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Research Article

Comprehensive Management Strategy for Tunnel Construction Quality Inspection and Monitoring

Xiong Zhou

China Merchants Chong Qing Highway Engineering Testing Center, CO., LTD. China

Abstract: With the increase in the number and scale of tunnel projects in China in recent years, the comprehensive management for quality inspection and monitoring measurement in the tunnel construction process is receiving more and more attention. Based on this, this paper analyzes the comprehensive management of quality inspection and monitoring during tunnel construction to ensure the quality of tunnel construction.

Keywords: Tunnel construction; Quality inspection; Monitoring and measurement; Comprehensive management

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****Corresponding author:*** Xiong Zhou, starchow27@163.com

1 Introduction

In the process of tunnel construction, scientific and reasonable quality inspection and comprehensive monitoring management are the keys to ensuring the overall construction quality and improving the overall project safety. Therefore, in specific construction, relevant units must do a good job in this work to ensure the construction quality of tunnel projects and meet the actual needs of the society for tunnel project quality.

2 Tunnel Construction Quality Inspection

2.1 Geological Radar Inspection

The ground penetrating radar detection is mainly applicable to the inspection of the initial support of the tunnel project, the thickness of the secondary lining, the cavity at the back and the detection of discontinuous concrete surface. In the actual inspection, the data signal is monitored with the help of geological radar, and it can be transmitted and received in real-time, and the actual situation at the site can be inspected in real-time by the close combination of antenna and concrete. Currently, the main specifications of radar geological inspection antennas include 400MHz and 900MHz types. With the help of these antenna devices, the thickness of concrete and its internal voids during tunnel construction can be scientifically inspected to determine concrete construction defects.

During inspection, the relevant information is assessed mainly by the reflection characteristics and the initial phase of the reflection wave. If the phase of the reflected wave is opposite to that of the incident wave, and the energy signal is very strong, it means that there is a cavity in the concrete; if the signal energy is weak, it means that the concrete is not dense enough. If the phase of the reflected wave is the same as that of the incident wave, and the energy signal is weak, it means that the concrete has no defects.

2.2 Clearance Section Inspection

The coordinate method is used as the detection principle, and the clearance section is inspected with the aid of a laser profiler. Set a physical direction as the starting direction, and measure the distance value of the vector diameter between the contour line during the specific excavation process and the focal position of the instrument's rotational center through the unique spacing. Meanwhile, the angle between the vector diameter and the measurement direction is measured. Perform measurement and connect the end-points of the vector radius to obtain the contour shape in the specific excavation process. With the help of the specific control of the construction wire in the cave, the directional fixed-point data of the short coat can be obtained, and then the automatic design can be carried out through the computer software. After the excavation contour line is designed, it needs to be compared with the construction space, and then matched into a corresponding graph, displaying and outputting the distance and area value between each inspection point and the design. In the measurement of the specific excavation effects of the contour line of the tunnel excavation surface, the laser profiler can be used to measure it to simplify the inspection procedures and improve the inspection accuracy, which is in line with the modern tunnel construction quality inspection requirements.

2.3 Acoustic Reflection Detection

With the aid of sound wave reflection detection technology, the length of the anchor rod and the grouting density in the tunnel construction can be inspected. In the process of construction inspection of the tunnel project system consisting concrete mortar, bolts and surrounding rock structures, elastic waves can be emitted from the top of the bolt and scattered by the bolt body, undergoing multiple transmissions and reflections between the bolt and mortar and between the mortar and surrounding rocks, and eventually propagated in a very complicated path. Through the analysis of the tunnel's anchoring variable cross-section system, it was found that if the form of material or cross-sectional area of the bolt changes, the transmission and reflection positions of the incident wave will be located on the cross-section, and the changes in the actual area of the cross-section and the impedance phase of wave drag will directly affect the magnitude of the transmitted waves and reflected waves. If the surrounding rock structure, mortar, and bolt have a relatively high density, there will not be a huge difference in wave impedance between these three. At this time, most of the energy will be transmitted to the surrounding rock, and only a small part of the energy of will be transmitted back through reflection, and the reflected signal is also very regular. If the construction mortar has quality problems such as poor uniformity or insufficient compactness, the mortar is prone to problems such as cavitations. At this time, the transmission and reflection of sound waves will occur at the end of the bolt. If there is any change in a construction parameter, the change in reflection will increase and the reflection effect will be enhanced. On the contrary, if all the parameters on the interface remain unchanged, the changes in reflection and reflection effect will gradually weaken. In specific inspection, in order to achieve further improvement on the assessment capability, the inspection should be combined with the exact sound wave reflection time and reflection intensity, so as to achieve further control of the effective information, and actively process the corresponding data to obtain more accurate testing results.

