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Investigation of debris-flow impact forces on bridge superstructures – laboratory experiments on the influence of bridge profiles

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Mountainous areas tend to have a high density of bridges due to their topography and mobility requirements. Furthermore, such areas are often characterized by frequent debris-flow activity, which in turn can endanger the structural integrity of bridges. The influence of debris flows on bridge piers has already been analyzed in the past, but mechanisms and consequences of debris-flow impact on bridge superstructures remain unclear.

We hypothesize that in addition to horizontal forces, frictional shear-forces and uplift forces may play a considerable role in bridge failure caused by debris-flow impacts. We also conjecture that the type of the bridge superstructure, specifically the bridge profile has an influence on the occurring forces.

In order to obtain a deeper understanding of impact forces on bridge superstructures, we aim to measure and quantify the forces exerted on different bridge profiles during debris-flow impact based on small scale experiments. We will investigate debris-flow impact on five different bridge profiles in the course of the project “Debris-flow impact forces on bridge superstructures (DEFSUP)”, funded by the Austrian Science Fund (FWF).

The laboratory setup consists of a 4 m long semi-circular channel with a diameter of 0.3 m and an inclination of 20°. The cement miniature bridge in the scale of 1:30 is mounted on a metal frame and is installed at the end of the flume. The debris-flow material corresponds to a granular debris flow, the mass is fixed at 50 kg for each experiment. The flume itself has been optimized in preliminary studies and ensures high reproducibility of stationary debris flows with predictably sufficient flow-heights for the impact on the miniature bridge. Each profile is subjected to at least three impacts. The impact forces on the bridge profile are measured with 3-axis-force sensors at both abutments of the bridge. Thereby it is possible to determine horizontal impact forces as well as uplift and shear forces. Additionally, flow heights, pore water pressure and normal stresses are gauged.

The results of the study are intended to contribute to recommendations for the structural design of bridges in vulnerable areas. This aims not only to protect human lives and to increase the safety of structures, but also to provide financial relief in the future, since there is evidence that the areas

prone to debris-flow events are likely to increase as a consequence of climate change.