Sensitivity Analysis Of Soil Parameters To Safety Factor Of Slope Based On Flac3d

Ji Li

School of Southwest Petroleum University, Chengdu 610500, China.

739092710@qq.com

Abstract

The use of strength reduction theory by FLAC3D is used to solve the slope safety factor, the static equilibrium calculation convergence and slope zone through and the slope displacement mutation as slope instability criterion, This paper based on the strength reduction method, using FLAC3D software of slope change only tensile strength or shear dilatancy angle of single factor sensitivity analysis, prioritized influencing factors, so as to design scheme optimization, treatment scheme selection basis, making the slope safety, economy and reliability is guaranteed.

Keywords

Slope, FLAC3D, Safety factor, Strength reduction.

1. Introduction

China is a mountainous country, slope instability often occurs, the safety of life and property pose a threat and bring huge economic losses, so the stability of the slope safety evaluation is particularly important. Before 1960s, the limit equilibrium method was used to evaluate the stability of the slope under the condition of satisfying the force and moment by the assumption and the problem of the soil. However these methods did not consider the soil within the should be relation of stress and strain and the need to assume the shape of sliding surface, and the actual status of the gap is bigger, has become increasingly unable to meet the now encountered in engineering in complex geological conditions. The strength reduction method is used to solve the slope safety factor has gradually become a new trend, compared with the traditional limit equilibrium method, strength reduction method not only satisfy the force balance condition, but also consider the material stress-strain relationship, calculation does not need to make any assumption, can automatically obtain the arbitrary shape of critical slip surface and the corresponding minimum safety factor, by using strength reduction method is very good on the slope stability judgment. However, it is not only necessary to judge the stability of the slope, but also need to find the main factors which influence the stability of the slope in the process of treatment.

Therefore, this paper uses professional software for geotechnical FLAC3D numerical model of the slope is established, by using strength reduction get the safety factor of slope stability, by changing the tensile strength of the rock mass and shear dilatancy angle of the size and the factor of safety of slope, in order to get their susceptibility to slope stability and engineering reinforcement to provide guidance.

2. Definition of Safety Factor of Slope

At present, there is no uniform definition of the definition of safety factor of the slope, and the definition of three kinds of safety factors in the calculation of the finite element method:

Shear strength ratio shear stress

$$F = \frac{[\tau]}{\tau} \tag{1}$$

Form in:$[\tau]$ is allowable shear strength for soils, τ is shear strength

In this paper, the Mohr-Coulomb yield criterion is used, and the Mohr-Coulomb material is:

$$[\tau] = c + \delta \tan\varphi \tag{2}$$

after the rock of actual shear strength and the critical damage reduction anti shear strength ratio is now in geotechnical engineering is widely used in the finite element strength reduction method[4], this paper for count example is using this method[2]:

$$c_F = \frac{c}{F} \tag{3}$$

$$\Phi_F = \tan^{-1}(\tan\phi / F) \tag{4}$$

Form in:c is cohesive force,c_F is bond strength after reduction,Φ is friction angle,Φ_F is reduced friction angle.

anti slide force than the sliding force of a specific surface:

$$F = \frac{\int_S [\tau] ds}{\int_S \tau ds} \tag{5}$$

Form in: s for the critical screen

3. Numerical Simulation Analysis of a Homogeneous Slope

At the foot of the slope to the left foot, high 10m, distance 2m, slope to the right side of the distance is 8m, the top down boundary extension 3m. Boundary condition is fixed at the lower part, about the two opposite sides of the constraints, the upper free boundary; using Mohr-Coulomb yield criterion, initial stress field according to the self weight stress; a convergence criterion for unbalanced ratio FLAC3D own solve FOS solving. The grid graph is shown below 1, and the rock and soil mass parameters are shown in table 1:

