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Comparison between monitored and modeled pore water pressure and safety factor in a slope susceptible to shallow landslides

Massimiliano Bordoni (1), Claudia Meisina (1), Davide Zizioli (1), Roberto Valentino (2), Marco Bittelli (3), and Silvia Chersich (1)

(1) Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy (massimiliano.bordoni01@universitadipavia.it), (2) Department of Civil, Environmental, Territorial Engineering and Architecture, University of Parma, Parma, Italy, (3) Department of Agricultural Science, University of Bologna, Bologna, Italy

Shallow landslides can be defined as slope movements affecting superficial deposits of small thicknesses which are usually triggered due to extreme rainfall events, also very concentrated in time. Shallow landslides are hazardous phenomena: in particular, if they happen close to urbanized areas they could cause significant damages to cultivations, structures, infrastructures and, sometimes, human losses.
The triggering mechanism of rainfall-induced shallow landslides is strictly linked with the hydrological and mechanical responses of usually unsaturated soils to rainfall events. For this reason, it is fundamental knowing the intrinsic hydro-mechanical properties of the soils in order to assess both susceptibility and hazard of shallow landslide and to develop early-warning systems at large scale.
The hydrological data collected by a 20 months monitoring on a slope susceptible to shallow landslides in an area of the North –Eastern Oltrepo Pavese (Northern Apennines, Italy) were used to identify the hydrological behaviors of the investigated soils towards rainfall events. Field conditions under different rainfall trends have also been modeled by using both hydrological and physically-based stability models for the evaluation of the slope safety factor . The main objectives of this research are: (a) to compare the field measured pore water pressures at different depths with results of hydrological models, in order to evaluate the efficiency of the tested models and to determine how precipitations affect pore pressure development; (b) to compare the time trends of the safety factor that have been obtained by applying different stability models; (c) to evaluate, through a sensitivity analysis, the effects of soil hydrological properties on modeling pore water pressure and safety factor.
The test site slope where field measurements were acquired is representative of other sites in Northern Apennines affected by shallow landslides and is characterized by medium-high topographic gradient (ranging from 22 to 35°). The bedrock is made up of gravel, sand and poorly cemented conglomerates; superficial soils, derived by the weathered bedrock, are prevalently clayey-sandy silts and clayey-silty sands with different amounts of pebbles and carbonate concretions. A geotechnical, mechanical, pedological and mineralogical characterization of superficial deposits was performed. Laboratory reconstruction of hysteretic soil water characteristic curves was also carried out to determine the main soil hydrological properties.
The experimental station consists in a pluviometer, a thermo-hygrometer, a barometer, an anemometer and a net radiometer. Six TDR probes equipped with a multiplexer are installed at 0.2, 0.4, 0.6, 1, 1.2, 1.4 m from ground level to measure volumetric water content; to measure pore water pressure, three tensiometers and three heat dissipation sensors are installed at 0.2, 0.6, 1.2 m from ground level. The data are collected by a CR1000 datalogger (Campbell Sci. Inc.) each 10 minutes.
In this work the results of the comparison between monitored and modeled pore water pressures and the safety factor in different conditions are analyzed in order to understand the hydro-mechanical properties that could predispose the triggering mechanism of shallow instabilities and the processes that have to be taken into account in the evaluation of shallow landslides susceptibility.