Analysis of the Testing and Evaluation Rules for the Carrying Capacity of Highway Bridges

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Abstract. Combining with the understanding of the "Procedures for Testing and Evaluating the Carrying Capacity of Highway Bridges" (JTG / T J 21-2011) and practical engineering applications, it is found that there are some deficiencies in the process of carrying out the carrying capacity testing and evaluation of bridges by using the "Procedures for Testing and Evaluating the Bearing Capacity of Highway Bridges" Some points, such as the difference in the calculation results of the bearing capacity check coefficient Z1, the ambiguity of some concepts in the specification, and the actual operability still need to be improved, etc., and put forward some suggestions for these problems.

1. Introduction
As of the end of 2018, the total national highway mileage was 4,486,500 kilometers, an increase of 73,100 kilometers over the previous year. Highway density was 50.48 km / 100 km2, an increase of 0.76 km / 100 km2. The highway maintenance mileage is 4,578,800 kilometers, accounting for 98.2% of the total mileage of the highway. There are 851,500 highway bridges and 55.649 million meters of highways across the country, an increase of 19.00 million and 34.297 million meters over the previous year, of which 5,053 are large bridges, 9.269 million meters, 98,869 bridges, and 26.704 million meters. [1].

Such a large number of in-use highway bridges have brought challenges to the management, maintenance and repair of the bridges. The main basis of highway bridge maintenance and repair is the bridge inspection and evaluation results. At present, the bridges in use are mainly determined according to the "Evaluation Standards for the Technical Conditions of Highway Bridges" (JTGT H21-2011) (hereinafter referred to as "Assessment Standards") and "Construction Specifications for Highway Bridge Conservation" (JTG H11-2004) (hereinafter referred to as "Maintenance Specifications") The technical status of the company is rated and maintenance measures are given. However, the bridge technology status assessment grade can only qualitatively reflect the actual bearing capacity of the bridge's current state to a certain extent, and cannot quantitatively describe the bridge's current and future bearing capacity within a certain inspection period. The qualitative or quantitative assessment of the bearing capacity is still required when the bridge is used for reinforcement design or in some special cases.

Bridge carrying capacity assessment is an important part of bridge assessment. The current "Guidelines for Testing and Evaluating the Carrying Capacity of Highway Bridges" (JTG / T J 21-2011) (hereinafter referred to as the "Evaluation Rules") play a very good standard role in the testing and
Appraisal of highway bridges. Helpful guidance. However, in the actual project application, there are also some questionable points in the "Assessment Regulations", as described below.

2. There is a difference in the calculation results of the carrying capacity check coefficient Z1

In carrying out the bridge structure carrying capacity check, the determination of the bridge bearing capacity checking coefficient Z1 is very important. Among the three indicators for calculating Z1, the weight of the defect detection indicator is 0.4 [2]. The bridge defect status assessment scale can be obtained according to the "Conservation Code" or "Evaluation Standard"; and different inspectors or even the same inspector often determine the technical condition grade of the bridge structure according to these two codes [3]. The reasons for this result are related to the differences in the calculation methods and content of the two assessment systems, in addition to the professional quality of the test staff. Specifically, the evaluation scores of the "Conservation Code" are calculated from the component level, and the evaluation scores of the “Evaluation Standards” are calculated from the component level, the latter calculation content is more detailed [4]. Moreover, the classification limits [5,6] (evaluation classification limits) of the bridge technical status of the two codes are different, as shown in Table 1.

| Specification        | Type one | Type two | Type three | Type four | Type five |
|----------------------|----------|----------|------------|-----------|-----------|
| "Conservation Code"  | [88,100] | [60,88)  | [40,60)    | [0,40)    | [0,40)    |
| "Evaluation Standards" | [95,100] | [80,95)  | [60,80)    | [40,60)   | [0,40)    |

The defect status assessment scales determined by the two standards are different, which results in a difference in the value of the bearing capacity check coefficient Z1; moreover, the defect status detection index occupies a larger weight, which indirectly magnifies the difference, as shown in Figure 1. Show.

