ANALYZING THE SEASONAL WATER LEVEL'S IMPACT ON DIKE EROSION USING GEOSLOPE SOFTWARE

PHÂN TÍCH ẢNH HƯỞNG MỨC NƯỚC THEO MÙA ĐẾN SẠT LỞ ĐÊ BẰNG PHẦN MỀM GEOSLOPE

Quang Vinh Pham
Email: phamquangvinh@mtu.edu.vn
Phone: 0902 542 351
Bao Quoc Le
Faculty of Civil Engineering, Mien Tay Construction University
Email: lebaoquoc@mtu.edu.vn

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Abstract:

Dike erosion during the rainy season is a common issue that significantly impacts the lives of people residing along the dike routes. One of the main factors contributing to the instability of dike structures is the formation of slip surfaces on the dike body as the water level fluctuates with the changing seasons. This study focuses on evaluating the stability of dike under seasonal variations in the river water level. The research employs two methods, namely the Finite Element Method (FEM) and the General Limit Equilibrium Method (GLEM), to assess the influence of geological parameters and soil drainage behavior on the dike's stability. The study aims to investigate potential instabilities in the dike's soil structure. The findings of the research indicate that using the SLOPE/W module of the GEOSTUDIO software with GLEM provides the recommended factor of safety (FOS). This factor is crucial in determining the stability of the dike under varying water levels, which can guide further actions to address potential erosion and ensure the safety of the dike and surrounding areas

Tóm tắt:

Sạt lở đê trong mùa mưa là một vấn đề phổ biến gây ảnh hưởng lớn đến cuộc sống của những người sinh sống dọc theo tuyến đê. Một trong những yếu tố chính góp phần làm cho cấu trúc đê không ổn định là việc hình thành các bề mặt trượt trên thân đê khi mực nước biến đổi theo mùa. Nghiên cứu này tập trung vào đánh giá sự ổn định của đê dưới tác động của biến đổi mực nước sông theo mùa. Nghiên cứu sử dụng hai phương pháp, đó là Phương pháp phần tử hữu hạn (FEM) và Phương pháp cân bằng giới hạn tổng quát (GLEM), để đánh giá ảnh hưởng của các thông số địa chất và hành vi thoát nước của đất đai đến sự ổn định của đê. Nghiên cứu nhằm mục đích điều tra các khả năng không ổn định trong cấu trúc đất đai của đê. Kết quả của nghiên cứu cho thấy việc sử dụng mô-đun SLOPE/W của phần mềm GEOSTUDIO kết hợp với GLEM cung cấp chỉ số an toàn đề xuất (FOS). Chỉ số này rất quan trọng để xác định sự ổn định của đê dưới tác động của biến đổi mực nước, từ đó hướng dẫn các biện pháp tiếp theo nhằm giải quyết nguy cơ sạt lở tiềm tàng và đảm bảo an toàn cho đê và khu vực xung quanh.

1. INTRODUCTION

The unusual and unpredictable changes in climate have brought about heightened concerns among people living in dike areas during the rainy season, as landslides become a looming threat. Repairing dike-related issues has become an urgent necessity before the stormy season arrives. Over the past years, natural disasters have grown increasingly complex and challenging to manage. Recent studies have highlighted alarming trends in Hanoi, where the water level has risen by approximately 60-70cm. Consequently, the estuary area has expanded, and sedimentation patterns have undergone significant alterations, leading to an increase in the floodwater level in the estuary region. These changes pose a considerable risk to the safety and well-being of communities residing in the affected areas. To address these pressing issues, there is an urgent need for comprehensive measures and strategies to strengthen dike infrastructure, manage water resources effectively, and implement sustainable land use practices to mitigate the impact of climate change and safeguard vulnerable regions from the adverse consequences of changing water levels and potential landslides. In 2012, Cam Van dike collapsed, affecting the stability of the entire dike route and endangering human life and property in the area [1]. Dijkstra, T. A. and Dixon, N. [6] have shown the impact of climate change on slope stability in the United Kingdom. Therefore, the study of the factors affecting the stability of the talus roof during the annual rainy and stormy season is very necessary to handle dangerous landslides in the upper dike section to protect dyke safety, people's lives and landslide site.

