

Analysis of slope management on a highway adjacent to a residence

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Abstract. By the influence of the construction excavation of the surrounding buildings, the natural mountain within the red line of a highway locally appeared a wide range of cracks and have a tendency to expand; in order to prevent further deformation and damage of the slope, and to ensure the safety of the construction of the highway after entering the field, the main sliding surface of the slope as the object of the study, constructed a finite element model of the slope, and analyzed the change of the slope stress field, displacement field, and determined that the stability coefficient of the slope is 1.1, which does not meet the Through on-site investigation and expert opinion, the reinforcement scheme of "Slope reduction + anti-slip pile + anchor" was determined, and the feasibility of the reinforcement scheme was verified through numerical analysis, and the stability coefficient of the reinforced slope was 1.43, which was 23% higher than that before reinforcement.

Keywords: finite element; stability; reinforcement; anchor; skid pile.

1. Introduction

As a hot issue in the field of geotechnical engineering, slope management analysis has been widely concerned by experts and scholars at home and abroad [1-3]. WANG Chuan et al [4] realized a rapid simulation of the evolution process of initiation, extension and penetration of intermittent fissures in rock bodies based on the fracture extension analysis method; ZHANG Wenlian et al [5] proposed a generalized Hoek-Brown criterion strength discount method based on the compressive strength of the rock body, and verified the reliability through engineering examples; ZHU Xueliang et al [6] established the energy balance based on the upper limit method of plastic limit analysis equation and its dimensionless critical height value expression, and verified the feasibility of the expression through slope examples; ZHANG Liang et al [7] investigated the difference between two-dimensional and three-dimensional slope stability analysis under different boundary conditions and its reasons; ZHANG Bangxin et al [8] investigated the sensitivity of the geotechnical body parameters and the impact of different reinforcement schemes on slope stability; JIA Jianqing et al [9] investigated the anisotropy of the soil strength parameter on the stability of slope and put forward a proposal of slope partitioning. and proposed a method to study the anisotropy of slope zoning.

Anti-slip piles and anchors are widely used in different types of slope projects as common reinforcement means for slopes [10]. In this paper, a slope is taken as the research object, and the

slope stability changes before and after reinforcement are compared and analyzed by using the combination of slope reduction + anti-slip pile + anchor reinforcement scheme.

2. Project Overview

Slope is located in Guangzhou Zengcheng District, near a new building, the section of the slope is a low mountain hilly terrain, terrain undulation, slope ground elevation of about 90 ~ 143m, the natural slope angle of the largest about 28 ~ 35 °, the mountain vegetation development; slope area is a southern subtropical monsoon climate, the average annual temperature of 20 °C ~ 22 °C, annual rainfall of more than 1,600mm; on-site investigation, measurement found that, is located in the freeway Site investigation, measurement found that the slope located in the red line range of the highway has cracks and wrong platform, and continue to develop and expand the trend, the expert discussion and analysis to determine the main slope surface as shown in Fig. 1; such as not in a timely manner to strengthen the slope treatment, the slope may collapse at any time, and preliminary prediction of landslides amount of earth about 300,000 square meters, which will cause a major geologic disaster.

