Evaluation Scheme of Live Load Standard of Railway Bridge Based on VR Technology

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Abstract. With the rapid development of China's railways and the extension of high-speed railways in all directions, China's railway departments have realized that the original design concept and design load can no longer meet the current requirements of railway operation. This paper mainly studies the design of the live load standard evaluation scheme for railway Bridges based on VR technology. This paper first introduces the theory of load experiment and analyzes the live load experiment and its standard in detail. Then, this paper analyzes the live load standard evaluation scheme of railway Bridges under VR technology, and carries out experiments. The experimental results show that when the spacing between main beams is 2.1m and 4m, the empirical distribution does not reject the test of normal distribution, lognormal distribution and extremum-I distribution, but the test value of normal distribution is the smallest, indicating that the distribution type of transverse distribution coefficient of load is closer to normal distribution. The results of this paper are helpful for the railway departments to carry out live load experiments on railway Bridges and promote the development of load evaluation of railway Bridges.

Keywords: VR Technology; Railway Bridge; Load Test; Live Load Assessment

1. Introduction
Our country land area of the world's third, unbalanced regional economic development, resource distribution imbalance, industry layout and unbalanced, it also determines the consumer market and production process may need to pass long distance, large capacity, low cost process for transportation, among numerous transportation, railway transportation with great advantages to become the main way of freight transportation around the world. With the increase of the service life of railway Bridges, cracks will occur in the concrete of Bridges under the influence of the outside world in the process of use, and the occurrence of cracks will cause corrosion of the stressed steel reinforcement, which will lead to the decrease of the bearing capacity of bridge structures and affect the operation safety of Bridges. In order to ensure the safe operation of the bridge, the bridge needs to conduct operational performance tests regularly during its use to ensure that the amplitude, acceleration, deflection and other performance indicators meet the requirements [1]. Before upgrading and upgrading of heavy-haul railway operation system of more than 30 tons, it is more necessary to master the performance index of the bridge, and it is more necessary to conduct operational performance test on the bridge.
It is a key issue of concern for all countries in the world to accurately master the operational performance of Bridges and ensure the safety of bridge structures. In order to accurately grasp the performance indicators of Bridges, after two years of unremitting efforts, Europe has finally established a set of more effective bridge management system. Zhao through the summary of the research status at home and abroad, the system introduces the significance of bridge reinforcement after evaluation, the basic concept of bridge reinforcement after evaluation, the main content of the evaluation after reinforcement and the suitable object, think it is after the bridge reinforcement technology, efficiency and effect evaluation index as the main content of bridge reinforcement after evaluation [2]. Griffin, the bearing capacity calculation expressions given in the specification, joined the adjustment coefficient of load and resistance, to determine the expression of reinforced concrete bridge safety assessment and reliability index, on the basis of the theory from the perspective of engineering and established the corresponding evaluation methods, through good results have been achieved in actual engineering [3].

This paper summarizes and analyzes the realization degree and difficulties of the live load experiment of railway Bridges, probes into the value and significance of VR technology in the live load experiment of railway Bridges, applies VR technology to the actual case of live load experiment of railway Bridges, and changes the traditional use mode of live load of railway Bridges.

2. Evaluation of Live Load Standard under VR Technology

2.1. Theory of Load Experiment
Bridge load test is a kind of engineering technology that applies static or dynamic load to the bridge, tests and analyzes the strain and deformation of the structure, obtains the real static and dynamic characteristics of the bridge structure, and then evaluates the healthy state of the bridge structure, and provides scientific basis for the completion acceptance and maintenance of the bridge.

(1) Static Load Test
Static load test usually refers to the external load on the bridge structure during normal operation, such as live load, etc. Due to its most intuitive, clear, simple test method and high reliability of test results, it has become the most common basic test measure in current load tests of Bridges [4]. At present, the loading of static load test is mainly carried out by the control method of hierarchical loading up to the most unfavorable situation; the most common is to load with heavy load vehicles.

(2) Dynamic Load Test
Dynamic load test of bridge structure is a kind of test method to measure the dynamic deflection or dynamic strain of bridge structure by external excitation or vehicle impact, so as to obtain the dynamic characteristics and dynamic response of the structure. This method is generally applicable to the actual site where the bridge structure is located [5].

The dynamic characteristics of the bridge structure (natural vibration frequency, period, etc.) are mainly measured by the pulsation test on the bridge site. The error between the theoretical value and the measured value can be obtained by comparing the dynamic load test data with the bridge frequency obtained by the static analysis model, and the method can also be used to evaluate the stiffness and safety of the bridge structure itself.