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In recent decades, several studies have been conducted to address the issue of slope stability concerning changes in water levels. Thai, N.C. et al. [2] analyzed slope stability when facing rapid water level recession, utilizing the limit equilibrium method through Geostudio software with SEEP and SLOPE modules. Similarly, Khabbaz, H., Fatahi, B., & Nucifora, C. [3] and Aryal, K. P. [4] utilized PLAXIS and GEOSLOPE to calculate the factor of safety (FOS) of slopes. Additionally, Meng, Q., Qian, K., Zhong, L., Gu, J., Li, Y., Fan, K., and Yan, L. [5] employed a combination of FEM and LEM methods to analyze slope stability. However, these studies mainly focused on comparing the FOS values without further analysis.

In contrast, this study takes a different approach by applying both the General Limit Equilibrium Method (GLEM) and the Finite Element Method (FEM) to investigate the impact of water level changes on slope behavior. Furthermore, the study also examines the influence of material escape characteristics on the analytical results. This comprehensive analysis aims to provide a deeper understanding of the factors affecting slope stability under varying water levels, which can be valuable for addressing slope stability issues more effectively.

2. STUDY AREA

Cam Van dyke was built in 2001 with a length of 1451.4m starting from Km23+500 to Km25+100 along the Chu River, Thanh Hoa province. This is the dyke border with a large elevation difference (H□ 14.0m), the slope coefficient is quite steep, located at the position of the dyke toe, which is curved and concave, so it is increasingly eroded and unstable. The dike surface is from 6m to 10.5m wide with a fairly flat route. The dike height is quite large from 14.0 - 16.0m, the top of the dike is at +13.7, the toe of the dike changes from the elevation (-0.4 to -1.50). From piles T30 to T41, the dike foot is located at the elevation of +0.4, from the beginning of the route to T30, the dike foot is at the height of -0.6 to -1.85. The riverside dyke roof has a slope of m = 2.0 ÷ 3.0, many positions of the dyke roof are deformed, forming soil blocks on the roof with a coefficient < 2.0, increasing the weight of the roof, causing the risk of instability. determine the dyke roof.

FIGURE 1. *Landslide at CamVan dike in August 2012.*

The stratigraphy of the area from Km24+620 to Km24+740 from top to bottom is depicted in Figure 2, mostly clay-gray-brown, yellow-brown, blue-gray clay, in hard plastic state.

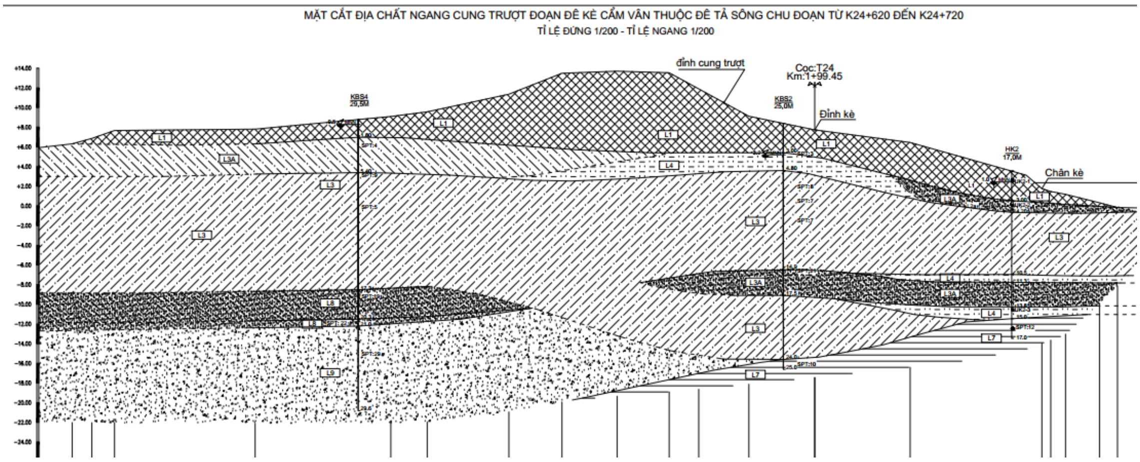

***FIGURE 2.** Geological stratigraphy.*

The stratigraphy of the study area is very complex as shown in Fig. 2. It consists of many thin interlayers with a thickness of 1 to 2 meters. In order to simplify the problem, the authors ignore these thin interlayers. The geological parameters are presented in Table 1.

