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Research on the Application of Geological Radar Detection Technology in Highway Engineering Detection

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Abstract

Aiming at the quality problems that are easy to occur in the application process of highway engineering, the geological radar detection technology is used for a comprehensive study. Below, taking the application principle of geological radar detection technology as the starting point, the advantages of geological radar detection technology are explained, the process of using geological radar detection technology and the specific application of geological radar detection technology are analyzed, and finally, the measures to control the application error of geological radar detection technology are summarized.

Keywords

Geological radar; Highway engineering; Pavement thickness; Pavement disease

Introduction

Geological radar detection technology is currently widely used in highway engineering inspection, and has achieved good application results during the specific application period. However, judging from the application of geological radar detection technology, in order to ensure that the role of technology can be reasonably exerted, it is necessary to continuously strengthen the exploration of geological radar detection technology.

1. Application principle of geological radar detection technology

Geological radar detection technology is a new type of highway engineering detection technology. Its principle during application is to transmit pulsed high-frequency electric measuring waves into the ground. When the electromagnetic waves are running underground, if they encounter different electrical materials, various physical phenomena such as scattering and reflection will occur. The receiving antenna installed on the ground can receive the electromagnetic waves [1]. Finally, when the relevant staff are carrying out their work, they will sort out the collected data, and then make accurate judgments on the electrical properties, structure and other contents of the specific location of the reflected wave based on various parameters such as intensity and shape, so as to provide support for the subsequent corresponding analysis work. In essence, the geological radar detection technology in highway engineering detection is to detect the situation of highway engineering by applying the principle of electromagnetic wave pulse reflection. When detecting the situation of highway engineering, it does not need to come into contact with the highway and will not cause damage to the highway engineering structure. The overall application effect is good [2].

2. Reflection of the advantages of geological radar detection technology

Highway engineering inspection work is a complex task, and many different types of technologies are used in actual

work. Through the application of various technologies and the continuous in-depth research, geological radar inspection technology was finally derived. This technology has significant advantages in highway engineering inspection, so it has been widely used. From the specific application situation, good application effects have been achieved, and its application and promotion should be strengthened. By analyzing the application of geological radar detection technology in highway engineering detection, it is mainly reflected in the following aspects:

2.1 High resolution

By applying geological radar technology, the resolution can reach the centimeter level during specific detection. During the operation, through a series of calculations and corresponding analysis operations, the electromagnetic wave reflection signal can accurately express the target medium information, thereby providing data support for subsequent corresponding work [3].

2.2 No damage to highway works

As a new type of highway engineering detection technology, when it is applied, there is no need to drill holes in the road for sampling, it will not damage the highway project, and the detection results are accurate.

2.3 High efficiency and strong anti-interference ability

Based on geological radar detection technology, corresponding detection operations are carried out, which makes the detection work more convenient and efficient, and can greatly reduce the workload of detection staff and reduce work pressure. Geological radar detection technology has strong resistance to external interference and can be reasonably applied to different detection links.

3. Process of using geological radar detection technology

3.1 Do a good job of preliminary judgment

The geological radar detection technology is applied in highway engineering inspection. Before the specific operation is carried out, the relevant staff should judge the specific inspection results of highway quality, which mainly include the following contents:

(1) Whether the geological structure of the highway project has any quality problems such as broken plates and cracks.

(2) Whether there are any quality problems such as broken plates or cracks on the road surface that affect the application of highway engineering and reduce the driving comfort of vehicles.

(3) Check whether the road slab has any problem of falling off the pit.

If a highway project encounters one or more of the above problems, it is necessary to pay more attention to the inspection of the specific quality of the highway project, ensure that quality problems can be accurately discovered, and take reasonable measures to solve the problems, so as to avoid serious quality problems after the highway project is put into use, which will affect the traffic environment [4].

3.2 Accurately select measuring points

For highway projects, if there are quality problems, such as the road panel being hollowed out, when a heavy-loaded vehicle passes by, the road panel will experience various types of defects such as shaking, lifting, and falling construction materials. In response to this situation, construction personnel must use geological radar detection technology to accurately judge the various quality problems that may occur in highway projects, and combine relevant practical experience and theoretical knowledge to complete the corresponding analysis and summary work, and clarify the main reasons for the hollowing out of the road panel. Generally speaking, the main reason for this phenomenon is that a large number of overloaded vehicles are driving on the road, and rainwater invades the road, causing the material to fall off, thereby causing muddy phenomena. In response to this phenomenon, when testing the highway project, it is best to choose the road panel connection as the detection point to ensure the smooth implementation of the detection work and improve the accuracy of the detection results.

3.3 Adjust parameters appropriately

When applying geological radar detection technology to highway engineering inspection, even if the high and low

values of the center frequency are in a normal state, it cannot guarantee that the actual depth of the highway detected by the radar is accurate. When carrying out specific operations, the detection results must be compared and analyzed. Through comparison and analysis, the data that best matches the actual detection results can be selected. It should be noted that the staff should calculate the detection results in detail, do the corresponding analysis work, and record the geological information in detail, especially focusing on the time-frequency characteristics and amplitude [5]. At the same time, the selection of radar detection equipment should be done well, and the corresponding equipment should be selected in a comprehensive manner based on the specific situation to ensure that the equipment finally used has good performance and accurate data can be obtained through detection.

