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Analysis of Bridge Inspection Technology for Highway Reconstruction and Expansion

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Abstract: This article focuses on bridge testing technologies in highway construction and expansion projects. It provides an overview of the inspection process for bridges in highway reconstruction and expansion projects, the main inspections, and strategies for improving the quality of inspections. Relevant units should conduct bridge inspections using appearance inspections, special inspections, and bearing capacity assessments in highway reconstruction and expansion projects. To effectively improve testing quality, relevant units should also focus on establishing and improving testing standards, strengthening material testing, and improving the overall quality of the testing personnel. This research aims to enhance the quality of highway reconstruction and expansion projects by supporting the sensible application of bridge inspection technology.

Keywords: Expressway; Reconstruction and expansion; Bridge engineering; Detection technology

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1. Introduction

In the current highway reconstruction and expansion project, bridge inspection has become an indispensable part of the work. Bridge inspection involves meticulous appearance, special inspections, and bearing capacity assessment. In this way, the overall quality and safety of bridge engineering can be guaranteed. This will benefit the construction, application, and development of bridge engineering in highway reconstruction and expansion projects.

2. Overview of highway reconstruction and expansion bridge inspection

2.1. Meeting the needs of a growing society

Through urbanization and industrialization, the number of industries and population in cities has been constantly increasing, and the number of automobiles has also shown a gradual upward trend. Under such a development model, many existing highway projects are beginning to modern actual transportation needs. To adapt to the development of today's society and meet the practical needs of highway transportation, many

highway projects need to be reconstructed and expanded [1]. In this way, we can effectively solve problems such as traffic congestion, poor road conditions, and insufficient bearing capacity that exist in traditional highway and bridge engineering applications, promote the development of the highway transportation industry, and create favorable conditions for socio-economic development.

2.2. Main ideas for renovation and expansion

The are several reconstruction and expansion ideas for bridge projects. (1) Design preparations: When designing a highway reconstruction and expansion project, the designer must do a good job in the preliminary design of the bridge project, including its beam structure, span and bearing capacity design, etc., to meet the actual reconstruction and expansion of the highway project and its subsequent application requirements. (2) Formulating a construction plan: Before formal construction, a proper construction plan should be formulated based on the type of project, including workflow, sequence of each segment, technology, and equipment used, detection technology, etc., to ensure maximum construction quality. (3) Following the construction plan strictly: The bridge should be constructed according to the design and plan, including pier construction, superstructure construction, wing wall construction, and guardrail construction, etc. (4) Quality inspection: Quality inspection is necessary after completing the construction of the bridge, including appearance inspection, special inspection, and load-bearing capacity assessment, etc., to achieve good control of construction quality and safety to meet the needs of subsequent practical applications of the overall bridge.

3. Main inspections in highway reconstruction and expansion bridge projects

Appearance inspection, special inspection, and load-bearing capacity assessment are the most important inspection contents when inspecting the bridge project. Therefore, these inspections should be carried out using proper methods.

3.1. Appearance inspection

For bridge projects in highway reconstruction and expansion projects, appearance inspection is the most basic inspection item during specific inspections. Normally, appearance inspection includes inspecting the main beams, side rails, bridge decks, etc. visually. Visual inspection are performed to look out for deformations, cracks, corrosion, or damage [2]. While visual inspection does not require advanced technology and equipment, the inspector should be experienced so that problems can be discovered and addressed in time.

3.2. Special tests

In the highway reconstruction and expansion project, relevant units and inspection technicians must also conduct special inspections to ensure the bridge project's quality.

The first test involves the inspection of physical structures. (1) Ultrasonic rebound test is used to detect the rebound value of the concrete surface of the bridge engineering structure, and the data obtained is used to calculate the concrete strength, and the calculation results are compared with the design requirements to determine if adjustments are needed. (2) Ultrasonic non-destructive testing technology is used to detect internal defects in the concrete structure.

The second step is flatness inspection. The flatness of the bridge can be inspected using a laser flatness measuring instrument. The flatness is measured based on the change between the emitted and reflected signals like speed, acceleration, and displacement. Laser flatness detectors are faster and more accurate than traditional flatness detectors.

