Analysis on Construction of a Sub-sea Tunnel

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Abstract. Based on numerical simulation, the construction analysis of a sub-sea tunnel is rewarded. Under the condition that the lateral pressure coefficient is equal to 0.5, two common construction methods that are processes of whole section excavation, schemes of benching excavation are analyzed. The result of that method of benching excavation will slightly disturb the surrounding rock compared the displacements of key-points and the distributions of plastic area on the surface of wall rock. Finally, the conclusion is reached that the reasonable bench pace between benching excavation is around 10 meters is proposed by analyzing tunnel stability under different bench lengths. The conclusion can direct the construction of the tunnel better.

Keywords: sub-sea tunnel, lateral pressure coefficient, plastic area.

1 Introduction

In recent years, experts have done much technical research on the construction of sub-sea tunnels. They researched the minimal rock cover of sub-sea tunnels by means of engineering analogy and numerical simulations. Many valuable results Have been acquired [1],[2]. However, study on the sub-sea tunnels is in the initial steps. In view of construction mechanics, this paper researches the effect of minimal rock cover about crucial profile (K28+800) on different excavation methods and construction sequences [3].

2 Geological Conditions

Geological construction in a tunnel zone is simple and the rock mass is intact. There are a few large faults. A few small faults may exist because of construct of fault around this zone. Most bores show a lot of growth crannies in the part of tunnel zone. The seismic data show that crannies or dikes may exist in eleven places on the shore.

3 Numerical Models

In a numerical model, the z-axis is the direction of the tunnel's axes. The direction vertical to the tunnel axes in the plane is the x-axis. The y-axis is

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vertical to the tunnel axes in the profile. The calculation range is between 0 meter and 160 meters on the x-axis. The range is between 0 meters and 10 meters on the y-axis. The range is 50 meters on the z-axis. The distance from the vault of the tunnel cave to the bottom of the numerical model is 80 meters. The horizontal boundaries have been put on both sides of the model. The vertical boundaries are put on the bottom. The top of model is free. The initial stress fields are caused by gravity on the model. Then the construction sequence is simulated. The hydrostatic pressure on the top of the model simulates the effect of seawater. The high level is 4.64 meter up the sea level. Various mechanical parameters of rock mass are shown in Table 1.

Table 1. Mechanical parameters of surrounding rock

Rock & soil	Density (kg/m^3)	Elastic modulus (MPa)	Poisson's ratio	Cohesion (KPa)	Friction angle	Tension strength (KPa)
Silty clay	1720	2.43	0.35	18.5	27	10
Gravel grit	1960	8.8	0.35	15.5	33.3	10
Subclay	1990	7.2	0.35	40.0	23.5	10
Slightly weathering tuff	2500	15000	0.25	1500	40	10
Slightly weathering Sandstone	2680	10000	0.26	8350	48	800
Andesite	2620	6000	0.28	500	35	500
Concrete lining	2500	30000	0.18	2740	55	

4 Result and Analyis Under Different Excavation Methods

The eight key-points on the tunnel wall are picked up. The lateral press coefficient is 0.5 and the excavation methods of whole section as well as benching are chosen. Then the displacement of key-points is computed and compared with each other (Fig.1 & Table 2). The results show the displacement of key-points under benching excavation is smaller than that of the whole section [4], [5].

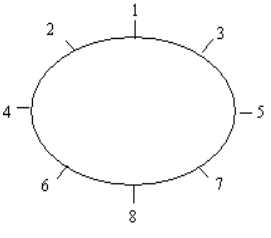

Fig. 1. Key-points on tunnel wall

Table 2. Profile of the displacements of key-points on the surface of wall rock of K28+800

Key-points	Whole section			Upper and down benching		
	x-dis(m)	y-dis(m)	totaldis(m)	x-dis(m)	y-dis(m)	totaldis(m)
1	-5.25E-06	-1.11E-03	1.11E-03	-5.18E-06	-0.92E-03	0.92E-03
2	-2.96E-04	-8.58E-04	9.08E-04	-2.83E-04	-8.46E-04	8.92E-04
3	2.98E-04	-8.56E-04	9.06E-04	2.86E-04	-8.43E-04	8.90E-04
4	-5.72E-04	1.02E-06	5.72E-04	-5.66E-04	1.02E-06	5.66E-04
5	5.74E-04	1.02E-06	5.72E-04	5.69E-04	1.02E-06	5.69E-04
6	-2.97E-04	8.36E-04	8.87E-04	-2.79E-04	8.34E-04	8.79E-04
7	2.94E-04	8.39E-04	8.89E-04	2.82E-04	8.35E-04	8.81E-04
8	-4.98E-06	0.87E-03	0.87E-03	-4.83E-06	0.82E-03	0.82E-03

5 Analysis of Construct Sequence

The step method is used extensively during tunnel construction. But different step lengths may affect tunnel stability in different ways, so it is important to make sure that the step length is reasonable. In view of benching excavation, this paper simulates the excavation effect under different space. Three kinds of step lengths such as 1D, 2D and 3D, are analyzed by numerical simulation [6].

The curvature of different points in the tunnel vault and in the rock cover is rewarded under three different step lengths (Fig.2.).

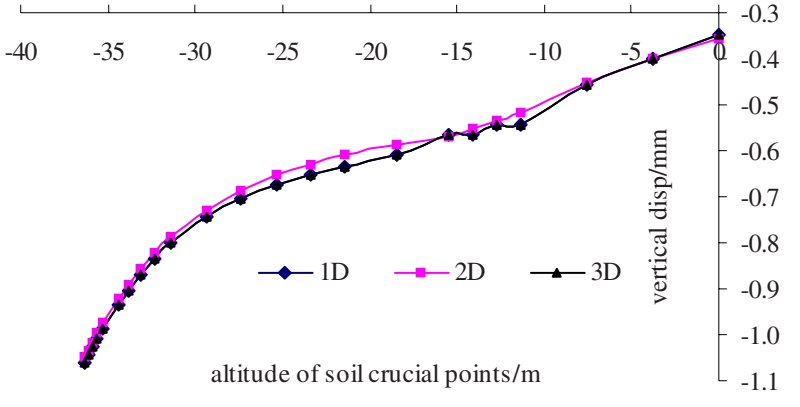

Fig. 2. Displacement compare in tunnel rock cover after excavation

The displacement contrast curve of crucial points in rock cover shows that the different construction sequences affect the final displacement of rock cover. The displacement compare curve of crucial points on tunnel vault shows that the vertical displacement is greatest and the horizontal displacement is small. The displacement movement stabilizes when the distance between frontal step and back step is about 10 meters. So the distance between two steps over about 10 meters is reasonable when using benching excavation.

6 Discussions

According to analysis, engineering experience and excavation methods, the upper and down benching excavation method may decrease the effect of disturbances and protect the stability of rock mass. Meanwhile it can reduce the cost of tunnel excavation.

The different construction sequences slightly affects the final displacement of rock mass. It produces the large displacement near the tunnel face. It affects to choose the reasonable support sequence during construction. The distance between two steps over about 10 meters is reasonable when using upper and down benching excavation. The stable zone of the vault displacement along the z-axis direction is about 10 meters.

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