

Strategies for Strengthening Highway Construction Testing and Quality Control

Linli Ni*

China Merchants Chongqing Highway Engineering Testing Center Co., Ltd., Chongqing 400060, China

*Corresponding author: Linli Ni, 398883471@qq.com

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Abstract: In recent years, the scale of China's highway projects have been expanding. However, in real life, road construction projects in some places have not passed professional and rigorous inspections, resulting in various quality problems, and seriously affecting the safety of drivers and pedestrians. This paper analyzes the current situation of highway engineering test and detection, expounds the application of new technologies for highway engineering test and detection. In this paper, a case study was carried out on ground penetrating radar (GPR), which aims to improve highway engineering test and detection and provide reference for reducing highway safety risks.

Keywords: Highway engineering; Test detection; Quality control

Online publication: May 31, 2023

1. Introduction

To ensure that the quality of the highway project is up to standard, the construction unit and relevant departments must conduct a comprehensive inspection of the entire project. There are many materials involved in highway engineering, such as cement, steel bars, etc. To ensure that the materials are of good quality, they must be sampled and tested, so that the project will not be affected. In order to ensure the quality of the project, the inspectors must conduct detailed inspections on the structural dimensions, material consumption, construction standards, etc. in accordance with the standards to make sure that the test results are accurate. In addition, the technology and machinery used in each process should follow a certain order, so that the construction process can be more coordinated. Moreover, we must strengthen the awareness of environmental protection during road construction. During the construction process, the waste of resources should be monitored to ensure that energy-saving and emission-reduction measures are implemented in the construction of the project. Outdated construction methods and equipment should be eliminated so that the speed of construction can be accelerated ^[1].

2. Analysis of the current situation of road construction test and detection

2.1. Defects in the sampling process

The sampling process should cover all road sections to prevent missing out some areas of the road ^[2]. However, there are obvious loopholes and deficiencies in the process of sample collection for highway projects, so the final data of the highway test may not be accurate. Sampling operators failed to carefully check the equipment and instruments required for sampling, resulting in incorrect selection of sampling. In addition, the entire process of sample collection is also dangerous, resulting in the loss of road test samples.

2.2. Poor quality of relevant personnel

Inspectors must have a clear understanding of the work they are doing, and make sure that they are capable of performing the required operations. However, there are still some workers of road construction test and detection who cannot guarantee the quality of roads according to the existing systems and rules, and are not willing to proactively learn information-based testing methods. In the process of collecting road samples and analyzing various parameters of the road, test engineers often incur extra expenses and increase the cost of road construction due to their incapacities.

2.3. Lack of necessary supervision

The process of road test and inspection must be strictly supervised. Or else, the work of road test and inspection will be disorderly. At present, there is a lack of strict supervision on the overall operation process of road test, and road test technicians can only deal with problems based on their own work experience. However, the final test results of highway construction must meet certain standards to be considered qualified. Without third-party supervision in this process, problems such as subjectivity and arbitrariness will appear in the process of highway testing, which makes decision-making difficult.

2.4. Defects in technical means

With the continuous expansion of the scope of highway construction, highway test and inspection work has become more difficult to perform. Therefore, the staff of each department will inevitably encounter difficulties when collecting a large amount of information. For road inspection, most of the inspection methods today requires the use of information technology. If the inspection staff does not have the relevant skills, some key data will be missed out during the inspection process, resulting in wrong inspection results. Therefore, it is of great practical significance for the staff to use and master the means of information technology. Because the data system is yet to be perfected, some important information in the highway test is lost. The operation and execution of highway engineering sample collection will affect the quality of highway construction. Therefore, it must be collected through an automated sampling data system. Relevant technicians should carry out real-time highway safety and quality management. If automation and information technology are not utilized, the highway inspection, supervision and control cannot be optimized

3. Analysis of new technologies for highway engineering quality inspection

Science and technology have promoted the upgrading of road construction quality inspection technology, thereby improving the efficiency and accuracy of road construction test and detection inspection. With the integration of Internet of Things and various fields, the test instruments of highway engineering are connected with the Internet of Things, so the test data can be intelligently processed, thereby improving the scientificity of test results, reducing manpower, and making the process fully automated, showcasing the capabilities of big data technology.

