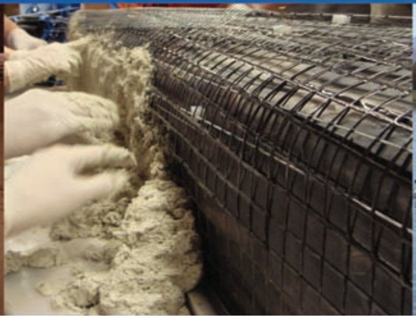
Cerulean

University of Nevada, Reno

2007
University of Nevada, Reno
Concrete Canoe Design Report

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Executive Summary

The University of Nevada, Reno is located in the Truckee Meadows, overlooked by the striking blue waters of Lake Tahoe and the snowy Sierra Nevada. It was in this location in 1887 that the Nevada Legislature created a land-grant university to serve the state by providing education in mining, agriculture, and the liberal arts. Since then, the University of Nevada, Reno has expanded to include 14 colleges of diverse disciplines and over 16,000 students. Home to one of the premier earthquake simulation facilities in the nation, the Department of Civil and Environmental Engineering has gained national recognition for its research in the field of earthquake engineering and is considered one of the top programs in the country. The department's 250 students are proud to be associated with some of the finest members of the engineering community.

Table 1: Canoe Details

Cerulean Details	
Weight	174 lbs
Length	19.98'
Width	28.5"
Depth	12"
Thickness	1/2"
Color	White Concrete/Blue
Concrete and Reinforcement	
Main Reinforcement	1" Carbon Fiber Scrim 1/4" Steel All-Thread (ribs) 1/2" Steel Mesh (bow, stern)
Prestress	1/16" dia. Steel Cable
Unit Weight	56.24 lbs/ft^3
Compressive Strength	1900 psi
Modulus of Rupture	300 psi
Composite Flexural Strength	1200 psi

The University of Nevada, Reno Concrete Canoe Team competes alongside several California universities in the Mid-Pacific Conference. The Nevada Concrete Canoe Team qualified for the National Concrete Canoe Competition (NCCC) for the first time in 2006 with **euphoria**, placing sixth overall. Following a fifth place Mid-Pacific Conference finish in 2005, **euphoria** marked only the second canoe constructed by Nevada after a seven-year hiatus. Experience and insight gained from the 2006 NCCC breathed new life into the concrete canoe program at Nevada.

In 2007, research drove the development of innovative construction techniques for casting a prestressed, monolithically poured canoe, the specifications of which are in Table 1. An emphasis on composite structural design resulted in a durable, resilient canoe capable of withstanding the rigors of both conference and national competitions. Advances in concrete mix design allowed engineers to design lighter and stronger concrete than used in any previous Nevada canoe, while significant advances in the hull design improved tracking and speed. Realization of Nevada's innovative design and construction advances came from a hierarchical project management system and an aggressive design/build philosophy. To reflect school colors and the natural beauty of Lake Tahoe and the Sierras, the team used white cement and blue acid stain to complement the distinctive hull design. It is with great pride and a well-founded sense of accomplishment that the Concrete Canoe Team of the University of Nevada, Reno presents… **Cerulean**!

Hull Design

Nevada's Hull Design Engineer developed **Cerulean** by evaluating and correcting performance issues with **euphoria**. While **euphoria** excelled in turning and stability, it lacked acceleration and straight-line speed. The design of **Cerulean** maintains stability while improving speed and tracking.

Table 2: Performance Indicators of euphoria & Cerulean

	euphoria	Cerulean
Waterline Length	20.76'	19.59'
Waterline Beam	26.6"	25.2"
Length/Beam	9.8	9.3
Wetted Area	37.5 ft^2	35.6 ft^2
Entrance Angle	19.9°	12.4°
C_p	0.61	0.53
Freeboard	7.1"	5.3"
Modified TM	6.2 ft^3	13.9 ft^3

The 2007 team radically altered the hull geometry of **euphoria** to improve speed and acceleration. A team-wide goal to reduce canoe weight by 20 percent was a key component of improved acceleration. The hull design's contribution to this effort is a 2' reduction in length (to 19.98') and a 1" reduction in depth (to 12"), resulting in 15 percent lower total surface area. Values are averaged for all load cases; Table 2 compares performance indicators. Below waterline, **Cerulean** has 5 percent less wetted surface area to improve speed and acceleration through lower drag. Further increase in acceleration comes from a lower prismatic coefficient (C_P), a measure of the narrowness of a canoe's bow and stern relative to its largest cross section. The Hull Design Engineer narrowed the entrance angle of **Cerulean** to reduce wave drag (Winters, 2005), resulting in a lower C_p. To improve speed, the canoe's waterline beam is 1.4" narrower than **euphoria**. To compensate for associated reductions in displacement and stability, the design has a flatter keel and harder chines (Gillmer and Johnson, 1982). Lower freeboard and a 2.5" narrower beam at gunwale (maximum width 28.5") increase **Cerulean**'s speed through ergonomics, by giving the paddlers easier access to the water.

In 2006, Nevada introduced a new method to predict and quantify the turning ability of a canoe, called "turning moment" (TM). TM is calculated by multiplying the submerged profile area of a canoe by its centroidal distance to the center of turning; a higher TM indicates greater resistance to turning. In 2007, further improvements to the TM method were developed based in part on work by Winters (2005) to predict tracking. Figure 1 shows how the new method, "modified turning moment," accounts for the sharpness of a canoe's keel. Multiplying each element of the centroidal TM calculation by the sine of its angle from horizontal at that location increases the effective TM calculated for sections with a sharp keel. Table 3 shows equations for all three TM-related methods.

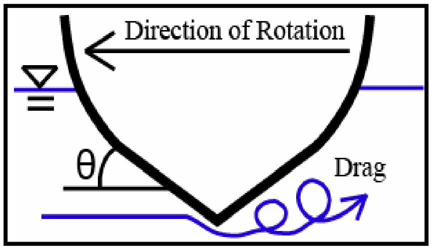


Figure 1: Keel's Resistance to Turning

Table 3: TM Calculations

TM	$\Sigma(A \cdot x)$
Winters Tracking	$\Sigma(A \cdot x \cdot \sin\theta)_{stern} - \Sigma(A \cdot x \cdot \sin\theta)_{bow}$
Mod. TM	$\Sigma(A \cdot x \cdot \sin\theta)$
A = profile area of element	
x = centroidal distance	
θ = angle of keel	

To offset the decrease in turning ability, the bow rocker is increased to 4.5" and extended 13' aft. Prolines 98™ (1998) draft data indicates this is the maximum allowable bow rocker to keep the keel submerged during the women's sprint. Moving the distribution of rocker forward shifts the center of turning aft, providing an extra 1' of torque to the front paddler in bow initiated turns. To improve tracking and compensate for displacement losses, **Cerulean** does not incorporate any stern rocker. Without rocker the stern acts as a rudder remaining firmly behind the bow with minimal corrective effort from paddlers; however, deliberate action by the bow paddler results in a swift and decisive turn. The 2007 paddling team feels **Cerulean**'s performance in the water is Nevada's best in the past three years.

Analysis

The analysis team's main goal was to develop a detailed finite element model to accurately predict stresses by emphasizing composite design. SAP2000™ v.10 (Computers and Structures, 2006) was selected as the primary analysis tool for its ability to model tendon elements (used to evaluate the proposed prestress system) and multi-layered shell elements (which improved the design of the composite structural system by accounting for the presence and stiffness of internal reinforcement). To justify the need for a refined finite element model, a detailed model of **euphoria** was created in SAP2000™ v.10 that accurately predicted observed cracking. Since previous methods were unsuccessful in predicting cracking on **euphoria**, this proved and justified the need for a refined finite element model.

The analysis considered five primary load cases: simply supported, display stand supported, 2-paddler, 3-paddler, and 4-paddler. Buoyant forces were modeled for each paddling load case as a surface pressure on the exterior of the canoe that varied linearly with depth based on waterlines calculated for the four race scenarios. To satisfy equilibrium, the stern of the canoe was modeled with a pin support and the bow with a roller support. Paddler locations were adjusted until the artificial support reactions at the bow and stern were minimized. Paddlers were assumed to be 180 lb loads, with each paddler's "knees" modeled as a surface pressure on four 0.5" x 0.5" shell elements.

The analysis and mix teams worked together in an iterative design process in which up-to-date material properties were applied to the model, then mix and reinforcement design requirements were reassessed. The initial model used 0.5" thick shell elements to model concrete with an elastic modulus of 1,500 ksi, a Poisson's ratio of 0.2, and a density of 55 lbs/ft^3, along with two layers of reinforcement with an elastic modulus of 29,000 ksi. Experience and research guided the Analysis Engineer in setting allowable stress limits of $0.6M_r$ and $0.7f'_c$ (where M_r is the 28-day modulus of rupture and f'_c is the 28-day compressive strength). An additional dynamic load factor of 1.25 was also applied to all loads (Paradis, 2006).

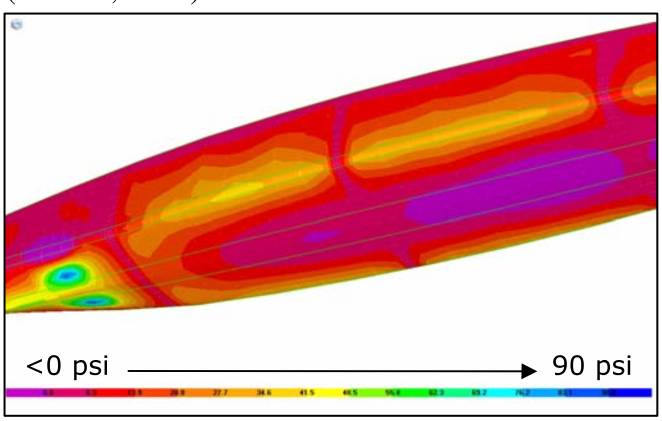


Figure 2: 2-Paddler Major Principle Tensile Stresses.

The finite element analysis used sixteen $^1/_{16}$" diameter tendon elements with a jacking force of 285 lbs each to model the longitudinal prestress system. Using the AASHTO (2006) provisions for lump-sum prestress losses, losses of 26 percent were estimated due to elastic shortening, relaxation, creep, and shrinkage. The analysis evaluated the effect of the prestress on each load case before and after losses to ensure that allowable stress limits were not exceeded. The analysis also considered the effects of integral ribs and an enlarged gunwale section. Four ribs were modeled, each with a cross section of 0.75 in^2 and containing 0.25" steel threaded rod. Rib locations were iteratively varied to minimize critical transverse stresses. The inclusion of the ribs and a 0.34 in^2 gunwale section reduced transverse tensile stresses by 31.6 percent. The critical load case, the 2-paddler sprint, yielded a major principle tensile stress of 90 psi. The stress diagram for the critical load case is shown in Figure 2.

The analysis revealed that the concrete requires a modulus of rupture of 190 psi, a compressive strength of 360 psi, and a minimum elastic modular ratio of 17:1 (reinforcement to concrete). **Cerulean** Analysis Engineers are confident that the design of the composite structure will result in a durable, solid canoe.

Development & Testing

To maximize the durability and strength of **Cerulean**, the Nevada Concrete Canoe Team emphasized composite design over conventional concrete mix design. Stresses in the concrete were minimized by developing a composite structure containing high elastic modulus reinforcement and low elastic modulus concrete (Biszick, 1999). In addition to structural requirements established by the analysis, the construction team needed a cohesive mix with a malleable consistency to ensure adequate consolidation for **Cerulean**'s monolithic casting. To help achieve the team objective of a 20 percent reduction in canoe weight, the mix design team set a goal for buoyant concrete with a maximum unit weight of 57.0 lb/ft^3.

