GATOR RAIDER

UNIVERSITY OF FLORIDA
2008 CONCRETE CANOE

DESIGN PAPER

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EXECUTIVE SUMMARY

Founded in 1853, the University of Florida is the state's oldest and most prestigious university. A major research institution located on a 2000-acre campus in Gainesville, FL, the University of Florida is ranked 49th in the 2008 *U.S. News and World Report* national rankings. UF's civil engineering students have extended the Gator Nation to all corners of the earth, earning the reputation of being world-class idea-generators, engineers, and citizens.

Table 1: **GATOR RAIDER** Details

Overall Weight:	**193 lbs**
Overall Length:	**19'-11"**
Maximum Width:	**2'-7"**
Maximum Depth:	**1'-1"**
Average Thickness:	**7/16"**
Colors:	**Black, Gray, Orange, Blue**
Avg. Concrete Unit Weight:	**64.6 pcf**
Reinforcement:	**Carbon Fiber Mesh**
Avg. 28-Day Strengths	
Compressive	**3020 psi**
Composite Flexural	**1490 psi**

The University of Florida Student Chapter of the American Society of Civil Engineers, with over 350 members, is one of the largest and most successful chapters in the nation. UF has placed first overall in nine of the last eleven Southeast Student Conferences, and was the recipient of the 2008 ASCE Region 5 Governor's Award.

In 2007, the University of Florida's *Gladigator* placed second in the National Concrete Canoe Competition, the team's finest finish to date. After sweeping the races and placing first in every category at the highly competitive Southeast Conference in 2008, UF's Concrete Canoe Team is representing the conference for the sixth time at the national level. Intent on continuing its tradition of excellence and driven by the spirit of competition, the 2008 UF Concrete Canoe Team proudly presents **GATOR RAIDER**, the specifications of which are in Table 1.

Focused on implementing more comprehensive scale model testing, improving form construction, and enriching the canoe's aesthetic appeal, the dedicated team members set out to create the most impressive product in the team's storied tradition. By implementing a new rotational scale model test, the team refined *Gladigator*'s solid hull design by reducing deadwood in the canoe's bow. Through new construction techniques and meticulous quality control, **GATOR RAIDER**'s form is the best in the team's history. Striving to extend a long tradition of superior aesthetics and theme integration, a team of graphics engineers created a stunning system of inlaid components that tie **GATOR RAIDER**'s theme together. A dedicated group of athletes began paddling and training relentlessly in early September. Thirty concrete mixture designs, enhanced with improved aggregate and new polypropylene fibers, have been tested and refined to ensure quality. The veteran squad, bolstered by new teammates and fresh ideas, is prepared to take on the finest concrete canoe teams in the nation.

HULL DESIGN

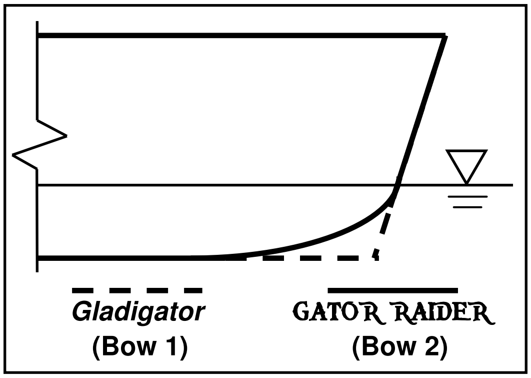
Objectives:
- *Refine bow design to maximize turning speed and minimize frictional resistance*
- *Introduce more comprehensive scale model testing to validate design choices*
- *Integrate components of previous designs to maintain hydraulic efficiency*

Approach: **GATOR RAIDER**'s hull design is an incremental improvement upon UF's proven 2007 *Gladigator* design. Veteran paddlers were consulted to determine the undesirable aspects of the *Gladigator* hull design. It was decided that deadwood would be removed from the bow in order to maximize turning efficiency. The team utilized both traditional scale model testing and a newly introduced rotational test to validate the design choices.

Hull Geometry: *Gladigator* featured a 3-inch bow rocker, 2-inch stern rocker, 3-inch rounded chines, an 8-degree bow angle, and a 15-degree reversed rake stern. The experience of veteran paddlers and past test data convinced the Florida team that the existing stern geometry, stern rocker, and soft chines provide the ideal balance of speed, stability, and maneuverability. A 20-degree bow replaced *Gladigator*'s 8-degree angle for aesthetic purposes, and the geometry of the bow was refined as described below.

Refinement: Paddlers from the 2007 *Gladigator* team observed unexpected resistance to turning when navigating the buoys in sprint and endurance races. The frictional resistance due to excessive material below the waterline impeded hull rotation (Winters 2006). To combat this, **GATOR RAIDER**'s bow rocker was increased to 6½-inches to remove deadwood from the bow and maximize turning efficiency. The result is a reduction of wetted surface area below the waterline, as shown in Figure 1.

Figure 1: Deadwood Removal



Testing: Scale model testing, presented in Table 2, was conducted to ensure that the removal of deadwood would improve **GATOR RAIDER**'s turning ability without adversely affecting straight-line speed. A basswood model and four interchangeable resin bows were constructed at 1/6th-scale. A straight line test was employed, in which the hydraulic drag force on the model is equal to the weight of the attached falling mass. Given a travel length of 30-feet, the average model speeds were calculated. Results showed that Bow 2, with deadwood removed, was slower than *Gladigator*'s design by a negligible 2.57%. Additionally, a new rotational test was utilized in order to assess the turning efficiencies of various bow shapes. The model was fixed to a shaft and rotated by a falling mass until ten revolutions were completed. The average rotational speeds were calculated, and it was determined that deadwood removal increased turning speed by 12.3%, sufficient to validate the design refinement.

Table 2: Summary of Scale Model Testing Data

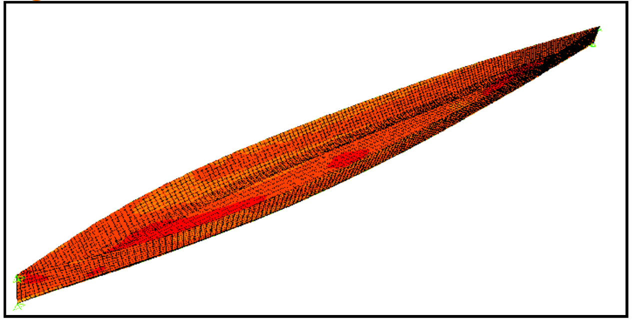
	Straight Line Test (L = 30')			Rotational Test (Constant = 10 Revs)		
Test	Average Trial Time (s)	Average Trial Speed (ft/s)	Percent Difference	Average Trial Time (s)	Average Trial Speed (rev/s)	Percent Difference
Bow 1	7.77	3.86	-	106	0.094	-
Bow 2	7.97	3.76	-2.57	93	0.108	12.3

ANALYSIS

Objectives:

- *Use traditional methods to determine the required concrete strength*
- *Use new software to refine UF's model to produce efficient yet accurate results*
- *Verify the model's accuracy by plotting non-smoothed versions of the model*

Figure 2: FEA Results for Two-Paddler Load Case



Methods of Analysis: **GATOR RAIDER**'s structural analysis and design were performed using finite element analysis (FEA). The **GATOR RAIDER** team began by importing the AutoCAD model of the canoe into SAP2000 v. 11.0.4 (CSI 2007). The model included all design changes implemented in the 2008 hull design, including the reduction in bow deadwood. The paddlers were assumed to weigh 175 pounds each, and the resulting buoyant force was calculated and applied using Archimedes' Principle (Cengel and Turner 2001). SAP2000 created a pin-supported model, which was iteratively evaluated to balance the total forces on the canoe. The FEA model was then generated using four nodes, six degrees of freedom, and layered shell elements. This allowed the carbon fiber reinforcement and concrete to be analyzed as separate entities. The flat shell elements can be used to model structures where both bending and stretching effects need to be considered, producing more accurate results (Hoit 1995). Loading consisted of a uniformly distributed buoyant force under the canoe and a step-wise linearly varying distributed hydrostatic force increasing with water depth down the sides of the canoe. Results were computed at the 2x2 Gauss integration points and interpolated over the remaining area. The stiffness matrix was analyzed using a four point integration scheme to achieve full integration of the stiffness integrand. Since the shape functions for a quadrilateral element produce a first order strain-displacement matrix, the integrand can be fully integrated using 2x2 Gauss integration or a four point integration scheme. In order to minimize errors due to element distortion, the elements were discretized in a manner to produce approximately rectangular shapes. Finally, the accuracy of the model was verified by plotting the results from non-smoothed versions of the model to confirm there were no large jumps in output data.

Parameters: The FEA model consisted of 6792 7/16-inch thick layered shell elements, as shown in Figure 2. The concrete was defined as a lightweight concrete with a compressive strength of 2970 psi. The carbon fiber reinforcement was modeled as an orthotropic material with a tensile modulus of 3340 ksi in its local x and y (in plane) directions.

Results: Two paddlers formed the critical load case. Considering combined bending and membrane forces, the maximum principal stress was determined to be 398 psi, located under the paddlers on the outer surface of the canoe. Composite test panels were constructed using the designed concrete mixture and carbon fiber reinforcement. A simple flexural test was performed to validate **GATOR RAIDER**'s final factor of safety. With a flexural strength of 1490 psi at 28 days, the canoe's actual factor of safety is 3.74. Due to exceeding the desired factor of safety of 3.0, **GATOR RAIDER** does not require structural elements such as bulkheads or thwarts.

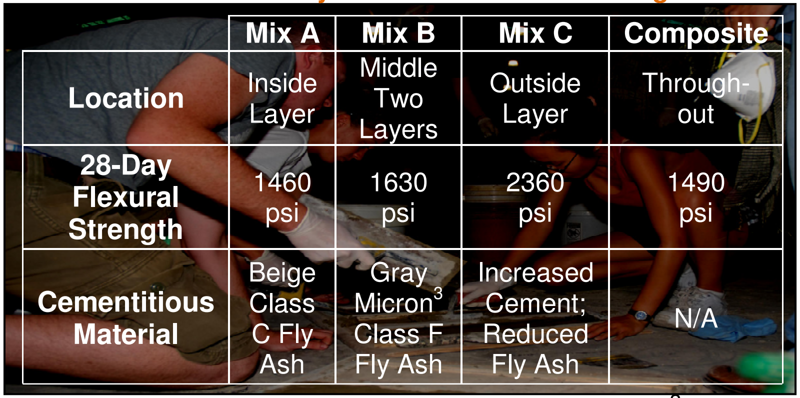
DEVELOPMENT & TESTING

Objectives:
- *Test a greater number of concrete mixtures to optimize concrete properties*
- *Introduce new polypropylene fibers to reduce micro cracking*
- *Implement traditional testing procedures to verify material properties*

Cementitious Material Design: Knowledge of the chemical hydration of Portland cement and the effects of mineral admixtures is essential to accurately analyze the cementitious behavior of the concrete mix. Briefly, dicalcium silicate (C_2S) and tricalcium silicate (C_3S) react with water to form calcium silicate hydrate (C-S-H) and calcium hydroxide (CH). C-S-H gives concrete strength and durability, C_3S provides early strength, and C_2S provides strength increase beyond seven days. CH, however, is a water-soluble by-product that can leach out and create a porous concrete, which drastically reduces durability. The use of pozzolanic materials, such as fly ash, alleviates the negative effects of CH. The silicon dioxide (S) in pozzolans reacts with CH from cement hydration to form more C-S-H (Darwin et al. 2003).

