Peridynamic modeling of fracture and damage in porous rock and concrete

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Failure in porous and heterogeneous materials like concrete has been difficult to simulate with computer models. Once they initiate, cracks in these materials develop in a brittle manner, their direction being significantly influenced by the microstructure: pores, aggregates, etc. Classical homogenization does not work for simulating crack growth in these types of materials, and I will show examples demonstrating that. While failure in these materials is nominally brittle, most existing models in the literature have been of elastoplastic type, with limited success. In this presentation, I will describe the "Intermediately-Homogenized Peridynamic" (IH-PD) models. These models avoid the extremely high cost of approaches that require the specific microstructural geometry, and yet they succeed in correctly predicting fracture evolution in porous rock and concrete, for example, by using only minimal information about the microstructure (e.g. porosity, the volume fraction of mortar/aggregates) in conjunction with linear-elastic and brittle damage constitutive laws. I will show results for the quasi-static and dynamic failure behavior of porous rock, concrete, and transverse loading of fiber-reinforced composites. The models cost the same as fully homogenized models but produce the correct failure modes observed experimentally in discriminating tests. I will conclude with possible future steps that will allow us to simulate large samples in 3D.