Realization of the mix design goals began with research and testing of various mix materials. Siscor® glass spheres, tested but passed over during the development of **euphoria**, were reevaluated and selected as the primary aggregate for their inexpensive cost and low specific gravity. 3M® K20 microspheres, selected for their high availability and low specific gravity (0.2), completed the composite aggregate. The team selected high strength polyvinyl alcohol (PVA) fibers (Figure 3), often used in engineered cementitious composites, to increase the ductility and flexural strength of the concrete. To enhance the aesthetic appearance of the concrete, the team used white portland cement and selected light-colored metakaolin as a replacement for gray silica fume.

Figure 3: PVA Fibers

The absolute volume mix design method was used to develop a baseline concrete mix which had a water/cementitious (w/cm) ratio of 0.48, a cementitious materials content of 683 lbs/yd^3 (65 percent Type I white portland cement, 20 percent Class F fly ash, and 15 percent metakaolin), 2 percent PVA fibers (by volume), and a blended composite aggregate that met the gradation specifications of ASTM C33. As part of the quality control program, the team cast 2" x 4" cylinders and third-point beam samples from the mix, which were tested at 7, 14, and 28 days using the methods prescribed by ASTM C39 and ASTM C78, respectively. The baseline mix exhibited a 28-day compressive strength of 1700 psi, a modulus of rupture of 500 psi, and a unit weight of 57.4 lbs/ft^3 (ASTM C138).

Based on test results of the baseline mixture, the mix team batched an additional seventeen mixes, adjusting cement, air, and fiber contents to achieve strength, density, and workability goals. Discrepancies between target and design unit weights led engineers to perform specific gravity tests on the Siscor® aggregates (Poraver, 2004); this testing yielded values higher than those reported by the manufacturer, which were corrected in subsequent batches. This phase of the mix design process also consisted of testing various admixtures to achieve proper concrete consistency. High-range water reducers (HRWR), viscosity modifiers, air entraining admixtures (AEA), and a proprietary admixture for dispersing PVA fibers were all tested. Maintaining adequate workability proved to be a significant mix design challenge because uniformly coating the large surface area of both the aggregate and fibers imposed a high demand on the cement. At the recommendation of the admixture manufacturer, polycarboxylate-based HRWR were used for their high efficiency. Adva® 170 was used as the main workability-improving agent, while Adva® Cast 555 promoted cohesion and prevented segregation in the mix.

Repeated trial batching revealed that dosages significantly higher than those recommended by the manufacturer were necessary to achieve the required consistency. To study the effect of the PVA fibers on slump (ASTM C143), several trial mixes were batched with admixtures at 300 percent of their recommended dosages with and without fibers; a dramatic correlation between fiber content and slump was noted. The addition of fibers at 1 percent of total volume of concrete with an initially high slump effectively reduced the slump to less than 0.5”. Typical dosage rates for Adva® 170 and Adva® Cast 555 are 3 to 9 fl oz/cwt and 8 to 20 fl oz/cwt, respectively. It was found that adding Adva® 170 at a rate of 25.5 fl oz/cwt and Adva® Cast 555 at 35 fl oz/cwt yielded a concrete with essentially zero slump, but acceptable cohesion and malleability for good consolidation. To ensure the concrete had a legal air content and low unit weight, various dosages of Micro-Air® AEA were tested until a gravimetric air content of 10 percent was achieved (ASTM C138). The manufacturer’s recommended dosage rates for Micro-Air® are 0.125 to 1.5 fl oz/cwt; 13.5 fl oz/cwt was necessary to meet air content goals. The team consulted the admixture manufacturers when typical admixture dosages were exceeded, and the team was assured that no adverse effects were to be anticipated.

The final structural concrete mix design had a cementitious materials content of 660 lb/yd^3 with a w/cm ratio of 0.5, a fiber content of 1 percent by volume, and a unit weight of 56.24 lbs/ft^3. This mix exhibited strengths that met and surpassed the requirements of the analysis. The structural concrete mix design is found in Appendix B.

The final step in the mix design process was development of a patch mixture. Experimental patching and sanding revealed the need to develop a more workable mix for use in the patching and sanding operations. In an effort to improve concrete consistency, the total cementitious materials content was increased to 758.2 lb/yd^3, and the mix did not incorporate PVA fibers. A more finely graded composite aggregate improved concrete finishing characteristics and allowed for easier sanding. The patch concrete mix design is found in Appendix B.

The team tested several reinforcing meshes in composite concrete beams with third-point loading (ASTM C78) to determine **Cerulean**’s primary reinforcement. Sample meshes of fiberglass, steel, and carbon-fiber were all considered. The stiffer reinforcement, carbon fiber, yielded higher composite flexural strengths, and its elastic modulus of 29,000 ksi met the minimum elastic modular ratio goals. A 1” x 1” carbon fiber grid was chosen with a 77 percent open area (POA), allowing better concrete bond than other meshes considered. Composite concrete beams were cast in molds made from 0.125” layers of plastic, allowing the team to control placement of the reinforcement and thickness of the beam, and to evaluate the effectiveness of monolithic concrete casting. The $^1/_{16}$” diameter steel prestressing cable was tested to determine its elastic properties, yield strength, and ultimate strength. Testing showed that the steel cable remained in its elastic range at the design jacking force of 285 lb. To monitor the level of stress in each tendon during construction, large steel springs were tested to determine their stiffness. The springs had an initial length of 7.13” and a stiffness of 100 lbf/in; the design level of tension was achieved when the springs elongated to 10”.

Composite testing and numerous trial batches resulted in a concrete composite that exceeded the requirements established by the analysis, summarized in Table 4. Third-point bending tests revealed composite flexural strengths of 1200 psi, demonstrating that **Cerulean** has the strength to withstand the rigors of competition and transport.

Table 4: Concrete Properties Summary

Cerulean Structural Concrete Properties		
Property	**Analysis Requirements**	**Actual**
Unit Weight	57.0 lbs/ft^3 (max)	56.24 lbs/ft^3
Compressive Strength	360 psi (min)	1900 psi
Modulus of Rupture	190 psi (min)	300 psi
Composite Flexural Strength	230 psi (min)	1200 psi
Elastic Modular Ratio	17 (min)	25

Project Management & Construction

Project Management had the monumental task of project scheduling, organizing personnel, funding, and overseeing the long and complicated process of the production of a state-of-the-art concrete canoe. A primary goal for project management was to distribute the workload evenly throughout the year and among project personnel. Minimizing preventable errors through quality assurance was also a goal.

Prior to the start of the project, the 2007 team developed a detailed schedule and deadlines for major project goals, including construction of two prestressed monolithically cast concrete canoes, development of durable concrete, and early progress in the academic aspects of the project. To facilitate the aggressive schedule, **Cerulean** project management instated a design/build philosophy to conduct major tasks simultaneously. Logic and experience guided the team in developing the critical path of major milestone objectives, which included the completed hull design, analysis, mix design, table construction, form construction, practice canoe construction, and race canoe construction. **Cerulean**'s project schedule, shown on page 8, details the planned and actual execution dates for all major milestones and denotes the critical path. The team experienced four milestone variances during the project; Table 5 contains a summary along with causes.

Table 5: Schedule Variances

Milestone	Completion Date	Variance	Reason
Hull Design	9/25/06	-12 days	Early start
Table Construction	10/3/06	-11 days	Early hull design
Practice Canoe Pour	12/16/06	14 days	Reinforcement placement
Race Canoe Pour	2/10/07	7 days	Reinforcement placement

A Project Manager and a Graduate Advisor oversaw and managed daily operations of the project. Their roles included budgeting, fundraising within the local engineering community, enforcing safety rules, providing quality assurance, and organizing and conducting weekly meetings. Five veteran team members were appointed Project Engineers to manage and oversee the completion of key project tasks: mix design, analysis, hull design, construction, and paddling. Project Engineers were responsible for tracking hours, monitoring quality control, achieving project deadlines by establishing detailed schedules, and managing Assistant Engineers in their respective project areas. Fifteen key team members contributed 3060 total hours to the design and construction of **Cerulean**, as shown in Table 6.

Table 6: Hour Breakdown

Phase	Hours
Design	425
Testing	135
Construction	1700
Paddling	800
Total	**3060**

Review of previous years' itemized budgets guided the development of a detailed project budget and bill of materials, yielding a total operating budget of $6,000. To reduce budgetary demands, the team reused materials from previous years whenever possible. Material donations and remaining funds from 2006 allowed for the procurement of all mix design materials without fundraising. Weekly meetings were important to the progress of the project, as they kept team members informed of current events and allowed Project Engineers to anticipate demands of materials and personnel. Team members routinely discussed safety hazards associated with each step of the project and methods to mitigate them. Safety rules established by the team mandated review of all applicable Material Safety Data Sheets, and that all personnel use personal protective equipment when appropriate, such as safety goggles, body suits, respirators, and gloves.

New construction techniques required the team to assess the difficulties and minimize the risks associated with the project, leading to construction of a full-scale concrete prototype canoe on a reusable mold. A financial analysis showed that this could be done inexpensively, and under the current project budget. Creation of the prototype revealed flaws in the casting and prestressing processes, allowing engineers to refine construction methods in preparation for casting the competition canoe. This ensured the team's ability to safely construct a durable canoe using new methodologies.

Throughout the 2007 project year, the construction team used a combination of innovative methods and proven techniques to overcome obstacles in the production of a state-of-the-art canoe. Innovations include a pretensioned canoe stressed to a total of 4,560 lbs between the 16 tendons, in combination with pre-placed dual-layer carbon fiber reinforcement and monolithic concrete casting.

The design/build approach to the project led to early establishment of gunwale coordinates, allowing construction to begin on the build table while the hull design was still in progress. As with **euphoria**, the top of the table curves logarithmically to produce gunwale sheer. The shape of the male form comes from 2" polystyrene cross sections (chosen for light weight and workability) shaped by hot wire, and then pushed together to create the interior of the canoe. After sanding and a coat of Elmer's™ glue to protect the polystyrene, the construction team applied fiberglass to increase the form's durability and allow it to withstand forces induced by the prestress system. Additional sanding and a coat of Bondo™ gave the form a smooth finish with tight tolerances. The construction team then cut out **Cerulean**'s four ribs with a grinder and hot wire and used drywall mud and a custom tool to create uniform shape. To allow for easy form removal, students cut the form into four pieces with a removable central key for easy form extraction. After removal, team members separated the polystyrene from the fiberglass shell and used the shell as a practice canoe for the paddling team.

Prestressing in **Cerulean** consists of 16 steel cables, each $^{1}/_{16}$" diameter. The construction team fabricated a prestress anchorage system from Nevada's 2004 ASCE Steel Bridge. To measure the initial prestress force, a steel spring was attached to one end of each tendon. The construction team placed all reinforcement and tendons prior to casting; tendons were placed in two levels, and reinforcement tied across each tendon level to ensure uniform separation. Temporary spacers kept the tendons at a constant height off the form, and students bound the carbon fiber grid to the tendons with braided monofilament. After binding the reinforcement, team members tensioned each tendon to 285 lbs, pulling the carbon-fiber scrim taut. Steel mesh was placed in the bow and stern to provide reinforcement in the anchorage zones.

Figure 4: Construction of Cerulean

The mix team pre-weighed each mix in an effort to speed up the batching process on pour day. Concrete placement, shown in Figure 4, started at the ends and gunwales, and worked inward and toward the keel for uniform consolidation. Three-quarter-inch radius circular trim nailed to the build table 0.5" off the form provided gunwale shape and uniformity, while temporary screws placed at intervals on the form to a depth of 0.5" provided depth control near the chines and keel. Vibrating trowels, an innovation of the 2006 team, provided good concrete consolidation and a smooth initial finish. After casting, the team placed **Cerulean** in a custom-built curing tent kept at 95 percent relative humidity and a constant temperature of 65 °F. The students began wet sanding and patching while the canoe was curing. After 14 days, team members released the prestress tendons and hand formed the bow and stern over the exposed tendons and steel mesh. After 14 additional days of curing, students removed the form and temporary tendon spacers, and patched and sanded the entire canoe. The team completed **Cerulean** by applying acid stain and two coats of a sealer. As per manufacturers' recommendations, the stain was brushed into the canoe surface in two coats, and the sealer applied uniformly in two passes. Airbrushed lettering of enamel paint put the final touches on the stunning white and Nevada-blue vessel.

