Highway Bridge Test Detection Technology and Application Method Based on Big Data

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Abstract. With the rapid development of transportation, highway bridges as a transportation hub have played an important role and become the link of economic development in the region. In recent decades, my country has built many types of highway bridges. During the construction and operation of these bridges on highways, many inspection activities are required to ensure the quality of construction and operational safety. This article mainly introduces the highway bridge test detection technology and various application methods based on big data. This paper uses big data to detect the dynamics of the highway bridge structure and establish a load test model. The model is solved by the energy-releasing method to strengthen the rigid structure of the highway bridge, evaluate the road condition, and use historical data to revise the model to improve the accuracy of the highway bridge load. The experimental results in this paper show that the highway bridge detection technology based on big data reduces accidents by 23%, and the test and evaluation results under big data show that the performance of highway bridges is excellent and meets the design.

Keywords: Big Data, Highway Bridge Test Detection, Load Test, Energy Release Method

1. Introduction
With the advancement of science and technology and the rapid economic development, major civil engineering structures such as long-span bridges and highways have been built, and highway bridge structures have also been rapidly developed as an important part of civil construction [1-2]. In engineering construction, the construction of highway bridge structure has a relatively large impact on traffic safety [3-4], speed and comfort. However, the bridge structure is affected by natural factors such as climate and environment during its long-term service (The impact of strong winds, heavy rainfall, earthquakes, etc.) or extreme abnormal loads can cause damage to the bridge structure [5-6].

In the 1920s, E. Freyssinet scientists successfully developed a prestressed concrete structure and used it for the first time on the Aue Bridge in the southwest of Dresden, Germany in 1937, becoming the world's first prestressed concrete bridge [7-8]. Prestressed concrete structure is the main form of current bridge construction, and prestressed steel bar is the main force member in large prestressed structure [9-10]. The appearance of prestress loss and irregular operations in construction will affect...
the final effective prestress. The actual effective stress in the prestressed tendons has very important significance for the calculation of the bending and cracking resistance of the combined section, the use and the calculation of the ultimate bearing capacity [11-12].

The innovation of this paper is to propose a highway bridge test detection technology based on big data. According to the analysis of the load ratio of highway bridges, several non-destructive testing methods used for concrete and steel reinforcement testing, thinking about traditional highway bridge reinforcement methods, and analyzing the feasibility of highway bridge "energy release method" reinforcement under the background of big data analysis, puts forward the idea and plan of "energy-releasing method" composite strengthening of highway bridges.

2. Highway Bridge Inspection System under Big Data

2.1 Factors Affecting Stress Loss of Highway Bridges

After pre-tensioning, affected by various factors such as construction level, material performance and environment, there is always a certain gap between the actual stress of the steel strand and the theoretical tension control stress. The stress loss will have a huge impact on the force and vertical deformation of the highway bridge structure, and seriously threaten the safety and performance of the bridge structure. Therefore, the analysis of the influence of the loss of prestress is extremely important.

Friction caused by the influence of the curve

The analysis of the pre-energizing loss of the pre-stressed tendons in the curve section is shown in Figure 1

Figure 1. Schematic diagram of curve affecting friction

In the curve section, take the micro-segment prestressed tendon \(d_l\) as the breakaway body, the corresponding bending angle is \(d_\theta\), the radius of the curve here is \(R\), then \(d_l = Rd_\theta\). If the friction coefficient between the prestressed tendons and the hole wall is \(u\), the friction force caused by the normal pressure \(F\) of the prestressed tendons on the inner wall of the hole is:

\[
dN_i = -\mu F
\]

(1)

According to the force balance condition, omitting the high-order traces, we get:

\[
F = 2N\sin\frac{d\theta}{2}
\]

(2)

Bring in with the above formula

\[
dN_i = -\mu N d\theta
\]

(3)

2.2 Working Principle of Highway Bridge Inspection System under Big Data

The structure of highway bridges is becoming an important project in civil engineering construction. The design, construction and service life of bridges have a significant impact on road construction,
transportation and maintenance. The proportion of existing and under construction bridges is large, with many viaducts and long bridges. At the same time, the bridge structure is required to have sufficient bearing capacity, sufficient rigidity, good dynamic characteristics, good wind resistance and seismic performance to meet the requirements of high-speed vehicles on the bridge structure. Higher requirements for static and dynamic performance. In order to ensure the safety of driving, it is necessary to establish a bridge structure health monitoring system and study the optimal configuration method of bridge structure sensors for bridge maintenance and damage warning.

