

Application Research of Cantilever Tunneling Machine in Subway Tunnel Excavation Construction

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Abstract

Taking Yan'an Road Station to Yangmingci Station of Guiyang Rail Transit Line 2 as the object of study, this paper introduces the application of cantilever tunneling machine in subway tunnel from the selection background and reasons, construction technology and construction characteristics. The research shows that cantilever tunneling machine can speed up the construction progress, reduce the disturbance of surrounding rock, reduce the safety risk and improve the excavation quality, which is incomparable with the traditional drilling and blasting method.

Keywords

Subway tunnel; cantilever tunneling machine; excavation; construction technology.

1. Introduction

In the construction of urban underground railway tunnels, the traditional blasting construction method has gradually been replaced by cantilever tunneling construction. The cantilever type roadheader[1] carries out the dark excavation of the subway tunnel and has less disturbance to the urban environment, flexible construction and better control of construction quality. At present, China's southwestern regions such as Guiyang, Kunming, Chengdu, etc. are carrying out urban rail transit construction, and it is necessary to take into account the outstanding advantages and characteristics of cantilever tunneling machines in urban subway tunnels.

Drawing on the experience of other tunnel construction, the tunnel of Guiyang Metro Line 1 was first used for tunnel excavation with cantilever roadheader[2], The tunnel construction practice shows that the cantilever tunneling machine construction meets the construction requirements. Li Jianying, Lei Shengxiang, Zhang Yuqi et al[3-6]. discussed the feasibility of the application of cantilever tunneling machine, and considered it to be the best non-blasting excavation construction method.

2. Project Overview

Guiyang Rail Transit Line 2 Phase I Civil Engineering Yan'an Road Station ~ Yangmingci Station Section Excavation Tunnel, Starting mileage is YDK 33+187.247 ~ YDK 34+371.496; ZDK 33+187.247 ~ ZDK 34+368.398 (ZDK 33+681.318=ZDK 33+660.000, long chain 21.318m) total 1184.249m.

2.1. Engineering Geological Conditions

The Quaternary artificial fill and red clay are covered in the interval, and the underlying bedrock is the Triassic Lower Anshun Group dolomite, argillaceous dolomite and mudstone, The limestone and mudstone of the Triassic Daye Formation, the Zhaobishan fault, the Liushenguan fault, the Yangmingyu 1 fault, and the Yangmingyu 2 fault are developed in the

interval. The cave is mainly located in the middle weathered dolomite and the middle weathered limestone.

3. Construction Plan Selection

3.1. Reasons for Using Cantilever Type Roadheader Construction

The direction of the Great Mile Yangming Station: the two-storey building adjacent to the Technology and Industrial Development Center and the 6-story building of the Jiudong Jiu Hua Courtyard are all old buildings in the 1980s. At the same time, there are many residential buildings around the tunnel, underground tunnels, underground. The pipe network is dense and the engineering environment is complex. The blasting construction will cause disturbance to the old buildings, and the blasting noise will affect the living of the surrounding residents. Small Mileage Yan'an Road Station Direction: The tunnel passes through the underground passage of the fountain, the North Gate Bridge, and the municipal drainage ditch. This section is the lowest point of the elevation in Guiyang City, and the water-rich area is turbulently excavated with high disturbance and high safety risk.

3.2. Model Selection

The section of the tunnel is mainly composed of moderately dolomite, argillaceous dolomite and limestone. The one-way compressive strength of the rock mass is 40-70 MPa, and the section is semi-circular arch type with a width of 6.52 m and a height of 7.02 m. The EBZ200H cantilever type boring machine is used in the direction of the Great Mile Yangming Station. It is 11.4m long, 2.6m wide and 2.22m high. The power supply voltage is 1140V, the rated output power is 387KW, the climbing ability is $\pm 18^\circ$, the total weight is 73t, and the rock one-way compressive strength: ≤ 80 MPa. The small mile Yan'an Road Station adopts the EBZ260H cantilever type roadheader with a length of 11.88m, a width of 3.6m and a height of 2.22m. The power supply voltage is 1140V, the rated output power is 447KW, the climbing ability is $\pm 18^\circ$, the total weight is 88t, and the rock is unidirectionally resistant. Compressive strength: ≤ 90 MPa. Both models are selected to meet engineering requirements.