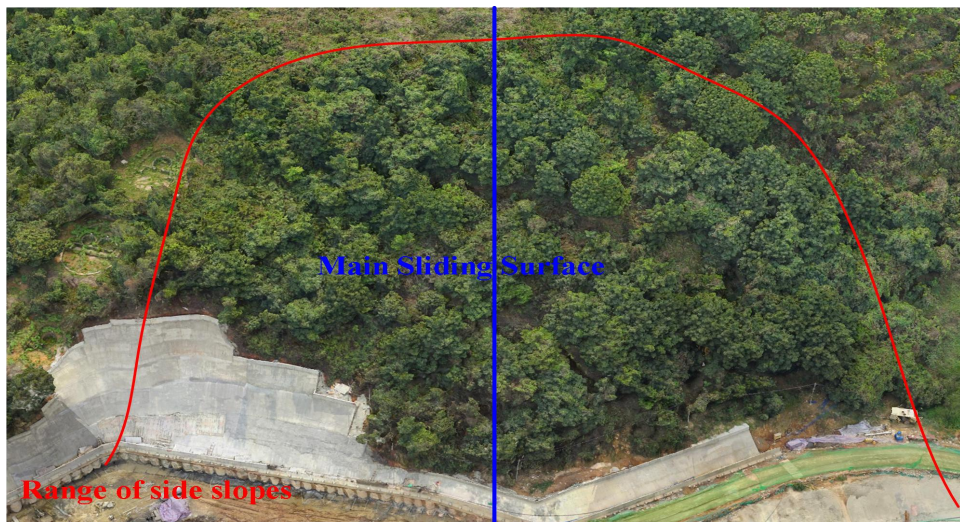


Fig. 1 Overall view of the slope

3. Parameterization and model construction

Through the field geological investigation, the geological structure of the main slip face of the slope was determined as shown in Fig. 2. The physical and mechanical parameters of the rock and soil bodies on the main slip face measured by indoor and outdoor tests are shown in Table 1.

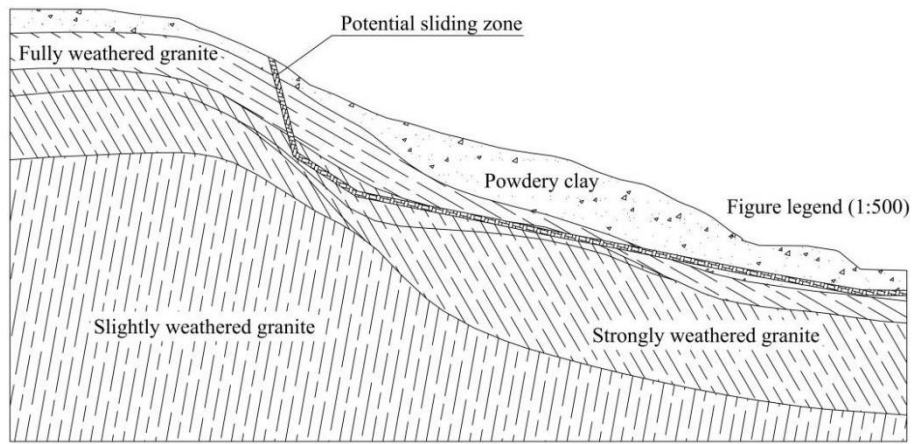


Fig. 2 Geological structure of the main slip surface

Table 1. Physical and mechanical parameters

Category	Severe/(kN.m ⁻³)	Cohesion/kPa	Friction angle/(°)	Modulus of elasticity/MPa	Poisson's ratio
sliding belt	18	21.5	16	14	0.3
Powdery clay	20	23	16.4	15	0.35
Fully weathered granite	19	12	20	200	0.32
Strongly weathered granite	22	24	25	300	0.37
Slightly weathered granite	28	45	60	2500	0.3
Pile	24	-	-	30000	0.2
Anchor	-	-	-	200000	0.35

Taking the main sliding surface of the slope as the research object, the finite element model is constructed as shown in Fig. 3; fixed constraints are applied to the two sides and the bottom of the slope, and the rest of the boundaries are free boundaries; CPE4 cell type is used to mesh the model.

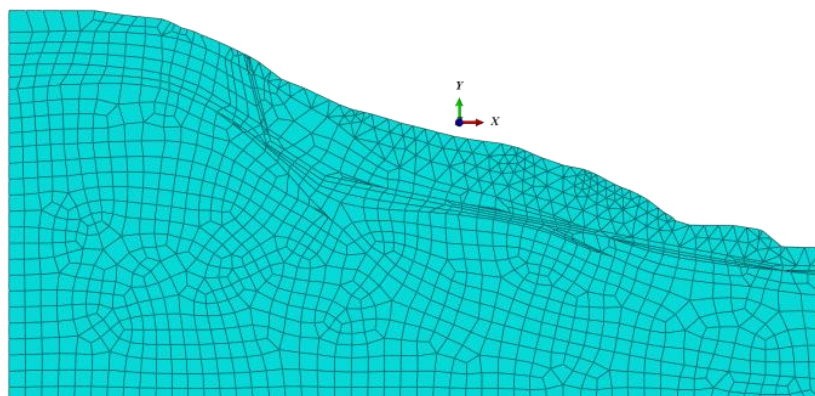


Fig. 3 Finite element model

4. stability analysis

Ground stress equilibrium was performed on the model first, after which stability calculation was performed on the model to obtain the average stress on the slope as shown in Fig. 4 and the displacement cloud as shown in Fig. 5.

