International Journal of Multidisciplinary Research and Development

Volume: 2, Issue: 8, 283-286
Aug 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 3.762

Wang Yongcun
(a) Chongqing Jiaotong University, Department of civil and architecture, Chongqing, 400074
(b) China Merchants Chongqing Communication Technology Research & Design Institute, Chongqing, 400074

Correspondence
Wang Yongcun
(a) Chongqing Jiaotong University, Department of civil and architecture, Chongqing, 400074
(b) China Merchants Chongqing Communication Technology Research & Design Institute, Chongqing, 400074.

The Influence of Water Level Fluctuation on the Bank Subgrade Stability

Wang Yongcun

Abstract
Using FLAC3D to simulate the change of the safety factor of the reservoir bank under different lifting rates of reservoir water level. The research shows that the safety factor of subgrade increases gradually with the increase of the water level of the reservoir and the higher the water level rises, the more the safety factor increases. When the reservoir water level falls, the subgrade safety factor decreases and the decrease rate is faster, the safety factor is reduced.

Keywords: Reservoir bank subgrade; Numerical simulation; The change of reservoir water lever.

1 Introduction

Engineering example shows that the reservoir water and the rise and fall of water level cyclical change will cause bank roadbed instability, and collapse and landslide will be caused. This means economic losses and potential safety hazard for the subgrade. When water level rises, the shear strength of slope decreases because of immersion effect, which could induce the slope instability. When water levels fall, on the one hand, buoyancy forcing on the bottom will reduced, on the other hand, it is difficult to discharge for the pore water from the soil, which makes water level in slope with is higher than the water level, the resulting seepage effect making the potential sliding surface of sliding resistance is reduced, and it is easy to induce slope instability. Therefore, it is necessary to study the effect of water fluctuation on reservoir bank subgrade.

Without considering the assumption of pore pressure dissipation, the limit equilibrium method was used to study the water level change on the influence of inhomogeneous slope safety factor by *Morgenstern*. Analysis showed that the slope safety coefficient increases with the rising water level [1]. Then based on the limit equilibrium method, *Desai* [2] and Cousins [3] also deeply discussed on the problem under the influence of the thinking of osmosis. In recent years, the finite element strength subtraction could gradually be taken seriously in the slope stability analysis. Based on the finite element software developed, *Griffiths* and *Lane* [4, 5], analyzed the influence of water level change on slope safety factor using strength subtraction. The results showed that the slope safety factor presented smaller before they became big trends with the increase of water. But *Griffiths* and *Lane*only discussed the slope with high water saturation line in the body case of the relationship between water level change and the safety factor, not how fast water level change influenced on slope safety factor.

Using the FLAC3D, this article discusses the Influence of water level fluctuation on the bank subgrade stability, which provides the theory basis for the protection of reservoir bank subgrade in actual engineering

2 Simulation parameters

2.1 The permeability coefficient

Permeability is one of the main parameters of fluid calculation, permeability coefficient k in FLAC3D is different from general concept of soil mechanics. The international units of k is (m2/Pa/SEC) in FLAC3D, which has the relationship between the permeability coefficient k in the soil mechanics (cm/s) as the following conversion relation:

$$k\left(m^2/P_a \cdot \sec\right) = K\left(cm/s\right)\times 1.02\times 10^{-6} \qquad (2\text{-}1)$$

In FLAC3D calculation, therefore, laboratory coefficient of permeability of the soil needs to be multiplied by 1.01 x 10^{-6}, after that, it can be used to calculate.

2.2 Bulk modulus and shear modulus

The conversion relations between Bulk modulus K, shear modulus G and young's modulus, Poisson's ration is as follows:

$$K = \frac{E}{3(1-2\nu)} \qquad (2\text{-}2)$$

$$G = \frac{E}{2(1+\nu)} \qquad (2\text{-}3)$$

2.3 Density

Three kinds of density parameters are Involved in the FLAC3D, which are the dry density of soil ρ_d, soil saturated density ρ_s and fluid density ρ_f.

In the seepage flow model, the only need to set the dry density of soil, according to the formula 2-4,automatically, saturated severe of each unit calculated by FLAC3D.

$$\rho_s = \rho_d + ns\rho_f \qquad (2\text{-}4)$$

Type, n is porosity, and s is saturation.

2.4 Simulation Parameters

The roadbed model parameters are used in this article as shown in table 1.

