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Technical Notes

Influence of water level fluctuation on phreatic line in silty soil model slope

Zong-Ling Yan [a,1], Jun-Jie Wang [b,c,*], He-Jun Chai [a]

[a] China Merchants Chongqing Communications Research & Design Institute Co., Ltd., 33 Xuefu Road, Nan'an District, Chongqing 400067, PR China
[b] Key Laboratory of Hydraulic & Waterway Engineering of Chinese Ministry of Education, Chongqing Jiaotong University, 66 Xuefu Road, Nan'an District, Chongqing 400074, PR China
[c] Department of Architecture & Civil Engineering, Logistical Engineering University, Chongqing 400041, PR China

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ABSTRACT

The water level fluctuation may affect the phreatic line in the waterfront soil slopes. In order to investigate the influence, three slope models were made using the silty soil. Four testing schemes for rising water level and three for lowering water level were done. The testing results indicated that such factors as the horizontal distance from the piezometer tube to the intersection of the slope surface and water level, the saturated state of the soil mass, and the rate of the water level fluctuation, might affect the changing rate of the water table in the piezometer tube. The comparison of the results obtained from the present approach with [Zhang Y.-Y. and Hu, X.-W., 2007. Calculation of saturation line of groundwater under reservoir water table uniform rising. Hydrogeology and Engineering Geology, 2007(5): 46–49. (in Chinese)] indicated that the works of Zhang and Hu (2007) may overestimate the elevation of the phreatic line under uniform rising conditions. The comparison of the results from the present approach with [Zheng, Y.-R, Shi, W.-M., and Kong W.-X., 2004. Calculation of seepage forces and phreatic surface under drawdown conditions. Chinese Journal of Rock Mechanics and Engineering, 23(18): 3203-3210. (In Chinese)] indicated that the works of Zheng et al. (2004) might estimate reasonably the elevation of the phreatic line under uniform lowering conditions, but when the lowering rate of the water level is very large, the works of Zheng et al. (2004) may underestimate the phreatic line.

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1. Introduction

The slope stability is a common and important problem in civil or geotechnical engineering works. During constructing the highways in mountain areas in PR China, more and more high and steep slopes are under construction or will soon be constructed by the designers and constructors of the highways. The stability of the slopes is very important to the safe of the highway. Thus it is always paid large attentions by almost everyone related to the highway including the designers, constructors, researchers, supervisors, and even drivers. Some of the highways in the mountain areas are under construction or will soon be constructed along the rivers or reservoirs. While the water level of the river or reservoir changes rising and lowering, the waterfront slopes may fail easily. In the factors which may affect the stability of the waterfront slopes, the water including groundwater and surface water may be the most principal reasons resulting in the failure of the waterfront slopes. The slope failures associated with the water level fluctuations were reported by many researchers, such as Jones et al. (1961), Morgenstern (1963), Lane (1967), Jappelli and Musso (1981), Lane and Griffiths (2000), Deng et al. (2000), Dai et al. (2004), Zhan et al. (2006), and Jia et al. (2009).

It is well known that the water level fluctuations may induce the change of the pore water pressure in the waterfront soil slopes. The change may further be a key factor resulting in the slope failure. Thus calculating the pore water pressure or phreatic line in the waterfront slopes is very useful to analyze the stability of the slopes. Some valuable works related to the problem were reported by Zheng et al. (2004) and Zhang and Hu (2007).

The change of the pore water pressure or the phreatic line in the waterfront soil slopes, which may be induced by the water level fluctuations, is very complex. The characteristics of the change may be affected by many factors such as the material, structure, permeability of the slope, and the amplitude and speed rate of the water level fluctuation. The amplitude of the water level fluctuation of the large water reservoirs is often very large. For instance, during the construction period of the Three Gorges Reservoir of China from 2007 to 2009, the reservoir level changed between 135 m and 156 m. The amplitude of the reservoir level is about 21 m. And after constructing the Three Gorges Reservoir, the reservoir level will change between 145 m (the normal low water level) and 175 m (the normal top water level). The most amplitude will be about 30 m.

Physical model tests provide an improved insight into the failure modes and mechanisms associated with changes in the water level adjacent to a slope, such that some works were reported by Hu et al.

* Corresponding author. Key Laboratory of Hydraulic & Waterway Engineering of Chinese Ministry of Education, Chongqing Jiaotong University, 66 Xuefu Road, Nan'an District, Chongqing 400074, PR China. Tel.: +86 1388 3116 938 (mobile); fax: +86 23 6265 0204.
E-mail addresses: yanzongling@yahoo.com.cn (Z.-L. Yan), wangjunjiehhu@163.com (J.-J. Wang), chaihejun@ccrdi.cmhk.com (H.-J. Chai).
[1] Tel.: +86 13647603515 (mobile); fax: +86 23 6265 3088.

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(2007) and Jia et al. (2009). The present study focused on the influence of the water level fluctuations on the phreatic line in silty soil model slopes. In order to investigate the problem, some laboratory physical model tests were done. In the physical model tests, three different slope model structures and three speed rates of the water level fluctuation were considered.

