Numerical study of the applicability of capillary barrier systems for prevention of rainfall-induced slope instabilities

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ABSTRACT

Many slope instabilities are caused by heavy and prolonged rainfall. The stability of a slope is enhanced by the presence of suction, which has a beneficial effect on the shear strength of the soil, but the suction may be lost or greatly reduced during a strong rainfall event [1]. Capillary barrier systems (CBSs) have primarily been employed as landfill covers in arid and semi-arid climates [2], with the purpose of avoiding percolation of water into the underlying landfill, but more recent field and laboratory studies have shown the potential of CBSs for suction control and slope stabilization purposes, i.e. reducing the risk of rainfall-induced slope instabilities [3]. Further studies are however required to identify the role of the different parameters (e.g. geometry and materials) and the range of applicability in terms of weather/climate conditions.

The behaviour of two slopes was studied numerically: a bare slope made of fine-grained soil and the same slope covered by a capillary barrier system. The time evolution of suction in the slopes subjected to realistic atmospheric conditions was studied by performing numerical Finite Element analyses with Code_Bright [4]. In particular, multi-phase multi-physics thermo-hydraulic analyses were performed, modelling the soil-atmosphere interaction over periods of many years. The suction distributions obtained from these analyses were then exported to the software LimitState GEO [5], which was used to perform limit analyses to assess the stability of the slopes.

The use of the capillary barrier system was shown to be effective in increasing the minimum values of suction attained in the underlying ground with comparison to the bare slope. The capillary barrier system was able to limit the percolation of water into the slope, due to its ability to store and divert water. This resulted in a higher factor of safety of the slope covered by a CBS than for the slope without a CBS. Thus, this study shows the potential applicability of capillary barrier systems for prevention of rainfall-induced slope instabilities and the potential of this numerical approach, which will be used in the future to assess the role of different parameters governing the problem.

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