Journal of Architectural Research and Development, 2023, Volume 7, Issue 3
http://ojs.bbwpublisher.com/index.php/JARD
ISSN Online: 2208-3537
ISSN Print: 2208-3529

Technical Analysis of Highway Bridge Static Load Test

Ke Tu, Yingying Ye, Daqing Wu, Yunyong Zhou*, Wenming Deng

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

***Corresponding author:** Yunyong Zhou, 474524632@qq.com

Abstract: Highway bridges are an important part of the transportation industry and can promote social economic construction and development. In actual operation, highway bridges are often damaged due to overload and natural factors, which tend to affect the safety and shorten the service life of these bridges. Assessing the overall state and performance of highway bridges is therefore a key element. Static load test, which is a type of sustainable detection experiment, has many advantages, including low cost, high efficiency, and high accuracy. In this paper, the bridge structure is analyzed through the application of theoretical calculations and relevant comparisons, so as to judge the operating state of the bridge.

Keywords: Highway bridge; Static load test; Detection technology

Online publication: May 31, 2023

1. Introduction

At present, China's transportation industry is developing rapidly, providing a strong foundation for the development of highway bridges. Bridges are important links between roads and play an extremely important role in the transportation industry. According to relevant data, more than 90% of all bridges in China are concrete bridges. Due to natural disasters or overload, the safety of bridges is affected, which may cause serious economic losses and even pose a threat to people's lives. In order to ensure the safety and stability of the structure, proper health inspection of the bridge structure should be done. The static load test is a common and effective detection method that can fully reflect the overall performance of the bridge, allowing us to effectively grasp the actual operating state of the bridge, timely address the existing problems to improve and optimize the quality of the bridge, and promote the development of the transportation industry.

2. Contents of static load test

The application of static load test mainly includes the following aspects: (i) strengthen vertical detection and lateral detection; in order to effectively improve the accuracy of detection, the layout of the measuring points should be optimized during the detection process to ensure that the location and quantity of the measuring points can meet the actual requirements; at least 3 measuring points should be set in each span; after clarifying the detection content, the deflection value of the bridge bearing can be obtained [1]; (ii) optimize the section stress detection work; through reasonable application of the detection technology, the partial load characteristics and the maximum value of the section stress can be analyzed; (iii) corners, expansion and contraction of the bearing, and displacement of pier tops are structures that are prone to problems in bridge structures; based on the detection results, the accuracy and efficiency of risk judgment

of bridge structures can be improved; (iv) with prolonged use, damages may occur at different positions, including cracks of different sizes at different positions; thus, the safety and stability of the bridge structure are not guaranteed; the crack detection work mainly includes the direction, position, length, and load.

3. Importance of static load test for highway bridges

The main purpose of the static load test is to test the main structure of the bridge. In the process, the actual structural performance and operating state of the bridge can be understood; the deflection and load stress of the bridge can be detected; the structural stiffness and load strength of the bridge can be verified; and whether the overall structural data of the bridge meets the relevant design requirements and design specifications can be determined. In project construction management, proper quality inspection and safety inspection must be carried out on a regular basis, so as to improve the overall quality of the project, ensure the normal operation of highway bridges, and lay a strong foundation for the development of the transportation industry [2]. Although the bridge inspection work in China is highly adept, many problems will arise in the production and construction stage. Therefore, proper inspection of the building structure and building materials must be done, so as to ensure that the materials and quality of construction meet the relevant regulations and requirements.

4. Bridge static load test equipment

For highway construction testing, specialized equipment should be used to strictly control the quality of data in order to ensure the accuracy of the test and prevent problems from arising. In the testing process, there are high requirements for testing capabilities and testing equipment; the testing equipment must be tested and proofread by the relevant personnel to ensure that it meets the data testing requirements. In laboratory testing, the testing equipment, as an extremely important tool, is the basis for carrying out various testing works. The optimization of the testing equipment improves the accuracy and overall quality of the test data. Applying specialized testing equipment can garner better test results and more accurate test data [3]. The detection and calibration of equipment should be strengthened to improve detection capabilities.

The testing equipment should be regularly checked, and the testing equipment should be regularly calibrated to ensure safe and stable operation and reduce the occurrence of aberrant situations. In equipment verification work, it is often necessary to move the testing equipment within a relatively special working environment. After the verification work, the analysis and research of the verification data should be performed. If there are large deviations in the data, the use of the equipment should be suspended, and the equipment should be inspected and repaired to ensure the accuracy of the obtained data.

