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New idea for solving safety factor of slope

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Abstract
Strength reduce method is an important way to solve the safety factor of slope, it has been applied widely since it was proposed. Based on strength reduce method built-in FLAC-3D software and traditional automatic strength reduce based on method of bisection, the paper introduces a new strength reduce method based on golden section point that it can more quickly find out safety factor of slope. And through the examples help to prove that this new strength reduce method not only can acquire the safety factor of slope more quickly than the method built-in FLAC3D software and traditional automatic strength reduce method but also can has the same accuracy with the other methods.

Keyword: FLAC3D; strength reduce method; golden section point; example verification

I. Introduction

There are four main ways to check the stability of the slope: limit equilibrium method; limit analysis method; slip line field method and strength reduce method. the first three methods mentioned above are tradition ways to check the stability of slope, they are proposed a long time ago and the application is also relatively wide(Zheng-Y, Zhao-S, MATSUI T,DAWSON E M). But the faults of those three methods is that before the analysis of slope stability the slip surface must be assumed, and under the condition of complex geology there will be a large different between the slip surface calculated by traditional methods and the actual slip surface. The last method mentioned above is a new method proposed in recent years, its main mechanism is through the reduce of soil parameters.(ZHANG Zhen-hua, ZHENG Hong)The theory of this method is simple, and do not need to assume slip surface, but this method need a large workload, while with the development of computing science makes the large-scale computing possible, so the strength reduce method to acquire safety factor of slope gets a big promotion, and a lot of theory and practice have proved that the strength reduce method has same scientific, reasonable and accurate(HUANGRun-qiu, EBERHARDT E,).

With the a lot of software about geotechnical aspects such as flac3d birth greatly promote the development of strength reduce method. While the automatic strengthreduce method as a quick way to acquire the safety factor of slope is more and more popular by scientific research personnel. (TANG Chun-an, XU Qiang)Based on automatic strength reduce method, a new strength reduce method based on golden section point is proposed, and this new method can acquire safety factor of slope accurately and quickly.

II. Based theory

The basic principle of strength reduce method is that the basic parameters of soil strength: cohesion *c*and friction *v* divided by a reduction factor F_{trial} at the same time, to obtain a new set of cohesion c' and

friction v' , then as a new parameters of soil strength to check the stability of slope, keep doing this until the calculation does not converge, the corresponding$F_{trial}$is called the minimum safety factor of slope. The slope at this time has reached the limit equilibrium state, the shear failure occur in slope, and can obtains the position of potential slip based on shear failure. The basic formula ofthestrength reductionare shown as follows:

$$c' = \frac{c}{F_{trial}}$$

$$v' = \frac{v}{F_{trial}}$$

III. New idea for automatic strength reduce method

3.1 traditional automatic strength reduce method

Traditional automatic strength reduce method is based on the method of bisection. The first assignment of this method is to confirm the upper and low safety factor, then the median of upper and low factor is used to check the stability of slope, and the result of this calculation if it is convergence shows that the median factor is too small need for a new round trial. In new trial the upper and median factor in last round turn to be the upper and low factor in new round, and in this round the reduce factor is the median upper and low factor, and the result of this new calculation if it is not convergence shows that the reduce factor in this round is too large need to a other new round calculation, and in this other new trial the median and low factor turn into upper and low factor in next round calculation. This law continue to select new reduce factor to check the stability of slope until the difference between upper factor and low factor less than a small predetermined value, this shows that the upper and low factor has nearly equal. This reduce factor is what we want. The traditional strength reduce calculation step is shown as figure 1.

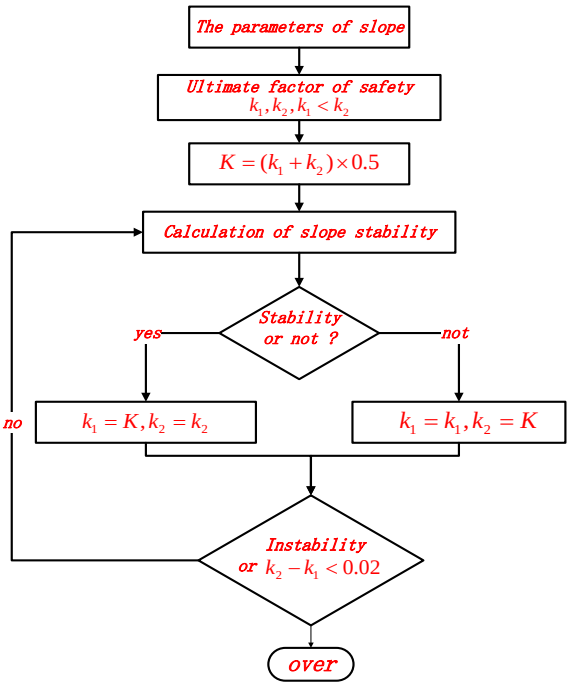

Figure 1 the calculation process of traditional method

3.2 new idea for automatic strength reduce

The theory and calculation steps of this new strength reduce are the same with traditional automatic strength reduce, the mainly difference between this strength reduce method is the reduction coefficient of new strength is golden section point:0.618, while the reduction coefficient of traditional strength reduce is median:0.5. thegolden section point reduce factor can obtain the final reduce factor than traditional methods. The calculation process is shown in figure 2

