

Research on highway tunnel construction technology and quality control

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Abstract: With the continuous construction of China's highway traffic network, tunnel has become one of the key and difficult points in the construction and construction of highway engineering, especially under the influence of the difference of geology and hydrology in different areas, tunnel construction is not only faced with many technical difficulties, but also prone to water inrush, water gushing, landslides and other kinds of accidents, Which poses a serious threat to the life safety of the construction personnel and the public. Therefore, this paper carries out research under this background, by analyzing the difficulties of highway tunnel construction, summarizing the tunnel construction process, explaining the tunnel construction technology, and then puts forward the strategies and methods of tunnel engineering quality management.

Key words: Expressway; Tunnel; Construction technology; Quality control

Tunnel is an important part of the highway, because it needs to pass through the mountain, so it is easy to be affected by many factors and interference, on the design scheme, construction progress, quality assurance, safety performance and so on. In recent years, our country has achieved good development results in terms of highway construction technology, and its related technology and equipment are at the world advanced level. However, because of its own characteristics, the tunnel must have a certain safety risk, so it is necessary to control its process, standards, efficiency, cost and quality in the construction process in an all-round way, in order to provide convenient transportation for people under the premise of safety.

I. Highway tunnel construction process

This paper takes highway tunnel construction project A as an example to specifically summarize the basic process of highway tunnel construction. First of all, geological survey, through the survey activities such as pay-off survey, to determine the basic scheme and requirements of the project construction. After the completion of the survey, the construction should be carried out for the elevation and retaining wall of the cut-off ditch and the entrance of the tunnel. After the completion of the construction, the position of the tunnel entrance needs to be leveled and hardened.

Secondly, after the completion of the hardening treatment, the implementation of advance support, and then lay hanging open tunnel waterproof layer to complete the lining task. Confirm the end wall, hole drainage ditch after the completion of construction activities, and then complete the construction content of the hole location. In the advance support link, the appropriate support technology should be selected according to the characteristics of the surrounding rock in the area. In this project, 40m advanced long pipe shed is selected for the entrance of the cave, and thus advanced small pipe support is implemented. In the V-class surrounding rock section, the advanced small conduit support technology can be directly adopted; In the IV class surrounding rock section, you can choose from the two technologies of advance bolt support and advance small conduit support.

Third, after the completion of the support technology, the location of the tunnel body can be excavated. Since the project includes the surrounding rock structure of three grades V, IV and III, it is necessary to excavate in strict accordance with the drawing scheme during the specific construction process. Specifically, first, the geological conditions of the location of the hole should be explored again, and at the same time, the position of the hole should be backfilled with soil and reverse pressure. Second, it is necessary to clarify the condition foundation of site construction, and select ring excavation method, step method or full section method according to the construction conditions.

Fourthly, the initial support construction of the tunnel also has strict process restrictions. First, concrete should be sprayed on the excavation face, second, steel arch or grid arch, third, steel mesh should be hung, fourth, concrete should be shotcrete, and fifth, bolt should be set. In this project, choose sand, cement, stone, water, accelerator, high efficiency water reducing agent to make concrete, of which the amount of each element is 858.kg, 485.kg, 858.kg, 199.kg, 29.28.kg, 3.90.kg. According to the proportion of mixing, screen out the large particles of stone, and then use the wet jet concrete jet machine, the concrete is sprayed on the excavation section, the spray wind pressure is required to be 0.45.MPa ~ 0.7.MPa.

Fifthly, invert is an important structure used to improve the stress of the upper supporting structure of the tunnel, which is characterized by reverse arch structure. The construction process of invert mainly includes excavation, testing bearing capacity, initial support, drainage design, concrete placement, filling and acceptance.

Finally, in the secondary lining of the tunnel, it is necessary to prioritize the stability of the initial support, and then install the longitudinal and circumferential drainage pipe. After the installation, geotextile and waterproof coil are used for waterproof treatment. At the same time, it is necessary to complete the installation and acceptance activities of the second lining steel bars and embedded parts, to ensure that the second lining car template is in a clean state, and then fully coated with release agent. After the measurement and positioning, adjust the fixed trolley, determine the installation of the plug plate and water stop belt, thus the concrete perfusion. After the final demoulding, the

construction link of the secondary lining can be completed through maintenance.

