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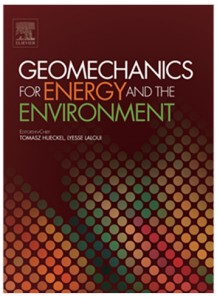

Theoretical and experimental investigations on the role of transient effects in the water retention behaviour of unsaturated granular soils

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Theoretical and experimental investigations on the role of transient effects in the water retention behaviour of unsaturated granular soils☆

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Abstract

In the present study, an experimental setup is presented and employed to examine the influence of rate of change of saturation on the transient water retention curves of granular soils with a low suction range. The results are evaluated and compared to existing theoretical approaches to model the non-equilibrium soil-water retention behaviour as well as to experimental findings from other researchers. Furthermore, suction stress characteristic curves under non-equilibrium conditions are obtained. Finally, the importance and the application of the results in hydro-mechanical modelling of unsaturated soils are discussed.

Keywords: Soil-water retention behaviour, transient effects, suction stress, granular soils, matric suction measurement

1. Introduction

1.1. Investigation of the soil-water characteristic curve

The experimental investigation of the soil-water characteristic curve (SWCC) or water-retention curve (WRC) is of great importance in soil science, soil mechanics and hydrology. This relationship between capillary pressure p_c or matric suction s and volumetric water content θ or degree of saturation S_r represents a key function for the modelling of the hydro-mechanical behaviour of porous media such as soils in the unsaturated state.

The SWCC is known to experience hysteresis and a multitude of scanning-paths on drying and wetting cycles between full saturation ($S_r = 1$) and the so-called irreducible saturation S_{irr}, as depicted in figure 1. Another phenomenon is the influence of air entrapment which occurs during an imbibition. The imbibition paths do not reach full saturation and they will have a difference ΔS_r due to entrapped air.

The hysteresis phenomenon is due to various microscopic effects during the flow of pore water through the pore space; such as contact angle changes upon drying and wetting paths, the bottle neck effect, as well as air entrapment (Bear, 1979). The macroscopic manifestation of these effects is the measurable SWCC with its highly non-linear behaviour and "hydraulic memory", i. e. path-dependence on hydraulic history.

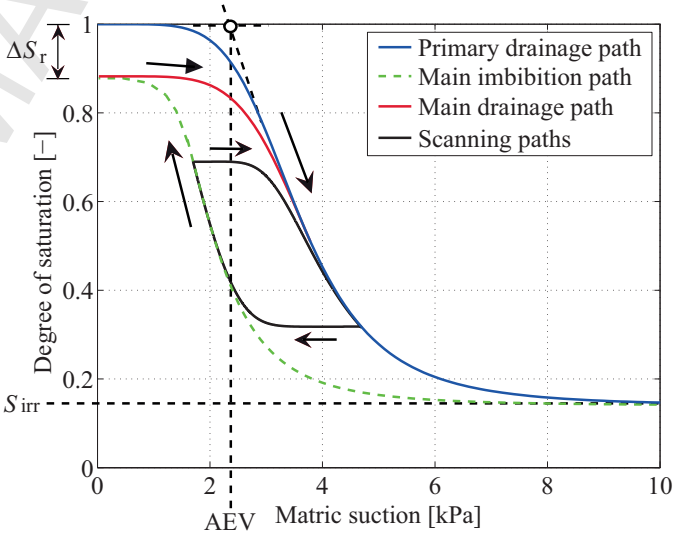

Figure 1: Idealised hysteretic soil-water characteristic curve of a sandy soil with primary drainage, main imbibition, main drainage paths and different scanning paths.

Several methods have been developed for the experimental investigation of the SWCC in the laboratory (Vanapalli et al., 2008). These methods are characterised by different ranges and control accuracies of soil suction and are used for suction control in the measurement of SWCC or in mechanical testing of unsaturated soils. For the control of very high suction levels up to several megapascals in fine grained cohesive soils, methods, such as the osmotic technique (Cui & Delage, 1996) or the water vapor method, have been developed. In order to control medium to low

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