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TDR water content profiles measurements in artificial and natural slopes covered with pyroclastic soils

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Recently, innovative approaches allowing to estimate water content spatial distribution along metallic probes with single Time Domain Reflectometry (TDR) measurements have been proposed. TDR estimates of soil volumetric water content are based upon the strong correlation with soil bulk dielectric permittivity. This is possible because the dielectric permittivity of soil water is significantly greater than that of the solid matrix and, consequently, bulk soil dielectric permittivity is very sensitive to changes in water content.

Very often, the empirical third order polynomial proposed by Topp et al. (1980), the so-called universal calibration relationship, is used to obtain soil volumetric water content from dielectric permittivity. Several authors, however, have proposed alternative expressions for the relationship between water content and dielectric permittivity, since in many soils a different dielectric behaviour has been observed: namely, soils with very low density, with high surface area, with high organic matter content, and rich with allophanic minerals. Pyroclastic soils that cover large areas of Campania (southern Italy) often present many of such features. In particular, allophonic aggregates are supposed to be responsible of the observed extremely high porosity, in some cases larger than 0.7, and high surface area.

In this study, water content profiles have been measured by TDR in either artificial or natural slopes with an inverse technique based on the integration of transmission lines equations (Greco, 2006). In order to obtain reliable data, the empirical relationship between volumetric water content and bulk dielectric permittivity of several volcanic ashes, collected in various areas of Campania, has been experimentally determined.

For all the investigated soils, the obtained relationships significantly differ from Topp et al. (1980) calibration relationship, which use may lead to unacceptable errors in the estimation of soil water content. In particular, for soils taken in sites that experienced small disturbance, the obtained water content vs. dielectric permittivity curves resulted close to relationships observed in literature for volcanic soils with similar characteristics. Conversely, different relationships, closer to Topp et al. polynomial, were observed for soils which had been subjected to disturbance by human activities, probably because of the destruction of aggregates.

The obtained results show how the determination of specific calibration relationships is mandatory for reliable estimation of water content profiles in pyroclastic soils.