Table 1: Subgrade mechanical strength parameters

Name	Volume-weight /(kN/m³)	Shear modulus /(MPa)	Bulk modulus /(MPa)	Tensile Strength /(MPa)	Coefficient of permeability /(m²/(pa-sec))	Cohesion /(kPa)	Internal friction angle /(°)
Value	1800	7.8	3.9	0	1e-9	8	30

2.5 The model of subgrade

The sketch map of reservoir bank subgrade is shown in figure 2-1.

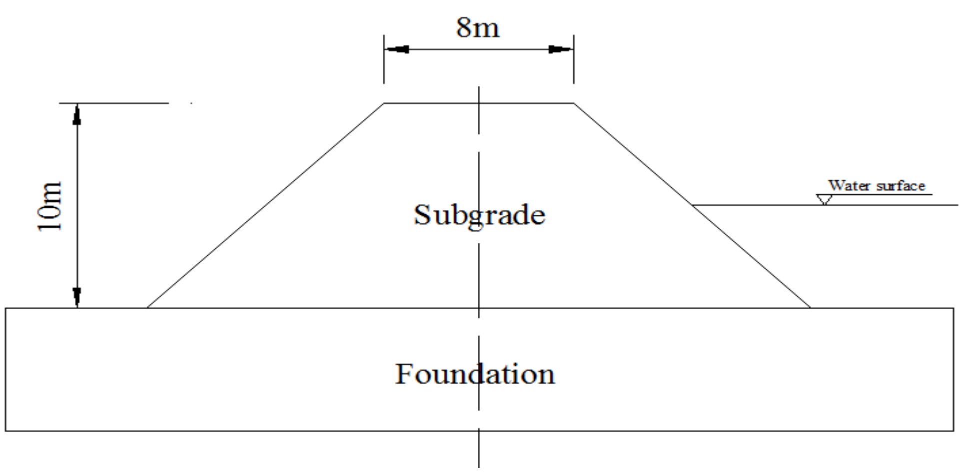

Fig 2-1: The sketch map of reservoir bank subgrade

Considering the symmetry of the form of the subgrade, the right half of the subgrade is taken as the object of study. The calculation model is shown in Figure 2-2, where the model Y direction length is 10 m.

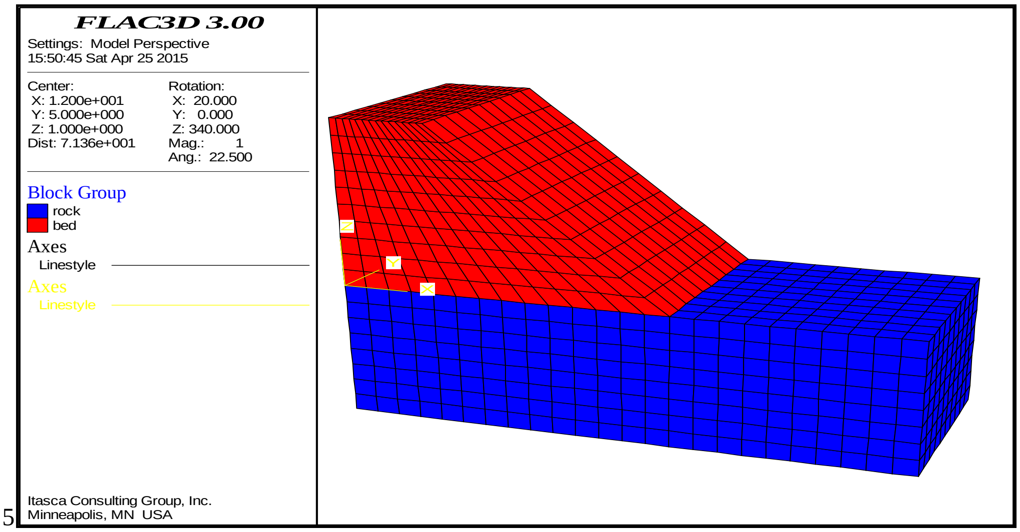

Fig 2-2: The calculation model with FLAC3D

3 strength reduction

Strength subtraction of the safety factor of slope stability is defined as the slope just reached the critical failure state, the shear strength of rock and soil degradation, safety factor is defined as the actual shear strength in geotechnical engineering and critical damage after the reduction of the ratio of shear strength. Strength subtraction is the use of the main points of the formula (3, 1) and (3-2)

$$c_F = c/F_{trial} \quad (3\text{-}1)$$

$$\phi_F = \tan^{-1}\left(\left(\tan\phi\right)/F_{trial}\right) \quad (3\text{-}2)$$

To adjust the strength of the rock mass index and (type, stick relay, for reduction of the friction Angle after the reduction, reduction factor), and then the numerical analysis of slope stability, by constantly increasing reduction factor, calculating repeatedly, until it reaches the critical damage and the reduction factor is the factor of safety.

