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Exploration of Advanced Geological Prediction for the Double-arch Highway Tunnel in Karst Area

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Abstract: Combined with the construction method of a highway double-arch tunnel in the karst area, a comprehensive advanced geological prediction method combining geological radar and advanced horizontal drilling is proposed, and the comprehensive advanced geological prediction method is successfully applied to the construction of a highway double-arch tunnel in a karst area of Guangxi. The result of site construction proves that the method has a satisfactory forecasting effect.

Keywords: Karst area; Double-arch tunnel; Geological radar; Advanced horizontal drilling

1. Introduction

As a new technical means, advanced geological forecasting can help construction personnel to understand the engineering geology and hydrogeology in front of the tunnel face, provide a basis for tunnel construction, and timely adjustment of support schemes, to effectively control the occurrence of geological disasters, ensure the safety of tunnel construction, and avoid or reduce personal injury; Improve the speed of tunneling and save investment [1]. The commonly used geological analysis method mainly includes the ground geological survey method, finger face geological catalog, advanced horizontal drilling method, advanced heading method, etc. Geophysical detection law includes the geological radar method, a TSP seismic reflection wave method, a transient electromagnetic method, a Beam advanced prediction method, a land sonar method, an infrared radiation temperature measurement method, and a three-dimensional resistivity inversion method[2]. In the actual project, it is necessary to combine the actual situation of tunnel construction and select the appropriate comprehensive method to carry out the advanced geological prediction to get the ideal effect. Combined with the geological condition, construction method, and schedule requirements of a highway double-arch tunnel in the karst area of Guangxi, this paper uses the detection method of advanced drilling and geological radar to carry out the comprehensive geological prediction of the tunnel excavation section, which effectively guides the tunnel construction.

2. Geological radar -- advance horizontal drilling advance geological forecast

2.1 Geological radar method

Geological radar technology[3] uses electromagnetic waves of different frequency segments to transmit specific frequency electromagnetic waves from the ground to the ground below the surface in the form of wide-frequency short pulses through the transmitting antenna. After reflecting through the interface of different media or strata underground, the electromagnetic waves return to the ground and are received by the receiving antenna. The received radar signals are processed and the image is interpreted to achieve the purpose of detecting the hidden target in front.

Most of the geological radar used now is the directional shield antenna, which has the advantage of the strong anti-interference ability in the complex electromagnetic interference environment in the tunnel, so the prediction of groundwater, karst cave, and fault fracture zone in the geophysical exploration means is more accurate[4]; However, due to the large dielectric constant of the underground medium, the energy of the electromagnetic wave in the process of underground medium propagation has a large attenuation, so that the effective detection distance of the geological radar is greatly limited, and the detection distance and the water content of the underground medium has a large connection, through a large number of practical detection applications show that the effective distance is short[5] compared with other geophysical means.

2.2 Advanced horizontal drilling method

Advanced horizontal drilling is by far the most accurate and direct method of geological exploration. It is to use the drilling rig to

drill 15 ~ 30m horizontally in the direction of excavation, through the drilling speed test, core adoption rate statistics, drilling core identification, and other means to determine the distribution of strata in front of the palm face, the degree of soft and hard formation rock, rock integrity and possible fault, hole distribution location. In the method of advanced horizontal drilling, the judgment of the geological condition is very accurate, but because of the time-consuming and high cost, there are certain limitations in the tunnel's advanced geological forecast.

2.3 Geological radar combined with advanced horizontal drilling integrated advanced geological forecast method

In the following, the construction method of the middle guide cave-positive tunnel step excavation method is taken as an example, and the comprehensive advanced geological prediction method of geological radar combined with advanced horizontal drilling is briefly introduced. In the process of the construction of the tunnel, the geological radar is fast and efficient, combined with the site environment of the small space of the palm surface of the tunnel, and equipped with a 100MHZ shielded antenna to advance the forecast of the karst cave, filling material and crushing zone about 20m in front of the palm surface of the tunnel, and the groundwater content detection of the suspected water-rich area is carried out in combination with the advance horizontal drilling. For the previous geological exploration situation is not much different, and there is no karst cave, the construction unit can be constructed according to the original construction plan; For the cases that are different from the previous geological exploration, such as karst caves, cracks and broken layers, professional engineers should accurately locate the abnormal position within the accuracy range of geological radar, and according to the possible harm degree of the abnormal body, inform the construction unit to drill the provided abnormal position with the aid of nearby blasting holes before 10 ~ 15m away from the abnormal body. Carry out accurate exploration of the position of the abnormal body in front, and confirm the details of the abnormal body, such as lithology, species filled in the karst cave, groundwater content, etc., so that the construction unit can make timely response plans. After the completion of the construction of the middle guide tunnel, because the unexcavated sections on both sides are all within the effective detection range of the geological radar, the unexcavated sections on both sides are detected by the geological radar. According to the detection results, advanced horizontal drilling is properly adopted for verification and confirmation, to find out the geological diseases of the unexcavated sections, provide detailed geological conditions for the construction of the positive tunnel, and make a response plan in advance.

3. Application examples of comprehensive advanced geological forecasting methods

3.1 Project Overview

Starting and ending mileage K74+335 ~ K74+940 of an expressway double-arch tunnel in Guangxi, passing through karst areas with a maximum buried depth of 96 meters. The geological survey report shows that the surrounding rock is mainly composed of limestone, dolomitic limestone, and fragmentary clay, local rock strata are broken and pass through faults, karst caves and joint cracks are relatively developed, and there may be landslides, water gushes, and mud protrusions.

3.2 Typical forecast examples

As shown in Figure 1, from the processed radar images, it can be seen that there is a banded anomaly, showing a large amplitude and strong reflection, and it can be seen that there is a significant difference in the reflected wave frequency of the radar reflection images on both sides of the banded anomaly. It is preliminarily judged that the area is a fault and rich in water, and the judging tendency is between 80° and 90° combined with the position of the measurement line. Advanced horizontal drilling exploration was carried out on the abnormal reflection position, and the drilling depth was about 10m. After drilling and exploration, the rock formation of the zonal body is broken, and the lithologies on both sides are limestone and quartz porphyry respectively. A large amount of water was gushed out from the advanced horizontal borehole, which further verified the accuracy of geological radar detection and interpretation. The construction unit adopts the method of advanced small pipe grouting and steel support to cross the water-rich fault fracture zone.

4. Conclusion

As a means of advanced geological prediction in tunnels and other caverns, geological radar has the advantages of convenient operation, strong anti-interference ability, and accurate prediction of geological disasters such as groundwater, karst caves, fault fracture zones, etc. However, there are still some limitations on the content of groundwater, the filling species in karst caves, and the detection distance. Combined with advanced horizontal drilling, it can give full play to the advantages of both and improve the forecast accuracy. The method of geological radar combined with advanced horizontal drilling is applied to advance the geological prediction of a highway double-arch tunnel in a karst area of Guangxi. Comparing the analysis and prediction results with the actual excavation results shows that the prediction of fissure water, karst cave, and water-rich fault by this method is more accurate and the prediction effect is ideal.

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