Research on Tunnel Monitoring Measurement Technology

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Abstract

At present, highway, high-speed railway and urban underground traffic tunnel construction problems, mainly involving safety issues (including construction safety and operational safety). Because the monitoring measurement is the support parameter, it is necessary to study the problem of tunnel monitoring. Therefore, in this paper, combined with the experience of the construction site monitoring measurement application development status, monitoring content and methods, the existing problems were analyzed and summarized.

Keywords

Tunnel, monitoring measurement, New Austrian Tunnelling Method.

1. Introduction

Tunnel and underground engineering is a field of our country infrastructure, especially since the reform and opening up the construction of railway tunnel, highway tunnel, underground railway, hydraulic tunnel and large underground caverns and other has made remarkable achievements in [1]. However, most of the excavation of the tunnel is in a complex geological environment and it is difficult to obtain accurate geological conditions before the tunnel excavation. The application of the new Austrian Tunneling Method in the tunnel excavation has been developed rapidly, as an essential part of the new Austrian tunneling method, the monitoring measurement has also been developed rapidly. Monitoring measurement know the construction feedback design, to solve the complex geological conditions of the construction provides a great help [3].

2. monitoring measurement application status and purpose

2.1 monitoring measurement application status

At present, the tunnel, underground engineering information collection in general use of mechanical, electronic and automatic remote sensing transmission technology[4]-[5]. Information processing mainly rely on traditional statistical calculation method at the same time, the introduction of some nonlinear processing methods, but regardless of statistical calculation method and nonlinear processing method can fully and truly reflect the various factors of surrounding effect [6]. So on the whole, the study is not high. Automatic collection and transmission of detection information of underground engineering, Analysis process and make decisions, is a huge, complex system, it requires different professional, different disciplines, different departments of professional and technical personnel to work together to be a good complete [7]. At present, although the research in these areas has made great achievements, but it is not much practical application in underground engineering. In the vast majority of projects, underground engineering monitoring information collection also mainly rely on human resources through a variety of means to complete the [8]-[10]. Today in the rapid development of computer technology, the monitoring information processing speed is very fast, but the information processing study on the new method, and application in underground engineering is just beginning, remains to be inspection [11]-[13] further research and engineering practice.

In the tunnel project monitoring and information design, China in the development of displacement test as the main tunnel construction monitoring system and monitoring information feedback theory has great progress [14]-[15].

With total station instrument as the main volume measuring instrument, developed with good performance of the tachometer observation targets and corresponding supporting software, can timely access to each section observation point analysis of cumulative displacement, displacement rate, cross section displacement trend diagram data information. Has been in the Beijing Metro complex 18 lines to build the eastern section of the construction site trial, the measurement accuracy of 1 mm[16]-[17].

Jiang Shuping the origin and control theory of Kalman filter (kalmam filter) is applied in underground engineering, carried out with the non deterministic anti analysis program (DEKFEN), and its use for the analysis of surrounding rock stability of a highway tunnel, on the surrounding rocks shear force distribution of plastic area estimates are calculated and analysed, and achieved good results in [18].

Japan from the 90s of the 20th century began, with geological image processing technology of tunnel face geological conditions for image processing, refine and surrounding rock classification related parameters, carries on the revision to the surrounding rock classification, and the development of the system of tunnel face image. Proposed by Kyoto University in Japan with a digital camera for tunnel clearance displacement measurement results, its precision can reach 1mm.

2.2 monitoring measurement work purpose

(1) By measuring the pressure of surrounding rock and supporting structure internal force, to understand the stress condition and stress distribution of the supporting structure, to make the evaluation and adjustment of the original supporting structure, supporting parameters and supporting time.

(2) To determine the internal force of the anchor bolt, and to understand the working state of the bolt [1].

(3) Through the horizontal convergence, vault settlement measurement, regression analysis to understand the law of deformation of surrounding rock, the original support structure, support parameters to make evaluation, and for the two time to make the lining of the construction time to make judgments.

In order to achieve the above monitoring measurement, the measurement work should be run through the whole process of the tunnel construction. Measurement data and analysis results immediately prior pre design of supporting parameters are compared, and make a correct evaluation of the pre designed, such as measurement results with the original design of greater access, it is necessary to support for strengthening or weakening of the correction of, the tunnel design and construction into the dynamic of science management.

3. main contents and methods of monitoring measurement

3.1 monitoring measurement content

At home and abroad, the content of monitoring measurement of tunnel construction is mainly divided into the necessary measurement project and the project selection. Must be measured items are: inside and outside of the tunnel observation, peripheral displacement, vault subsidence, surface subsidence; monitoring project: steel internal force and external force and surrounding rock body displacement, surrounding rock pressure, two layer support care pressure, axial force of bolt, support and lining should force, surrounding rock elastic wave velocity, blasting vibration, seepage pressure and water flow. At present most, the most effective with tunnel face geological observation, vault subsidence and the surrounding convergence and complex geological area increase auxiliary measures, such as geological radar, infrared detection, water, TSP and other geophysical methods. Other selected test items will be implemented when some research work is carried out. Such as Nan Cun tunnel for the convenience of construction, speed up the construction progress, the monitoring content includes only the geological and initial support nursing observation and sketch, the surrounding displacement and the vault subsidence measurement, shallow buried section of surface subsidence of these three aspects.

