

The Influence of Soil Parameters on the Stability of Loose Slope

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Abstract. The Loose slope composed of soils and rocks, and its internal structure is complex. The stability of the Loose slope is related to the water, load, slope shape and soil parameters. The soil parameter determines the engineering properties of the slope itself. Based on existing research results, respectively analyzing the dry bulk density, internal friction angle and cohesive force on the stability of Loose slope by establishing Midas/GTS numerical model. Designing Orthogonal test combined with Midas/GTS numerical model to obtain safety factors under the change of three factors. Finally, the degree of sensitivity of the three factors is obtained based on MATLAB combined with orthogonal test and the end result is: internal friction angle $\Phi >$ dry bulk density $\gamma >$ cohesive force C .

1. Introduction

The loose slope is mainly composed of rockfall and weathered soil, and its structure is loose, which may cause local slippage under external forces [1-3]. In recent years, with the construction of high-grade highway, the instability of roadbed slope caused by loose slope is becoming more and more serious, so it is necessary to analyze the slope stability of loose slope. The stability of the slope is related to the water, load, slope and soil parameters, and the soil parameter determines the engineering properties of the slope itself. Gang Feng used the finite element software PLAXIS2D to conduct numerical simulation analysis to study the deformation and instability of the complex pile slope [3]. Wei Shan analysis The effect of density, moisture content and additional load to elastic modulus of soil [5]. The present study shows that the analysis of slope stability is usually a single parameter, but the sensitivity analysis of parameters is less.

2. Midas/GTS numerical simulation

2.1 The establishment of slope model

The MADAS/GTS two-dimensional slope model is established as shown in Fig. 1. The slope height is 5 m, the top platform is 2 m and the slope is 1: 1. The point of A1, A2 and A3 are characteristic points when we respectively analysis the stress , Strain and displacement. As shown in Fig. 2 for the slope mesh, the mesh size is 0.5, and the software automatically generates 193 cells.

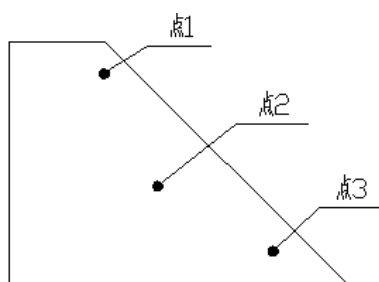


Fig. 1. Slope model diagram

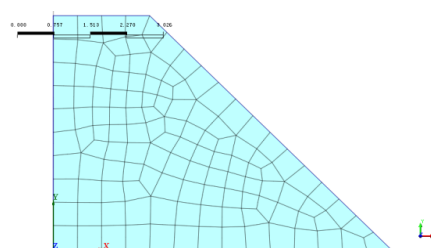


Fig. 2. Slope grid map

2.2 The Selection of model parameters

By arranging the research results of the currently existing soil parameters (slope line), the parameters used in the calculation are shown in Table 1.

Table 1. Numerical simulation parameter table

Category	Elastic modulus E/MPa	Poisson ratio μ	Bulk density γ /Kn/m3	Water content ω /%	Internal friction angle ϕ /o	Cohesive Strength C/KPa
Numerical	98.43	0.3	20	16.5	33.4	39.6

When using Midas/GTS for numerical simulation to solve the safety factor, the elastic modulus, poisson ratio and water content of the slope were kept unchanged and mainly changing the three parameters of dry bulk density, internal friction angle and cohesion.

2.3 Define boundary conditions

Selecting support, that is, choosing to add the lateral restraint of the slope body, and add constraints to the two sides, bottom and back, and the slope body load is defined as self - weight.

2.4 Calculation

After adding load and selecting slope stability analysis, the numerical simulation results of slope are obtained by numerical calculation. As shown in fig. 3.

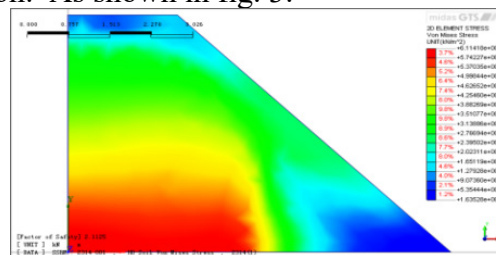


Fig.3. Numerical results

3. Effect of dry bulk density, internal friction angle and cohesion on stability of loosely deposited slope

Based on the results of Midas/GTS numerical simulation, respectively from the change of safety factor, the distribution of slope stress, the analysis of maximum shear strain and the slope position shift trend to analysis dry density, Angle of internal friction, cohesive force of loose slope stability , the influence of the conclusions are as follows:

(1) The influence of dry bulk density on the loose slope stability: under the conditions of slope and other soil parameters, the increase of dry bulk density will lead to the increase of slope stress, maximum shear strain and displacement Lead to the slope safety factor reduction. According to the change of bulk density, the slope design can select the corresponding slope height, slope, engineering measures and so on, in order to achieve the goal of cost saving and reasonable arrangement under the premise of ensuring safety.

(2) The influence of internal friction angle on the loose slope stability: under the condition of slope condition and other soil parameters, the increase of internal friction angle will lead to the decrease of slope stress, strain and displacement Lead to the slope safety factor increase. Design and construction of the slope should be based on soil friction angle changes caused by changes in the stability of the slope, so as to adopt the appropriate design concepts and engineering measures.

(3) The influence of Cohesion on the loose slope stability: Under the condition of slope type and other soil parameters, the increase of cohesion will lead to the decrease of slope stress, strain and displacement Make the slope safety factor increase. Design and construction of the slope should be

based on changes in cohesion of soil to adopt the appropriate design concepts and engineering measures.

