# Comparison of interfacial and continuum models for dynamic fragmentation analysis

B. Bahmani, P.L. Clarke, R. Abedi

Brittle (quasit)-brittle materials are rate-dependent due to the significant dependency of their failure energy and failure ultimate load on the load rate. Experimental observations show that increment in the load rate increases both the failure energy and ultimate capacity of the brittle materials. Bulk and interfacial models are two of the main approaches that degradation is modelled in quasi-brittle materials. While the enforcement of specific interface constitutive equations (contact, friction, *etc*.) and loading (hydraulic loading) on crack surfaces is simpler than incorporating such effects with a bulk representation, accurate tracking of crack surfaces is main drawback of these models. We will present an interfacial damage model and a bulk model formulated based on Allix's time-delay evolution model to compare the behavior of these models for problems that initially lack stress concentration points and singularities such as crack tips. Both models are characterized by fracture strength and time scales with the latter dictating a (maximum) rate at which damage can accumulate.

Due to the lack of significant energy dissipation mechanisms in quasi-brittle materials, *e.g.* in comparison to plasticity for ductile materials, their response is highly dependent on microstructural defects. There exist many approaches to involve microstructure effects in numerical simulations, e.g., numerical homogenization and computational homogenization. In large-scale problems, the efficient way of incorporating microscale properties is obtaining the macroscopic properties based on the upscaling of the underlying microstructure and randomness through a numerical homogenization method. In the present work, we use Voronoi tessellation-based statistical volume elements (SVEs) to characterize a scalar fracture strength and damage threshold fields at the mesoscale. The microstructure information is mapped to macroscale equations through the Karhunen-Loeve (KL) method. The KL method constructs the corresponding realizations of the underlying randomness to be used in the stochastic equations of motion and damage.

The purpose of using SVEs, as opposed to more commonly used representative volume elements, is to maintain 1) material inhomogeneity, 2) randomness in macroscopic fracture parameters such as ultimate load and fracture energy. We will focus on aspect 1) in that by using different sizes of SVEs, hence the resolution of realized random fields, we study how fracture patterns are affected for both interfacial and bulk damage formulations. The comparisons are performed for fragmentation simulations under uniform stress field to better demonstrate the effect of material randomness and underlying SVE sizes. The comparisons show how effectively the proposed damage formulation can be considered as a proper candidate in fracture analyses.