In addition, the dynamic response state in dynamic load test is often evaluated by measuring the impact coefficient of bridge structures. The impact coefficient is determined by sports car, brake and jump test. In practice, it is to obtain the dynamic deflection or dynamic strain of the relatively weak point of the structure when the vehicle passes through the bridge, and then compare and analyze the peak values of static and dynamic situations, and finally calculate the dynamic increment of the bridge structure caused by the vibration of the vehicle.

(3) Live Load
Train load diagram is a generalized expression form of the static action of railway train on line infrastructure. It is formulated comprehensively according to different types of railway transport mobile equipment and considering certain reserve and development coefficient. In the early railway
bridge design, each version of the standard load diagram was single, and the original design load ("medium-live load"), the current passenger/cargo collinear load (ZKH load), and the heavy load (ZH load) were used to check and calculate the bearing capacity of the bridge [6].

According to the new bridge regulations, formula (1) is modified to formula (2) while the formula for calculating the dynamic coefficient remains unchanged:

\[
\alpha = 4(1 - h) \leq 2 \quad (1)
\]

\[
\alpha = 0.32 \times (3 - h)^2 \leq 2 \quad (2)
\]

2.2. BIM and VR Integration Approach

(1) Overview of VR Theory

VR technology is to use computer technology as the core of modern technology, together with other electronic technology can generate realistic visual, hearing, touch, the integration of a range of virtual environment, users can use the sensor equipment necessary to natural way interaction with objects in the virtual environment, in order to gain equal to the real environment of feeling and experience [7-8]. With the development of computer hardware and electronic technology in recent years, the application of VR technology in the field of transportation has also expanded. The application of VR technology in the field of transportation includes testing traffic schemes, rail transit simulation, road and bridge, and driving training. VR technology, as an emerging technology, is being widely used in various fields at various stages.

On the whole, the research on BIM and VR technology is basically separate. However, with the frequent crossover between BIM and VR application, more and more people have noticed the great potential of "BIM+VR" technology, especially in the construction and transportation fields where the application of BIM and VR is most frequently crossed.

The integration method of BIM and VR is realized through the intermediate file JSON and database. JSON file is used to reconstruct the model in Unity3d, and the attribute database is used to realize the migration of model attribute information to Unity3d. This method can not only avoid material map loss and model attribute query after Revit model is exported in *.fBX format and imported into Unity3d, but also avoid problems such as inconsistency of the same model size in different coordinate systems.

(2) Set Model Reconstruction in VR

The model in Unity3d is based on Mesh, and Mesh is composed of triangle network. In Unity3d, Mesh class is provided to realize the construction of triangulation. A most basic triangulation can be constructed by the given vertex coordinates of the triangle and triangle array in a clockwise order, and a complete model can be formed by adding normals and UV information on the basis of the triangulation. In Unity3d, the MeshFilter component is provided to carry Mesh data, and the MeshRenderer component is used to render the Mesh [9]. BIM and VR integration method needs to use the above export JSON file, use the LISTJSON library to parse the JSON file and convert it into a custom mode data object. It should be noted that the fields in JSON should be consistent with the property fields in the data class, otherwise the stored data information cannot be obtained. The detailed reconstruction process of VR geometric model is as follows:

1) Create custom menu and parse JSON file. Create custom menu, do not need to run the software to load the script, for debugging function requirements more convenient and fast.

2) Traverse the data class and reconstruct the model Mesh. The complete data constituting the Mesh is stored in each data class. Through traversal of these data, vertex coordinate information, order of the Mesh, normal coordinate and UV are respectively assigned to the Mesh grid, and the geometric appearance of the BIM model is finally integrated in the VR platform with the ID of the model as the name of the Mesh.

3) Create Material, index according to ID and assign corresponding Mesh. The Material map data information in THE JSON file is read, the stored map is read and the Material is created. The ID of the element is taken as the identification index, and the generated Mesh is assigned to complete the
3. Test the Transverse Distribution Coefficient of Load

Load transverse distribution coefficient of the probability distribution type through test analysis to determine K - S, K, S test are calculated by using the K - S check value compared with the known threshold and to determine the load distribution types of a highly efficient distribution we fitting method, the determination of the critical value according to the significance level of K - S inspection and test to an array of interval number. The k-S test value is defined as follows:

$$D_n = \max\{|F_n(x_i) - F_0(x_i)|\}$$  \hspace{1cm} (3)

Where \(n\) represents the interval number of the array to be tested by K-S; \(X_i\) is the maximum value of the ith interval array; \(F_n(x)\) represents the cumulative empirical distribution function; \(F_0(x)\) represents the theoretical cumulative distribution function.

The general steps of k-S fitting test are as follows:

First, according to the curve distribution shape provided by frequency histogram, it is assumed that the sample population obeys a certain theoretical distribution.

