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Frictional behaviour of cohesionless rock joints under frozen conditions – data analysis from laboratory experiments and their implementation in rock mechanical concepts

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Degrading permafrost in rock walls is considered to be a major hazard due to both rockfall activity and slow rock deformation that endanger infrastructure and human lives. An increasing number of rock slope failures were recorded in recent years from permafrost rock walls.
Current stability analysis of permafrost affected rock slopes were conducted by geomorphologists and glaciologists and are based on the findings of Davies (2000) assuming ice-filled joints. Consequently, the physical basis is limited to the deformation behaviour of pure ice and rock-ice contact under normal and tensional loads.
Several studies from rock engineers on rock strength parameters show a significant decrease under thawing conditions. Tested parameters are the uniaxial compressive strength and tensile strength, fracture toughness and subcritical fracture propagation. These findings may be very important for stability issues of thawing permafrost in rock slopes and must be implemented into concepts of failure criteria of rock-masses.

Considering the failure criterion for shear failure of separated rock-blocks from Barton & Choubey (1977), we suggest a reduction of shear strength of thawing permafrost rocks due to diminishing friction. Here we present the methodical setup and data from laboratory experiments on shear strength of discrete frozen and unfrozen rock samples (Wetterstein limestone) in comparison. We can show that friction systematically increases along frozen fractures. We assume that the reduced friction for thawed samples is due to the shearing of asperities which is a statistical consequence of reduced uniaxial compressive and tensile strength of asperities. The significance of the reduced shear strength effect due to thawing is dependent on temperature and the relation of initial roughness and applied normal load. Further important parameters like moisture content and the phenomenon of ice segregation are discussed.
These data provide an important contribution for a physically-based process understanding which is necessary to estimate the temporal and spatial occurrence of future rock slope instabilities in permafrost affected rock slopes.