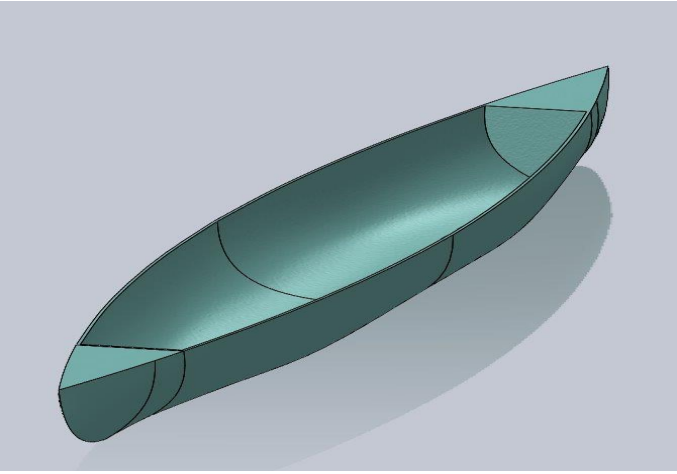

Figure 16: Final Hull Design [1]

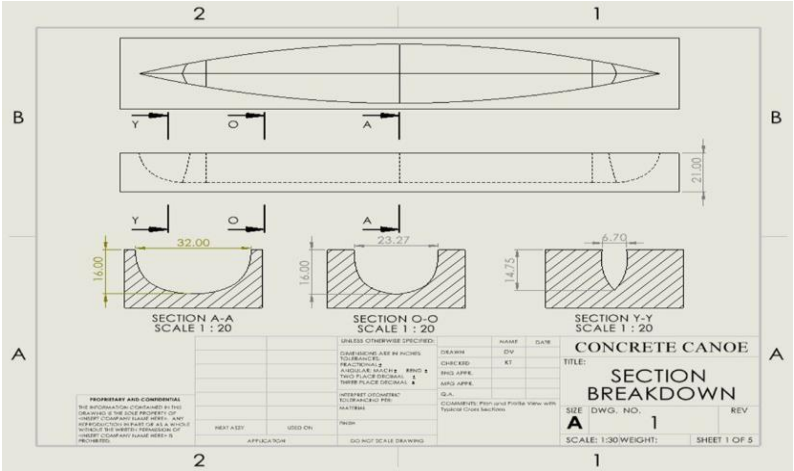

Figure 17: Mold Construction Drawings

STRUCTURAL ANALYSIS 2D

Table 6: Male Tandem Loading

Load	Max Shear Magnitude (lbs.)	Max Shear Location (ft)	Max Moment Magnitude (lbs.*ft)	Max Moment Location (ft)
Male Loading	88	13.5	131	9

Table 7: Free Body Diagram Results

Load Condition	Demand	Capacity
Shear Force (lbs.)	88	194
Moment (lbs.-ft)	131	5,999
Punching Shear (psi)	10	66