3 Comprehensive Management of Tunnel Construction Monitoring Measurement

In specific tunnel construction, strengthening the monitoring and measurement of each process can ensure the quality and safety of the tunnel project on the basis of ensuring the orderly implementation of the project. Therefore, in the specific construction, it is necessary to strengthen the research on the comprehensive management of monitoring and measurement, and adopt reasonable measures to carry out the comprehensive management of monitoring and measurement in each process.

3.1 Comprehensive Management of Displacement Monitoring and Measurement

In the comprehensive management of tunnel construction monitoring and measurement, good monitoring of surrounding rock displacement is the key content of stability assessment for surrounding rocks and construction guidance. As far as traditional displacement inspection is concerned, there are two main technical methods, the specific details are as follows:

Table 1. Details of the Two Types of Displacement Monitoring Techniques

Serial No.	Monitoring Technology	Monitoring Method
1	Manual Monitoring	During the construction, the measurement section is set up, and the measurement is carried out by dedicated personnel at fixed time interval through the corresponding mechanical convergent gauge, or through a mechanical-electronic convergent gauge.
2	Instrumental Monitoring	Use tunnel profiler to measure at fixed-point and fixed-timing.

The advantages of these two measurement techniques are that the instruments and equipment are relatively simple, but they cannot perform real-time monitoring of displacement. The measurement is dangerous and will cause great interference to the construction, the data is not reliable enough, and the measurement cost is relatively high. In order to effectively overcome these shortcomings in traditional displacement measurement, real-time and effective measurement can be carried out by setting up a laser real-time monitoring system in specific tunnel surrounding rock displacement measurement. For example, in the process of tunnel collapse, the system can be used to realize real-time knowledge of the supporting structure and surrounding rock stability of the collapsed construction section.

3.2 Comprehensive Management of Stress Monitoring and Measurement

If the tunnel has relatively stable surrounding rock conditions, the actual requirements of monitoring and measurement can be effectively fulfilled with the help of geological observation of working face and surrounding rock displacement monitoring. However, if the tunnel does not have relatively stable surrounding rock conditions, or the tunnel structure is very complex, or the stratum has serious deviations, more sensitive measurement techniques are needed to fully obtain low stress information to ensure the quality and safety of tunnel construction. In the specific stress monitoring and measurement, the results of the displacement monitoring around the tunnel and the infiltration monitoring results of the tunnel roof can be used as the basis, and the stress on the side of the back-stress retaining wall can be measured by a steel string compressor. In this way, the stress can be monitored and controlled reasonably, construction quality and safety can be guaranteed, and the overall management efficiency can be further improved.

3.3 Comprehensive Management of Anchor Rod Axial Force Monitoring and Measurement

In the construction of tunnel projects, it is usually necessary to use a large number of anchor rods to render support. Therefore, in the specific construction, a comprehensive knowledge of the specific working status of the anchor rods at a specific position is of vital importance to the economics and safety of the entire support system. In the specific monitoring measurement, three sensors can be set on each anchor rod to be tested, so that it can measure the axial force values at three different positions on the anchor rod. When the anchor rod is under tension, its axial force is positive; and when it is under stress, its axial force is negative. The difference between the actual load and the design load value of the anchor rod is assessed by the measurement of the maximum absolute value of the axial force and its occurring position. Axial force distribution is used to determine whether the forces on the anchor rod are tension or stress and to analyze whether if the forces on both sides of the anchor rod are symmetric. Only in this way can the concrete supporting structure and surrounding rock conditions be reasonably tested after the tunnel excavation, so as to ensure the overall tunnel construction quality and meet the requirements for actual tunnel construction.

4 Concluding Remarks

In summary, tunnel construction has become more and more common in the construction of traffic facilities today. The tunnel construction technology will have a direct impact on the quality and safety of tunnel use. Therefore, relevant units should conduct inspections of construction quality through geological radar detection, clearance area inspections, and acoustic reflection detection technology during construction; and monitor and measure surrounding rock displacement, stress, and bolt axial force. In this way, the overall improvement of inspection of tunnel construction quality and management quality of monitoring measurement can be achieved. This will have a very positive impact on the improvement of the construction quality of subway tunnels, the fulfillment of the actual needs of social transportation and the well development of social economy.

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