DISCRETE MODELING OF QUASIBRITTLE MATERIALS: FRACTURE, FRAGMENTATION AND SIZE EFFECT

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ABSTRACT

Quasibrittle materials include concrete, rock, cemented sands, stiff clays, various ceramics, and fiber composites. They are characterized by material heterogeneity, and inelastic behavior that involves discontinuous displacement fields with strain softening. Quasibrittle fracture can be simulated by either assuming the existence of a discrete cohesive crack embedded in a continuous medium, or by adopting discrete material models which capture the effect of heterogeneity on fracture. Regarding the latter, significant improvements have been made in recent years, and their ability to model quasibrittle fracture is well established. Their main disadvantage is that when applied to simulate continuous media, the ability to calculate key aspects of the elastic continuum is limited. These include the full range of Poisson effect, and the magnitude and direction of principal stresses and strains. Significant improvements have also been made regarding the ability of continuum models (finite element), to embed cohesive cracks, but these methods typically involve complex, and therefore very costly, computational procedures. An overall goal of this thesis is to provide a uniform framework where the main advantages of discrete and continuum modeling are available in one computational setting.

Herein, three different studies which advance the fields of discrete and quasibrittle modeling will be presented. First, the feasibility of using Bažant's size effect law to identify the cohesive fracture parameters of concrete is examined. The calculations will be continuum based, and a classical technique will be utilized where a line of cohesive interface elements is inserted a priori into the mesh. Then, a recently established mesostructural model for concrete, the Lattice Discrete Particle Model, is advanced further by adding fiber reinforcing capability. This is a purely discrete model, and to maintain that nature, individual fibers are randomly located within the mesostructure. Their pullout evolution and crack bridging forces are modeled for the entire length of a simulation. Finally, a discrete model is presented, which in its initial 2D implementation, possesses the positive capabilities of both continuum theory for elastic behavior and discrete modeling for quasibrittle fracture.