

Research on Quality Inspection and Reinforcement Technology of Road Bridge

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Abstract: With the acceleration of urbanization, road bridges play a crucial role in urban transportation, and their quality condition is directly related to traffic safety and urban development. The article analyzes the common problems of existing road bridges, mainly including cracks, settlement problems and other aspects, to provide a reliable basis for the maintenance and reinforcement of road bridges. Based on this, the article mainly researches the quality inspection technology of road bridges and the reinforcement technology of old bridges at the present stage, and analyzes the application of quality inspection technology and reinforcement technology in improving the structural quality of road bridges according to the construction cases of Jialingjiang Bridge, Qiuyun Bridge and Luoxi Bridge in Heyang, so as to improve the safety of road bridges and prolong the service life of bridges.

Keywords: Road bridges; quality problems; quality inspection; reinforcement.

1. Introduction

Economic development, transportation first, road and bridge as an important part of transportation infrastructure, bear the important function of connecting the various regions of the city. The construction and improvement of roads and bridges can promote the economic links and resource sharing between cities, improve traffic efficiency, reduce transportation costs, and promote industrial development and urbanization. At the same time, the construction of roads and bridges can also drive the development of related industries and inject vitality into economic development. However, due to long-term use, natural disasters, design defects and other reasons, many road bridges have quality problems and safety hazards, which seriously affects the smooth flow of transportation and requires active maintenance and inspection of road bridges. Therefore, the inspection of road bridges and the reinforcement of old bridges are particularly important. Through the use of modern monitoring technology and methods, problems in the bridge structure can be found in time, and corresponding repair and reinforcement measures can be taken to ensure the safety and stability of road bridges.

2. Common Problems with Road and Bridge Quality

2.1. Cracks in Road Bridges

At present, cracks are a common disease that exists in many roads and bridges, and concrete materials are the basic materials in road and bridge construction projects, which directly affect the structural performance and service life of roads and bridges. In the construction process, the concrete material has thermal expansion and contraction properties, the bridge is affected by the temperature change of the external environment, in the case of a large temperature difference between day and night temperature changes will occur caused by the expansion and contraction of the concrete, resulting in an increase in the internal stress in the concrete, which may cause cracks in the bridge. In addition, the use of concrete in the construction of road and bridge projects by construction

personnel does not meet the required standards, such as improper operation in the process of concrete maintenance, pouring, etc., will also increase the possibility of cracks in the bridge. Nowadays, many road bridges have been used for a long time, daily wear and tear and natural aging, etc. lead to a reduction in structural strength, and vehicles traveling on the bridge will impose loads on the structure, which may lead to structural stress overload in the long term, thus causing cracks, corrosion and other problems, affecting the load-bearing capacity of the bridge and safety.

2.2. Settlement Problems of Road Bridges

Settlement problem is a common problem in the operation of road and bridge, in the process of use, due to various factors lead to pavement or bridge subsidence. The characteristics of the soil in the foundation, water content and other factors will affect the bearing capacity and stability of the foundation, for example, in the soft soil area of the foundation base or uneven foundation conditions are prone to cause bridge settlement. Changes in hydrogeological conditions such as changes in groundwater level, river scour, etc., such as falling or rising groundwater level, may cause settlement problems. Unreasonable structural design of bridges in the design stage of road and bridge projects, failure to consider the load of bridges and improper selection of support methods may also lead to settlement of bridges. The bridge may not be able to settle. In addition, the loading effects such as long-term mass vehicle traffic and overloaded vehicle traffic will also have a certain impact on the road and bridge, accelerating the settlement process.

2.3. Road and Bridge Maintenance Issues

After long-term use of road bridges, if the maintenance is not timely or lack of regular inspection, it will lead to structural damage of the bridge, and there are potential safety hazards. In the quality inspection of road and bridge projects, inspection technology and inspection equipment play a crucial role in the quality inspection results. If the testing equipment is backward and the technical level is low, it may not be able to obtain accurate parameters, and the technicians

cannot accurately assess the health of the bridge structure, which leads to a lag in the testing and maintenance of road bridges by construction technicians. Moreover, it may not be able to detect small cracks or damages in the road and bridge structure, which is easy to ignore potential safety hazards and unable to provide accurate data support, delaying the maintenance time, leading to further deterioration of the quality of the road and bridge, and making it difficult to ensure the safety and durability of the road and bridge.

