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Granular Materials by Design

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Granular materials are large amorphous aggregates of discrete, individually solid particles. One of the key issues has long been how to link particle-level properties in a predictive manner to the behavior of the aggregate as a whole. In particular, the shape of particles has been recognized as important factor, with smooth spherical shapes known to behave quite differently from angular or faceted ones. However, except for a small set of simple convex shapes, very little detailed knowledge exists that allows one to predict aggregate mechanical response from individual particle properties. Furthermore, for actually designing a granular material, the inverse problem needs to be solved: for a given desired overall mechanical response, the task becomes finding the appropriate particle-level properties. This talk discusses recent experiments on a wide range of convex and non-convex particle shapes in an effort to provide a baseline for modeling the effect of non-sphericity on parameters such as the effective Young‘s modulus or yield stress of a granular material. It also discusses a new approach to tackle the inverse problem by bringing concepts from artificial evolution to granular materials design, making it possible to find with high efficiency the shapes best adapted to a given goal. These results have general applicability and open up wide-ranging opportunities for materials optimization and discovery.