3.1. Optical fiber sensing technology

Optical fiber sensing technology has properties like anti-interference and anti-corrosion. It can achieve long-term transmission without reducing accuracy, and can also adapt to various conditions such as high or low temperature, and can improve the accuracy of detection data of highway engineering. However, in reality, due to the constraints of the working environment, it is difficult to directly obtain a lot of data through optical sensors. During highway construction, the preset of optical cable sensor devices should be done in advance. In the stage of highway construction inspection, optical cable sensors should be used to transmit data in real time accurately. At the same time, presetting optical cable sensors can also facilitate

the follow-up road construction quality inspection work.

3.2. Ground-penetrating radar technology

Ground-penetrating radar technology uses the reflection of electromagnetic waves to detect the structure of the road. This method is widely used because it does not damage the road. Its working principle is as follows: Energy is emitted from an energy transmitting device and the reflected energy goes into the receiving device, then the corresponding signal will be processed and analyzed by a computer. Due to the difference in the material, hole, interlayer, and other factors of the medium, there are differences in the energy propagation speed of the medium ^[2]. However, the propagation speed of the same medium is more continuous and constant, and its energy amplitude tends to be more balanced. Therefore, the quality of the road can be determined through the analysis of electromagnetic waves, which facilitates the evaluation and rectification of the road.

3.3. Echo detection technology

Echo detection technology is the safest technology in highway construction inspection. This technology will not generate any radioactive substances, and it will not damage the structure of the highway project. When testing, echo waves is sent into the road structure. If there are corrosion lesions or defects on the road, the echo waves will be reflected, resulting in changes in the collision diameter data. The relevant data is then be collected saved in real time, and the frequency of the echo wave is studied. In this way, the defects of the road structure can be identified, and the condition of the highway section can be understood.

3.4. Radiographic testing

Through the use of X-ray inspection technology, the internal structure of highway engineering can be fully understood and evaluated. The basic principle of this technology is that X-rays are used to detect the structure of road construction. High-speed electrons collide with the surface of the road to generate X-rays. The X-rays are then analyzed to determine the condition of the road. The position of the hole and the degree of fracture of the steel bar can be accurately determined using X-ray, thereby helping technicians to make an accurate judgment on the condition of the road and providing a basis for future maintenance ^[3].

3.5. Non-destructive imaging technology

There are many ways to detect highway projects, and the use of non-destructive imaging technology can understand the quality of the project more intuitively and efficiently. There are two main types of image non-destructive imaging technology: holographic imaging and infrared imaging. The experimental detection of road construction was carried out by using these two methods. These imaging methods can determine the degree of damage or condition of the road through the data collected ^[4].

4. Application of highway engineering test and detection technology

The working principle of ground penetrating radar (GPR) detection technology is shown in **Figure 1**.

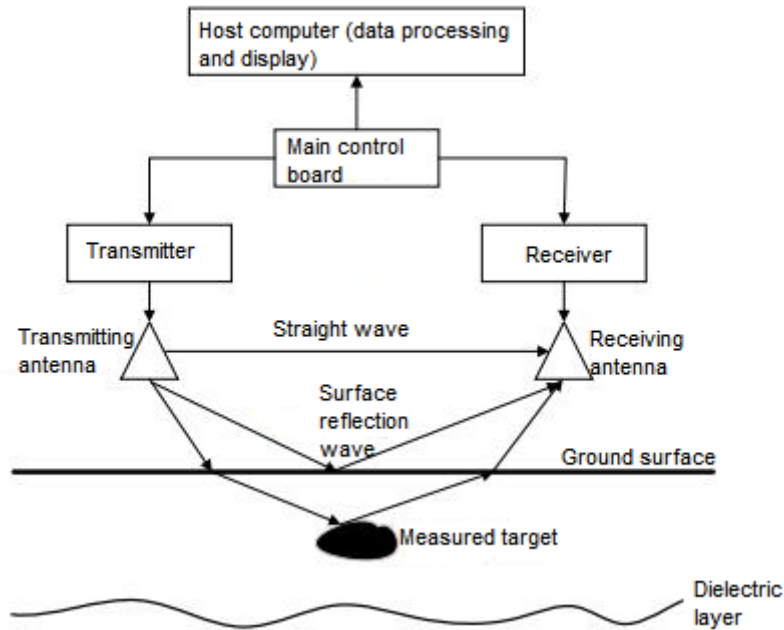


Figure 1. Schematic diagram of road detection by GPR

4.1. Detection of highway pavement surface thickness

At present, the thickness of roads in our country is between 10–20 cm, 20–30 cm, and 40 cm. Therefore, higher requirements are put forward for detection accuracy. Usually, the resolution of the detection signal is only 1/4 of that of the detection wavelet. EP-71011 GPR technology can carry out precise, continuous, non-destructive, and accurate measurements on the road. It can carry out comprehensive, precise, and continuous measurement of more than 100 meters of the road within one day. Besides, it is non-destructive, and compared to other technologies, its detection cost per kilometer is relatively low, with good detection results, and it is highly adaptable, which means it can be used for different road projects or networks.

