

Analysis on Construction Monitoring Scheme of Highway Tunnel with Small Spacing

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Keywords: small spacing; highway tunnel; construction; NATM; monitoring scheme

Abstract. Monitoring is an important work to measure the rationality of tunnel design and construction, especially for highway tunnel with small spacing. The design of construction monitoring scheme was analyzed based on a practice of small spacing tunnel engineering. The method to determine the monitoring items, monitoring sections, monitoring points and monitoring frequency was pointed out. The monitoring items depend mainly on the construction safety and relevant technical research. The general monitoring items can be set one section average per 50m along the tunnel, and the research monitoring items should be set at least one section in each grade surrounding rock. The experience and conclusions presented can provide reference for the monitoring of similar tunnel engineering.

Introduction

The mechanical property of surrounding rock in tunnel construction is not only influenced by the formation conditions and geological conditions of the rock, but also by the action of tunnel excavation method, supporting type, supporting time and parameters. So it is very difficult to find the physical and mechanical model of rock mass [1]. Thus, the main reference is engineering analogy method and mathematical analysis method in the design and construction of tunnel [2]. Through the real-time monitoring of surrounding rock, monitoring data analysis and comprehensive judgment during the construction process, the design program was improved and the corresponding construction measures were put forward. Construction monitoring becomes an important work to measure the rationality of tunnel design and construction [3,4].

Small spacing tunnel, a new and effective structure type to solve the problem of high grade highway alignment, is more and more widely used. However, its design theory and construction method are imperfect. The theoretical analysis and numerical simulation results also need to be tested in practical engineering. Therefore, monitoring and measurement is an indispensable part during the construction of highway tunnel with small spacing [5,6].

Engineering Situation

The length of the small spacing highway tunnels with three lanes in single tunnel is about 450m. The design span of single tunnel is 15.052m, the maximum excavation span is about 16.69m, and the net interval between two tunnels is only 5.66m.

In the tunnel, the natural slope angle is about 16° at the entrance of tunnel, and 20° at tunnel exit. The maximum and minimum burial depth of the tunnel is about 62m and 4m, respectively. The whole tunnel passes through V, IV and III grade rock mass.

Monitoring Purposes

The role of monitoring in the construction of tunnel is mainly reflected in the following aspects:

Ensure safety. The displacement and stress state of surrounding rock and support are needed to investigate. The stability of the ground structure should be understood for the shallow buried tunnel.

And at the same time dynamic management should be carried out. The tunnel can be constructed scientifically depend on the information of monitoring.

Guide construction. After analyzing and processing the data, the final settling time of the tunnel surrounding rock is predicted and confirmed, which can give reference for the construction sequence and supporting time of the second lining.

Modify design program. According to the amount of information obtained during the tunnel excavation, comprehensive analysis can be conducted, and the predesign program of the tunnel can be inspected and modified.

Accumulate data. The measurement results of the existing projects can be indirectly applied to other similar projects as a reference for design and construction.

Monitoring Scheme

Monitoring Items. The choice of monitoring items depends on the specific purpose of tunnel monitoring. Based on the purpose of monitoring, monitoring items usually come from the construction safety and relevant technical research.

In the process of tunnel construction, the tunnel construction safety is usually most concerned. In view of this purpose, the monitoring items, pointed out by the highway tunnel construction specification, include geology and support observation, crown settlement, convergence, surface subsidence and other routine monitoring items [7]. However, in order to provide more experience and data for similar projects, or solve a number of key technical issues, it is necessary to carry out the relevant scientific research, as much as possible to choose the relevant test of deformation and stress. Through the implementation of these monitoring items, combined with numerical simulation analysis and other means, the tunnel design and construction scheme can be optimized in similar engineering conditions.

For large section and small spacing highway tunnel, the current design theory and construction technology are not mature, and the relevant engineering practice is not common, so it is necessary to carry out relevant research, monitoring and analysis. Therefore, combining with the characteristics of the tunnel project and related technology research objectives, the selection of the monitoring items is shown in table 1.

Table 1. Monitoring items of small spacing tunnels

Monitoring Types	Monitoring Item
General monitoring	geology observation
	crown settlement
	convergence
	surface subsidence
Research monitoring	rock internal displacement
	contact pressure
	arch centering stress
	internal force of lining
	axial force of anchor bolt
	vibration test

Layout of Monitoring Points. After the monitoring items are determined, the selection and layout of the corresponding monitoring section and monitoring points can be done. If the location is not appropriate or too much, it will not only reduce the monitoring efficiency, but also increase the number of unnecessary human and material resources [8]. Therefore, according to the actual situation of the tunnel surrounding rock and the characteristics of the tunnel structure, a reasonable monitoring section and measuring points are selected according to the engineering practice.

