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Analysis and Research of Shallow Buried Bias Single-Lane Tunnel Based on CAE Simulation

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Abstract. Single lane tunnel is a common engineering type in water conservancy and highway, and shallow buried biased pressure tunnel is the most obvious problem in tunnel tunneling stage, which is a major problem in tunnel excavation construction. Due to shallow soil cover and partial pressure, slope instability is easy to occur, which is unfavorable to tunnel structure and surrounding rock. The lateral pressure coefficient of the surrounding rock outside the tunnel is affected by the calculated friction Angle of the surrounding rock, the friction Angle on both sides of the middle rock pillar and the bias slope Angle, and the lateral pressure coefficient of the inner surrounding rock of the double tunnel is also affected by the buried depth and the net distance of the tunnel. The vertical pressure distribution of tunnel vault is affected by tunnel depth, bias Angle and lateral pressure coefficient, but it is most affected by tunnel depth. The horizontal pressure of the surrounding rock of the tunnel is affected by the lateral pressure coefficient of the tunnel and the buried depth of the tunnel, but the buried depth of the tunnel plays a major role. The greater the buried depth, the greater the horizontal pressure of the tunnel. How to ensure tunnel quality and avoid safety accidents has become an important research topic. With the development of engineering technology, more and more computer-aided tools are applied to the solution analysis of complex engineering. Based on CAE simulation analysis method, this paper carries out slope stability checking calculation, structure and surrounding rock pressure analysis of BIM model of shallow buried biased single-lane tunnel, and summarizes a structural design method suitable for this type of tunnel.

Keywords. Shallow buried bias, tunnel, single lane, BIM, CAE simulation analysis.

1. Introduction

This project is Wuxuhai-Shangtuan Township - Mengdi Communication Township road reconstruction project, which is a traffic highway serving Mengdigou hydropower station. The road grade is referred to the single lane standard of Class IV special highway [1-2], and the design speed is 15km/h [3]. The tunnel layout is subject to the external traffic and transportation requirements of the power station hub layout, the

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general construction layout and the overall construction schedule [4-5]. Several tunnels arranged along the route are located in the shallow buried bias section [6-9]. This project selected the most unfavorable section Yangjiaping 1# tunnel entrance section for CAE [10-12] simulation analysis (figure 1).

The entrance section of Yangjiaping 1# tunnel is located on the small-radius curve. According to the relevant technical specifications of hydropower engineering, the tunnel section has been widened [13-15], as shown in the figure 2 below.

Figure 1. Structure diagram of pre-drilling presso.

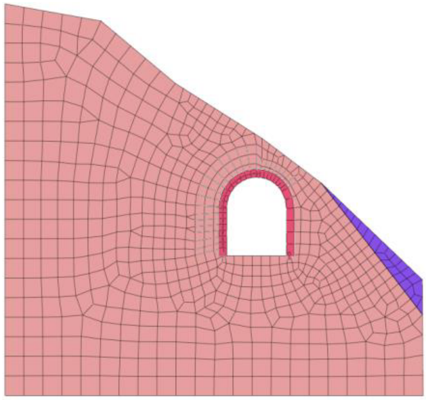

Figure 2. Typical section of shallow buried bias.

The tunnel design dimensions are shown in table 1 below.

Table 1. Tunnel construction boundary parameters.

Tunnel name	Net width (m)	Clear height (m)	Carriageway (m)	Lateral width (m)	Residual width (m)
Yangjiaping 1# Tunnel	5.0	5.0	1×4.0	2×0.25	2×0.25

2. Introduction of Geological Engineering Background

The project area is located in the eastern margin of the Qinghai-Tibet Plateau, and the geomorphological division belongs to the west Sichuan Plateau, close to the southwest Sichuan high mountainous area. The route area is mostly a typical alpine "V" shaped canyon, with steep valley slopes on both sides, the slope is generally 35° ~ 45°, and the local section is up to 60°. The local section at the foot of the slope is cut by the gully, forming a cliff and steep wall, and several gullies are developed on both sides [16].

