A Statistical Volume Element Averaging Scheme for Fracture Analysis of Microcracked Rock

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Abstract

We propose an approach based on statistical volume elements (SVEs) to characterize rock fracture strength at the mesoscale. The microcrack statistics of a Yuen-Long marble is used to develop a simulated two-dimensional material domain for analysis utilizing this process and compared against realistic fracture strengths from material tests. In addition, the crack length distribution type and shape are analyzed using the SVE averaging approach. While the Yuen-Long marble crack length distribution is shown to follow a Power-law distribution, due to the ease of changing the Weibull power parameter to change the crack length distribution shape four different Weibull shape distributions are analyzed. These different crack length distributions are then used in an averaging process to determine fracture strength of SVEs. Further, the effects of changing the SVE size and the domain crack density are investigated. Finally, the given minimum fracture strength fields calculated using the SVE process are used by the asynchronous Spacetime Discontinuous Galerkin (aSDG) method to obtain dynamic fracture patterns for each material microstructure. We derive a macroscopic strain-stress response and homogenize a bulk damage model from aSDG fracture simulations. It is shown that for the same mean crack length, the distributions of crack length with higher variability result in lower mesoscopic minimum averaged fracture strength for SVEs, and subsequently lower macroscopic ultimate stress in a uniaxial tensile example. The distribution of microcrack is also shown to greatly affect developed fracture patterns at the macroscale.