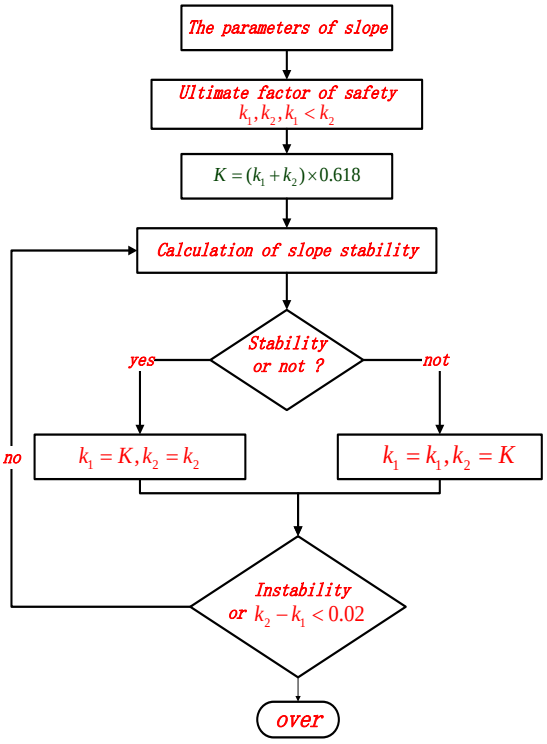

Figure 2 the calculation process of new method

software , tradition strength reduce method and new strength reduce method based on golden section point to run the same sample to compare the length of those three ways' calculation time.

The geometric model diagram of this example is shown in figure 3, Mechanical parameters of this example is shown in table 1.

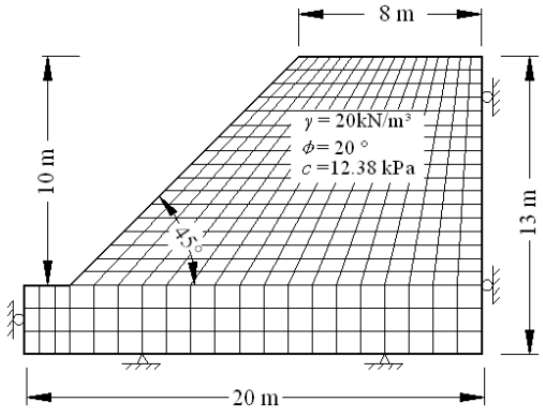

Figure 3 the size of model

IV. Example verification

In order to test the strength reduce based on golden section point proposed in this paper, this section three ways: method built-in FLAC3D

Table 1 Mechanical parameters of model

ρ / kg • m^{-3}	K / MPa	G / MPa	c / kPa	ϕ / （°）	σ^t / MPa
2000	100	30	0.35	20	10000

After the calculation of the strength reduce method built-in FLAC3D software, traditional automatic strength reduce method whose safety factor are 1.354, 1.352 and 1.357, and the safety factor of three methods are almost equal. The figure 4-6 shows the shear increment of three methods when they reach their safety factors, from the figures we can know the shear increment of three methods are almost same. Finally from above two points we can get the conclusion of the new strength reduce method based on golden section point is reasonable and scientific.

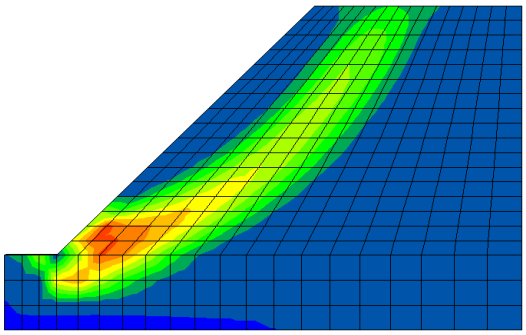

Figure 4method built-in FLAC3D

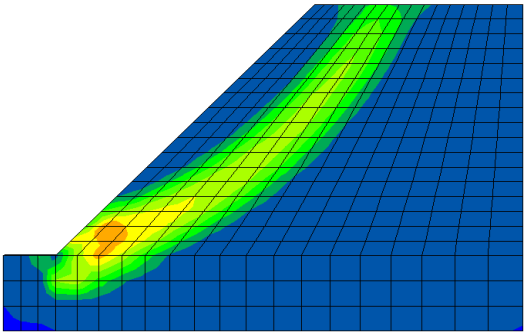

Figure 5traditional method

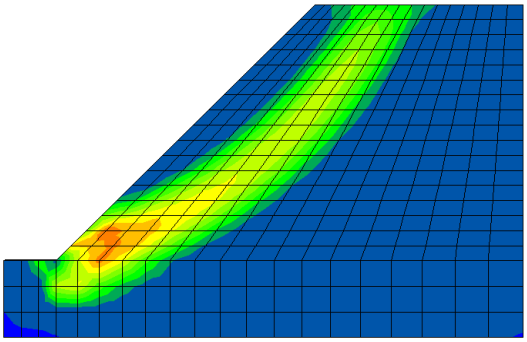

Figure 6new method

The calculation time of three methods: method built-in FLAC3D software, traditional method and new method are 981s, 365s and 240s. from above we can know the calculation of new method is least to verify the correctness of the results.

V. Conclusion

1 Through analysis of traditional strength reduce method, although it spend less time than the method built-in FLAC3D software, the calculation time is also much long.

2 The paper introduces the golden section point , then combines the golden section point and traditional strength reduce method to raise a new strength reduce method. Finally the design flow chart of this new method is put forward.

3 Aimed at checking the new method. Three ways to solve the same example to validate the reasonable and scientific of this new method and validate the calculation time of the new method is least at the same time.

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