3.4 Analyzing Data

After obtaining the corresponding test data, the software needs to calculate the obtained data in detail, complete the analysis and processing, and finally obtain the test results. In order to ensure that the accuracy of the final test results can meet the expectations, the test results must be processed in real time and scientifically to ensure that the data obtained from the two tests are consistent.

4. Specific applications of geological radar detection technology

4.1 Detecting the thickness of highway pavement

When testing highway pavement, thickness is an important testing indicator. This is mainly because some construction units often reduce the thickness of highway pavement and the amount of construction materials used in order to obtain higher profits during highway construction. Pavement thickness is an important indicator when carrying out highway engineering testing work. Its thickness will have a direct impact on the final quality of the entire highway. Therefore, for the control of the overall cost of highway engineering, it is necessary to take the highway pavement thickness that can meet the required standards as the benchmark to ensure that the quality of the final highway construction can meet expectations [6].

When testing the thickness of a highway pavement, construction workers need to select a section of the highway pavement for testing. Workers should insert antennas at intervals on the highway, first test the pavement, and then perform core testing on the lanes. In order to ensure that the data finally obtained can accurately reflect the specific conditions of the highway project, three test points need to be set. When the testers are working, they apply the data sent back by the first test point to infer the conditions of the second and third test points, and then carry out corresponding operations. From the current specific construction situation of highway projects in China, most asphalt pavements are laid in 2-3 layers. Considering the difficulty of highway construction, errors are inevitable between the bottom layer and the subbase layer, especially the lower layer. Errors often occur, and errors cannot be completely avoided. The errors should be kept to a minimum. Therefore, when carrying out the testing work, construction workers must carefully test and complete the measurement of the specific thickness of the lower and middle layers of the highway. Especially for the thickness of the lower layer, when the specific work is carried out, the thickness of the middle and upper layers can be adjusted according to the specific thickness of the lower layer of the highway. In particular, the thickness of the middle layer should be adjusted to ensure that the final thickness of the highway engineering layer can meet the required standards [7]. Therefore, when using geological radar detection technology, high accuracy requirements are required. This technology can be used to carry out detection operations when detecting highway pavement.

Table 1. Actual measured values of detection points 12 and 6

Detection point	Specific data
Checkpoint 12	The average thickness of the highway pavement is 19.23cm, with the minimum thickness being 18.42cm and the maximum thickness being 19.78cm.
Checkpoint 6	The average thickness of the highway pavement is 18.82cm, with the minimum thickness being 16.41cm and the maximum thickness being 19.02cm.

For example, a highway project has a total length of 24.58 km, with two-way four lanes. The highway project was completed and put into use in 2015. Due to the rapid development of the local economy and the continuous increase in vehicle load, the road surface has been damaged and severely worn. In order to complete the analysis of the

highway section, the geological radar detection technology should be used to detect the thickness of the highway road surface. When the specific detection operation is carried out, the data of two detection points can reflect the actual changes in the road surface thickness of this highway section. During the specific detection, the actual measurement values of detection points 12 and 6 are shown in Table 1.

Through the data in Table 1, combined with the specific application years of the highway and the corresponding standards, if the thickness of the highway pavement is above 19.00cm, it can be concluded that the quality of the highway project meets the requirements, while the thickness of some sections of this section of the highway does not meet the standards. Therefore, the construction unit must carry out and maintain the highway sections to improve the overall quality of the highway project, ensure that it can meet the application requirements, and improve the traffic environment.

4.2 Detection of road surface damage

After a highway project is put into use, over time, affected by factors such as wind, rain, and vehicle pressure, different types of road surface diseases will appear. By applying geological radar detection technology to detect highway pavement, the causes of the disease and the specific location can be determined, and reasonable solutions can be found to maintain the road surface [8]. For example, after a section of highway was completed and put into use, different types of diseases appeared. In order to ensure the stability and safety of vehicles during driving, the geological radar detection technology was used to detect the highway section. The road pavement structure of the highway was a subbase layer, a cement concrete layer, and an asphalt layer. The inspection personnel first took samples from the highway and then carried out corresponding inspection work. The data obtained from the inspection should be analyzed and processed to obtain the road pavement conditions. Through the inspection, it can be found that the main problem of this section is the loose top surface of the base layer. The cause of this disease is that the base layer ingredients are unreasonable during construction, and the compaction degree does not meet the required standards. In the subsequent period, due to the influence of various factors such as vehicle load and wind and rain during driving, the top surface of the base layer is prone to loose diseases. In addition, the base layer will have settlement problems, the structural layer will slip, and the roadbed will have settlement problems, causing undulations on the top of the road surface and making the highway uneven. The above problems must be dealt with in a timely manner to improve the overall quality of the highway project.