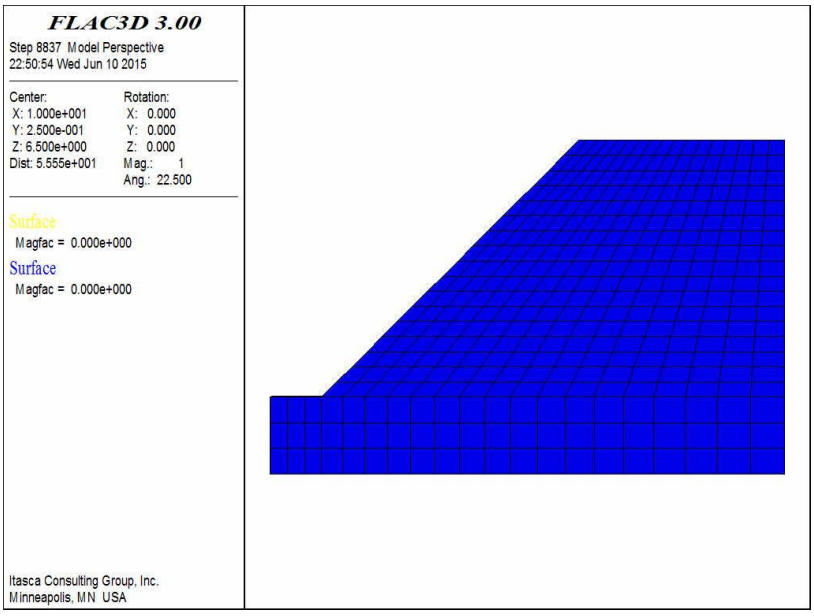

Fig. 1 mesh division of model

Table 1 Parameters of rock and soil

$\rho/kg*m^3$	K/MPa	G/MPa	c/KPa	$\Phi/(°)$	δ^t/MPa
2500	120	25	0. 35	20	10000

Using FLAC3D calculation software solve FOS command, through the continuousreduction of rock friction angle and cohesion, the numerical model of slope calculation does not converge into the fold reduction coefficient as the slope safety factor (as shown in Figure 2, this paper calculates the stability coefficient is 1.05). By strength reduction method in the slope into the unstable state, slope slip surface not presuppose, such as in the example shown, when the slope sliding and sliding surface soil

is bound to enter the plastic yield state, therefore, can be through to sliding surface plasticity zone through as judged to obtain critical slip surface of slopes.

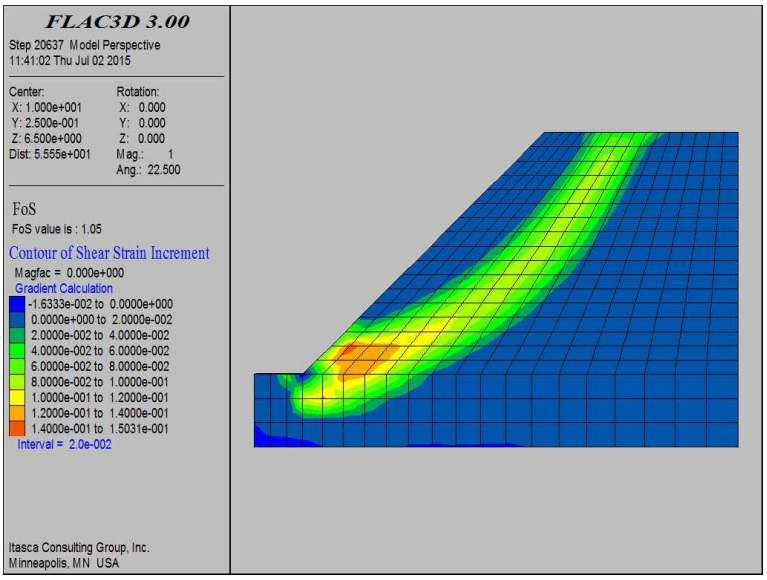

Fig. 2 model safety factor and shear strain increment

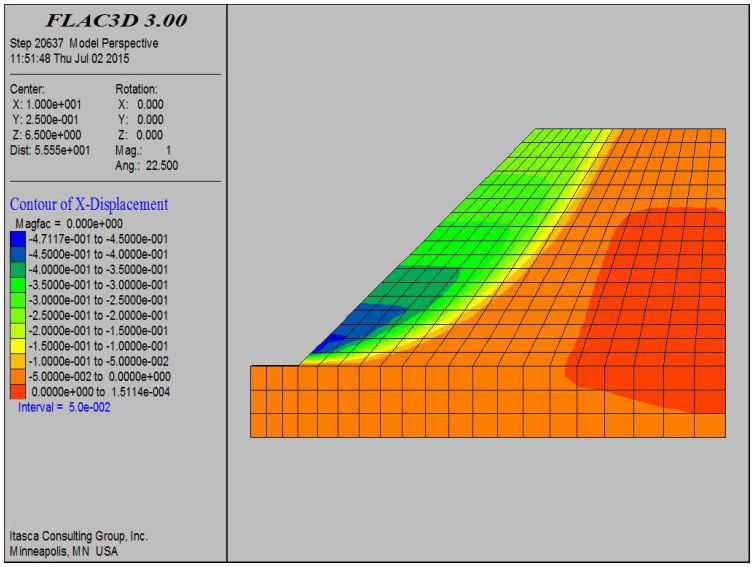

Fig. 3 x direction displacement

From Figure 2 the model from the safety coefficient, plastic penetration area from the foot to the top of the hill is the area for potential sliding surface. From Figure 3 can be obtained at X direction of maximum displacement is 470mm, that has been sliding surface.