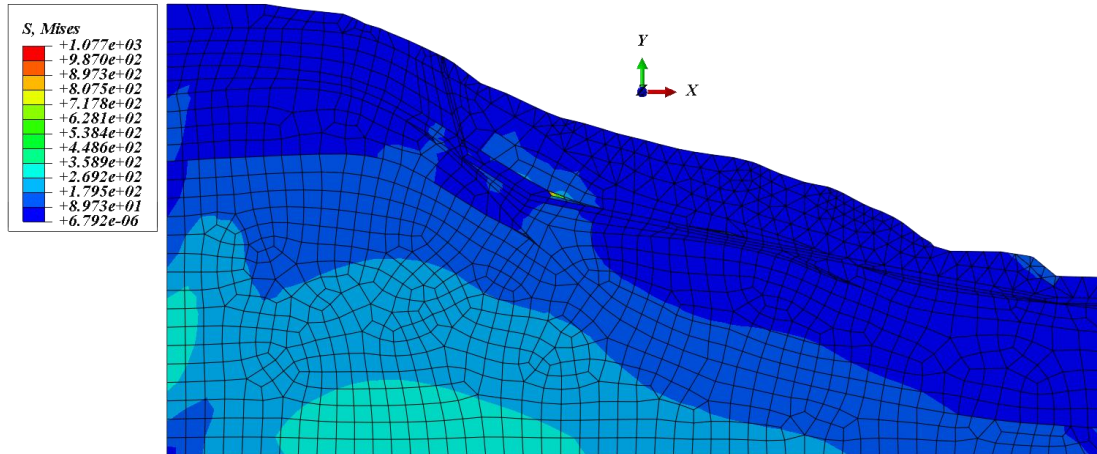


Fig. 4 Average stress

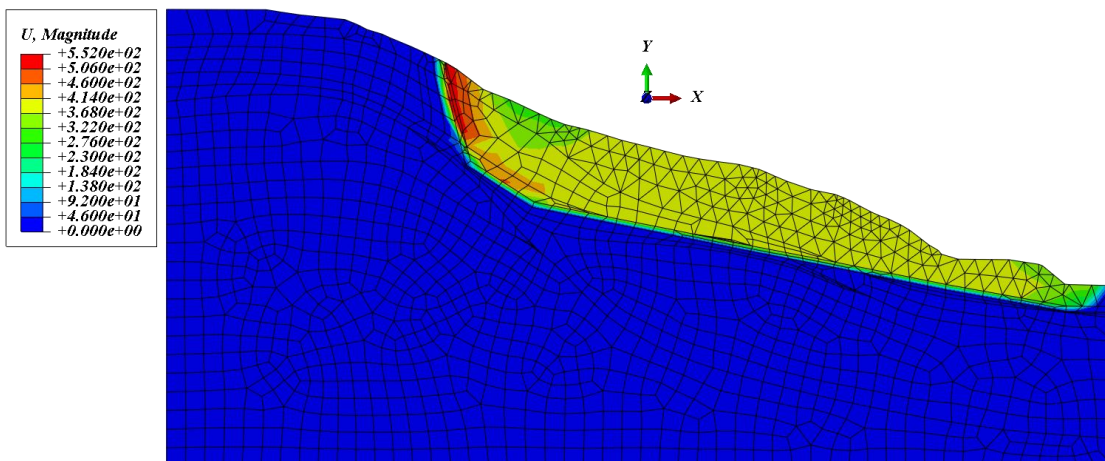


Fig. 5 Displacement cloud map

It can be seen from Fig. 4: the overall average stress of the slope is small, the average stress at the bottom is obviously larger than the average stress at the top, and the overall trend is gradually increasing from top to bottom; the average stresses of the pulverized clay, the fully weathered granite, and the strongly weathered granite are similar, and the maximum value of the average stress is located near the potential sliding zone. From Fig. 5, it can be seen that: the sliding area is located above the potential sliding zone, and is mainly concentrated in the chalky clay area; the maximum value of displacement is 552mm, which is mainly concentrated above the sliding area, and the minimum value of displacement is concentrated in the area of the potential sliding zone.

Taking the upper starting point of the displacement sliding area of the main slip surface as the study point, and taking the inflection point of the displacement value as the slope stability evaluation criterion, the change curve of the stability coefficient of the main slip surface is obtained as shown in Fig. 6.

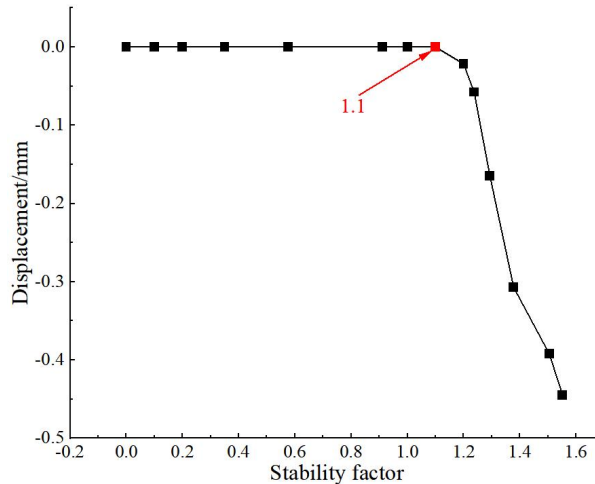


Fig 6 Stability coefficient change curve

It can be seen from Fig. 6: the main slip surface displacement value in the stability coefficient of 1.1 when the sudden change, according to the slope stability evaluation standards to determine the stability coefficient of 1.1, while the engineering specification standards, this kind of slopes in the natural conditions of the stability coefficient of the range of 1.2 ~ 1.3, obviously does not meet the specification requirements, indicating that the slope is in the state of understability, and with the expansion of the cracks in the surface of the slope, slope Stability coefficient coefficient will continue to decline. Therefore, it is necessary to take targeted measures to stabilize the slope.

5. Reinforcement of governance

Through on-site investigation, measurement and multi-party expert argumentation, it is determined to adopt the "slope reduction + anchor + anti-slip pile" reinforcement program to manage the slope; construct the finite element model shown in Fig. 7, with fixed constraints on both sides and the bottom of the slope, and the rest of the boundaries are free boundaries; respectively, CPE4 cell type is adopted on the slope, T2D2 cell type is adopted on the anchor, and B21 cell type is used for the anti-slip pile to carry out the mesh delineation; and the specific layouts of the reinforcement program are shown in Fig. 8.

