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2D transient granular flows over obstacles: experimental and numerical work

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Landslides are an ubiquitous natural hazard, and therefore human infrastructure and settlements are often at risk in mountainous regions. In order to better understand and predict landslides, systematic studies of the phenomena need to be undertaken. In particular, computational tools which allow for analysis of field problems require to be thoroughly tested, calibrated and validated under controlled conditions. And to do so, it is necessary for such controlled experiments to be fully characterized in the same terms as the numerical model requires. This work presents an experimental study of dry granular flow over a rough bed with topography which resembles a mountain valley. It has an upper region with a very high slope. The geometry of the bed describes a fourth order polynomial curve, with a low point with zero slope, and afterwards a short region with adverse slope. Obstacles are present in the lower regions which are used as model geometries of human structures. The experiments consisted of a sudden release a mass of sand on the upper region, and allowing it to flow downslope. Furthermore, it has been frequent in previous studies to measure final states of the granular mass at rest, but seldom has transient data being provided, and never for the entire field. In this work we present transient measurements of the moving granular surfaces, obtained with a consumer-grade RGB-D sensor. The sensor, developed for the videogame industry, allows to measure the moving surface of the sand, thus obtaining elevation fields. The experimental results are very consistent and repeatable. The measured surfaces clearly show the distinctive features of the granular flow around the obstacles and allow to qualitatively describe the different flow patterns. More importantly, the quantitative description of the granular surface allows for benchmarking and calibration of predictive numerical models, key in scaling the small-scale experimental knowledge into the field.

In addition, as the material is traditionally oriented in a predominant longitudinal direction and the layer of the mass is thin in comparison to the scale of interest, the depth-averaged procedure can be performed in the mass and momentum equations. Regarding the friction theory embedded in the landslide motion, a Coulomb-like basal friction law can be assumed as a first attempt of reproducing the phenomena. On the other hand, the presence of obstacles, involves the study of the development of schock waves imposing the simulation of the granular behavior by means of a schock-tracking numerical scheme. The numerical scheme employed, is based on an approximate solvers based on Roe approaches, devoting especial attention to the frictional source terms.

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