4. Parameter sensitivity analysis

Sensitivity analysis of the parameters is carried out by using the orthogonal test method based on MATLAB. The safety factor obtained is used as a reference value, and then calculated by MATLAB as the design scheme of the variation. Finally, the sensitivity of the three parameters is obtained.

4.1 Orthogonal table establishment

First of all, according to the orthogonal test theory to design the orthogonal experiment table of three factors and two levels, as shown in Table 2. Select soil parameters, dry bulk density is 19.4KN/M3, internal friction angle is 26.4° , cohesion force is 39.6KPa, and then set the coefficient of variation ($K=0.08$) according to orthogonal theory to change two different levels, as shown in Table 3, where: Level 1 = Factor $\times (1-K)$; Level 2 = Factor $\times (1 + K)$. After entering the level value, the soil parameter 3 factor 2 level orthogonal table is obtained, as shown in Table 4.

Table 2 The orthogonal table of three-factor and two-level

factors	Factor 1	Factor 2	Factor 3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

Table 3 The table of soil reference parameter level value

Category level	Bulk density Kn/m ³	Internal friction angle °	Cohesive Strength KPa
1	17.848	24.288	36.432
2	20.952	28.512	42.768

Table 4 The table of 3 factors 2 level orthogonal

Category group	Bulk density Kn/m ³	Internal friction angle °	Cohesive Strength KPa
1	17.848	24.288	36.432
2	17.848	28.512	42.768
3	20.952	24.288	42.768
4	20.952	28.512	36.432

4.2 Establishment of orthogonal experimental calculation model based on Midas/GTS

The establishment of the slope model is shown in Fig. 4. The slope mesh model is shown in Fig. 5, and a total of 2218 elements are divided.

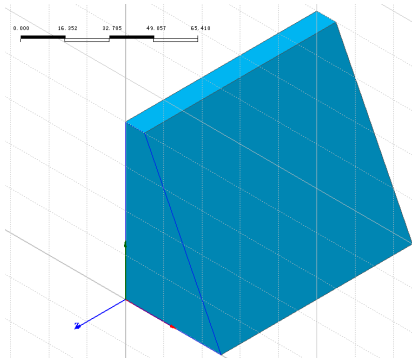


Fig.4. Slope model diagram

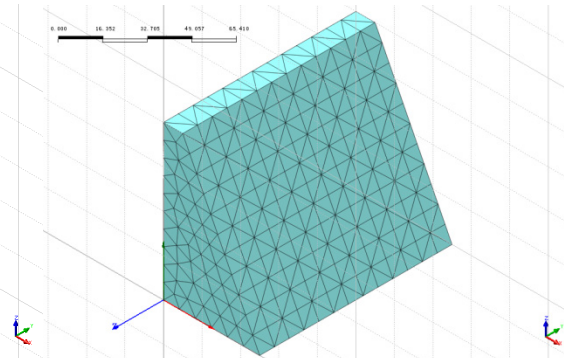


Fig.5. Slope grid map

4.3 The parameter selection and numerical simulation results statistics

Through orthogonal design and back calculation of MIDAS, 4 groups of 3-factor parameter values and corresponding safety factors are obtained, as shown in Table 5.

Table 5. Soil parameters and related safety factor statistics table

Category groups	Elastic modulus E/MPa	Poisson ratio	Natural bulk density Kn/m ³	Saturated bulk density Kn/m ³	Water content %	Internal friction angle °	Cohesive strength KPa	Safety factors
1	98.43	0.3	20.83	21.519	16.72	24.288	36.432	1.6875
2	98.43	0.3	20.83	21.519	16.72	28.512	42.768	1.9875
3	98.43	0.3	24.46	24.623	16.72	24.288	42.768	1.6875
4	98.43	0.3	24.46	24.623	16.72	28.512	36.432	1.7875

4.4 Parameter sensitivity analysis based on MATLAB

We can calculate the parameters of the target function extreme difference, the corresponding level of difference and sensitivity by the MATLAB program , as shown in Table 6.

Table 6. The objective function extreme difference, The difference between the corresponding level of factors, Sensitivity

Category Parameter	Dry bulk density	Internal friction angle	Cohesive strength
The objective function extreme difference	0.1	0.2	0.1
The difference between the corresponding level of factors	3.104	4.224	6.336
Sensitivity	0.0322	0.0473	0.0158

The sensitivity of dry bulk density、 internal friction angle and cohesive strength to the stability of the slope is shown in Fig. 6.

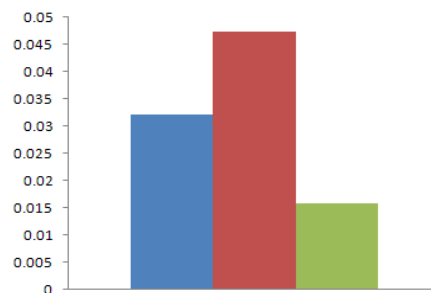


Fig.6. Parameter sensitivity comparison chart

As can be seen from Figure 6, the most sensitive to soil stability is the internal friction angle, followed by dry weight and cohesion. And the sensitivity of the internal friction angle is much larger than the cohesion, the sensitivity of dry weight is basically in between.

5. Conclusion

1) Based on the slope stability model of subgrade, the influence of dry bulk density, internal friction angle and cohesion on slope stability is analyzed. For slope stability, the larger the dry bulk density is, the smaller the stability. The larger the internal friction angle , The greater the stability; the greater the cohesion, the greater the stability.

2) Based on orthogonal experiments, the sensitivity of slope bulk density, internal friction angle and cohesion to slope stability was analyzed by MATLAB. The conclusion is: The internal friction angle was the most sensitive to slope stability, followed by dry bulk density and cohesion.

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