Stability Analysis of Non-homogeneous Soil Slopes under Rainfall Conditions

A Thesis

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ABSTRACT

Natural slopes are non-homogeneous in the form of stratifications or variation in different material properties and hydraulic conditions with depth because of various geological formations and climatic conditions. Even in case the of uniform stratification, variations of different hydraulic properties like saturated permeability, and unsaturated permeability function with depth make the slope non-homogeneous in nature. Many slopes have failed due to rainfall infiltration. Presence of a ground water level (GWL) divides the slope into saturated and unsaturated zones. In the unsaturated zone, the matric suction significantly contributes to enhanced shear strength. Under rainfall conditions, rainwater infiltration occurs leading to the rise of ground water levels as well as the pore water pressures. The rise of pore water pressures in the unsaturated zone leads to shallow failure of slopes under infiltration conditions due to the reduction in suction levels and thereby the shear strength. Behaviour of non-homogeneous slopes will be different from that of homogeneous slopes, particularly under rainfall conditions, which may lead to failure under critical situations.

Present research work targets to investigate the slopes of different configurations under different conditions. The objective of the present study is to investigate the stability of non-homogeneous slopes of different forms of non-homogeneity, particularly under rainfall conditions. The effect of coarse-grained soil (high hydraulic conductivity) over fine-grained soil (low hydraulic conductivity) and vice versa under infiltration conditions is studied. Seepage behaviour of such layered configurations and its effect on the stability of the slope will be analyzed. The critical slip surfaces for different types of non-homogeneous slopes has been studied to understand the failure mechanisms.

Three different soils were selected with different mechanical and hydraulic properties to model the homogeneous and non-homogeneous slopes. Two-dimensional (2D) numerical models of homogeneous and non-homogeneous slopes are prepared using a numerical package SLIDE2.

Transient seepage analysis for the slopes with rainfall infiltration was performed in the finite element framework. The pore pressures obtained from the seepage analysis were used in the slope stability analysis, which was performed using the limit equilibrium framework. Parametric studies have been carried out to investigate the influence of rainfall intensity, duration, slope angle and slope height. The effect of transient seepage under rainfall infiltration is investigated to gain information about the changes in pore water pressures, a factor of safety, and critical slip surface within the slopes.

The study reemphasizes the importance of consideration of ground water level (GWL) and unsaturated soil characteristics in the analysis, as the slope behaviour totally depends on the suction levels and the associated shear strength values. The suction for soils with relatively high permeability reduces quickly which initiates shallow failure within the slope. The effect of rainfall on low permeable soils is rather slow, the suction reduces very slowly and hence the changes in safety factor is minimal. The study highlights the behaviour of different types of soils under rainfall consideration with due importance to unsaturated soil behaviour. As the slope behaviour is totally depends on the type of soil exist at the top layers, due consideration shall be given for the non-homogeneous nature including the variation of the moisture levels and the associated changes in suction and permeability characteristics.