4. Cantilever Tunneling Machine Construction Technology

4.1. Ready to Work

1 excavation frame has 1 output voltage of 1140V special transformer (1140V high voltage input for cantilever roadheader); box type substation with high voltage capacity of 630kVA and cable with corresponding length from the box to the working position of roadheader Supporting excavators and slag transport vehicles. The geological advance prediction technology adopts geological prediction methods such as acoustic wave detection method and advanced horizontal drilling.

4.2. Tunneling Construction Personnel and Mechanical Configuration

The cantilever roadhead excavator is equipped with 4 workers in each shift, and 2 shifts are arranged on site; the cantilever roadheader line is dedicated line and control cabinet, and the line needs to extend from the tunnel to the excavation plane. The specific resource configuration is shown in the table. 1.

Table 1. Resource Configuration Table

Numbering	number	number	Person, device name	Quantity	Specification model	Remarks
	1		Cantilever roadheader	2 sets	EBZ200H, EBZ260H	
	2		Operator	4 people	/	2 shifts
	3		transformer	2 sets	630KVA,1140V	
	4		Mine shielded cable	500m	myp3*95 ² +1*25 ² ,0.66/1.14kv	
	5		Vacuum feed switch	2 sets	kbz630/1140	
	8		Dump Truck	8 sets	4m ³	

4.3. Cantilever Roadheader Excavation Process

The excavation section of the cantilever roadheader is the IV and V-class surrounding rock, the arch spacing is 0.5, 0.8m, the single-cycle excavation footage is 1~1.6m, and the excavation section is 25.3m². The cantilever roadheader is divided into upper and lower steps for excavation. The excavation height of the upper cantilever roadheader is 4.5m, and the lower platform and the inverting arch are cold-opened.

- (1) Excavator excavation steps;
- (2) Applying the initial support around the upper step: firstly spraying concrete, laying radial anchors, laying steel mesh, standing arch steel frame and setting lock anchors/tubes, re-spraying concrete to design thickness;
- (3) Applying the next cycle of advance support;
- (4) The roadheader excavates the lower steps and the attack;
- (5) The initial support for the lower step: that is, the first shot concrete, the radial anchor bolt is laid, the steel mesh is laid, the long steel frame is connected and the lock anchor is set, and the concrete is sprayed to the design thickness;
- (6) Application of the initial support of the tunnel bottom: that is, the first shot concrete, the standing steel frame, the steel mesh re-sprayed concrete to the design thickness (suitable for the case where the tunnel bottom has sneeze and steel frame).

5. Cantilever Type Roadheader Construction Features

5.1. Comparison between Traditional Blasting Excavation and Cantilever Roadheader

(1) On the economic aspect, according to the current actual situation of our project, the unit price of blasting excavation and cantilever roadhead excavation cost is calculated and compared, and the cycle footage is set to 1.0 m and the IV level is 1.6 m. (The blasting time is controlled), the unit price of the blasting excavation is about 170 yuan/square, and the unit price of the excavation of the cantilever road boring machine is about 395 yuan/square, which is 225 yuan more than the blasting excavation.

(2) The advantages of the cantilever roadhead in terms of ergonomics are as follows: Small disturbance to surrounding rock and buildings, Easy to control over-excavation, small excavation, unlimited working hours, no need to slag process time, the slag can be discharged while excavating, low security risk and low noise.

5.2. Insufficient Cantilever Roadheader

(1) The cantilever type roadheader has a slow moving speed, the average walking speed is 0~0.65m/min, and the waiting time for the working surface conversion is too long.

(2) The turning radius of the cantilever type roadheader is too large, and the structural size of the logistics channel is high. The construction consideration in the early stage is insufficient. The subsequent expansion and adjustment of the construction logistics channel will cause certain losses.

(3) The teeth are expensive. The ordinary limestone excavation 10m replaces 10~20 teeth, and the dolomite excavates 10m to replace 50~100 teeth.

6. Conclusion

Through the research on the cantilever tunneling machine in the underground tunnel construction, the following conclusions are drawn:

(1) Using EBZ200H and EBZ260H cantilever type roadheader to carry out excavation tunneling construction in Yan'an Road Station-Yangmingyu Station section, the construction progress can be accelerated, the planned construction period goal can be achieved, and the safety and stability of surface buildings can be ensured.

(2) Compared with blasting excavation, cantilever type roadheader has relatively low economic efficiency, but the construction efficiency is very good, the construction quality is better, the construction period is shorter, and the impact on the surrounding environment is weaker.

(3) The experience and summary of the use of the arm-type roadheader in the project has important guiding significance for the future application of the cantilever roadheader in engineering tunnels.

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