4.3 Testing highway steel mesh

In order to accurately understand whether the steel mesh of the road surface of the highway project has been damaged during the long-term operation of the highway, the staff can use geological radar detection technology to conduct detection and complete the corresponding analysis. The steel mesh in the highway project is sensitive to magnetic positions. During the specific detection period, the specific characteristics of the steel mesh on the road surface can be grasped by applying the principle of electromagnetic waves. During the detection period, the image display is closely related to the degree of steel loss. If the loss is serious, the coaxial is relatively dense, and if the steel loss is low, the coaxial will be a small arc.

4.4 Testing the compaction of highway pavement

During the highway construction process, non-standard construction links and insufficient compaction will reduce the compaction of the highway pavement structure. If the density is uneven, the highway medium distribution in the area will be uneven. The geological radar detection technology is used for detection. In the road imaging profile, there will be few layered waveforms, no rules to follow, and few regular waveforms. This will cause the final compaction of the highway pavement to fail to meet the required standards.

5. Measures to control application errors of geological radar detection technology

5.1 Reasonable measures to control the time error of transmitted signals

When applying geological radar detection technology to highway engineering inspections, errors may occur due to the influence of various factors. When carrying out specific work, relevant staff must strengthen the analysis of the causes of errors so that they can take reasonable measures to control the errors and ensure that the final detection

results are accurate. When using geological radar detection technology, the launch time will have a certain impact on the results of geological information analysis. When the actual measurement is carried out, the recording of various information is mainly carried out manually, and errors often occur due to the ability of the staff. For this type of error, taking reasonable measures to control it can improve the accuracy of the final result. When carrying out specific work, the following measures can be taken:

(1) Scientifically selecting time nodes and doing this work well can ensure that the test personnel can reasonably process various data on the one hand, and on the other hand, it can improve the accuracy of recording reflection time. Generally speaking, the starting point of the reflection signal is recorded as the starting point of the reflection time, and the test personnel take reasonable technical measures to complete the zero point mark to eliminate time recording errors.

(2) During the actual recording period, in order to ensure the accuracy of the final recorded results, a technician should be assigned to record the start and stop times, so as to control the recording time error within a reasonable range and ensure that the final test results are accurate.

5.2 Measures to control the calibration error of highway structure intermediate points

During the detection of highways, the electromagnetic wave propagation is easily affected by the medium point constant of the highway engineering structure, making it difficult to ensure the accuracy and scientificity of the final detection results. Therefore, when using geological radar detection technology, the medium point constant must be calibrated. During the specific measurement period, calibration error is a common error. Common calibration methods are as follows:

5.2.1 Core Drilling Calibration

By utilizing the interval between the drill core and the electromagnetic wave reflection, the dielectric constant of the highway structure is accurately determined. However, this calibration method is easily affected by the density of the highway structure and it is difficult to ensure accuracy.

5.2.2 Computer calibration

By applying the computer to build a model, the thickness of the highway project structure can be determined by applying the built model, and subsequent calibration work can be carried out. It should be noted that after the calibration is completed, corrections should be made in a timely manner.

5.2.3 Reflection wave calibration

Through the electromagnetic wave reflection coefficient method, the specific connection between the reflection coefficient and the dielectric constant is fully completed, and based on this, the dielectric constant is judged. During highway construction, the density and uniformity of the structure will have a certain impact on the application of this method, which also leads to certain limitations in the application of this method. During specific construction, what method to adopt should be determined according to the actual situation.

6. Conclusion

Applying geological radar detection technology to highway engineering inspection can timely discover problems, report them to the relevant units, formulate corresponding repair and maintenance measures based on specific problems, and minimize the losses caused by diseases. In order to enable the constructed highway projects to provide people with a good traffic environment and promote economic development, it is necessary to strengthen the application of geological radar detection technology in research, continuously improve it, and ensure that the role of technology can be reasonably played.

References

[1] Yan Liang. On the importance of highway engineering test and inspection for highway engineering management[J]. Juye, 2022(03):160-162.

[2] Cai Yichao, Li Xiaomeng, Luo Ying, Shi Rujun. Application of geological radar in tunnel lining quality inspection: A case study of a highway tunnel in Yunnan[J]. Engineering Technology Research, 2021, 6(18): 114-115.

[3] Xiong Bin. Research on the application of highway engineering detection in highway engineering quality control[J]. Low Carbon World, 2021, 11(06): 241-242.

[4] Tan Chunteng. Application of geological radar in tunnel engineering quality inspection: Taking Changde to Anhua (Meicheng) Expressway Tunnel Engineering as an example[J]. Jiangxi Building Materials, 2021(05):32-33.

[5] Li Yulong. Analysis on standard control of highway engineering inspection in the process of highway engineering quality inspection[J]. Heilongjiang Transportation Science and Technology, 2020,43(05):216+218.

[6] Li Congde. Analysis of lining inspection quality by geological radar method for the entrance of Dadishan No. 1 tunnel of Molin Expressway [J]. Construction Technology Development, 2020, 47(07): 125-127.

[7] Jing Zhitao. On the practical application of highway engineering test and detection technology in highway construction[J]. Engineering Construction and Design, 2017(16):75-76.

[8] Tan Chun. Geological radar detection and analysis of common diseases of soft soil roadbed highway[J]. Shanghai Land and Resources, 2016,37(03):92-96.