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Compliance Certificate

Michigan Technological University's 2008-2009 Concrete Canoe team hereby certifies that the construction and finishing of Polaris has been completed in compliance with the rules and regulations set forth by the National Concrete Canoe Competition. Additionally, the canoe has been completely built within the current academic year of the competition. The ten (10) registered participants are qualified, eligible student members and National Student Members of ASCE as specified in the rules and regulations of the National Competition. The team acknowledges that all material safety data sheets (MSDS) have been read by the project management team and acknowledges receipt of the *Frequently Asked Questions* (FAQ).

Registered Members of the 2007-2008 Michigan Tech Concrete Canoe Team

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Table 1: Polaris Characteristics

Polaris Dimensions	
Overall Weight	210 pounds
Max. Length	20 feet 0 inches
Max. Width	31.2 inches
Depth (Max.)	14.0 inches
Thickness	0.375 inches
Accretion Mix Properties	
Unit Weight (Density)	59.4 pcf (951.5 kg/m^3)
28-day Tensile Strength	603 psi (4.16 MPa)
28-day Compressive Strength	3278 psi (22.6 MPa)
Air Content	6.18%
Composite Properties	
28-day Flexural Strength	142 inch-pounds per inch (631.7 N-m/m)

We certify that the aforementioned information is valid.

____________________ Date

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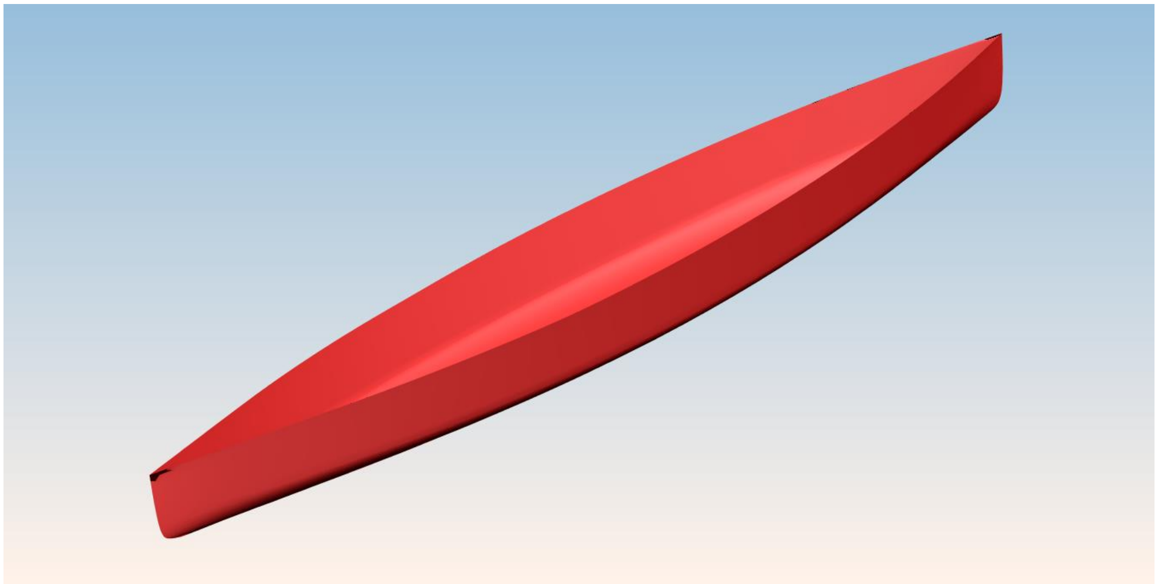
Mold Construction



Once Michigan Tech received the rules from the CNCCC, the team made a Unigraphics model of the canoe design. The model was used as a blue print by the team's CNC-milling industry partner.

The polystyrene foam female mold was subcontracted to a CNC-milling industry partner to obtain the exact dimensions of this year's canoe.

The interior of the mold was lightly painted with a coat of epoxy to aid in removal and create a water tight barrier.

