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Research Article

Analysis of Non-destructive Testing and Disease Diagnosis Technology of Tunnel Projects

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Abstract: Engineering incidents caused by the quality of tunnel construction and geological diseases occur from time to time, which not only causes many problems in engineering geophysical prospecting, but also provided a broad space for the application and development of engineering geophysical prospecting technology. Non-destructive testing technology has made great progress. Combining the diagnosis and treatment of tunnel diseases, the ground penetrating radar non-destructive detection technology is discussed.

Keywords: Tunnel engineering; Non-destructive testing; Disease diagnosis

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1 Introduction

In recent years, due to the tremendous increase in tunnel projects, the requirements for the quality of tunnel projects are getting higher and higher. Traditional tunnel quality inspection and control methods are heavy-duty, low-efficiency, high-cost and lowly-representative. Compared with traditional engineering testing methods, non-destructive testing technology has obvious advantages and does not require the use of other reagents or extensive preparation. Meanwhile, it has more prominent functions than traditional testing methods, such as non-destructive testing, random testing, remote testing, and field testing, etc. Whether the tunnel structure can achieve the expected function is a comprehensive process. Tunnel conditions diagnosis usually uses a combination of on-site prospecting and non-destructive testing. The diagnosis results of tunnel structural diseases can scientifically evaluate the health of the tunnel structure. However, the application of these methods is not yet universal across China. Many project technicians and managers do not understand the principles, detection methods and existing problems of these geophysical prospecting methods. This not only hinders the solving of engineering problems, but is also not conducive to the wide application of engineering geophysical technology. Currently, non-destructive testing technology has played a very important role in China's tunnel projects. Commonly used non-destructive testing methods are ground emission radar method, infrared method and ultrasonic method. With the continuous improvement of China's technical level, various non-destructive testing technologies have made considerable progress. With the help of non-destructive testing technology, the safety of various tunnel projects is greatly guaranteed. The research on non-destructive testing technology has a significant impact on the future development of highway tunnel engineering in China. Therefore, it is necessary to strengthen research and investment in this technology, and continuously improve the quality and efficiency of non-destructive testing technology.

2 Non-destructive Testing and Disease Diagnosis Technology

Tunnel condition diagnosis usually uses a combination of on-site prospecting and non-destructive testing. The diagnosis results of tunnel structural diseases can scientifically evaluate the health of the tunnel structure. However, the national application of these methods is not yet universal. Many engineering technology and management personnel do not understand the principles, detection methods and existing problems of these geophysical prospecting methods. This not only hinders the solving of engineering problems, but also hinders the wide application of engineering geophysical technology. In addition, it is difficult to fully and accurately grasp the state of highway tunnel projects only through on-site investigation in the status detection of tunnels. Therefore, it is necessary to accurately understand the internal conditions of highway tunnels. As non-destructive testing technology can effectively detect and analyze various quality defects and voids on the surface, interior, surrounding rocks, and between surrounding rocks and the lining, it has been widely used in road tunnel structural testing.

2.1 Non-destructive Testing Technology

Non-destructive testing is to analyze the structural rationality, material characteristics, design defects, and physical parameters, etc. of the test objects through acoustic wave, electromagnetic wave, infrared and spectroscopic analysis under the premise of ensuring the integrity without damaging the test objects. How to discover problems. In tunnel lining, non-destructive testing methods are usually used to detect the thickness of the lining, the gap behind the lining, the gap between the intermediate layers of the synthetic lining, and the distribution of lining steel bars. The non-destructive testing methods commonly used for tunnel linings in actual projects include acoustic wave method, ground-penetrating radar method and optical analysis method.

Ground-penetrating radar close to the surface of the geophysical prospecting can accurately detect targets such as shallow structures. As the ground-emitting radar works, high-frequency broadband short pulse electromagnetic waves are sent to the target and reflected by the transmitting antenna, then return to the ground and received by the receiving antenna. By analyzing the waveform, width and time-varying characteristics of the reflected electromagnetic waves, we discussed the performance of the lining structure and tested the construction quality of the lining structure. The conductivity is different from the dielectric constant, and the electromagnetic wave reflected at the interface of different materials will be different. The resolution of ground-penetrating radar (GPR) is usually inversely proportional to the measurement distance. The choice of antenna frequency is based on the measurement range. In order to improve the resolution, the measurement range and antenna frequency must be comprehensively considered according to application requirements.

