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Brittle Fracturing during Folding of Rocks: A Finite Element Study

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The goal of the present work is the development of a novel computational analysis tool to elaborate folding-induced fracture of geological structures. Discrete failure of brittle rocks is characterized by three sets of governing equations: the bulk problem, the interface problem and the crack problem. The former two sets which define the deformation field are highly nonlinear and strongly coupled. They are solved iteratively within a Hansbo-type finite element setting. The latter set defines the crack kinematics. It is linear and solved in a single post-processing step. To elaborate the features of the computational algorithm, we define a unique benchmark problem of a single, geometrically nonlinear plate, which is subjected to layer-parallel in-plane compression combined with different levels of superposed in-plane shear. The resulting folding, or buckling, induces brittle failure in the tensile regime. By systematically increasing the shear strain at constant compression, we develop crack deviation angle versus shear-to-compression ratio tables. We determine the corresponding damage zones, analyze the folding modes and elaborate the force versus amplification diagrams. The proposed two-field folding-induced fracture algorithm can ultimately be applied to interpret natural folded rocks and understand their evolution, structural development and histology.