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ASCE 2011 National Concrete Canoe Competition

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The Concrete Canoe competition began in the United States in the 1960s, when a few ASCE student chapters began racing concrete canoes in small intramural races. It has since grown into a national event that draws more than 280 student chapters each year. Each canoe must be in compliance with very strict national rules and regulations, and is then scored based on four major criteria: Final Product (25%), Races (25%), Technical Paper (25%), and Oral Presentation (25%). This year, the American Society of Civil Engineers (ASCE) Student Chapter at IPFW compiled the knowledge and skills of its members to complete a 20 foot long, buoyant canoe made of lightweight concrete. The canoe will be taken to the Regional 2011 ASCE Concrete Canoe Competition in Milwaukee, WI to compete against 15 other regional universities that have been participating in this conference for many years.

One of the most challenging aspects of the competition is getting a canoe made of concrete to float. As the dimensions for the canoe are set each year by the National Concrete Canoe Committee (NCCC), the only available option to achieve the necessary buoyancy is lightweight concrete. Lightweight concrete is typically composed of lightweight aggregates, Portland cement, water, and air. The lightweight aggregate used in the canoe is required to be at least 50% sustainable materials. However, the two aggregates used in the IPFW canoe are composed of 100% sustainable materials. Expanded shale composed 75% of the total aggregates in the concrete. Shale can be used as an aggregate in normal weight concrete before it is heat treated. It has been previously discovered that the thermal process that bloats the materials results in a product that increases the volume, reducing the amount that needs to be mined and allows for shipping of a lighter material, lowering the amount of energy needed for transportation. The other sustainable aggregate used is microsphere glass beads that are environmentally friendly fillers, made from recycled glass. The beads are very light, yet pressure resistant, which allows for optimum use in this application.

In order to achieve the hydrodynamic design necessary to race a 20 foot concrete canoe, the canoe skeleton must not only be made of lightweight concrete, it also must be very thin. The concrete mixture for the canoe was based on creating a malleable, lightweight concrete that would be able to withstand the forces that canoes undergo, while being light and buoyant enough to float when four people are racing it. The walls of the canoe are designed to be approximately 1 - 1.5 inches thick in order to meet the weight required to float. A thin layer of steel mesh is used to reinforce the canoe concrete to prevent cracking. This small thickness was designed based on the fundamentals of mechanics, structures, and reinforced concrete design to withstand the anticipated stresses. Finite element simulations were also conducted to verify that the expected induced stresses will not exceed the tensile strength of the concrete for the used thickness. To achieve the strength and bonding necessary, a mixture of cementitious materials is used along with latex. The mixture of cementitious materials is composed of Type I Portland cement (50%), fly ash (20%), slag (20%), and silica fume (10%). The use of latex allowed for superior bonding and increased malleability. In addition, the polymerized latex creates a membrane in the concrete that will prevent water intrusion during racing. Due to the high tensile stresses expected in the canoe, polypropylene fibers were used to increase the tensile strength of the concrete.

Specimens were taken from the concrete mix to verify the fresh and hardened properties including compressive strength, tensile strength, air content, and unit weight of the canoe concrete. The 28-day compressive strength was found to be greater than 3000 psi, the tensile strength was more than 300 psi, air content was approximately 10%, and the un it weight was 69 lb/ft^3, just within the target range of 65 – 70 lb/ft^3. It is important to remind that this is the first IPFW concrete canoe and many lessons were learned while fabricating this canoe. This is simply the foundation for many canoes to come with greater potential for success.