The working principle of this system uses the big data system to detect the safety failure of the highway bridge structure. The sensor subsystem detects the load and effect of the bridge structure in various environments by installing various sensors, and collects the data through the data acquisition and transmission subsystem. The data is converted and transmitted, and stored in the computer in a certain way. The data processing and control subsystem is used to comprehensively control data collection, transmission, processing, storage and display, and can assist in the extraction of data. Through calibration, processing, transmission and reliability testing of the data acquired by the data acquisition and transmission subsystem, Key data for subsequent status assessment. The data management and analysis evaluation subsystem mainly includes functions such as monitoring data management, structural state early warning, reliability evaluation, fatigue evaluation, and comprehensive structural state evaluation.

3. Highway Bridge Load Test Experiment

3.1 Purpose of Highway Bridge Load Test

The main purpose of this experiment is to measure the actual response of the highway bridge under the test load. The key parts of the highway bridge are tested for the deformation and stress data, and then the bridge standard theoretical data is compared and analyzed. In evaluating the actual performance and value of a highway beam bridge.

3.2 Theoretical Calculation of Highway Bridge Load

According to the design load of the bridge, load it according to the equivalent load. Calculate and determine the test load, and combined with the actual situation on site, select the vehicle and vehicle weight that meet the test for test loading. In order to ensure that the load arrangement can effectively stimulate the response of the bridge structure, theoretical calculations were carried out before the test. The specific data are shown in Table 1.

| Model      | Center and rear wheelbase | Front center wheelbase | Total rear wheel base weight |
|------------|---------------------------|------------------------|-----------------------------|
| Heavy car  | 135                       | 385                    | 350                         |

According to the static load test efficiency and the design value of the bending moment of each control section, a total of 12 35t (vehicle weight + load) three-axle (dual-rear axle vehicles) were used in this test.

3.3 Highway Bridge Load Loading Method and Test Regulations

The test adopts the step-by-step loading method, so that a relatively complete structural response curve can be obtained, and at the same time, it can effectively prevent the structure from causing accidental hazards. Each working condition is divided into three levels of loading, and the important loading test is repeated once for each working condition. Note that the vehicle speed should not exceed 5kmh when unloading.

Before the formal loading test, a load-carrying vehicle is used to conduct a cross-bridge symmetrical preload test in each span. The pre-loading response to the bridge structure can be completely eliminated before formal loading. The formal loading sequence is strictly based on the
design sequence. Each level of loading must be completed after the previous level of loading is completed.

The static test needs to be carried out in a time period when the ambient temperature and structure temperature do not change much, usually in the early morning at night. In the static load test, each level of loading needs to wait for the action of the previous level of load to stabilize the structural response before continuing to load. During the loading process, the loading should be stopped when the section stress, the deformation of the control point, or the abnormal failure of the bridge construction.

3.4 Highway Bridge Load Detection Data
Since the stress detection under the reverse tension method is a comprehensive detection of prestress loss, the loss caused by various factors cannot be analyzed item by item; and in the existing code, the effective prestress evaluation coefficient is determined by the design tension control stress. There is no specific study on whether the size of the T-beam span has an effect on the selection of coefficients. Therefore, these two aspects are worthy of further study in combination with the inverted pull method field test data, and the method of formula calculation and comparison with actual data and theoretical values, so as to summarize the relevant laws and provide a reference for the same type of anchor stress detection.

In the code, the value of the effective prestress is determined by the design tension control stress; in the calculation of the theoretical formula, the magnitude of the prestress loss will change according to the actual length of the beam section, which is the most fundamental of the two the difference. The following is a comparative analysis of the calculated value of the theoretical formula and the standard value based on the measured data. The specific data is shown in Table 2

| Bridge name   | Channel design | Effective prestress specification value | Effective prestress formula calculation | in conclusion |
|---------------|----------------|-----------------------------------------|----------------------------------------|---------------|
| Narrow mouth  | N1             | 1255                                    | -2.5                                   | qualified     |
| bridge        | N2             | 1255                                    | -1.6                                   | qualified     |
|               | N3             | 1255                                    | -1.7                                   | qualified     |
|               | N4             | 1255                                    | -1.0                                   | qualified     |

By comparing and analyzing the calculated value and the standard value using the theoretical formula, there is a certain difference between the calculated value and the standard value, but the difference is small, the maximum difference is 25%, which appears in the 40m T beam, and the remaining differences are all within 1%. It proves that the two have a high degree of agreement and can be used as the effective stress reference value, as shown in Figure 2
Figure 2. Effective prestress comparison histogram

Compared with the standard value, the number of holes with a smaller effective value is 17 holes, the proportion is 85%, and the number of holes with a larger effective value is 3 holes, the proportion is 15%. From the analysis of the deviation value, the measured effective stress under most anchors is less than the theoretical value of effective prestress, and only some of the holes are larger.

