Geophysical Research Abstracts
Vol. 20, EGU2018-10359-1, 2018
EGU General Assembly 2018

Mechanical laboratory studies on the stability of thawing permafrost rock and rock joints

Philipp Mamot (1), Samuel Weber (2), Benjamin Jacobs (1), Daniel Funk (3), Tanja Schröder (1), Saskia Eppinger (1), Johannes Leinauer (1), Riccardo Scandroglio (1), and Michael Krautblatter (1)

(1) Technical University of Munich, Chair of Landslide Research, Munich, Germany (philipp.mamot@tum.de), (2) Department of Geography, University of Zurich, Zurich, Switzerland, (3) Deutscher Wetterdienst, Offenbach am Main, Germany

The failure activity of permafrost-affected rock slopes has significantly increased coincident to warming in the last decades. Most of the currently observed failures in permafrost-affected rock walls are likely triggered by the degradation of bedrock permafrost and ice-filled joints which may evolve into potential shear planes.
To anticipate failure in a warming climate, we need to better understand how rock-ice mechanical processes affect rock slope destabilization and failure with temperatures increasing close to 0 °C. Warming permafrost in rock slopes decreases the shear resistance along rock joints (considering ice or soil infillings and cohesive rock bridges) as well as the compressive and tensile strength of saturated intact rock (Krautblatter et al., 2013).
Here we present a comprehensive set of laboratory studies on a broad spectrum of mechanical properties of warming bedrock and rock joints. Tests were performed with various rock types from the permafrost-affected i) Zugspitze, Germany, 2962 m a.s.l. (Wetterstein limestone), ii) Kitzsteinhorn, Austria, 3203 m a.s.l. (calcareous mica-schist) and iii) Manndalen valley, northern Norway, approx. 1100 m a.s.l. (gneiss and mica-schist). The tested mechanical properties of the intact rock contain the uniaxial compressive strength (σc), the tensile strength (σt) and the Young′s modulus (E). Investigated rock joint properties involve the shear strength of rock joints filled with ice or soil and rock joints without infilling.
We are able to demonstrate a temperature-dependent strength reduction for all investigated parameters and rock types:
• the shear strength of ice-filled rock joints reduces by 75-85 % for 4-15 m rock overburden and increasing temperature from -10 to -0.5 °C (Mamot et al., submitted to The Cryosphere),
• the basic joint friction angle of rock-rock contacts decreases by 10-17 %,
• the shear strength of soil-filled joints sinks by 5-65 % depending on the grain size,
• the tensile strength of intact rock falls by 20-23 %,
• the unconfined compressive strength of intact rock reduces by 9-17 %,
• the Young′s modulus decreases by 20-39 % and
• the bulk modulus K and shear modulus G (derived from the Young′s modulus and Poisson ratio) reduce by 7-10 and 22-46 % respectively.
The studied parameters are a key requirement to develop meaningful numerical models. They will enable scientists and engineers to anticipate more accurately the strength reduction of degrading permafrost rock slopes, as they reproduce real-world strength conditions in different rock types and along sliding planes.

Krautblatter, M., Funk, D., Günzel, F. K. (2013): Why permafrost rocks become unstable: a rock-ice-mechanical model in time and space. Earth Surface Processes and Landforms 38, 876-887.
Mamot, P., Weber, S., Schröder, T. and Krautblatter, M.: A temperature- and stress-controlled failure criterion for ice-filled permafrost rock joints. Submitted to The Cryosphere.