4. Sensitivity Analysis of Slope Stability

In slope engineering, the sensitivity analysis method to analysis of the sensitivity of slope stability on the influencing factors, through the analysis and prediction of the major uncertain factors of the impact of changes on the evaluation index, find out the sensitive factors, determine the evaluation index of the factors sensitive degree and slope stability on the changes of bearing capacity. In this paper, we use the single factor analysis method, that is, a change of one factor, but not other factors, and the safety factor of the slope can be regarded as a function of the various factors. Using FLAC3D software to establish the numerical model of the slope, and does not change the slope of the other parameters, only to change the tensile strength of the soil or shear dilatancy angle has different safety factor, and to analyze the parameter sensitivity, as follows:

Table 2 the influence of the angle of shear expansion on the safety factor

dilation angle	20	15	10	5	0
safety factor	1.05	1.04	1.04	1.03	1.01

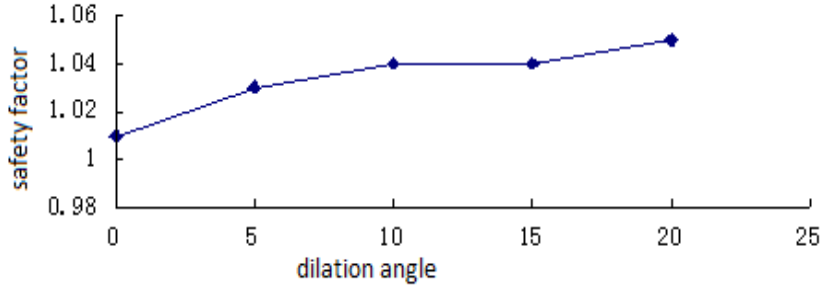

Fig. 4 the change of the safety factor with the shear angle

Figure 4 shows that the safety factor increases with the increase of the shear angle. Although the change in shear dilatancy angle size can affect the safety coefficient. However, for general materials of rock and soil, shear dilatancy angle changes are in between, range is very small, so for safety factor of influence is limited in scope, so under normal circumstances shear dilatancy angle is sensitive parameters.

Table 3 Effect of different tensile strength on safety factor

δ^t (KPa)	1×10^7	1×10^6	1×10^5	1×10^4	1×10^3	100	10	0
safety factor 1.05		1.05	1.05	1.05	1.05	1.05	1.03	1.03

From table 3 of the calculation results show that, with the decrease of tensile strength, by reduced to, the safety factor of the slope variations of 0.2, it changes little effect on the calculation of the factor of safety. Thus, it can be concluded that tensile strength and for safety coefficient is insensitive to parameter.

5. Conclusion

In this paper, the use of professional geotechnical software FLAC3D for side slope numerical simulation, sensitivity analysis by strength reduction method calculating safety factor of slope stability and influencing on slope stability factors. The results showed that layer friction angle of slope stability influence is bigger, the tensile strength of rock influence on the stability of slope is not, can provide some reference for the treatment of slope engineering.

References

[1] Lin hang. Slope strength reduction method based on linear and nonlinear failure criteria [D]. Central South University, 2010

[2] Zhang Yuan, Tao Lianjin, Li Fengyi, Lv Zhibin. Lagrange and its application software FLAC[J]. mine pressure and roof management, 1997, Z1:227-229.

[3] Zheng Hong, Tian Bin, Liu Defu, Feng Qiang. The definition of safety factor in the stability analysis of the finite element slope [J]. Chinese Journal of rock mechanics and engineering, 2005,13:2225-2230.

[4] 2002,10:57-61+78. [4], Zheng Ying Ren. Chowdhury, Zhang Lu Yu. Using the strength reduction finite element method for slope stability analysis [J]. China Engineering Science.

[5] Ping Ping Ling, Yang Xue Qiang, to Shenghua, Liu Wen Zhi. The elastic modulus, Poisson's ratio and shear dilatancy angle on the slope safety factor influence. Geotechnical engineering

[6] Mogrenstern,H.R.nad Price.VE.The analysis of the stability of general slip surfaces[J]. Geotechnical, Vol.15,1965.