A Brief Analysis of Advance Geological Prediction Technology and Application of Highway Tunnel

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Abstract: Tunnel construction, especially in the case of harsh geological conditions, will suffer from many geological disasters such as cement flow and fault collapse in karst areas. Geological forecasting techniques can provide a better understanding of geological conditions so that preventive measures can be taken. This paper introduces the early geological prediction technology widely used in highway tunnels, and discusses the principles, advantages and disadvantages and applicable conditions of various methods.

Keywords: Highway Tunnel Project; Comprehensive Advance Geological Forecast; Technical Means

Introduction

With the development of road transportation in China, more and more road tunnels need to be built. Tunnel construction under complex geological conditions will suffer from many geological disasters such as karst concrete flow, defects, and landslides. To avoid a catastrophic accident, it is important to understand the geology ahead of the tunnel before excavation. In recent years, advanced geological forecasting has begun to play a role in tunnel construction in my country, especially in other large-scale tunnels. Advanced geological forecasting has been listed as a key technical link. Preliminary geological prediction of tunnels refers to the discovery, analysis and interpretation of the geological conditions prior to the tunnel's passing function, as well as the inaccurate geological features and predictions of engineering, location and events. The main contents of advanced geological forecast include: Fault structure and fault fracture zone, Karst, cavity fissure and its scale and filling condition, groundwater state, Soft Layered Surrounding Rock and so on.

1. Optimizing the Application of Advanced Geological Prediction Techniques in Highway Tunnels

1.1 Rayleigh wave detection technology

As a new technology for geological forecasting of expressway tunnels emerging in recent years, this technology has the advantages of high precision, little impact on the construction site, and wide application. Specifically, Rayleigh waves, as one of the seismic surface waves, are also known as geotropic waves or waves revolving around industries. If the tunnel section is large, technicians can use it directly as an air center and use Rayleigh wave sensors to discover the geology of future wells. For the layout of the Rayleigh wave sensor, firstly, the receiving sensor, the triggering sensor and the triggering element responsible for control must be placed in a straight line; secondly, the axial direction of the sensor should be used as a device. The working direction of Rayleigh wave detection, the sensor should be guaranteed. The axis is perpendicular to

the road tunnel surface, and again, if the rock near the road tunnel is hard, technicians will need to take regular measurements to make sure the sensor is connected, even when digging the road surface with a hammer. Dig a hole from 5cm ± f = 16 to 20 mm, then solid brazing is performed. In this way, the Rayleigh wave sensor can be installed on the metal rod through the pressure point by means of magnetic force, which not only improves the efficiency of the detection function, but also ensures the coupling performance of the sensor.

1.2 Transient electromagnetic multi-component and array detection techniques

At present, the most advanced geological prediction technology adopts the middle ring device, that is, the scanning line is arranged on the surface to obtain the two-dimensional distribution of impedance. However, this technique cannot reflect 3D images of water-bearing geological structures. To this end, technicians must upgrade the multi-component tunnel and array detection technology according to the central loop device, that is, after arranging receiving points at multiple points in the power supply circuit, a group of receiving points is formed. In this way, senior geological forecasting technicians can use the discovery of each receiving element to obtain a visible resistance curve, that is, 3D interpretation of the visible resistance data of all measuring points, thereby obtaining a visible 3D image. But this improvement makes the solution of the magnetic field response difficult, so in cases where the receiver's point is not in the middle, the answer must be analyzed by combining the two Bessel functions. In addition, integrated core processing can also be done by means of core operations. This is a way to overcome real depreciation for the purpose of numerical integration. Specifically, timely placement is carried out according to the multimodal shape of the central magnetic field response, and the center is defined as a visible barrier, thereby providing theoretical technical support for the realization of preliminary predictions of electromagnetic discoveries.

1.3 TSP advanced geological forecasting technology

As a fast, non-destructive and effective wave reflection detection technology, the technology can set the precision of the well to release the sound wave while maintaining a certain distance after tunnel magnification. The blast signal caused seismic waves to travel across the rock, and when the seismic waves met on the other side in front of the tunnel, some of the seismic waves bounced off the interface. At this point, the receiving sensor converts it into an electrical signal and amplifies it. Then, by changing the reflection time and the seismic wave propagation velocity, the interface space where reflection occurs, the distance to the tunnel surface, and the junction with the tunnel axis can be obtained. As shown in Figure 1, it is a schematic diagram of the application principle of TSP detection technology.

