

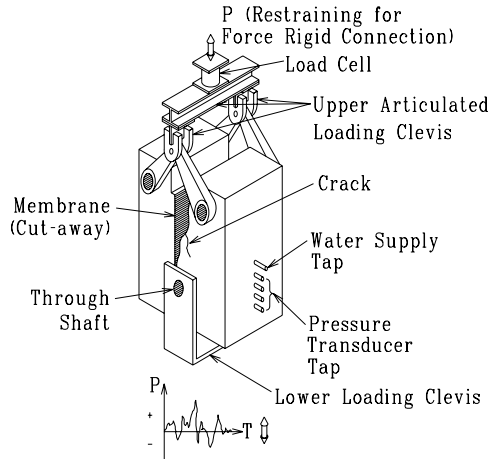
# Fluid-Fracture Interaction Studies

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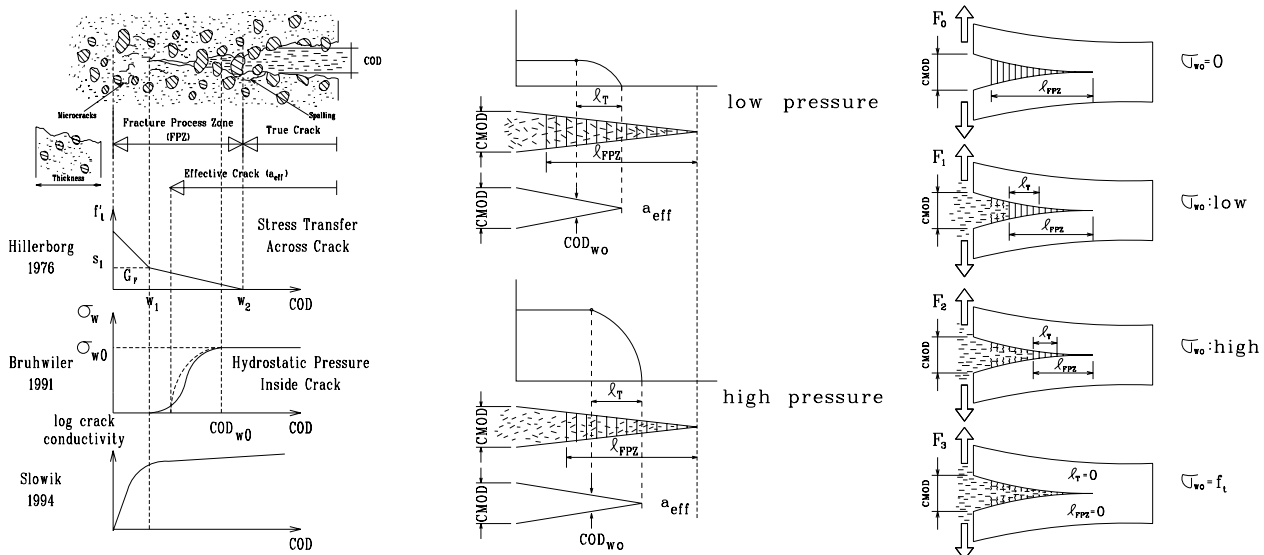
As part of an industry funded project (Electric Power Research Institute), the static and dynamic interaction between fluid and fracture was investigated. Two experimental set-ups which allowed static and dynamic crack opening (with imposed crack opening and closure) were adopted.

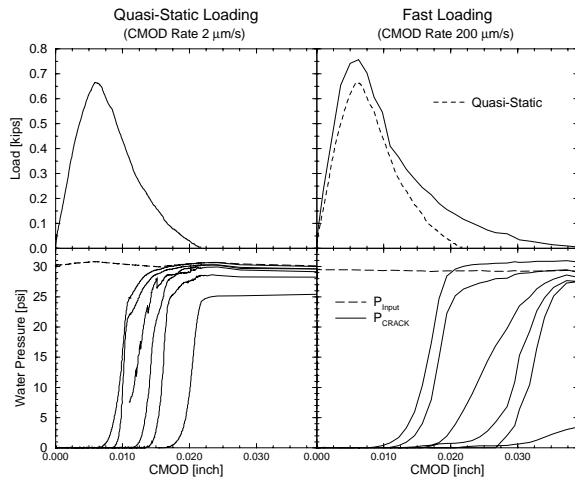


Some of the fundamental questions addressed were: What is the hydrostatic pressure in a crack? Is it a function of crack openings? Would the hydrostatic pressure affect the crack resistance to growth? What happens to the bond stress in reinforced concrete structures in the presence of fluid pressure? During an earthquake what are the velocities of a concrete crack in a dam and the one of the water? During sudden crack opening is there a negative pressure? during sudden crack closure what happens to the water inside a crack? what is the conductivity of a concrete crack in terms of its openings?

