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Application of Non-destructive Testing Technology in Road Engineering

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Abstract: With the continuous improvement of China's economic development level, road engineering construction has become an important aspect of social development. In road engineering construction, it is necessary to ensure the safety issues of people in daily traffic behavior. Based on this, the country has incorporated non-destructive testing technology in road engineering construction into its key work policy. This article mainly analyzes the working principles and characteristics of non-destructive testing technology in current road engineering, and proposes targeted solutions based on the problems that often occur in current road engineering construction.

Keywords: Road engineering; No-destructive Testing Technology; Application

1. Introduction

With the increasing recognition of the importance of road engineering construction issues, a large number of construction experts have emerged, greatly promoting the progress of road engineering construction in China, improving the quality and level of road construction, constructing channels for communication and economic exchanges between provinces and cities, greatly driving the speed of economic development in China, accelerating resource circulation, and facilitating people's daily lives. However, with the continuous expansion of road construction scale, we are also facing more and more quality problems in road engineering. To effectively control the quality of road engineering, it is necessary to attach great importance to non-destructive testing technology in road engineering. In the past, most of the detection techniques we used were damage monitoring. However, this detection method would consume a lot of manpower, material resources, and financial resources, and the detection cost was relatively high. However, the actual abstract detection efficiency was relatively low. With the continuous improvement of computer technology, non-destructive testing technology for road engineering has been rapidly developed and has been widely applied. The application of non-destructive testing technology in road engineering not only improves testing efficiency, but also greatly reduces testing costs, which helps to improve the current level of road engineering construction in China.

2. Non-destructive Testing Technology for Road Engineering

Non-destructive testing technology is a general term for engineering techniques that inspect macroscopic defects or measure work characteristics without causing damage to the road. We still use some traditional non-destructive testing methods today, such as tapping instruments to determine whether there are cracks through echoes.[1] However, this traditional method cannot accurately determine the size and specific location of defects, so there is a significant gap between the detection results obtained and non-destructive testing technology. The use of non-destructive testing technology can ensure the accuracy of testing results and the repeatability of operations. By using non-destructive testing technology, specific acceptance standards can be referenced to control the quality of road engineering within the range that can meet the performance requirements, so that there will be no problem of "excessive quality" due to the continuous improvement of quality requirements.[2] Through non-destructive testing technology in road engineering, the specific location of defects can be found based on the testing results. Without any impact on design performance, some defective road engineering can be used, such as the degree of defects within the machining allowance, or local repairs can be made, or construction techniques can be improved to place defects in areas that can be removed through machining methods. This treatment method will effectively improve the utilization rate of building materials, thereby saving building resources and improving economic benefits. Therefore, the use of non-destructive testing technology can effectively reduce engineering costs, improve construction efficiency, meet the most basic performance requirements of road engineering, and also effectively improve economic benefits, with very high use value.

3. Application of Non-destructive Testing Technology in Road Engineering

(1). The specific role of road engineering inspection

With the rapid development of transportation, road infrastructure construction has also been correspondingly developed. With the continuous expansion of road engineering construction scale, the importance of detection technology has been increasingly recognized.[3] Road engineering is a linear project with characteristics such as wide line length, large investment, large project scale, and multiple influencing factors. In road engineering construction, every link is very important, and any construction problem may cause serious harm to the quality of the project, even causing huge economic losses and casualties. Therefore, it is of great significance to take necessary quality control measures in road engineering construction. In the process of road construction and management, road engineering inspection technology is a very important link and also an important measure for controlling construction quality. Whether it is the government's engineering quality supervision department, construction units, or supervision units, they must establish a complete simulation laboratory that can meet the needs of engineering construction to ensure supervision and management of the entire construction process. Road engineering inspection is an important component of road engineering construction technology management, and is also an indispensable component of road engineering construction quality control and handover acceptance evaluation. Quantitative evaluation of the quality of all materials and building components is conducted through experimental testing, in order to scientifically evaluate the quality of road construction. Therefore, strict testing of construction raw materials and road construction quality can effectively improve the quality of road engineering.[4] To ensure that roads can meet the normal usage requirements of society and extend their service life as much as possible, it is necessary to carefully design and supervise the construction party to strictly follow the design documents and technical specifications for construction. During the construction process, all technical personnel and

testing personnel involved in the construction should strictly control the quality of road materials and construction parameters while thoroughly mastering the construction and testing technical standards. By strictly controlling the construction process and conducting engineering quality acceptance work step by step, we can truly do a good job in road construction quality control. The detection technology used in the construction process of road engineering is an advanced technology that combines detection theory, operational skills, and basic subject knowledge of road engineering. It has now become the basic basis for engineering design drawings, engineering quality supervision, project acceptance evaluation, and engineering management decision-making. Through testing, building raw materials can be utilized more reasonably and efficiently, enabling the faster application of new materials and technologies, thereby better controlling construction progress and evaluating construction quality. Past construction experience has taught us that the main reason for engineering quality problems is that we do not attach great importance to quality inspection and control during the construction process, relying solely on experience to avoid problems. [5] Therefore, the significance of non-destructive testing in road engineering lies in the more efficient and reasonable utilization of construction resources, accelerating construction progress, further improving project quality, and promoting the further improvement of road construction technology.

