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A CONSTITUTIVE MODELLING APPROACH FOR THE DESCRIPTION OF RAPID GRANULAR FLOWS: FROM THE INCEPTION TO THE ARREST

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The mechanics of granular media is particularly fascinating for a large variety of reasons, among which, the most interesting is the capability of the material of behaving like a solid as well as a fluid according to the grain packing. According to the imposed conditions, the same grains may either develop complex networks of force chains or flow by colliding among each other and the passage from one to the other state can be interpreted as a sort of phase transition. Very numerous are in nature the examples of this solid to fluid and vice versa phase transition but in geo-mechanics this phenomenon is mainly studied in relation to very rapid landslides.

The authors, in this presentation, will illustrate a constitutive model, and more precisely a constitutive modelling approach, suitably tailored to simulate this phenomenon. The model is based on both the standard critical state and kinetic theories and assumes: (i) the material to be dry, (ii) the void ratio and the granular temperature, measuring the material agitation, as material state variables; (iii) the grains not to be crushable and (iv) the grain distribution to be fixed.

According to the model conceived by the authors, the energy can be stored by the medium as either elastic or kinetic energy, increasing this latter with the material agitation. Analogously, the energy can be dissipated by means of either sliding among grains when permanent contacts develop or grain collisions. A parallel scheme is suggested: stresses are subdivided into two contributions; one quasi-static, corresponding to the well known effective stress tensor, and one collisional, corresponding to the stresses that grains can transmit to each other during collisions.

The kinetic fluctuating energy balance, written for the representative elementary volume, is assumed to govern the evolution of the granular temperature. The same equation, in a general boundary value problem, introduces a sort of non-local effect into the constitutive model, justifying the spatial propagation of the phase transition phenomenon within large masses of soil.

The model has been defined under both simple shear and three dimensional conditions and the constitutive parameters are calibrated on numerical results taken from the literature and obtained by performing numerical simulations of simple shear and true triaxial tests performed on monodisperse spherical granular assemblies.