5. Testing standards and conditions

In the process of highway construction testing, the testing methods and standards promulgated by the state should be applied and used as data assessment standards. All data testing results must be supported by the testing standards. Samples must be stored in accordance with the relevant specifications during the actual testing process. The best sample collection can be achieved through the testing of related equipment, and the environment and related samples can be tested effectively. In highway bridge inspection, there are high requirements for the inspection work. Temperature, humidity, and climate can affect the inspection results. A huge difference between the detection environment and the collection environment can easily affect the inspection equipment and the accuracy of the detection data [4]. Relevant test personnel should carry out comprehensive monitoring and testing of the environment, so as to improve the accuracy of data testing.

6. Preliminary test preparation for static load test

6.1. Select the test hole

In order to improve the accuracy and effectiveness of data detection, it is necessary to arrange the test holes in accordance with the relevant regulations and requirements in the preparatory process as well as the actual state and characteristics of highway bridges. This would help ensure that the number of test holes is adequate and promote the static load test work.

6.2. Select the scaffolding and fixtures

In the detection process, many large-scale devices need to be used, each of which has its own unique functions. However, these devices will affect each other. Therefore, it is necessary to control the distance between equipment when planning and arranging the equipment at the testing site. For example, independent scaffolding and test fixtures should be set up to minimize the impact and interference of the test results [5]. In addition, steel structures are required for scaffolding and test fixtures in order to improve the stability and safety of the bridge structure.

6.3. Select the loading position

A reasonable selection of the loading position can directly affect the detection efficiency and results. A large difference between the actual requirements and the selected loading position will affect the accuracy of the detection results [6]. Therefore, strict adherence to the loading effect and loading principle is mandatory when selecting the position, so as to ensure the safety and accuracy of the test results.

7. Inspection process of highway bridge static load test

7.1. Load test condition

The current bridge structure and operation quality should be inspected in detail. In order to improve the overall quality of the test results, the test conditions must be in line with the following requirements [7]: (i) ensure the quality of the continuous girder bridge; in the actual static load test, the load test plays an extremely important role, and since there are various test conditions, they should be selected according to the test requirements and actual test conditions [8]; due to the particularity of the overall structure of highway bridges, the continuous beam structure is usually a single-box, single-chamber, cross-section structure, with high rigidity in the transverse direction, and symmetrical loads are often applied below; (ii) common positive load conditions and partial load conditions; in equipment selection, two heavy-duty vehicles, each of which weighs about 30 tons, are used in the static load test; they are important equipment in the test and detection; dynamic changes should be recorded, and the indicator data under different conditions should be compared. For comparison of specific indicators, see **Table 1**.

Table 1. Calculation value of loading test and loading efficiency

Loading conditions	Theoretical value (kN·m)	Test value (kN· m)	Loading efficiency (η)
Maximum positive bending moment of the section (working condition 1)	1232	1174	0.951
Maximum positive bending moment of the section (working condition 2)	1232	943	0.76

7.2. Determine the test load

When applying the beam static load test to highway bridges, it must be in line with the following principles:

(i) control the load; during the detection process, it is necessary to analyze and optimize the load area of the bridge; the vehicle load can be divided into two types, 30 tons and 20 tons, respectively; there are certain differences between the load conditions and the construction load in which the deviation is controlled to ascertain the volume of the load and determine the test requirements and time efficiency; (ii) uninstall the program; in the process of carrying out the static loading work, the program should be selected and optimized according to the structural change; in the static load test of highway bridges, it can be divided into three levels, with each level being defined through the control strength and the actual test situation on site [9]; after the loading and unloading work is carried out in accordance with the relevant regulations, it is necessary to take readings after a period of time to control the data deviation.

7.3. Measuring point layout

There are certain particularities to the location and deflection of strain measuring points of highway bridges. In actual detection work, it is necessary to set up as many measuring points as possible, with the number of measuring points controlled to about 3 in special locations and 7–10 in cross-section mid-span positions.