Monitoring section is usually divided into two types; one is the general monitoring section, the average of one section per 50m along the tunnel. At the tunnel entrance and exit, and the complex geological conditions, the monitoring sections can be appropriately added, which can be encrypt to the average of one section per 10m; the other is the representative monitoring section (that is, the research monitoring section), it usually layout one section in each grade surrounding rock. The representative monitoring section is also divided into two types depend on the tunnel buried depth. When the tunnel buried depth is deep, internal displacement of surrounding rock should be monitored in the tunnel. When the buried depth is shallow, the internal displacement can be monitored from the surface, and the surface subsidence monitoring should be conducted at the same time.

In addition, in the relevant scientific research monitoring, the monitoring points of the representative section should be arranged in the same section as far as possible. The more sections of monitoring projects, the more complete data, and the project can also be mutual test or verification, after calculation and analysis can further optimize the design and construction scheme.

In view of the characteristics of the small spacing tunnel, combined with the field of surrounding rock conditions, three typical monitoring sections were arranged in III, IV, V grade rock respectively, and 18 general monitoring sections were arranged along the tunnel [9].

The monitoring items and points of representative monitoring section are shown in Fig.1.

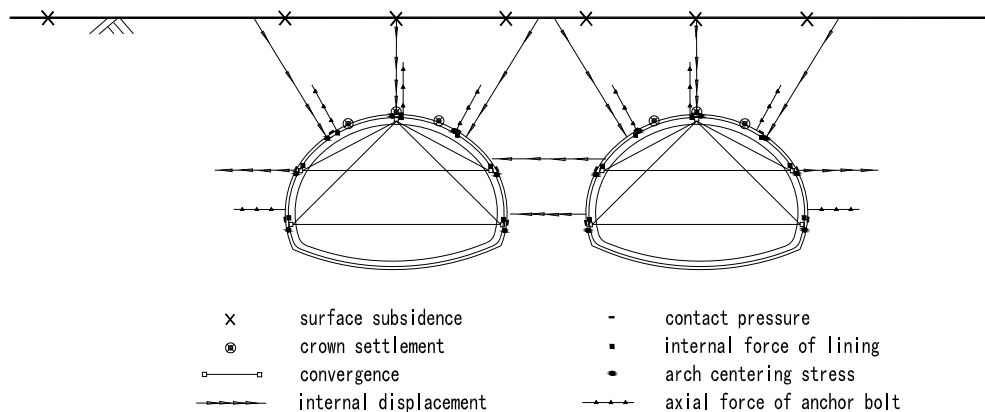


Fig. 1. Schematic of monitoring items of representative monitoring section

Monitoring Frequency. Monitoring point is installed about 2m away from tunnel working surface. And the first data should be recorded 24 h before blasting or next blasting. Monitoring frequency can be adjusted appropriately depend on the surrounding rock, supporting deformation and the distance from the tunnel working surface. When the geological conditions are poor, or surrounding rock deformation rate becomes large, the measurement frequency should be increased. Otherwise, measurement frequency can be appropriate reduced.

In the actual monitoring process of the tunnel, the monitoring group insisted that monitoring at least once a day, In the area near the working face, increased the monitoring frequency and strengthen observation, grasp the dynamic changes of monitoring timely, and good results were obtained.

Data Processing. All monitoring data are recorded in special form. According to the data, the time and spatial relationship curves were plotted, and the trend of the curves was observed from the curve of time and space. The trend of the development of surrounding rock and supporting structure is predicted, and the dynamic changes of surrounding rock and supporting structure need to be grasped timely and feedback, then guide construction and prevent the occurrence of collapse accidents. When the displacement increases rapidly, strengthen the monitoring frequency, pay close attention to the changing trends, and report the monitoring data every day. If the displacement rate is linear with time, submit an emergency monitoring report and strengthen or modify support parameters.

In addition, it is necessary for the monitoring staff to write a diary carefully, including weather, observation, monitoring, construction progress, instrumentation working condition, etc.

Conclusions

Tunnel construction monitoring can obtain first-hand data quickly and accurately, and can make information feedback and forecast timely. The excavation of the left and right is interacted in small spacing tunnel, and the excavation process also directly affects the stability of surrounding rock and structure. Strengthening the construction monitoring is the essential means to ensure the tunnel safety. The reasonable monitoring plan should be selected and designed according to the purpose of the monitoring combined with the specific characteristics of the actual project, and the reasonable scheme can make the monitoring task more effective.

In the construction process of the tunnel engineering, a professional monitoring group was set up. The monitoring staff earnestly fulfilled their duties of monitoring with high degree of responsibility, and ensured the construction safety of the tunnel. Furthermore, a mount of monitoring data were collected for small spacing tunnel. The monitoring programs and research results can provide useful reference for similar tunnel engineering.

Acknowledgements

This work was financially supported by the National Natural Science Foundation of China (51208395) and Research project of Education Department of Hubei Province of China (Q20111101).

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