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Experimental evidence of pore pressure diffusion in clayey soils prone to landsliding

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Failures occurring along natural slopes often involve the shallow weathered horizon of soil and are triggered by intense rainfall events. Such observations have guided the research efforts spent during the last decade to develop predictive models based on the coupling of an infinite slope stability analysis with a simplified hillslope hydrologic model. The predictive capabilities of these models are usually tested against the areal distribution of landslides while the ability of the hydrologic model to reproduce actual pore water responses is rarely questioned.

In order to investigate the groundwater response to precipitation of a unstable clay slope, we set up an experimental study based on the automated measurement of pore pressures at different depths and locations. The deployed system includes moisture and pressure sensors designed to capture both short and long-term pore pressure variations in spite of the low hydraulic conductivity of the soil. The first three years of measurements indicate that at depth of tens of centimeters to few meters below the ground surface, moisture and pressure sensors are characterized by a relatively fast responses to precipitations. The pore pressure increase is highly transient and clearly associated to single rainfall events, and the pressure pulses advance downward within the saturated domain attenuating with depth.

The observed behavior is well reproduced by the linear diffusion equation. The predictive capabilities of the model have been tested against 129 experimental pressure head responses. When the validity domain is respected, the model captures the essential physics of the phenomenon and it is able to simulate the observed sensors response using realistic values of the hydraulic parameters (hydraulic conductivity and soil moisture capacity at saturation). However, because of the difficulties related to the prediction of the initial condition of the slopes, and given the inherent uncertainties of hydraulic parameters, the practical utility of the linear diffusion model in the framework of areal slope stability assessment is rather limited. Within this context we stress the importance of field monitoring and discourage the application of models not adequately supported by data to predict landslide susceptibility.