Downslope granular flow through a forest of obstacles

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Natural and artifical obstacles are known to mitigate the damages provoked by avalanches and other geophysical hazards. In order to design obstacles that reduce efficiently these damages, a fine understanding of the interaction between a granular flow and obstacles is required. Benito *et al.* have investigated the role of a "forest" of cylindrical pillars on the stability of a granular layer on an incline [1]. They revealed that the presence of pillars increases the stability of the granular layer towards larger slope angles. They succeeded in rationalizing this effect by a simple model that takes into account the additional friction force exerted by the pillar forest onto the granular layer. However, the stationary flow of grains crossing a forest of obstacles has not been considered yet while it is of interest to better understand the coupling between granular flows and multiple obstacles. More recently, Luong and co-workers have studied the spreading of a mass of grain on a slope that contains a regular array of pillars [2]. They found that the presence of pillars slows down the spreading of the granular mass and enhances its lateral dispersion. Luong *et al.* proposed an empirical model to capture the slow-down of the granular mass through forested regions introducing an effective friction coefficient that depends on inter-pillars distance. However, the stationary flow of grains crossing a forest of obstacles has not been considered yet while it is of interest to better understand the coupling between granular flows and multiple obstacles.

This work explores the effect of a forest of obstacles made of cylindrical pillars on the stationary granular flow running down an incline. The experimental setup consists of a plane of 50 cm in length and 37 cm in width that can be inclined by an angle from the horizontal up to 45 degrees. The plane is covered by a layer of glued glass beads to avoid wall-slip at the bottom of the granular layer. The main specificity of this setup is to include a forest of pillars positionned along a regular arrangement. The diameter of pillars is 2 mm and their height (35 mm) is always larger than the thickness of the flowing granular layer. We quantify how the steady flow rate of grains is affected by the inter-pillars distance for different layer thicknesses and slope angles. We propose a model for this problem based on a depth-average approximation associated with $\mu(I)$-rheology [3] and that considers the average force exerted by the pillars on the granular layer. This model allows to predict under which conditions a forest of obstacles significantly decreases the energy carried by the granular flow.

Références

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