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Application of numerical modeling for reconstruction of a landslide event in the Mosel River valley, Luxembourg

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The landslide of Deisermillen occurred in 1964 in the vicinity of Grevenmacher, Luxembourg (Mosel River valley). It was one of the most remarkable recent landslides in Luxembourg causing destruction of several buildings and regional motor road. Sliding occurred in the colluvium cover consisting of various size dolomite blocks and soil mixture over a denudated marl surface.

Various hydrogeological triggers could have contributed to the landslide initiation. The Mosel River level was raised by 4.45 meters after construction of a river sluice. Moreover springs discharging in the landslide affected area and increased precipitations during autumn of 1964 could have triggered the landslide as well.

The objective of this study is to determine more precisely which factors caused the Deisermillen landslide. The understanding and quantification of trigger factors allows to determine whether an actual risk for a landslide exists and evaluate the impact of anthropogenic factors on the geomorphologic system. Moreover understanding past landslide triggers allows to predict hillslope evolution under climate change in the Upper Mosel River valley in the future.

We applied a 3D fully coupled hydrogeological model (HydroGeoSphere) to maximally precise reconstruct the hydrogeological conditions before landsliding. The model considers saturated and unsaturated flow, actual precipitation amounts before the landslide, water infiltration from the Mosel River and springs discharging in the landslide area. The hydrogeological model was calibrated using PEST code and further pressure heads from hydrogeological model were applied in the slope stability simulation.

A hybrid finite element stress-limit equilibrium slope stability simulator (GeoStudio) was used to estimate a safety factor for hillslopes. A crucial task for the slope stability modeling was the determination of the soil mechanical parameters at the study site. As the colluvium cover consists of very heterogeneous material, sampling and parameter estimation in laboratory was not appropriate. In situ soil mechanical parameter estimation methods such as pressuremeter- and phicometer tests were applied in the study site. Moreover pressuremeter measurements clearly indicate possible rupture surface in the landslide body which is relevant for back calculation of slope stability.

Results of the modeling show that hillslope stability is highly dependent on the soil mechanical parameters applied in the model. Therefore in a real-world landslide area detailed estimation of soil mechanical parameters is a precondition for reliable estimation of hydrogeological impacts on hillslope stability.

Modeling reveals that the hillslope in the study area is under unstable equilibrium conditions which make it susceptible to move under slight anthropogenic and climatic impacts. Therefore high resolution numerical models, which can detect physical processes affecting landslides with a high detail, are a useful tool to better identify trigger mechanisms of landslides.