3.2 monitoring measurement section arrangement and monitoring method

(1) Monitoring section spacing

Under normal circumstances, portal section and buried depth is less than two times the radius of the tunnel area every 5-10m spacing design a measuring section; the remaining sections according to the geological conditions, measurement section may be appropriate to increase the, but must ensure along the tunnel axis each kind of wall rock and at least a measuring section. For long tunnel geological conditions, and continuous, and convergence value stable with large distance measure; for poor surrounding rock and convergence value of long-term stability, progress faster or excavation, excavation, reduction amount of section distance measurement. Peripheral convergence displacement, vault settlement measurement, the measuring points should be generally arranged in the same section.

(2) Monitoring location selection

Several representative measurement points must be fixed on each monitoring section. The measuring line is usually composed of a horizontal line and a triangular line, as shown in Figure 1. Compared with the horizontal line, the triangle measurement line has the advantage of accurate monitoring data.

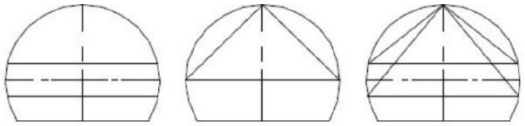

Figure 1. The covergence monitoring lay-out of the tunnel surrounding rock

(3) Monitoring measurement data processing

Because of the measurement precision instruments and accidental errors affect the amount of test data is discrete, according to these data sorting out the original temporal curve (time displacement curve) is often zigzag, so must by mathematical method on the amount of measured data obtained were analyzed, makes further consolidation, discovers the surrounding rock deformation with time change rule and the different wall rock deformation and the development trend of the surrounding rock and maximum deformation calculation of displacement of surrounding rock, in the same deformation critical value compared, in order to determine the deformation of tunnel surrounding rock is within the allowable range. At the same time, we also need to understand the time curve and the original data to show the discrete and stochastic volatility, so as to predict the results of the forecast and analysis of the data used in the accuracy and error.

At present, there are many methods for the application of the time curve of displacement, such as intelligent algorithm, non linear regression analysis and time series analysis. At the same time, in order to use the measured displacement back analysis, the surrounding rock mass index and load are obtained, and the stress and deformation analysis of support system is carried out by using these indexes.

4. Lack of monitoring measurement

(1) Feedback application of monitoring information is not timely or not pay attention

Most of the data measured by the monitoring side is a Monday, which will result in monitoring information feedback is not timely. Data has not been submitted to the drawings, the program has been set, the monitoring information is not valued.

(2) Monitoring instruments and testing methods need to be further improved

Most of the current monitoring instrument of low precision, environmental adaptability, low degree of automation, operability is not strong, often there will be some sensor data disorders and other quality problems in the underground, which leads to the reliability of the monitoring data is low. At the same time, a new test method is too slow, basically manual operation monitoring, this not only can cause an error because the monitoring of the operation, also caused great threat to their personal safety, although there are such as real time monitoring system of Bassett system, total station automation monitoring system and profiler monitoring system, Geoauto automatic real-time monitoring software system of tunnel, but popular in Engineering practice are high.

(3) Special sections of the monitoring method is less

Special sections including through rivers, lakes, seas, and the karst areas. At present, China in the rivers, lakes and oceans built tunnel engineering is still in its infancy, the construction technology is not mature, the monitoring is difficult, land lots of monitoring method can applied directly to these places is still a question. In the karst area of construction safety monitoring can not be guaranteed, the surrounding rock caused by inrush inrush reason should force change is difficult to predict. Ordinary site monitoring can not be real-time monitoring, and ultimately lead to the construction of the project can not be monitored in the process of monitoring or control can be measured.

(4) Measurement lag

To monitor the amount measured in the actual implementation process due to various objective conditions, monitoring tend to lag behind in the deformation of surrounding rock, which will enable human data acquisition error, decrease the accuracy of monitoring, further affect the monitoring measurement feedback construction.

5. Conclusion

Tunnel monitoring measurement is an important part of the new Austrian tunneling method construction, the new Austrian tunneling method that allows the surrounding rock moderate deformation, but also to control the transition deformation of the surrounding rock. Through the tunnel monitoring measurement for tunnel excavation and construction of branch support and secondary lining provides dynamic data analysis, forecasting and confirmation of tunnel surrounding rock in ultimate stabilization time, guide the construction sequence and construction time of secondary lining. By monitoring the results of measurement data can be directly applied to the follow-up of the same type of surrounding rock or indirectly applied to other similar projects, as a reference for construction. To strengthen the research of monitoring measurement to better serve the construction of the tunnel.

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