High Performance Computing for Concrete Fatigue Failure in Poro-Elastic Media

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The fatigue behavior of concrete with high moisture content has become an important subject of interest with the expansion of offshore wind energy systems. Investigations in the literature indicated that the numbers of cycles to failure significantly decreases with the increased moisture content in concrete. This work presents a novel variational phase-field model for modeling water-induced failure mechanisms due to the cyclic loading in concrete. As a key feature, the fatigue-induced fracture is formulated based on the accumulation of the bulk energy in time, and so a critical stress state (which indicates the crack initiation) will be drastically reduced [1].

These failure mechanisms are coupled to fluid flow, resulting in a Darcy-Biot–type hydromechanical model [2]. Here, the model employs a micromechanics-based theory for description of specific fracture driving state function to model compression/shear regime in concrete. As another important feature, the model includes a non-associative frictional plasticity law which is suitable for the concrete [3, 4]. Numerical results confirmed that the fatigue effect results in the reduction of the crack resistance for the water-saturated case in comparison to the dry test. So the number of cycles to failure for both dry and fully saturated cases are analyzed over the degradation process.

Finally, the complete failure state of the specimen is further examined with an experimental observation to verify the proposed model. To do so, the influence of the loading frequency on the fatigue behavior of concrete has been investigated. This has been done for both dry and fully saturated media. We observed that the failure of high concrete moisture contents is more pronounced for lower load frequencies. This is further investigated through our proposed numerical formulation, and validated with experiment.

References

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