Finally, there is dynamic experimental detection, which involves driving a test car on the bridge and measuring the inclination and strain conditions of each structural point in the bridge project, so as to determine the damping value, natural frequency, and mode shape of the bridge structure. During this process, the acceleration is set at the 1/4 span, 1/2 span, and 3/4 span positions of the bridge and Basic Data Infrastructure (BDI)-supporting data processing software is used to analyze the changes in the bridge structure when the vehicle is being driven on it, and these data will be used to determine if further optimizations are needed [3].

3.3. Bearing capacity assessment

Load-bearing capacity assessment is a key content in highway bridge reconstruction and expansion project inspection. The load-bearing capacity of the bridge is assessed through static and dynamic load tests.

(1) Static load test

The amount of load applied should be determined based on the influence line of the bridge, and the load should be placed at the most the most fragile portion of the bridge. A mobile load-tracking device is then used to track and detect the load-bearing capacity of the portion of the bridge. Subsequently, a bridge deflection detector is used to measure the deflection of each most unfavorable loading position. To ensure the accuracy of the test results, before the formal loading test is carried out, two standard loading trucks should be positioned at the test span for 20 minutes or more. This process is called transverse symmetrical preloading and control the load duration. Formal loading is performed after the preloading and the bridge structure is fully restored. Formal loading needs to be carried out in stages, and only after the deformation of the upper-level structure is relatively stable can the next stage of loading be carried out [4]. The deformation of the bridge should be less than 20% with no obvious cracks upon the completion of the last loading test.

(2) Dynamic load test

This test is mainly to detect the impact coefficient of vehicles on the bridge structure at different driving speeds, including a barrier-free driving test, vehicle jumping test, and braking test. The vehicle impact coefficient on the bridge structure can be calculated based on the test results and comparing it to a reference value. In this way, the dynamic load capacity of the overall bridge structure can be scientifically evaluated.

4. Strategies to improve inspection quality of highway reconstruction and expansion bridge projects

4.1. Establishment and improvement of testing standards

To further improve the inspection of bridge engineering structures in highway reconstruction and expansion projects, suitable inspection standards will need to be established based on the technologies used and the type of project. The establishment of standards involves several aspects. (1) The testing items and targets should be determined based on the needs of the project [5]. (2) The standard operating procedure, the parameters measured, and the maintenance of the test equipment should be well-understood. (3) The responsibilities of each staff must be clearly-defined. (4) A strict reward and punishment system should be established to ensure that all workers perform their tasks responsibly. By taking these measures, the quality of inspection can be improved, with clearer standards, thereby facilitating subsequent works [6].

4.2. Strengthening of material testing

For bridge projects in highway reconstruction and expansion projects, ensuring the quality of the materials is

the key to ensuring the overall quality of the project. Therefore, the materials used in these types of projects should be inspected thoroughly. Currently, the main materials used in such projects include cement, sand, gravel, steel bars, etc. Several strategies can be adopted in the inspection of materials. (1) The materials should be inspected at the production site before they are transferred to the construction site. The materials should only be transferred after confirming that they are up to standard. (2) Another round of inspection should be done when the materials arrive at the construction site [7]. Unqualified materials should be returned to the manufacturer promptly. (3) The materials should be inspected for the last time before being put into use [8]. In this way, the quality of all materials in the construction of such projects can be well guaranteed. By taking these measures, defects caused by subpar materials can be avoided.

4.3. Improvement of comprehensive quality of inspection personnel

The competence of the staff will directly impact the inspection quality. Therefore, the comprehensive quality of inspection personnel should be cultivated [9]. The quality of the staff can be improved through several ways. (1) The recruitment standards for inspection technicians should be raised, and staff with a university degree in related fields and experienced staff should be prioritized. (2) All staff members should be given regular training to ensure that they are updated about the latest technologies and equipment available [10]. (3) All staff members should be assessed regularly and their wages should be proportionate to their competence. These measures can help improve the quality of inspection by reducing human factors.

5. Conclusion

As the number and scale of modern expressway reconstruction and expansion projects continue to increase, bridge engineering inspection has also been increasingly highlighted by relevant experts. Proper structural inspection should be carried out to effectively ensure the quality of bridge structures in such projects. Besides, it is important to improve the quality of inspection to facilitate the development of modern highway reconstruction and expansion bridge projects.

Disclosure statement

The authors declare no conflict of interest.

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