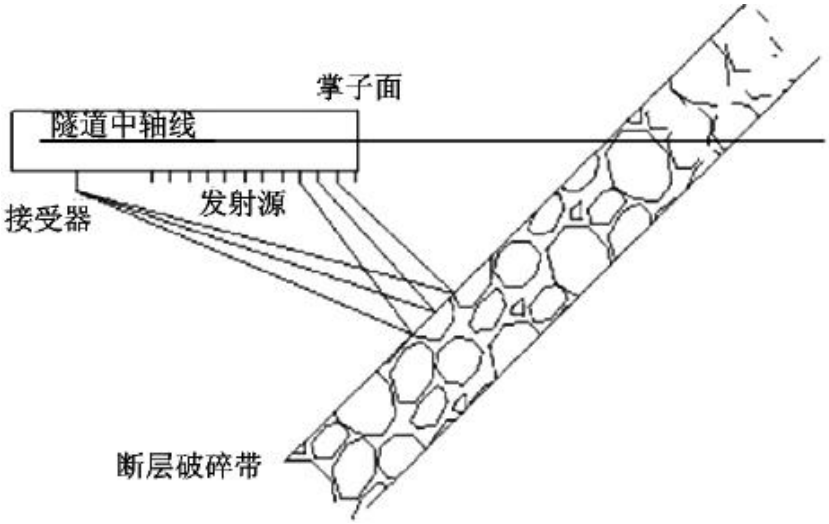

Figure 1 TSP Schematic diagram of detection principle

Its optimization must start from the perspective of the problem, that is, according to the accuracy and precision of the forecast, technicians should make full use of the detailed relay map, event table and reflection surface extraction to fully judge the indicators. Only in this way can accurate geological disasters be made to the geological conditions of karst development, and the safety and stability of highway construction can be ensured.

1.4 Geological Radar Detection Technology

This technology mainly uses various electrostatic properties of various rocks to analyze and judge the rock environment around the tunnel. In the final analysis, it is a large-scale electromagnetic wave technology. In the actual application process, due to the electrical differences of different rock groups, the refraction, reflection and scattering of intervening radio waves are also different. In this case, major geological forecasters can analyze and read the echoes according to the program that comes with the system, so as to estimate the space, shape and distribution of the target object. This is an excellent way to obtain information on the preparation of geological forecasts for the main tunnel and has become one of the most important ways to use the latest short-range geological forecasting techniques.

2. Advantages of GPR

（1）Repeating ahead of time can more accurately judge the unsuitable geological objects within the 20~30m column，Eg: karren, underground river, fault zone, fracture zone and so on.

（2）Detection of geological errors associated with caves and water is more sensitive, so caves can be effectively predicted and TSP sensitivity of small caves can be corrected to some extent.

（3）Radar is often used in the detection of hidden karsts under caves and can achieve satisfactory results.

3. Problems Existing in Geological Radar Prediction

(1) As a short-term forecasting technology, although GPR is sensitive to water and vacuum, its detection distance is short and cannot overcome the difference in detection distance and accuracy. Tunnels of the same length require more time for diagnosis, so it is often difficult to play the role of the primary prediction technique as a long-term prediction technique.

(2)In the process of detecting radar that penetrates the ground, the reflector is easily affected or even interfered by surface water flow, groundwater, surface attachments and antennas, making it difficult to reflect the target.

(3) Ground-based radar is also faced with the problems of confusing interpretation of data results, many solutions, and

complicated interpretation. It is important for discoverers to gather experience and improve the accuracy of their discoveries.

Therefore, in the process of radar detection, it is first necessary to select appropriate instrument parameters in order to obtain satisfactory radar waves; When processing data, the first thing to do is to distinguish and remove interfering signals. The common features of radar waves are searched in real time, a large amount of image data is collected, and the quantification processing rate is improved.

4. Future Trends in Early Highway Tunnel Predictions

(1) Upgrade the hardware, improve the processing software, improve the prediction accuracy.

Technological progress is inseparable from modern precision equipment. In the future, the level of early geological prediction should be improved based on the existing data. Software upgrading is a very fast and complex task for existing devices.

(2) The glossary of fault geological body judgment, indication of unsuitable geological interface features and volume index of rock classification are provided. Previously, the transformation of physical data was more about quality and experience-based decisions. In the future, we must study the dynamics and variation characteristics of the wave field in order to achieve the development goal from species to estimation.

(3) Carry out detailed early geological predictions: It is not a complete geographical approach and it is impossible and unscientific to expect that only one geophysical technique can provide a clear understanding of future adverse geological conditions.

5. Conclusion

In short, in order to improve the construction efficiency of highway engineering, it is necessary to adopt advanced geological forecasting technology to minimize the impact of adverse geological disasters on the surrounding rock structure. In this process, construction technicians are required to determine the best management techniques and strategies based on the use of advanced geological forecasting techniques. That is to apply: Rayleigh wave detection technology; transient electromagnetic multi-component and array detection technology; TSP advanced geological forecasting technology and geological radar detection technology and other scientific and technological means are used to improve the accuracy of the application of advanced geological forecasting and detection technology, thereby improving the safety and stability of the structural functions of various parts of highway tunnel construction. The detection technology of infrared water detection uses infrared detectors to detect hidden water-bearing structures or micro-water-bearing structures.

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