TABLE 1. Soil parameter

		Unit	Layer 1	Layer 2	Layer 3	Layer 4
Moisture content	W	%	29.02	31.34	62.84	42.2
Unit weight	ρ	g/cm^3	1.887	1.874	1.567	1.727
Dry unit weight	ρ_κ	g/cm^3	1.462	1.427	0.968	1.214
Density	Δ	g/cm^3	2.706	2.702	2.576	2.692
Void ratio	e	-	0.85	0.89	1.68	1.22
Porosity	n	%	45.98	47.19	62.46	54.89
Saturation	S	%	92.24	94.64	96.1	93.23
Liquid limit	W_l	%	37.21	45.46	67.73	43.73
Plastic limit	W_p	%	23.34	24.55	44.8	29.74
Plasticity Index	I_p	%	13.87	20.91	22.94	13.99
Liquidity Index	I_s		0.41	0.32	0.79	0.89
Total Cohesion	C	kG/cm^2	0.182	0.175	0.115	0.102
Total Friction angel	φ	độ	$18^0 06'$	$19^0 11'$	$11^0 13'$	$10^0 12'$
Effective Cohesion	C'	kG/cm^2	0.132	0.144	0.116	0.865
Effective Friction angel	φ'	độ	$28^0 28'$	$26^0 51'$	$20^0 37'$	$22^0 09'$
Young Module	E_{1-2}	kG/cm^2	78.08	86.21	46.09	40.17
Coefficient of permeability	K	cm/s	3.08×10^{-6}	1.66×10^{-6}	2.11×10^{-5}	1.09×10^{-5}

3. METHODS OF ANALYSIS

The paper utilizes the GEOSTUDIO software with the SLOPE/W module, employing the General Limit Equilibrium Method (GLEM): Ordinary Method, Bishop' Method and Janbu's Method to assess the impact of geological parameters and drainage behavior on stable calculation results. The conditions for changing the water level in the study are as follows:

Case 1: There is water inside the field; the river side is 95% low water, corresponding to an elevation of +1.4m. On the top of the dike, there are vehicles operating.

Case 2: There is water inside the field, on the river side, the water level recedes from the height of +10m to the water level at the time of measurement +2.4m. There is no vehicle on the top of the dike.

Case 3: There is water inside the field, on the river side, the water level recedes from the design water level +12.82m to the water level at the time of measurement +2.4m. There is no vehicle on the top of the dike.

Case 4: There is water inside the field, on the river side, the water level recedes from the design water level +12.82m to the low water level of 95% with an elevation of +1.4m. There is no vehicle on the top of the dike.

Anti-slip stability test condition:

$$K_{min} \geq [K]$$

[K]- Factor of safety anti-slip allowed according to TCVN 9902-2013, [K]= 1,3

K_{min}: Factor of Safety of each calculation case.

4. RESULTS AND DISCUSSIONS

Table 2 present the GeoSlope's results of three first cases, the factors of safety calculated by the Ordinary method are all less than 1 and the factors of safety calculated by other methods are all less than 1.4. That indicated that the current cross-section of the section Km24+620 ÷ Km24+740 are unstable.

TABLE 2. Factor of Safety K_{min} of each calculation case

Case	Ordinary Method	Bishop's Method	Janbu's Method	Morgenstern-Price Method
1	0.864	1.121	1.014	1.122
2	0.975	1.137	1.059	1.132
3	0.893	1.084	0.991	1.078

Figure 3, 4, 5 shows the most dangerous sliding arc of the three cases and the first case has the slip surface form that is closest to the actual slip surface.

