A macroscopic constitutive model for geomaterials with account for two micromechanical sources of inelastic deformation: with emphasis on granular materials

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Abstract

Macroscopic constitutive models for geomaterials based on the elasto plasticity theory have been found to fail to describe some deformation features of the material of this kind, e.g., the coupling behavior between shear and consolidation. This shortcoming can be attributed to the model assumption that one distinct micromechanical source operates during inelastic deformation and no effect of plastic deformation on elastic properties.

After reviewing the micromechanical process of geomaterials with special emphasis on granular materials, an alternative constitutive formulation is presented in which two micromechanical sources of inelastic deformation are taken into account. Both stress space and strain space formulations are presented and their relations are described.

1. Intorduction

The constitutive modeling of geomaterials has been the objectives of numerous works during recent two decades, which has been facilitated by the advance of high speed computers as well as the advanced numerical analyses. A lot of elasto-plastic constitutive models have been developed for geomaterials with remarkable success.

However, it is appropriate to point out that the elasto-plastic constitutive modeling has been developed mainly concerned with the behavior of polycrstalline solids. In polycrystalline solids, deformation can be attributed to two micromechaical sources; namely, lattice deformation leading to elastic deformation and slippages along the crystallographic plane as a source of plastic deformation. Thus, the fundamental decomposition in the elasto plastic constitutive modeling: $d\varepsilon_{ij} = d\varepsilon^e_{ij} + d\varepsilon^p_{ij}$, closely corresponds to the micromechanical processes. (see, e.g., Havner (1983)[1], Asaro (1983)[2]) This decomposition in the elasto plastic models does not necessarily correspond to the micromechanical process in geomaterials such as rocks, soils and granular materials. The difference between the assumption in the elasto-plastic constitutive models and the micromechanical process in the geomaterials undergoing inleastic deformation seems to be of more importance than it appears.

In this paper, we present a general mathematical formulation of macroscopic constitutive modeling of geomaterials with special emphasis on cohesionless granular materials with

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