(1) Formation lithology

1) Covering layer

The overlying layer in the project area is mainly quaternary slope-flood.

Quaternary landslide deposit

The Quaternary landslide deposit is mainly distributed in the gentle slope area and the foot of the slope. The layer thickness is generally 5 ~ 25m, and it is dominated by gravel. The main composition is related to the lithology of the slope at the back edge..

Quaternary alluvial diluvium

The quaternary alluvial and diluvial layers are mainly distributed in the gully bed and floodplain, and the thickness is generally 15 ~ 30m, the longitudinal thickness is stable, the transverse upper gully center is the thickest, and gradually thinned to both sides.

2) Bedrock

In the working area, the intrusive rocks are developed, mostly in the form of batholith and rock strains, and the lithology is mainly granodiorite, light gray to dark gray, with medium fine grained structure. The parameters of tunnel surrounding rock are shown in table 2 below.

Table 2. Suggested parameter table of tunnel surrounding rock.

Level of surrounding rock	γ(kN/m^3)	K(MPa/cm)	E(GPa)	μ	φ(°)	C(MPa)
II	25~27	50~70	10~20	0.22~0.25	48~60	1.3~1.8
III	23~25	30·50	5~10	0.25~0.3	35~48	0.6~1.3
IV	20~23	5~30	1~5	0.3~0.35	27~35	0.2~0.6
V	17~20	1~3	0.5~1	0.35~0.45	20~27	0.05~0.2

3. Analysis of Calculation Results

3.1. Numerical Calculation Results of Tunnel

Figure 3-6 show the displacement and Shape development zone of surrounding rock of shallow buried biased pressure tunnel excavation. Therefore, the control conditions are mainly based on the horizontal action in the vertical direction and the horizontal tensile stress of the slope structure in the inclined direction [17-18].

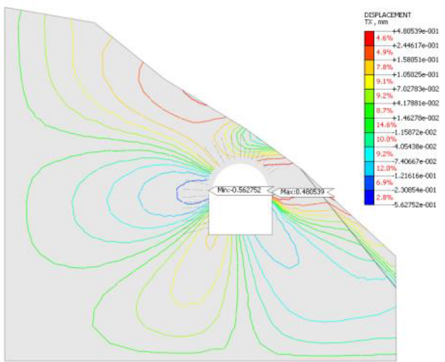

Figure 3. Displacement of X direction-S1 (mm).

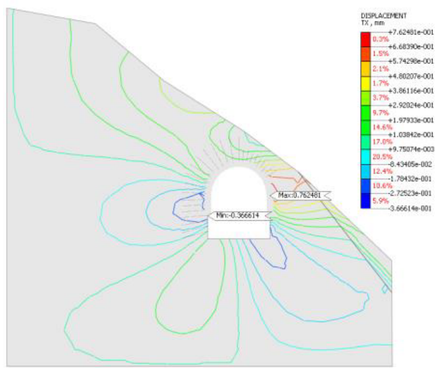

Figure 4. Displacement of X direction-S2 (mm).

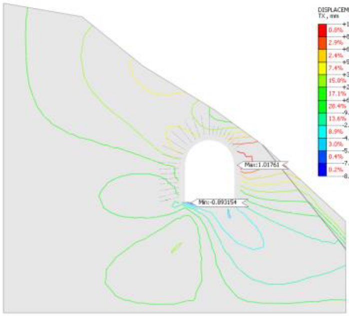

Figure 5. Displacement of X direction-S3 (mm).

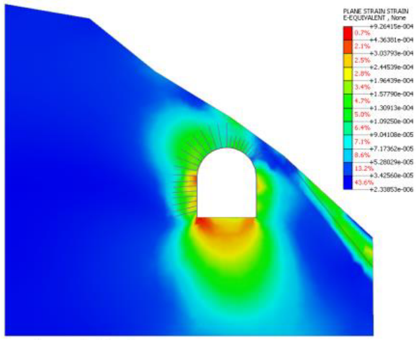

Figure 6. Surrounding rock molding development area.