Table 8: Free Board

Load Case	Freeboard (in)
Male Loading	2.3

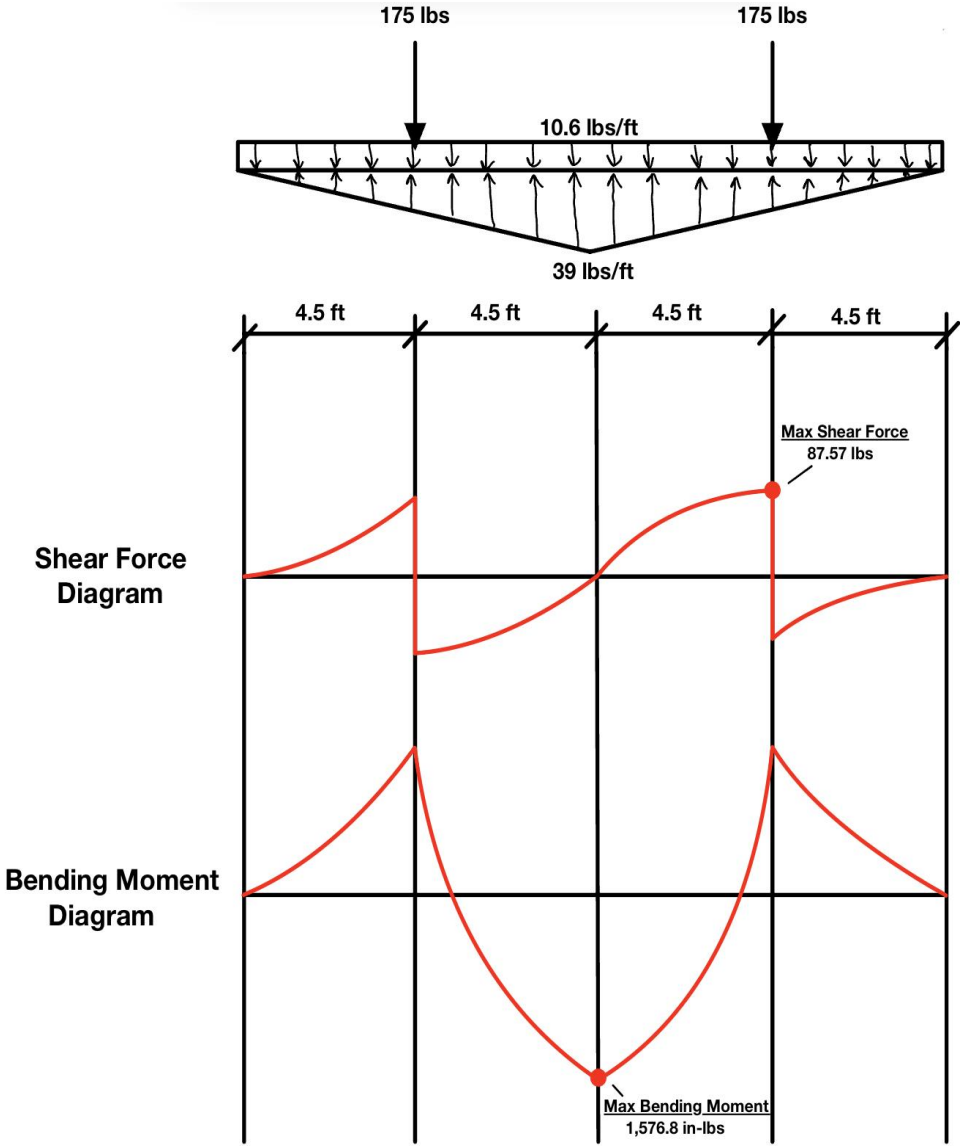

Figure 18: Free Body Diagram w/ Shear Force & Bending Moment

STRUCTURAL ANALYSIS 3D

Table 9: Compressive & Tensile Capacities

Max Compressive Strength (psi)	Max Tensile Strength (psi)
1000	140

Table 10: Principal Stress States

Max Compressive Stress (psi)	Max Tensile Stress (psi)	Slope of Tangent Line
21.5	43.24	y = -1.0494x + 194.68

