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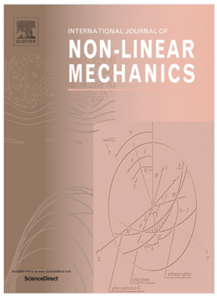

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A COMPUTATIONAL MODEL FOR THE SIMULATION OF DRY GRANULAR MATERIALS

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Abstract. *This work presents a computational model for the simulation of problems involving dry granular materials. The approach is based on the discrete element method (DEM), using phenomenological models to describe the various forces involved. It is intended to be simple, as well as clear and clean in the formalism, such that (i) a base framework may be established, from which future generalizations or particularizations to specific problems of granular systems may be conducted, and (ii) newcomers to the field may benefit and get started right away with their developments. Details of its solution method are provided and a few numerical examples are shown to illustrate the potentialities of the scheme. Simple, consistent computational models may be a useful tool for the study of dry granular materials and, in a broader sense, many other non-linear particle systems.*

Keywords: *granular materials; discrete element method; particles; computational simulation.*

1. INTRODUCTION

Granular materials are observed in innumerous natural phenomena and human applications, and across various length scales: from rock stacks and gravel piles to fine powders and particulate flows; from heaps of nuts and beans and mounds of sand to compact aggregates of very high added value in the pharmaceutical, chemical, food and microelectronics industries. Knowledge on the physics of such materials has evolved significantly over the past decades, especially with the aid of computational methods, but still there is a lot to pursue.

Granular materials distinguish from solid and fluid materials in many aspects. One of the most intriguing is that, depending on the external forces to which they are exposed, they may behave either like solids or like fluids, or even like something very different from these two – and often counter-intuitive. When highly excited, granular materials may resemble gases, like in dust clouds or fluidized beds in industrial facilities. They also may be pumped in the interior of pipes or open channels, like liquids (even showing wave patterns such as in free surface flows). And they may form static piles that do not dismantle or dissolve spontaneously, featuring some sort of shear strength, as typical of solids.

From the point of view of their theoretical representation, granular materials cannot be idealized as a continuum – unless the length scale of the physical phenomenon one is interested in is very large in comparison to the size of the grains, as happens, e.g., in the overall deformation of soil massifs in geotechnical engineering problems. Instead, they must be understood a priori as a discrete medium, in which matter is concentrated in a very large number of elementary entities, each with well-defined shape and volume. In the context of this work, a granular material is defined as an agglomerate of discrete solids of macroscopic size that are in contact most of the time (this definition is more or less in line with that of Duran [1], whom is, in the opinion of the author, one of the present-day top