

Analysis of riverside stability under groundwater effects

Wei-Ting Hsu¹ Jia-Wei Kang¹ Iau-Teh Wang^{1, 2}

¹ Department of Civil Engineering, R.O.C, Military Academy, Taiwan R.O.C.

² Corresponding author

Abstract

The seepage caused by the groundwater causes the piping phenomenon to affect the slope stability. This paper studies the influence of groundwater level on the stability of river bank slope, evaluates its ability to resist sliding damage, and provides reference for engineering construction. Use the Stable program to calculate the safety factor of the slope. The research results show that the safety factor of the slope does not decrease with the increase of the slope. The minimum value occurs at 60°, and it gradually decreases with the increase of the groundwater level. The smaller the slope percentage, the greater the downward trend of the safety factor.

Key words: riverside, groundwater, slope

1. Introduction

Under the influence of extreme climate, it is easy to form torrential rain phenomenon, which leads to the increase of unstable factors of river bank slopes. River bank slopes are susceptible to collapse due to rising groundwater levels in the rainy season. In this paper, the influence of groundwater level on the stability of river bank slope is analyzed. According to the limit equilibrium theory, the Stable program is used to calculate the safety factor.

The Limiting Equilibrium Analysis method assumes that any point on the sliding surface of the slope reaches the limit state at the same time, in order to conform to the moment balance, and the safety factor is the ratio of the resistance force of the sliding surface to the driving force. Assuming that

the slope is Rotational Slides, the failure type is arc-shaped sliding, and the surface of the failure is close to the arc type, which mostly occurs in natural slopes, river banks and areas with thick fills. And calculate its safety factor to ensure the stability of the slope. According to the architectural design and construction code according to the architectural technical rules, when building on a slope with a slope, the safety factor must meet the safety standard [1].

The failure mechanism of the slope is directly related to the development process of the shear strain region, and the node displacement can be used to judge whether the slope has reached the failure state [2]. The stability and displacement of the slope under the simultaneous action of horizontal and vertical acceleration are studied, and the results show that the vertical acceleration

has a considerable influence on the stability and displacement of the slope [3, 4]. Through the displacement of the observation point and the intensity reduction factor, determine the position where the displacement mutation occurs. When the slope reaches the critical state of failure, there is a large difference in displacement before and after failure, and the reduction factor at this time is the safety factor [5, 6].

2. Parametric application

According to Article 262 of the Architectural Design and Construction Code, if the height of the natural river bank exceeds the range of 5m, the development regulations of different minimum safety distances for river banks with different slopes. The height of the bank slope is set to 6m. Because the groundwater level changes with the seasons, this study assumes that the groundwater level is 2.7m below the surface in summer and 1.3m below the surface in winter.

Soil sampling analysis shows that the cohesion of the 0.07 and the friction angle is 25° . The one dimensional compaction test results show that the compression ratio and the expansion ratio are 35% and 2.3%, respectively. The unified soil classification symbol SP is for poorly graded gravel-containing sandy soils.

3. Stable analysis of riverside stability

An increase in shear stress or a decrease in the shear strength of the slope leads to sliding failure of the least resisting surface. The safety factor is calculated based on the

ratio between the shear strength of the failure surface and the shear stress.

The safety factor of the bank slope is affected by the groundwater level. This paper analyzes the safety factor of the slope 6m away from the river bank and the slope is 30° , 45° , 60° , 75° , and 90° . The analysis results are shown in Figures 1-10. The analysis results clearly found that the safety factor was reduced. The higher the groundwater level, the higher the decrease of the safety factor, and the slope is more unstable in summer than in winter.

4. Conclusion

In this study, the low plasticity soil material parameters were used to analyze the stability of river bank slopes and provide relevant research references. Numerical analysis shows that the safety factor decreases as the groundwater level rises.

The safety factor of the slope composed of low plastic soil (SP) does not decrease with the increase of the slope, and the lowest value occurs at 60° . In unstable conditions, engineering facilities such as cage revetment, riprap revetment, ground construction anti-corrosion mold bag, and stepped revetment can be used to increase the safety factor.