(2). Application of non-destructive testing technology in road engineering

Currently, non-destructive testing technology has been widely applied in road engineering construction, mainly in the following aspects.

1.Spectral analysis technology

The basic principle of spectrum analysis and detection technology is to analyze the frequency characteristics of surface waves propagating in different media. When we give a vertical instantaneous force impact to the road surface, a set of Rayleigh wave surfaces with different frequency components centered on the vibration source will appear and propagate along the surface at a certain depth. By using different hammer weights or hammerheads, wave surface signals with different frequency components can be obtained. By using cross spectral analysis and frequency domain coherence analysis techniques, sensors can be set up at different positions to detect the propagation frequency of waves, thereby achieving the ultimate goal of detecting the mechanical parameters of layered media at different depths. Compared with the methods used in the past, this technology has significant advantages such as fast detection speed and high frequency. Through it, the thickness uniformity and interlayer contact of road engineering can be detected.

2.Image technology

This technology mainly includes two types, namely infrared imaging technology and laser holography technology. The basic working principle of infrared imaging technology is based on the differential thermal conductivity of different materials and media. Under the influence of heat sources, the surface of an object will exhibit different temperature distributions, clearly reflecting the different thermal conductivity of the surface and underlying materials and structures. The use of thermal sensors can record the isotherms of the road surface in real-time, and then identify the specific structure and existing defects of the road interior through thermal images. The basic working principle of laser holography technology is to analyze holographic images, obtain the desired data from the images, and then calculate the corresponding mechanical quantities.[6]

3.Ultrasonic testing technology

Ultrasound is a high-frequency sound wave that exceeds the highest frequency that can be received by the human ear. The propagation process of ultrasound also follows the basic propagation laws of waves. The ultrasonic testing technology used in road engineering is a new type of testing technology that determines

whether there are defects inside the structural road by emitting ultrasonic waves into the material medium and receiving the relevant parameters of the reflected wave non-destructive testing method. By placing sensors at different positions in the medium, the time required for the completion of ultrasonic propagation within the corresponding distance is measured, and then the actual propagation speed is calculated using the corresponding velocity formula. The accurate measurement of material related parameters, such as elastic modulus, bending strength, and compressive strength, can be achieved through the relationship between velocity and medium related parameters. It can also be used to detect internal defects in materials or structures. As early as the 1970s, China used ultrasonic technology to measure the specific compressive strength of rocks, and used to determine the properties of the rocks themselves. Ultrasonic detection technology has significant advantages such as simple detection process, convenient excitation, low operating difficulty, and low equipment price, and has a very broad application prospect in road detection work. At present, practical applications have been achieved in detecting the compaction and elastic modulus of roadbed and pavement materials, detecting the compressive and flexural strength of concrete, detecting the thickness and porosity of roadbed and pavement, and quickly detecting roadbed VVI.

4.Laser technology

The laser detection technology in road engineering is a comprehensive application of the three major optical principles of light diffraction, optical time difference, and photoelectric reflection. The diffraction principle of light is based on the basic principle that laser diffraction reactions occur at the slit position. By adjusting the width of the slit, several different light and dark stripes are determined on the screen, and a corresponding relationship is established between the two. We accurately judge the different changes in slit width based on the specific conditions of these stripes. The principle of photoelectric reflection is based on the basic principle that the higher the laser intensity, the higher the photocurrent intensity. With the help of photoelectric conversion equipment, the light energy is converted into electrical energy. When the laser intensity changes, the luminous current also changes. We need to set the relationship between photocurrent and displacement in advance, and can calculate the specific changes in deflection displacement based on the specific changes in photocurrent. The principle of optical time difference is to record the time difference generated by the laser passing through a short distance based on the basic principle of very fast laser propagation speed.

4. Conclusion

Road engineering construction has greatly promoted the speed of China's economic development. With the continuous expansion of road engineering construction scale, we are also facing more and more problems. How to better avoid quality issues is a problem that we must pay attention to. In the process of road engineering construction, we need to comprehensively consider the construction cost, quality issues of building materials, construction durability issues, and inevitable maintenance issues. Therefore, we need to carefully optimize the design of the construction plan, effectively supervise and manage the construction process, promptly identify areas that do not meet construction standards, and identify problems for specific analysis, so as to improve the defects in the current construction process of road engineering in China. The non-destructive testing technology of road engineering is a general term for engineering techniques that inspect macroscopic defects or measure work characteristics without causing damage to the road. Its use can effectively reduce engineering costs, improve construction efficiency, meet the most basic performance requirements of road engineering, and also effectively improve economic benefits, with very high practical value. The application of non-destructive testing technology in road engineering not only improves

testing efficiency, but also greatly reduces testing costs, which helps to improve the current level of road engineering construction in China.

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