Organization Chart

Project Manager
Nick Maxon

Organized and coordinated schedules, kept team communication strong, kept project running smoothly

Assistant Project Manager
Christine Harms

Assisted project manager in facilitating project. Provided management in needful areas.

Graduate Student Advisor
Michael Taylor

Provided experience and expert know ledge to Project Manager and Engineers, kept project running smoothly

Technical Consultants
Dr. David Sanders
Dr. Patrick Laplace
Wayne Nuusbaum
David St. Lawerence
Charles Albright

Design & Analysis

Hull Design Engineer
Corbin McFarlane

Designed a new hull w ith superior speed and tracking based on extensive research and new methods

Assistant Engineers
Nick Maxon
Suzanne Durr

Structural Analysis & Design Engineer
Michael Taylor

Assistant Engineer
Christine Harms

Mix Design Engineer
Kelly Doyle

Researched and created concrete mixes, performed testing. Directed mixing during research and pours.

Assistant Engineers
Michael Taylor
Christine Harms

QA/QC
Matt Pontoni

Construction

Construction Engineer
Adam McNutt

Performed all necessary construction tasks. Coordinated construction w ork by all other team members

Assistant Engineers
Chad Lyttle
Nick Maxon
Suzanne Durr
Corbin McFarlane

Cutaway Section
McNutt/Lyttle/Maxon

Canoe Stand
Lyttle

Canoe Cart
Fitzgerald/Lyttle

Academics & Administration

Fundraising Coordinator
Nick Maxon
Dale Keller

Design Paper
McFarlane /Taylor

Oral Presentation
Nick Maxon
Christine Harms

Engineer's Notebook
Taylor/Doyle

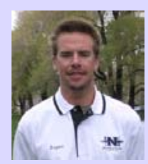
Final Product Display
Kelly Doyle/Kyle Jones

Form/Canoe Drawings
Taylor/McFarlane

Web Development & Graphics
Ben Menesini
Nick White

Paddling

Paddling Engineer
Bryan Truce

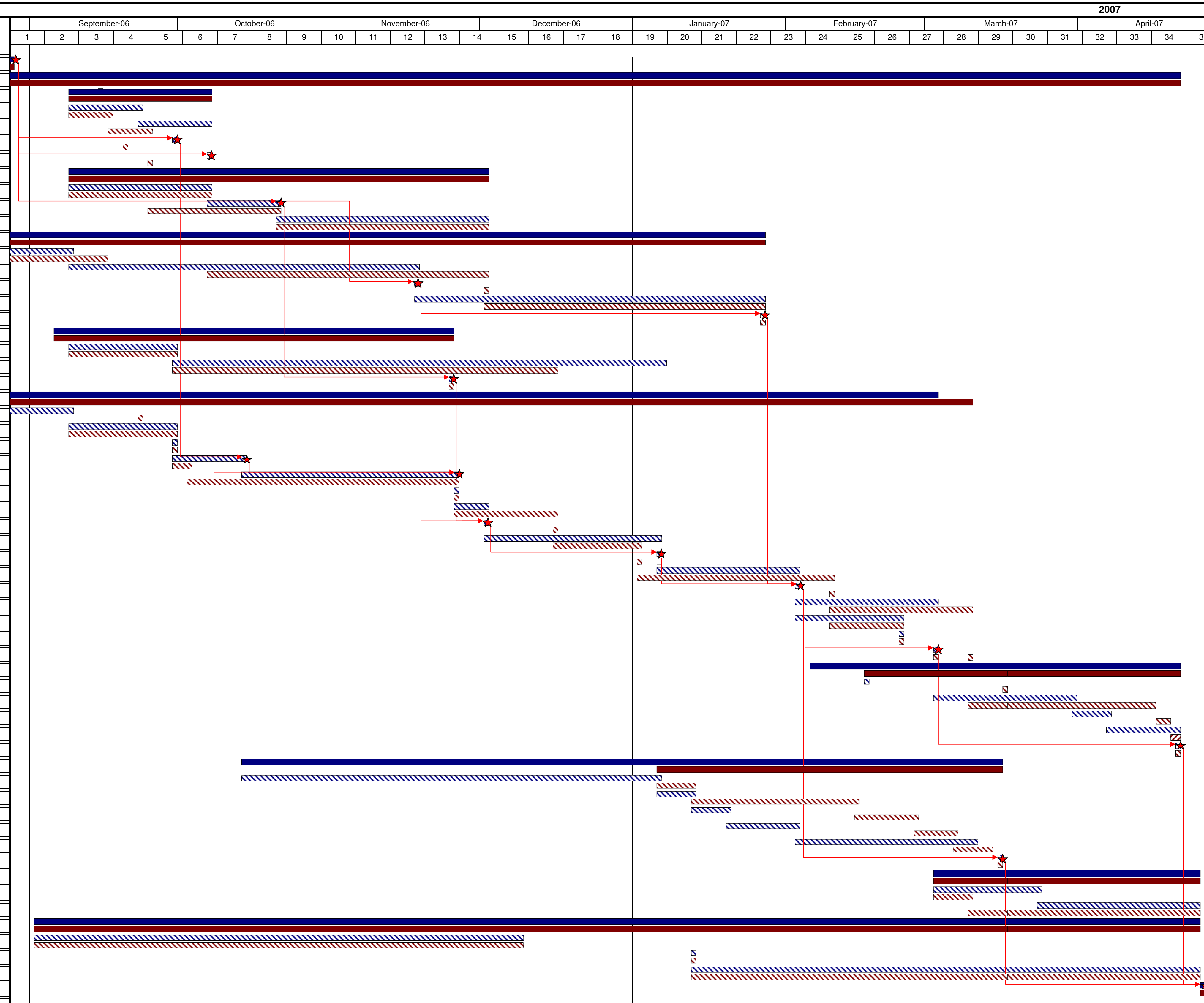


Organized paddling practices, demonstrated techniques, and motivated paddlers

Paddlers
Kara Bymers
Suzanne Durr
Brian Fitzgerald
Dale Keller
Nick Maxon
Brittany Miller
Matt Savage
Tarin Strickler
Bryan Truce

