Shear Strain Localization and Fracture Evolution in Rocks

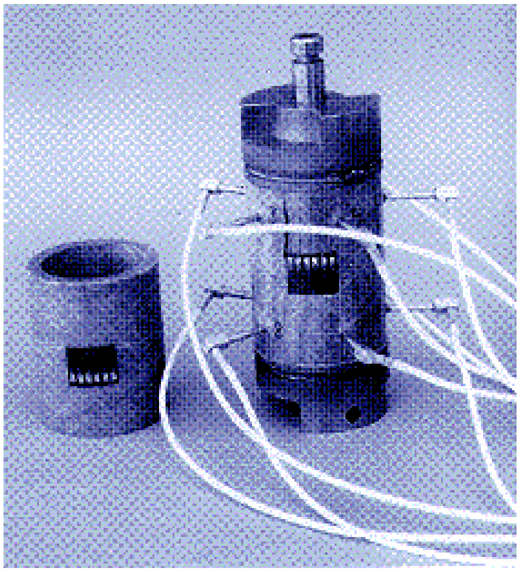
Need

Shear strain localization as a precursor to faulting and macroscopic fracture of rock is being studied with combined experimental and analytical techniques. The investigation focuses on the applicability to fracture formation of a theory that describes faulting as a constitutive instability leading to a localization of shear deformation from a homogeneous pattern into a thin tabular zone. The main goals of this work are to: (1) determine the onset of localization in experiments, (2) measure critical constitutive parameters, and (3) test the main predictions of the theory. A correlative objective is to use these studies to assess constitutive relations for multiaxial, inelastic rock deformation and to provide a framework for the use of these constitutive models in numerical simulations of geologic and man-induced processes in the earth.

Description

One prediction of the theory is that materials that vertex harden, show a higher propensity for instability. Unique zig-zag stressing tests on rocks have shown that vertices develop on the yield curves both for sandstones and a marble. Therefore, faulting cannot be predicted by classical failure criteria such as Mohr-Coulomb; more comprehensive constitutive models must be implemented for rocks and other frictional cohesive materials.

Zones of pure compaction and severely reduced porosity and permeability called compaction bands were experimentally induced in Castlegate sandstone, and an analysis of their formation in terms of strain localization theory was carried out. The theory predicts that internal friction, and the evolving values of Poisson's ratio and the dilatancy factor control the formation of compaction bands. Futher study is underway because of the potential impact these structures can have on oil and gas reservoirs and aquifers.



Thin-Walled Rock Cylinder Before Torsion Test Under Pressure.

Critical constitutive parameters for marble have been measured and a constitutive model developed that captures the hardening, softening and dilatant behavior under conventional triaxial stress states. Using the constitutive model, the predicted behavior of the marble for more general stress paths was modeled. Localization is predicted to occur post-peak for the triaxial stress state, but pre-peak for plane strain tests. One surprising result was that significant plastic strain is predicted to occur in the out-of-plane direction for plane strain deformation.

References

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