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Pan Conghong

L. Kucherenko

ANALYSIS OF THE ROLE OF STATIC LOAD TEST METHOD IN BRIDGE DETECTION

Vinnytsia National Technical University

Анотація

В даній роботі розглядаються значення, тестовий вміст, технічні точки та запобіжні заходи методу статичного навантаження, щоб надати рішення щодо підтримки, реконструкції або обмеження навантаження мосту. Тест статичного навантаження мосту відноситься до статичного навантаження, що діє на визначеному положенні на мостній палуб. Досліджуються випробування статичної деформації, статичного напруження та статичного зміщення структури, виведення робочого стану та здатності використання мостової структури під навантаженням, тим самим визначаючи, чи відповідає фактичний робочий стан мостової структури, що відповідає значенням очікування. Це найбільш прямий та ефективний метод тестування продуктивності мосту та робочого стану (наприклад, міцність та жорсткість структури).

Ключові слова： Статичне випробування, навантаження, міст аналіз ефектів.

Abstract

This article mainly explains the significance, test content, technical points, and precautions of the static load test method, in order to provide opinions on the maintenance, reconstruction or load limit of the bridge. The bridge static load test refers to the static load acting on the designated position on the bridge deck, testing the static strain, static stress and static displacement of the structure, inferring the working state and usage ability of the bridge structure under the load, thereby determining whether the actual working state of the bridge structure is consistent with the design expectation value. It is the most direct and effective method to test the bridge performance and working state (such as the strength and stiffness of the structure).

Keywords： Static load test； Bridge detection； Effect analysis

Introduction

With the development of transportation, the problem of bridge aging is gradually becoming prominent. Both developed and developing countries have a large number of bridges that have insufficient carrying capacity due to structural damage and material aging. In order to ensure the safety and durability of bridges, existing bridges and operating bridges must be inspected, such as the bridge settlement value, crack size, quality defects, etc., to objectively and accurately evaluate the health status of the bridge.

Purpose and significance of bridge static load test

When testing bridge structures in static load tests, the placement of strain gauges is mainly used for

measurement, and the strain gauge is placed at different structural positions of the bridge to measure the magnitude of the strain forces in each structural part of the bridge. By measuring the bridge structure and other data, the bridge structure can be analyzed and studied more targeted and scientifically, so as to properly protect and maintain its structure. The application of static load test in highway bridge structure detection can accurately monitor the structure and quality of the bridge, thereby effectively ensuring the high performance use of highway bridges.

The static load test mainly determines the test operating conditions based on the calculated influence line, and tests the strain and deflection values of the controlled cross-section under the action of each operating condition

The lateral and longitudinal deflection of the bridge is measured, and the deflection deformation of the cross-sectional beam is controlled by step-by-step loading detection. At the same time, it is necessary to arrange measurement points at the fulcrum position to ensure the accuracy of measurement.

It mainly detects the stress distribution state of each control section of the bridge, and detects and records the stress distribution and stress magnitude of the control section through step-by-step loading. Special sections require stress analysis of their shear stress.

During the static loading process, it is necessary to record the crack development on the surface of the beam, including the development of original cracks and the generation of new cracks. For prestressed structures, structural cracks are not allowed to appear.

After the static load is loaded and unloaded, it is necessary to record and analyze the deflection and stress residual values of the measured points. At the same time, the expansion, angle and displacement of the bridge are also the focus of detection.

The static load test of bridges can be divided into pre-test preparation stage, detection loading and observation stage, and test result analysis and evaluation stage.

Before preparing the static load test plan, on-site inspection is required to investigate the structure of the bridge. The test plan generally includes engineering overview, test purpose, test content and methods, testing personnel and equipment, side measurement point arrangement, test process and test result analysis, etc.

After the test plan is prepared, structural calculation and analysis are carried out according to the design requirements and with the help of professional bridge analysis software (such as Midas or Bridge Doctor). Comparison of the strain and displacement values of bridges under different loads and the generated position.

The load conditions are also part of the static load test, and the most unfavorable load conditions can directly reflect the difference between the actual deformation of the structure and the design state. For side beams, the lateral bias loading conditions need to be added to consider the symmetry of the structure; if the component has stressed cracks, the intermediate and bias loading conditions need to be added. Generally, when selecting the loading section, the calculated bending moment envelope diagram, the shear envelope diagram or the deflection envelope diagram, the cross section should be selected according to the most unfavorable principle, and the specific test method should be determined. Table 1 shows the loading test sections and contents of common bridges.

Table 1 — Shows the loading test sections and contents of common bridges

Bridge Type	Theoretical calculation frequencyf_d (Hz)
Simple support beam bridge	Beam end shear force, main beam midspan deflection and positive bending moment

Continuous beam	The middle deflection and positive bending moment of the middle span, the shear force at the end of the side span beam, the 1/4L deflection and positive bending moment of the side span
Cantilever beam	Negative bending moment of the fulcrum, cantilever end deflection, beam end shear force
Arch bridge	Arch foot bending moment, arch top bending moment, arch top deflection, 1/4L bending moment and deflection
Steel bridge	Positive bending moment and deflection in 1/4L of the side span and midspan
Suspension bridge	Main cable internal force, tower foot cross-section internal force, 1/8L and 3/8L internal force and deflection
Cable-stayed bridge	Cable force, fulcrum settlement, tower foot internal force, bending moment and deflection in the middle span

The stress and strain measurement points of general sections need to be arranged in consideration of the forces in the two directions of height and width; the displacement measurement points should be able to obtain the maximum value and displacement change law; for special measurement points such as the deviation displacement test of cable towers, three direction displacements need to be considered.