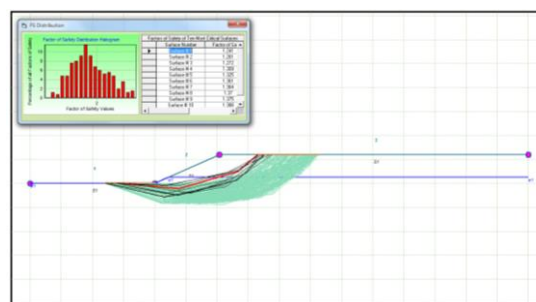


Figure 1: Slope: 30° ; Groundwater level:

1.3m; Safety factor: 1.24

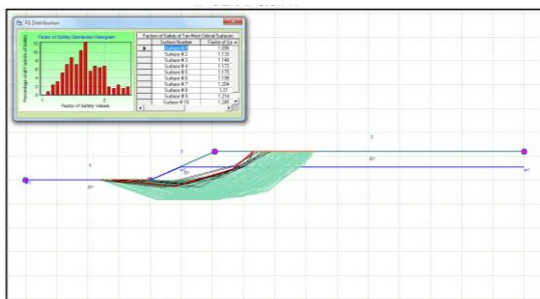


Figure 2: Slope: 30; Groundwater level: 2.7m; Safety factor: 1.10

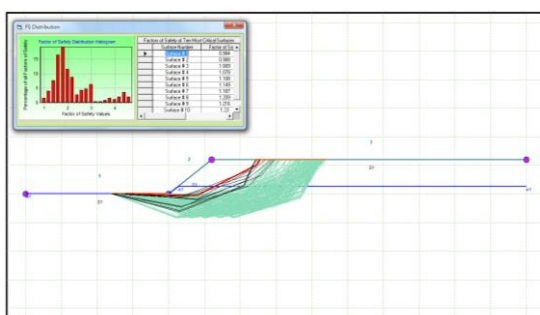


Figure 3: Slope: 45; Groundwater level: 1.3m; Safety factor: 0.98

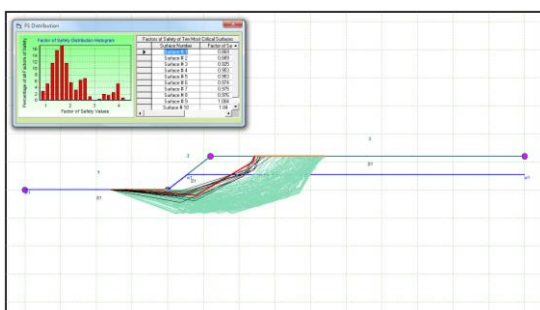


Figure 4: Slope: 45; Groundwater level: 2.7m; Safety factor: 0.87

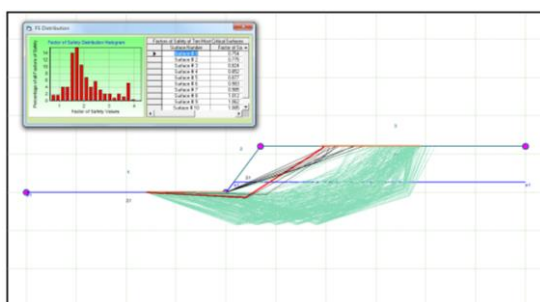


Figure 5: Slope: 60; Groundwater level: 1.3m; Safety factor: 0.75

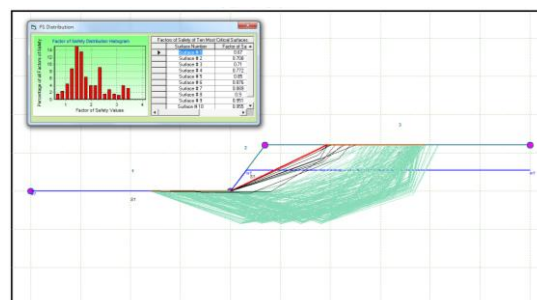


Figure 6: Slope: 60; Groundwater level: 2.7m; Safety factor: 0.67

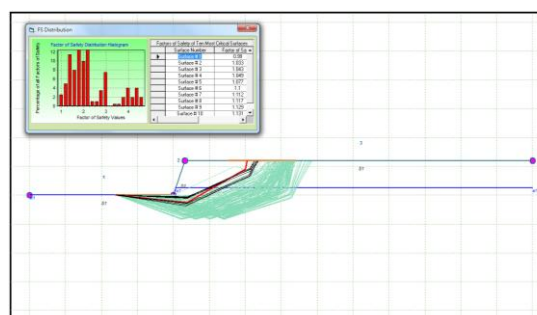


Figure 7: Slope: 75; Groundwater level: 1.3m; Safety factor: 0.99

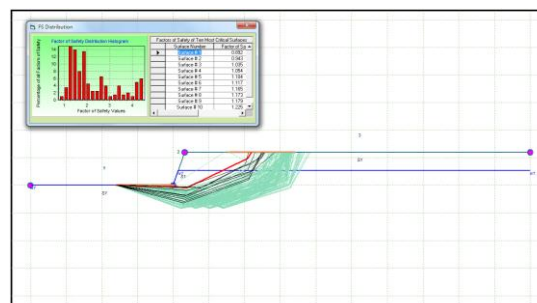


Figure 8: Slope: 75; Groundwater level: 2.7m; Safety factor: 0.89

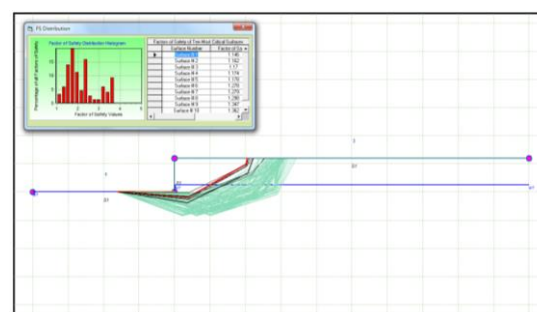


Figure 9: Slope: 90; Groundwater level: 1.3m; Safety factor: 0.89

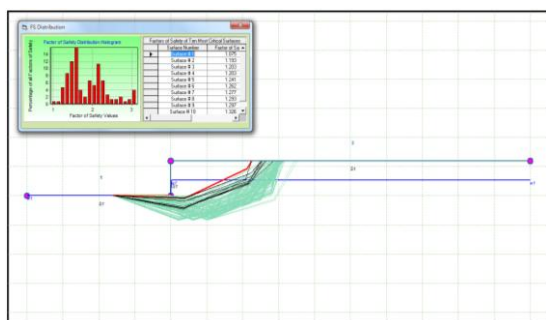


Figure 10: Slope: 90; Groundwater level: 2.7m; Safety factor: 1.15

Foundations, Vol. 32, pp. 59-70, 1992.

- [6] Duncan, J. M., and Chang, C. Y., "Nonlinear analysis of stress and strain in soils, "Journal of the Soil Mechanics and Foundation Division, ASCE, Vol. 96, pp. 637-659, 1970.

