The Effects of Cavitation Due to Pulses Propagating Through a Fluid-Filled Crack

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Background and Motivation

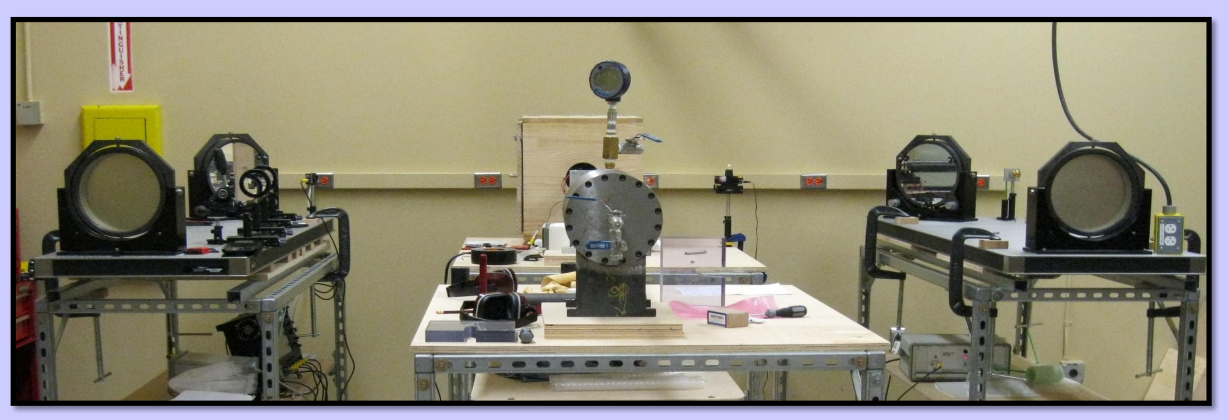
High energy loads can create waves that propagate through the ocean and impact solid structures (e.g. coastal buildings, the Earth's crust) at various speeds. Such shock waves can damage a structure upon impact, creating cracks along its surface. **Cracks serve as nucleation sites for water to vaporize to cavities. Bubbles have the potential to rupture, or cavitate, at high pressures and emit more liquid jets and shockwaves.** Such cavitation can yield more damaging results to the structure, to what extent of which has not been thoroughly researched yet.

Idea

It is of interest how cavitation and overall fluid-structure interaction affect crack behavior. Polycarbonate samples with cracks were filled with varying levels of water, and a pressurized gas gun was used to simulate shock impact. Both single-frame and high-speed photography were used to capture the moments of impact. **By examining crack propagation due to shock-induced cavitation, we can assess the strength of structures** and suggest viable options that can be done to avoid damage.