II. The basic technology and precautions of highway tunnel construction

1. Tunnel opening excavation

In the construction of the tunnel entrance, it should be carried out from the following aspects: First, the concept of zero excavation should be implemented throughout the whole process, that is, the excavation area should be reduced as much as possible, the section area should be reduced as much as possible, and environmental pollution and ecological damage should be reduced as much as possible. Second, the excavation of the entrance needs to choose mechanical excavation means, but the principle of excavation and measurement must be adopted to avoid the problem of overexcavation in the excavation process, and to achieve the slope rate required by the design. Third, the excavation of the hole shall not adopt the bottom-up excavation sequence, and the problem of overlapping should be avoided, so as to ensure that the top-down excavation method is adopted throughout the whole process. At the same time, protection measures for the slope of the hole must be taken in advance when digging, so as to avoid landslide problems in the digging process. Fourth, when blasting technical support is needed in the excavation process, smooth blasting molding needs to be done in advance, and a reasonable amount of charge needs to be filled, so as to implement blasting activities. After the blasting activities, the surrounding soil slag and gravel should be cleaned to ensure the safety and cleanliness of the construction site. Fifth, there are great differences in the geological and climatic environment of different tunnel openings, and geology and climate will directly affect the construction safety and quality, so the excavation activities should avoid the rainy season, and at the same time, the drainage system and protection system should be done in the excavation process to ensure the safe construction of the tunnel opening.

2. Tunnel advance support

In the tunnel advance support link, different methods can be selected according to the needs. First, double-row small pipe pre-grouting advance support. The construction material used in this method is a sharp cone hot-rolled seamless steel pipe, which is required to have a length of 4.5 meters, an outer diameter of 42 mm, a construction ring spacing of 40 cm, and a staggered level interval of 20 cm. Specifically, first of all, a rock drill should be used to drill and clean up, and the pipe should be inserted after verification. The pipe is driven into the drill hole using the percussion method of the rig, and the pipe insertion length is required to reach at least 95% of its pipe length. After passing the inspection, grouting is carried out, requiring the use of cement paste. After the grouting is completed, it is also necessary to do the initial spray sealing treatment. Second, single-row small pipe pre-grouting advance support. This method also uses the steel pipe material of the first method, and the construction process and sequence are roughly the same, but only a single row of steel pipes need to be designed. Third, advance bolt support. This method uses advance hollow grouting bolt as the main material, requiring a length of 4.2 meters and an outer diameter of 25 mm. First of all, it is necessary to process the bolt, drill and clean the rock drill, manually insert the treated bolt into the hole, and then use the drill to push the bolt into the hole, and also require the bolt insertion length to reach at least 95% of its rod length. At the same time, the tail end of the anchor rod needs to be welded with the belly of the steel arch to strengthen the common supporting ability. Secondly, hemp wire and anchoring agent should be used to fill and block the gap between the anchor rod and the hole wall, and the head and hole valve should be used to block the pipe mouth. Finally, it is necessary to use cement slurry grouting, requiring the water-cement ratio of 1:1, after the grouting is completed, it is necessary to do the initial spray closure treatment. Fourth, the tunnel body advance pipe shed support. The use of hot-rolled seamless steel pipe, but the outer diameter requirement is 89 mm, the construction link mainly includes "shed positioning, pipe shed drilling, hole clearing, hole inspection, pipe jacking, grouting".

3. Tunnel body excavation construction

The excavation of the tunnel body needs to be completed through the following four links. First, it is necessary to do a good job of detection and preparation before excavation, require the construction to meet the technical requirements of the new Austrian Method, adhere to the principle of digging and testing, and avoid accidents and construction deviations. Second, before excavation, it is necessary to do a good job of technical docking work, review and verify the drawings, find the excavation route, and clarify the tunnel plane, longitudinal plane, elevation and other relevant data. Third, when using blasting technology, it is necessary to detect and record relevant geological and hydrological data before and after blasting, and collect image data such as photos. Fourth, drainage facilities must be done before construction to ensure good drainage. Fifth, the internal environment needs to be cleaned at any time during the construction process, and the debris should be cleaned and shipped out regularly.

