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Size-dependence of the flow threshold in dense granular materials

DAVID HENANN, DAREN LIU, Brown University — The flow threshold in dense granular materials is typically modeled by a local criterion, involving only a quantity given through the stress - typically the ratio of the shear stress to the pressure. However, nonlocal effects lead to phenomena that cannot be captured with such local criteria. In a widely studied example, flows of thin layers of grains down an inclined surface exhibit a size effect whereby thinner layers require more tilt to flow, and hence, sufficiently thin layers will not flow, even when the stress in the layer exceeds the flow threshold. In this talk, we consider whether the size-dependence of the flow threshold observed in inclined plane flow is configurationally general. Specifically, we consider two additional examples of inhomogeneous flow - planar shear with gravity and vertical chute flow - using two-dimensional discrete element method (DEM) calculations and show that the flow threshold is indeed size-dependent in these flow configurations, displaying additional strengthening as the system size is reduced. We then show that the nonlocal granular fluidity model - a recently-proposed, nonlocal continuum model for dense granular flow - is capable of quantitatively capturing the observed size-dependent strengthening of thin granular bodies in all flow configurations.

David Henann
Brown University

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