Cerulean Project Schedule

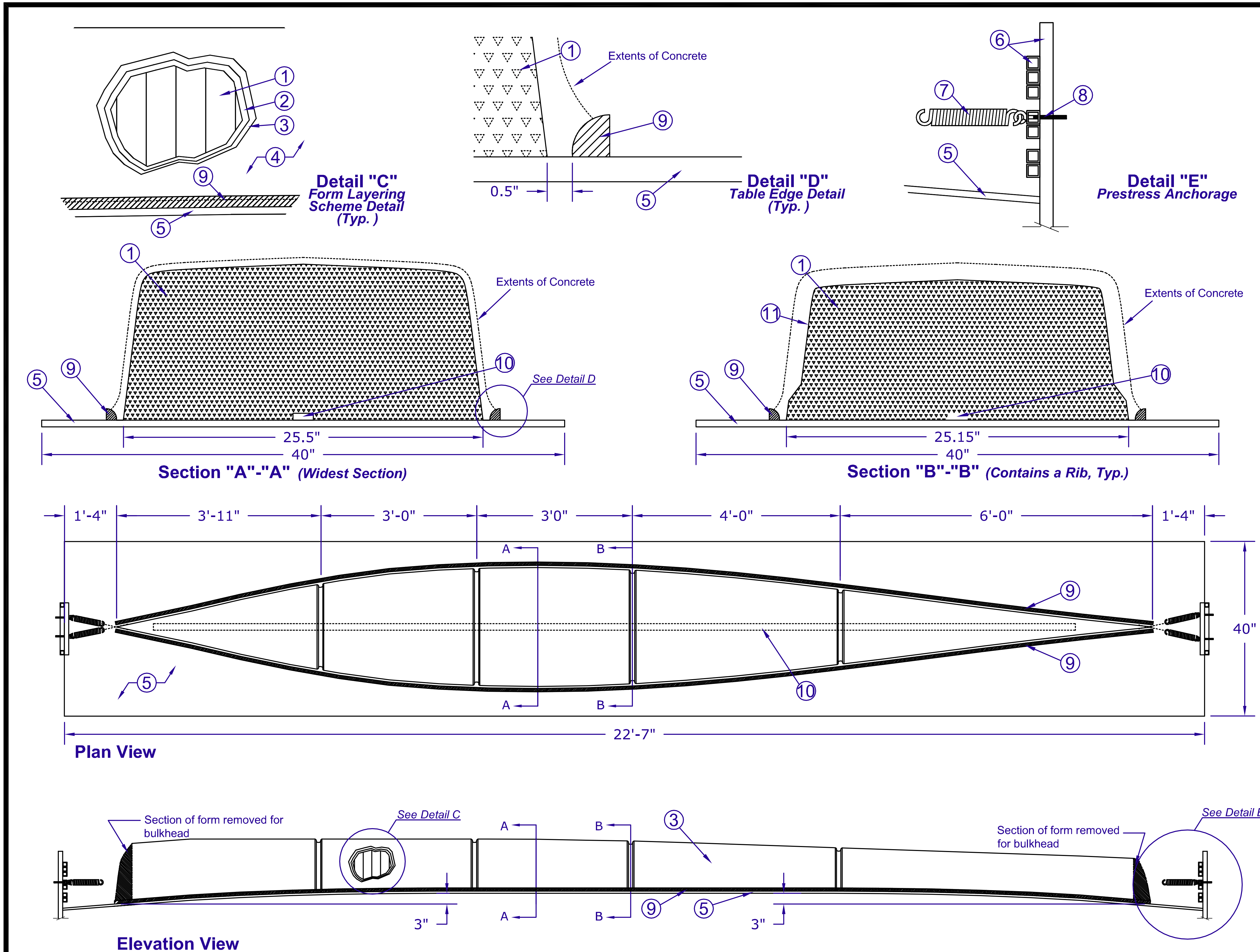
ID	Task Name	Planned Start	Planned Finish	Actual Start	Actual Finish	Variation
1	**First Meeting & Start**	**8/28/2006**	**8/28/2006**	**8/28/2006**	**8/28/2006**	**0 days**
2	**Fundraising *(Maxon/Taylor/Doyle)***	**8/26/2006**	**4/21/2007**	**8/28/2006**	**4/21/2007**	**0 days**
3	**Hull Design *(McFarlane)***	**9/9/2006**	**10/7/2007**	**9/9/2006**	**10/7/2006**	**-365 days**
4	Research & Modeling	9/9/2006	9/23/2006	9/9/2006	9/17/2006	-6 days
5	Hull Design & Analysis	9/23/2006	10/7/2006	9/17/2006	9/25/2006	-12 days
6	Gunwale Profile Finished	9/30/2006	9/30/2006	9/20/2006	9/20/2006	-10 days
7	Final Hull Selection	10/7/2006	10/7/2006	9/25/2006	9/25/2006	-12 days
8	**Structural Analysis/Composite Design *(Taylor)***	**9/9/2006**	**12/2/2006**	**9/9/2006**	**12/2/2006**	**0 days**
9	Initial Meeting, SAP Training	9/9/2006	10/7/2006	9/9/2006	10/7/2006	0 days
10	Composite Analysis & Design	10/7/2006	10/21/2006	9/25/2006	10/21/2006	0 days
11	Hull Analysis	10/21/2006	12/2/2006	10/21/2006	12/2/2006	0 days
12	**Mix Design *(Doyle/Taylor)***	**8/28/2006**	**1/27/2007**	**8/28/2006**	**1/27/2007**	**0 days**
13	Materials Research	8/28/2006	9/9/2006	8/28/2006	9/16/2006	7 days
14	Preliminary Design & Testing	9/9/2006	11/18/2006	10/7/2006	12/2/2006	14 days
15	Final Mix Selection (Practice Canoe)	11/18/2006	11/18/2006	12/2/2006	12/2/2006	14 days
16	Refinement Designs & Testing	11/18/2006	1/27/2007	12/2/2006	1/27/2007	0 days
17	Final Mix Selection (Race Canoe)	1/27/2007	1/27/2007	1/27/2007	1/27/2007	0 days
18	**Reinforcement *(Taylor/Doyle)***	**9/6/2006**	**11/25/2006**	**9/6/2006**	**11/25/2006**	**0 days**
19	Reinforcement Research & Analysis	9/9/2006	9/30/2006	9/9/2006	9/30/2006	0 days
20	Composite Testing	9/30/2006	1/7/2007	9/30/2006	12/16/2006	-22 days
21	Reinforcement Selection	11/25/2006	11/25/2006	11/25/2006	11/25/2006	0 days
22	**Construction *(McNutt/Maxon)***	**8/28/2006**	**3/3/2007**	**8/28/2006**	**3/10/2007**	**7 days**
23	Fiberglass Canoe Pour (euphoria)	8/28/2006	9/9/2006	9/23/2006	9/23/2006	14 days
24	Form Material Acquisition	9/9/2006	9/30/2006	9/9/2006	9/30/2006	0 days
25	Form Type Selection, Mix Requirements	9/30/2006	9/30/2006	9/30/2006	9/30/2006	0 days
26	Form Table Construction	9/30/2006	10/14/2006	9/30/2006	10/3/2006	-11 days
27	Form Construction	10/14/2006	11/26/2006	10/3/2006	11/26/2006	0 days
28	Fiberglass Canoe Pour ('07 Boat)	11/26/2006	11/26/2006	11/26/2006	11/26/2006	0 days
29	Form Preparation, Practice Canoe	11/26/2006	12/2/2006	11/26/2006	12/16/2006	14 days
30	Practice Canoe Pour Day	12/2/2006	12/2/2006	12/16/2006	12/16/2006	14 days
31	Practice Canoe Cure	12/2/2006	1/6/2007	12/16/2006	1/2/2007	-4 days
32	Form Removal, Practice Canoe	1/6/2007	1/6/2007	1/2/2007	1/2/2007	-4 days
33	Form Refinishing & Preparation	1/6/2007	2/3/2007	1/2/2007	2/10/2007	7 days
34	Race Canoe Pour Day	2/3/2007	2/3/2007	2/10/2007	2/10/2007	7 days
35	Race Canoe Cure	2/3/2007	3/3/2007	2/10/2007	3/10/2007	7 days
36	Cross Section Construction	2/3/2007	2/24/2007	2/10/2007	2/24/2007	0 days
37	Cross Section Pour Day	2/24/2007	2/24/2007	2/24/2007	2/24/2007	0 days
38	Form Removal, Race Canoe	3/3/2007	3/3/2007	3/10/2007	3/10/2007	7 days
39	**Finishing *(McNutt/Maxon)***	**2/6/2007**	**4/21/2007**	**2/17/2007**	**4/21/2007**	**0 days**
40	Stain/Sealer Selection	2/17/2007	2/17/2007	3/12/2007	3/12/2007	23 days
41	Patching/Sanding	3/3/2007	3/31/2007	3/10/2007	4/17/2007	17 days
42	Staining (Race Canoe)	3/31/2007	4/7/2007	4/18/2007	4/20/2007	13 days
43	Sealing (Race Canoe)	4/7/2007	4/21/2007	4/20/2007	4/21/2007	0 days
44	Canoe Finished	4/21/2007	4/21/2007	4/21/2007	4/21/2007	0 days
45	**Design Report *(Engineering Staff)***	**10/14/2006**	**3/16/2007**	**1/6/2007**	**3/16/2007**	**0 days**
46	Compose Rough Draft	10/14/2006	1/6/2007	1/6/2007	1/13/2007	7 days
47	Initial Editing	1/6/2007	1/13/2007	1/13/2007	2/15/2007	33 days
48	Revisions & Rewrite	1/13/2007	1/20/2007	2/15/2007	2/27/2007	38 days
49	Peer/Professional Review and Editing	1/20/2007	2/3/2007	2/27/2007	3/7/2007	32 days
50	Final Revisions & Review	2/3/2007	3/11/2007	3/7/2007	3/14/2007	3 days
51	Design Report Finished	3/16/2007	3/16/2007	3/16/2007	3/16/2007	0 days
52	**Oral Presentation *(Maxon/Harms/Taylor/Doyle)***	**3/3/2007**	**4/25/2007**	**3/3/2007**	**4/25/2007**	**0 days**
53	Compose Presentation	3/3/2007	3/24/2007	3/3/2007	3/10/2007	-14 days
54	Practice & Critique	3/24/2007	4/25/2007	3/10/2007	4/25/2007	0 days
55	**Paddling *(Truce)***	**9/2/2006**	**4/25/2007**	**9/2/2006**	**4/25/2007**	**0 days**
56	Tryouts	9/2/2006	12/9/2006	9/2/2006	12/9/2006	0 days
57	Team Selection	1/13/2007	1/13/2007	1/13/2007	1/13/2007	0 days
58	Paddling Team Practice	1/13/2007	4/25/2007	1/13/2007	4/25/2007	0 days
59	**Mid-Pacific Regional Conference (SJSU/SCU)**	**4/26/2007**	**4/28/2007**	4/26/2007	4/28/2007	0 days
60	**National Concrete Canoe Competition**			**June 2007**		



University of Nevada, Reno
Concrete Canoe

Summary (Planned) — Task (Planned) — Major Milestone

Summary (Actual) — Task (Actual) — Critical Path



University of Nevada, Reno
Concrete Canoe

Bill of Materials

Part	Qty	Description
1	119 ct	Expanded Polystrene (2" thick sections)
2	60 sf	Elmer's Glue Shell (Surface Treatment)
3	60 sf	Fiberglass Shell (Surface Treatment)
4	60 sf	Bondo (Surface Treatment)
5	76 sf	Plywood (½" thick, 7-ply)
6	12 lf	Steel Tube (½" x ½" x ⅛")
7	16 ct	Steel Spring (7-⅝", 1-⅛" dia., k=300 lbf/in)
8	32 ct	Eye Bolts/Nuts (3" long, ¼" dia.)
9	40 lf	Plastic Trim (¾" radius)
10	18 lf	Wood Chamfer Strip (1-½" x ½")
11	3 sf	Dry Wall Mud (Surface Treatment, ribs only)

Cerulean Form Design Drawing

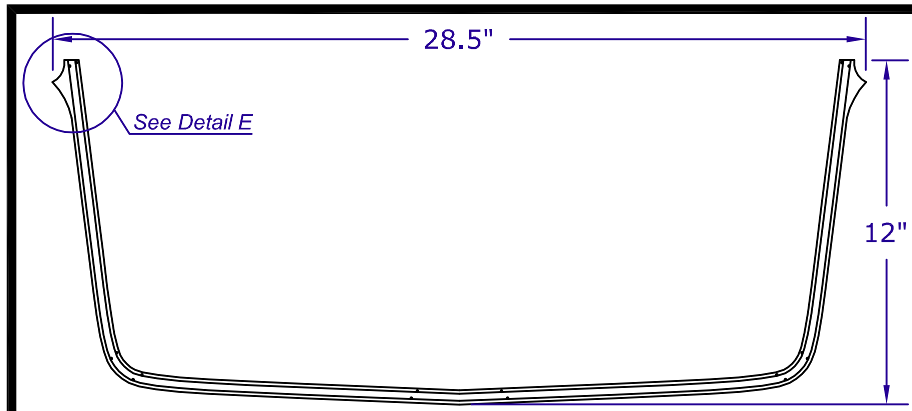
General Notes:
1. Drawings not to scale
2. Only two prestress anchorages are shown for clarity

Date: 3/10/2007

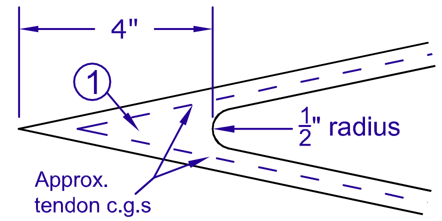
Engineer: MCNUTT/MCFARLANE/MAXON

Drawn By: TAYLOR

SHEET 9 OF 10

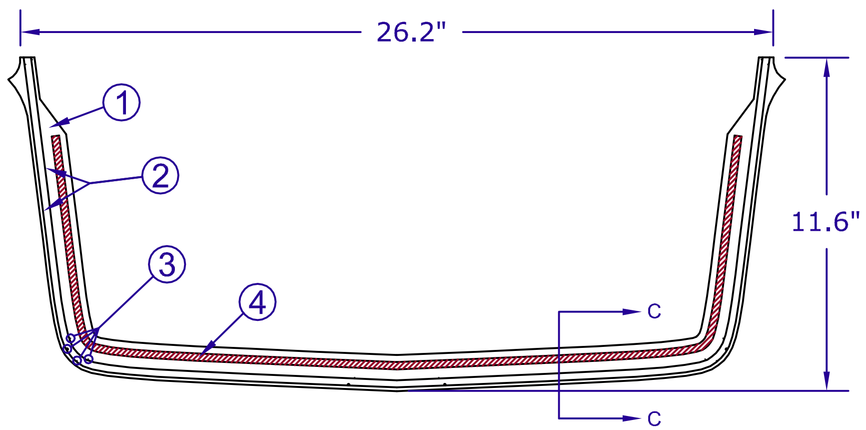


Section "A"-"A" *(Widest Section, 12' aft)*

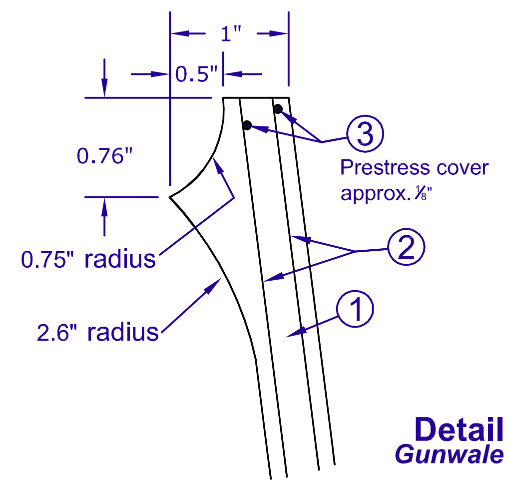


Detail "D"
Bulkhead Detail (Typ. Bow & Stern)