Armed with an understanding of pozzolanic materials, the **GATOR RAIDER** team incorporated Headwaters' Class C fly ash into *Mix A*. With the final product's color scheme in mind, this beige fly ash was chosen for aesthetic reasons. Class C fly ash provides a higher early strength when compared to typical Class F fly ash, which is desirable for concrete located on the inside of the canoe. Past research by the Florida team revealed that Boral's Micron^3 fly ash, which satisfies the ASTM C618 standard for Class F fly ash, is more reactive than Class C fly ash due to its small particle size and increased surface area. In addition, Micron^3 fly ash eliminates more CH through a secondary reaction with alumina, present in the Z-Light Ceramic Microsphere aggregate, to create C-S-H. As a result, the **GATOR RAIDER** concrete mix utilizes Micron^3 fly ash throughout the remaining layers of the canoe in *Mix B* and *Mix C.*

Table 3: Summary of Concrete Mixture Designs



	Mix A	Mix B	Mix C	Composite
Location	Inside Layer	Middle Two Layers	Outside Layer	Through-out
28-Day Flexural Strength	1460 psi	1630 psi	2360 psi	1490 psi
Cementitious Material	Beige Class C Fly Ash	Gray Micron^3 Class F Fly Ash	Increased Cement; Reduced Fly Ash	N/A

Concrete Mixture: After determining the ratio of cementitious materials, the mix design team began selecting the water content, the water-to-cement ratio, and the cementitious materials content using the volumetric mix design method. In small test batches, combinations were selected and evaluated based on unit weight, workability, and flexural strength. The Florida team designed and tested thirty concrete mixtures, double the number of designs used by 2007's *Gladigator* team. This was done to ensure the concrete reached an exceptional balance of strength, durability, and unit weight. Keeping Headwaters' Class C fly ash constant throughout the testing and design process, *Mix A* was finalized. Based on test results, **GATOR RAIDER** was designed with a water content of 300 lb/cy and a water-to-cement ratio of 0.40. Holding other components constant, the UF team substituted Micron^3 fly ash into *Mix B* in order to quickly obtain a higher ultimate strength throughout the outside layers of the canoe. Due to material shortages on pour day, engineering judgment was used to design *Mix C*, which increased cement and fine aggregates as a substitute for reduced amounts of fly ash.

Aggregate Selection: The **GATOR RAIDER** team began the aggregate selection process by investigating alternative lightweight aggregates. Filling the finer gradations with K1 glass bubbles and ceramic microspheres, the team considered potential replacements for the extremely porous and absorbent expanded perlite used in 2007. After acquiring samples of several alternatives and evaluating their viability based on material properties, the team selected the less absorbent Poraver and Pliolite aggregates. Poraver provides the concrete with its light weight, while Pliolite bolsters the mix's strength. Using ASTM C33 (Standard Specification for Concrete Aggregate), the Florida team performed sieve analyses on Poraver, Pliolite, K1 glass bubbles, and ceramic microspheres. All of these aggregates fulfill a portion of the gradation requirement set forth by the fine aggregate section of ASTM C33.

Reinforcement: UF concrete canoe teams have had great success using Kevlar-impregnated carbon fiber weave for reinforcement. *Gladigator*'s performance in 2007 demonstrated that four layers of concrete and three layers of carbon fiber were sufficient to reach the target factor of safety of 3.0. Due to minute construction variances, fluctuations in load distribution, and microscopic crack formation, the middle layer of carbon fiber did not rest directly on the neutral axis. As a result, this layer of carbon fiber provided some additional flexural strength. Thus, **GATOR RAIDER** features three layers of carbon fiber reinforcement with a percent open area of 49.2%.

Fibers: After observing excessive micro cracking in 2007's *Gladigator*, the **GATOR RAIDER** team researched the use of either polyvinyl alcohol or polypropylene fibers in the 2008 mixture. Propex Fibermesh 150 polypropylene fibers, shown in Figure 3, were chosen for their low density and were included in all mixes.

Figure 3:
Polypropylene Fibers

Admixtures: The manufacturer recommends the use of 3 to 5 fl oz/cwt of ADVA 120 superplasticizer. The UF team determined through testing that 1.95 fl oz/cwt produced the desired workability for *Mixes A* and *B*. *Mix C* did not require superplasticizer. All **GATOR RAIDER** mix designs were within the manufacturer's recommended dosage range of DAREX AEA air entraining admixture (½ to 3 fl oz/cwt of cement). The concrete mixtures required 1.0 fl oz/cwt to meet air content restrictions.

Testing: Flexural beam tests in accordance with ASTM C78 were utilized to determine the strength of all concrete mixtures. However, this standard was used only as a guide, as the 7/16-inch thick test panels were too thin to fully conform to ASTM C78. The 28-day flexural strengths, reported in Table 3, confirm the superior properties of Micron^3 fly ash and indicate that three layers of carbon fiber reinforcement are adequate, when compared to the results of the finite element analysis, to exceed the desired factor of safety of 3.0. Additionally, compressive tests conforming to ASTM C39 were performed on 4-inch by 8-inch concrete cylinders. The average 28-day compressive strengths of *Mixes A*, *B*, and *C* were 3010, 3250, and 2790 psi, respectively. Finally, unit weight tests were utilized to determine if cured concrete specimens were buoyant. Although buoyant mixes were achieved, the team opted to reduce micro cracking by incorporating polypropylene fibers, resulting in final unit weights of 65.2, 63.4, and 65.3 pcf, respectively.

PROJECT MANAGEMENT & CONSTRUCTION

Objectives:
- *Refine project management to meet all critical path milestones*
- *Utilize new construction techniques to create the finest hull in UF's history*
- *Implement enhanced quality control to ensure superior construction*

Project Management: After the University of Florida's outstanding national finish in 2007, the revitalized team leadership immediately set a course of action for 2008. Knowing that project planning was a vital part of a venture of this magnitude, the experienced group proposed a planning process to account for cost, time, quality control, and risk management. The **GATOR RAIDER** team reviewed lessons learned from previous years and developed an overall operation plan, tentative goals and deadlines, a project budget, and desired outcomes before the 2008 rules were released. Additionally, a log of person-hours was kept throughout the duration of the project, allowing for an accurate account of the time spent on each phase. As Figure 4 shows, over 4000 person-hours were distributed among administration, hull design, mix design, construction, academics, and athletics.

Figure 4: Project Person-Hours

Admin.	100
Hull Design	125
Mix Design	400
Construction	1800
Academics	200
Athletics	1400
Total	**4025**

Organization Structure: A senior project manager was selected among the returning *Gladigator* team members based on dedication, knowledge, and previous performance. The project manager oversaw team communication and coordination, project finances, and the overall project schedule. Additionally, the **GATOR RAIDER** team leader appointed and supervised five project engineers. Due to rule changes specifying the increased importance of product display, the Florida team introduced a new project engineer dedicated to coordinating the project's theme and visual aesthetics. Primary goals for the project management team included distributing workload equitably among the team members and minimizing preventable errors through proper planning and quality control. Duties for the project engineers and the overall team organization can be seen on the flow chart on page7.

Finances: The University of Florida Concrete Canoe team, receiving no direct financial assistance from the UF Civil & Coastal Engineering Department, immediately set out to raise funds through corporate contacts, former employers, and UF Concrete Canoe alumni. A project budget was developed early in the process. Financial transactions, material procurement, and adherence to the budget were monitored by the senior project manager and the UF ASCE Chapter's faculty advisor to ensure integrity and appropriateness of all decisions.

Project Schedule: **GATOR RAIDER**'s major milestone activities, as illustrated on the Gantt chart on page 8, fall on the critical path and are identified as those activities whose completion is necessary for the project to advance without adding time to the schedule. Those activities include small scale model testing and CAD model development, final hull design and construction, and pouring, curing, and finishing the canoe. Milestone activities not falling on the critical path include mix design and testing, completing the design paper, preparing and practicing the oral presentation, selecting the paddling team, and constructing the competition display. There were no significant deviations from the planned completion dates of critical path milestones. Successful establishment and achievement of deadlines were accomplished through the experience and dedication of veteran team members combined with hard work, good planning, and attention to detail. Regular, informal progress meetings ensured that the project moved forward smoothly.

Form Construction: The form for **GATOR RAIDER** was completely redesigned in an effort to improve upon 2007's innovative form lift mechanism. Plywood cross-sections were attached to a sturdy wooden beam to drastically reduce flexure when removing the form. This skeleton was coated with water sealer to prevent warping during moist curing. Two layers of ¼-inch plywood strips were nailed to the cross-sections in lieu of the traditional single layer to create a more rigid shell. This shell was then covered with plastic body filler and meticulously sanded to produce clean lines and curves. The practice of shrink-wrapping the mold was abandoned in favor of painting the mold with gel coat to create a smooth, durable finish. A wooden model of the stern was carved and coated with plastic body filler to produce a rigid, detachable section that would allow for removal of the form despite the reverse stern angle. Keeping with long-standing UF tradition, an extensive array of intricate inlaid graphics cut from commercial sandblasting mask was applied to the mold. Gunwale forms featuring a detailed vertical profile were attached directly to the movable mold rather than to the table to create a seamless finish. The improved form lift system turned the often arduous process of removing the finished canoe from the form into a relatively simple task. The form and canoe were raised off the table, and the gunwale forms were removed. Blocks were positioned under the gunwales, and mechanical jacks were used to slowly pull the form downward to separate it from the canoe.