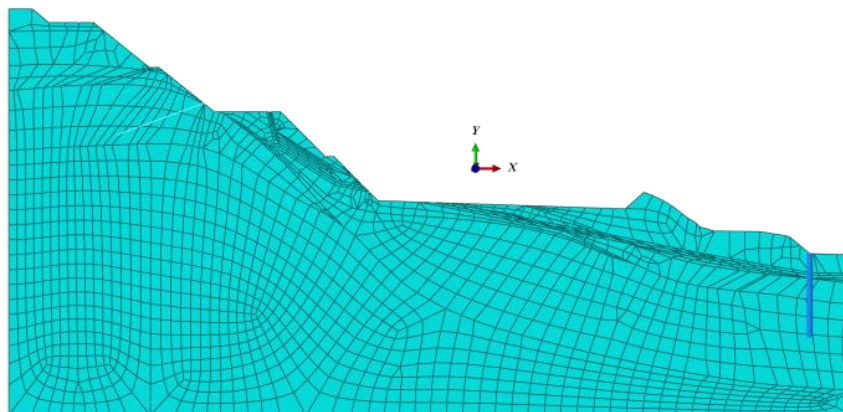


Fig. 7 Finite element model of the reinforcement scheme

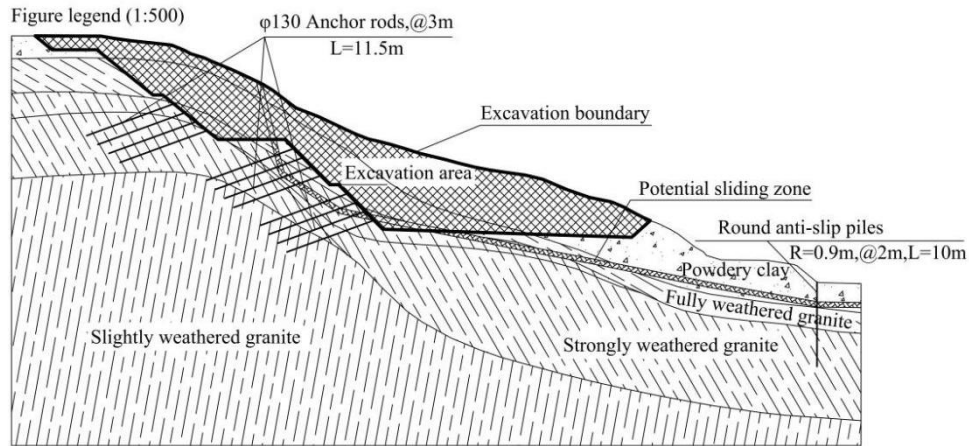


Fig. 8 Layout of reinforcement scheme

The average stress on the main slip surface after reinforcement is obtained by stress balance and stability calculation as shown in Fig. 9, and the displacement cloud is shown in Fig. 10.

