A novel augmented elasto-plastic potential model for granular materials and some micro-mechanical considerations

David Harris

School of Mathematics
University of Manchester
Oxford Road, Manchester M13 9PL, UK
e-mail: david.harris@manchester.ac.uk,

ABSTRACT

The equations governing a novel augmented elasto-plastic potential model for deformations and flows of granular materials are presented. The model presented here is a generalisation of that presented and analysed in Harris [1]. The constitutive equations are augmented by a term analogous to a term present in the double-shearing model due to Spencer [2].

It is known that the classical non-associated plastic potential model is of indefinite type. The work-hardening model is not elliptic and the perfectly plastic model is not hyperbolic. The purpose of the augmented term in the model presented here is to render it elliptic and hyperbolic in the hardening and perfectly plastic regimes, respectively.

The original double-shearing model contained a term involving the spin of the principal axes of stress and this term destroyed the hyperbolicity of the model. The augmented plastic potential model presented here replaces the spin of the principal stress axes by a quantity defined in a Cosserat continuum, namely the intrinsic spin. A constant value (at all places and all times) of the intrinsic spin corresponds to flow or deformation in a classical continuum, whereas a non-zero gradient for the intrinsic spin requires consideration of the couple-stress and a non-symmetric stress tensor. The model is presented for a Cosserat continuum in a manner which carefully preserves the structure of the classical model and enables the Cosserat quantities to be readily neglected when appropriate.

The model was developed in the spirit of phenomenological plasticity but its construction has been informed by informal and intuitive micro-mechanical considerations. These will be explicitly discussed in the talk and the possibility of future development of the model in the context of input from micro-mechanical studies will also be discussed.

The talk will emphasise the importance of using a theoretical framework in which the resulting constitutive equations give rise to a model of the appropriate type in order that it can be used to correctly solve boundary and initial value problems.

REFERENCES

[1] D. Harris, "A hyperbolic augmented elasto-plastic model for pressure-dependent yield", Acta Mechanica, 225, 2277-2299 (2014).

[2] A.J.M Spencer, "Deformation of ideal granular materials" in H.G. Hopkins and M.J. Sewell (eds.) Mechanics of Solids: the Rodney Hill Anniversary Volume, Pergamon Press, Oxford, 607-652 (1982).