The Construction Technology of Subway Large Section Subway Station Construction Channel Picking Top Into the Main Hole Construction Technology

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Abstract: Concealed excavation station as a commonly used way of subway station construction, mainly used in the complex surface environment does not have the conditions of open excavation in urban areas, through the auxiliary channel into the station body for construction. Due to the large cross-section of the subway station, the general auxiliary channel into the station needs to be picked up to find the top of the channel construction, the traditional top of the channel will generally be higher than the station body tunnel, the need to use concrete backfill the gap between the two, the construction cycle is long, over-excavation and backfill volume. In view of the above problems, this paper innovatively puts forward a new construction method of construction channel picking top into the main tunnel, and uses finite element software to simulate the rationality and feasibility of this method. This method adopts two-layer primary arch, i.e. gantry + station main arch arch support, which makes full use of the primary structure of the picket channel, reduces the arch change construction, reduces the amount of over-excavation and backfilling, and effectively ensures the construction period.

Keywords: Large Cross-Section; Excavated Station; Construction Access; Numerical Simulation; Arch Replacement Construction

1. Introduction

In today's booming urban rail transit era, the construction of subway stations are faced with many complex geological conditions and construction environment challenges. Concealed excavation of large cross-section subway station construction is one of the most difficult projects, and its construction access to pick the top into the hole construction technology is particularly critical.

With the deepening of the development and utilization of urban underground space, subway stations [1] often need to cross a variety of complex strata, such as soft soil, sand, rock and water-rich strata. The traditional open cut method is restricted in some specific environments, while the concealed excavation method is widely used for its small impact on the surrounding environment and strong adaptability. As an important link in the construction of concealed excavation large section subway station, the construction channel picking top into the main hole is directly related to the construction safety, progress and quality of the whole project. Through reasonable program design, accurate measurement and positioning, scientific support system construction and strict control of construction technology, this construction technology aims to effectively solve a series of difficult problems such as rock stability control [2], construction space conversion and structural connection in the process of roof picking. Its successful application not only ensures the smooth progress of concealed excavation construction in subway stations, but also provides valuable practical experience and technical reference for similar projects, and helps the urban subway construction cause to develop efficiently and safely under the complex geological and environmental conditions [3], which is of great significance to the engineering practice and the industry promotion value.

2. Project Overview

Rail transit line 18 north extension project civil construction 1 standard Qixinggang station is located in loquat mountain street below, for the underground two-storey concealed excavation station, the total length of 223m, width of 25.9m, the excavation height of 22.27m, excavation area of 492.5m³. The depth of the station is deep, the thickness of the cover layer of the tunnel vault is about 54.4m ～ 83.3m, of which the thickness of the overburden rock is about 52.4m ～ 80.3m, the surrounding rock is sandstone and mudstone interlayer, and mudstone is the main one, and the comprehensive enclosing rock grade IV.

3. Construction Technology

3.1 Construction Process Flow

Construction channel and station body tunnel interface force complex, construction channel to station body construction using the pick top method construction, the first station body cross channel construction, in the cross channel to the station on both sides according to expanding the foot of the arch step method for the station on the top of the step arch section construction.Station main cross passage portal steel frame section excavation width 8.6m, height 9.315 ~ 12.378m, length 26.8m, perimeter rock grade IV, using step method construction, the lower step in the construction of the passageway door joint three bays of the arch according to the height of the 2m left to set up the lower step, and then to 15 °up to the height of the lower step of 4m, turn straight line 9.5m and then to 15 °down to the entrance and exit of the No. 7, construction The 2m step at the entrance of the passageway is sloped in reverse to backfill the soil for the equipment to go up and down.The height of the upper step is adjusted with the arch top of the pick-up section, and the cyclic feed is not more than 3m, and the support at the top of the cross-channel adopts double-layer initial support arch section, i.e., gantry + station main arch arch support, the gantry support is carried out first, and then the station main arch steel support is carried out in four segments, and the lengths of the main steel frame segments are 7m, 4.7m, 7.18m and 7m respectively, and the main steel frame and the gantry cross beams are broken after breaking the concrete of the gantry welding, and then carry out the initial support. After the completion of the upper step, the construction of the lower step will be carried out. The portal steel frame and the steel frame of the main arch of the station were installed by utilizing the existing working platform at Entrance No. 6.

The process flow of the shield slurry treatment system is shown in Figure 1.

