Western Michigan University Concrete Canoe Team Stays Afloat with Abaqus

Western Michigan University's student chapter of the American Society of Civil Engineering (ASCE) recently used Abaqus to enhance their competitiveness in the 2008 North Central Regional Conference of the National Concrete Canoe Competition. The competition is designed to provide civil engineering students an opportunity to gain hands-on project management experience and leadership skills by working with concrete mix designs and computer-aided engineering tools. It has challenged the knowledge, creativity, and stamina of more than 400 teams and 5000 students throughout its 20-year history.

The Western Michigan University team's entry, a concrete canoe dubbed *Meridian*, was modeled and analyzed in Abaqus under hydrostatic pressure load. In a departure from previous competitions, the students built finite element models of various canoe configurations and performed structural analysis to identify critical stress zones and optimize the hull thickness of their canoe.

After studying several configurations, the students established Meridian's length at 18.5 feet. This length was shorter compared to previous years' entries, and was selected to improve maneuverability and lower the overall weight. The length was calculated by allotting 3.5 feet of space per rower, with 2.25 feet of bow and stern to be left unused. The maximum width of the canoe was determined to be 28 inches, with a depth of 16 inches and a hull thickness of 0.875 inches.

Figure 3: *Meridian* (left) just after removing the forms and (right) during finishing

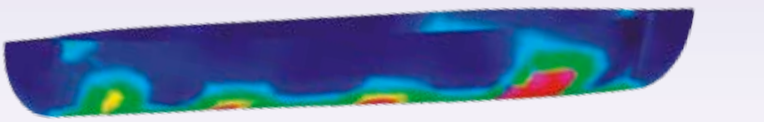

Figure 1: Stress contours

Figure 2: Displacement contours

Figure 4: *Meridian* in the race

Matt Czachowski developed the finite element model, which contained 809 shell elements, and then used Abaqus to run the analysis under hydrostatic pressure with the guidance of Dr. Upul Attanayake, Assistant Professor of Civil and Construction Engineering. The estimated total weight of the rowers and the canoe was 1,050 pounds, and the racing depth was 8 inches. The highest level of stress was located on the hull, where the paddlers' knees were placed (Figure 1). The largest of these was located in the bulge of the canoe—toward the stern—and was of a magnitude of 80 psi tensile stress. The magnitude of the deflection was not controlling with estimated modulus of light weight concrete of 300 ksi. Figure 2 illustrates the displacement contours.

After careful consideration of structural behavior and the level of stress under expected hydrostatic pressure loads, the students decided to make four structural ribs, located approximately 4 inches behind each paddler's knees, for structural reinforcement. The ribs were designed to dissipate tension in the composite concrete layers along the hull, and also to act as cantilevered supports that would resist deflection and bending in the hull (Figure 3). Finally, *Meridian* was built with a concrete mix that had an average density of 56.1 pcf, compressive strength of 700 psi, and tensile strength of 250 psi. The weight of the canoe was 252.5 pounds.

The Western Michigan University Concrete Canoe Team took third place in the women's endurance race, as well as fourth place in all the remaining events (Figure 4). They plan to continue leveraging Abaqus to further improve their canoe design for future competitions.

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