參考文獻：

- [1] Zhao, S. F., Luan, M. T., and Lu, A. Z., "FEM-based nonlinear numerical analyses for limit equilibrium problems in geotechnics considering no associated flow rule, " Rock and Soil Mechanics, Vol. 25, pp. 121-125, 2004.
- [2] Zienkiewicz, O. C., Humpheson, C., and Levis, R. W., "Associated and nonassociated visco-plastic plasticity in soil mechanics, " Geotechnique, Vol. 25, pp. 671-689, 1975.
- [3] Ling, H. I., Leshchinsky, D., and Mohri, Y., "Soil slopes under combined horizontal and vertical seismic accelerations, "Earthquake and Structural Dynamics, Vol. 26, pp. 1231-1241, 1997.
- [4] Chi, S. C., and Guan, L. J., "Slope stability analysis by Lagrangian difference method based on shear strength reduction, " Chinese Journal of Geotechnical Engineering, Vol. 26, pp. 42-46, 2004.
- [5] Matsui, T., and San, K. C., "Finite element slope stability analysis by shear strength reduction technique, " Soils and

地下水對河岸穩定影響分析

徐偉庭¹ 康家瑋¹ 王耀德^{1,2}

¹陸軍軍官學校土木工程學系

²通訊作者

摘要

地下水產生之滲流導致管湧現象影響邊坡穩定。本文研究地下水位對河岸邊坡穩定之影響，評估其抵抗滑動破壞之能力，提供河岸邊坡工程建設參考。應用Stable程式計算邊坡之安全係數。研究結果顯示邊坡之安全係數，並非隨著坡度增加而下降，最小值發生在60°，且會隨地下水位增加而逐漸變小；其中坡度百分比愈小，安全係數下降趨勢愈大。

關鍵詞：河岸、地下水、坡度

