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Large-scale field testing on flexible shallow landslide barriers

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Open shallow landslides occur regularly in a wide range of natural terrains. Generally, they are difficult to predict and result in damages to properties and disruption of transportation systems.

In order to improve the knowledge about the physical process itself and to develop new protection measures, large-scale field experiments were conducted in Veltheim, Switzerland. Material was released down a 30° inclined test slope into a flexible barrier. The flow as well as the impact into the barrier was monitored using various measurement techniques. Laser devices recording flow heights, a special force plate measuring normal and shear basal forces as well as load cells for impact pressures were installed along the test slope. In addition, load cells were built in the support and retaining cables of the barrier to provide data for detailed back-calculation of load distribution during impact. For the last test series an additional guiding wall in flow direction on both sides of the barrier was installed to achieve higher impact pressures in the middle of the barrier. With these guiding walls the flow is not able to spread out before hitting the barrier. A special constructed release mechanism simulating the sudden failure of the slope was designed such that about $50\ m^3$ of mixed earth and gravel saturated with water can be released in an instant.

Analysis of cable forces combined with impact pressures and velocity measurements during a test series allow us now to develop a load model for the barrier design. First numerical simulations with the software tool $FARO$, originally developed for rockfall barriers and afterwards calibrated for debris flow impacts, lead already to structural improvements on barrier design. Decisive for the barrier design is the first dynamic impact pressure depending on the flow velocity and afterwards the hydrostatic pressure of the complete retained material behind the barrier. Therefore volume estimation of open shallow landslides by assessing the thickness of the failure layer and the width of the possible failure are essential for the required barrier design parameter height and width. First results of the calculated drag coefficients of dynamic impact pressure measurements showed that the dynamic coefficient c_w is much lower than 1.0 which is contradictory to most of existing dimensioning property protection guidelines.

It appears to us that special adaptation to the system like smaller mesh sizes and special ground-barrier interface compared to normal rock-fall barriers and channelised debris flow barriers are necessary to improve the retention behavior of shallow landslide barriers.

Detailed analysis of the friction coefficient in relationship with pore water pressure measurements gives interesting insights into the dynamic of fluid-solid mixed flows. Impact pressures dependencies on flow features are analyzed and discussed with respect to existing models and guidelines for shallow landslides.