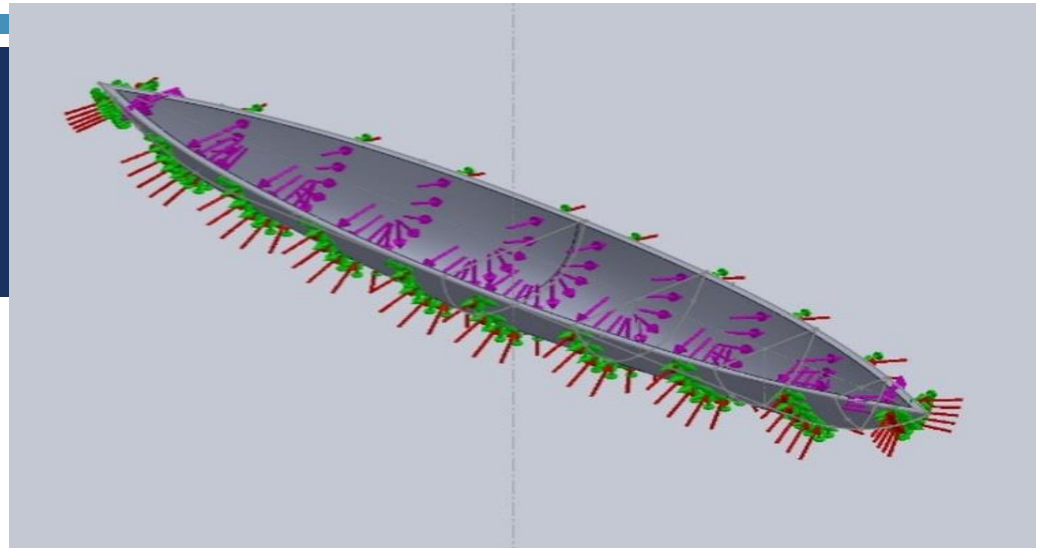

Figure 19: SolidWorks Display

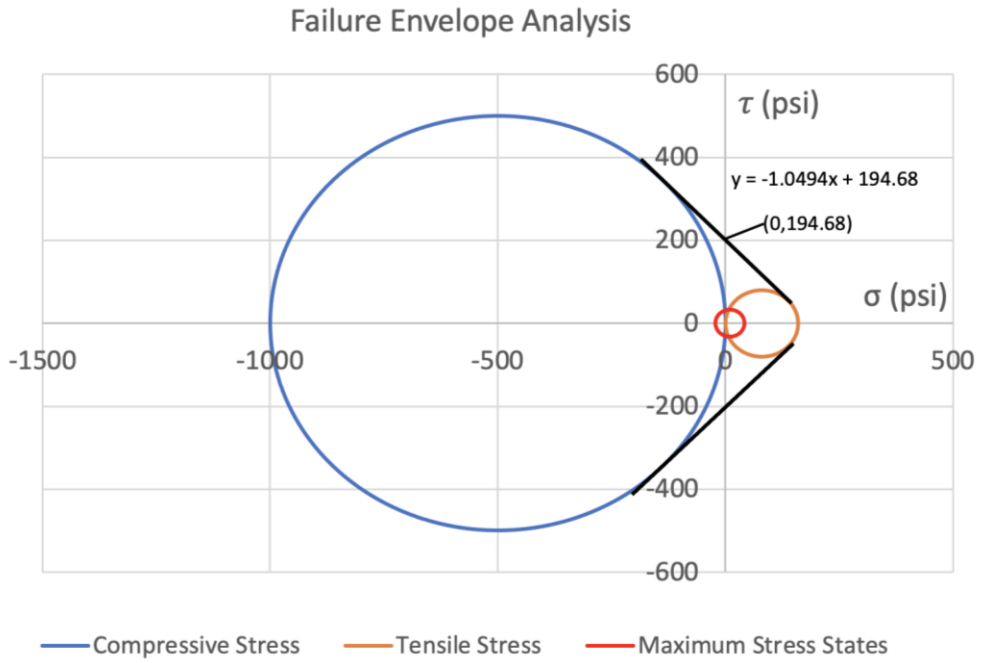

Figure 20: Failure Envelope Analysis

PRE-CANOE FABRICATION

Figure 21: Mold Pickup

Figure 22: Mold Assembly

Figure 23: Final Mold Assembly

Figure 24: Mold Sanding

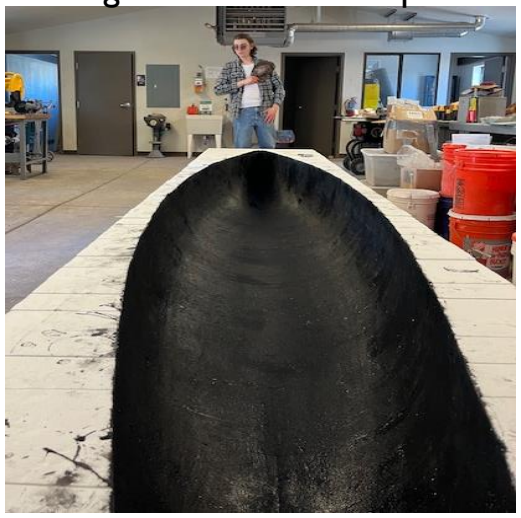

Figure 25: Releasing Agent Application

Figure 26: Curing Chamber

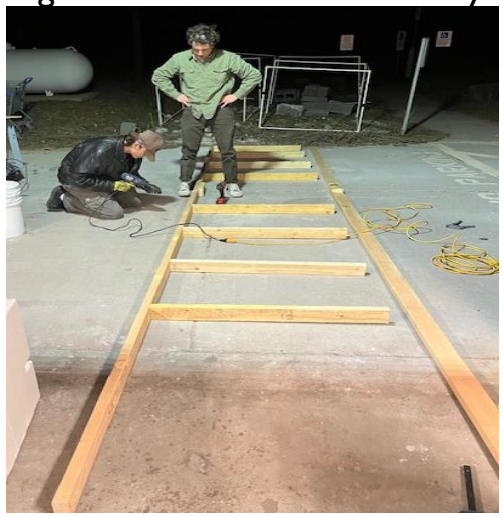

Figure 27: Curing Table Construction

Figure 28: Curing Table

CANOE FABRICATION

Figure 29: Reinforcement Fitting

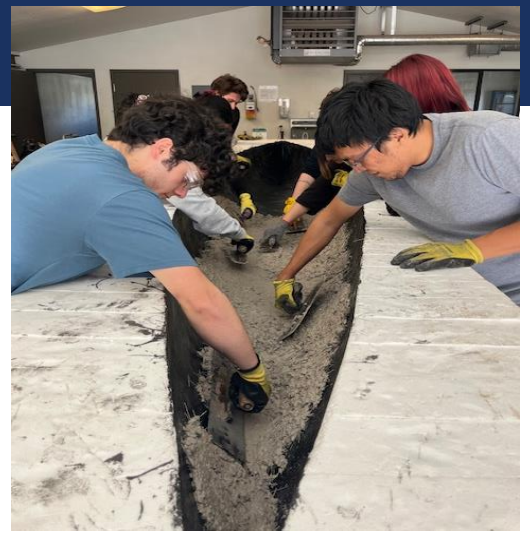

Figure 30: First Layer Application

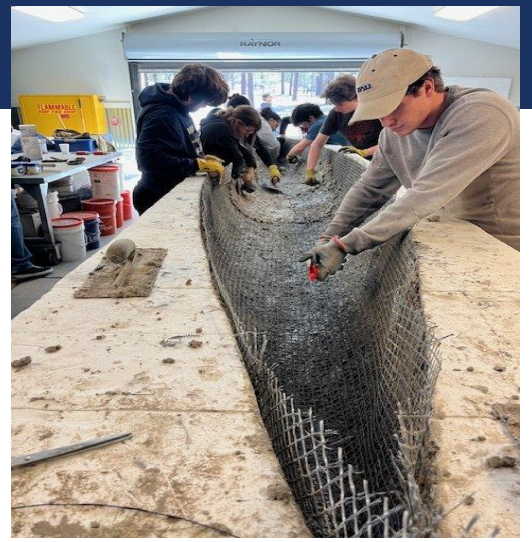

Figure 31: Reinforcement Placement

Figure 32: Second Layer Application