3. Road and Bridge Quality Inspection Technology

3.1. Ultrasonic Detection Technology

Ultrasonic testing technology utilizes the property of ultrasonic waves propagating at different speeds in different materials to test the quality of road and bridge projects. The main principle of this technology is to use professional instruments such as ultrasonic detectors and acoustic converters to detect the propagation speed of ultrasonic pulses, the main frequency and vibration waves, etc., and use the collected data to study and analyze the quality of the road and bridge, so as to detect defects or structural conditions inside the bridge. The advantages of ultrasonic inspection technology are that it can detect defects or structural conditions within the bridge. The advantages of ultrasonic inspection technology are low inspection cost, simple operation, and the ability to detect smaller defects or cracks and provide accurate results. The technique is an advanced non-destructive testing technique that does not cause damage to the object being tested. If water, air, etc. exists inside the bridge, it may be interfered with during ultrasonic testing, resulting in inaccurate reflected wave data and inability to accurately detect the internal structure.

Take the Heyang Jialing River Bridge as an example, this bridge is a steel-tube concrete arch bridge. For example, this bridge is a steel pipe concrete arch bridge, using RS-UT01C acoustic detector for the initial quality inspection of the 24 main chords of the main span and side spans of the Heyang Jialing River Bridge after concrete filling, 27 abnormal ultrasonic data were detected, and many steel pipes were found to have the phenomenon of de-voiding. The re-inspection results after rectification of concrete patching inside the pipe showed that the concrete inside the steel pipe after patching treatment was in close contact with the steel pipe wall, with no de-voiding phenomenon, and the strength met the design requirements. This case shows that the use of advanced testing equipment and technology can effectively detect and solve the hidden problems, improve the quality of road and bridge projects, and ensure the safety of the bridge structure.

3.2. Fiber Optic Sensing Detection Technology

Fiber optic sensing detection technology uses optical fiber to convert external physical quantities into detectable optical signals, so as to detect prestress, overall tension, strain, etc. in road and bridge engineering. Compared with the traditional detection technology, this technology has been able to effectively meet the current needs of bridge detection, fiber optic sensing detection technology has high sensitivity, which helps to find the problems of road and bridge structures early. The external environment has less impact on the fiber optic sensing detection technology, which can work in a complex environment to ensure the accuracy of the detection data.

Fiber optic sensing detection technology is flexible and can be made into different shapes according to different detection requirements on site. In addition, fiber optic sensors can accurately monitor the failure range of road and bridge structures, and can take timely repair or maintenance measures to improve the safety of road and bridge.

3.3. Infrared Thermal Imaging Detection Technology

Infrared thermal image detection technology uses the thermal radiation characteristics of the object, through the infrared thermal camera will be the object surface of the infrared radiation signal into a visible thermal image, through the analysis of these thermal images can obtain the temperature distribution of the target object. The technology can detect the temperature distribution of the road surface or bridge structure to find the existence of quality problems, such as thermal damage, cracks, leakage and so on. The advantage of infrared thermography is that it does not require direct contact with the object to be detected, which reduces the damage and interference to the road and bridge structure and protects the integrity of the structure. In addition, infrared thermal imaging detection technology can provide a high-resolution thermal image to show the changes in the surface temperature of the target object, which can help to find the damage of the bridge structure in time. However, infrared thermography requires high environmental conditions, such as temperature, humidity and other factors may affect the accuracy of the detection results.

3.4. Geological Radar Technology

Geo-radar technology is a non-destructive testing technique that utilizes the properties of electromagnetic waves propagating through the subsurface medium to obtain information about subsurface structures. When a geo-radar system sends out high-frequency electromagnetic waves, these waves are reflected or refracted at different media interfaces in the subsurface. By receiving and analyzing the characteristics of these reflected waves, the location, depth and material properties of underground structures can be determined. Geo-radar technology has high efficiency and high resolution, can quickly obtain information about underground structures to complete the inspection work, and can provide high-resolution underground images to provide comprehensive information for road and bridge construction and maintenance. However, this technology also has some limitations. However, the technology also has certain limitations, the detection depth of geo-radar is affected by the electromagnetic wave frequency and the characteristics of the underground medium, and there are certain limitations for the detection of deeply buried underground structures.