4 Water level elevating rate influences on embankment safety coefficient

According to strength subtraction, it simulates the different water level lifting rate, the safety factor of slope with the time changes, as shown in Figure 4-1 and Figure 4-2. Water level rise is in total height of 8 m, water level drop is the height of 8 m.

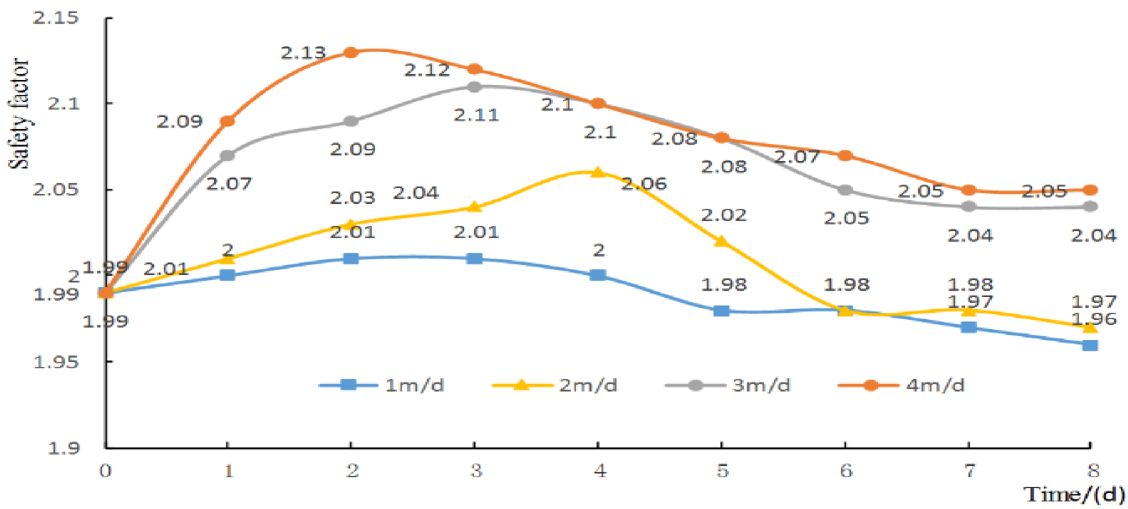

Fig 4-1: The change of safety factor with time under different water level rising rate

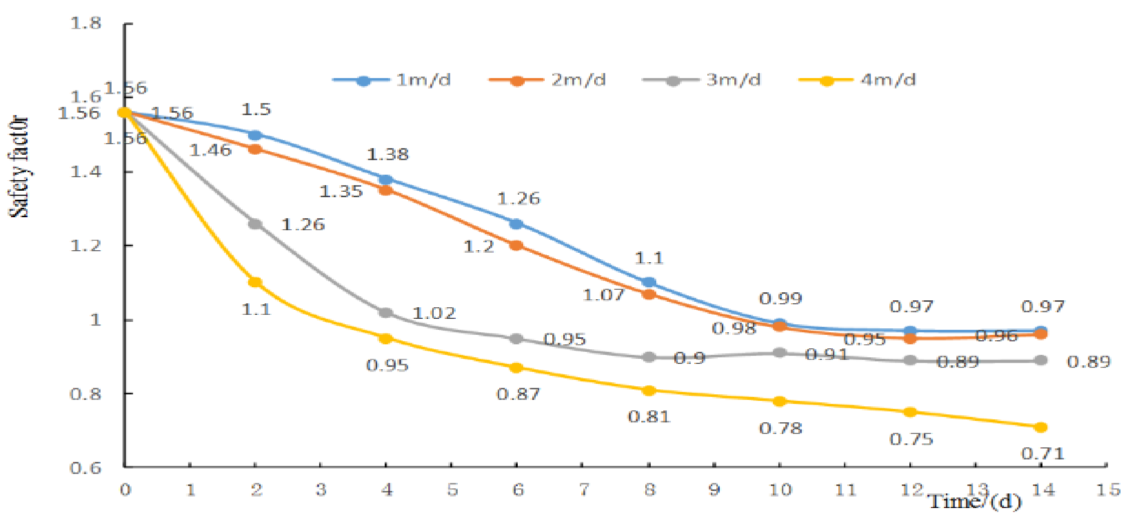

Fig 4-2: The change curve of safety factor with time under different water level drop rate

From Figure 4-1, the water level rise, in the process of embankment safety coefficient gradually rises, when the water level after reaching 8 m, safety coefficient decreases with the increase of the time. This is because the seepage flow, water level rises, in the process of reservoir water is not completely thorough subgrade, hydrostatic pressure is good for the influence of the subgrade, causing safety factor to rise. As the growth of the time, subgrade moisture content increases, the effective stress decreases, and shear strength is reduced, safety coefficient reduced. Seepage force at the same time, changing the soil particle structure, making the soil particles become loose, and lowering the safety factor. With the increase of water level rising rate, embankment safety factor is growing larger.