Figure 33: Bulkhead Construction

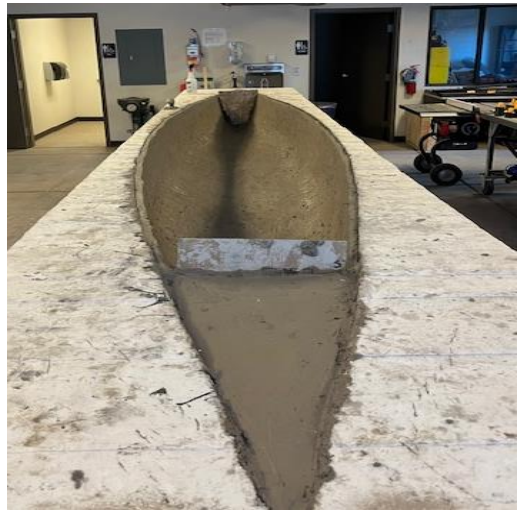

Figure 34: Finished Product

Figure 35: Curing Process

PRE-COMPETITION PREPARATION

Figure 36: Mold Removal

Figure 37: Patch Work

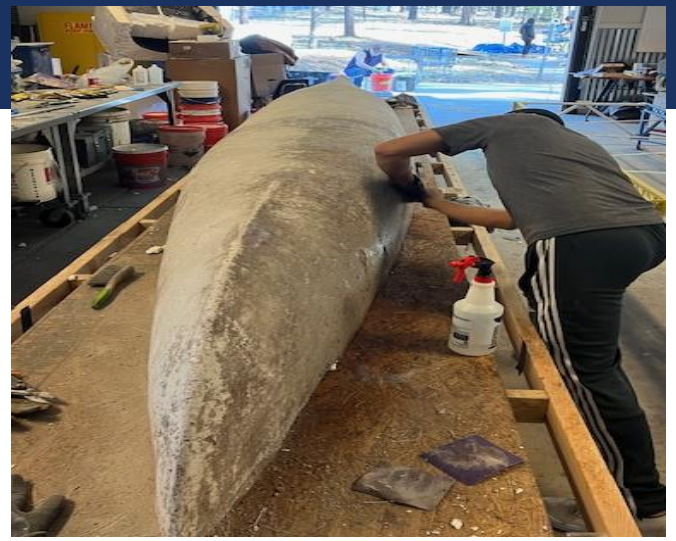

Figure 38: Final Sanding

Figure 39: Sealant Application

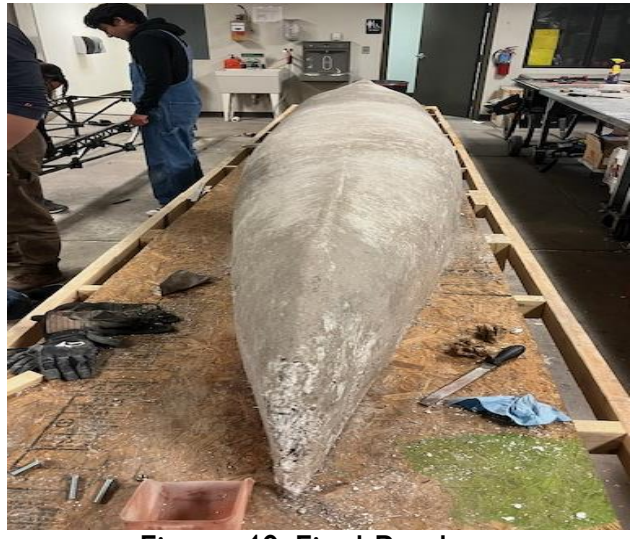

Figure 40: Final Product

Figure 41: Transportation Preparation

CONFERENCE COMPETITION

- Display
  - All materials
  - Poster explaining structural, hull, mix components
  - Canoe prototype displayed
- Presentation
  - Five-minute technical slideshow
- Race
  - Slalom
  - Sprint

Figure 42: ISWS Presentation (Credit Kylie Handson)

Figure 43: ISWS Display (Credit Kylie Handson)

Figure 44: Male Tandem Race (Credit Kylie Handson)

COMPETITION RESULTS

- Best In State!

Figure 45: Swamp Test

Table 11: Race Results from Competition

Race Results					
	Womans Slalom	Men's Slalom	Womans Sprint	Men's Sprint	4 Person-Coed
Time	5 mins 9 sec	6 min 45 sec	2 min 53 sec	2 min 11 sec	2 min 51 sec
Place	4th	7th	4th	3rd	4th

IMPACTS

- Social Impacts
  - Building interest in engineering
  - Canoe's performance
- Economic Impacts
  - Use of alternative materials
  - Hard to replace concrete as material
- Environmental Impacts
  - 70% materials used were alternative
  - Concrete greenhouse gases

Figure 46: Canoe Display (Credit Kylie Handson)

REFERENCES

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QUESTIONS?