2. Design and construct of physical model

The scale effects between the laboratory model slopes and the natural slopes were paid attention by some researchers such as Jia et al. (2009). The scale effects occur primarily as a result of difference in stress level between the model slopes and the natural slopes. The larger the size of the model, the smaller the difference in the stress level between the model slope and the natural slope. But in laboratory model tests, it is almost impossible to build the model slope as large as or near the nature slope. In addition, the influence of the scale effects on the testing results is related to the object of the model test. The influence may be large while investigating the mechanisms or process of the slope failure. The present study focused on the change of the phreatic line in the model slope with rising and lowering water level, but not the mechanisms or process of the slope failure. The influence of the size effects on the testing results should therefore be small, or even negligible.

2.1. Design of physical model

The model slopes were made in a testing water channel in the Key Laboratory of Hydraulic & Waterway Engineering of Chinese Ministry of Education. The testing water channel with 220.0 cm in width, 90.0 cm in height and 2880.0 cm in length is made of steel frame, glass wall and concrete base. The strength of the glass wall of the water channel is less than the requested in the model testing, such that some brick walls with 12.0 cm in thickness and 90.0 cm in height were built in the water channel (Fig. 1).

Three slope models were designed. Fig. 1(b) illustrated the structures of the slope models. The height and thickness of each slope are 80.0 cm, and the top width is 20.0 cm. The grading angle and base length of the model #1 are respectively 40° and 115.3 cm. Those of the model #2 are respectively 35° and 134.3 cm. And those of the model #3 are respectively 30° and 158.6 cm.

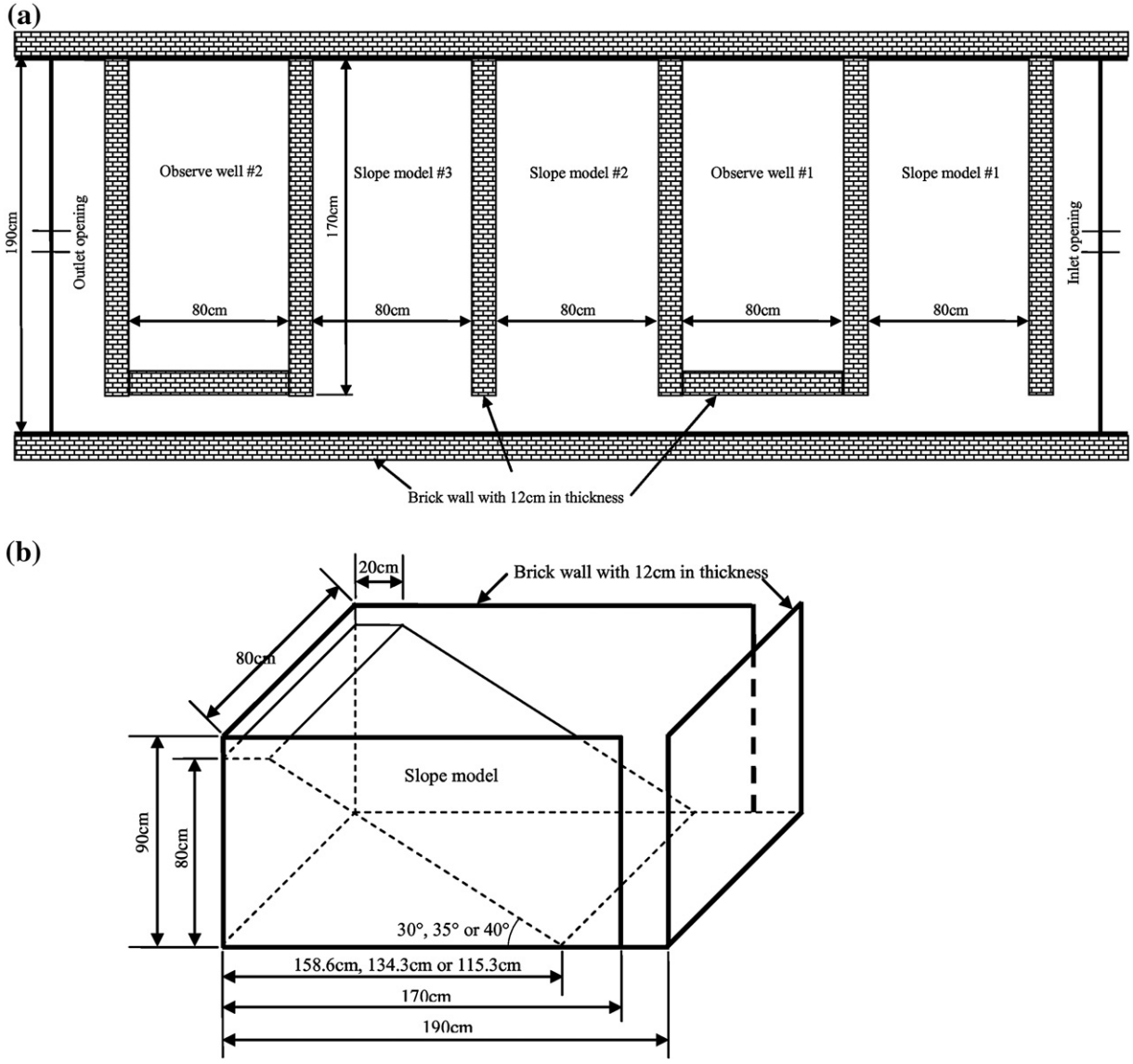

Fig. 1. General arrangement of slope models. (a). Plan view; and (b). three-dimensional view.

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