Coupled numerical modelling of progressive failure in creeping constrained landslides under steady state and transient state conditions

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ABSTRACT

Creeping landslides are a threat to many mountainous communities. Some of these landslides are constraint either artificially or naturally and are slowing down. This slowing down might cause a false impression of safety even though a subsequent reacceleration of the landslide cannot be ruled out.

Herein a numerical method is presented that can capture several features that have been observed in the creeping Brattas landslide which affects the ski resort town of St. Moritz. Extensive field observations and laboratory testing have revealed a variety of coupled phenomena, which are also common to other constrained landslides.

A simple finite difference algorithm combined with a mechanical constitutive model is presented to simulate these phenomena along the entire slope. The model is based on the mechanism of progressive failure in a zone of intense shearing along the slip surface. Also the effect of rate dependent shear resistance is captured and two different rate dependency relations are analysed.

Combining this mechanism with visco-elastic behaviour in the landslide body explains a phase of gradual slowing down of the landslide until 1991. Subsequent acceleration of the landslide can be described by visco-plastic yielding in a zone at the landslide foot where the pressure is close to passive earth pressure. Observed large differences in the velocity of the landslide between its upper and lower sections are attributed to secondary compression.

The coupled numerical procedure is also capable of capturing not only the steady state behaviour but also the slope's reaction to precipitation (i.e. the transient state) by introducing a simple linear reservoir type model to relate changes in pore pressure to observed precipitation. The numerical procedure can be used for back-calculating parameters of the slope as well as for predictive purposes. These predictions indicate that further significant deformations in the constructed zone of the landslide have to be expected which makes additional observations and monitoring of sensitive structures essential. In combination with probabilistic models for exposures (e.g. development of precipitation and duration cold periods) the numerical model will also allow for proper risk analysis in the area affected by the Brattas landslide.

REFERENCES

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