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Model slope infiltration experiments for shallow landslides early warning

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Occurrence of fast landslides has become more and more dangerous during the last decades, due to the increased density of settlements, industrial plants and infrastructures. Such problem is particularly worrying in Campania (Southern Italy), where the fast population growth led a diffuse building activity without planning: indeed, recent flowslides caused hundreds of victims and heavy damages to buildings, roads and other infrastructures.

Large mountainous areas in Campania are mantled by loose pyroclastic granular soils up to a depth of a few meters from top soil surface. These soils have usually a grain size that falls in the domain of silty sands, including pumice interbeds (gravelly sands), with saturated hydraulic conductivities up to the order of 10-1 cm/min. Such deposits often cover steep slopes, which stability is guaranteed by the apparent cohesion due to suction under unsaturated conditions, that are the most common conditions for these slopes [Olivares and Picarelli, 2001]. Whereas rainfall infiltration causes soil to approach saturation, suction vanishes and slope failure may occur.

Besides soil physical properties, landslide triggering is influenced by several factors, such as rainfall intensity, soil initial moisture and suction, slope inclination, boundary conditions. Whereas slope failure occurs with soil close to being saturated, landslide may develop in form of fast and destructive flowslide.

Calibration of reliable mathematical models of such a complex phenomenon requires availability of experimental observations of the major variables of interest, such as soil moisture and suction, soil deformation and displacements, pore water pressure, during the entire process of infiltration until slope failure. Due to the sudden trigger and extremely rapid propagation of such type of landslides, such data sets are rarely available for natural slopes where flowslides occurred. As a consequence landslide risk assessment and early warning in Campania rely on simple empirical models [Versace et al., 2003] based on correlation between some features of rainfall records (cumulated height, duration, season etc.) and the correspondent observed landslides.

Laboratory experiments on instrumented small scale slope models represent an effective way to provide data sets [Eckersley, 1990; Wang and Sassa, 2001] useful for building up more complex models of landslide triggering prediction. At the Geotechnical Laboratory of C.I.R.I.AM. an instrumented flume to investigate on the mechanics of landslides in unsaturated deposits of granular soils is available [Olivares et al. 2003; Damiano, 2004; Olivares et al., 2007]. In the flume a model slope is reconstituted by a moist-tamping technique and subjected to an artificial uniform rainfall since failure happens. The state of stress and strain of the slope is monitored during the entire test starting from the infiltration process since the early post-failure stage: the monitoring system is constituted by several mini-tensiometers placed at different locations and depths, to measure suction, mini-transducers to measure positive pore pressures, laser sensors, to measure settlements of the ground surface, and high definition video-cameras to obtain, through a software (PIV) appositely dedicated, the overall horizontal displacement field. Besides, TDR sensors, used with an innovative technique [Greco, 2006], allow to reconstruct the water content profile of soil along the entire thickness of the investigated deposit and to monitor its continuous changes during infiltration.

In this paper a series of laboratory tests carried out on model slopes in granular pyroclastic soils taken in the mountainous area north-eastern of Napoli, are presented. The experimental results demonstrate the completeness of information provided by the various sensors installed. In particular, very useful information is given by the coupled measurements of soil water content by TDR and suction by tensiometers.

Knowledge of soil water content at the occurrence of slope failure is of key importance, since high soil moisture, in such loose granular soils, may lead the landslide to develop in a fast flowslide, either by modifying the rehological properties of the mud, or by affecting slope equilibrium. However, actual water content is not predictable from suction measurements alone, because soil water retention curve is modified by shear stress and by soil bulk volume

change under wet conditions.

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