6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

A numerical study into normal contact laws for particles exhibiting compressible plasticity

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Keywords: *Contact laws, computational plasticity, Drucker-Prager Cap, granular materials*

Contact laws describing force-displacement relationships for contacting particles provide convenient descriptions of particle mechanics as well as key inputs for bulk modelling of granular media, such as the Discrete Element Method [1] and homogenization approaches. Existing contact laws can incorporate a wide range of phenomena including hardening plasticity, viscoelasticity, viscoplasticity and adhesion [2]. However, continuum elastoplasticity models developed for soils, granular materials and powders allow for the development of compaction/dilation and evolution of elastic moduli, the influence of which on normal force-displacement relationship for particles in contact have not previously been considered in contact laws.

In this work, we present the derivation of an implicit hypoelastic-plastic constitutive model with elastic parameters dependent on plastic state variables, its implementation as a subroutine interfacing with the finite element code Abaqus, and its validation. An application of this model to contact between granules of pharameutical powders is demonstrated. Bulk powder calibration procedures [3] are used to determine the parameters of a variable Drucker-Prager model, which serves as a base case. By conducting parametric studies, the influence of model choice, plastic compressibility, dilatancy and hardening rates on nondimensionalised interparticle normal contact relationships is shown, as well as stress distributions and plastic flow regimes that develop during contact. The influence of compressible plastic effects for different classes of particles is discussed.

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