Geometric cohesion in granular systems composed of star-shaped particles

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ABSTRACT

Geometric cohesion is the ability of some granular systems to behave as a solid body, even in the absence of attractive or adhesive interactions at the contacts. This behavior emerges as a consequence of the geometry of the particles composing the system. This was first observed in systems composed of rods [1, 2], and later it was also observed for U and Z shaped particles [3, 4, 5] and hexapods [6, 7].

The aim of this work was to investigate the occurrence and the magnitude of geometric cohesion in two-dimensional granular systems composed of grains that have star-like shapes. We explored a parametric space composed of star-like particles with varying numbers of arms (i.e., 4, 6, 8, 10, and 12 arms) and with varying arm lengths (i.e., from 2 to 16 times their thickness). In order to do so, we performed a series of column collapse tests using columns of increasing size. These numerical experiments allowed for estimating the size of the cohesive clusters that typically form for each grain shape, which we then use as a measure of magnitude of geometric cohesion. We found that the shape that exhibits the largest geometric cohesion is that with eight arms. On the other hand, we found that geometric cohesion increases with arm length.

Currently, we are extending our research to three-dimensional systems (i.e., dolos and platonic polypods). Our objective is to study the usability of these granular systems in the construction of geotechnical structures such as anti-avalanche and erosion-control barriers. These structures can be advantageous because of their cohesive behavior and extremely low solid fraction. Because of these properties, these structures are considerably more environmentally-friendly than those that are used nowadays.

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