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Study on the Reliability of the Supporting Structure of A Station Slope Using Numerical Simulation

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Abstract. The safety and reliability of the support structure is very important to the stability of slope. This paper takes a station slope project as the engineering background. On the basis of geological survey results and indoor geotechnical mechanics experiment, the 3D geological model was established by FLAC3D. According to the field excavation support design, the stability and reliability of the supporting structure was studied after the excavation and backfilling of the slope platforms formed. Which shows that the existing slope support structure and parameters can control slope stability well. The research results provides a reference for optimization support design.

1. Introduction
With the implementation of the national One Belt And One Road strategy. A large number of transportation, water conservancy, hydropower, construction and other infrastructure are accelerating construction [1-2]. Yunnan, as a radiation center facing South Asia and Southeast Asia, is accelerating the construction of five major infrastructure networks. Along with a lot of infrastructure construction, inevitably produces a lot of engineering slope. The stability of these massive engineering slopes seriously restricts economic and social development, affecting people's life and property and security [3-4]. The study on excavation plan and control measures of engineering slope is of great significance to national economic development and people's life and property safety [5]. This article takes a station slope in Yunnan province as the engineering background, the supporting structures stability of the slope is studied after the excavation and support of each platform are finished. Which provides reference to optimize supporting scheme.

2. Project profile
A Tunnel project construction and living quarters Located in Xundian County, Kunming City, belong to the monsoonal climate of low latitude subtropical plateau in northern latitude.The water system is the Jinsha River.The geological structure is complex, the formation is more, the zone is affected by crustal movement and natural weathering, faults and folds, ground breaking, mountain peaks, ravines

crossbar, relatively high difference is bigger. Surface water and groundwater are abundant, the Luliu River has clear water all year round. Tunnel entrance and bridge area belong to tectonic erosion of zhongshan deep valley landform area, the terrain is steep on both sides of the slope, and the slope of the entrance is about 40 to 60 degrees, vegetation is relatively sparse.

The area near the exit of the tunnel is steep hill, gully, narrow, there is no gentle terrain within 1500m near the entrance of the cave. Tunnel construction and life station are selected near the entrance to the right side in the range of 20m~170m.The slope is excavated and the retaining wall is constructed,the method of filling out 6.06 mu is used for tunnel construction and life resident construction. The topography of this area is relative to the whole slope is more gentle, the slope is about 40 degrees, the site is close to the hole, It is convenient for construction personnel to enter the hole construction and convenient for the transportation of materials and materials needed in various holes.

Construction and living location is on the right side of A tunnel project YK87 + 710 ,and it is on the left side of the construction main road BDK1+190~BDK1+360. The site has living area, rebar processing area,machinery parking area and transformer, air compressor,it is divided into three layers, one of which is the first and the secondary platform belongs to the excavation side slope, the tertiary platform belongs to half - dug and half - filled slope. At the same time, the tertiary platform is supported by 8m high slurry block stone retaining wall. Site covers an area of 11.64 mu.

3. The establishment of the model and parameter selection

3.1. The establishment of the model

Numerical simulation model of the whole station is established, the length of model is 70m (The width of the slope), height is 81m. In order to optimize the grid at the same time also can meet the requirements of accuracy, the excavation and filling and the surrounding parts of the unit is encrypted distribution. The total units of model is 66430, the total nodes of model is 70929. Simulation model is shown in figure 1, and supporting structure is shown in figure 2. In left and right boundary of the model, X direction displacement is fixed, in the front and back boundary of the model, Y direction displacement is fixed, and at the bottom of the model, displacement is fixed. Take the vehicle load and the combination of the surrounding building load as the initial conditions. Mohr-Coulomb strength criterion is adopted [5-7].

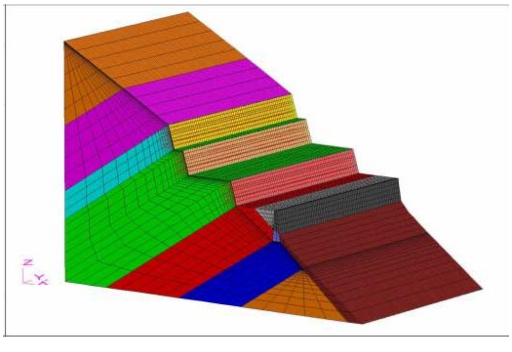

Fig 1. Computational simulation model

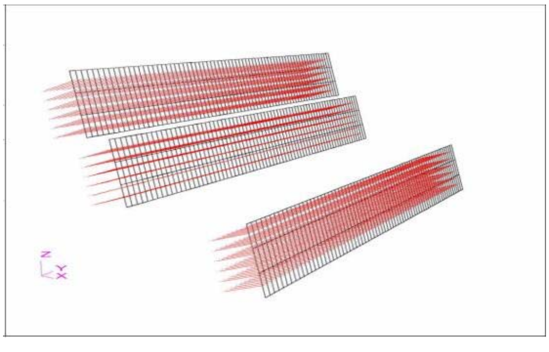

Fig 2. The support structure of shotcrete cable mesh

3.2. Geotechnical mechanics parameters

Geotechnical mechanics parameters was determined according to<Geological survey report on the construction and residential slope of A Tunnel project>.Table 1 shows mechanical parameters of concrete. Table 2 shows geotechnical mechanics parameters of numerical simulation.