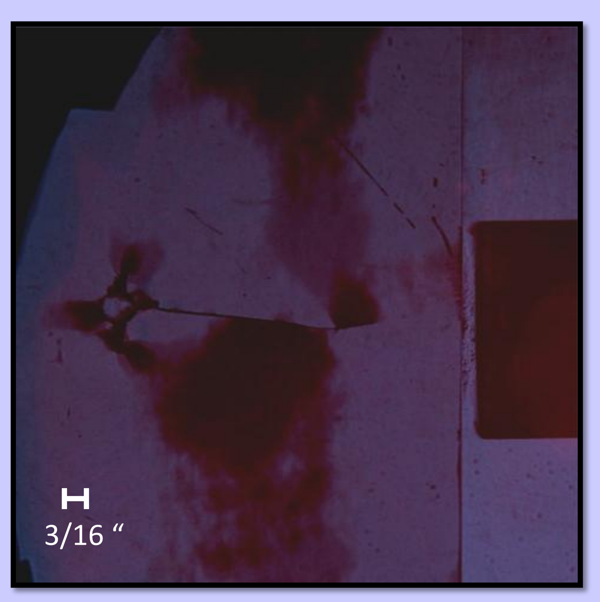
Experimental Setup

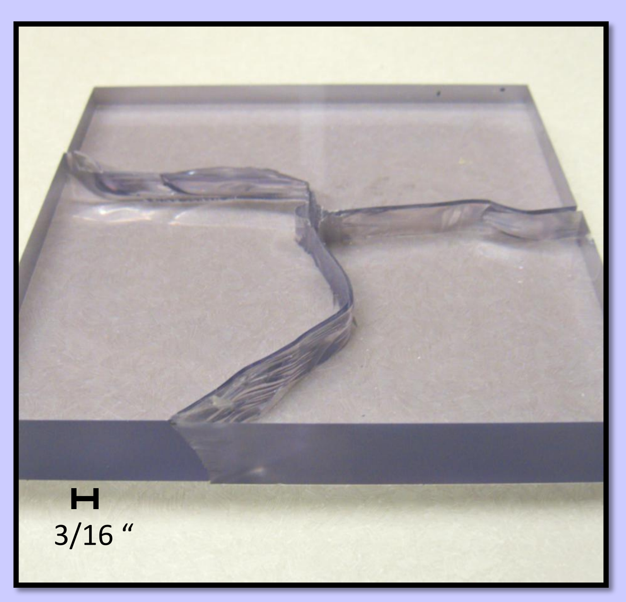
The setup replicated shock impact onto a solid structure and capture images of shock wave propagation. It consisted of a pressurized gas gun and a wooden "catcher box" to contain the test samples, an optical system to assist in Schlieren photography, and velocity sensors. A cylindrical bullet (2 inch diameter) was used to impact each sample from the edge. A laser, spark source, delay generator, and digital oscilloscope were synced to trigger the single-frame camera and capture the moment of impact.



Case 1

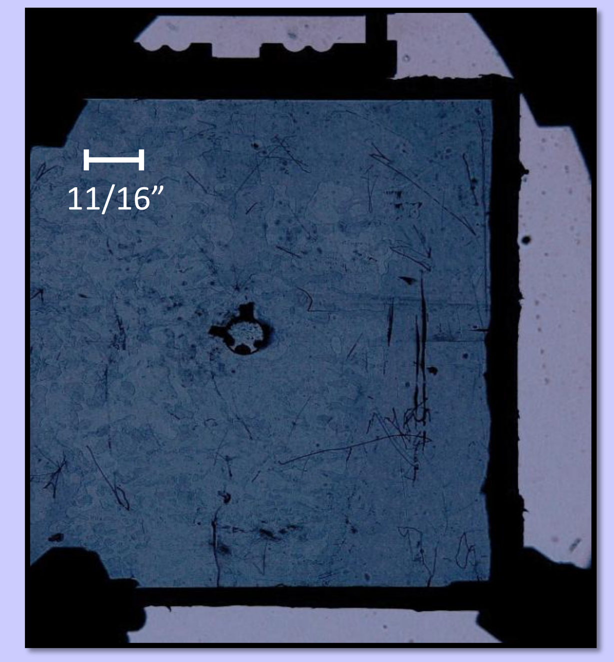
A simple polycarbonate sheet with a machined crack was shot to examine wave interaction with crack growth.

