Initiation of instability on a plane fault system under slip dependent friction

Abstract

We study an unstable elastodynamic process during the initiation phase (i.e. the period between a perturbation of a unstable state and the onset of rupture propagation associated with the seismic wave radiation). We consider the elastic anti-plane problem for a system of finite faults under a slip-weakening friction law. A spectral analysis is used to determine the existence, or not, of a catastrophic evolution of the slip. We find that long initiation durations are expected. We also investigate the possibility of defining an effective friction law for a finite fault with a small scale heterogeneity. The "spectral equivalence" between an heterogeneous fault system and an homogeneous fault is pointed out. Surprisingly good agreements are found between the heterogeneous fault model and the homogeneous fault with an effective friction law. Finally we analyze the initiation pattern as a possible signature of instability and we show how the weakening rate is transmitted in the elastic medium through a "domain of confidence".

Sufficient conditions of non-uniqueness for the Coulomb friction problem

Abstract

We consider the Signorini problem with Coulomb friction in elasticity. Sufficient conditions of non-uniqueness are obtained for the continuous model. These conditions are linked to the existence of real eigenvalues of an operator in a Hilbert space. We prove that, under appropriate conditions, real eigenvalues exist for a non-local Coulomb friction model. Finite element approximation of the eigenvalue problem is considered and numerical experiments are performed. We propose and study a new technique using mixed finite elements with two multipliers in order to determine numerically critical friction coefficients for which multiple solutions to the friction problem exist. The theory is illustrated with several computations which clearly show the accuracy of the proposed method.

The blocking of an inhomogeneous Bingham fluid. Applications to landslides

Abstract

This work is concerned with the flow of a viscous plastic fluid. We choose a model of Bingham type taking into account inhomogeneous yield limit of the fluid, which is well-adapted in the description of landslides. After setting the general threedimensional problem, the blocking property is introduced. We then focus on necessary and sufficient conditions such that blocking of the fluid occurs. The anti-plane flow in twodimensional and onedimensional cases is considered. A variational formulation in terms of stresses is deduced. More fine properties dealing with local stagnant regions as well as local regions where the fluid behaves like a rigid body are obtained in dimension one.

Existence results for dynamic problems with state-dependent friction

Abstract

The dynamic evolution of an elastic medium undergoing frictional slip is considered. The Coulomb law modeling the contact uses a friction coefficient which is a non-monotone function of the slip-rate. This problem is ill-posed, the solution is non-unique and shocks may be created on the contact interface. In the particular case of the one-dimensional shearing of an elastic slab, the (perfect) delay convention can be used to select a unique solution. Different solutions in acceleration and deceleration processes are obtained. To transform the ill-posed problem into a well-posed one and to justify the choice of the perfect delay criterion, a visco-elastic constitutive law with a small viscosity is used here. An existence and uniqueness result is obtained in three-dimensions. The assumptions on the functions implied in the contact model are weak enough to include both the normal compliance and the Tresca model. The following conjecture, based on results of numerical simulations, is stated : in the elastic case the solution chosen by the the perfect delay convention is the one obtained from the solutions of the problem with viscosity, when the viscosity tends to zero.
The dynamic evolution with frictional contact of an elastic body is considered. In modeling the contact the Tresca model and a slip dependent friction law are used. The existence of a solution is proved in the two-dimensional case. The uniqueness is proved for the one-dimensional shearing problem.