Second, in order to calculate the observed values of test statistics, the measured data are arranged in order of magnitude and grouped to calculate the deviation of \(|F_n(x) - F_0(x)|\) between theoretical distribution \(F_0(x)\) and empirical distribution \(F_n(x)\).

Third: Given the significance level, obtain the k-S test critical value corresponding to the significance level by looking up the table, compare the size of Max \(D_n\) and the corresponding critical value, and determine whether the sample complies with the distribution type assumed in the first step.

When the spacing between main beams is 2.1m and 4m, the interval number of load transverse distribution coefficient is set as 13. When the spacing between main beams is 2.92m, the interval number of load transverse distribution coefficient is set as 10. For all Bridges, the significance level of distribution test is set as 0.01.

4. Test Results of Transverse Distribution Coefficient of Load

4.1. Test Results of Lateral Load Distribution Coefficient

**Table 1.** Test results of lateral load distribution coefficient

| Main girder spacing | 10   | 20   | 30   | 40   | 50   |
|---------------------|------|------|------|------|------|
| 2.1 m               | 0.093| 0.075| 0.066| 0.081| 0.073|
| 2.92 m              | 0.202| 0.289| 0.241| 0.189| 0.257|
| 4 m                 | 0.089| 0.092| 0.077| 0.086| 0.061|

As shown in Table 1, in addition to the bridge girder spacing of 2.92 m, all K - S inspection values are lower than the critical value, which means when the girder spacing is 2.1 m and 4 m empirical distribution does not refuse to normal distribution and lognormal distribution and extreme value type I distribution of the three distribution types of inspection, but the minimum value of normal distribution test, shows that the distribution of the load transverse distribution coefficient of type closer to normal distribution. When the girder spacing was 2.92m, only the local beta distribution passed the test for the three distribution types: the local beta distribution, the local lognormal distribution and the local extremum -I distribution.

4.2. Probability Distribution and Fitting Result of Transverse Distribution Coefficient of Load
As shown in FIG.1, when the spacing of main beams is 2.1m and 4m, the probability distribution of transverse load distribution coefficient is fitted with normal distribution; when the spacing of main beams is 2.92m, the local beta distribution is used to fit the probability distribution of transverse load distribution coefficient.

4.3. Variation Coefficient of Transverse Distribution Coefficient of Bridge Load

| Main girder spacing | 10    | 20    | 30    | 40    | 50    |
|---------------------|-------|-------|-------|-------|-------|
| 2.1 m               | 0.142 | 0.112 | 0.075 | 0.069 | 0.062 |
| 2.92 m              | 0.051 | 0.028 | 0.017 | 0.016 | 0.015 |
| 4 m                 | 0.108 | 0.075 | 0.058 | 0.044 | 0.039 |

As shown in table 2 and figure 2, all the stress of the bridge girder of the critical (critical girder stress is defined as a vehicle within the scope of the lateral load load when the load of the main girder
and most that the maximum values of the transverse distribution coefficient of the girder and the most unfavorable girder) also known as the stress of the load transverse distribution coefficient of the coefficient of variation (COV). As can be seen from the figure, when the girder spacing is the same, the value of variation coefficient decreases gradually with the increase of bridge span. When the span of the bridge is the same, the variation coefficient of the load transverse distribution coefficient of the bridge with the main girder spacing of 2.1m is the largest, and the value of the variation coefficient of the load transverse distribution coefficient of the bridge with the main girder spacing of 2.92m is the smallest. It can be inferred that bridge span and girder spacing have great influence on the variation coefficient of the probability distribution of load transverse distribution coefficient. The variation coefficient reflects the dispersion degree of a group of data. The larger the variation coefficient is, the larger the variation range of load transverse distribution coefficient is; the smaller the variation coefficient is, the smaller the variation range of load transverse distribution coefficient is. It can be seen that when the main beam spacing is the same, the bridge span is smaller, the transverse distribution coefficient of load dispersion degree is greater.

5. Conclusions
With the continuous development of society, railway Bridges play an important role in the process of national infrastructure construction and social production development. Vr-based railway bridge operation and maintenance management can bring promotion, development and support to all parties. VR technology management greatly improves the safety, reliability, stability, efficiency and energy saving of railway bridge operation. In the life cycle of railway bridge operation, it maximizes the operating value of railway bridge and gives full play to the maximum utility of railway bridge. Firstly, this paper briefly summarizes the characteristics and process of bridge structure state assessment. Then, the live load standard evaluation scheme of railway Bridges under VR technology is analyzed in detail. Finally, through the load test data analysis and application of the case bridge based on load test, the construction of the corresponding evaluation index, the determination of weight interval, evaluation matrix and membership function determination, so as to test the evaluation of the bridge state.

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