Figure 7-8 show the internal forces of axial forces and bending moments at different positions after the tunnel surrounding rock lining support construction is completed, figure 9 shows Statistical table of monitoring process data of different parts of tunnel .

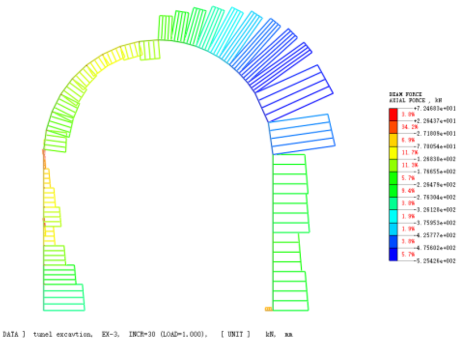

Figure 7. Axial force of Tunnel lining support (kN).

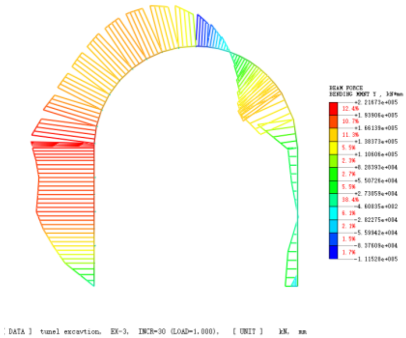

Figure 8. Bending moment of Tunnel lining support (kN).

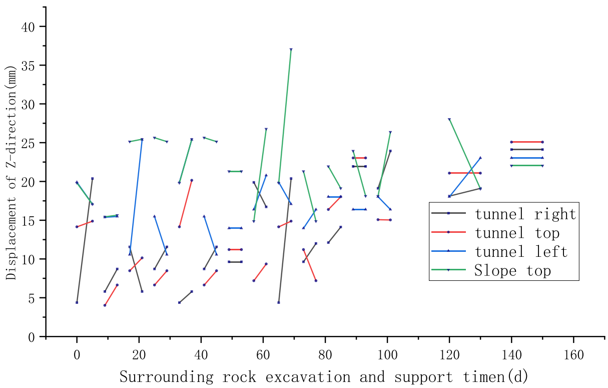

Figure 9. Statistical table of monitoring process data of different parts of tunnel (mm).

4. Conclusion

(1) In order to determine the selection of the calculation method for the surrounding rock pressure of the pressure-dependent tunnel under the condition of variable slope, the formula for calculating the surrounding rock pressure in this paper under the condition of variable slope is derived and compared with the standard formula to verify the rationality of the formula, and it is analyzed that the variable slope section of the tunnel has a small influence on the vertical bias rate of the tunnel and a larger influence on the horizontal bias rate of the tunnel. The horizontal bias ratio of the tunnel increases due to the variable city.

(2) With the increase of natural slope, the horizontal pressure coefficient of the deep buried side is small and the sliding positive force T increases accordingly; With the increase of the cohesion of rock mass, the horizontal pressure coefficient of shallow buried side), the star first increases and then decreases, and the decreasing trend is slow with the increase of natural slope, but the decreasing trend has no obvious change with the increase of the Angle of variable slope section [19]. With the increase of the Angle of the variable slope section, the horizontal pressure coefficient of the shallow buried side will decrease, and with the increase of the natural slope, the influence of the variable slope Angle on the horizontal pressure coefficient will decrease.

(3)The axial force on the side of the biased tunnel near the free side of the slope is too large, and it can be concluded by analysis that the design of the compression reinforcement should be strengthened at the free side [20]. The calculation result of the internal force of the tunnel supporting structure near the inner side of the slope is larger, which is consistent with the theoretical and field analysis results. Therefore, the configuration of the bending reinforcement near the inner side of the slope should be increased in the design process.

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