4.2. Characteristic parameters of the medium

Table 1. Characteristic parameters of medium

Medium	Relative permittivity ϵ_r	Conductivity (S/m)	Wave speed (m/ns)	Attenuation factor α (dB/m)
Air	1.0	0	0.3	0
Freshwater	81	0.5	0.033	0.1
Seawater	81	30000	0.01	1000
Concrete	4–10	1	0.09–0.15	
Asphalt	3–5	0.12–0.18		
Clay	5–40	2–1000	0.06	1–300
Sandy soil	4–7	0.01–1	0.06–0.15	0.01–0.3
Granite	4–6	0.01–1	0.15	0.01–1

On the ground, low-frequency electromagnetic signals will be absorbed by the ground, while high-frequency electromagnetic signals can be transmitted over long distances. When it is transmitted in a lossy medium, it will cause energy loss, and the conductivity coefficient of the lossy medium is $\sigma = 0$, so that its amplitude continues to decrease^[5]. Therefore, in a lossy medium, the electromagnetic wave can be obtained by the following formula:

$$V = \frac{\omega}{\beta} = \frac{c}{\sqrt{\left(\frac{\mu_r \varepsilon_r}{2} \left[1 + \left(\frac{\sigma}{\omega \varepsilon}\right)^2 + 1\right]\right)}}$$

5. Quality control strategy for road construction test and detection and inspection

5.1. Good supervision and management of the testing process

With the continuous development of society, market conditions have become more complex. Some domestic construction companies are still unable to keep up with the construction needs of current highway projects. At the same time, they are also facing internal imperfections in terms of organization and management, and the requirements specific engineering process required are also unclear^[6]. Therefore, it will not only cause adverse consequences to highway construction, but also pose a serious threat to the safety of highway construction. Besides, the advantage of testing technology also cannot be fully utilized in highway construction. Therefore, effective supervision and control is necessary to improve the process of highway testing and detection. Highway construction test and inspection work must be strictly regulated to ensure that the whole process is orderly^[7].

5.2. Improve the comprehensive quality of testing personnel

The comprehensive ability of testing personnel affects the results of road construction test and detection. Therefore, specific executive personnel are required to have more excellent professional quality^[8]. At present, the daily inspection and supervision work of some highway sections is poorly implemented, and there are hidden dangers in highway safety and engineering quality. Therefore, the operators involved must have better knowledge, professional quality, and professional ethics. It is necessary to ensure that testing personnel fully understand the importance of road test and detection. Besides, it is necessary for testing technicians to utilize intelligent testing equipment to perform their tasks, so that they can better deal with large-scale road test and detection work while ensuring the accuracy of test results^[9].

5.3. Improving test equipment and working environment

When selecting highway construction test and detection equipment, it is necessary to consider the cost along with the practical benefits, and at the same time pay attention to the requirements for relevant indicators, so as to ensure the accuracy of testing and testing equipment. The results will only be credible if they are accurate^[10]. Therefore, it is important to do some research before purchasing instruments to fully understand the characteristics of various instruments, and to select the instruments that best meet the testing requirements and match the testing environment. In addition, the working environment of the instruments and equipment needs to be improved and should be suitable for the surrounding geological conditions and specific requirements. In the detection process, it is very important to ensure that the detection conditions meet the corresponding technical requirements.

6. Conclusion

In highway construction, test and detection of highway construction projects plays a decisive role in its quality and safety. However, there are still some problems in the current highway engineering test and detection process. If the problems are not solved, the quality and service life of highway construction will be affected. Therefore, relevant government departments, management departments, and testing personnel should vigorously promote the specification of highway engineering test and detection to ensure the accuracy of testing data and the standardization of the testing process, thereby ensuring the safety and reliability of highway construction.

Disclosure statement

The author declares no conflict of interest.

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