Canoe Construction: Prior to the placement of concrete, the form and inlaid graphics were treated with a coat of form release wax to ensure a clean separation of the form from the canoe after curing. Concrete mix ingredients were pre-batched to aid in the quality control of concrete production. Four layers of concrete were applied using a pneumatic shotcrete system consisting of a modified drywall texture gun and a forced-feed hopper constructed from PVC pipe. This system allowed for the application of extremely thin and uniform layers of concrete, thus reducing the overall hull thickness and preserving the clean lines and curves of the form throughout construction. Each concrete layer was hand-trowelled before the placement of Kevlar-reinforced carbon fiber mesh to provide additional quality control. The reinforcement layers were smoothed into the wet concrete using plastic trowels to ensure proper bonding while preventing the creation of high- and low-spots that frequently results from hand-smoothing. The carbon fiber mesh was trimmed to terminate in the gunwales, and the process was repeated for a total of four layers of concrete and three layers of reinforcement. Pour day quality control was achieved by permanent task assignments, constant monitoring of the performance of the shotcrete system, meticulous visual inspection of the hull's contours, and extensive preparation. The canoe was placed in a curing tent for 28 days under heat lamps and a sprinkler system that provided the warm, moist environment necessary to maximize strength through complete hydration of the concrete. During the curing process, **GATOR RAIDER**'s exterior was wet-sanded to eliminate any imperfections and to produce the desired finish. At the end of the curing period, the form was removed and stain was applied to the interior and exterior of the canoe. **GATOR RAIDER** was placed in a wind tunnel fashioned from plastic sheeting for an additional two weeks to allow the canoe to dry as much as possible before the application of sealer took place in accordance with the manufacturer's recommendations. Safety was ensured throughout the project by providing respirators, gloves, goggles, and appropriate training during all phases of construction.

ORGANIZATION CHART

CONSULTANTS

Dr. Thomas Sputo
Dr. Robert Thieke
James Gravesen
Anthony Dion

PROJECT MANAGER

Nicole Walker

RESPONSIBILITIES

- Supervise project engineers
- Oversee project's critical path
- Manage finances and budget
- Maintain team communication

HULL DESIGN AND CONSTRUCTION ENGINEER

James Hoffman

RESPONSIBILITIES

- Conduct scale model testing
- Construct form
- Oversee concrete finishing
- Direct display construction

ASSISTANT ENGINEERS

Scott Gutowski
Carl Harrigan
Joshua Jolley
James Knox
Amanda Lavigne

CONCRETE MIXTURE DESIGN ENGINEER

Anna Lai

RESPONSIBILITIES

- Research and test possible mixtures
- Oversee concrete mixing on pour day
- Determine final mixture properties

ASSISTANT ENGINEERS

Melissa Ackert
Sally Deschamps
Kellie Douglas
Chris Egan
Eric Ho
Megan Salvetti

ACADEMIC PRESENTATION ENGINEER

Daniel Cushing

RESPONSIBILITIES

- Author design paper
- Develop and coordinate oral presentation
- Document all project activities

ASSISTANT ENGINEERS

Aaron Elias
Jessica Mackey
Brett Rowan
Zharel Silva

GRAPHICS AND THEME INTEGRATION ENGINEER

Zharel Silva

RESPONSIBILITIES

- Develop project visuals for design paper and oral presentation
- Design inlaid graphics and outer hull color scheme

ASSISTANT ENGINEERS

Daniel Cushing
Mariana Diaz
James Hoffman
James Knox
Jessica Rigdon

PADDLING AND RACE SITE ENGINEER

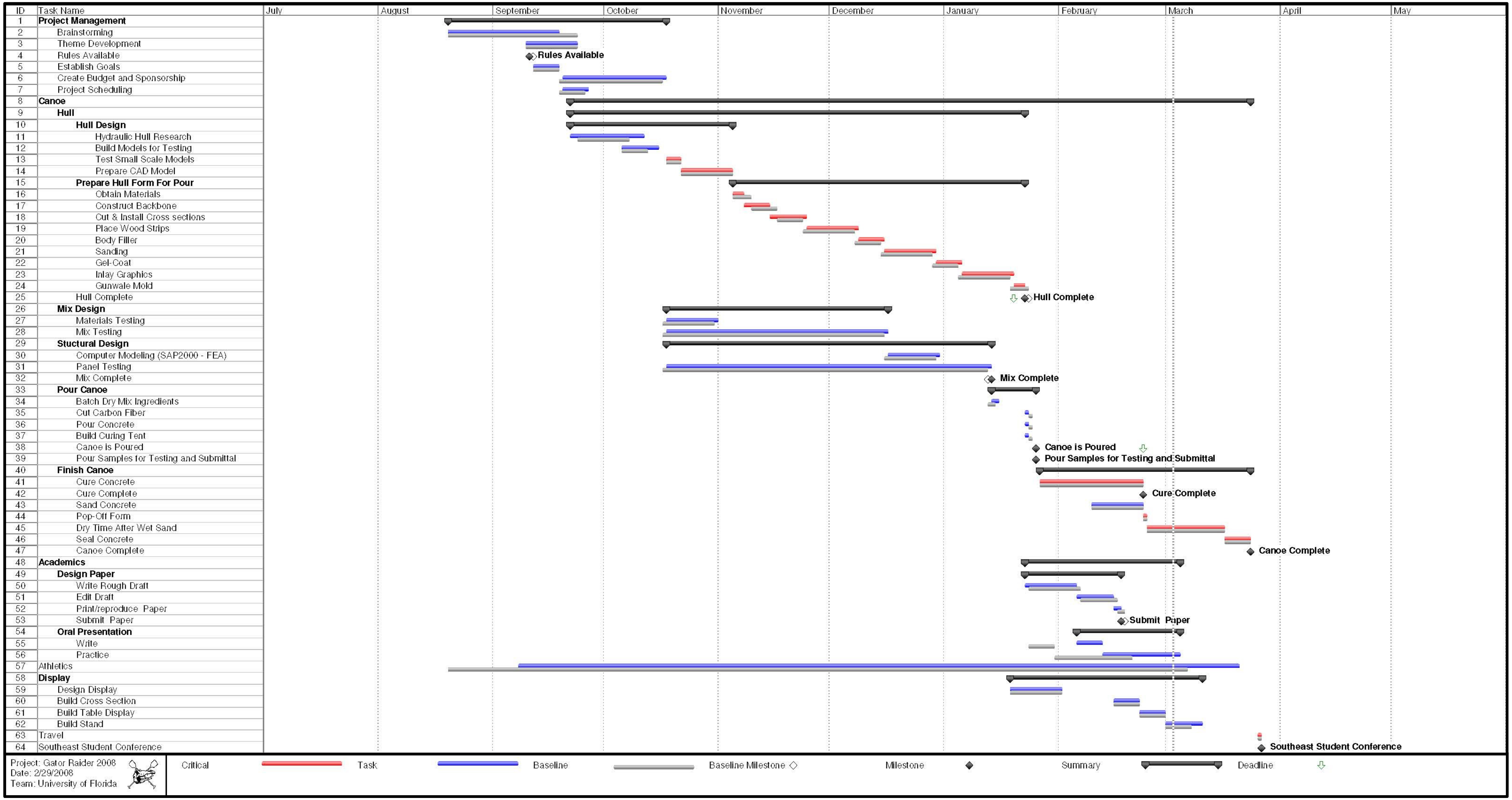
Jessica Mackey

RESPONSIBILITIES

- Demonstrate and teach paddling technique
- Determine final paddling teams
- Lead workout regimens

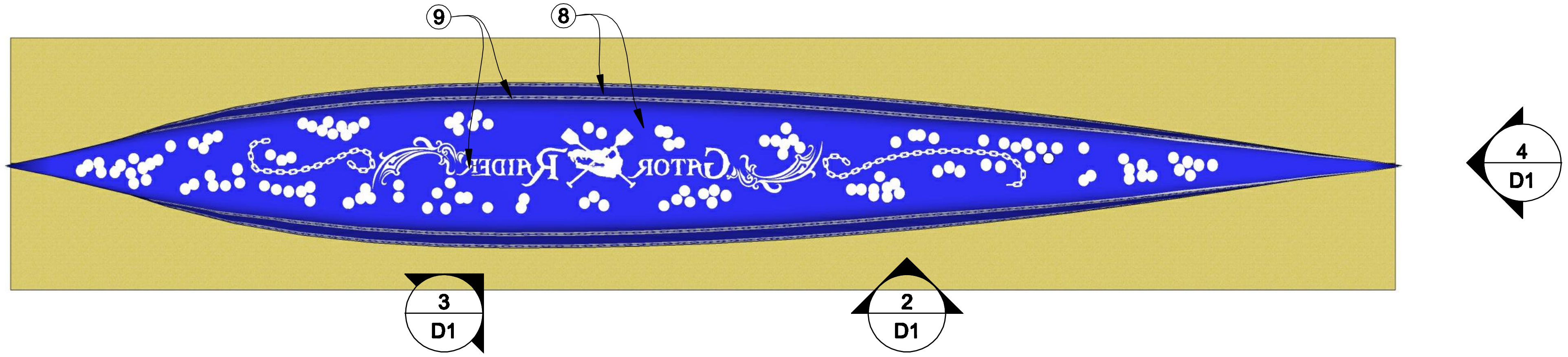
PADDLING TEAM

Chris Egan
James Hoffman
James Knox
Amanda Lavigne
Zharel Silva
Nicole Walker

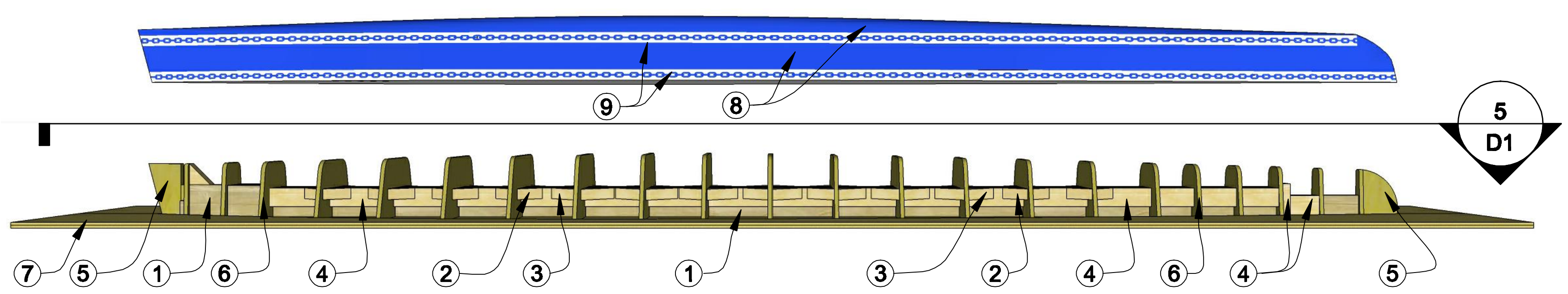


ID	Task Name
1	**Project Management**
2	Brainstorming
3	Theme Development
4	Rules Available
5	Establish Goals
6	Create Budget and Sponsorship
7	Project Scheduling
8	**Canoe**
9	**Hull**
10	**Hull Design**
11	Hydraulic Hull Research
12	Build Models for Testing
13	Test Small Scale Models
14	Prepare CAD Model
15	**Prepare Hull Form For Pour**
16	Obtain Materials
17	Construct Backbone
18	Cut & Install Cross sections
19	Place Wood Strips
20	Body Filler
21	Sanding
22	Gel-Coat
23	Inlay Graphics
24	Gunwale Mold
25	Hull Complete
26	**Mix Design**
27	Materials Testing
28	Mix Testing
29	**Stuctural Design**
30	Computer Modeling (SAP2000 - FEA)
31	Panel Testing
32	Mix Complete
33	**Pour Canoe**
34	Batch Dry Mix Ingredients
35	Cut Carbon Fiber
36	Pour Concrete
37	Build Curing Tent
38	Canoe is Poured
39	Pour Samples for Testing and Submittal
40	**Finish Canoe**
41	Cure Concrete
42	Cure Complete
43	Sand Concrete
44	Pop-Off Form
45	Dry Time After Wet Sand
46	Seal Concrete
47	Canoe Complete
48	**Academics**
49	**Design Paper**
50	Write Rough Draft
51	Edit Draft
52	Print/reproduce Paper
53	Submit Paper
54	**Oral Presentation**
55	Write
56	Practice
57	Athletics
58	**Display**
59	Design Display
60	Build Cross Section
61	Build Table Display
62	Build Stand
63	Travel
64	Southeast Student Conference