Before the actual operation begins, in order to ensure the test effect, the static loading object should be selected reasonably to ensure that the selected object is representative. If the same structure type but different spans are selected, the span with the largest span will be selected.

Perform load tests. For prefabricated bridges, the randomness of the experiment is emphasized and the sampling test method is chosen. For the test pier, select the position with the most unfavorable stress state and the worst state.

The loading scheme plays a decisive role in static load testing, including loading equipment, loading loading, loading duration and unloading procedures. The loading equipment mainly includes heavy objects and loading vehicles, which usually include water tanks, sandbags and precast concrete parts, etc., are convenient for loading step by step to meet different loading needs, and are mainly used in pile foundation bearing capacity static load tests. Vehicle loading tests are mainly used in static load tests for a bridge, and at the same time, ensuring that the load and wheelbase errors are controlled below 5%. When determining the loading amount, loading time and unloading program, the hierarchical loading should be adopted according to the total load to ensure that the stress and strain curve remains continuous, and the hierarchical load is usually not less than four levels. Do a good job of monitoring during the loading and unloading test, discover problems in a timely manner, and avoid affecting the test results. In order to reduce the impact of temperature on the bridge static load test results, it is usually chosen from 22 pm to 6 pm, which can also minimize the impact on traffic.

The main observations in the static load test are deformation, stress, cracks, inclination, and pier production. Deformation is mainly the deflection of the beam and various non-vertical displacements. The overall deformation reflects the overall performance of the bridge, and the local deformation reflects the local conditions of the bridge components.

In order to ensure the reliability of the test results, the arrangement is based on the principle of appropriate quantity, and the arrangement of measurement points is reduced by using the principles of structural symmetry and structural mutualism to avoid waste of resources due to excessive arrangement. At the same time, the

selection of measurement points needs to be representative and observable, considering the realization of detection technology.

Commonly used instruments currently include scale magnifying glasses, displacement meters, strain gauges, static strain meters, etc. The measurement accuracy of the instrument must meet the test requirements and be suitable for the detection environment. In addition, when measuring the same parameters, try to select a unified model of instruments to reduce the system error caused by the instruments. Organize personnel to conduct technical briefings in advance, and try to observe and record the same set of data by the same person as much as possible to reduce observation errors.

After the static load test is completed, the data sorting and information verification stage will be entered. Testers carefully check the test results according to specifications and technical guidelines to ensure the accuracy of the test data, and timely output data records and test reports to make judgments.Whether there are problems with the bridge structure, a special person needs to be sent to inspect the weak links.

After the static load test is completed, the test data and theoretical calculation data are compared to obtain the bearing data of the bridge. In bridge engineering, the verification coefficient η is often used to judge the situation of a bridge. The check coefficient is the ratio of the detected value to the theoretically calculated value. When the calibration coefficient $\eta=1$, it means that the actual measured value is exactly consistent with the calculated value; when the calibration coefficient $\eta<1$, it means that the detection bridge has good performance and reliable structural safety; when the calibration coefficient $\eta>1$, it means that the test bridge does not meet the standards, and the bridge structure is security does not meet the requirements. In addition, the verification coefficient cannot be too small, because the bridge structure calculation is oversimplified and the bridge's self-weight is ignored.

The structure in a completely elastic deformation does not have residual stress (strain) after the unloading of the static load of the structure is completed. When the residual value of the test is smaller, it means that the working condition of the bridge is better. On the contrary, the bridge may undergo greater plastic deformation, and some deformation cannot be restored, and the bridge may be damaged. The residual strain value of common bridge static load tests should be $\leq 20\%$. If there is a large residual strain, a comprehensive inspection of the bridge is required to determine the damage of the bridge.

Conclusion

To sum up, static load test is the most commonly used method in bridge inspection. It can detect the load-bearing capacity and structural performance of the bridge, comprehensively judge the health status of the bridge, and provide a strong reference for the maintenance and management of the bridge. Based on the purpose and significance of the bridge static load test, this paper summarizes the bridge static load test methods and contents in three stages. Inspection technicians should control the key contents of the static load test as a whole, promptly discover hidden dangers of the bridge, and ensure the normal operation of the bridge.

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Pan Conghong — master of the Department of Building, Urban and Architecture of the Vinnitsa National Technical University. email: 549515464@qq.com.
Kucherenko Liliya — PhD, Associate professor of the Department of Building, Urban and Architecture of the Vinnitsa National Technical University. email: liliya13liliya13@gmail.com.

Пань Цунхунь — магістр кафедри будівництва, міського господарства та архітектури, Вінницький національний технічний університет. email: 549515464@qq.com.
Науковий керівник: Кучеренко Лілія Василівна — к.т.н., доцент кафедри будівництва, міського господарства та архітектури, Вінницький національний технічний університет. email: liliya13liliya13@gmail.com