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Soil Water Retention Behaviour of a Sandy Clay Fill Material

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Abstract

The performance of transportation networks is critically dependent on the performance of cutting and embankment slopes. An instrumented embankment has been established at Nafferton farm in North East England to investigate the response of an embankment to changing climatic conditions. Higher pore water pressures (near to hydrostatic) were observed during winter months (typically January) falling back to lower values in March. The pore water pressures showed generally positive values in the upper 3 m of the embankment although suctions existed at 4.5 m depth. Soil water retention curves (SWRC) are essential to understand the changes in water content and suction that can take place during seasonal cycles and during extreme weather events. SWRCs for the embankment soil have been measured in the laboratory using novel high suction tensiometer based equipment. The results confirm that wetting and drying paths for the soil show significant hysteresis. The major differences occur in the first cycle of drying and wetting and smaller differences are seen in subsequent scanning curve paths.

Keywords: Embankment; Unsaturated soil; Soil water retention curve; Tensiometer

1 Introduction

The UK's transport infrastructure is one of the most heavily used in the world. The performance of the transportation networks is critically dependent on the performance of cutting and embankment slopes. Many of these slopes are old and suffer high incidents of instability (increasing with time). There is evidence that the scenario of increased (and more intense) rainfall has already had an impact on UK transport infrastructure (Kilsby *et al.*, 2009) and climate change scenarios for the UK present the potential for these issues to accelerate. To investigate these issues, the research project iSMART

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(Infrastructure Slopes: Sustainable Management And Resilience Assessment) has been established as a collaboration between six UK academic partners (Universities of Durham, Loughborough, Newcastle-upon-Tyne, Queens Belfast and Southampton and the British Geological Survey) and 11 asset owners and industrial partners. Together, the partners are using a combination of field measurements, laboratory testing and development of conceptual and numerical models to improve our understanding of the interaction between weather, vegetation and soil.

One of the sites being monitored within the iSmart project is an instrumented embankment to investigate the response to changing climatic conditions. The BIONICS embankment was built at Nafferton farm in North East England (Hughes *et al.*, 2009). The fill material was a glacial till (Durham Lower Boulder Clay), a common fill material in North East England and hence representative of earthwork construction. The fill material can be classified as a sandy clay of intermediate plasticity.

An important aspect of embankment fill behaviour is to be able to understand the changes in suction during drying and wetting. The relationship between suction and water content is called the soil water retention curve (sometimes also known as a soil water characteristic curve). A typical water retention curve (in terms of volumetric water content) is shown in Figure 1. It is highly hysteretic in nature. If the soil starts from a saturated state and is subject to drying, it will follow the *Primary Drying Curve*. On wetting from an oven dried state, the soil will follow the *Primary Wetting Curve* (Figure 1). When the suction is reduced to zero, the final volumetric water content may be lower than the initial saturated value, θ_s, either due to air bubbles remaining trapped within the soil, or as a result of irrecoverable shrinkage of the soil.

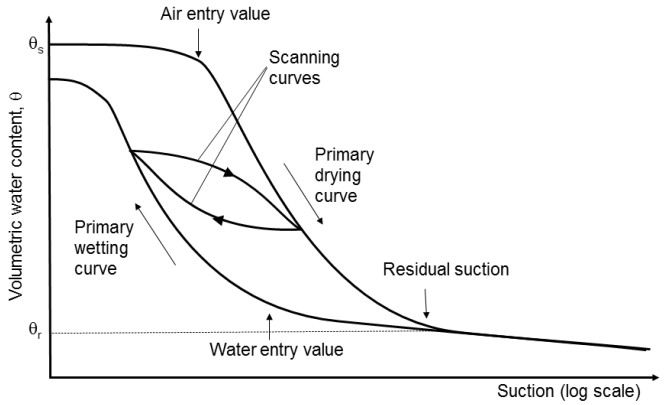

Figure 1. Typical Soil Water Retention Curve (after Toll, 2012)

The primary drying and wetting curves define an envelope of possible states within which the soil can exist. If drying is halted partway down the primary drying curve and wetting is started, the soil will follow an intermediate *Scanning Curve*, that is flatter than the primary wetting curve, until the primary wetting curve is reached. Similarly, if wetting is halted partway up the primary wetting curve and drying is started, the soil will follow another Scanning Curve, that is flatter than the primary drying curve, until the primary drying curve is reached.

The soil water retention curves (SWRC) for the BIONICS soil have been measured in the laboratory using novel high suction tensiometer based equipment.