4. Water gushing treatment of tunnel construction

When water gushing occurs in the construction process, it needs to be treated in accordance with the following requirements. First, it is necessary to strengthen geological survey, forecast and monitoring during construction to verify the underground water volume. Especially in the fault fracture zone, joint dense zone, groundwater development zone and other locations, it is necessary to do a good job in advance to prevent water inrush and collapse prevention plans. Second, in addition to drainage facilities, it is necessary to add temporary drainage means, such as mechanical drainage. In view of the possible phenomenon of water gushing, arrange in advance. Third, broken jade burst water problem, you can install emergency pipelines, and use high pressure pump emergency pumping. Fourth, a perfect emergency plan should be established, and corresponding prevention and solution measures should be set up for different locations and different types of mud gushing water problems. In the event of water gushing accident, the staff need to evacuate to the safety zone at the first time, and the manager's command to implement the rescue work.

III. Highway tunnel construction quality management

For the quality management of highway tunnel construction, it is generally necessary to improve the quality control effect through the following two aspects of measures. On the one hand, we should pay attention to the expansion and innovation of management methods. Construction units should master and apply the PDCA cycle management method, which will decompose each construction activity into four aspects of “P (plan) D (implementation) C (inspection) A (treatment)”, through the formulation of a plan, implementation of the plan, inspection results, deal with the problem of the four parts of the reasonable mix, so as to ensure the final construction quality and safety standards.

On the other hand, it is necessary to strengthen the application of information management. First, “BIM+zigbee” technology should be adopted. zigbee can provide wireless communication function for tunnel construction, ensuring smooth communication and convenient information transfer. BIM technology with its cooperation can establish the construction site safety early warning system, but also can establish the quality supervision system. Specifically, the staff can accurately locate the construction personnel based on BIM technology and wireless positioning technology, and the construction personnel can transmit the specific information they observe to the outside in real time. At the same time, the BIM platform terminal can directly observe the position and status of employees in the tunnel model, so as to supervise the construction situation. Second, we should actively apply computer vision technology. With the combination of camera and computer, automatic intelligent monitoring system can be established. The infrared camera can collect information about the construction situation inside the tunnel, while the computer can supervise the construction process with the help of image enhancement technology and image analysis technology. Third, we should give full play to the advantages of artificial intelligence. Under the application of computer vision technology, the image information of the construction process can be collected and sorted out, and artificial intelligence can use the machine learning method to extract, analyze and calculate the image features, and then achieve the goal and effect of target detection. For example, with the help of SIFT technology, haar image technology, directional gradient histogram algorithm, etc., the construction status can be intelligently analyzed, and then decision-making opinions and early warning reports can be made in advance.

IV. Conclusion

To sum up, in the construction of China’s highway network, tunnel construction has become an important part, which not only needs to face the multiple influencing factors in the construction link, but also involves the application of many key technologies, so the relevant units and staff need to be vigilant. Then through scientific construction plan, clear construction technology, perfect construction process, complete safety guarantee, advanced information technology, etc., to ensure the safety and high quality level of highway tunnel construction, and then realize the scientific expansion of tunnel construction management mode and the effective implementation of information construction management, to achieve high-quality construction process control objectives. Significantly improve the effect of tunnel construction.

References:

- [1] Boyu Wang. Analysis of Highway tunnel construction methods [J]. Transportation Manager World,2023,(25):113-115.
- [2] Bin Zhang. Key Techniques of Quality Control of Highway tunnel construction projects [J]. Urban Construction Theory Research (Electronic Edition),2023,(22):156-158.
- [3] Ren Xu. Highway Tunnel construction technology and quality control Measures [J]. Public Standardization,2023,(12):25-27.
- [4] Guangyi Guo,Fangwen Wang. Technology and Quality Control in Expressway tunnel construction [J]. Sichuan Building Materials,2023,49(06):192-194.
- [5] Yongbi Yuan. Analysis of highway tunnel construction technology and quality management [J]. Urban Construction Theory Research (Electronic Edition),2023,(15):107-109.