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Instabilities in alpine Permafrost: Characterisation, Monitoring and Modelling of Active Rock Glaciers

Thomas Buchli (1), Sarah M. Springman (1), and Hansruedi Maurer (2)

(1) Institute for Geotechnical Engineering, ETH Zürich, Zürich, Switzerland , (2) Institute of Geophysics, ETH Zürich, Zürich, Switzerland

Global climate change has a big influence on the sensitive cryogenic regions of the Alps. Increasing mean temperature, accompanied by extreme weather conditions such as heavy rainfall events, may initiate landslides and instabilities in the coming decades due to accelerated motion of the ground. Various forms of hazard to human life and infrastructure may be a consequence. Examples of this phenomenon include the catastrophic 1997 debris flow at Val Pola and rapid motion of entire rock glaciers in Turtmanntal (CH). The correlation between thermohydrological processes and natural hazards are poorly understood. Therefore the seasonal effects of temperature cycles on deformation within the rock glaciers and mechanical behaviour of warm alpine permafrost, i.e. at temperatures close to 0°C, need to be investigated in order to gain better understanding of rock glacier dynamics and stability of permafrost slopes in cold regions.

A rock glacier on Furggwanghorn, located in the Turtmanntal (Valais, CH) was chosen as a site for field characterisation and long term monitoring. The rock glacier shows clear signs of thermal degradation and high velocity creep down slope movement. The research programme includes three main phases, namely characterisation, monitoring and modelling of this rock glacier, which will be conducted by three research groups in geotechnics, geophysics and hydromechanics.

Several measuring instruments have been installed to observe the behaviour of this area following preliminary characterisation of the ground using surface geophysical methods (seismic, georadar and geoelectric). Coordinates for four boreholes were identified and the holes were drilled to a depth of 25 m in September 2010, in order to install thermistor chains. Each chain contains 30 temperature sensors at a distance of between 0.5 and 1.0 m between sensors. 10 supplementary temperature sensors were placed on the surface around each borehole. These sensors will give an overview of the temperature distribution at the surface. In addition, a 24 m long Inclinometer was installed in the fifth borehole in order to detect the horizontal displacement of the body of the rock glacier. The in place inclinometer consists of 48 stiff segments, which are bonded with a hinge. Each segment measures the inclination of that segment in comparison to the adjacent segment. It is possible to obtain the displacements of the body by integration of the inclination angle over the whole length, as the position of the instrument on the surface is always known using geomorphological surveying techniques. Unlike a normal inclinometer, the in place inclinometer allows the data to be received during the whole year, even when the surface is covered by a thick snow layer and therefore inaccessible.

The measurements taken within the rock glacier are supplemented by a meteorological station, which collects long-term measurements of air temperature, precipitation, humidity, wind direction/speed, snow depth and radiation. The data from the meteorological station is important for the interpretation of the measurements taken inside the boreholes. The data collected will be used for a mechanical - thermohydrological analysis, after calibrating a constitutive model with results from laboratory tests on material removed from the field.