AN ANALYTICAL MODEL FOR ELASTO-PLASTIC POROUS MATERIALS FOR CYCLIC LOADINGS WITH ISOTROPIC AND KINEMATIC HARDENING

Long Cheng[1], Djimedo Kondo[2], Andrei Constantinescu[3], Kostas Danas[3]

[1] Laboratoire de GeoRessources, Université Lorraine, Vandoeuvre-lès-Nancy, France
[2] IJLRA, CNRS, Université Piere et Marie Curie, Paris, France
[3] LMS, CNRS, Ecole Polytechnique, Palaiseau, France
konstantinos.danas@polytecnique.edu and http://www.kostasdanas.com

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In this work [1], we propose a semi-analytical micromechanical model to study the elasto-plastic response of porous materials subjected to cyclic loading with isotropic and linear kinematic hardening at finite strains. To this end, we use an approximate but numerically efficient decoupled homogenization strategy between the elastic and plastic parts. The resulting effective back stress in the porous solid, similar to the macroscopic stress and plastic strain, has non-zero hydrostatic terms and depends on the porosity, the void shape and orientation as a result of the homogenization process. Subsequently, a complete set of equations is defined to describe the evolution of the microstructure, i.e., void volume fraction (porosity), (ellipsoidal) void shape and orientation both in the elastic and the plastic regimes [2]. The model is then numerically implemented in a general purpose user-material subroutine. Full field finite element simulations of multi-void periodic unit cells are used to assess the predictions of the proposed model. The latter is found to be in good qualitative and quantitative agreement with the finite element results for most of the loading types, hardening parameters and porosities considered in this study, but is less accurate for very small porosities. The combined analytical and numerical study shows that elasticity is an important mechanism for porosity ratcheting in addition to strain hardening. Specifically, in order to recover the main qualitative features of porosity ratcheting for all cyclic loads considered in the present study, it is shown to be critical to take into account the evolution of the microstructure not only during the plastic loading, as is the usual hypothesis, but also during elastic loading. Finally, the effect of isotropic and linear kinematic hardening is found to be highly non-monotonic and non-trivial upon porosity ratcheting for most cases considered here.

REFERENCES

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