Study on Mining Method for Urban Subway Tunnel

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Abstract

With the rapid growth of the national economy, people's demand for traffic is getting higher. Metro projects are generally concentrated in urban areas with complex surrounding environment and high risk of construction. In this paper, taking a subway tunnel with complex formation and karst cave development as the background, the mine construction method is put forward. The construction of ingate, mechanical excavation of soil layer, earth rock connection and rock section blasting excavation are described in detail. The exploration and treatment measures of karst cave are introduced. Through a series of effective measures to ensure the safety of tunneling and construction quality of the tunnel.

Keywords

Subway tunnel,Mine method,Karst cave,Blasting.

1. Introduction

With the rapid growth of the national economy and the increase of the per capita consumption level, the demand for traffic is getting higher and higher, and the urban subway project is increasing in this atmosphere. However, the subway construction is characterized by concealment, complex engineering geological conditions and generally located in the downtown area. Therefore, reasonable construction methods are not only convenient for management, but also ensure the construction cost, quality, safety and progress.

Metro Tunnels in cities are usually constructed by shield or mining method. But the shield method is generally applicable to the soft stratum tunnel with depth less than 6m depth and not less than the diameter of the shield machine and relatively uniform geology. It has caused the limitation of the shield method, and the mine method is widely applicable and flexible, especially for the tunnel with more complex strata.

In this paper, the construction technology of mining method is introduced in detail in the context of a subway tunnel with complex formation and karst cave development.

2. Engineering Geology and Hydrology

2.1 Engineering Geology

According to the different excavation methods, the strata are divided into three situations. The first situation is the soil layer, and the tunnel layer is the clay layer.The second situation is the earth rock junction. The upper part of the tunnel is mainly clay layer and residual soil, and the lower part is middle weathered marl.The third situation type is rock section. The tunnel layer is mainly composed of middle weathered marl, gray limestone, medium weathered limestone and medium weathered sandstone.

2.2 General Survey of Interval Faults

There are three faults in the project, namely F1 faults, F2 faults and F3 faults.

The F1 fault strike the north east, the fault width is about 55 meters, the geology is mainly breccia, the rock is hard, brittle, and the intensity is higher.

The F2 fault strike the north west, the width of the fault is about 15 meters, the material in the belt is mainly fractured rock, the rock mass is broken, the limestone area has a strong melting erosion, and many karst caves are found.

The F3 fault nature is assumed to be interlayer dislocation, fault width 7~13 m, the main material in the belt is breccia, the breccia diameter is generally 0.5~10cm.

2.3 Survey of the Distribution of Interval Karst Caves

157 karst caves are exposed in the project, most of the cave height are between 0.1~1.5m and 66.1% of the total. In the lower Permian Qixia formation limestone cave, the cave height is mainly 0.1~1.5m, the number of the above caves is 13, and the height of the cave in the Triassic Daye group limestone is most 0.5~1.0m, accounting for 33.3% of the total number of cave.

2.4 Hydrogeology

The soil layer of this project is micro permeable (or impermeable) stratum, and the groundwater content is less. There are karst caves fissure water and pressure water in the boundary section and rock section of the earth and rock. The groundwater is influenced by the water level of the Hanjiang River, and the annual variation is 3~5m. The closer the riverbed area is, the greater the annual variation of groundwater will be.

3. Construction Technology of Mine Tunnel

3.1 General Idea of Construction

The length of the mining section of the tunnel is about 1447m, and the total length of the left and right lines is 2894m. 2 construction wells and intermediate air wells are used respectively as the material transport port. The construction of the tunnel is completed after completion of shaft and intermediate shaft.

3.2 Construction of Ingate

Before the construction of the ingate, the grille steel frame around the contour line will be reinforced two times. Two rows of small diameter 42mm pipes are set at 150 degrees along the arch section of the excavation contour. and grouting reinforcement was carried out. The longitudinal distance between the small pipe rings was 0.3m×1.0m, and the length was 2.5m.

The construction of the main hole of the ingate is divided into the upper and the lower steps to reserve the core soil. After 5 meters of the upper stage, the step construction began, and in the construction of the lower step, two blocks are excavated in the left and right sides, and the distance between them is 50cm to avoid excavation at the same time, resulting in the upper part of the whole suspension. 3 steel arch frames combined with the grid steel frame of the ingate, the first steel arch of the main line tunnel and the main bar of the vertical grille steel frame are welded together, and the front small tube and the lock angle bolt are welded firmly with the main bar of the grid steel frame.

3.3 Soil Layer Construction

The excavation of the soil section is divided into the upper and the lower steps to carry out construction, the height of the upper step is 3 meters. The distance between the upper and lower steps is 3~5m, and the PC60 excavator is used to excavate, and each cycle is 0.5m.