7.4. Test results

In static load test and detection, prestressed, prefabricated hollow slabs of certain specifications should be used as the main reference standard. The application of static load test and detection work strengthens the judgment of the actual situation of the bridge structure and improves the accuracy of data calculation. Through a detailed analysis of this detection link and content, it is known that the concrete thickness of the bridge deck is relatively high. In order to reduce the probability of concrete cracks, the application principles of the steel-joined beam method should be perfected in the prefabricated slab optimization and calculation work. There is a difference between the half-wave sine load and the actual load. In the actual calculation process, the content and data of the elastic modulus of the concrete should be fully considered, and the consideration and research on the vehicle load and the vehicle itself should be strengthened. The coefficient K = K1 • K2 • K3. In the application of static load test, many factors need to be considered. Among them, there are significant differences in the values of K1 and K2; the corresponding calculation work should be carried out according to the actual situation of the construction site. At the same time, the effective value of K3 is obtained by the hinged plate method. The comparison between the calculated results and the experimental values is shown in **Table 2**.

Table 2. Comparison of calculation results and test values

Data	Maximum deflection of side plate (cm)	Maximum strain of side plate (με)
Before correction	5.543	202.4
After correction	4.623	167.9
Test value	3.875	162.4

7.5. Test results and bearing capacity evaluation

The last part in the static load test of highway bridges is to analyze the test results. The specific evaluation methods include the following aspects: (i) the detection coefficient; in the actual application process, the static load test detection technology can effectively reflect the bridge data and provide feedback on the state of the bridge; it is expressed by the ratio between the calculated value and the measured value; a detection coefficient less than 1 indicates that the bridge bearing capacity meets the relevant requirements and the performance of the bridge is relatively good, but a detection coefficient greater than 1 indicates that the bearing capacity of the bridge is weak, which will affect the safety and stability of the structure; in the

actual application process, the data of the detection and verification system should be effectively controlled because if the data is too great or too little, the quality and specifications of the detection cannot be guaranteed, and the results will be greatly affected [10]; (ii) the relationship curve between theoretical value and measured value; when carrying out the load test and detection work, the monitoring of the use of the bridge and its safety should be strengthened; the actual and theoretical value curves provide feedback on the working condition of the bridge; an insignificant deviation between the two curves indicates that the bridge has good performance and is in good operating state, with low safety risk; however, a significant deviation between the two curves indicates that there are certain problems in the operating state and overall performance of the bridge, with high safety risk; hence, it should be dealt as soon as possible.

8. Conclusion

Generally speaking, in the development of highway bridge projects, the safety and performance of bridges are important issues that need to be considered. Therefore, the static load test detection technology has been widely applied to highway bridges. The static load test is a detection method with high accuracy and detection efficiency and low cost. Through the application of this technology, we can have a clearer understanding of the structural health and bearing capacity of highway bridges and objectively evaluate the actual state of highway bridges. In addition, we can also see the shortcomings of these bridges and address them in time, so as to optimize the structure, improve the overall quality, and promote the development of the transportation industry .

Disclosure statement

The author declares no conflict of interest.

References

[1] Sun Z, 2022, Application of Static Load Test Detection Technology of Cast-In-Situ Pile Self-Balancing Method in Highway Bridge Engineering. Traffic World, 2022(11): 152–155.

[2] Wang Y, 2020, Research on the Role of Static Load Test in Highway Bridge Inspection from the Perspective of Modernization. Regional Governance, 2020(20): 173 + 187.

[3] Pang T, 2021, Analysis of Ultra High Performance Concrete Detection Technology in Rural Highway Bridge Reconstruction. Traffic World, 2021(8): 133–134.

[4] Zhang T, 2019, Analysis of the Role of Highway Bridge Load Test Detection in Bridge Maintenance. Encyclopedia Forum Electronic Magazine, 2019(11): 103–104.

[5] Wang J, 2020, The Role and Countermeasures of Highway Bridge Load Test Detection in Bridge Maintenance. Traffic World, 2020(8): 97–98.

[6] Tian Y, 2020, Talking About the Test and Detection Technology of Reinforced Concrete Bridges and Its Development Trend. Encyclopedia Forum Electronic Magazine, 2020(10): 1489–1490.

[7] Yang N, Chen H, 2020, Analysis of Static Load Test and Detection Technology of Expressway Box Girder. Traffic World, 2020(12): 147–148.

[8] Wang Y, 2020, Analysis of Static Load Test and Detection Technology of Expressway Box Girder. Traffic World, 2020(10): 103–104.

[9] Wang Y, 2020, Research on the Role of Static Load Test in Highway Bridge Inspection from the Perspective of Modernization. Regional Governance, 2020(20): 173 + 187.

[10] Zhang G, 2020, On-Site Load Test Detection Technology for Bridges. Guangdong Building Materials, 36(8): 4 + 32–34.