Stability analysis of wharf slope under large water level difference in inland river

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Abstract

Because of the complex topography in southwest region of China, the water level of the inland river has a large amplitude of variation which causes a frequent diversification of water content in the river slope. The flow caused by the infiltration of the terminal slope stability will induce a great impact on the slope stability of wharf. This paper uses an ideal elastic-plastic model and the Moore Coulomb yield criterion for numerical simulation. Through the b an k slop e stability of the overhead-type terminal s under the changes of water, we obtained the impact of all factors on the bank slope in the course of water lowering. It was found out that the impact from the cohesion of the geo-materials of the bank slope on the slope stability is greater than that from the internal friction angle.

Keywords

slope; Three- Gorges reservoir area; strength reduction; seepage.

1. Introduction

There are numerous rivers in the southern region of China, so the water resource is abundant. However the big variation of terrain result in the drop of mountainous rivers are large. For example , the drop of Three Gorges reservoir water level is 30 m above. Slope stability of wharf is especially pronounced under such hydro geological conditions. Factors affect slope stability of wharf are diverse, including the internal friction angle , soil cohesion c ,and the slope of slope ,the fluctuation of water level and so on. Infiltration caused by the drop of water level is another important factor which will have a negative impact on the stability of wharf slope. The drop of water level is likely to lead to the failure of slope, The reason is that the saturation line always lag behind instead of keeping pace with the drop of water level which will produce the pore water pressure, it may lead to slope instability. A large number of facts show that: over 90% failure of soil slope is caused by water. Especially, under all kinds of dangerous hydraulic conditions, infiltration will cause landslide easily. In this paper, the unsaturated infiltration theory is used to analyze the change of slope infiltration field in the process of change of water level in Three Gorges Reservoir. determining the location of the infiltration line by finite element software. On this basis, the stability of slope is analyzed by the finite element strength reduction method .

In our country, the port, water conservancy, infrastructure construction and other projects will inevitably encounter the problem of slope stability. Slope stability is the first consideration in the engineering construction. The water transportation engineering of our country is mostly built on the soft soil foundation along the coast. Slope stability often determines the success or failure of the project, and most of the landslide accidents in the port project have caused great losses. The slope stability analysis of port engineering commonly used simple slice method. Shear strength parameters are mainly measured by different methods according to different soil properties, such as fast shear, the consolidated quick shear and the cross shear strength and so on. Individual design also considers the effect of stress history.

2. Analysis of infiltration characteristics of inland river wharf

2.1 Infiltration theory

wharf is divided into two parts of saturated and unsaturated zone along with the fluctuation of the water level. The unsaturated region is above the saturation line, and another is saturated zone. Therefore, the saturated and unsaturated seepage theory should be applied to analyze this phenomenon.

It is assumed that soil is anisotropic homogeneous isotropic soil and infiltration of slope is two-dimensional.

Percolation equation:

$$k_x\frac{\partial^2 h}{\partial x^2}+k_z\frac{\partial^2 h}{\partial z^2}=0 \qquad (1)$$

Formula: K is permeability coefficient in the direction of x; K is permeability coefficient in the direction of x; h for the head function.

The head function of steady seepage is:

$$h=z+\frac{p}{\rho g} \qquad (2)$$

Formula: z is altitude height of a point; ρis the density of water; P hydrostatic pressure.

2.2 Determination of infiltration line

Unstable infiltration of groundwater in semi infinite aquifer in the course of drop of water level can be summarized by following mathematical model:

$$\frac{\partial u}{\partial t}=a\frac{\partial^2 u}{\partial x^2} \quad 0<x<\infty,\ t>0 \qquad (3)$$

$$u(x,0)=h_{0,0}-h_{x,0} \quad 0<x<\infty$$

$$u(0,t)=vt \quad t>0$$

$$u(\infty,t)=0 \quad t>0 \qquad (4)$$

simplified calculation formula for infiltration line when the water level drops:

$$h_{x,t}=\begin{cases} h_{0,0}-vt\,(0.109\ 1\lambda^4-0.750\ 1\lambda^3+ \\ 1.928\ 3\lambda^2-2.231\ 9\lambda+1) & (0\leqslant\lambda<2) \\ h_{0,0} & (\lambda\geqslant 2) \end{cases} \qquad (5)$$

Simplified coefficient : $\lambda=\frac{x}{2}\sqrt{\frac{\mu}{kh_w t}}$; Average thickness of aquifer: $h_w=\frac{(h_{0,0}+h_{0,t})}{2}$; Degree of water supply: $\mu=1.137n\,(0.000\ 117\ 5)^{0.607(6+\lg k)}$;k is Permeability coefficient; t is fall time of water level;υis falling speed of water level.

3. The analysis method of slope stability

At present, there are two main methods to analyze the stability of slope:1) To calculate safety coefficient directly according to according to the ratio of sliding force and sliding force. the limit equilibrium method is the most classical method among them, In addition, the key block theory is also a part of deterministic analysis. 2) The displacement field and stress field of slope are determined by means of numerical analysis. Then, the slope is in the limit state by the overload method and the strength reduction method, thus the safety factor can be obtained indirectly.

Slope is so important as the main body of the dock and land connection structure, slope stability are a very important research topic from a technical and economic point of view bank. Scholars at home and abroad have been nearly a hundred years of research work on slope stability analysis, The

calculation methods of the slope stability include the strip method, the numerical analysis method, the plastic limit method, the reliability method and the fuzzy mathematics method and so on. These methods and the calculation method of foundation bearing capacity in soil mechanics form the limit equilibrium method.

4. Conclusion

Wharf slope and on the upper part of the wharf structure influence each other, due to the existence of the pile, anti slippery function, makes the whole wharf slope safety coefficient increased; Physical and mechanical parameters of slope soil friction angle and viscosity cohesion affects the stability of slope has a linear relationship and cohesion of wharf safety factor of influence to internal friction angle of impact. Therefore, in the actual engineering can as a basis, fill in the layered laying geo grid, reinforced soil complex formation, increase cohesion, in order to improve the overall stability of wharf slope.

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