2.2 Tunnel Disease Diagnosis Technology

Seismic tomography is the application of CT technology in the field of geophysics. The seismic wave attenuation observation data can accurately and reliably reflect the internal structure of the geological body. On the other hand, when the medium has high speed and high density, it is related to the high elastic modulus and high shear strength of the medium. Therefore, it can also effectively explain the distribution boundary of various rocks and soil and the degree and distribution of rock mass fragmentation. It is usually used in engineering geological prospecting to detect the location, shape and mechanical strength of bad geological bodies (structures), such as fault zones, joints, aquifers, karst caves and weathered zones. It can also be used for 2D and 3D geological imaging by observing geological conditions (such as drilling, tunnels, slopes, mountains and ground).

3 Analysis of Non-destructive Testing Technology Application

3.1 Site Preparation

In order to ensure the quality of the tunnel lining, the non-destructive testing of the lining structure can be effectively guaranteed. Technological innovation and development have effectively controlled the quality of tunnel lining. Record the construction site, determine the applicable radar antenna types according to the guidance of relevant technical standards, and select the personnel who can correctly place the prospecting ship on this basis. The integral characteristics of the test objects were comprehensively evaluated. Good at designing parameters of ground penetrating radar. Finally, determine the dielectric constant of the area. Non-destructive testing technology is affected by environmental factors and has a narrow application range. It requires a large amount of parametric calculation to directly connect with the tunnel lining structure in the area. When constructing the tunnel lining, corresponding treatment and backup should be carried out according to the service life and rigidity of the structure. Various non-destructive testing techniques can be combined with the characteristics of actual testing to ensure smooth testing.

3.2 Placement of Markers and Measuring Lines

When placing markers and measuring lines, two-dimensional objects should be used as the reference. Based on this, a high degree of parallelism can be achieved before the measuring lines, and all measuring lines must be perpendicular to the target axis. For 3D objects, you need to use the grid method to place the measurement lines. The layout specification of the master-slave measuring instrument requires five for each hole. If there are special requirements, a comprehensive level measuring instrument must be installed. When performing horizontal wiring, the test requirements must be strictly followed. If some segments fail in the actual test process, tightening measures must be taken to meet the test requirements.

3.3 Construction Site Environmental Records

Geological radar technology is prone to influences from the wild environment. Therefore, it is necessary to prepare before construction, to understand the geological conditions of the area by referring to environmental data, etc., and to record the site environment as a basic guide for subsequent data processing.

3.4 Data Processing and Disease Diagnosis

The signal received by GPR is converted from analog to digital, and then transmitted to the computer. After processing a series of data (such as filtering and gain recovery), a radar detection image is formed. GPR image is the basic image of data interpretation. As long as there is an electrical difference between the target and the surrounding medium, it can be reflected in the contour of the radar image. The wave traveling time t of the target reflected wave can be determined by tracking the phase axis. The depth of the target layer can be calculated according to the electromagnetic wave velocity V of the underground medium and the propagation time of the radiation wave. And according to the analysis of this section, the final result of the entire prospecting area is the map. Since the thickness of the decorative layer and the impermeable layer is too thin, an effective response cannot be obtained by the detection unit. The interfaces in different layers have different events, and the distribution of steel bars has diffraction. When the original rock wall attached to the initial support is destroyed, reflected signals will appear when partially filled with water, and the scattered signals will increase.

3.5 Organize Analysis and Diagnosis Results

Then they are drilled to identify each problem point to ensure the reliability of the diagnosis. Prepare the final disease distribution table based on the on-site investigation and diagnosis results. The content of the distribution table provides the scientific basis for the final research plan, including mileage, station number, station pictures, radar outline function description, disease type and condition description, condition deductions, condition levels and preliminary treatment plan.

4 Conclusions

Compared with the conventional methods, the non-destructive testing method can effectively solve the problem of lining damage caused by the conventional testing methods and eliminate potential safety hazards. It can be seen that non-destructive testing methods play an irreplaceable role in the diagnosis of tunnel diseases, and selecting appropriate technical parameters for field testing is an effective method to improve the quality of tunnels.

References

[1] Chen YD. Health diagnosis and disease treatment of highway tunnels [J]. Sichuan Building Materials, 2020, 46(3): 153-154.

[2] Yang CH. Nondestructive Testing Technology in Quality Testing of Tunnel Projects [J]. Sichuan Building Materials, 2019, 45(9): 190-191.

[3] Hu XH. Thoughts on the Development of Nondestructive Testing Technology for Tunnel Lining [J]. Communications Science and Technology Heilongjiang, 2017, 40(9): 153-154.

[4] Yang ZN. Health and disease diagnosis technology of tunnel[J]. Shandong Jiaotong Keji, 2015(5): 92-93+95.