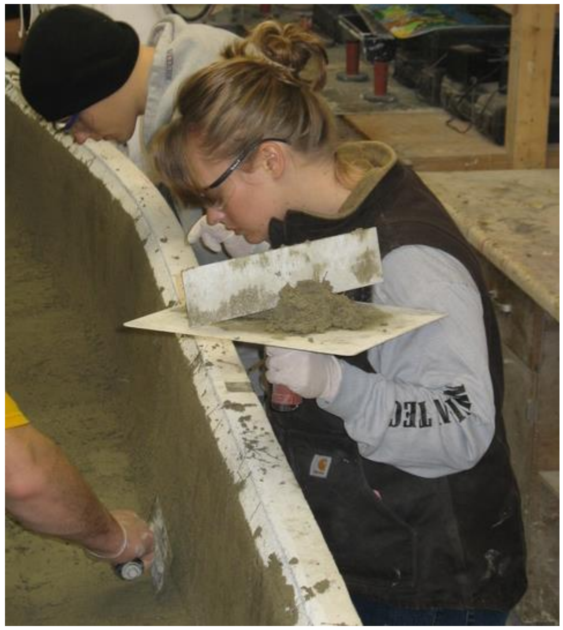
Following the epoxy application, a fine aggregate mixture was spread onto the wet epoxy to create a textured surface that helped prevent sloughing during troweling.

The three mold pieces were attached together using wooden dowels, and then the entire mold was attached to a custom table top to provide stability during casting.

Exterior inlays were cut from vinyl placemats and secured to the mold with staples.

An oil-based release aid was sprayed on to the completed mold prior to casting.

Canoe Construction



Concrete was applied to the mold in three separate layers, each $^{1}/_{8}$" thick. Steel trowels and hawks aided trowelers in placing the concrete.

Two layers of epoxy-coated carbon fiber reinforcement were placed between layers of concrete. The mesh was cut into 3-feet sections with a 1.5-inch overlap on both ends.

Weights were attached to the reinforcement and suspended from the outside of the mold to help conform the reinforcement to the shape of the hull.

Concrete finishing was performed using a custom-made vibrating trowel
to obtain sufficient consolidation.

A 20-piece concrete "Husky Card" inlay adorns the inside of the canoe.

End caps were cast into each end of the boat for strength and to encapsulate Styrofoam for flotation purposes.

Finishing Techniques

The interior and exterior of the hull were treated with finishing and slurry mixes to fill in any minor defects that were found.

Hand and mechanized sanding was used to smooth the interior and exterior of the canoe.

The exterior design was created by masking the canoe with tape and cutting out the designs with a utility knife. Acid stains were used to finish the look of *GAMBLER*.

The entire canoe was then sealed using Seal Cure to complete *GAMBLER*.

Hull Thickness Calculations

Annotation

$T_w := 0.068in$	Thickness of one layer of reinforcement, measured in accordance with Section 4.3.1
$T_h := 0.375in$	Thickness of the canoe hull

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

Solution

Two layers of mesh were used throughout the entire hull.

$$2 \cdot T_w = 0.136in$$

$$\frac{2 \cdot T_w}{T_h} = 36.27\%$$

The two layers of reinforcement make up approximately 36.27% of the hull, which is is less than the maximum value of 50% outlined in sectoin 4.3.1.