The tip of concrete is not well defined, and is preceded by a so-called fracture process zone (Hillerborg Model). At the tip of the fracture process zone, the tensile stress is equal to  $f'_t$ , and gradually decreases to zero once the crack opening displacements reach a critical value (depending on the stiffness of the structure, this zone may be quite large).

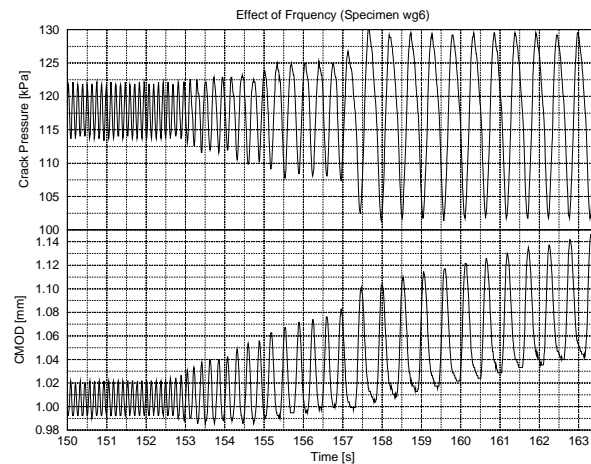
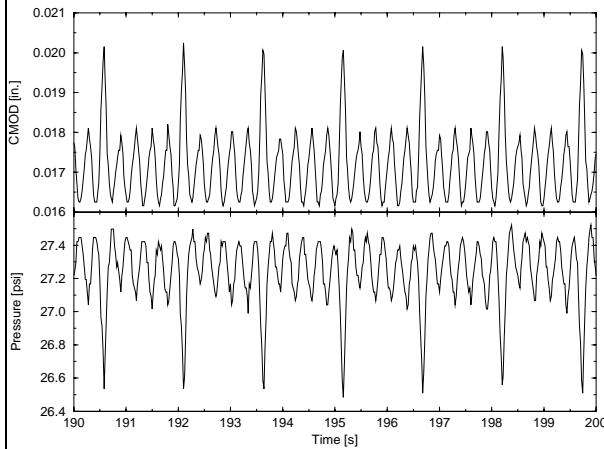
For static tests, it was found that 1) hydrostatic pressure depends on the crack openings, 2) pressurized water will reduce the fracture resistance to growth (Brühwiler).



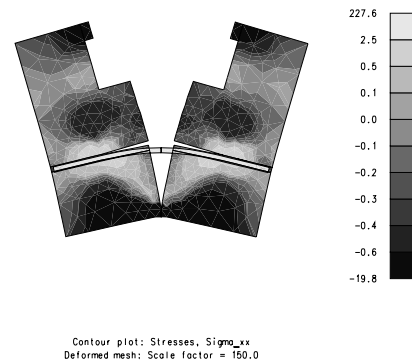
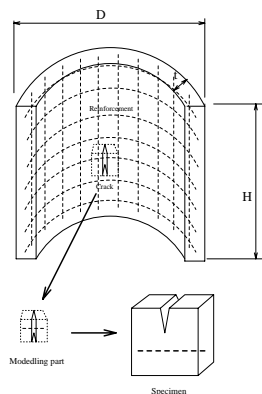


Some of the major results: crack front and water fronts travel at different velocities during an earthquake; In the most extreme cases, we may neglect any hydrodynamic forces, in other (slow loading) these are present. There can be negative pressure (cavitation) during sudden crack opening; there is a “wedge effect”, i.e. the water is trapped inside the crack during impact crack closure which may lead to very high tensile stresses in other locations; pressure variation depends on the load frequency. A numerical model has been developed to account for all those effects.

Also measured was the relationship between the crack permeability in terms of the crack opening displacements.



Finally, tests were also conducted on reinforced concrete specimens.



Whereas this research was conducted to study the safety of concrete dams subjected to earthquake, its results can be of potential interest in the safety assesment of cracked concrete offshore structures, safety of cracked concrete containers of hazardous wastes, freezing and thawing of concrete slabs.

Brühwiler, E., and Saouma, V. **The Effect of Hydrostatic Pressure on the Fracture of Concrete**, EPRI Technical Report TR-105823, November 1995

Saouma, V. and Slowik, V. **Cyclic, Dynamic and Hydrodynamic Fracture Response of Concrete**, Report (in preparation)

Brühwiler, E., and Saouma, V.E., **Water Fracture Interaction in Cracked Concrete; I Fracture Properties**, *ACI Materials Journal* Vol. 92, No. 3, pp. 296-303, 1995

Brühwiler, E., and Saouma, V.E., **Water Fracture Interaction in Cracked Concrete; II Hydrostatic Pressure in Cracks**, *ACI Materials Journal*. Vol. 92, No. 4, pp. 383-390, 1995