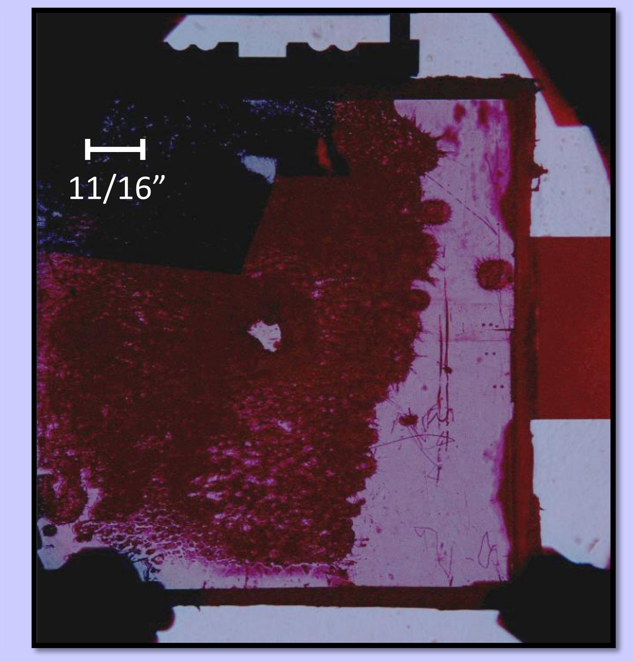


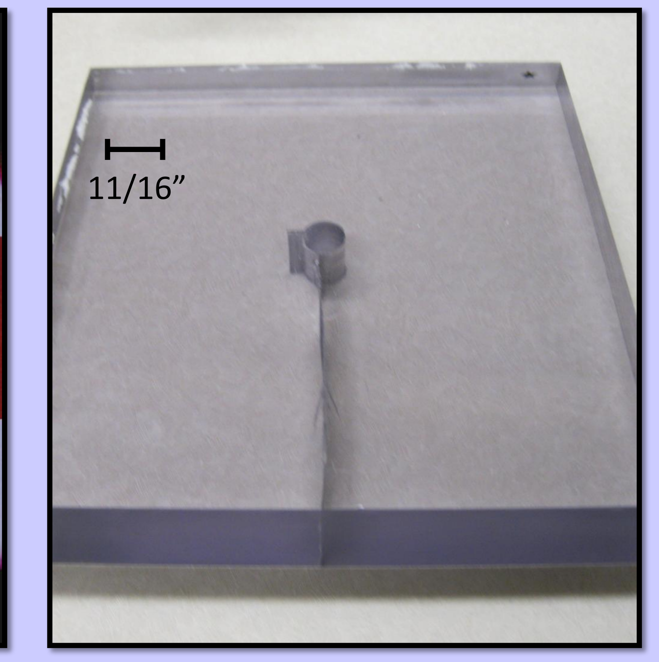


Case 2

Two polycarbonate sheets were placed on both faces of the sample to contain water in the crack. Silicon adhesive was used to glue the cover material to the sample.

