On the geometrically exact nonlinear hyperelastic and hypoelastic granular interactions

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Abstract

This study investigates several granular interaction laws used in the modelling of discrete granular media and the static response of a small assembly of 4 identical grains (diamond pattern). In the considered model, each grain interacts with its neighbour with a coupled shear-normal interaction law. The analysis is performed in a geometrically exact framework allowing large rotation and displacement evolutions, without any geometrical approximations (see also [1] for the granular *elastica* problem). It is shown that most of the granular interaction laws available in the literature are classified as hypoelastic interaction laws [2], [3] (such as the initial interaction models of Serrano and Rodriguez-Ortiz, 1973 or the popular model of Cundall and Strack, 1979 which gives birth to Particle Flow Codes). The interaction is weakly hypoelastic if an integral form exists, whereas it remains strongly hypoelastic when only an incremental formulation is available. Hyperelastic interaction laws may be also considered, that avoid possibly artificial dissipation (model of McNamara et al [4] or model of Turco et al [5]). We also show that along specific loading paths for which the normal and tangential laws are uncoupled, is the behaviour hyperelastic for all the studied models. For the three types of interactions, the modes of instability are then characterized for large displacement of the diamond pattern. We discuss the discrepancies between each granular model during the deformation process of some displacement-based loading tests.

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