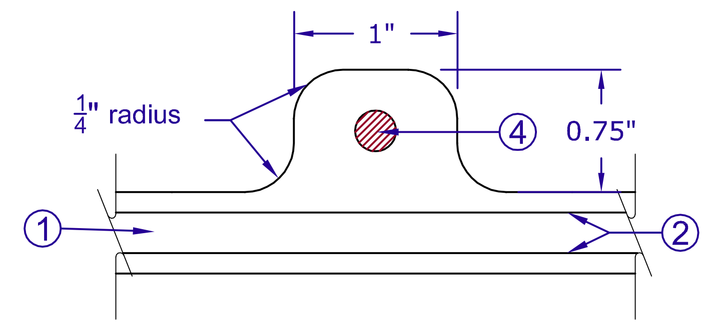
Isometric View



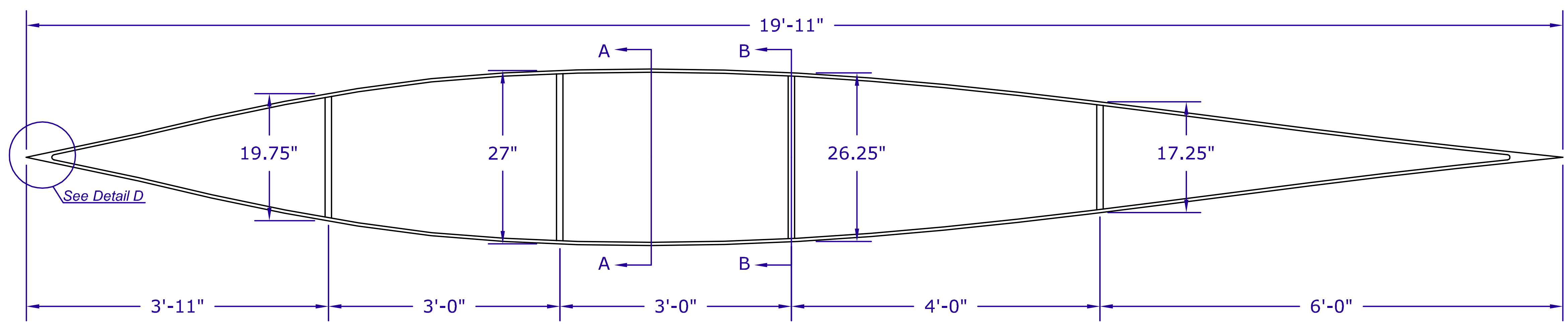
Section "B"-"B" *(Contains a Rib, Typ.)*



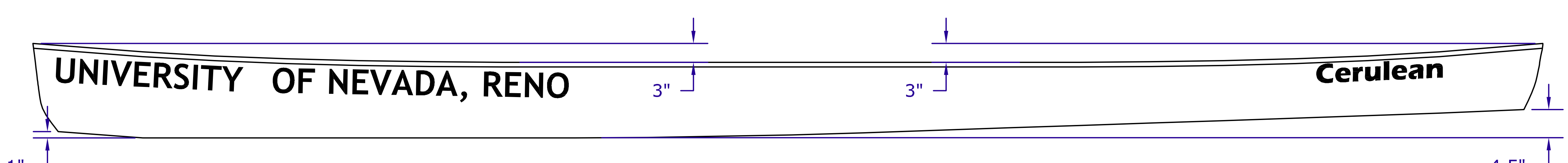
Detail "E"
Gunwale Detail



Section "C"-"C" *(Rib Detail, Typ.)*



Plan View



Elevation View

University of Nevada, Reno
Concrete Canoe

Bill of Materials

Part	Qty	Description
1	2.74 cf	Structural Concrete (1900 psi, 56.2 pcf, 10% air)
2	116 sf	Carbon Fiber Mesh (1"x1" grid, 77% open area)
3	320 lf	Prestress Tendon (1/16" Woven Steel Cable)
4	11.33 lf	Threaded Rod (1/4" Steel, each rib)
5	116 sf	Finishing Concrete† (60.3 pcf, 10% air)

Cerulean Hull Design Drawing

General Notes:
1. Drawings not to scale
2. Width measurements do not include gunwale, except where noted
3. Total Prestressing Force: P_{jack}=4.56 kips, Losses=1.19 kips (26%)
4. Concrete Compressive Strength at Release: 1500 psi

†Applied to surface of canoe after form removal

Date: 3/10/2007

Engineer: TAYLOR/MCFARLANE

Drawn By: TAYLOR

SHEET	OF
10	10

Appendix A: References

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Appendix B: Mixture Proportions

2007 Concrete Canoe Mix Design

Structural Concrete Mixture

Batch Size (ft^3): 0.326

		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. ***Portland Cement, Type I, (White)***	3.15	429.29	2.184	5.18	0.026	427.28	2.174
2. ***Fly Ash, Class F***	2.6	132.09	0.814	1.59	0.010	131.47	0.810
3. ***Metakaolin***	2.68	99.07	0.592	1.20	0.007	98.60	0.590
Total of All Cementitious Materials		660.44	3.591	7.97	0.043	657.35	3.574
Fibers							
1. ***Nycon PVA Fibers***	1.30	21.90	0.270	0.26	0.003	21.80	0.269
Aggregates							
1. ***Siscor 1-2 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.46	147.85	5.385	1.78	0.065	147.16	5.360
2. ***Siscor 0.5-1.0 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.58	140.59	4.023	1.70	0.049	139.93	4.004
3. ***Siscor 0.25-0.5 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.78	142.10	3.036	1.72	0.037	141.44	3.022
4. ***Siscor 0.1-0.3 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.94	17.05	0.304	0.21	0.004	16.97	0.302
5. ***3M K20 (Glass Bubbles)*** Absorption: 0.0% Batched Moisture Content: 0.0%	0.20	30.32	2.429	0.37	0.029	30.17	2.418
Total of All Aggregates		477.91	15.177	5.77	0.183	475.67	15.106
Water							
Batched Water	1.0	325.95	5.224	3.94	0.063	324.43	5.199
Total Free Water from All Aggregates	1.0	-17.90	-0.287	-0.22	-0.003	-17.82	-0.286
Total Water from All Admixtures[§]	1.0	22.17	0.355	0.27	0.004	22.07	0.354
Total Water		330.22	5.292	3.99	0.064	328.68	5.267
Admixtures	% Solids	Amount (fl oz/cwt)	Water[±] in Admixtures (lb/yd^3)	Amount (fl oz)	Water[±] in Admixtures (lb)	Amount (fl oz/cwt)	Water[±] in Admixtures (lb/yd^3)
1. ***Adva Cast 555 (HRWR)***	36.0%	36.2	10.672	2.9	0.129	36.0	10.622
2. ***Micro-Air (AEA)***	5.0%	13.7	6.722	1.1	0.081	13.6	6.691
3. ***Adva 170 (HRWR)***	65.0%	26.4	4.776	2.1	0.058	26.3	4.754
4. ***GST 1200 GX (Specialty Fiber Disperser)*** [†]	100.0%	25.6[†]	0.000	2.0	0.000	25.5	0.000
Cement-Cementitious Materials Ratio		0.65		0.65			0.65
Water-Cementitious Materials Ratio		0.50		0.50			0.50
Slump, in.		0.0		0.0			0.0
Air Content, %		10		6			10
Density (Unit Weight), lb/ft^3		56.37		56.24			56.17
Gravimetric Air Content, %				10.20			
Yield, ft^3		27.0		0.3			27.0

* 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.

[†] Denotes solid admixture; units shown are oz/cwt or oz, where appropriate

2007 Concrete Canoe Mix Design

Patch Concrete Mixture

Batch Size (ft^3): 0.326

		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. ***Portland Cement, Type I, (White)***	3.15	492.80	2.507	5.95	0.030	489.11	2.488
2. ***Fly Ash, Class F***	2.6	151.63	0.935	1.83	0.011	150.49	0.928
3. ***Metakaolin***	2.68	113.72	0.680	1.37	0.008	112.87	0.675
Total of All Cementitious Materials		758.16	4.122	9.15	0.050	752.47	4.091
Fibers							
1. ***None***							
Aggregates							
1. ***Siscor 1-2 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.46	110.10	4.010	1.33	0.048	109.28	3.980
2. ***Siscor 0.5-1.0 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.58	144.15	4.125	1.74	0.050	143.07	4.094
3. ***Siscor 0.25-0.5 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.78	127.13	2.717	1.53	0.033	126.18	2.696
4. ***Siscor 0.1-0.3 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.94	68.61	1.222	0.83	0.015	68.10	1.213
5. ***3M K20 (Glass Bubbles)*** Absorption: 0.0% Batched Moisture Content: 0.0%	0.20	28.70	2.300	0.35	0.028	28.49	2.282
Total of All Aggregates		478.70	14.373	5.78	0.174	475.11	14.265
Water							
Batched Water	1.0	381.30	6.111	4.60	0.074	378.44	6.065
Total Free Water from All Aggregates	1.0	-18.00	-0.288	-0.22	-0.003	-17.86	-0.286
Total Water from All Admixtures§	1.0	15.78	0.253	0.19	0.003	15.66	0.251
Total Water		379.08	6.075	4.57	0.073	376.24	6.029
Admixtures	% Solids	Amount (fl oz/cwt)	Water± in Admixtures (lb/yd^3)	Amount (fl oz)	Water± in Admixtures (lb)	Amount (fl oz/cwt)	Water± in Admixtures (lb/yd^3)
1. ***Adva Cast 555 (HRWR)***	36.0%	26.1	9.074	2.4	0.107	25.9	9.006
2. ***Micro-Air (AEA)***	5.0%	11.9	6.703	1.1	0.081	11.8	6.653
Cement-Cementitious Materials Ratio		0.65		0.65			0.65
Water-Cementitious Materials Ratio		0.50		0.50			0.50
Slump, in.		0.0		0.0			0.0
Air Content, %		9		6			10
Density (Unit Weight), lb/ft^3		60.72		60.31			60.26
Gravimetric Air Content, %				9.61			
Yield, ft^3		27.0		0.3			27.0

* 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 & Tables

Concrete Aggregate:	***Siscor 1-2 mm***
Sample Weight (g):	***90.3***
Specific Gravity (Gs):	***0.44***
Fineness Modulus:	***3.73***

Sieve (U.S. Standard)	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0.0	0.0	100.0%
No. 4	4.75	0.0	0.0	100.0%
No. 8	2.36	0.0	0.0	100.0%
No. 16	1.18	70.8	70.8	21.6%
No. 30	0.60	17.5	88.3	2.2%
No. 50	0.30	0.4	88.7	1.8%
No. 100	0.15	0.0	88.7	1.8%

Concrete Aggregate:	***Siscor 0.5-1.0 mm***
Sample Weight (g):	***91.7***
Specific Gravity (Gs):	***0.56***
Fineness Modulus:	***2.52***

Sieve (U.S. Standard)	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0.0	0.0	100.0%
No. 4	4.75	0.0	0.0	100.0%
No. 8	2.36	0.0	0.0	100.0%
No. 16	1.18	0.0	0.0	100.0%
No. 30	0.60	53.3	53.3	41.9%
No. 50	0.30	35.3	88.6	3.4%
No. 100	0.15	1.0	89.6	2.3%

Concrete Aggregate: ***Siscor 0.25-0.5 mm***
Sample Weight (g): ***76.2***
Specific Gravity (Gs): ***0.75***
Fineness Modulus: ***1.86***

Sieve (U.S. Standard)	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0.0	0.0	100.0%
No. 4	4.75	0.0	0.0	100.0%
No. 8	2.36	0.0	0.0	100.0%
No. 16	1.18	0.0	0.0	100.0%
No. 30	0.60	0.0	0.0	100.0%
No. 50	0.30	67.0	67.0	12.1%
No. 100	0.15	7.9	74.9	1.7%

Concrete Aggregate: ***Siscor 0.1-0.3 mm***
Sample Weight (g): ***44.1***
Specific Gravity (Gs): ***0.90***
Fineness Modulus: ***0.89***

Sieve (U.S. Standard)	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0.0	0.0	100.0%
No. 4	4.75	0.0	0.0	100.0%
No. 8	2.36	0.0	0.0	100.0%
No. 16	1.18	0.0	0.0	100.0%
No. 30	0.60	0.0	0.0	100.0%
No. 50	0.30	0.0	0.0	100.0%
No. 100	0.15	39.1	39.1	11.3%

Concrete Aggregate: ***3M K20 (Glass Bubbles)***
Sample Weight (g): ***60.6***
Specific Gravity (Gs): ***0.20***
Fineness Modulus: ***0.01***

Sieve (U.S. Standard)	Diameter (mm)	Weight Retained (g)	Cumulative Weight Retained (g)	Percent Finer (%)
3/8 inch	9.50	0.0	0.0	100.0%
No. 4	4.75	0.0	0.0	100.0%
No. 8	2.36	0.0	0.0	100.0%
No. 16	1.18	0.0	0.0	100.0%
No. 30	0.60	0.0	0.0	100.0%
No. 50	0.30	0.0	0.0	100.0%
No. 100	0.15	0.6	0.6	99.0%