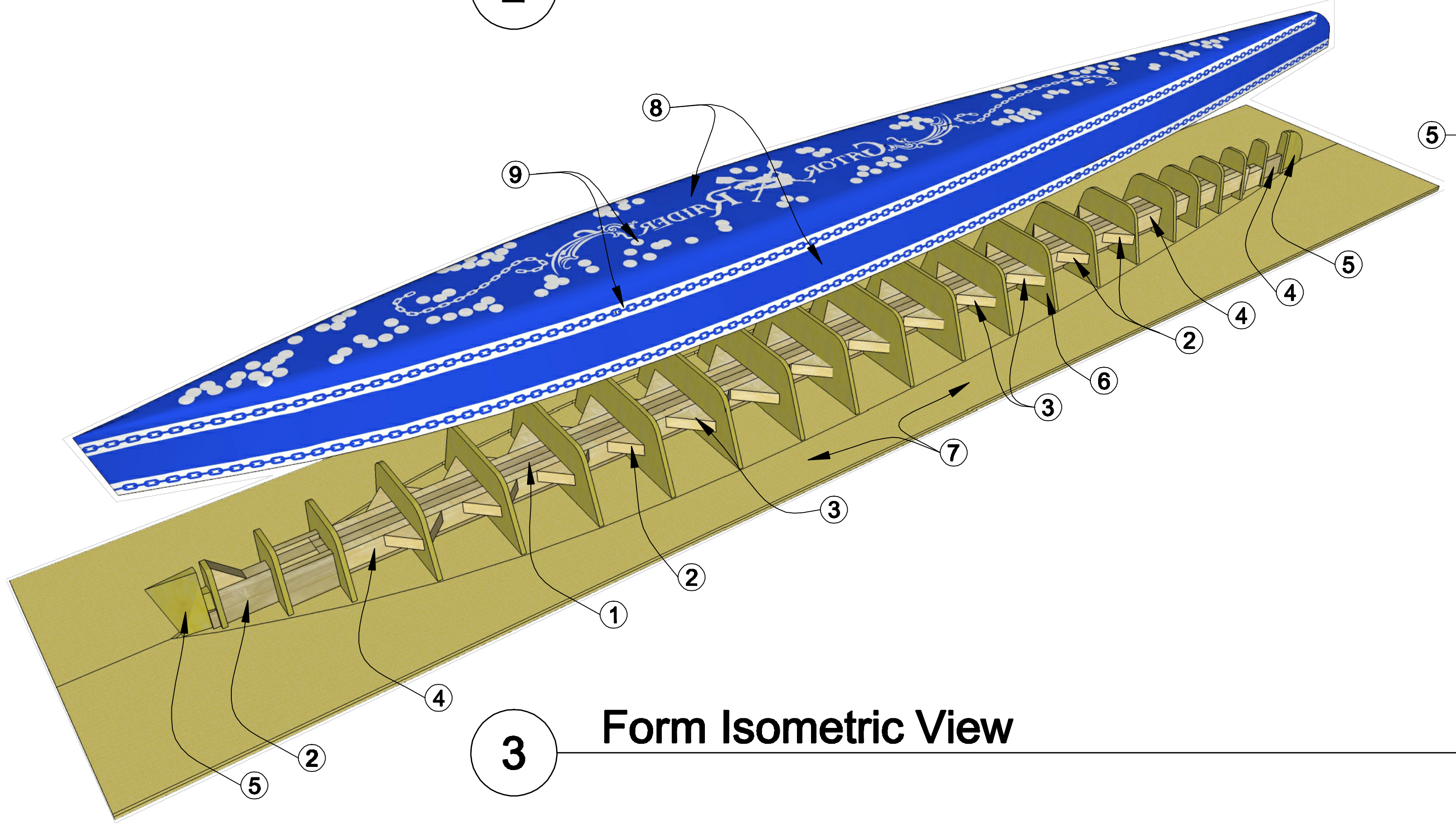
Project: Gator Raider 2008
Date: 2/29/2008
Team: University of Florida



1 Form Plan



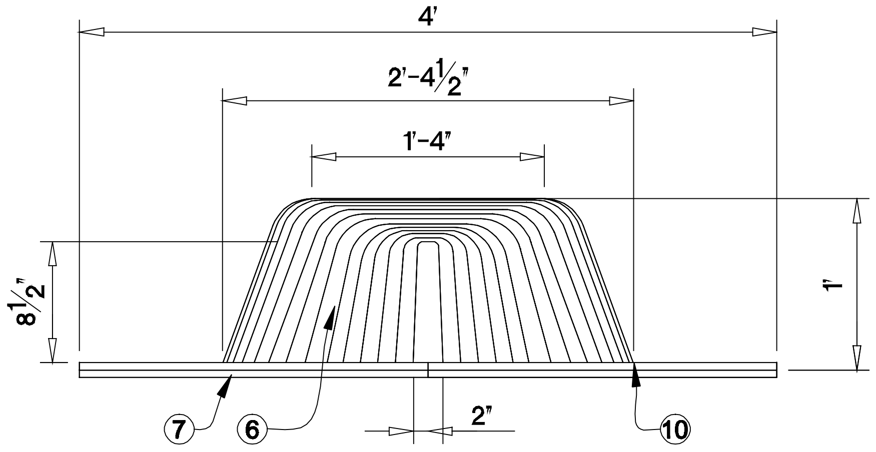
2 Form Elevation



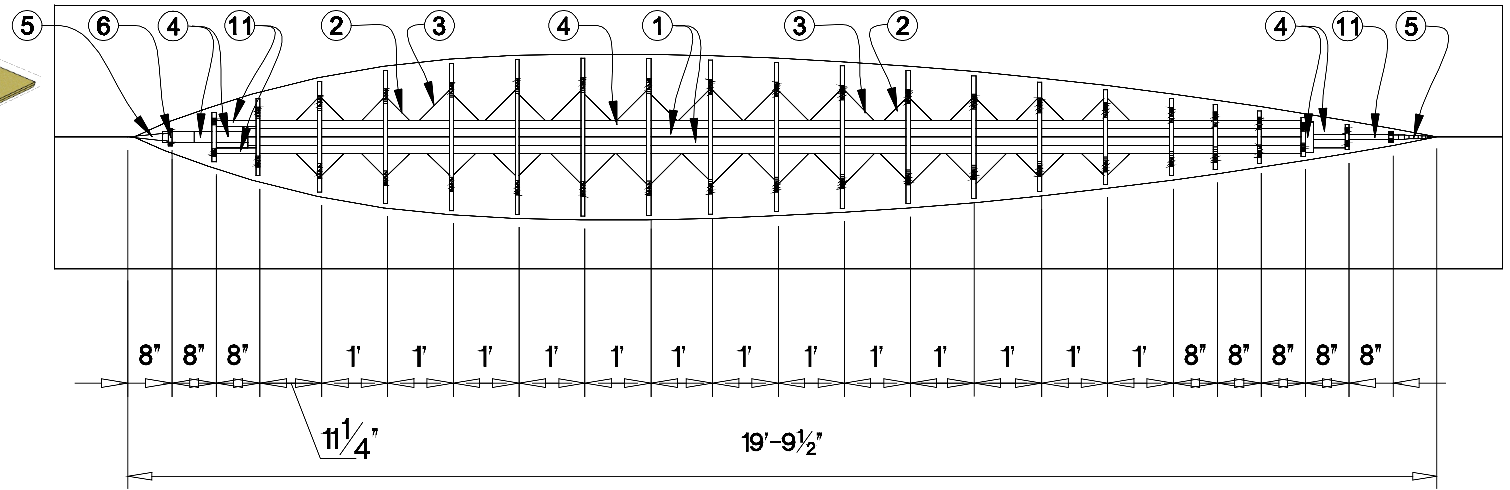
3 Form Isometric View

University of Florida
American Society of Civil Engineers
Concrete Canoe Team

Item	Qty.	Component	Description
1	2	Spine	2"x6"x16' pressure treated wood
2	24	Bracing	2"x4" white pine
3	28	Bracing	2"x6" white pine
4	26	Spacer	2"x4" white pine
5	2	Bow/Stem	2"x12" curved white pine
6	22	Cross Section	¾" plywood
7	1	Shelf	½" plywood
8	1	Covering	¼" plywood, Bondo, & gel coat
9	141	Inlays	Decorative sand-blasting masks
10	1	Gunwale Form	1" moulding
11	3	Spacer	1"x4" white pine