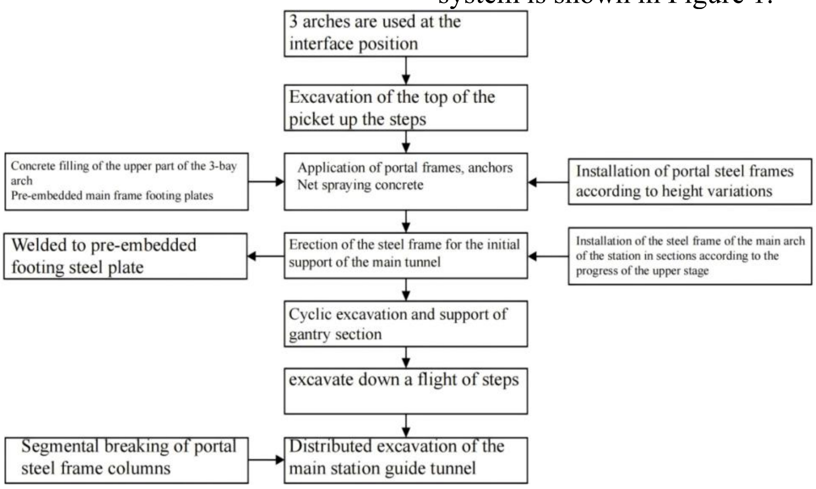

Figure 1. Flow Chart of Non-Blasted Full-Section Tunnel Construction Process Under Hard Rock Conditions

3.2 Construction Method

Concealed excavation of large section subway station roof channel roof channel double-layer initial support method first station main tunnel roof channel construction, and then from the roof channel to the station on both sides according to the station excavation method for construction [4]. The station main roof channel portal steel frame section excavation width of 8.6m, using the step method of construction, the next step in the auxiliary access door joint three-bay arch according to the height of 2m to stay set up the next step, and then 15° up to a certain height (according to the height of the equipment to open the height and pick the top of the section of the elevation of the determination), turn straight line for the construction of the roof channel (the length of the station main body according to the width of the determination), and then to 15° down to the roof channel. The other end, auxiliary access door 2m step reverse slope backfill slag, for non-blasting equipment up and down the channel. The height of the upper step is adjusted with the picking of the high section of the arch, and the cyclic feed is not more than 3m, the top support of the picking of the top channel adopts a two-layer initial support arch, that is, gantry + station main arch arch support, the first gantry support, the picking of the top channel is completed, break the gantry inside the concrete, and then divided into four segments of the station main arch support, the main steel frame and portal steel frame beam welded, and then the initial support. The upper step is completed and then the lower step is constructed. The specific support parameters are shown in Table 1. A schematic of the construction access road is shown in Figure 2.

Table 1. Supporting Parameter Table of Construction Channel And Main Hole [2]

Supporting structure		Correct hole	Construction access
Initial support	System Anchor	Φ25 hollow grouting anchor L=4.5m, spacing 1×0.75m	Φ25 hollow grouting anchor L=4.5m, spacing 1×0.75m
	Steel framework	Grille steel frame H280×240, spacing 0.75m	Grille steel frame H280×240, spacing 0.75m
	shotcrete	C25, 350mm	C25, 320mm
	reinforcing mesh	Φ8 steel mesh @200×200mm	Φ8 steel mesh @200×200mm
secondary lining		C40, P12	C40, P12

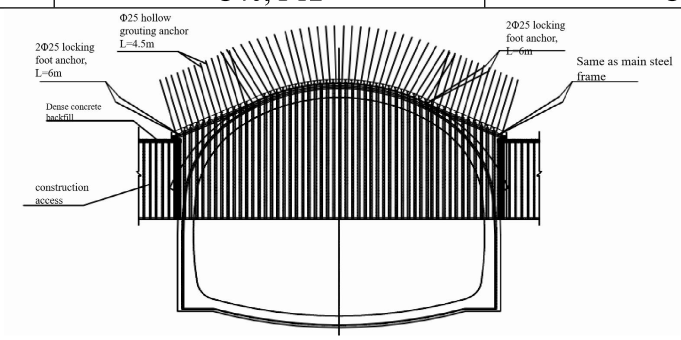

Figure 2. Schematic Diagram of the Construction of the Raised Roof Access

Step 1: the auxiliary channel to the interface position with the gantry section to start picking the top construction, excavation using modified 485 short-arm crushing hammer, excavation completed in the picking the top of the gantry section at the beginning of the position of the dense row of 3 bays of steel frame, 3 bays of steel frame welded to the upper part of the steel frame, behind the gap using concrete to fill the dense and buried the main body of the steel frame to fall down to the diagonal steel plate, the application of gantry section and the initial support (including the main body of the initial support anchors.The drawing of the steel frame of the door and the connection of the main steel frame with the steel plate are shown in Figures 3 and 4.