Concrete Aggregate: ***Structural Concrete Composite Aggregate***
Fineness Modulus: ***2.48***

Sieve (U.S. Standard)	Percent Finer (%)					
	Siscor 1-2 mm	Siscor 0.5-1.0 mm	Siscor 0.25-0.5 mm	Siscor 0.1-0.3 mm	3M K20	Composite†
3/8 inch	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
No. 4	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
No. 8	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
No. 16	21.6%	100.0%	100.0%	100.0%	100.0%	75.7%
No. 30	2.2%	41.9%	100.0%	100.0%	100.0%	52.6%
No. 50	1.8%	3.4%	12.1%	100.0%	100.0%	15.0%
No. 100	1.8%	2.3%	1.7%	11.3%	99.0%	8.4%

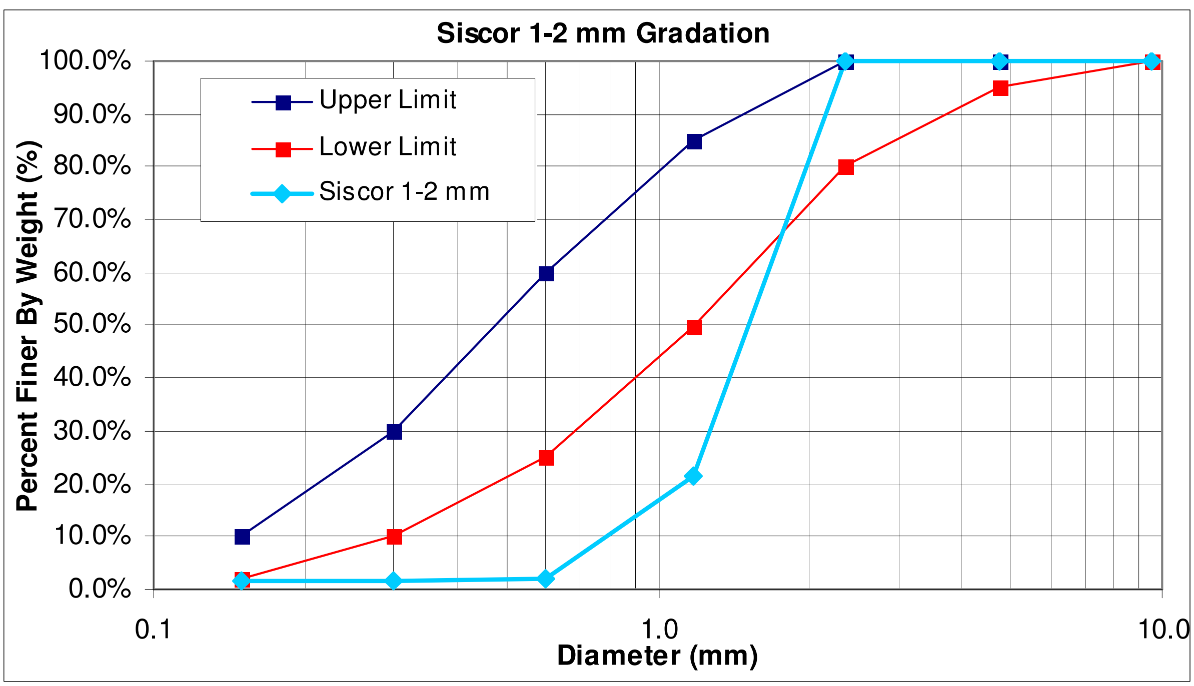
†Blend Ratio is 30.9% Siscor 1-2 mm, 29.4% Siscor 0.5-1.0 mm, 29.7% Siscor 0.25-0.5 mm, 3.6% Siscor 0.1-0.3 mm, 6.3% 3M K20

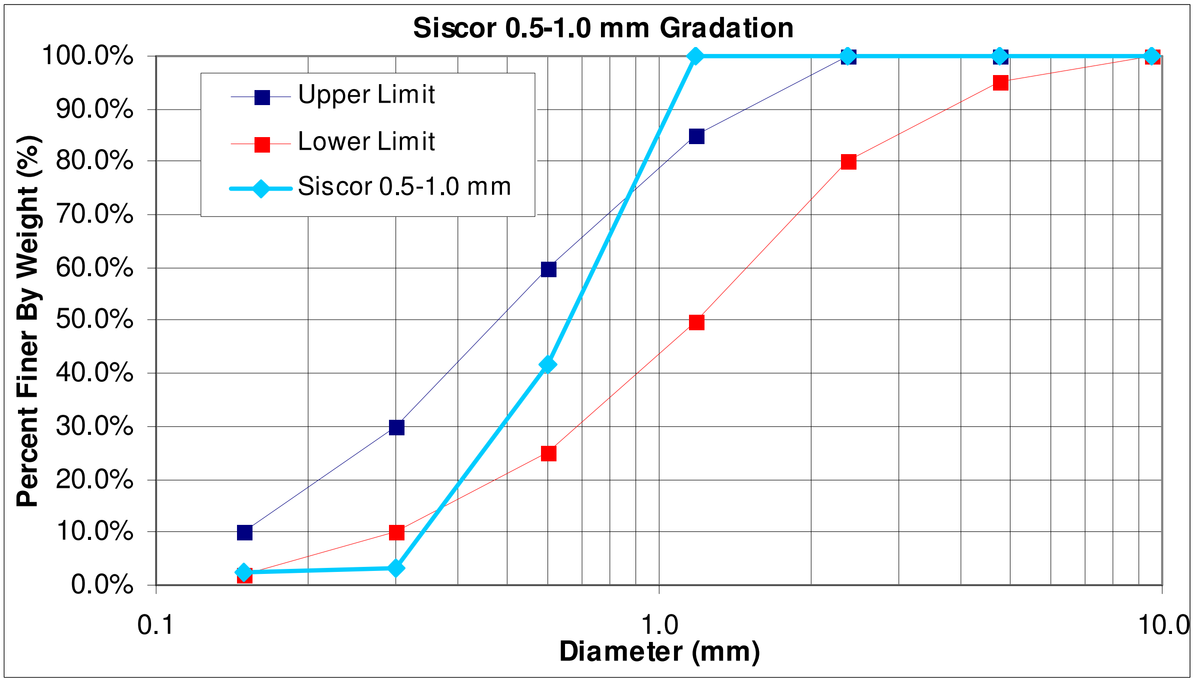
Concrete Aggregate: ***Patch Concrete Composite Aggregate***

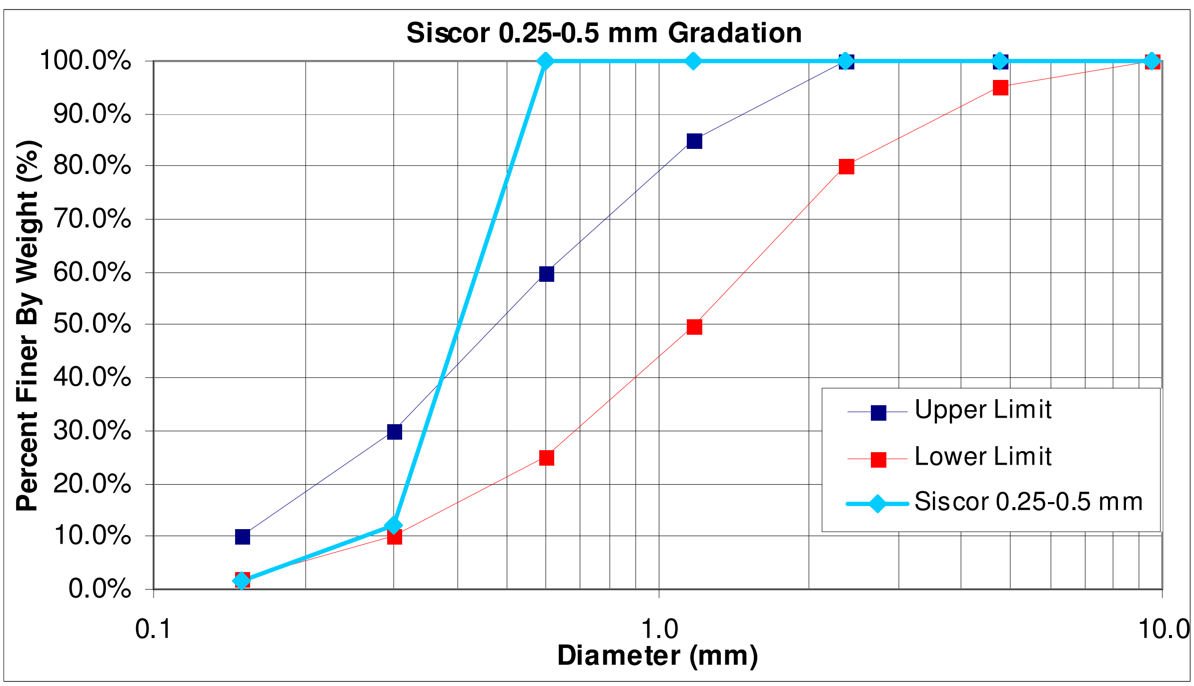
Fineness Modulus: ***2.24***

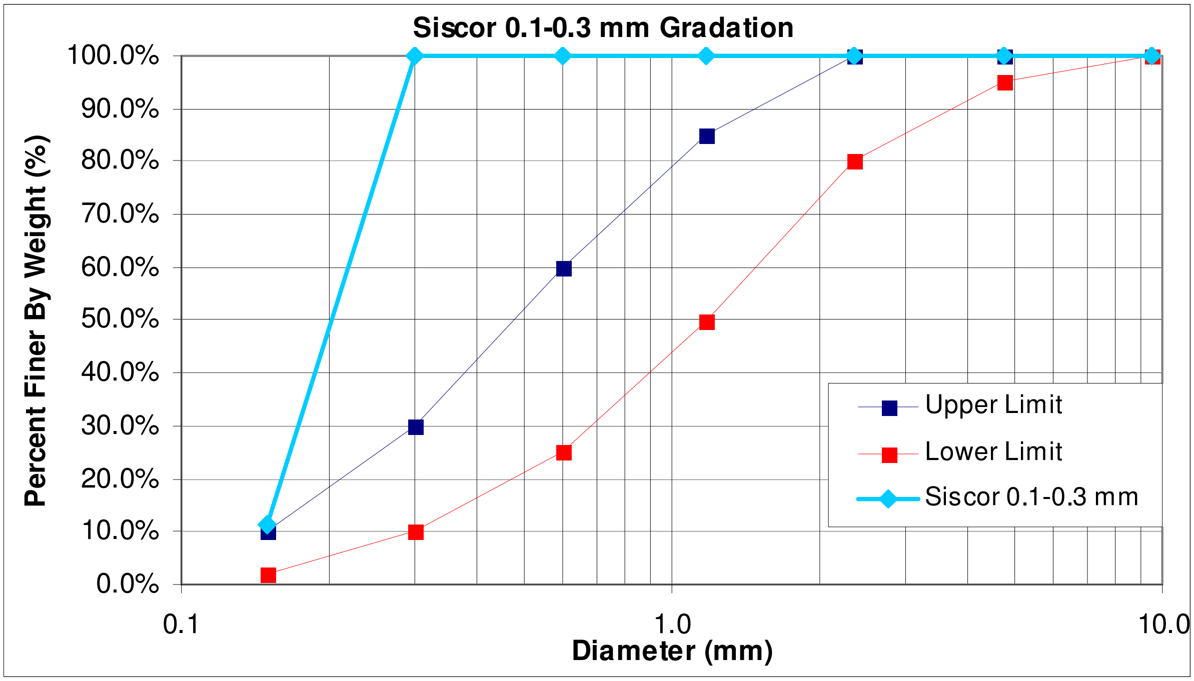
Sieve (U.S. Standard)	Percent Finer (%)					
	Siscor 1-2 mm	Siscor 0.5-1.0 mm	Siscor 0.25-0.5 mm	Siscor 0.1-0.3 mm	3M K20	Composite†
3/8 inch	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
No. 4	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
No. 8	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
No. 16	21.6%	100.0%	100.0%	100.0%	100.0%	82.0%
No. 30	2.2%	41.9%	100.0%	100.0%	100.0%	60.0%
No. 50	1.8%	3.4%	12.1%	100.0%	100.0%	24.9%
No. 100	1.8%	2.3%	1.7%	11.3%	99.0%	9.1%

