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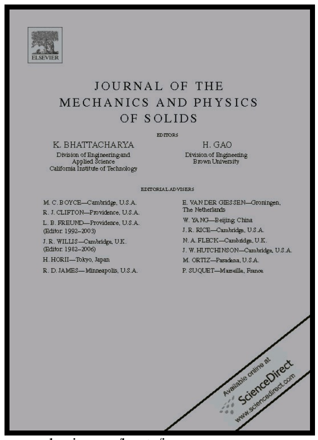

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Limit analysis and homogenization of porous materials with Mohr-Coulomb matrix. Part I: theoretical formulation

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Abstract

The present two-part study aims at investigating the specific effects of Mohr-Coulomb matrix on the strength of ductile porous materials by using a kinematic limit analysis approach. While in the Part II, static and kinematic bounds are numerically derived and used for validation purpose, the present Part I focuses on the theoretical formulation of a macroscopic strength criterion for porous Mohr-Coulomb materials. To this end, we consider a hollow sphere model with a rigid perfectly plastic Mohr-Coulomb matrix, subjected to axisymmetric uniform strain rate boundary conditions. Taking advantage of an appropriate family of three-parameter trial velocity fields accounting for the specific plastic deformation mechanisms of the Mohr-Coulomb matrix, we then provide a solution of the constrained minimization problem required for the determination of the macroscopic dissipation function. The macroscopic strength criterion is then obtained by means of the Lagrangian method combined with Karush-Kuhn-Tucker conditions. After a careful analysis and discussion of the plastic admissibility condition associated to the Mohr-Coulomb criterion, the above procedure leads to a parametric closed-form expression of the macroscopic strength criterion. The later explicitly shows a dependence on the three stress invariants. In the special case of a friction angle equal to zero, the established criterion reduced to recently available results for porous Tresca materials. Finally, both effects of matrix friction angle and porosity are briefly illustrated and, for completeness, the macroscopic plastic flow rule and the voids evolution law are fully furnished.

Keywords: Ductile porous materials, Mohr-Coulomb matrix, Homogenization, Limit analysis, Lagrangian minimization method, Karush-Kuhn-Tucker conditions

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