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EFFECTS OF PERENNIAL GRAMINAE ON HYDRO-MECHANICAL BEHAVIOR OF PYROCLASTIC SOILS

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Pyroclastic soils are widely diffused all over the world and they are generally characterized by high porosity and an open metastable internal structure. Those produced by the past eruption activities of Vesuvius volcano are usually in unsaturated conditions[1], covering the shallowest layers of slopes in Campania region (South Italy). During the rainy season they are often involved in rainfall induced shallow flow-like landslides[2]. The rain water infiltration leads to a volumetric collapse of the metastable structure in unsaturated conditions, and to the static liquefaction when pore water pressures can not dissipate in fully saturated conditions during the post-failure stage[3]. As consequence, the liquefied propagating mass, due to its high velocity, can reach great distances causing loss of life and economic damages to structures or infrastructures. Structural passive control works, such as dissipative basins and/or brindles, have been usually adopted as risk mitigation measures for these rainfall induced flow-like landslides, even if they are expensive and require frequent maintenance.

Among the active control works, bio-engineering practices using vegetation for slope stabilization can represent an alternative sustainable risk mitigation measure for shallow pyroclastic covers. However, no significant contributions are currently available in literature quantifying the effect of vegetation, in particular roots, on the hydro-mechanical behavior of unsaturated pyroclastic soils.

Perennial graminae grass species with fine and fasciculate long roots (up to 2 m) has been seeded in 1D plexiglass column (200 cm high and inner diameter of 190 mm) filled with pyroclastic soil belonging to class ‘B’[4]. Tensiometers and soil moisture sensors monitored the soil suction and the volumetric water content (VWC) respectively at 30 cm, 60 cm, 120 cm and 180 cm depth. In addition, another 1D instrumented column, only filled with bare soil, was built up as control. During growth period, the monthly root length and the height of foliage showed a strong linear correlation. 15 days drying tests in both rainy (April) and dry season (July) were conducted on both vegetated and bare soil columns to quantify the effect of roots on the daily suction increment and the VWC along depth. Results show that the presence of roots enhances the soil suction increment in both rainy and dry season, in particular this increment is higher in shallowest layers and increases with the elongation of the duration of drying. The experimental Soil Water Retention Curves (SWRCs) show that roots increment apparently the soil density and this is clearly reflected in a reduction on VWC for a fixed amount of suction value, compared to the bare soil. These effects are highlighted in shallowest layers, up to 120 cm depth.

Wetting tests of different duration were conducted by applying an artificial rainfall of fixed intensity (1-4 mm/h) selected on the base of the most frequent events occurred in one test site of Campania region from 2001 to 2011[5]. The soil suction reduction (Δs) due to water infiltration was computed respectively at 30 cm and 60 cm depth as the difference between the soil suction measured at initial condition (s_0) and the soil suction at the end of the artificial rainfall event. In general, independently on the presence of vegetation, experimental results highlight that s0 influences the response of soil under wetting[5] and the Δs decreases with depth. Furthermore, the vegetation affects the magnitude of Δs depending on s0 and the duration of the event: i) for small s_0 the response of both bare and vegetated soil under wetting is quite similar, while Δs in vegetated soil is lower than bare soil as s_0 increases; ii) for short rainfall the water infiltration is delayed in vegetated soil, thus Δs is reduced independently on the initial soil suction and this delay is reflected also at deeper depth; iii) with the increasing of rainfall duration the responses of both vegetated and bare soils become similar.

The volumetric collapse due to wetting was investigated through oedometer collapse tests on both bare and vegetated unsaturated reconstituted samples. For a fixed vertical net stress applied with the increase of initial porosity of the structure, the magnitude of collapse due to wetting increases[6]. Furthermore, in samples with similar initial porosity, the magnitude of collapse decreases passing from bare to rooted soil. This might be to the effect of roots which act like a network increasing apparently the density of the whole root-soil matrix.

Finally, isotropic consolidated drained and undrained triaxial tests were performed in saturated condition on rooted soil samples taken at different depths from the vegetated soil column and compared with those conducted on bare soil samples. Results show that the presence of roots increases both total cohesion and the internal friction angle, proportionally with the root biomass in the soil. Moreover, in consolidated triaxial tests in undrained conditions the presence of roots reduces drastically the increment of pore water pressures during post-failure stage, by turning into dilatant the typical contractive behavior of these loose soils.

All those insights represent a basic framework encouraging further experimental investigations aimed to consider this technique a sustainable risk mitigation measure in unsaturated pyroclastic soils of the Campania region.

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