Discharge Flow of a Granular Media from a Silo: Confinement Effect in a quasi 2D Silo

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Abstract

Silos are widely used in the industry. While empirical predictions of the flow rate, based on scaling law, exist for more than a century (Hagen 1852- Beverloo et al 1961), recently advances have been made on the understanding of the control parameters of the flow. In particular using continuous modeling together with a mu(I) granular rheology seem to be successful in predicting the flow rate for large number of beads in the aperture (Staron et al, 2012,2014).
However few studies concern the prediction of the mass flow rate of a granular media discharged from a silo with a lateral orifice, a situation which can have practical interest considering a tank of granular material with a leak on its side. This situation has some relevant similarity with the fuel particle ejection out of a rod within the core of a nuclear power plant during an hypothetical accident.

Based on these considerations, we have studied experimentally the effect of the position of the orifice on the discharge flow of a granular media from a thin rectangular silo, filled by spherical monodisperse beads. We have varied the size and the aspect ratio of the orifice, and we have considered three configurations for the orifice position: at the center of the base of the silo, at the lateral size of the silo, and at the corner of the base of the silo.
We have identified two regimes of discharge according to the aspect ratio (of width to height) of the rectangular orifice and its position. We propose a simple physical model to describe the effect of these parameters, considering a continuous granular media with a mu (I)-rheology and taking into account the role of the confinement. Using continuum Navier-Stokes simulations we showed that this model describes well the discharge flow of granular media from quasi 2D silos.

Keywords: granular flow, silo discharge, granular rheology

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