(III－119) Numerical Analysis for Effects of Drainage Boring on Slope Stability during Rainfall

群馬大学　学生会員　蔡飛
群馬大学　正会員　鵜飼恵三，若井明彦

Introduction

Rainfall has been causing many landslides and slope failures. The drainage boring is an effective measure to lower the ground water level and to increase the slope stability during rainfall. The effects of the length, the spacing, and the direction angle of the drainage boring on the ground water level is conducted with the 3D FE analysis of transient water flow through unsaturated-saturated soils. The slope stability is evaluated with the global safety factor, obtained with the 3D elasto-plastic shear strength reduction FEM [1].

Model slope

An idealized slope is analyzed with the 3D FE mesh, in which the number of cross sections is adjusted to keep the interval of 1.5 ～ 2.0m between two cross sections based on the spacing (Fig.1). Three sets of the van Genuchten model parameters of the hydraulic characteristics for the Glendale clayey loam (GCL), the Uplands silty sand (USS), and the Bet Degan loamy sand (BLS), as shown in Table 1, are used to investigate their effects on the ground water level and the slope stability during rainfall. The initial relative degree of saturation is assumed to be 0.617, at the slope crest, and linearly increases to unity at the horizontally initial water level.

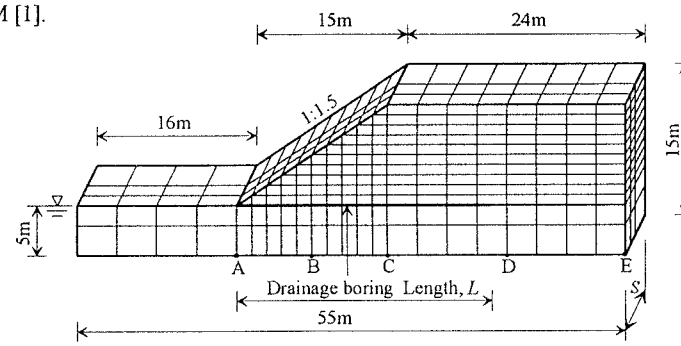

Fig.1 Model slope and 3D finite element mesh

Table 1 Hydraulic properties of soils

Soil	$\alpha(m^{-1})$	n	θ_r	θ_s	$K_s(10^{-4}cm/s)$
GCL	1.0601	1.3954	0.106	0.469	1.516
USS	7.0870	1.8103	0.049	0.304	18.292
BLS	2.7610	3.0224	0.044	0.375	63.832

In order to compare the effects of hydraulic characteristics, the mechanical parameters of the three soil types are assumed to be the same as follows: E=98.1 MPa, ν =0.3, γ =17.66 kN/m^3, c'=7.85 kPa, ϕ'=25° and ϕ =0°. The rainfall of the uniform intensity 10mm/hr is assumed to last 72 hours. The calculated results show that the ground water level reaches the steady state after the rainfall lasts a certain hours less than 72 hours.

Effects of drainage boring length

The horizontal drainage boring is installed at the height of the lower ground surface, as shown in Fig. 1, and simulated with the specified pressure head of zero. The spacing of the drainage boring is assumed to be 10m, i.e. S=5m in Fig.1. The contours of the pressure head for the longitudinal sections at the appointed points (Fig.2) shows the 3D effect of the drainage boring in the slopes, which is more remarkable for the soils with lower hydraulic conductivity. The pressure head at the bottom of any longitudinal section is about the same, so that the effects of the drainage boring on the ground water level can be confirmed by the

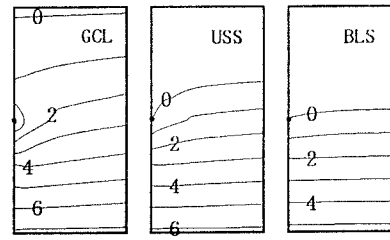

Fig.2 Contours of pressure head for longitudinal section at point B

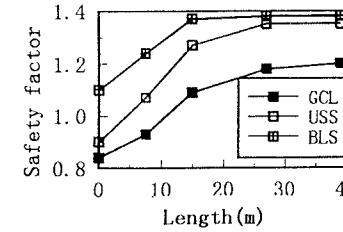

Fig.3 Safety factor versus length

Keyword: Drainage boring, Seepage analysis, Slope stability, Finite element, Rainfall
群馬県桐生市天神町 1-5-1 群馬大学工学部建設工学科，Tel (Fax):0277-30-1620

pressure head at the appointed points in Fig.1.

