The Yield Criteria of Granular Material with micro-mechanical considerations

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ABSTRACT

The constitutive models of granular materials generally follow the framework of the classical plasticity, which was initially developed for metal based on phenomenological observations. The mathematical formulations of classical plasticity have been supported by the physical background in metallographic studies [1], while the plastic deformation of metal crystals is mainly due to the movements of dislocations through crystal lattice. It is obviously different from granular materials, which has been known as a self-organizing material with discrete nature. As its consequence, the stress-strain behaviour of granular materials is observed to be more complicated, so does the constitutive theory.

For granular materials, the micro-structural expression of the stress tensor shows that the stress tensor defined on the equivalent continuum scale can be expressed as the tensor product of contact forces and contact vectors [2], or further in terms of their statistical descriptors, known as the Stress-Force-Fabric relationship [3]. Directional statistical theory has been used in deriving a tensorial form of the SFF relationship [4]. In support of the Discrete Element (DEM) simulation data, the evolutions of fabric and force have been explored with consideration of their inter-dependence when sheared [5].

This research continues to model material shear strength in aid of the SFF relationship and knowledge of the force and fabric evolutions when subjected to monotonic shearing, leading to a micro-mechanics based yield criteria. Several existing anisotropic yield criteria will be revisited and compared. Discussions will also be extended to the flow rule of anisotropic granular materials. The proposed modelling approach predicts the deformation non-coaxiality of granular materials without introducing new model parameters.

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