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Granular flow behavior at sharp changes in slope

Giovanni Crosta, Fabio De Blasio, and Michele Locatelli
università degli studi di Milano Bicocca, scienze geologiche e geotecnologie, Dept. of Earth and Environmental Sciences, Milano, Italy (giovannibattista.crosta@unimib.it)

This study extends some recent experiments and analyses performed by the authors to examine the behavior of granular flows along path characterised by sharp changes in slope. In particular, various series of experiments along a bi-linear broken slope (an inclined initial sector followed by a horizontal one) have been completed using a uniform (Hostun, 0.32 mm) sand and a uniform fine gravel (2 mm grains). 60 new have been performed by releasing different volumes (1.5, 2.1 and 5.1 L) on surfaces characterized by different slope angles (35-60°), type of materials (wood and plexiglass), with or without an erodible layer (sand), or in presence of a shallow water pond (0.5 cm). These geometrical features are typical of many large rock and snow avalanches, rock falls and of chalk flows. The latter are usually typical of coastal cliffs where a shallow water environment is typical.
The evolution of the flow has been monitored through a laser profilometer at 120 Hz sampling frequency and high speed camera, and in this way it has been possible to follow the evolution of the flow and deposition, and to analyse the change in deposition mode at varying the slope angle, the material and the basal friction. This is an extremely interesting development in the study of the evolution of the deposition and of the final morphology typical of such phenomena, and can support the testing of numerical models.
Propagation and deposition occur forward or backward accordingly to the slope angle and the basal friction. Forward movement and deposition occur at high slope angles and with low basal friction. The opposite is true for the backward deposition. The internal “layering” within the deposit is also strongly controlled by the combination of such parameters.
The time evolution of the flow allowed to determine the velocity of flow and the mode of deposition through the analysis of the change in thickness, position of the front and of the flow tail. Presence of water reduces the runout of the sand on the horizontal sector of the path, whereas the opposite seems true for the gravel. In these cases, as already shown by the authors (Crosta et al., submitted), a partial reflection of the flow occurs and the same holds true when a shallow water reservoir exists. Furthermore, a sort of hydroplaning phenomenon occurs which controls the initial part of the expansion along the subhorizontal sector of the path.
Results of the experimental campaign have been compared against those from simple analytical models which assume the energy loss at the slope break and numerical simulations performed by a FEM-ALE (2D and fully 3D) modeling.