Instability in Himalayan Rock Slope under Recurrent Freeze-Thaw

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The highways in the Himalayas region have an important concern as these are the only connecting corridors to the nearby land area. Manali-Leh highway is one such important route in India which is interrupted frequently by landslides and rockslides events due to freeze-thaw activity, earthquake, heavy rainfall and anthropogenic activities are major triggering factors. In the freeze-thaw activity, water enters into the cracks in rocks during rainfall, subsequently, it freezes, leads to enlargement of cracks and/or the initiation of new cracks due to the volumetric expansion of ice. In the summer season, the ice melts and water migrates to the newly generated cracks and later freezes in the winter season. This, in turn, weakens the rock structure that leads to the reduction of the rock mass strength which promotes instability in the rock slopes. This study focuses on the stability assessment of rock slope along the highway from Solang Valley in Himachal Pradesh, India. This highway connects the Solang Valley to the south portal of the Rohtang tunnel and provides all-weather connectivity, as the Manali-Leh highway shut down during the winter season due to heavy snowfall.

An extensive geotechnical survey was carried out on the studied slope and the rock samples were collected from the field. The artificial freeze-thaw environment was created in the laboratory for the rock specimens to account the natural freeze-thaw effect. Laboratory tests were conducted on the rock specimen conditioned with freeze-thaw to determine the physico-mechanical parameters of intact rock prior to the numerical simulation. The results indicate the significant loss in compressive and tensile strength of rock as the number of freeze-thaw cycles increases. A three-dimensional numerical modelling was performed to assess the stability of the rock slope using the Distinct Element Code (3DEC software). Slope geometry was prepared to represent the actual slope and the various discontinuity sets observed at the field was mapped on the model. The behaviour of the discontinuity sets was modelled using a Mohr-Coulomb slip with residual strength. Normal stiffness of the joints was calculated from rock mass deformation modulus, intact rock young's modulus and joint spacing. Similarly, the shear stiffness was calculated. The results of numerical modelling show that the displacement of blocks increases and the factor of safety of the slope decreases as the number of freeze-thaw cycles increases.