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Table 1. Mechanical parameters of concrete

component	Density (kg/m3)	Elastic modulus (GPa)	Poisson's ratio	Bulk modulus (GPa)	shear elasticity (GPa)
concrete C25	2480	27.5	0.167	13.9	11.9

Table 2. Geotechnical mechanics parameters of numerical simulation

Geotechnical name	Density (g/cm3)	Cohesion (kpa)	Internal friction angle(°)	Poisson's ratio	Deformation modulus (MPa)
Fill	1.80	15	24	0.33	0.012
clay	1.80	18	25	0.33	0.028
Crushed clay	1.90	24	20	0.30	0.016
Strong weathered sandstone	2.1	34	25	0.28	3.0
Medium weathered limestone	2.5	41	40	0.24	6.0
Weakly weathered limestone	2.40	50	45	0.25	11
Middle weathered sandstone	2.2	35	42	0.20	2.8

4. Calculation results and analysis

The calculated results show that the stress concentration occurs at the corner of concrete shotcrete layer, with the maximum principal stress being 3.37mpa, which mainly occurs at the slope shoulder position of the secondary platform. In most areas of the concrete spray layer, the maximum main compressive stress is 0.5-2.0mpa (Fig.3). The tensile stress appeared in the upper part of the concrete spray layer at the shoulder of the first grade platform. The maximum tensile stress was 1.15mpa, and the tensile stress of the rest part was less than here (Fig.4). It is suggested that in the area with large tensile stress, the spacing between bolts should be reduced, the spacing between steel mesh should be reduced, and the diameter of reinforcement should be increased.

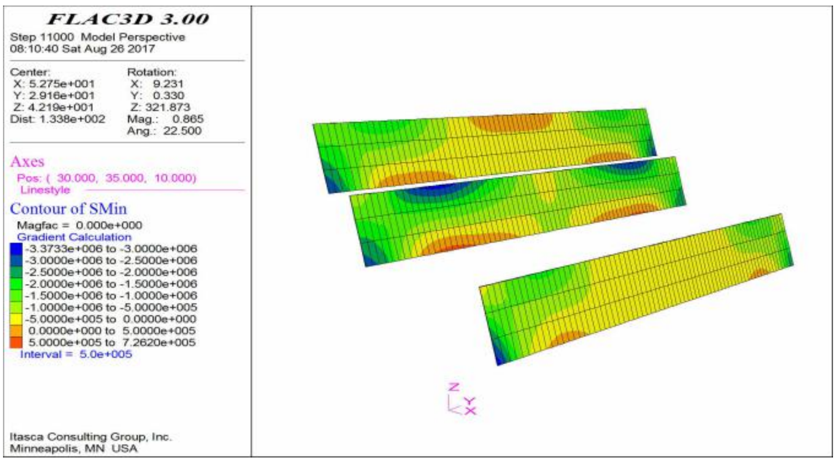

Fig 3. The maximum principal stress

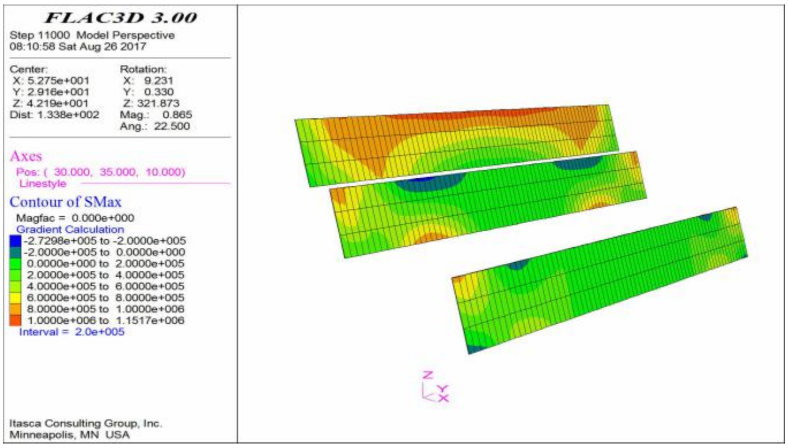

Fig 4. The minimum principal stress

Figure 5 and Figure 6 respectively show the x-direction displacement and z-direction displacement of the concrete spray layer of slope after the excavation of the three-stage platform. The calculated results show that after the completion of the excavation support of slope, the horizontal displacement of concrete shotcrete layer of slope is 0.5 to 1cm, and the displacement of slope surface of the secondary platform is large. The maximum vertical displacement of concrete spray layer is 3.39cm, which is also at the edge of the secondary platform.