3.5. Camera Monitoring Technology

Camera monitoring technology monitors the deformation, vibration and other information of the road and bridge in real time by installing cameras, capturing video images or photos, and analyzing and processing the image data by using computer vision and image processing technology to get the visualization information of the bridge. Camera monitoring technology can capture the operating conditions of road and bridge in real time, discover abnormal problems of the bridge in time and take corresponding maintenance measures to ensure the safe operation of road and bridge. The technology can realize remote monitoring at the same time can record the

monitoring data, convenient for technicians to view the monitoring data and analyze the changes of the bridge, and timely detection of potential safety hazards. Camera monitoring technology in road bridge maintenance can improve monitoring efficiency, reduce labor costs, timely detection of problems and take measures to help protect the safety and reliability of the bridge.

4. Application of Quality Inspection Techniques in Bridge Reinforcement Projects

In bridge reinforcement, road and bridge quality inspection technology plays a crucial role, and its application scope covers many aspects. Firstly, in structural assessment, the quality inspection technology can comprehensively detect the defects, cracks and corrosion of the bridge structure, providing accurate data and reliable basis for the reinforcement technology. Secondly, in terms of load capacity assessment, this technology can assess the bearing capacity of the original structure of the bridge through load calculation and structural calculation, so as to determine the specific direction of the reinforcement technology. In addition, this technology can also be used for material quality testing to ensure that the quality of reinforcement materials meets the standard requirements and improve the reliability of old bridges. In terms of construction quality monitoring, the road and bridge quality inspection technology can monitor the quality problems in the process of reinforcement construction, and timely find and solve the situation of substandard construction quality. Finally, quality inspection technology can be applied to structural safety monitoring, which can monitor the reinforced bridge structure in real time, verify the reinforcement effect, and guarantee the safety and stability of the structure. The quality inspection technology can be applied to structural safety monitoring. Therefore, the application of road and bridge quality inspection technology in the reinforcement of old bridges is of broad and important significance, which not only helps technicians to assess the health status of bridge structures, but also guides the development and implementation of reinforcement programs. Through timely detection of potential problems and taking corresponding measures, it provides key support and guarantee for the design, construction and structural safety of bridge reinforcement projects, which helps to extend the service life of bridges and improve the safety of transportation.

5. Bridge Reinforcement Techniques

5.1. Strengthening Techniques for Increasing Cross Section

Increase cross-section reinforcement technology by increasing the cross-section area of the concrete structure or planting reinforcement to improve the stability and load-bearing capacity of the bridge structure. The construction process is relatively simple, the technical requirements are not high and the reinforcement effect is obvious, is a commonly used bridge reinforcement technology, its main principle is to add a new concrete layer above, below or around the existing structure, and with appropriate steel reinforcement, and then jointly bear the load. The main principle is to add new concrete layers above and below or around the existing structure with suitable reinforcement, so that they jointly bear the load, thus enhancing the overall structural load-bearing

capacity and stability.

Take the Qiuyun Bridge For example, with a total length of 241.5 meters, the superstructure is a rigid arch and the substructure is a solid pier. Detection found that the main disease including arch ribs, diagonal bracing and transverse beam cracks, as well as 1 # pier pier body bottom and bearing platform combined surface fracture. In view of the disease situation, the arch ribs and transverse bulkheads take the method of increasing the cross-section for repair and reinforcement, and at the same time optimize and increase the cross-section size of Pier 1, strengthen the pier body planting reinforcement, as well as to strengthen the combination of old and new concrete and the pier body with the foundation. Through the comparison of finite element model calculation and measured deflection value, the bearing capacity of Qiuyun Bridge after repair and reinforcement meets the requirements of original design load, and significantly improves the strength and stiffness of each member of the rigid arch, and increases the bearing capacity of the bridge.