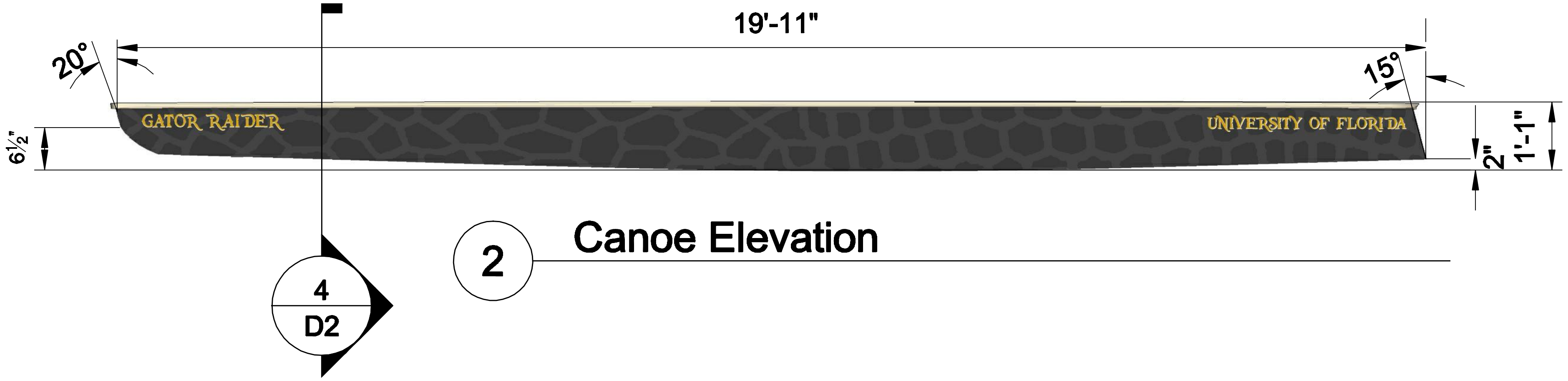
4 Cross-Section Elevation



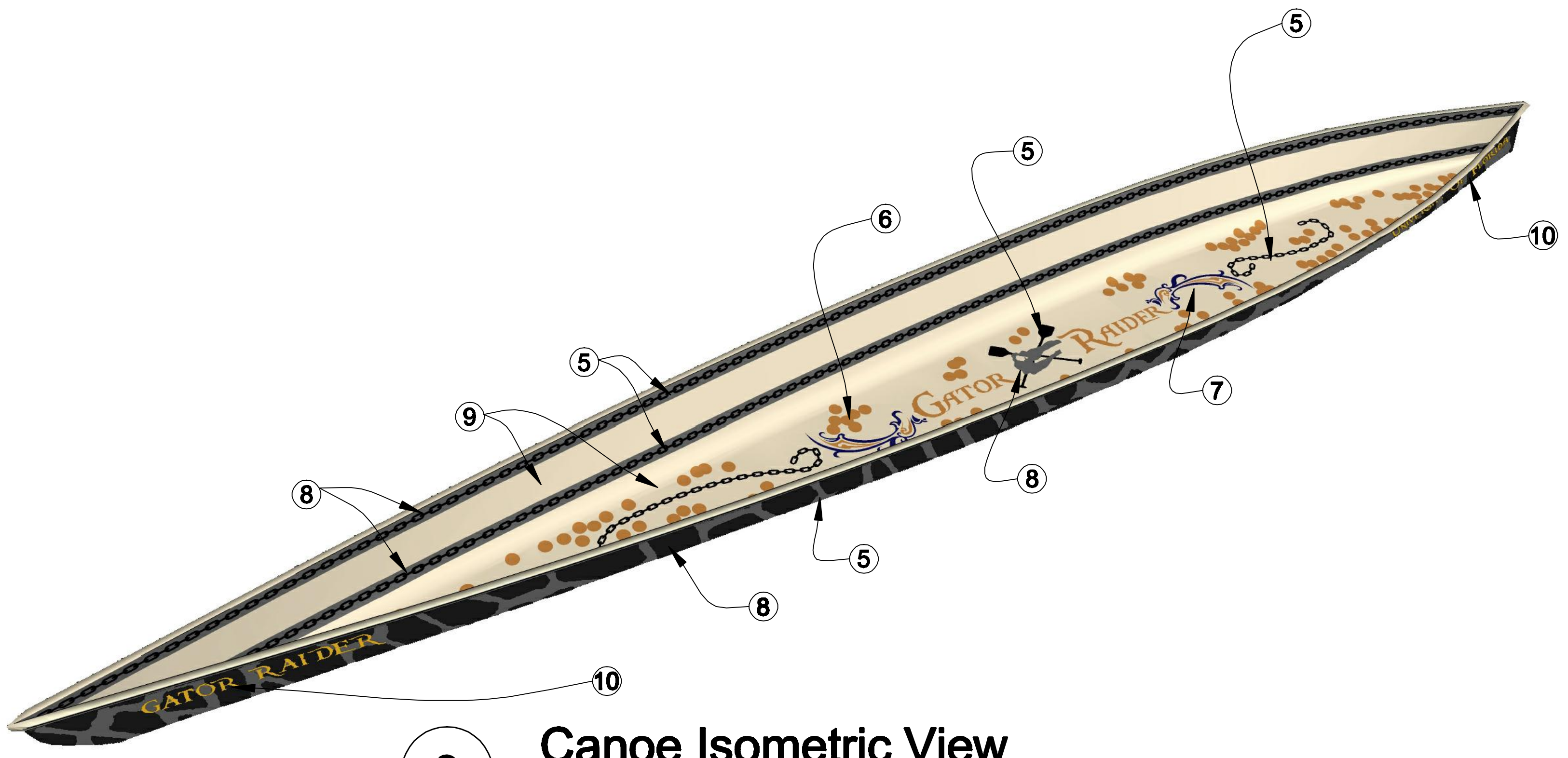
5 Cross-Section Layout Plan

Drawing Title:	Gator Raider Form Drawings		
Project Name:	2008 UF Concrete Canoe		
Drawn By:	ZAS	Date:	02-28-08
Scale:	NTS	Sheet:	D1

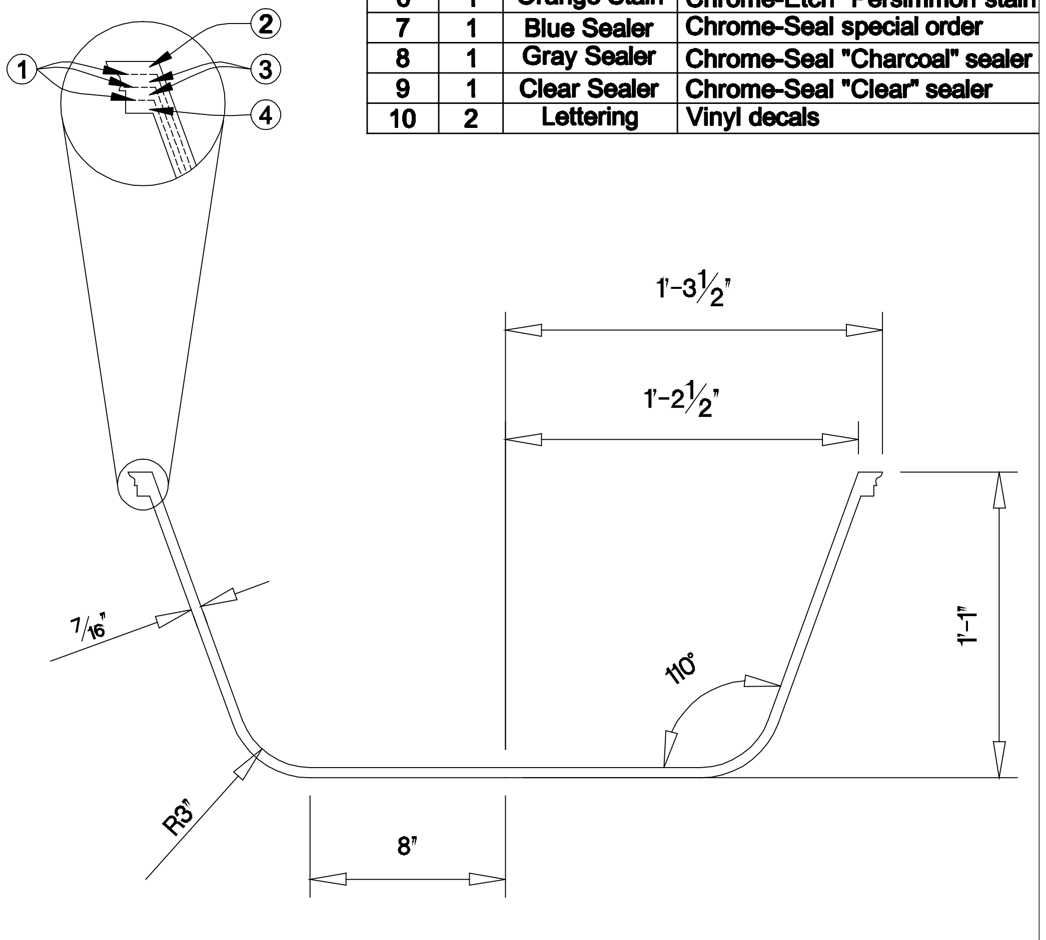
1 Canoe Plan



2 Canoe Elevation



3 Canoe Isometric View



4 Maximum Canoe Section

UNIVERSITY OF FLORIDA
AMERICAN SOCIETY OF CIVIL ENGINEERS
CONCRETE CANOE TEAM

Item	Qty.	Component	Description
1	3	Reinforcement	8570 square inches carbon fiber/kevlar weave
2	1	Concrete	234 cubic inches Gator Raider mix A
3	1	Concrete	467 cubic inches Gator Raider mix B
4	1	Concrete	234 cubic inches Gator Raider mix C
5	1	Black Stain	Chrome-Etch "Kahlua" stain
6	1	Orange Stain	Chrome-Etch "Persimmon"stain
7	1	Blue Sealer	Chrome-Seal special order
8	1	Gray Sealer	Chrome-Seal "Charcoal" sealer
9	1	Clear Sealer	Chrome-Seal "Clear" sealer
10	2	Lettering	Vinyl decals

DRAWING TITLE:	Gator Raider Canoe Drawings		
PROJECT NAME:	2008 UF Concrete Canoe		
DRAWN BY:	ZAS	DATE:	02-28-08
SCALE:	NTS	SHEET:	D2

APPENDIX A – REFERENCES

ASTM C29-03, "Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate," ASTM International.

ASTM C33-03, "Standard Specification for Concrete Aggregates," ASTM International.

ASTM C39-05, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens," ASTM International.

ASTM C78-02, "Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)," ASTM International.

ASTM C128-07, "Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate," ASTM International.

ASTM C138-01, "Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete," ASTM International.

ASTM C618-05, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete," ASTM International.

ASTM C1315-06, "Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete," ASTM International.