Percent Open Area Calculations

Calculations per Section 4.3.2

Given

$n_1 := 4$

$n_2 := 4$

Number of larger apertures (1) in sample

$n_3 := 4$

$n_4 := 5$

Number of smaller apertures (2) in sample

$t_1 := 0.09375in$

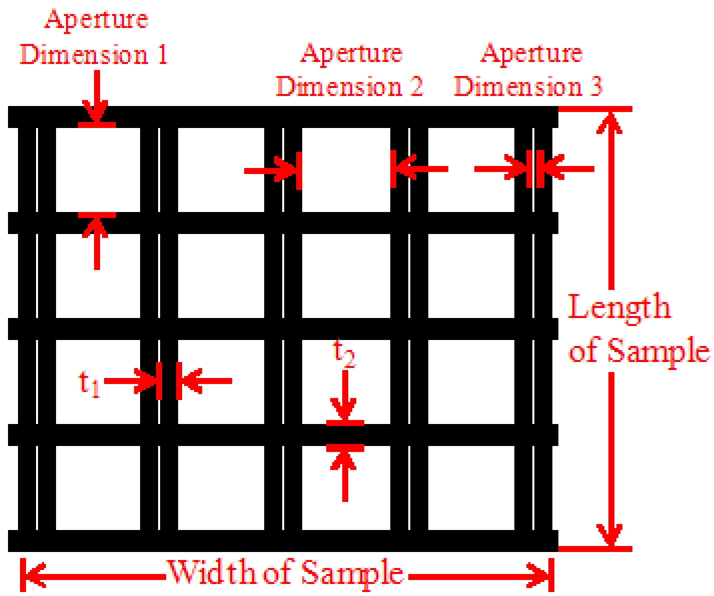
$t_2 := 0.125in$

Thickness of reinforcement

aperture_dimension_1 := 0.875in

aperture_dimension_2 := 0.78125in

aperture_dimension_3 := 0.03125in



Sample of Reinforcement

$d_{11} := \text{aperture\_dimension\_2} + 2 \cdot \frac{t_1}{2}$ $\quad d_{11} = 0.875in$

$d_{12} := \text{aperture\_dimension\_1} + 2 \cdot \frac{t_2}{2}$ $\quad d_{12} = 1in$

Spacing of reinforcement (center-to-center) for the large apertures

$d_{21} := \text{aperture\_dimension\_2} + 2 \cdot \frac{t_1}{2}$ $\quad d_{21} = 0.875in$

$d_{22} := \text{aperture\_dimension\_3} + 2 \cdot \frac{t_1}{2}$ $\quad d_{22} = 0.125in$

Spacing of reinforcement (center-to-center) for the small apertures

Determine Percent Open Area for the Saint-Gobain® FibaCrete® alkali-resistant fiberglass mesh sample.

Solution

$Length_{sample} := n_1 \cdot d_{11} + n_3 \cdot d_{22}$

$Width_{sample} := n_2 \cdot d_{21} + n_4 \cdot d_{22}$

$Length_{sample} = 4 in$

$Width_{sample} = 4.125 in$

$Area_{openlarge} := n_1 \cdot n_2 \cdot aperture\_dimension\_1 \cdot aperture\_dimension\_2$

$Area_{opensmall} := n_3 \cdot n_4 \cdot aperture\_dimension\_1 \cdot aperture\_dimension\_3$

$Area_{open} := Area_{openlarge} + Area_{opensmall}$

$Area_{open} = 11.484 in^2$

$Area_{total} := Length_{sample} \cdot Width_{sample}$

$Area_{total} = 16.5 in^2$

$POA := \frac{Area_{open}}{Area_{total}} \cdot 100\%$ $POA = 69.6\%$

The POA is greater than the 20% minimum required, so it is OK

Missing MTDS's:

Triple-S™ Concrete Acid Stain- Have an MTDS but it does not state that the stain is in compliance with the rule specifications; the MSDS does state that it is in compliance, but according to the rules we cannot include MSDS's with the notebook. Eric should be working on obtaining a letter. Should double check.

PVA Fibers (Kuralon™ RF4000 (30mm))- MTDS is missing, but Cotter is currently working on either obtaining one for us or a letter stating that the product is in compliance.

Xycrylic® Admix- Have an MTDS and a letter verifying that the admixture meets the required ASTM, but Cotter forwarded me an email that TJ sent him saying don't include it. I'm looking for some input; my gut tells me to include the letter.

Alabama Pigments- Have an MTDS, but it does not state that the product is in compliance with ASTM C979