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Stress induced shallow landslides due to transient infiltration.

S. Simoni (1), N. Lu (2), R. Rigon (1)

1. University of Trento, Italy, (2) Colorado School of Mines, CO, USA

(silvia.simoni@ing.unitn.it / Phone +39 0461-882610)

In shallow landslide hazard analysis, the assumption of worst-case (i.e. saturated) conditions is typically made with the belief that this approach is conservative and can be used for sound policy decisions. However, recent theoretical and experimental work points to the occurrence of shallow landslides in the absence of widespread areas of positive pore-water pressure. Therefore, analyses that consider saturated conditions only, may be appropriate for engineering designs of man-made slopes, but may inadequately capture time-dependent failure processes of natural slopes at regional scales. Using a physically-based approach, we attempt to describe shallow soil failures as a consequence of stress changes in the hillslope due to the progressive wetting during rainfall infiltration. Based new theory of effective stress in the unsaturated zone we extend an infinite slope-stability analysis to account for interparticle stresses that develop with variation in water content. This analysis describes the evolution of slope stability without imposing a specific failure mechanism.

To simulate the effect of transient infiltration processes on slope stability during rainfall events, we calculate a static limit-equilibrium safety factor at arbitrary times for numerically-computed pore-water conditions. This more physically realistic description of soil effective stress combined with the distributed evolution of soil moisture conditions provides a time-variable assessment of slope stability.

We have implemented this new approach in quasi-three dimensions in a version of a distributed coupled hydrological-geotechnical, GEOtop-SF and describe and application to an area prone to landsliding, located south of Seattle, Washington, USA. Topographic input data were derived from LIDAR topography and point landslide locations with timing information are available to test results. Results show that the total

area predicted to be unstable in a given rainstorm is less than that computed assuming saturated conditions. In addition, results show that the time-dependent redistribution of moisture and matric suction during infiltration controls transient changes in suction stress profile. The reduction of suction stress, as soil becomes wetter, can be identified as the physical mechanism triggering many shallow landslides when slopes are subjected to intensive precipitations.