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THE MODELING OF AXIAL SPLITTING AND RELATED ISSUES

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ABSTRACT

Many specimens composed of quasibrittle materials such as concrete and ice exhibit axial splitting when subjected to uniaxial compression. Even though some experimentalists are doubtful that axial splitting exists, there is no doubt that there are large changes in the orientation of the failure plane with respect to lateral pressure when the lateral pressure is close to zero. Considering the importance of the phenomenon, it is surprising how little is reported in the literature on modeling such a constitutive feature.

Most efforts at modeling failure focus primarily on predicting accurately the stress at the initiation of failure. Only modest attempts have been made at providing agreement between experimental data and predictions of the orientation of the failure plane. Recently, a failure model has been described [1] that specifically focuses on the problem of accurately predicting the orientation of the failure plane for a complete spectrum of stress paths. With a suitable choice of material parameters, axial splitting can be specifically predicted. In addition, it is shown that for plane stress, there is a smooth transition to a mixed mode of failure as the state of stress transitions to one of biaxial compression, with the predicted orientation in agreement with observed experimental data for ice.

Nevertheless, axial splitting based on a mathematical model of failure must necessarily be an idealization of the situation that governs specimens subjected to uniaxial compression. The idealization implies that a specimen splits in two but continues to support the axial stress. Most photographs of failed specimens indicate that a mechanism has to be created as exhibited for example by a combination of axial splitting and additional failure planes oriented at angles. Often, one such plane intersects the surface of the specimen at an edge coincident with the edge of the loading platen. Such an effect is often attributed reasonably to either imperfections in the material or the lack of a non-uniform traction on the loading surface. It appears that to reflect accurately the features exhibited by uniaxial compression, a complete three-dimensional analysis is needed. Even then there is the idealized problem that any number of splitting orientations is possible because of axial symmetry.

The object here is to attempt to develop features within a constitutive equation that would preclude the need for a full three-dimensional analysis but provide the essential features observed experimentally. The essential point of the proposed approach is that

once one axial plane is formed the material parameters are modified to preclude additional splitting planes for the same stress. However, an additional failure plane with a mixed mode at a slightly larger stress is allowed. The result is that first axial splitting is predicted but a further increase in stress is allowed. Then a mixed mode failure mode is initiated with a subsequent drop in stress-carrying capability.

These features are illustrated through the use of a constitutive equation subroutine called by a driver program that provides paths in a manner similar to those obtained in large-scale computational simulations.

REFERENCES

[1] H.L. Schreyer, "Modelling surface orientation and stress at failure of concrete and geological materials," *J. for Numerical and Analytical Methods in Geomechanics*, Vol. **31**, pp. 141-171, (2007).