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The effect of subsurface hydrology on shear destruction of a sandy slope

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To improve the accuracy of predictions of shallow landslide timing induced by rainfall, we focused on the mechanism of subsurface hydrology at an artificial sandy slope of 32? that was 9 m long, 1 m wide, and 0.7 m deep. We measured pore water pressures and volumetric water content occurring prior to shallow landslides in a flume experiment using the artificial slope with rainfall intensities of 80 mm/h. In addition, we evaluated changes in the internal stresses in the slope up to shallow landslide initiation (i.e., effective soil weight, apparent soil cohesion, and seepage force under saturated and unsaturated soil water condition). Then, based on the local safety factors in the landslide body obtained by the internal stresses, we tried to get quantitative information on the effect of the hydrological process on soil displacement and subsequent shallow landslide initiation.

We found that:
1) The timing of the directional change in subsurface flow to parallel the slope in the deep part of landslide body coincided closely with onset of soil displacement.
2) Changes in the local safety factors in the landslide body showed that the expansion of instable area at the up part of the landslide body resulted mainly from the appearance of buoyancy and subsequent decline of the apparent soil cohesion.
3) Changes in the local safety factors prior to the shallow landslide initiation showed that the down part of the landslide body had been holding the instable upslope.
4) Excess shear stress in the up part of landslide body, attributed to the changes in direction and magnitude of saturated and unsaturated subsurface flows, caused both the sudden increase in shear stress in the down part of the landslide body and subsequent whole slope instability, and simultaneously the shallow landslide was induced.
5) Seepage force was more important factor to cause the shallow landslide than the effect of buoyancy and consequent changes in the effective weight of soils. This implies that the changes in local safety factors combining the seepage force under saturated and unsaturated conditions provided the accuracy to predict the timing of shallow landslide initiation.

Therefore, the seepage force controlled by changes in direction and magnitude of saturated and unsaturated subsurface flows in slopes can be the important parameter of soil displacement and shallow landslide initiation.

Keywords: Seepage force, Flow direction, Excess shear stress, Flume experiment, Precursor