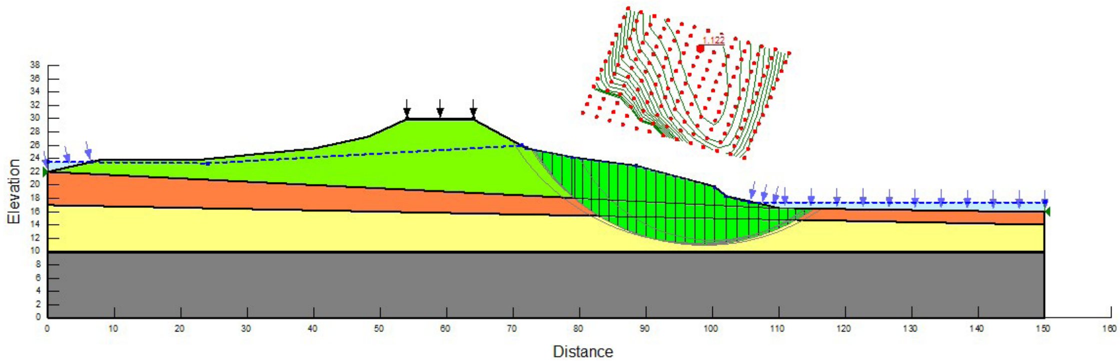

FIGURE 3. *GEOSLOPE Results of case 1.*

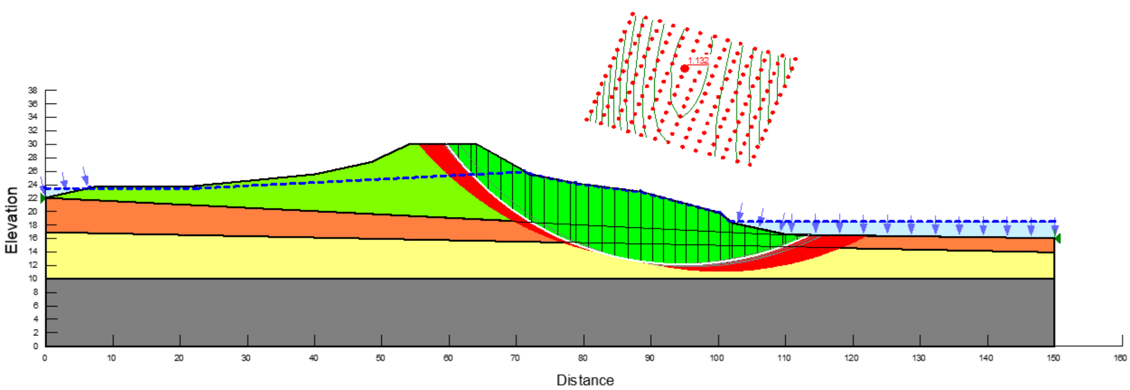

FIGURE 4. *GEOSLOPE Results of case 2.*

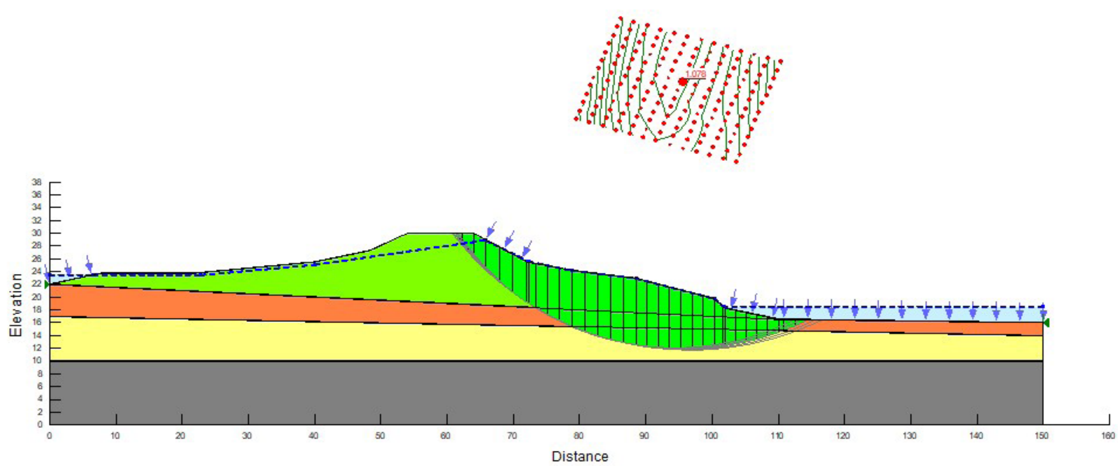

FIGURE 5. *GEOSLOPE Results of case 3.*

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5. CONCLUSIONS

From the simulation results of the above cases, it is shown that the basic rule of the earth dike is that it moves in while the water level rises and moves out when the water level drops. From the analysis results for the cases, the author found that the riverside dike foot of all those cases was damaged. Thus, the simulation is completely accurate with the position of the dike toe, which is also the reason why the landslide troubleshooting units reinforce the dike foot very firmly such as gabions, sandbags.

Therefore, in order to get a realistic asymptote, it is necessary to consider many cases because each problem is only true in a certain time of reality, and at the same time, it is necessary to know which case is the most dangerous for the project.

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