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Silo discharge dynamics: grain shape effect

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Extended Abstract

Abstract

Granular discharge from silos is a classical problem in granular physics with significant industrial relevance. While the Beverloo law effectively describes the flow rate of spherical grains, its applicability to non-spherical grains remains uncertain. In this study, we investigate the influence of particle shape on three-dimensional, gravity-driven silo discharge using numerical simulations. Grains are modeled as spherocylinders with aspect ratios (AR = length-to-diameter ratio) ranging from 1 (spheres) to 4, keeping particle mass and volume constant to isolate shape effects. The discharge process through a circular orifice (D) is simulated using the Contact Dynamics method. Results show that for all aspect ratios, the flow rate increases with orifice diameter following a D^(5/2) scaling, consistent with the Beverloo law. However, the Beverloo parameters exhibit a strong dependence on particle shape. Specifically, the flow rate slightly increases for AR = 1.1 and then decreases linearly for larger aspect ratios for a given orifice diameter. Detailed analysis of velocity and packing fraction profiles at the orifice indicates that particle elongation modifies the dome-like structure of the flowing region, while radial profiles remain largely independent of orifice size for a given aspect ratio. Flow rates predicted using models from literature show good agreement with the numerical results. These findings demonstrate that particle shape significantly influences granular discharge by altering both local packing and velocity fields, leading to measurable variations in flow rate. The results provide a quantitative basis for extending classical flow-rate models to non-spherical grains and offer guidance for the design of industrial silos handling non spherical grains.

Keywords:

Granular flow Numerical simulation DEM