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Investigation on the water retention curve of loose pyroclastic ashes of Campania (Italy) and its potential implications on slope stability

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Loose pyroclastic soils in Campania cover a large amount of steep slopes in the area surrounding the volcanic complex of Somma-Vesuvius. The stability of such slopes is assured by the contribution of suction to soil shear strength, which decreases during rainy periods till the possible attainment of a failure condition. The resulting landslide may evolve in form of a fast flow, if at the onset of instability the soil is nearly saturated and undrained conditions establish, so that soil liquefaction arises.

The attainment of instability near saturation is not uncommon, as it requires the slope to have an inclination close to the friction angle of the soil constituting the deposit. The pyroclastic ashes of Campania are typically silty sands with friction angle between 36° and 38°, and small or even null cohesion. Many of the flow-like landslides, occurred during the last decades, were indeed triggered along slopes with inclination around 40°, which are quite common in Campania.

As a suction of few kPa may be enough to guarantee the stability of a slope, knowledge of the water retention curve of the soil constituting the deposit is mandatory to correctly predict soil conditions at failure. Several studies report that the pyroclastic ashes of Campania exhibit a quite complex water retention behavior, showing a bimodal porosity distribution and, in some cases, a marked hysteresis domain, possibly enhanced by air entrapment during the infiltration of steep wetting fronts. In this study, a series of vertical infiltration and evaporation cycles have been carried out over two reconstituted specimens, both 20cm high, of pyroclastic ashes collected at the slope of Cervinara. TDR probes and minitensiometers were buried at various depths to provide coupled measurements of soil water content and suction. In order to highlight the possible hysteretic effects due to air entrapment, different hydraulic boundary conditions were established at the base of the two specimens: in one case a pervious boundary was realized by means of a geogrid covered with a geotextile layer in free contact with atmosphere; in the other case, the impervious boundary was constituted by a plexiglass panel.

The obtained results indicate that the water retention curves followed by the soil during the wetting and drying phases were different, and that such a difference is more pronounced in the specimen with impervious bottom, thus confirming that air entrapment may be significant, especially during fast transient infiltration. In the field, where the infiltration front penetrates at much larger depths, the effect of air entrapment is expected to be even higher, leading to infiltration processes evolving under smaller suction at a given water content, and approaching a smaller saturated water content. Hence, the establishment of slope instability in unsaturated conditions is favored, and the evolution of the landslide in form of a flow is more unlikely.