Based on the Georgia road tunnel slope location optimization

Xiaowei Zhang¹, Chen Di²*, Fuhua Wang¹, Yetao Wang³, Zhen Liu¹
¹CCCC No.4 Highway Engineering Bureau Co. LTD 100011, China
²School of Civil Engineering, Xi'an University of Architecture and Technology, Shaanxi Xi'an, 710055, China
³China Road and Bridge Corporation, Beijing 100011, China
*Corresponding author: duanyuxin@xuat.edu.cn

Abstract — In order to maintain the stability of the mountain under the premise of reducing the cost in the tunnel construction, to Georgia highway and tunnel as an example, put forward in the process of excavation of tunnel, in the case of guarantee the stability of the mountain, reduce the excavated volume of the mountain, the mountain slope forward 4 m, and using numerical analysis software MIDAS to two kinds of schemes are numerically simulated, compared to the original plan and put forward solution two kinds of working conditions of the mountain slope ground stress, stress and settlement of slope of tunnel lining first. The numerical simulation results show that after the mountain slope is moved forward, the peak value of ground stress of the mountain decreases, the shear stress of the initial lining decreases, and the slope settlement is basically the same as the original plan. Generally speaking, the settlement value of the vault decreases, and the uplift value of the arch bottom increases by 2mm. Therefore, in future tunnel construction, according to the corresponding geological conditions, the slope can be appropriately moved in front of the mountain to reduce the amount of mountain excavation and save costs.

1. INTRODUCTION
In recent years, in order to deepen the relations between China and its neighbors and in response to the "Belt and Road Initiative" policy of general secretary XI Jinping, many roads have been built between China and neighboring countries, facilitating state-to-state exchanges and deepening the economic ties."Belt and Road Initiative" line, from western of China to Europe, with many of the mountains, great difficulties were caused to the construction of the land route. The tunnel, as a kind of buried in the mountain or underground concealed work, compared with winding mountain roads, greatly shorten the distance of road, so in today's mountain highway railway construction, tunnel is widely used. In the process of the construction of a tunnel, inevitable to excavation mountain, a working face for construction should be dug to ensure effective construction before entering the hole, this part of the project accounts for a large part of the construction cost. Therefore, it is an important aspect to save construction cost to find an appropriate method to reduce the amount of excavation of the mountain under the premise of ensuring the stability of the slope, slope and the entrance section [4].

Zeng Youjiang [5] studied the side slope of tunnel entrance in Tianlan section of Baolan passenger dedicated line as the research object, and analyzed the stability of the side slope of tunnel entrance along the passenger dedicated line; Wang Lu Road [6], in view of the geological conditions and actual engineering conditions of the slope at the entrance of the tunnel, the upper limit principle of limit analysis is used to analyze the stability of tunnel opening side slope; Da Xiaowei [7] took The Machu High-speed
Xiangshan Tunnel as the engineering background, A three-dimensional finite element model of the tunnel opening was established according to the geological conditions and topography of the tunnel site. Based on the numerical simulation and field monitoring data, the variation trend of displacement, stress and strain in the excavation process of tunnel opening and overhanging slope is analyzed. The variation law of displacement field and stress field of slope and slope at the entrance is summarized, and the position of potential slip plane is given. On this basis, the optimal treatment scheme of the mouth of the cave and the slope is put forward; Zhao Yufei and Chen Zuyu recorded [8] landslide cases collected by Chinese water conservancy and hydropower workers in the past ten years, at the same time, the classification and arrangement of these slope data are also introduced; through the form of table, the classification of statistical results of the slope, to understand the slope engineering has great reference significance; Li Huapeng [9] made a detailed investigation of 147 rock slopes on 12 main railway lines in China, statistical analysis, probabilistic methods, quantitative theory and fuzzy mathematics were applied to make an in-depth analysis of the survey data; on this basis, the quantitative relation formula between the quality index of rock mass and the slope slope of railway rock is established, and the evaluation method of the stability of railway rock slope is put forward; Moreover, finite element software [10-12] has also been widely used in slope engineering, for example, in MIDAS-GTS NX, strength reduction method, virtual element strength reduction method, analytical method and other methods are used to analyze the stability of slope. When the slope is unstable due to poor geological conditions or other reasons, a large number of researchers have also studied various treatment measures [13-14]. However, there are few researches on how to reduce the amount of excavation in slope release.

In this study, based on Georgia highway tunnel imports as the research object, in order to make sure the mountain, the premise of the stability of the tunnel and the use of finite element analysis software MIDAS GTS - NX, build a model of the original plan, to build a slope will put forward the optimization model, calculated and compared to two kinds of schemes after construction slope, slope and tunnel vault, arch bottom displacement change, the results provide a certain reference for similar engineering.

| Material       | Constitutive | Unit type | E(kPa) | \( \gamma \) (kN/m³) | \( \mu \) | C(kPa) | \( \phi^\circ \) |
|----------------|--------------|-----------|--------|---------------------|-------|-------|----------------|
| Rock soil      | Morculen     | Physical unit | 1.0e6  | 25                  | 0.3   | 120   | 54             |
| Concrete panel (C30) elasticity | Physical unit | 3.0e7  | 25       | 0.20                 | -     | -     |
| Spray mixing (C30) elasticity | Board unit | 3.0e7  | 24       | 0.20                 | -     | -     |
| Anchor rod     | elasticity   | Implantable truss unit | 2.8e7  | 25            | 0.20 | -     | -             |

2. MATERIALS AND METHODS

2.1. Introduction to Georgia Road 1 Tunnel Project

Georgia 1 tunnel is located in the middle of the Georgian block, between the Transcaucasia block, the north Greater Caucasus and the south Lesser Caucasus. The tunnel is a double-hole and double-line tunnel with 0+992.700 ~ 1+918.500 starting and ending mileage, with a total design length of 926.5m. The roadmap of Georgia's E60 project is shown in Figure 1. The maximum buried depth of the tunnel is 98m and the minimum is 1.45m. The left and right tunnels are 13.5m apart.

