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A director theory for anisotropy of granular media

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All granular materials show anisotropic behaviour to some extent. There are various forms of anisotropy according to the groups of symmetrical transformations, e.g. transversal and orthogonal anisotropy. For natural soils, the most relevant form is transversal anisotropy, where the deposition plane coincides with the plane of symmetry. Differentiation is often made between inherent and induced anisotropy. The former is dictated by the fabric immediately after deposition, while the latter is acquired through deformation.

Despite the discrete nature of granular materials, their mechanical behaviour can be reasonably described by the principles of continuum mechanics. Frequently, the constitutive models for anisotropy are developed along the line of plasticity theory, where the deformation is decomposed into elastic and plastic parts. As a result, the effect of anisotropy on the elastic and plastic behaviour is treated separately. Usually this gives rise to rather involved formulations and numerous parameters. An alternative approach to anisotropic behaviour of granular materials was proposed within the framework of hypoplasticity theory. A distinct feature of hypoplasticity lies in the fact that the deformation is not decomposed but treated as an entity. The irreversible deformation is obtained from a single nonlinear tensor function. In this way, a unified description of the anisotropic behaviour of deformation and strength is achieved.

In our previous publications, some anisotropic hypoplastic models are proposed. For transversal anisotropy, the constitutive equation depends on the anisotropy vector (director), i.e. the normal vector of the isotropy plane. The director remains unchanged in the course of deformation. In the present paper, the director is allowed to evolve by making use of a purely kinematical evolution equation. This constitutive model

bears some resemblance to the director theory for transversely anisotropic fluids proposed by Ericksen. The constitutive model is implemented in a finite element code. The effect of director evolution is shown by studying shear localization.