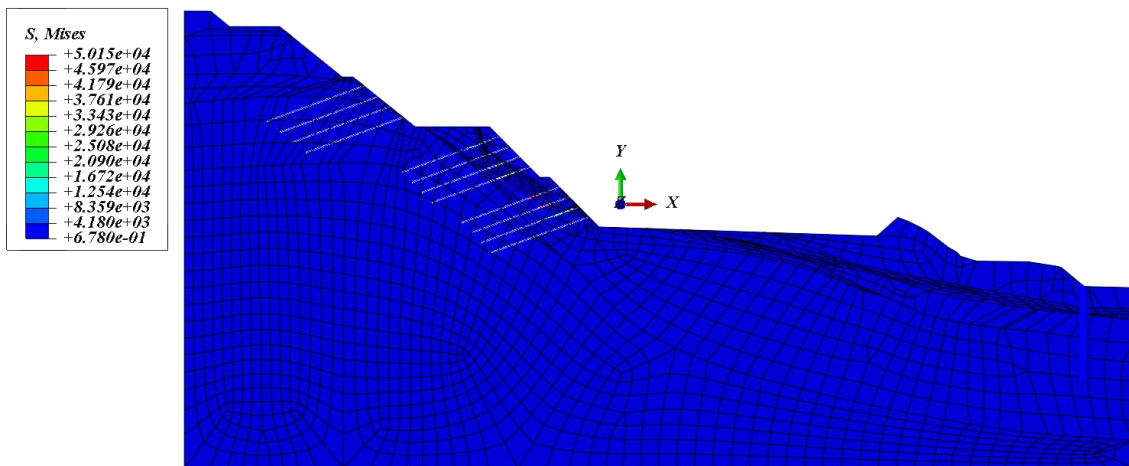


Fig. 9 Average stress

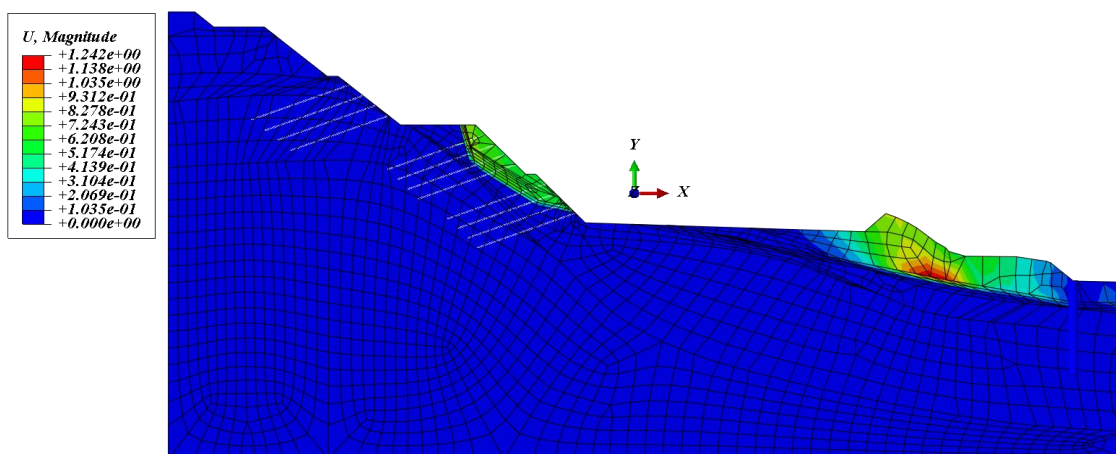


Fig. 10 Displacement cloud map

It can be seen from Fig. 9: the overall average stress value of the main sliding surface after reinforcement is similar; the maximum value of the average stress is mainly concentrated in the anchor rods, and the lower anchor rods are subjected to greater deformation; it can be seen from Fig. 10: the maximum displacement of the main sliding surface after reinforcement is 1.242mm, which

is 99.7% lower compared with the maximum value of 552mm displacement value before reinforcement in Figure 5, and it is mainly concentrated in the lower part of the main sliding surface, and the displacement value of the upper part is smaller, which shows that the anchor rods and anti-slip piles play an important role in preventing the sliding of slopes. This shows that the anchor and anti-slip pile play an important role in preventing the slope from sliding.

Still take the starting point above the main slide displacement sliding area as the research point, and take the inflection point of the displacement value as the evaluation standard of slope stability, and get the change curve of slope stability coefficient of the main slide after reinforcement as shown in Fig. 11.

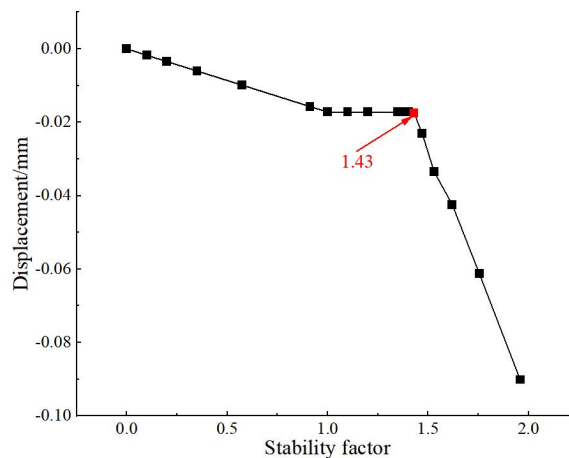


Fig. 11 Stability coefficient variation curve

From Fig. 11 can be seen: the main slip surface displacement value in the stability coefficient of 1.43 when the sudden change, according to the stability coefficient evaluation criteria to determine the stability coefficient of its reinforcement for 1.43, relative to the reinforcement before the improvement of 23%, to meet the engineering specification requirements.

6. Conclusion

(1) The stability coefficient of the main slip surface before reinforcement is 1.1, which does not meet the requirements of engineering specifications, indicating that the slope is in an unstable state.

(2) The stability coefficient of the main slip surface after reinforcement is 1.43, which is 23% higher than that before reinforcement and meets the requirements of engineering specifications.

(3) Relative to the pre-reinforcement, the overall displacement value of the slope is reduced, the overall average stress is reduced and the stability coefficient is increased, which indicates that the reinforcement program of "Slope reduction + Anchor + Anti-slip Pile" is feasible.

Acknowledgments

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