ELASTIC-PLASTIC-FAILURE CONSTITUTIVE MODELING OF GEOLOGICAL MATERIALS

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The development of constitutive models for representing both the continuum and discrete (failure) response of geological materials remains one of the most difficult aspects of computational mechanics. Both plasticity and continuum damage mechanics are currently being used in an attempt to accurately reflect stress-strain behavior within the hardening regime. A popular approach for predicting the initiation of failure is to perform a bifurcation analysis. Such an analysis yields the instant at which failure begins and the orientation of the failure plane. Although theoretically attractive the method has the practical difficulty in that the constitutive equation for a given material must be constructed to predict both stress-strain data and the failure mode that agree with experimental data. Agreement with experimental data for both aspects is rarely discussed. Micro-structural arguments provide the necessary insight for the development of these constitutive equations but, with the exception of isolated cases, general formulations do not exist.

The object of the present research is to approach the problem by separating the continuum and discrete constitutive equations. Then the continuum part of the constitutive equation can be restricted to providing good stress-strain predictions in the hardening phase and the governing equations are always well-posed. As an example, with the use of carefully designed evolution equations for internal variables, it is shown that a plasticity model with an associated flow rule can be constructed to provide a reasonable match to experimental data for concrete samples subject to triaxial compression.

The primary focus can then be on a discrete model that predicts the initiation and evolution of failure including the orientation of the failure plane. The details of a possible model will be given together with results of a parameter study to show that the predictions are also reasonable as indicated by experimental results from concrete specimens that show changes in failure angle with initial confining pressure. Since the general features of these results are similar to those of many rocks the proposed approach may have a wide degree of applicability in geomechanics.

The presentation will also include a discussion of the computational aspects of a constitutive equation algorithm that involves checking the decohesion algorithm simultaneously with the elastic-plastic subroutine. Also, implicit is the need to incorporate a length parameter based on the numerical scheme.