Geophysical Research Abstracts
Vol. 20, EGU2018-3257, 2018
EGU General Assembly 2018

Numerical simulation of the thermally-induced wedging ratcheting mechanism is rock slopes

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In this research, a thermally induced wedging-ratcheting mechanism for slope stability is investigated using a three-dimensional version of the numerical Distinct Element Method (3DEC). Our goal is to examine whether daily or annual surface temperature fluctuations can induce downslope, irreversible displacement and to create a quantitative model for thermally controlled block displacements. Problems of heat conduction are often too complex to solve using analytical solutions alone. Numerical approaches allow us to study complicated geomechanical problems for which exact analytical solutions do not exist or cannot be obtained. We construct a three-dimensional model in 3DEC to simulate the thermal expansion of a sliding block and the resulting block displacement down an inclined frictional slope. According to the proposed wedging-ratcheting mechanism, this displacement is assumed irreversible. Our results show that block displacement down the slope indeed occurs when the block boundaries are subjected to increased temperatures. Results of the numerical model are compared with experimental results obtained from a physical model in a climatically controlled room (detailed separately in an abstract entitled: "Experimental study of the wedging – ratcheting mechanism in rock slopes using a large physical model in thermally controlled room").

In addition, we compare numerical simulations with monitored displacements of a slender block in the East slope of Mount Masada as up until recently the governing mechanism for this block displacement has been assumed to be seismically driven. By application of our approach to the exact physical dimensions of the block in the field we find that, in fact, thermal loading alone can explain this displacement. We believe this failure mechanism may play a significant role in slope stability problems due to the cumulative and repetitive nature of the displacement, particularly in places prone to high temperature oscillations.