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Effects Of Bedrock Shape And Hillslope Gradient On The Pore-Water Pressure Development: Implication For Slope Stability

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Shallow Landslides are one of the most important causes of loss of human life and socio-economic damage related to the hydro-geological risk issues. The danger of these phenomena is related to their speed of development, the diffculty of foreseeing their location, and the high density of individual phenomena, whose downhill trajectories have a relevant probability of interfering with urbanized areas. Research activity on precipitation-induced landslides has focused mainly on developing predictive understanding of where and when landslides are likely to occur. Nevertheless, some major aspects that may be related to activation of landslides have been poorly investigated. For instance, landslide susceptibility zones are generally predicted assuming constant thickness of soil over an impervious bedrock layer.

Nevertheless, recent studies showed subsurface topography could be a first order control for subsurface water-flow dynamics, because of the effects of its own irregular shape. Tromp-van Meerveld and McDonnell (2006) argued that connectivity of patches of transient saturation were a necessary prerequisite for exceeding the rainfall threshold necessary to drive lateral flow. Connectivity - ”how the hillslope architecture controls the filling and spilling of isolated patches of saturation” (Hopp and McDonnell, 2009) - appears to be a possible unifying concept and theoretical platform for moving hillslope and watershed hydrology forward. Connectivity could also have important implications on triggering of shallow landslides, because the particular shape of bedrock may limit the water-flow downhill.

Here we present a number of virtual numerical experiments performed to investigate the role of bedrock shape and hillslope gradient on pore-water pressure development. On this purpose, our test is represented by the subsurface topography of the Panola Experiment Hillslope (PEH). That is because scientific literature on PEH provides substantial documentation about the role of bedrock layer on subsurface water-flow dynamics. We also exploit the concept of Downslope Index (DWI) (Hjerdt et al., 2004) and Upslope Contributing Area (UCA) as indicators of the areas more susceptible to landslide.

The results indicate that bedrock shape influences the max pore-water pressure, even with different hillslope gradients; meanwhile, hillslope gradient affects the persistence-time of the max pore-water pressure. Moreover, results suggest DWI as an useful index to improve the capability of the very-used SHALSTAB model to assess for landslide susceptibility areas.