4. Highway Bridge Test Detection Energy Release Method

4.1 Main Content of the Highway Bridge Energy Release Method

The traditional "energy-releasing method" reinforcement is to carry out system conversion and internal force adjustment within the entire arch ring. Basically, it considers that the influence of the arch abutments or piers on both sides is relatively small. However, the arch truss part of the truss arch bridge really plays the role of the arch. It is necessary to pay attention to the system conversion and internal force analysis of the truss arch reinforced by the "energy-releasing method" than the general "energy-releasing method" reinforcement of a hingeless arch bridge.

According to the existing diseases of most truss arch bridges, it can be seen that the joints of the double vertical rods and diagonal rods of the truss arch bridge are the weak links of the entire structure system, and are also the places where the most diseases occur. When the "energy-releasing method" is used for composite reinforcement of truss arch bridges, the design and construction requirements are relatively high, and many factors are considered. In the simulation analysis of the "energy-releasing method" composite reinforcement of the truss arch bridge, we found that the different construction loading sequence of the foot section, the second section and the third section of the bridge span structure, the force of each member is different. This requires finding the most advantageous construction loading procedure, so that the force of each member is more balanced during reinforcement, so that the ideal reinforcement effect can be achieved.

4.2 Energy Release Method for the Bearing Capacity of Highway Bridges

The "energy-releasing method" adopted for highway bridges is exactly the same as the "energy-releasing method" of truss combined arch bridges. At the same time, it needs to be combined with the traditional increasing section method. The large section method is used to strengthen the lower chord, and then the new section is treated with a special method at the new arch foot. After the system conversion of the whole bridge structure and the redistribution of internal forces, the original bridge is
converted from a hingeless arch to a "energy-releasing arch ". Considering that the "energy-releasing method" computer program must first calculate the hingeless arch before calculating the "energy-releasing arch", the static performance analysis of the truss arch bridge using the "energy-releasing method" combined with the traditional enlarged section method can be based on The following principles and methods are carried out

① Calculate the structural gravity effect of each part of the original bridge from the original calculation model

② The new section of the full bridge is used as a reinforcement load to act on the original calculation model, and the influence of the new section on the original bridge (load effect) is calculated

③ Without considering the energy release method, finite element software is used to simulate the new and old cross-sections. The live load is shared by the new and old cross-sections. Since the structural system has changed at this time, the vehicle load is divided into the live load internal force influence line at this time. Load the cloth and calculate the live load effect

④ The load effect of the above three is superimposed, and the structure analysis of each section of the original bridge without considering the "energy release method" is carried out.

4.3 Threshold Search for Bridge Bearing Capacity

On the gray scale fluctuation curve, if the gray level of a single pixel is the dividing line between the peaks and valleys, the target and the background can be effectively separated by searching for its position and then dynamically dividing its peaks and valleys. Suppose the gray curve function of the S component is \( g(k) \), \( k=0,1,2,...255 \), \( k \) is the gray value, and \( g(k) \) is the number of pixels corresponding to the gray value \( k \). The specific data is shown in Figure 3.

![Figure 3. Gray-scale fluctuation curve](image)

Finding the crests and troughs on the grayscale curve and their corresponding dividing lines is an important part of the threshold segmentation of grayscale fluctuations. However, the crests and troughs under normal conditions are shown in the figure, but they are not so smooth, and there are varying amplitude fluctuations. Although there are different peaks in the figure, there are also some peaks with high similarity. We can find that there are many smaller crests hidden in the larger crests.

5. Conclusions

Although this article introduces the research and application of highway bridge detection technology under big data, there are still many shortcomings. Based on big data, there are still many in-depth contents worthy of research on highway bridge test detection technology and application methods. There are many steps in the energy interpretation process that have not been involved due to reasons such as space and personal ability. In addition, the actual application effect of highway bridge load analysis can only be compared with traditional models from the level of theory and simulation. With the development of modern science and technology and the in-depth application of computer big data, the accuracy of highway and bridge testing equipment has improved, and the testing technology has
been further strengthened. Highway bridge testing has become more and more accurate, and the incidence of safety accidents has been greatly reduced.

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