The Figure 4-2 shows that reservoir water in the process of decline, embankment safety coefficient has been reduced. And the faster the water level drops rate, the faster embankment safety factor reduces. This is because the roadbed groundwater declines relative lag effect, which makes roadbed produce excess pore water pressure, as shown in Figure 4-3.

At the same time, the water will fall on the roadbed unloading effect, thus in the subgrade crack in middle water hammer effect, these are unfavorable to the stability of the roadbed. And the faster the water level declines rate, water surface and the reservoir water level within the subgrade surface elevation difference is larger, the unloading effect, the more obvious, the roadbed is disadvantaged.

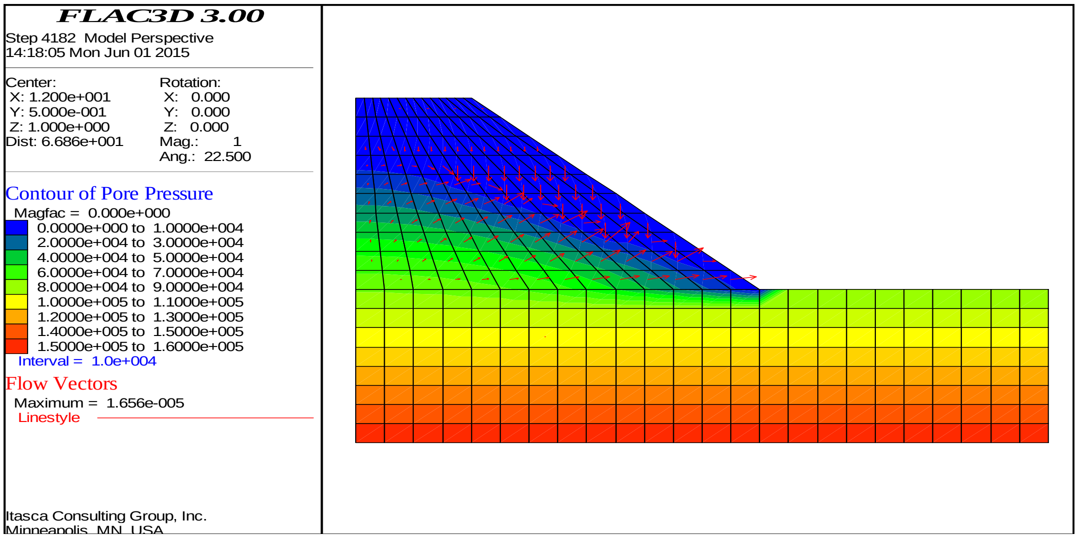

Fig 4-3: The flow direction and hole Yayun map

5 Conclusions

(1) In the course of the rise of the water level, the safety coefficient of subgrade increases gradually with the increase of water level, but the safety coefficient of the subgrade decreases gradually when the reservoir water level reaches 8m.

(2) At the same time, the safety factor decreases with the increase of the decrease rate. At the same rate, the safety factor decreases with the increase of time. The main reason is that the water level of reservoir bank roadbed and subgrade formate water level elevation, the inner hole pressure is not dissipated.

(3) The water level of the reservoir has a great impact on the safety factor of the subgrade, and the water level of the reservoir should be controlled in the actual project. The water drop rate of the reservoir is decreased and the influence of decreasing water on the roadbed is reduced.

6 Reference

1. Morgenstern NR. Stability charts for earth slopes during rapid drawdown. Geo-technique, 1963, 13:121～ 131
2. Desai CS. Drawdown analysis of slopes by numerical methods. Journal of Geotechnical Engineering, ASCE, 1977,103(7):667～ 676
3. Cousins B F. Stability charts for simple earth slopes. Journal of Geotechnical Engineering, ASCE, 1978, 104(2):267～ 279
4. Griffiths D V, Lane P A. Slope stability analysis by finite elements. Geotechnique,1999, 49(3):387～ 403
5. Lane P A, Griffiths D V. Assessment of stability of slopes under drawdown conditions. Journal of Geotechnical and Geo-environmental Engineering, 2000, 126(5):443 ～ 450.