The tunnel is excavated through the granite (PzGr formation) as shown in Figure 2. The formation is composed of intrusive rocks and metamorphic rocks of the protrozoic crystalline basement, mainly powder gray granite, metamorphic granite and granodiorite, which are characterized by hardness. Grade of surrounding rock is III ~ IV level.
2.2. Description of the excavation and support of the overhanging slope at the mouth of the cave
This construction is the exit of No. 1 tunnel. The first step is to excavate the mountain and place slopes for a total of seven layers. The construction sequence is to excavate one layer first, then insert anchor rods on the excavated slope, and spray-mix the slope after the anchor rods are inserted. After the grading was completed, the left and right tunnels were excavated at the same time, with an excavation footage of 6m, followed by the change in the properties of the opening of the first excavation section, and it became a concrete structure. Then there is the construction of the concrete entrance section of the tunnel. After that, excavation is carried out every 2m and the initial support is carried out immediately. The thickness of the support layer is 0.2m, and the support method adopts C30 concrete spraying. The tunnel calculation model is shown in Figure 1. Until the end of the excavation, after the initial support is completed and the deformation is stable, the second lining shall be applied. The second lining shall be constructed with the invert and vault at the same time. The thickness of the invert support layer is 0.8m and the thickness of the dome support layer is 0.65m. The supporting material is C30 concrete, and the material parameters are shown in Table 1. The left and right openings of the tunnel are determined as the B0 section according to the grade of surrounding rock. The completed model of mountain grading is shown in Figure 2.

2.3. Numerical simulation of tunnel excavation and grading
According to the engineering data, the first support of the slope and tunnel is 20cm thick C30 concrete, and the second lining is C35 concrete. The diameter of the full-column grouting anchor steel bar: 20-25mm, the ultimate tensile strength of the steel bar: ≥140KN. Rebar type: B450C, yield strength: 450 MPa. Specific attributes refer to Table 1.

3. Numerical results analysis
3.1. Stress analysis of horizontal ground stress field
It can be seen from Figures 7-8 that the deformation trend of the tunnel surrounding rock and the initial branch did not change before and after the improvement of the scheme. The maximum settlement difference between the two schemes was 2mm, and the settlement of the initial branch of the tunnel changed by the original scheme It is 1mm smaller, and the amplitude is reduced by 33%. Compared with the original plan, the settlement change amplitude of the tunnel is reduced by 0.5mm, which is a decrease of 33% year-on-year.
At the tenth step (during tunnel excavation), the initial support settlement of the AT tunnel vault has a sudden change. The initial support and the vault displacement of the surrounding rock change upward by 4mm. Then the surrounding rock and the initial support converge. The convergence of the initial support stabilizes after the 20th step, which is equivalent to 9 construction steps apart, and when the distance between the tunnel face and the monitoring point is 27m, the excavation has no effect on the stability of the previously excavated tunnel. After the improvement (the slope is moved forward), the initial settlement of the tunnel vault is finally 4mm, and the vault is 2mm.

3.2. Analysis of settlement of side slope and upside slope

By comparing the settlement of the upside slope, it is found that the original construction plan and the construction plan after the grading is moved forward. Figure 5. Figure 6 shows the vertical settlement and settlement trend of the original plan for the upper slope of the TA tunnel and after the grading move forward. The numerical settlement of the scheme is completely consistent with the settlement trend. The characteristic point is selected on the top layer of the tunnel. During the grading process, due to the excavation and unloading of the mountain, the slope surface is uplifted. Compared with before the excavation, It was uplifted by 4mm. After the excavation of the mountain was completed, the settlement of the slope surface was stabilized. As the tunnel excavation proceeded, the settlement of the slope surface did not change.
3.3. Analysis of the settlement of the tunnel vault

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4. CONCLUSIONS

This paper proposes an improved plan for the slope location of the mountain excavation at the entrance of the Georgia No. 1 tunnel, uses numerical simulation to simulate the original plan and the improved plan, and compares the following conclusions:

(1) After the grading front is moved, the horizontal principal stress of the formation shows the characteristic of decreasing the peak stress. This fully shows that this improvement plan is beneficial to reduce the stress of the mountain.

(2) In the entrance section of the tunnel, the shear stress of the initial support before the improvement of the comparison scheme is significantly reduced, which shows that the improvement of the scheme has reduced the force of the initial lining.

(3) Comparing the settlement of the slope upside before and after the optimization of the scheme, the settlement trend is basically the same after optimization, and the settlement is reduced by 2mm after optimization, indicating that the optimization of the scheme has basically no effect on the stability of the slope.

(4) By comparing the deformation of the tunnel vault, the surrounding rock at the arch bottom, and the initial support before and after the optimization of the plan, it is found that the deformation law of the arch bottom is basically the same before and after the plan is improved.

(5) After the grading is moved forward by 4m, the amount of excavation is greatly reduced and the excavation cost is saved. Therefore, in future similar projects, the grading front can be moved appropriately.
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