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Internal deformation within an unstable granular slope: insights from physical modeling

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The collapses of granular materials frequently occur in nature in the form of, for example, rock avalanches, debris avalanches and debris flow. In previous studies of collapses of a granular material, most of the focus has been on the effect of initial geometry and mechanical properties of the granular materials, the run-out distance, and the topography of final deposit. In this study, results of analogue models and scanned natural failed slopes are used to outline the mode of failure of an unstable slope. Model results and field observations are used to argue that a granular mass moves downslope in a wavy pattern resulting in its intensive deformation.

In the models, we mainly investigated the internal deformation of collapses of granular slopes in terms of their internal structures and the spatial and temporal distribution of the latter. Model results showed that a displaced mass of the granular slope has the following two features: (1) Initial collapse resulted in a series of normal faults, where hanging-wall blocks were slightly deformed, like the slump-shear structures in nature; (2) With further collapse, a set of secondary structures, such as deformed/folded fault surfaces, faulted folds, displaced inclined folds, and overturned folds formed near the slope surface. The occurrence of these structures reflects the failure process of the granular mass in space and time. In addition, our model results show that the nature of basal friction has a significant influence on the geometry and kinematics of these structures at the slope toe. Model results show also that the mass does not glide downslope along only one surface, but includes several gliding surfaces each of which take part of the sliding. These gliding surfaces become steeper deeper in the sliding mass. Some of these features observed in the models are also detected in the field. Scanned failed slope surfaces show a wavy pattern similar to that in the models, reflecting the presence of normal faults at the head of the slope and folding at the slope toe.