ABSTRACT

The hydraulic processes that control the water movements through the soil strictly depend on the configuration and distribution of the soil pores. Natural soils are often characterized by the presence of heterogeneities of various kinds which directly impacts on the distribution and structure of the pore network system; this may result in significant consequences on the hydraulic response of the soil and indirectly on the mechanical behavior. In literature it has been shown that a wide class of "heterogeneous" soils should be adequately represented by commonly defined "dual-porosity" models (or dual structure, dual permeability or still). These models conceptually consider the whole soil pore system as constituted by two distinct but interacting porous sub-domains to which it is possible to assign two different hydraulic behaviors.

In dual-structure soils the water movement is frequently described as a combination of the flow matrix (or microstructural flow), that affects the micropores between the primary particles of the soil, and the flow in macropores (or macrostructural flow) that is generally faster than the previous. Assuming that the size scale of heterogeneities is comparable with Darcy scale (therefore the hydraulic processes can be adequately described by the Richards' equation), an analysis approach is to consider dual-structure soil as a continuous medium in which the complex heterogeneity of the porous system and its related hydrological response can be described by bimodal models.

This work explores the influence of dual-structure on the stress-strain behavior of unsaturated terrain and proposes a new analytical method to assess the effects of the hydraulic properties on soil shear integrating a bimodal lognormal function to describe water retention behavior within the suction stress theory framework. Hydraulic properties affect the shear strength of unsaturated soils in terms of suction, predicted as a function of water volume in the pores. The proposed bimodal suction stress method originates from the double structure typically exhibited by widely-graded soils, which are characterized by a bimodal pore-size distribution that is conceptually divided into micro and macrostructures.

The model is validated against literature data from soils with aggregated macrostructure or with a prevailing coarse fraction. Depending on the soil type and the range of suction investigated, the micro and macrostructures should prevail affecting the mechanical soil response subject to environmental loading, such as rainfall events. In order to investigate the bimodality effects in timing analysis the processes are dynamically described by a numerical solution of Richards' equations. A novel one-dimensional column Richards-based code (Ri.D1) have been developed using lognormal bimodal functions to describe the hydraulic properties. The work attempts to focus on the possible differences (and its magnitude) that occur between using conventional unimodal and bimodal interpretative models. The observed differences were investigated by comparing predictions in term of water contents and suction head profiles. In order to evaluate the effects of the hydraulic bimodality on the shallow landslides triggering processes, Ri.D1 includes a dedicated-module for simulating slope stability analysis. Comparisons between the results obtained from a "fully-unsaturated and bimodal approach" and a conventional slope stability analysis has been performed. From a practical point of view, taking into account the dual-structure network should be fundamental in the set-up of proper prediction models for shallow landslides induced by rainfall.