For the four or five types of bridges that need to be tested and evaluated for bearing capacity, the defect status index has a greater impact on Z1. This directly affects the results of carrying capacity check analysis. So, in order to unify the results of carrying capacity assessment and avoid divergences, it is recommended to use a standard to assess the technical status of the bridge; or to take a less favorable result. The rating system of "Assessment Standards" is meticulously classified, and quantitative standards for evaluation indicators are proposed, which are more operable. Based on this, it is recommended to use the "Evaluation Criteria" to evaluate the defect status.

Note: When calculating Z1, the evaluation scales of material strength and natural frequency are both 1. The changes of eccentric tension, eccentric compression, local pressure-bearing members and bending members are completely consistent.

3. Some concepts refer to ambiguity

The rating scale D of the load-bearing capacity calculation coefficient in the "Assessment Regulations" 7.7 is for the structure or components of the bridge. The evaluation scale D is determined based on the defect status, material strength, and natural frequency; while the evaluation status of the defect status is based on Article 4.2 of the "Assessment Regulations", which only corresponds to the bridge deck system, the upper structure, and the lower structure; no component is mentioned. Similarly, the natural frequency of Article 5.9 of the "Assessment Regulations" only corresponds to the superstructure and substructure. In practical applications, for example, when carrying capacity calculation and analysis is performed on a beam of a multi-girder bridge, the technical condition level of the component can be evaluated according to the "Evaluation Standards", but how to determine its natural frequency evaluation scale.

For the calculation of the self-resonant frequency evaluation scale, the "Evaluation Regulations" does not indicate which order of frequency or the ratio of the measured value to the theoretical value of one...
or some characteristic frequencies; the results obtained based on different frequencies are not exhaustive. The same [7]. According to relevant theoretical research and a large amount of experimental data, it is found that the ratio of the measured first-order natural mode frequency to the newly-measured first-order natural mode frequency can be used as a state indicator and can reflect the safety status of the bridge [8]. It is recommended to determine the scale of natural frequency evaluation based on the measured and theoretically calculated first-order frequency of the bridge.

4. The operability in practical use still needs to be improved
Compared with the "Evaluation Method of Highway Old Bridge Carrying Capacity (Trial)", the "Evaluation Standard" has solved the problem of quantification of test results, and also introduced a sub-item calculation coefficient to improve the objectivity and operability of bridge load capacity assessment [9]; but there are still difficulties in actual operation.

In calculating the calculation coefficient of the bearing capacity of masonry bridges, the material strength evaluation of masonry structures is involved. The materials for bridge and culvert masonry structures are mainly stone and concrete. Only 5.3.5 of the "Assessment Rules" for concrete strength assessment standards. For ordinary concrete components, the rebound method, ultrasonic-rebound method, rebound-coring method can be used to detect the strength of structural concrete, but it is difficult to accurately measure the material strength when applied to masonry structures [10].

jumping method, the environmental random vibration test method (pulsation test), and the jumping residual vibration method can be used to analyze and determine [11]. However, testers are required to have high professional skills, and the frequency measurement technology for complex bridges is still immature. In addition, for a large number of small and medium-span old bridges, due to their long history and lack of data, it is often difficult to establish a bridge model that conforms to the actual situation; it is also impossible to calculate their natural frequency. For this lack of structural self-vibration frequency evaluation scale, the practice of the "evaluation standard" can be used for reference, that is, the value of the missing index weight is allocated according to the proportion of the existing index weight among all the existing index weights.

5. Conclusion
The "Evaluation Regulations" did play a very important role in the evaluation of the bearing capacity of the old highway bridge, but there are also some deficiencies in the actual application process. In summary, there are three main points.

(1) Due to the different standards for the assessment of bridge defect conditions, the calculated bearing capacity check coefficient $Z_1$ is different. The value of $Z_1$ directly affects the reduction of the resistance of the bridge structure, so the calculation and analysis of the bearing capacity of the bridge will also cause a large difference.

(2) In the "Assessment Regulations", the references to related concepts are slightly vague. When determining the deficit status of components or structures and the scale for assessing the natural frequency, it is easy to make the auditors out of order.

(3) For certain types of bridges in the "Assessment Regulations", the relevant indicators are difficult to accurately measure or theoretically calculated, and some indicators may even be missing. This brings difficulties to the practical application of the "Assessment Regulations" for the testing and assessment of the carrying capacity of bridges in use.

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