Influence of particle shape on the statics and dynamics of granular materials

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Particle shape is a major ingredient of both naturally occurring granular materials such as soils and manufactured powders and granulates. From DEM simulations of sheared granular materials composed of various particles shapes, I discuss generic features of the organization of the contact network and force transmission in granular materials in terms of force-shape relations or granular “archi-texture" by analogy with general principles governing the stability of structural arches. It is shown that face-face contacts are dynamically triple contacts, i.e. equivalent to three point contacts, and they concentrate strong force chains despite their generally low number in a granular assembly. Furthermore, because of the higher energy cost of their rotations, the behavior of a material composed of spherical particles interacting via rolling resistance matches well to the behavior of a material composed of polyhedral particles. As a result of hindered rotations, the shear deformation of the material is increasingly accommodated by relative sliding of the particles. We will also discuss how a low-order shape parameter, measuring the degree of deviation from spherical shape, is able to generalize and unify the observed features such as the linear increase of shear strength as a function of shape parameter, unmonotonic dependence of packing fraction on shape parameter, enhanced force concentration and force anisotropy, and enhanced friction mobilization and sliding. Finally, I discuss the effects of nonaffine displacements and particle shape on the orthotropic elastic moduli of granular samples composed of polyhedral particles.