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Influence of 3D stress state on the triggering and evolution of shear localization and cataclastic flow in porous rocks

R.I. Borja (1) and J.R. Rice (2)

(1) Stanford University (borja@stanford.edu), (2) Harvard University (rice@esag.deas.harvard.edu)

Under low temperature porous rocks can fail either by deformation band localization or by cataclastic flow. Deformation band localization, including compaction band, results from the coalescence of microcracks leading to a tabular zone of intense deformation, whereas cataclastic flow is characterized by grain crushing and pore collapse resulting in a severely damaged but macroscopically homogeneous compacted continuum. In this work we view the two types of instability as arising from two distinct bifurcation modes. The first mode, predicted from the singularity of the acoustic tensor, produces an indeterminate strain rate tensor with one nonzero eigenvalue and defines a deformation band. The second mode, when abruptly precipitated by pore collapse, may correspond to the singularity of the tangent constitutive operator and produces an indeterminate strain rate tensor with three nonzero eigenvalues (for 3D stress condition). After identifying the relevant bifurcation mode, we present a framework for capturing post-failure responses through constitutive branching. The post-collapse constitutive response features a cohesion softening-friction hardening applied either to an emerging fault for shear localization or to the bulk constitutive theory for pore collapse instability. The formulation is carried out under a general 3D state of stress and highlights an elastoplastic constitutive model for porous rocks that incorporates all three invariants of the stress tensor. In particular, we focus on the role of the intermediate principal stress on the triggering of deformation band localization that otherwise would not be captured with a two-invariant constitutive model.