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APPENDIX B – MIXTURE PROPORTIONS

Mixture: GATOR RAIDER Mix A

Batch Size (ft^3): 1.00

		SSD Proportions as Designed		Actual Batched Proportions		SSD Yielded Proportions	
Cementitious Materials	Specific* Gravity	Amount (lb/yd^3)	Volume (ft^3)	Amount (lb)	Volume (ft^3)	Amount (lb/yd^3)	Volume (ft^3)
1. ASTM C150 Portland Cement Type I	3.15	450.00	2.29	16.67	0.08	460.81	2.34
2. Class C Fly Ash	2.66	300.00	1.81	11.11	0.07	307.20	1.85
Total of All Cementitious Materials		750.00	4.10	27.78	0.15	768.01	4.20
Fibers							
1. Polypropylene Fibers	0.91	2.14	0.04	0.08	0.00	2.19	0.04
Aggregates							
1. K1 Glass Bubbles Absorption, 19.90% Batched Moisture Content, 0.0%	0.13	23.52	2.51	0.73	0.09	24.08	2.58
2. Ceramic Microspheres Absorption, 8.20% Batched Moisture Content, 0.0%	0.75	148.56	2.93	5.09	0.11	152.13	3.00
3. Pliolite Absorption, 9.00% Batched Moisture Content, 0.0%	0.99	21.38	0.32	0.73	0.01	21.89	0.33
4. Poraver Absorption, 30.10% Batched Moisture Content, 0.0%	0.34	280.70	10.17	7.99	0.38	287.44	10.41
Total of All Aggregates		474.16	15.94	14.53	0.59	485.55	16.32
Water							
Batched Water	1.00	300.00	4.81	28.21	0.45	307.20	4.92
Total Free Water from All Aggregates	1.00			-17.10	-0.27		
Total Water from All Admixtures§	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Water		300.00	4.81	11.11	0.18	307.20	4.92
Admixtures	% Solids	Amount (fl oz/cwt)	Water‡ in Admixture (lb/yd^3)	Amount (fl oz)	Water‡ in Admixture (lb)	Amount (fl oz/cwt)	Water‡ in Admixture (lb/yd^3)
1. Darex AEA Air Entrainer	10.00	1.0		0.3		1.0	
2. Adva 120 Superplasticiser	35.00	1.9	0.53	0.5	0.15	1.9	0.53
Cement-Cementitious Materials Ratio		0.60		0.60		0.60	
Water-Cementitious Materials Ratio		0.40		0.40		0.40	
Flow (flow table), Slump, Slump Flow, in.		5.0		7.0		7.0	
Air Content, %		6.00%		6.00%		6.08%	
Density (Unit Weight), lb/ft^3		56.53		72.30		72.30	
Gravimetric Air Content, %				6.08%			
Yield, ft^3		27		0.98		27	

* For aggregates provide ASTM C 127 saturated, surface-dry bulk specific gravity.

‡ Water content of admixture.

§ If impact on water-cementitious materials ratio is less than 0.01 enter zero.

Mixture: GATOR RAIDER Mix B

Batch Size (ft^3): 1.00

		SSD Proportions as Designed		Actual Batched Proportions		SSD Yielded Proportions	
Cementitious Materials	Specific* Gravity	Amount (lb/yd^3)	Volume (ft^3)	Amount (lb)	Volume (ft^3)	Amount (lb/yd^3)	Volume (ft^3)
1. ASTM C150 Portland Cement Type I	3.15	450.00	2.29	16.67	0.08	449.97	2.29
2. Micron^3 Fly Ash	2.53	300.00	1.90	11.11	0.07	299.98	1.90
Total of All Cementitious Materials		750.00	4.19	27.78	0.16	749.96	4.19
Fibers							
1. Polypropylene Fibers	0.91	2.14	0.04	0.08	0.00	2.14	0.04
Aggregates							
1. K1 Glass Bubbles Absorption, 19.90% Batched Moisture Content, 0.0%	0.13	23.38	2.50	0.72	0.09	23.38	2.50
2. Ceramic Microspheres Absorption, 8.20% Batched Moisture Content, 0.0%	0.75	147.69	2.92	5.06	0.11	147.69	2.92
3. Pliolite Absorption, 9.00% Batched Moisture Content, 0.0%	0.99	21.26	0.32	0.72	0.01	21.25	0.32
4. Poraver Absorption, 30.10% Batched Moisture Content, 0.0%	0.34	279.07	10.11	7.94	0.37	279.05	10.11
Total of All Aggregates		471.39	15.84	14.44	0.59	471.37	15.84
Water							
Batched Water	1.00	300.00	4.81	28.16	0.45	299.98	4.81
Total Free Water from All Aggregates	1.00			-17.05	-0.27		
Total Water from All Admixtures§	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Water		300.00	4.81	11.11	0.18	299.98	4.81
Admixtures	% Solids	Amount (fl oz/cwt)	Water‡ in Admixture (lb/yd^3)	Amount (fl oz)	Water‡ in Admixture (lb)	Amount (fl oz/cwt)	Water‡ in Admixture (lb/yd^3)
1. Darex AEA Air Entrainer	10.00	1.0		0.3		1.0	
2. Adva 120 Superplasticiser	35.00	1.9	0.53	0.5	0.15	1.9	0.53
Cement-Cementitious Materials Ratio		0.60		0.60		0.60	
Water-Cementitious Materials Ratio		0.40		0.40		0.40	
Flow (flow table), Slump, Slump Flow, in.		5.0		6.5		6.5	
Air Content, %		6.00%		6.00%		6.07%	
Density (Unit Weight), lb/ft^3		56.43		70.46		70.46	
Gravimetric Air Content, %				6.07%			
Yield, ft^3		27		1.00		27	

* For aggregates provide ASTM C 127 saturated, surface-dry bulk specific gravity.

‡ Water content of admixture.

§ If impact on water-cementitious materials ratio is less than 0.01 enter zero.

Mixture: GATOR RAIDER Mix C

Batch Size (ft^3): 1.00

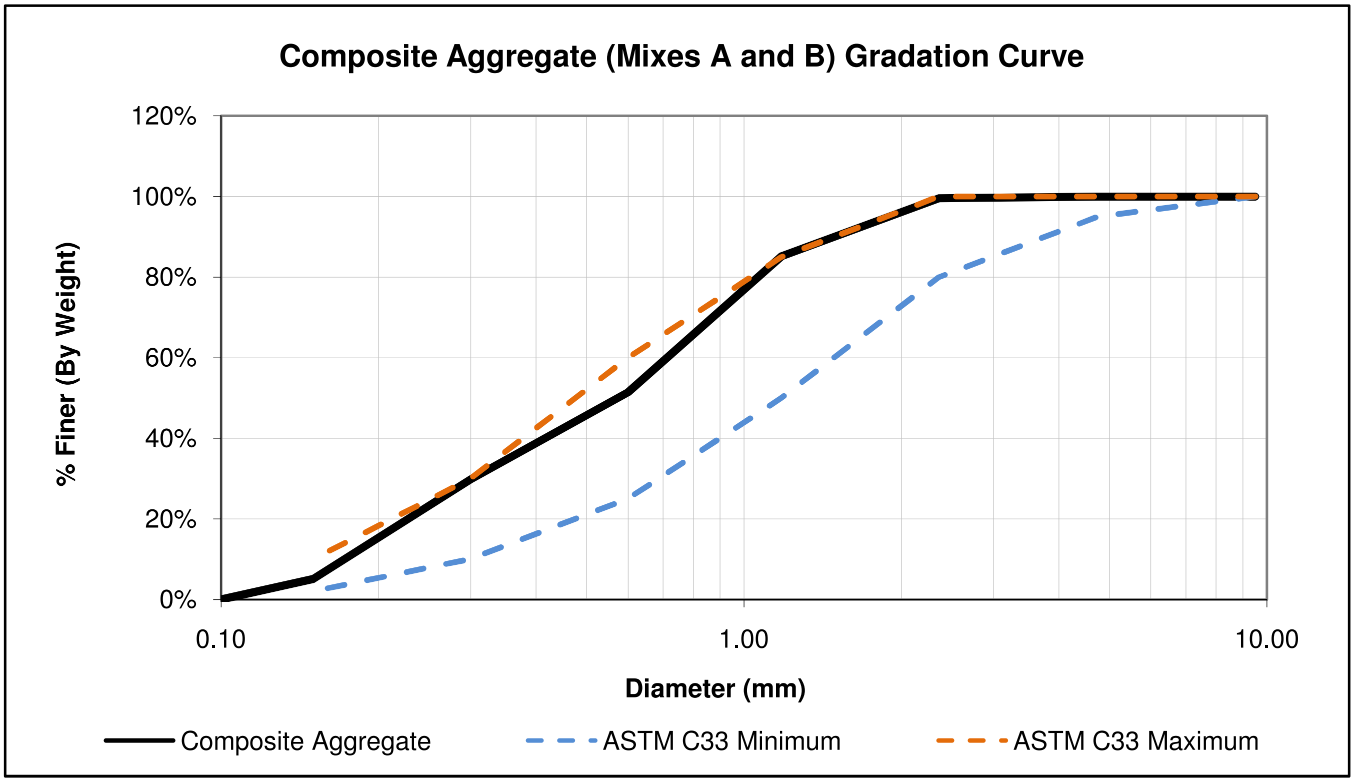
		SSD Proportions as Designed		Actual Batched Proportions		SSD Yielded Proportions	
Cementitious Materials	Specific* Gravity	Amount (lb/yd^3)	Volume (ft^3)	Amount (lb)	Volume (ft^3)	Amount (lb/yd^3)	Volume (ft^3)
1. ASTM C150 Portland Cement Type I	3.15	522.95	2.66	19.37	0.10	534.01	2.72
2. Micron^3 Fly Ash	2.53	264.72	1.68	9.80	0.06	270.32	1.71
Total of All Cementitious Materials		787.67	4.34	29.17	0.16	804.33	4.43
Fibers							
1. Polypropylene Fibers	0.91	2.14	0.04	0.08	0.00	2.19	0.04
Aggregates							
1. K1 Glass Bubbles Absorption, 19.90% Batched Moisture Content, 0.0%	0.13	20.70	2.21	0.64	0.08	21.14	2.26
2. Ceramic Microspheres Absorption, 8.20% Batched Moisture Content, 0.0%	0.75	157.15	3.10	5.38	0.11	160.47	3.17
3. Pliolite Absorption, 9.00% Batched Moisture Content, 0.0%	0.99	18.82	0.28	0.64	0.01	19.22	0.29
4. Poraver Absorption, 30.10% Batched Moisture Content, 0.0%	0.34	294.36	10.66	8.38	0.39	300.58	10.89
Total of All Aggregates		491.02	16.26	15.04	0.60	501.41	16.60
Water							
Batched Water	1.00	264.72	4.24	27.14	0.43	270.32	4.33
Total Free Water from All Aggregates	1.00			-17.33	-0.28		
Total Water from All Admixtures§	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Water		264.72	4.24	9.80	0.16	270.32	4.33
Admixtures	% Solids	Amount (fl oz/cwt)	Water‡ in Admixture (lb/yd^3)	Amount (fl oz)	Water‡ in Admixture (lb)	Amount (fl oz/cwt)	Water‡ in Admixture (lb/yd^3)
1. Darex AEA Air Entrainer	10.00	1.0		0.3		1.0	
2. Adva 120 Superplasticiser	35.00	0.0	0.00	0.0	0.00	0.0	0.00
Cement-Cementitious Materials Ratio		0.66		0.66		0.66	
Water-Cementitious Materials Ratio		0.34		0.34		0.34	
Flow (flow table), Slump, Slump Flow, in.		5.0		7.5		7.5	
Air Content, %		6.00%		6.00%		6.09%	
Density (Unit Weight), lb/ft^3		57.24		72.94		72.94	
Gravimetric Air Content, %				6.09%			
Yield, ft^3		27		0.98		27	

* For aggregates provide ASTM C 127 saturated, surface-dry bulk specific gravity.