The ground water level is effectively lowered, and slope stability increases with the drainage boring installed. However, the ground water level at the points B and C is not lowered further, and the slope stability does not increase further when the drainage boring are extended beyond a certain length, i.e., the horizontal distance between the slope toe and slope shoulder (Fig.3-4)

Effects of drainage boring spacing

When L= 7.5m, the ground water level is slightly lowered, therefore, the slope stability increases a little with the spacing becoming smaller. In contrast, when L=15m, the ground water level is definitely lowered, and the slope stability increases with the spacing becoming smaller except for the BLS slope, due to its very low ground water level even when the spacing is 20m (Fig.5).

Effects of drainage boring direction

The drainage boring is installed in a group in the horizontal plane for easy construction. It is assumed that the group consists of three drainage borings, and only half of the group is analyzed due to its symmetry. When L=7.5m, the spacing is assumed to be 15m. When L=15m, the spacing is assumed to be 30m. The ground water level is changed little during rainfall for different direction angle of the drainage boring for all three types of soil either L=7.5m or L=15m (Fig.6). It implies that the ground water level is slightly lowered further by increasing the number of the drainage boring in a group if the length of the drainage boring in the group is the same, because the ground water level has been lowered by installing the drainage boring with the direction angle of zero degree and the other drainage boring in the group are installed in the region with the lowered ground water level.

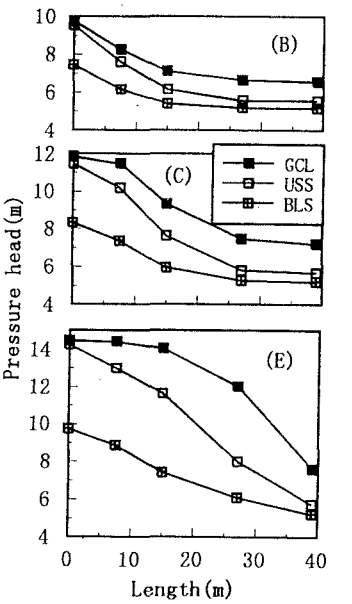

Fig.4 Pressure head versus length

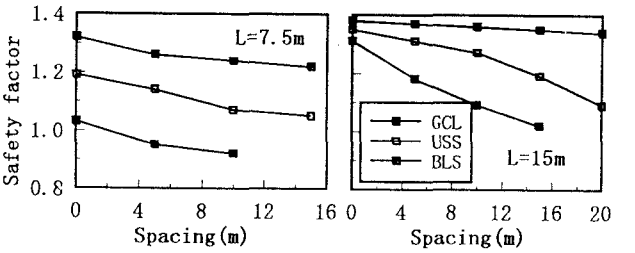

Fig.5 Safety factor versus spacing

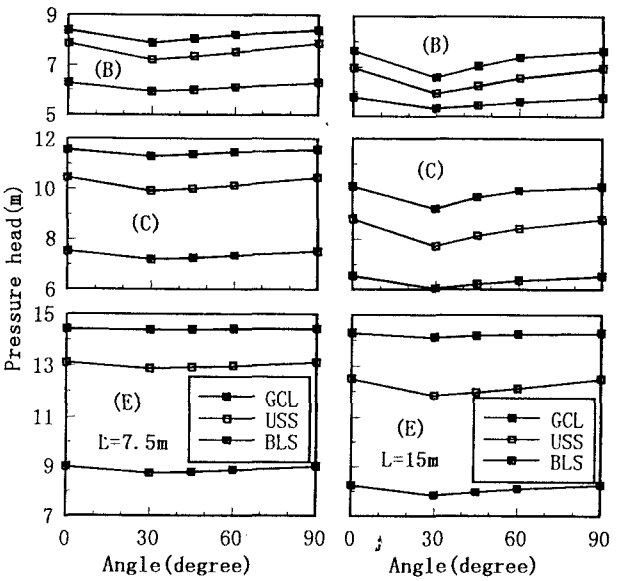

Fig.6 Pressure head versus direction angle

Conclusion

The ground water level is effectively lowered and the slope stability increases with the drainage boring installed in the slope, and it is the most effective to extent the drainage boring until the length of the drainage boring reaches a certain value, i.e. the distance between the slope toe and the shoulder.

References

1. Ugai, K. and Leshchinsky, D., Three-dimensional limit equilibrium and finite element analyses: a comparison of results. *Soils and Foundations*, 1995, **35**(4), 1-7.
2. van Genuchten, M. T., A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. *Soil Science Society of America Journal*, 1980, **44**, 892-898.