3.4 Earth Rock Connection and Rock Section Excavation Method

Earth and rock intersection and rock segment is divided into the upper and lower step excavation. Grouting reinforcement with advanced small ducts and blasting method was adopted.The blasting cycle is 1.5m (the distance between the two pieces of the arch). Different blasting methods are designed according to the scope of rock intrusion. If the upper steps are all stone, the blasting is used in the way of cutting. In the upper stage, the hole is laid out. If the upper steps are mixed with soil and stone, it does not need to lay out the hole and use the broken blasting method directly.

3.4.1 Full Blasting Construction Method

The blasting holes for tunnel blasting are: cut hole, two circle hole, peripheral hole, bottom hole and row hole. The hole arrangement is arranged in the left and right symmetry. The cutting hole is set up on the upper step. There are 2 rows in each side. The distance between the inner circle hole and the surrounding hole is 600mm. The width of the tunnel excavation is about 6.3m and the height is 6.648m. Fig. 1 is the layout of the hole, Fig.2 is the layout of the slot hole, Table 1 is the blasting parameter.

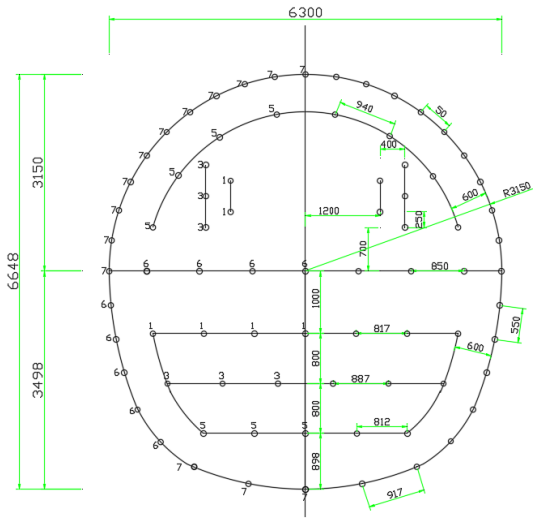

Fig.1 the layout of the hole

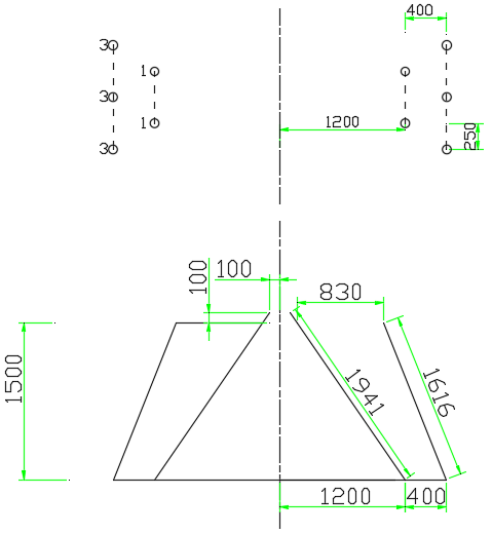

Fig.2 the layout of the slot hole

Table 1.the blasting parameter

Position	Serial number	Eye name	Paragraph number	Eye depth (m)	Eye number	Type of explosive (kg/one)	Single pore volume (kg)	Single section charge (kg)	Length of charge (m)	Charge structure
Up the steps	1	Slotting hole	1	1.94	4	0.18	1.26	5.04	1.40	focus
	2	Slotting hole	3	1.62	6	0.18	1.08	6.48	1.20	focus
	3	Two ring hole	5	1.5	8	0.18	0.72	5.76	0.80	interval
	4	Peripheral hole	7	1.5	21	0.18	0.54	11.34	0.60	interval
	5	Bottom hole	6	1.6	7	0.18	0.90	6.30	1.00	focus
Lower steps	6	First row of holes	1	1.5	7	0.18	0.72	5.04	0.80	interval
	7	Second row of holes	3	1.5	6	0.18	0.72	4.32	0.80	interval
	8	Third row of holes	5	1.5	5	0.18	0.72	3.60	0.80	interval
	9	Peripheral hole	6	1.5	10	0.12	0.36	3.60	0.60	interval
	10	Bottom hole	7	1.5	5	0.18	0.90	4.50	1.00	focus

3.4.2 Local Blasting Construction Method

Local blasting only sets peripheral hole and row hole. The arrangement of the row holes is the same as that of the lower steps. The peripheral holes are arranged according to the distance between peripheral holes and the depth of holes in the step method. As shown in Fig.3, the blasting parameters are shown in Table 1.