‡ Water content of admixture.

§ If impact on water-cementitious materials ratio is less than 0.01 enter zero.

APPENDIX C – GRADATION CURVES AND TABLES

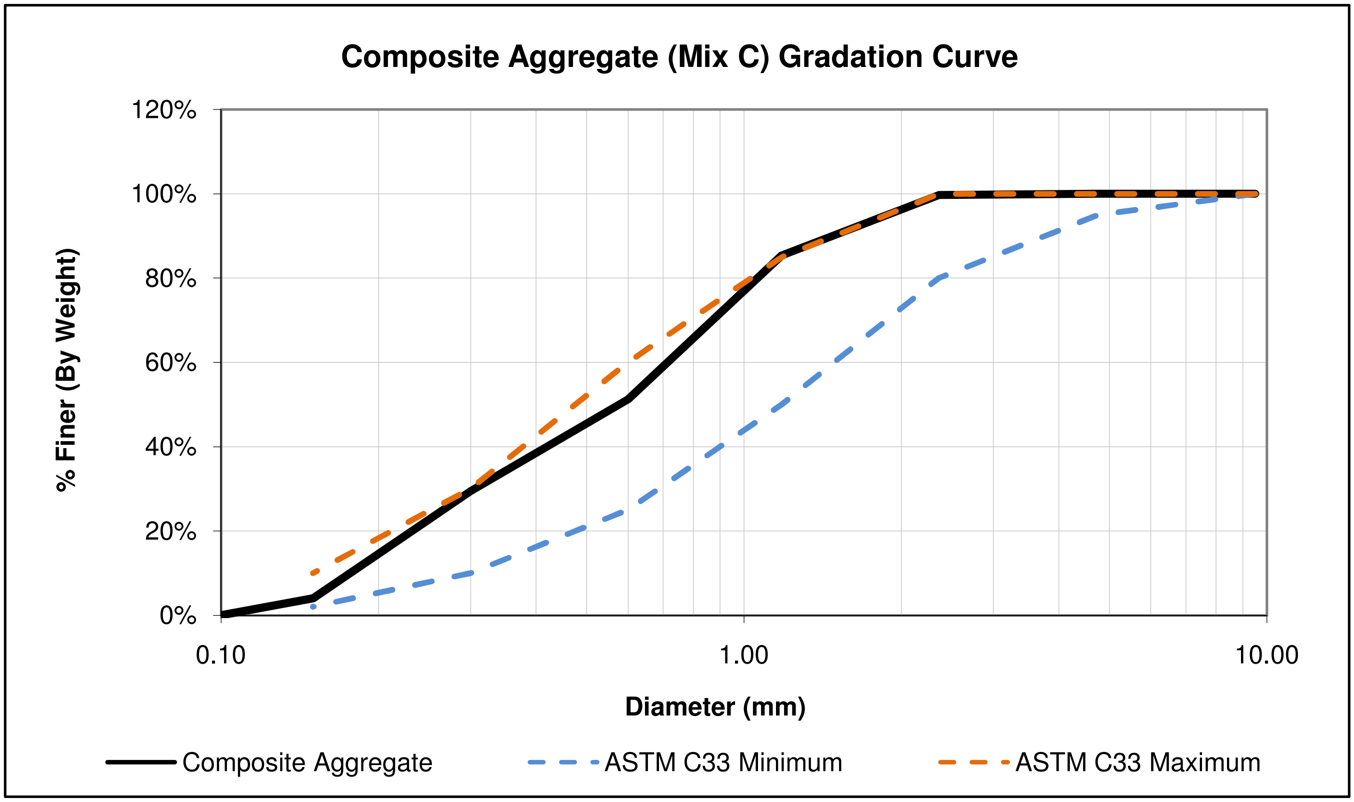


Concrete Aggregate: GATOR RAIDER Composite Aggregate (Mixes A and B)

Sample Weight: 1000 grams

Blending Ratio: 55 : 35 : 5 : 5
Poraver : Ceramic Microspheres : Pliolite : K1 Glass Bubbles

Sieve	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0	0	100%
No. 4	4.75	0	0	100%
No. 8	2.36	4	4	100%
No. 16	1.18	144	148	85%
No. 30	0.60	338	486	51%
No. 50	0.30	216	702	30%
No. 100	0.15	247	949	5%
Pan	0.00	51	1000	0%

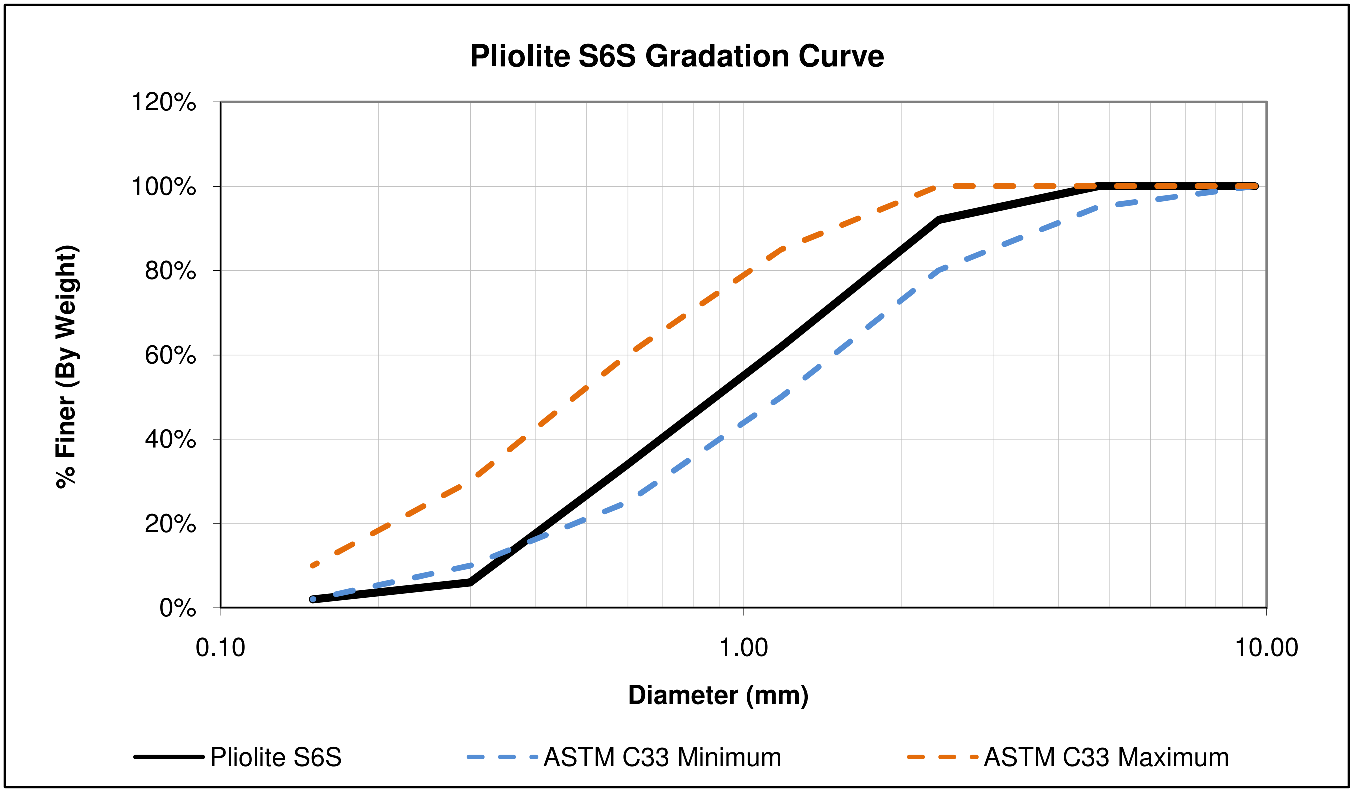


Concrete Aggregate: **GATOR RAIDER** Composite Aggregate (Mix C)

Sample Weight: 1000 grams

Blending Ratio: 56 : 36 : 4 : 4
Poraver : Ceramic Microspheres : Pliolite : K1 Glass Bubbles

Sieve	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0	0	100%
No. 4	4.75	0	0	100%
No. 8	2.36	3	3	100%
No. 16	1.18	143	146	85%
No. 30	0.60	342	488	51%
No. 50	0.30	218	706	29%
No. 100	0.15	254	960	4%
Pan	0.00	40	1000	0%