Step 2: Continue to construct the upper step portal frame section, set up portal steel frame according to the height change, and apply the first layer of initial support in time. Pick the top channel hole portal steel frame spacing 0.75m, the top of the excavation contour line from the top of the auxiliary channel to 15 ° inclination pick high to the design of the station main arch part, and then in accordance with the station main arch part of the excavation of the outer contour line of the outer expansion of 320mm set, excavation according to the step method of section excavation within the station section of the rectangular channel, the construction process needs to be according to the height of changes in the erection of portal steel frame, portal steel frame assembly according to the construction situation to choose the overall installation or step-by-step installation, the overall installation of the portal frame pre-assembled good, and in time to do the first layer of initial support. According to the construction situation, choose to install the portal steel frame as a whole or install it step by step, install the portal steel frame as a whole, assemble the portal steel frame in advance, then fix the portal steel frame in a specific position, and connect the portal steel frame with rebar; install the portal steel frame step by step, firstly fix the columns, and then install the upper components in turn, after assembling, the rebar connects the neighboring portals, the Φ22 rebar connects two I-beams on the top of the arch, and the spacing of the ring direction is 1m, and the I-beam is welded to the connecting steel plate, and M20 bolts are used to connect the steel plate with the other I-beam. The I-beam is welded on the connecting steel plate, and the connecting steel plate is connected with M20 bolts.

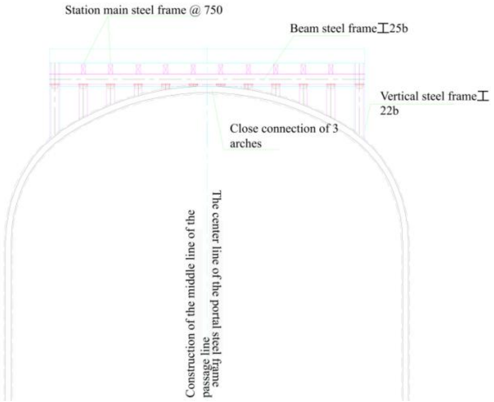

Figure 3. Section Drawing of Steel Frame Connection of Cave Door

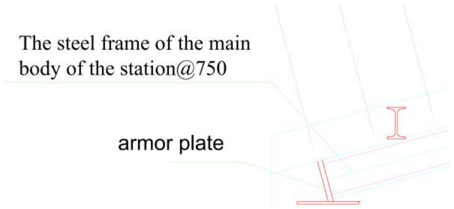

Figure 4. Main Steel Frame and Steel Plate Connection Diagram

Step 3: pick the top channel portal steel frame installation is completed to carry out the main body using the same anchor spray parameters with the main tunnel support. Portal steel frame inside and station main initial support outer contour contains within, and apply to do the main tunnel initial support hollow grouting anchor.

Step 4: After the overall construction of the picket top channel is completed, SY155 crushing hammer breaks the sprayed concrete on the inside of the portal steel frame.

Step 5: The construction of the main body of the main tunnel preliminary support arch, the main body of the tunnel preliminary support arch arch supported on a dense row of 3 bays of steel frame and through the foot of the steel plate [5] and the supporting portal steel frame welded firmly, at the same time in the main tunnel at the end of the steel frame applied to the two locking anchor pipe Φ25mm mortar anchors 6m long, to ensure the stability of the steel frame, hanging the steel frame mesh.

Step 6: Shotcrete the main body initial support concrete [6], using wet spraying robot spraying operation.

Step 7: After the monitoring data are stabilized, according to the excavation sequence of the main tunnel of the station, the portal steel frame columns will be cut out, the steel frame of the arch of the upper section of the station will be applied and shotcrete will be sprayed, and the steel frame of the station will be firmly connected with the steel frame of the portal opening. When the main construction of the transfer station is underway, the distance between the first digging guide hole and the palm surface of the later digging guide hole is staggered by not less than 5m, and the main body of the roof channel on both sides of the opposite side to the guide hole shall not be excavated at the same time.