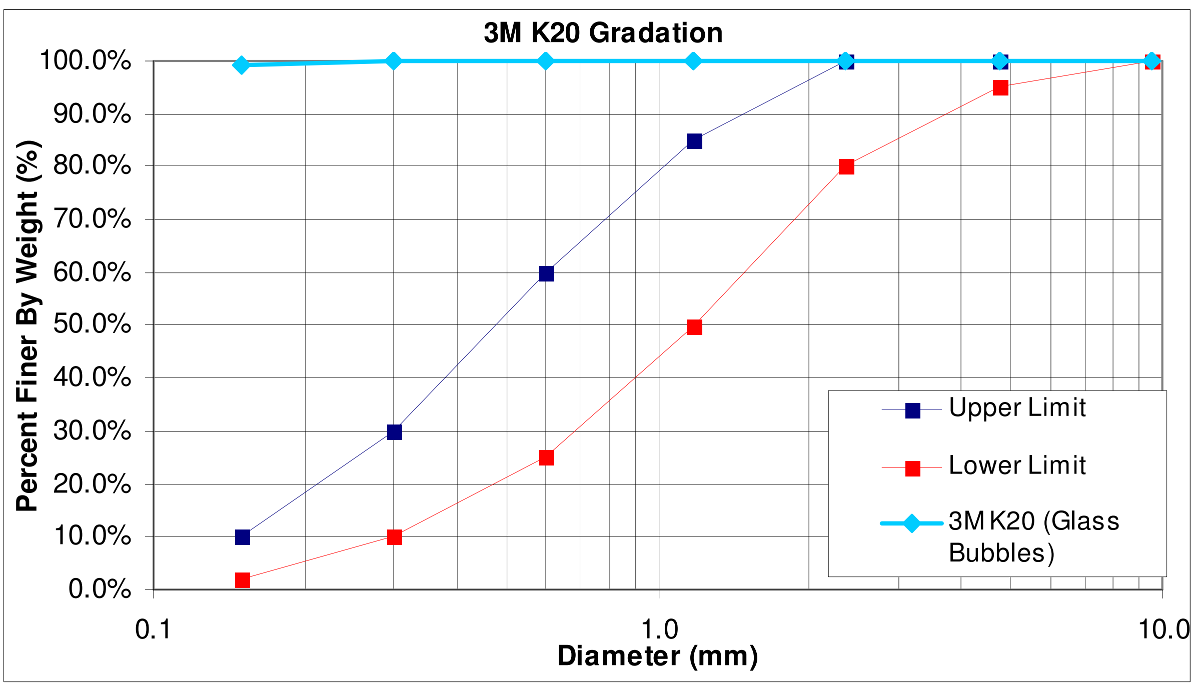
†Blend Ratio is 23.0% Siscor 1-2 mm, 30.1% Siscor 0.5-1.0 mm, 26.6% Siscor 0.25-0.5 mm, 14.3% Siscor 0.1-0.3 mm, 6.0% 3M K20

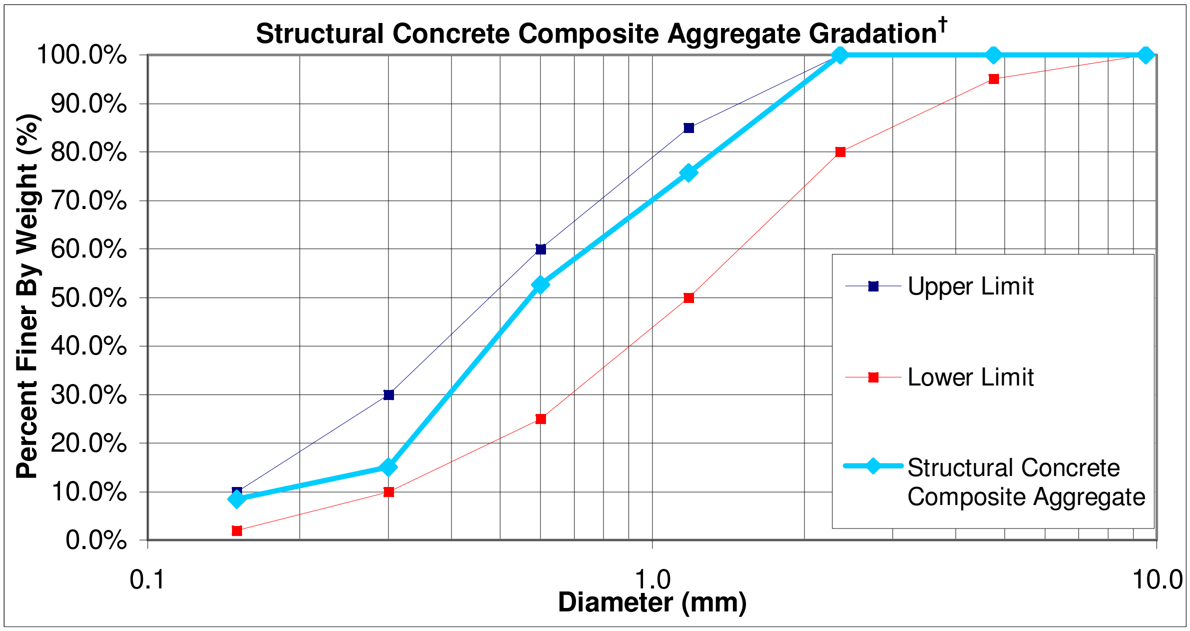



Siscor 0.5-1.0 mm Gradation
Upper Limit
Lower Limit
Siscor 0.5-1.0 mm
Percent Finer By Weight (%)
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0.1
1.0
10.0
Diameter (mm)

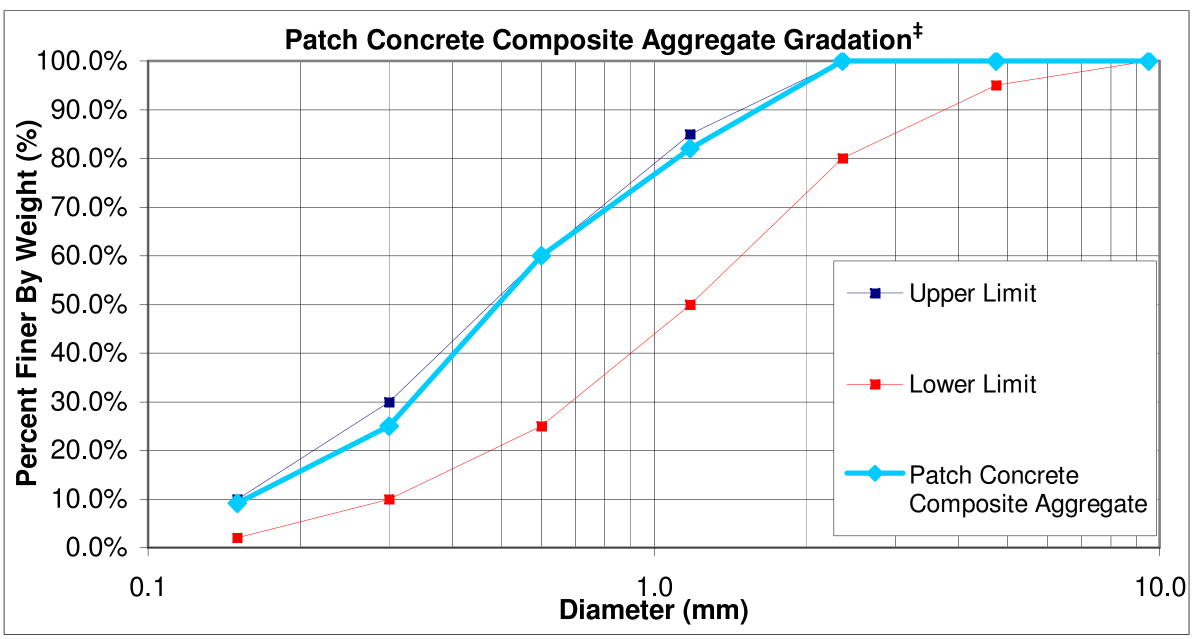

Siscor 0.25-0.5 mm Gradation
Upper Limit
Lower Limit
Siscor 0.25-0.5 mm
Percent Finer By Weight (%)
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0.1
1.0
10.0
Diameter (mm)


Siscor 0.1-0.3 mm Gradation
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Percent Finer By Weight (%)
0.1
1.0
10.0
Diameter (mm)
Upper Limit
Lower Limit
Siscor 0.1-0.3 mm


3M K20 Gradation
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Percent Finer By Weight (%)
0.1
1.0
10.0
Diameter (mm)
Upper Limit
Lower Limit
3M K20 (Glass Bubbles)



†Blend Ratio is 30.9% Siscor 1-2 mm, 29.4% Siscor 0.5-1.0 mm, 29.7% Siscor 0.25-0.5 mm, 3.6% Siscor 0.1-0.3 mm, 6.3% 3M K20



‡Blend Ratio is 23.0% Siscor 1-2 mm, 30.1% Siscor 0.5-1.0 mm, 26.6% Siscor 0.25-0.5 mm, 14.3% Siscor 0.1-0.3 mm, 6.0% 3M K20

REPAIR PROCEDURE REPORT

School Name:	University of Nevada, Reno
Canoe Name:	Cerulean
Team Captain(s):	Nick Maxon, Christine Harms
Date of Request:	5/3/2007

Description of Cause:
The damage to *Cerulean* was caused by an accidental collision with UC-Berkeley's canoe, *Bear Force One*. The incident occurred upon completion of the coed sprint race.

Description of Repair:
The proposed repair is a patch to replace the 1" x 1" piece of concrete that was chipped off Cerulean's bow in the collision. The patch will be sanded to shape after the concrete has been allowed to cure, and two coats of an approved sealer will be applied to match the original finish.

Materials used in Repair:
The structural concrete developed for Cerulean will be used as the primary material used in the repair. Additionally, an ASTM C-1315 sealer will be applied to the finished surface.

Description of Supporting Documentation:
Univeristy of Nevada, Reno Repair Procedure Report
Structural Concrete Mix Design
MTDS of proposed sealer

CNCCC Disposition			
Date:	*8 May 2007*	Michael Carnivale III	
Request to Repair Canoe:		☒ **Granted**	☐ **Declined**

Reason for Disposition:
The canoe was damaged resulting from a collision with another canoe and was not the result of a durability issue. UNR is granted permission to repair their canoe per their Repair Procedure Report and the 25-point deduction on Final Product at the National Competition has been waived

This report, CNCCC disposition, and supporting documentation shall be included in Appendix D of the Design Paper. Failure to do so will result in a 25-point deduction from the Design Paper final score.

Filing this report does not guarantee the school will be granted permission to conduct repairs to their canoe. The ability to do so is a function of the reason for the request and the supporting documentation. Under no circumstances should a school consider a verbal disposition permission to repair their canoe.

If the school is permitted to conduct repairs, that school will receive a 25-point penalty for doing so. The maximum final product points will be reduced to 75 out of 100 points. This penalty may be waived at the discretion of the CNCCC on a case by case basis.