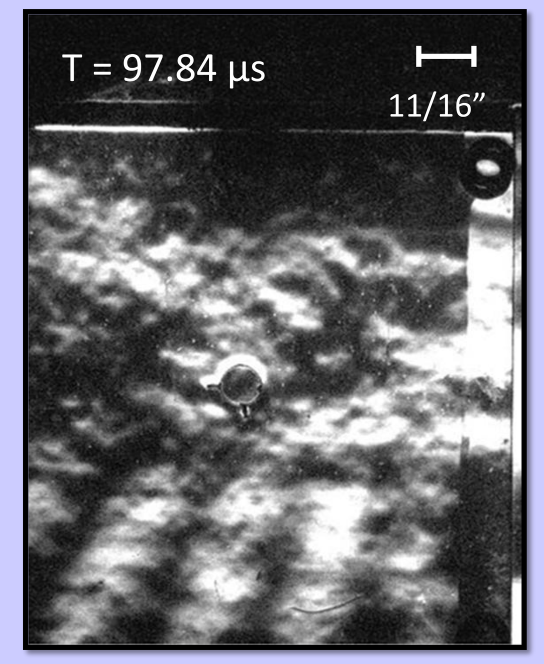


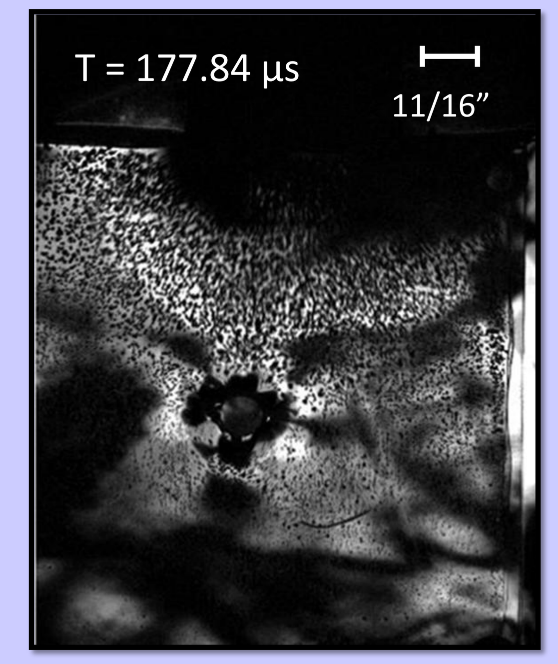


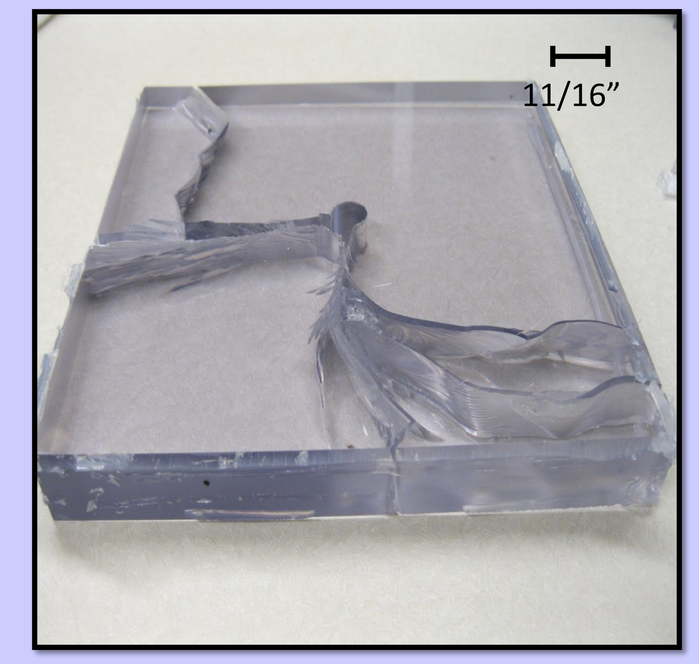


Case 3

Washers were placed at each corner of the sample on both sides, and two polycarbonate sheets were adhered to both faces of the sample using silicon adhesive. The washers enabled for more water to fill the sample.

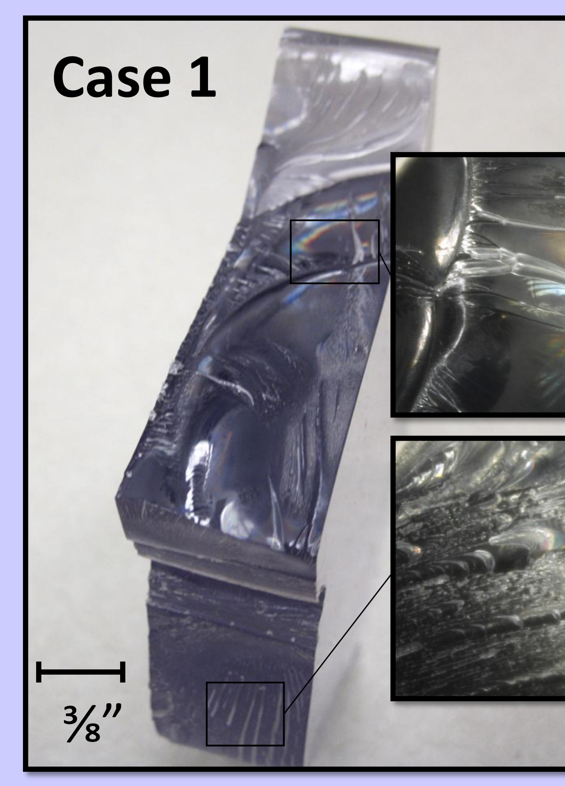


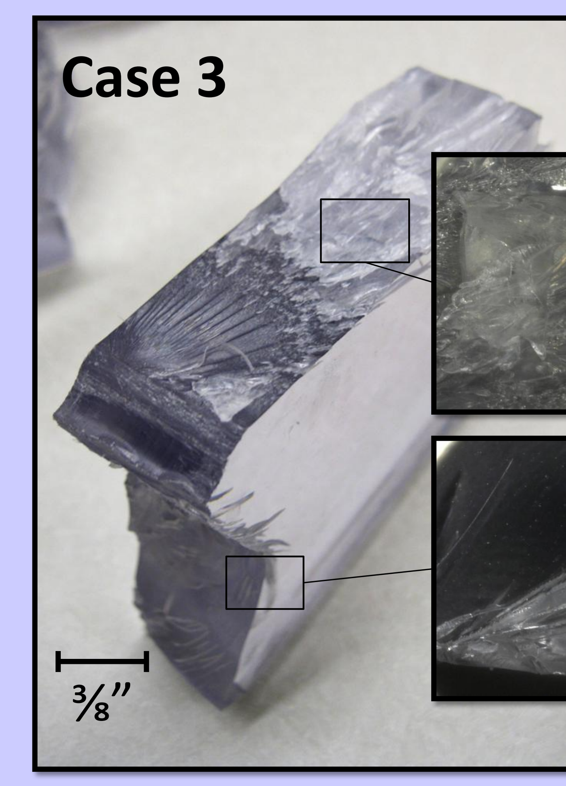




Fracture Surface Analysis

From examining the fracture surfaces of samples, it was observed that while the surface for Case 1 was more smooth and mirror-like, the surface for case 3 was much rougher and featured more secondary cracks, or "hackle fringes."





Conclusions and Future Work

This experiment was designed to analyze and compare the behavior of crack growth in solid structures. From the case studies presented, it was observed that the addition of more water led to greater damage of the samples. **Fracture surface analysis has led us to hypothesize that cavitation increases the crack velocity.** More test runs are necessary to confirm if these observations are consistent. Photo-elasticity and caustics are two additional visualization methods that will be used to understand crack growth and aid in developing a model to measure crack velocity.

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