4. Inite-element Numerical Simulation

In terms of engineering geology and support parameters, there is no difference between the construction channel and the connection between the left side and the right side of the station, so the finite element model only takes half of the engineering volume instead of the whole, analyzes the stress distribution and deformation of the surrounding rock and support structure of the intersection section, and then verifies the reasonableness of the construction method. MIDAS/GTS finite element software is used to establish a three-dimensional numerical calculation model, and 3D solid cells are selected for the soil body, and 2D plate cells are used for the picket top and tunnel lining. The number of solid cells is 70751 and the total number of nodes is 41946 using standard mesher [7], as shown in Figure 5

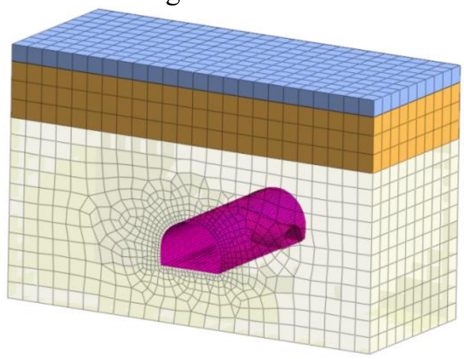

Figure 5. Slant well pick top model

4.1 The Surrounding Rock Stress

The stresses in the cross construction section of the inclined shaft and the tunnel are mainly manifested in the arch top and the bottom plate. Above the vault, the average value of stress is about 0.2 MPa, and the construction stress release is mainly concentrated in the vault. The degree of stability of this part of the rock layer depends on the means of support adopted during the construction of the tunnel. The average value of stress in the bottom plate is around 0.01MPa, but the release range is relatively small compared to the vault. Numerical simulation results show that, in order to ensure the construction safety, the arch should be supported during the construction process, and the arch stress should be released.The stress distribution in the surrounding rock is shown in Figure 6.

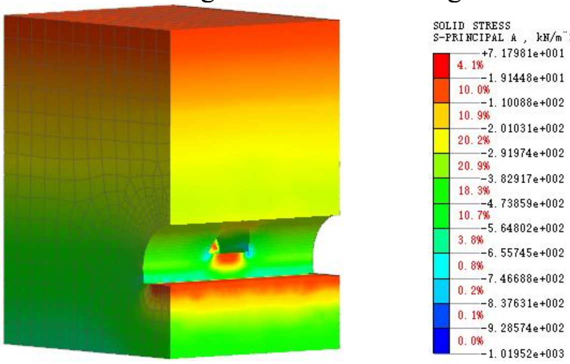

Figure 6. Enclosed Rock Stress Map

4.2 Deformation of Surrounding Rocks

As can be seen from the figure, the maximum displacement of the peripheral rock arch top is 2.45mm. the maximum displacement of the floor plate is 2.64mm. the maximum displacement of the arch top of the picket top tunnel is 2.47mm, and the displacement of the floor plate is 0.82mm. with the excavation of the inclined shaft to the picket top section, the peripheral rock of the tunnel at the picket top is increased by the perturbation in the course of the construction, and the change of the vertical displacement at the distance from the picket top is increased. At the location away from the top of the pick, the surrounding rock is still in a stable state. During construction, anchor rods, small conduits and other engineering measures should be used to reduce the settlement of the vault at the top of the pick.The displacement of the surrounding rock is shown in Figure 7.