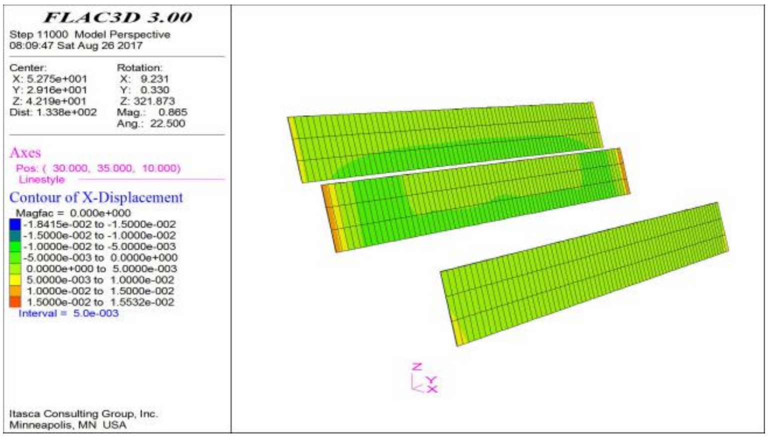

Fig 5. The displacement of X direction

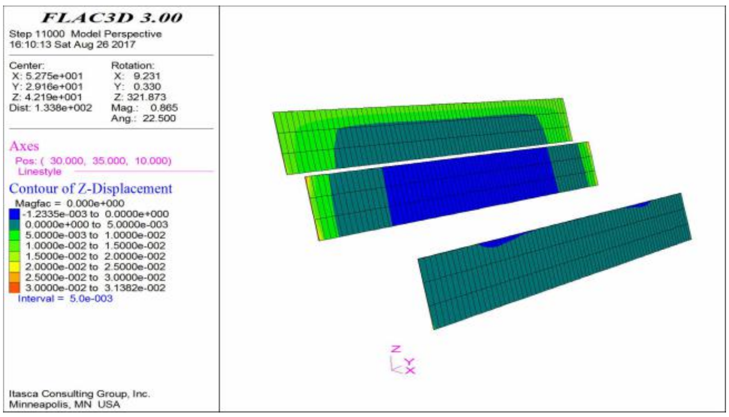

Fig 6. The displacement of Z direction

The calculation results of anchorage stress distribution of bolt show that the maximum axial force of bolt is 111.8KN (Fig.7). The anchorage stress of the bolt increases gradually from the middle to the end and presents a triangular distribution of small inside and large outside.It can be seen from the figure that the maximum anchorage stress is 37.31Kpa (Fig.8). The force of the bolt is in good condition and no damage occurs.

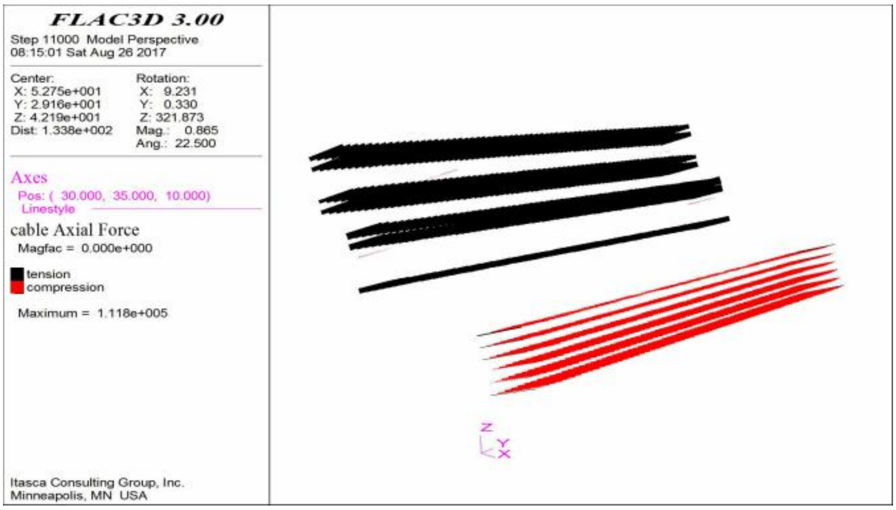

Fig 7. The distribution of bolt axial force

Fig 8. The stress distribution of bolt anchorage

5. Conclusion

Through analysis to stress, displacement of the slope supporting structure by FLAC3D, results show that the instability of the station slope does not occur. The concrete shotcrete layer and anchor bolt are in good stress state and there is no damage. This certifies that the slope stability is well under the existing support parameters which has a certain guiding significance to the slope design and production safety.

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