Consolidation of Polyhedral Packings due to Grain Fracture

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ABSTRACT

Granular packings under mechanical stresses are an important part of our built and natural environment, belonging to the class of frictional materials. Examples range from structural foundations to railway tracks, the handling of bulk materials or novel digital fabrication approached for fiber reinforced printed granular architecture [1]. For such systems, even for moderate stresses, forces transmitted through the network of contacts can be quite large, resulting in individual grain fracture, force network re-configurations and consequently compaction or consolidation. To assess the behavior and dynamic processes in granular matter, grain scale models with rigid moving particles, called Discrete Element Models (DEM) are most suitable. However, dynamic contact interactions require rather small time steps, what renders failure assessment, based on elastic stress fields inside of grains unfeasible. As a consequence simplistic grain fracture models have to be used to avoid computationally expensive fracture simulations. Polyhedral grains prove to be most suitable with the DEM framework for representing bed fractures, since degradation along planes will produce additional polyhedra, which are objects of the same kind.

In this contribution we explore with Contact Dynamics (CD), a DEM with volume exclusion [2], the case of single grain crushing of polyhedral particles between two plates as well as of a grain packing under uni-axial strain [3]. We study the macroscopic compaction behavior, fracture and fragmentation mechanisms and evolving particle size distributions. Additionally, we investigate the force networks and the average coordination number during the process of compaction. For the single grain crushing, a log-normal distribution is found, while the packed bed fragmentation produces the characteristic power law distribution. We further explore possibilities of a new generation of grain fracture models that give an estimate of the particle degradation plane as the response of a shallow neural network, previously trained from the experience of isolated fracture events.

REFERENCES

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