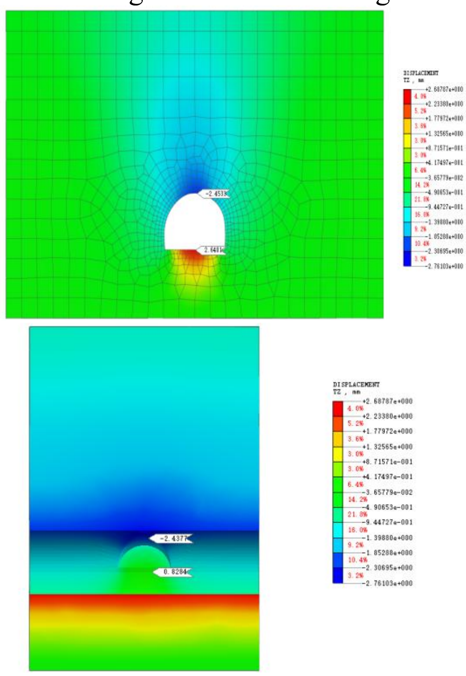

Figure 7. Enclosed Rock Displacement Cloud Map

4.3 Structural Stresses in the Lining

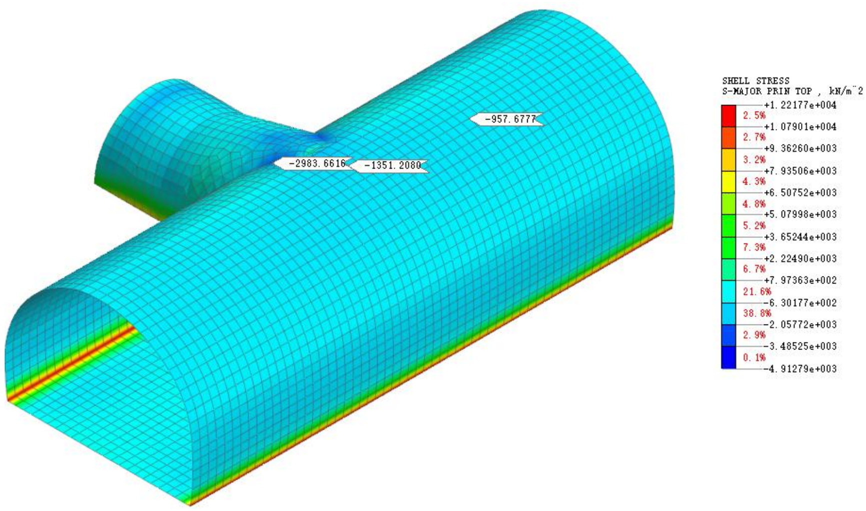

Figure 8. Cloud Drawing of Lining Roof Stress

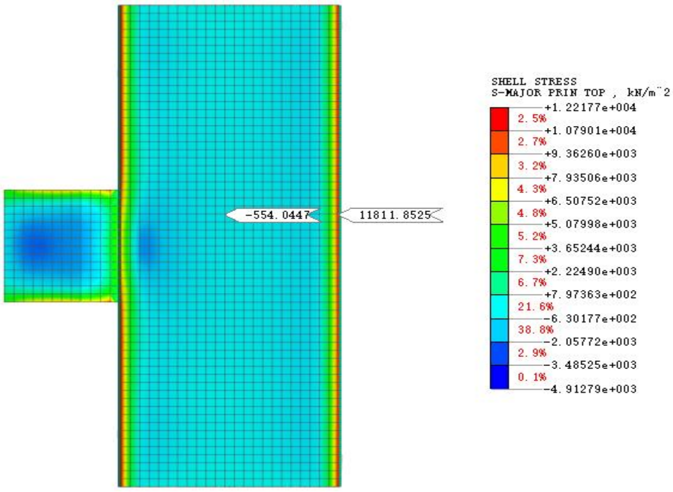

Figure 9. Cloud Map of Lining Bottom Plate Stress

From the figure, it can be seen that there is a stress concentration at the intersection of the lining and the inclined shaft, and the maximum stress is close to 3.0 MPa, and the top plate stress at the approach of the picket top is 1.3 MPa. On both sides of the picket top, the stress at the arch top basically shows a symmetrical distribution and gradually decreases. At the corners of the lining bottom plate, there is a concentrated stress phenomenon, and the stress reaches 11 MPa. The other positions have little fluctuation in stress, close to 0.5 MPa. Numerical simulation results show that the construction method of picking the top of the construction channel to enter the main cavern meets the requirement of safety and stability of the tunnel. The stress distribution in the lining is shown in Figures 8 and 9.

5. Conclusion

(1)When this method is applied to this project, the three-dimensional stress is concentrated and complicated. Therefore, when formulating the program of picking the roof, it must be mainly stabilized, and the initial support should be stronger rather than weaker, and the excavation method should preferably adopt weak blasting or non-blasting excavation, and pursue the progress under the circumstance of ensuring the safety.

(2)In the lifting section of the construction channel into the main hole, the monitoring and measurement of the construction channel should be strengthened, because here, the stress distribution situation is complicated. And the way of strengthening support should be adopted to achieve good control of the deformation of the surrounding rock [8].

(3)When applying this technology to construction, the support scheme and parameters should be further optimized according to the actual cross-section design size at the site in order to improve the construction efficiency.

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