Particle size effects and non-coaxiality in viscous-plastic materials

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Some of the most interesting and frequently occurring geological structures such as shear bands, fault zones and folds may be explained as a consequence of changes in the type of the governing model equations. Such changes or bifurcations depend strongly on the details of the constitutive relationships such as strain softening, thermal or chemical effects, associated or non-associated - coaxial or non-coaxial flow rule. Here we focus on non-coaxial flow rules. The term non-coaxial refers to the non-coincidence of the principal axes of the stress and the plastic strain rate tensor. Non coaxial plasticity models were originally proposed by Josselin de Jong and A. J. M. Spencer. The geometric structure of most non-coaxial models is defined by the assumption that the plastic deformation is carried by one (single slip) or two (double slip) slip systems that are inclined at , to the less compressive principal stress axis; is the internal angle of friction of the material. Both cases- single and double slip-are considered here. A particular feature of the double slip model is the occurrence of an additional variable requiring an additional constitutive relationship. Geometrically the additional variable may be interpreted as a spin. Spencer assumed that in 2D the additional spin is equal to the rate of rotation of the principal axes of the stress tensor. Here we propose a closure for the double slip model within the framework of a Cosserat Continuum theory. In a Cosserat continuum, a material point possesses the degrees of freedom of an infinitesimal rigid body: three translations and three rotations. In this case the indeterminacy of the double slip model is removed by the angular momentum balance equation associated with the rotational degrees of freedom. We propose constitutive relationships for the Cosserat model and illustrate the behavior of the model by means of an analytical solution of the simple shear problem.