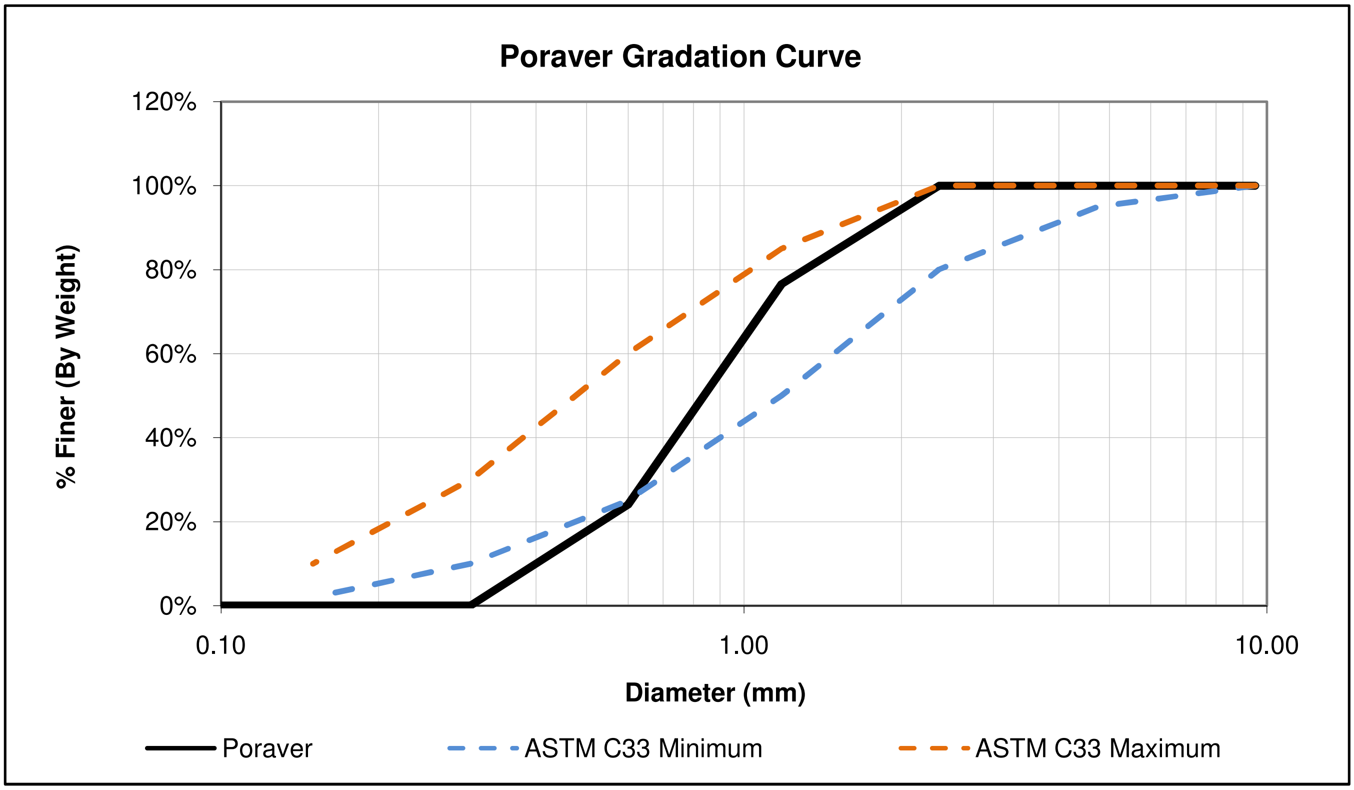


Concrete Aggregate: Pliolite S6S

Sample Weight: 500 grams

Specific Gravity (G_s): 0.99

Sieve	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0	0	100%
No. 4	4.75	0	0	100%
No. 8	2.36	40	40	92%
No. 16	1.18	150	190	62%
No. 30	0.60	140	330	34%
No. 50	0.30	140	470	6%
No. 100	0.15	20	490	2%
Pan	0.00	10	500	0%

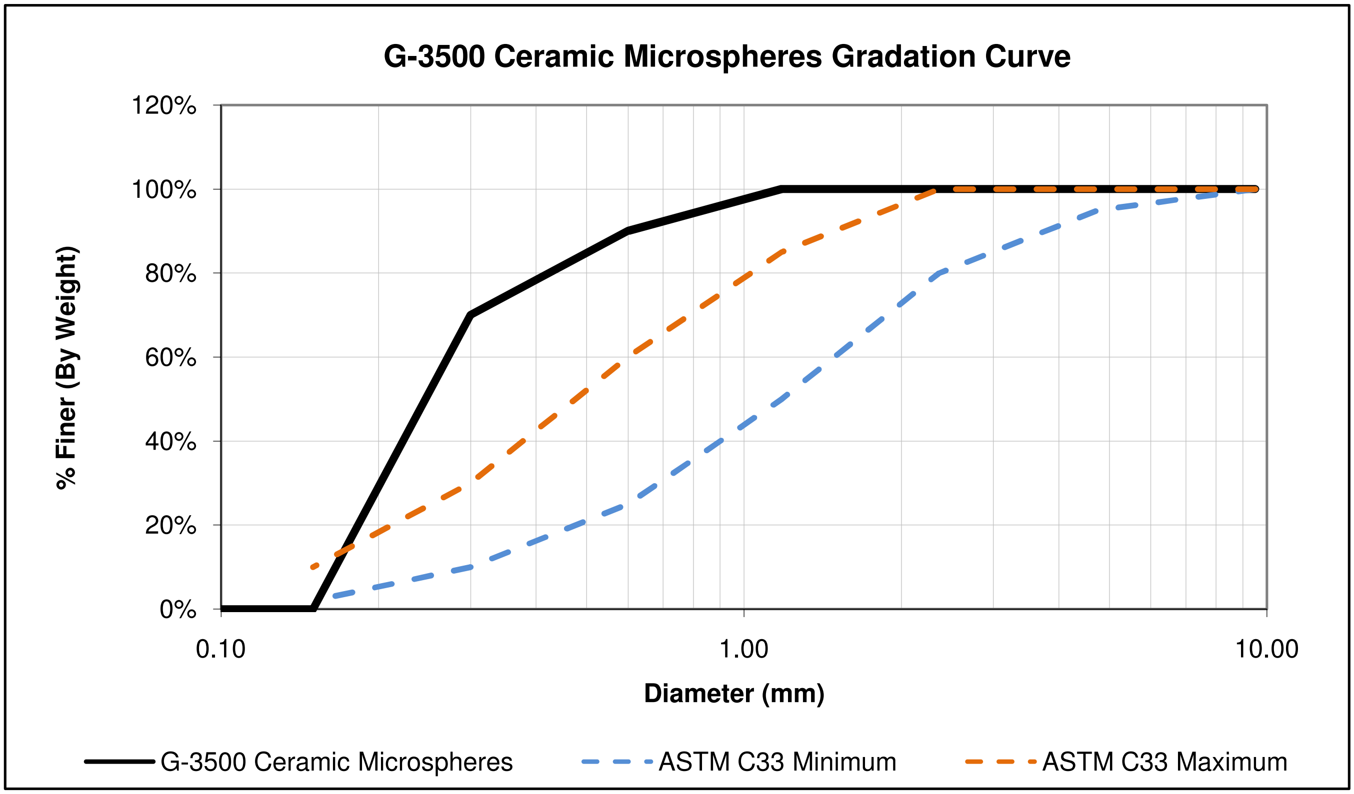


Concrete Aggregate: Poraver

Sample Weight: 500 grams

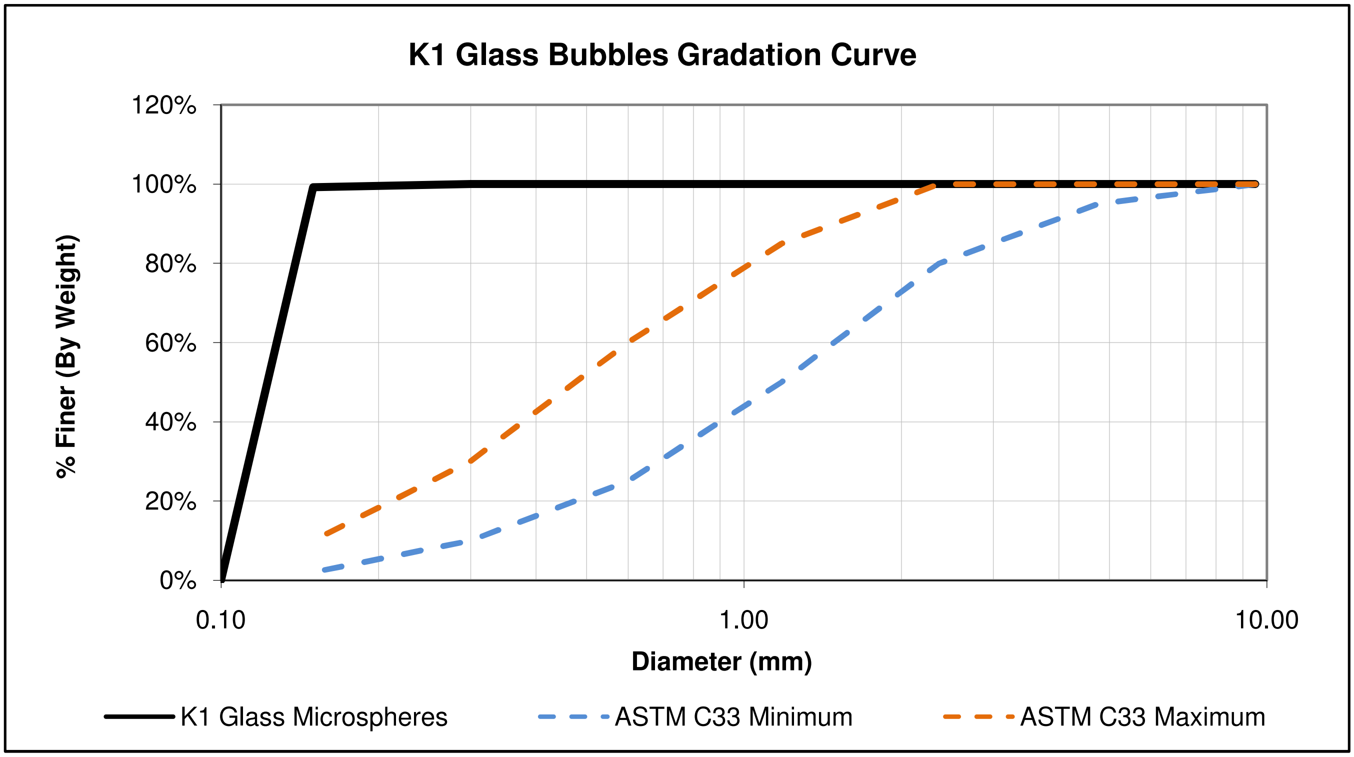
Specific Gravity (G_s): 0.34

Sieve	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0	0	100%
No. 4	4.75	0	0	100%
No. 8	2.36	0	0	100%
No. 16	1.18	117	117	77%
No. 30	0.60	263	380	24%
No. 50	0.30	120	500	0%
No. 100	0.15	0	500	0%
Pan	0.00	0	500	0%



Concrete Aggregate:	G-3500 Ceramic Microspheres
Sample Weight:	500 grams
Specific Gravity (G_s):	0.75

Sieve	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0	0	100%
No. 4	4.75	0	0	100%
No. 8	2.36	0	0	100%
No. 16	1.18	0	0	100%
No. 30	0.60	50	50	90%
No. 50	0.30	100	150	70%
No. 100	0.15	350	500	0%
Pan	0.00	0	500	0%



Concrete Aggregate:	K1 Glass Bubbles
Sample Weight:	500 grams
Specific Gravity (G_s):	0.13

Sieve	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0	0	100%
No. 4	4.75	0	0	100%
No. 8	2.36	0	0	100%
No. 16	1.18	0	0	100%
No. 30	0.60	0	0	100%
No. 50	0.30	0	0	100%
No. 100	0.15	4	4	99%
Pan	0.00	496	500	0%