## 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 has not been considered yet while it is of interest to a strong horested 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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