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# Experimental study on the dynamics of dry granular chute flows over an erodible bed

Luigi Carleo (1), Luca Sarno (1), Maria Nicolina Papa (1), Yih-Chin Tai (2), Paolo Villani (1,3)

(1) University of Salerno, Civil Engineering, Fisciano, Italy (lcarleo@unisa.it), (2) National Cheng Kung University, Hydraulic and Ocean Engineering, Tainan City, Taiwan, (3) CUGRI, University Consortium for Research on Major Hazards, Fisciano, Italy

Geophysical gravity-driven flows, like avalanches, pyroclastic flows and debris flows, involve the rapid motion of granular mixtures. The full description of the rheological stratification in dry granular flows still represents an open problem. Experimental investigations at the laboratory scale are an essential tool that can provide precious informations about their dynamics.

In this work, we present an experimental campaign devoted to the measurement of the velocity and the volume fraction of dry granular chute flows over a loose bed. Optical non-invasive techniques were employed.

The employed granular medium consists of acetal-polymeric beads (mean diameter d of 3.3mm) and an internal angle of friction of 27°. All the experiments were carried out in a 2m-long Plexiglas flume with a 8cm-wide rectangular cross section. The upper part of the channel was used as a reservoir where the granular material was loaded and let flow down through an adjustable gate. A small weir was placed at the end of the channel in order to allow the formation of a lower wedge of granular material, corresponding to the erodible bed. Several mass flow rates were investigated by imposing different gate openings.

Two high-speed cameras were employed. One camera was placed aside the channel to obtain sidewall velocity and volume fraction measurements while the other camera was located above the free surface. The open-source particle image velocimetry (PIV) code PIVlab [Thielicke and Stamhuis, J. Open Res. Softw., 2014] was employed for estimating the flow velocities. The stochastic optical method (SOM), recently proposed by [Sarno et al., Granul. Matter, 2016], was used to get reliable estimations of the near-wall volume fraction profiles.

All the free surface velocity profiles exhibit an approximately parabolic shape, due to the sidewall friction, with a maximum at the cross-section midpoint and a minimum at the sidewalls.

All the sidewall profiles can be divided into three zones. In the lower zone, the volume fraction reaches high approximately constant values, close to the loose packing volume fraction ($\approx$0.6), whereas the flow velocities are small and exhibit an exponential tail. Friction among the grains is the main momentum exchange mechanism in this layer. In the central zone, volume fraction still shows high constant values and a linear trend of the velocity is observed. The upper zone, beneath the free surface, was found to be of the same thickness ($\approx$2d) in all the experiments. Herein, the velocity profile show a convex ($\partial zz(ux)<0$) shape and the volume fraction rapidly decreases indicating a more collisional behavior. A velocity threshold was used to identify the interface between the faster flowing layer and the slower one (creep flow) in all the experiments. Interestingly, by aligning the velocity profiles at this meaningful interface, we observed that they collapse onto a unique master curve, with the only exception of the upper collisional layer. It suggests that the flow dynamics is governed by the lower basal boundary condition.