5.2. Adhesive Steel Plate Reinforcement Technology

When applying the pasted steel plate method for bridge reinforcement construction, high-strength steel plates or steel plate composite materials are utilized, which are pasted on the surface of concrete members and fixed with special adhesives or pasting materials to improve the stress performance of concrete members. This technology can effectively repair and reinforce the damaged and aging concrete structure, reduce the development of concrete cracks, and extend the service life of the bridge. With the advantages of simple construction process, low material loss and short construction period, the adhesive steel plate reinforcement technology is widely used in repairing and reinforcing damaged bridge structures.

5.3. Paste Fiber Reinforcement Technique

Paste carbon fiber reinforcement technology is an advanced bridge structural reinforcement method, through the use of epoxy resin binder to paste the carbon fiber cloth on the surface of the structure, in order to improve the structural load-bearing capacity and ductility. The carbon fiber material has a very high resistance. Carbon fiber material has very high tensile properties, when the bridge structure load increases, the carbon fiber material works together with the original structure to offset the load effect. The bonding material needs to have enough stiffness to withstand the stresses due to the loading effect, and enough strength to resist the shear and tensile forces, to ensure that the bond between the carbon fiber cloth and the concrete will not fail under the loading effect.

5.4. Replacement Concrete Reinforcement Technology

The Concrete Method is a method that can repair structural damage and improve the load carrying capacity and durability of a bridge structure by replacing the damaged portion with new concrete. In the replacement concrete reinforcement process, the damaged or heavily deteriorated concrete portion is cleaned and removed, and then new concrete is poured over the cleaned surface to fill in the voids in the formwork and restore the integrity and strength of the structure. By pouring new concrete, the bearing capacity and durability of the structure can be increased, extending the service life of the bridge structure. However, the replacement concrete

reinforcement technique requires a long construction period, may damage the steel reinforcement in the original structure, and the construction cost is relatively high.

5.5. Extracorporeal Prestressing Reinforcement Technology

Extracorporeal prestressing reinforcement technology improves the bearing capacity and stiffness of the bridge structure by applying prestressing force on the outside of the bridge structure, and the core components of the extracorporeal prestressing system constructed by it generally include prestressing tendons, anchoring devices, steering devices and horizontal beam positioning. In extracorporeal prestressing reinforcement technology, prestressing tendons, such as thick steel bars or steel strands, are generally used, and by tensioning the prestressing tendons and fixing them on the outside of concrete members, the concrete members are subjected to a certain amount of compressive stress, so as to increase their stressing performance. This method can effectively improve the performance of bridge members. This method can effectively improve the bending and shear resistance of bridge members, reduce the width of concrete cracks, and improve the overall stability of the bridge structure. Through the reasonable design of the prestressing force, the optimal performance of the bridge structure in bearing the load can be realized to meet the engineering design requirements and ensure the long-term stable operation of the bridge structure.

Take Luoxi Bridge For example, Luoxi Bridge is located on the national highway G105 in Guangzhou, which is a two-way four-lane bridge with a total length of 1916 meters, and the bridge deck was originally made of cement concrete, and then asphalt concrete was added. In view of the actual situation and disease problems of Luoxi Bridge, pre-stressed carbon fiber reinforcement technology was adopted to reinforce the old bridge with 30m span prestressed concrete T-beam. The reinforcement scheme includes the use of linear carbon fiber plates with a tensile strength of 2400 MPa, three carbon fiber plates on each T-beam, and a tensile control stress of 1100 MPa. Through the scientific and reasonable application of pre-stressed carbon fiber plate reinforcement

technology, combined with the actual damage of the old bridge and in accordance with the standard specifications for the reinforcement work, effectively enhance the structural safety and load-bearing capacity of the old bridge to extend its service life, providing a reliable guarantee for people's travel and transportation.

6. Summary

Quality inspection and reinforcement play a crucial role in the construction and maintenance of road bridges. Quality inspection technology provides an important basis for timely reinforcement through comprehensive assessment of the bridge structure and timely detection of potential defects and problems. Reinforcement work can take effective measures to repair the existing problems of the bridge and improve the carrying capacity of the bridge. Therefore, in the construction and maintenance of road bridges, quality inspection and reinforcement work should be fully emphasized, and constantly improve and perfect the construction technology and means, in order to ensure the safe operation of road bridges.

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