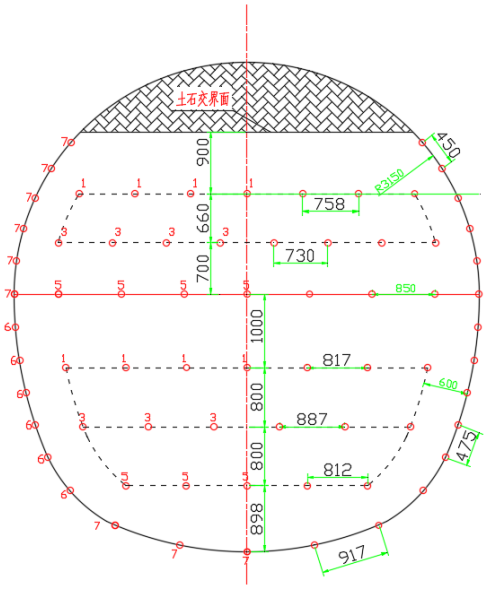

Fig.3 design drawing of local blasting at the boundary of soil and rock

3.5 Tunnel Ballast and Transportation

The ballast in the tunnel is loaded by the excavator, the truck is transported by the dump truck, the ballast is transported in the construction shaft and the middle air shaft, the transportation ballast is lifted from the lifting equipment to the ground, and the ballast truck is transported to the ballast yard. The shaft is equipped with a grab lifting equipment, and the middle shaft is equipped with two lifting equipments.

3.6 Initial Support of Tunnel

The initial support adopts grid steel frame and C25 early strength concrete is poured. The main bar of the grid steel frame is 4 steel bars with diameter 22mm. The ring direction hoop is 8mm diameter steel, the distance is 300mm, the middle reinforcement adopts the steel bar with diameter 14mm, and the spacing of the grid steel frame is 0.5m or 0.75m. The longitudinal connection bar is connected by double diameter 22mm steel bar, and the circumferential spacing is 1m. 4 foot diameter anchor locks with diameter of 4mm are installed at the arch foot of the upper step. The length is 3m, each set. The mesh adopts steel bar with diameter of 8mm, and the spacing is 150mm×150mm grid form.

3.7 Secondary Linings of Tunnel

The use of C35 waterproof concrete for the secondary lining, the inverted arch and the tunnel bottom filling construction after the tunnel excavation support completion, subsection and full amplitude construction in time by trestle bridge way. The secondary lining of the arch wall is constructed after the deformation of the surrounding rock is basically stable, and the construction is started by the construction shaft, the 10.5m long cross section hydraulic trolley is adopted.

3.8 Initial Support and Secondary Lining Backfill Grouting

After the initial support is closed, the backfill grouting is carried out behind the 2 rings at intervals, so as to reduce the settlement deformation of the initial support and ensure the stability of the initial support as soon as possible.

In the process of secondary lining construction, backfill grouting pipe should be reserved. The grouting pipe is arranged to encrypt the seepage point of the initial support of the tunnel. When the strength of the secondary lining concrete is reached to 80% of the design strength, the filling grouting should be carried out. After the grouting is completed, the small ducts exposed on the surface of the structure should be removed and the quick dry cement is used to the grouting. The pipe is blocked.

3.9 Treatment Scheme for Interval Karst Cave

3.9.1 Karst Cave Exploration

In the karst cave development section, the 5m long forward exploration hole is set up, and the exploration hole is connected with 2m, and the number of each circulating probe is less than 5. the detection and early warning of the karst cave situation in front of the work face,and strengthen the supplementary detection when finding the abnormal situation.

3.9.2 Karst Cave Treatment Measures

The cavern above the arch waist and above, using a small catheter with a diameter of 42mm to carry out the advance grouting support, the initial support is buried by the pump, and the C15 concrete backfill is used. According to the size of the cave, 1.2 x 1.2m spacing anchor is applied to the surrounding rock, the rock bolt is not less than 1.0m, the side wall is dissolved in the cave, and the C15 concrete backfill is used within the 1.5 meter range. 1.5 meters beyond 1.5 meters throwing stone backfilling; inverted arch cave at the bottom of the tunnel, at the bottom of the tunnel to do a high expansion foundation, based on grouting backfilling; excavated outside the surface of the cave, 6m do not handle, 6m within the grouting backfilling; the full section of the tunnel through the karst cave development zone, the vault with the diameter of the 42mm small catheter in advance grouting support, the side wall to do 1.2m×1.2m spacing anchor, invert construction 1m high expansion foundation, 10m grouting in the scope of the foundation.

4. Conclusion

The subway tunnel is located in the urban concentrated area, the surrounding environment is complex, and the construction risk is high. In this paper, the construction of a subway tunnel with complex formation and karst cave development is described in detail in the construction of the construction of the ingate, the mechanical excavation of the soil layer and the intersection of soil and rock in the rock section, and the exploration and treatment measures of the karst cave are introduced. Through a series of effective construction measures of mining method, the safety driving and construction quality of the subway tunnel are guaranteed.

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