University of Nevada, Reno Repair Procedure Report

Incident Description

The damage sustained to the University of Nevada's 2007 canoe, *Cerulean*, took place at the conclusion of the coed sprint race at the Mid-Pacific Conference Competition in an accidental collision with the University of California, Berkeley's *Bear Force One*. The lane assignments established by the host school, Santa Clara University, resulted in Nevada being assigned to Lane 2, and UC-Berkeley assigned to Lane 3. As both school's made their way back towards the finish line, *Cerulean* ended up on the extreme left side of Lane 2 and *Bear Force One* ended on the extreme right side of Lane 3. *Bear Force One* crossed the finish line several seconds before *Cerulean*, and continued drifting to the right upon completion of the race, into Lane 2. *Cerulean*'s paddler's took notice of the errant canoe as they neared the finish line, and veered left in an attempt to miss *Bear Force One*, consequently crossing the finish line on the wrong side of the final buoy. Moments after crossing the finish line, the two canoes collided, with neither school successfully able to avoid the collision, although all attempts were made. *Cerulean* struck *Bear Force One* several feet aft of center, almost perfectly perpendicular. The conference judges ruled the collision and interference accidental, and granted Nevada the opportunity to re-race the event, determining that the effort of trying to avoid the collision was the cause of finishing on the wrong side of the buoy.

Damage Description

Cerulean suffered minor damage as a result of the collision. As shown in the pictures below, a 1" x 1" piece of the bow was knocked off at the gunwale in the collision. Minor scrapes and chips are also present on the bow below the gunwale. Inspection of the rest of the hull has not revealed any more damage; all of the damage is concentrated in the bow of the canoe. Please refer to Figures 1 and 2 below for pictures of the damage on *Cerulean*, and Figure 3 for the damage sustained by *Bear Force One*.

Fig 1: Damage to the bow of *Cerulean* (note the scrapes at the bottom)

Fig 2: Damage of *Cerulean*

Fig 3: Damage caused to *Bear Force One* in the collision

Proposed Repairs

Upon permission to repair granted by the CNCCC, the University of Nevada would like to re-build the piece of the bow that was damage/lost during the accident. Additionally, minor touch-ups in the form of small patches are proposed to fix the minor scrapes and chips on the bow, below the gunwale. The materials that would be used for the repair is the structural concrete mix (see attached mix design) that was developed for *Cerulean*, as well as two coats of sealer on the new concrete upon completion of concrete curing.

The proposed method of repairing the damaged portion of the canoe would proceed similarly to the methods used for patching. The existing surface is to be slightly scoured to help improve bond between the patch and the new concrete. The existing surface would then be brought to a saturated surface dry condition to help promote bond. Concrete would then be hand placed, and slightly overbuilt to allow for sanding and forming the bow/gunwale shape after the concrete had been allowed to cure for 7 days. After sanding of the canoe is complete, two layers of an ASTM C-1315 sealer (see attached MTDS) would be applied to match the existing concrete surface. The undamaged portions of the boat will be taped off to ensure that sealer will not be applied to any other portion of the canoe. Since no acid stain is located on the bow, touch-ups will not be necessary.

We appreciate the Committee on National Concrete Canoe Competitions consideration of the proposed Repair Procedure Report.

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Project Manager
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Email: nevadacanoe@gmail.com

Dr. David Sanders
Nevada ASCE/AGC Faculty Advisor
Phone: (775) 784-4288
Email: sanders@unr.edu

Appendix B: Mixture Proportions

2007 Concrete Canoe Mix Design

Structural Concrete Mixture

Batch Size (ft^3): 0.326

Cementitious Materials	Specific Gravity*	SSD Proportions as Designed: Amount (lb/yd^3)	SSD Proportions as Designed: Volume (ft^3)	Actual Batched Proportions: Amount (lb)	Actual Batched Proportions: Volume (ft^3)	SSD Yielded Proportions: Amount (lb/yd^3)	SSD Yielded Proportions: Volume (ft^3)
1. ***Portland Cement, Type I, (White)***	3.15	429.29	2.184	5.18	0.026	427.28	2.174
2. ***Fly Ash, Class F***	2.6	132.09	0.814	1.59	0.010	131.47	0.810
3. ***Metakaolin***	2.68	99.07	0.592	1.20	0.007	98.60	0.590
Total of All Cementitious Materials		660.44	3.591	7.97	0.043	657.35	3.574
Fibers							
1. ***Nycon PVA Fibers***	1.30	21.90	0.270	0.26	0.003	21.80	0.269
Aggregates							
1. ***Siscor 1-2 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.46	147.85	5.385	1.78	0.065	147.16	5.360
2. ***Siscor 0.5-1.0 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.58	140.59	4.023	1.70	0.049	139.93	4.004
3. ***Siscor 0.25-0.5 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.78	142.10	3.036	1.72	0.037	141.44	3.022
4. ***Siscor 0.1-0.3 mm*** Absorption: 4.0% Batched Moisture Content: 0.0%	0.94	17.05	0.304	0.21	0.004	16.97	0.302
5. ***3M K20 (Glass Bubbles)*** Absorption: 0.0% Batched Moisture Content: 0.0%	0.20	30.32	2.429	0.37	0.029	30.17	2.418
Total of All Aggregates		477.91	15.177	5.77	0.183	475.67	15.106
Water							
Batched Water	1.0	325.95	5.224	3.94	0.063	324.43	5.199
Total Free Water from All Aggregates	1.0	-17.90	-0.287	-0.22	-0.003	-17.82	-0.286
Total Water from All Admixtures§	1.0	22.17	0.355	0.27	0.004	22.07	0.354
Total Water		330.22	5.292	3.99	0.064	328.68	5.267
Admixtures	% Solids	Amount (fl oz/cwt)	Water± in Admixtures (lb/yd^3)	Amount (fl oz)	Water± in Admixtures (lb)	Amount (fl oz/cwt)	Water± in Admixtures (lb/yd^3)
1. ***Adva Cast 555 (HRWR)***	36.0%	36.2	10.672	2.9	0.129	36.0	10.622
2. ***Micro-Air (AEA)***	5.0%	13.7	6.722	1.1	0.081	13.6	6.691
3. ***Adva 170 (HRWR)***	65.0%	26.4	4.776	2.1	0.058	26.3	4.754
4. ***GST 1200 GX (Specialty Fiber Disperser)*** †	100.0%	25.6†	0.000	2.0	0.000	25.5	0.000
Cement-Cementitious Materials Ratio		0.65		0.65			0.65
Water-Cementitious Materials Ratio		0.50		0.50			0.50
Slump, in.		0.0		0.0			0.0
Air Content, %		10		6			10
Density (Unit Weight), lb/ft^3		56.37		56.24			56.17
Gravimetric Air Content, %				10.20			
Yield, ft^3		27.0		0.3			27.0

* 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.

† Denotes solid admixture; units shown are oz/cwt or oz, where appropriate

University of Nevada, Reno Concrete Canoe

DAYTON SUPERIOR®
Chemical & Cement Products

Technical Data

SAFE CURE & SEAL™ 25% (J-22 WB)

Water Base Acrylic Cure, Seal and Dustproofer V.O.C. COMPLIANT

PRODUCT DESCRIPTION:

Safe Cure & Seal 25% is a water based acrylic copolymer containing 25% solids that offers outstanding curing, sealing and dustproofing for freshly finished concrete surfaces. The high solids content will form a long lasting surface coating with a high gloss finish and it will provide excellent cure performance. This product dries to produce a non-yellowing, durable, clear film on concrete. Safe Cure & Seal 25% is ideal for interior applications because it is free of noxious fumes and it is non-flammable.

PURPOSE:

Safe Cure & Seal 25% is a convenient, safe to use product that surpasses the ASTM C-309 & ASTM C 1315 specifications as a superb membrane forming curing compound and it is an excellent dustproofer and surface sealer. It is designed for interior and exterior use on both freshly finished and older concrete surfaces. Safe Cure & Seal 25% will resist many chemicals, help protect against staining and allows for easy removal of mortar splatters.

ADVANTAGES:

- Water Based
- High Solids Content
- High Gloss Sealer & Dustproofer
- Low Odor, Ideal for Interior Applications
- Non-Flammable
- Easy Clean Up with Water
- Good Chemical and Stain Resistance
- Interior/Exterior

MEETS SPECIFICATIONS:

ASTM C-156 (Method of testing for ASTM C-309)
ASTM C-309, Type 1, Class A & B
AASHTO M-148, Type 1, Class A & B
ASTM C 1315, Type I, Class A
Note: Federal Specification TT-C-800A has been cancelled and is officially replaced by ASTM C-309. Safe Cure & Seal 25% 30% (J-19) meets the obsolete specification TT-C-800A.

V.O.C. CONTENT

Less than 350 g/l. Complies with Federal EPA & OTC Standards for Concrete Curing Compound.

APPLICATION INSTRUCTIONS:

Fresh Concrete:
Apply when all free water has disappeared and surface cannot be marred. Do not delay in applying Safe Cure & Seal 25%. Use low-pressure spray, roller or brush. Do not thin. Apply uniformly without puddles. The second coat, which is optional, will provide a longer lasting surface coating with a higher gloss finish.

Old Concrete:
Clean and restore surface as required. Apply two uniform applications as above. Allow first coat to dry before applying second coat.

APPROXIMATE COVERAGE:

	FT² per Gallon	M² per Liter
Curing	300	7.4
Sealing	200 – 400	4.9 – 9.8
Second Coat	400 – 600	9.8 – 14.7

Texture and absorption of surface will influence final coverage rates.

DRY TIME:

Approximately 2-3 hours at 70°F (21°C) for recoating or light traffic. Wait 12 hours for heavy traffic. Dry time is temperature, wind and humidity dependent.

PACKAGING:

5-gallon (18.9L) pails and 55-gallon (208L) drums.

CLEAN UP:

For tools and equipment use warm soapy water.

LIMITATIONS:

This product should not be used at temperatures below 40°F (4°C).
Do not apply concrete or mortar toppings over sealed surfaces.
Avoid spraying Safe Cure & Seal 25% into joint prior to installation of sealant.
May show rubber tire marks.
Do not allow the stored product to freeze.

WARNING:.

- Use with adequate ventilation
- Keep out of reach of children
- Do not take internally
- In case of ingestion, CALL A PHYSICIAN immediately. Do not induce vomiting.

If splashed in eyes, flush thoroughly with water for a minimum of 15 minutes. CALL A PHYSICIAN immediately. May cause irritation to the skin. If brought into contact with the skin, wash thoroughly with soap and water. Seek medical attention if redness or soreness occurs. Avoid breathing vapors or mist. Keep away from heat, sparks, open flames and other possible sources of ignition. Reseal container after each use. Wear protective clothing, gloves and goggles. Safe disposal of rags is necessary to avoid possibility of spontaneous combustion. Read MSDS before using product.

TECHNICAL SERVICES:

Contact the technical staff for assistance at:
1-866-329-8724 • 1-913-233-1750 • FAX: 1-913-279-4806
daytonsuperiorchemical.com

WARRANTY

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Dayton Superior Specialty Chemical Corp. (DSSCC) warrants, for 12 months from the date of manufacture or for the duration of the published product shelf life, whichever is less, that at the time of shipment by DSSCC, the product is free of manufacturing defects and conforms to DSSCC's published specifications in force on the date of acceptance by DSSCC of the order. DSSCC shall only be liable under this warranty if the material has been applied, used, and stored in accordance with DSSCC's instructions in this technical data sheet.

The purchaser must examine the product when received and promptly notify DSSCC in writing of any non-conformity before the product is used, or no later than 30 days after such non-conformity is first discovered. If DSSCC, in its sole discretion, determines that the product breached the above warranty, it will, in its sole discretion, replace the non-conforming product, refund the purchase price or issue a credit in the amount of the purchase price. This is the sole and exclusive remedy for breach of this warranty.

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