Bridge structure safety assessment

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Abstract. With the passage of time, more and more highway bridges gradually enter the old age, and the safety assessment of bridge structures is particularly urgent. According to the use status of in-service reinforced concrete bridges and the actual problems of highway bridges, the necessity and urgency of this subject research are pointed out. At the same time, it comprehensively analyzes the technical specifications, research and application status of bridge structure safety assessment at home and abroad, and points out the advantages and disadvantages of existing technical specifications and research results in terms of content, methods and applications, and aims at the existing technical specifications and research results. Insufficiency, the main research content of this topic is proposed.

1. Research background and significance
During the service life of the bridge, its service conditions will inevitably be affected by vehicles and various unfavorable environmental factors, resulting in varying degrees of physical and mechanical damage to the bridge structure, especially reinforced concrete bridges built in the 50s, 60s and even 70s. The design standards are generally low, the bridges have been in overloaded working conditions for a long time, and after 30-50 years of harsh environmental effects, this phenomenon has been particularly prominent. Most bridges have been in sick working conditions, which seriously endangers the safety of driving. Take Shandong Province as an example.

The above-mentioned bridge collapse accidents are mainly caused by overloading or material deterioration leading to the strength failure or instability of the bridge structure as a whole or components. Such accidents can be avoided through the safety assessment or carrying capacity appraisal of the bridge structure. Based on the actual conditions of in-service bridges at home and abroad, in order to avoid the recurrence of vicious bridge collapse accidents, the bridge management department must conduct general inspections of the bridges on a regular basis, and perform the assessment of the bearing capacity of the bridge structure when necessary. Facing the increasing number of highway bridge collapse accidents and the increasingly arduous task of strengthening and rebuilding dangerous old bridges on active highways, it is urgent to establish a systematic, reliable and feasible assessment system for the safety of in-service bridge structures in order to timely, reasonably and effectively Evaluate the current working status of the in-service bridge to avoid malignant bridge collapse accidents caused by the failure of the bridge structure or component strength, and provide a basis for the decision-making of bridge maintenance, repair, reinforcement or reconstruction. To this end, domestic and foreign highway scientific research and technical personnel have carried out a large number of fruitful research work and obtained fruitful research results, and have formulated technical guidelines or specifications for the
strength evaluation and condition evaluation of the bridge structure. For a long period of time in the future, the focus of bridge research has shifted from the research on bridge design theory to the research on effective maintenance and management techniques for in-service bridges.

In recent years, there have also been several vicious accidents of bridge collapse caused by ships colliding with bridge piers in China, such as the boat collision and collapse accident of the pavilion bridge in Suzhou Hengtang section of the Beijing-Hangzhou Grand Canal (2004) and the boat collision and collapse accident of the Jiujiang Bridge in Nanhai District, Foshan City (2007.6). Dayang Bridge Cargo Ship Collision and Collapse Accident in Kunshan City, Jiangsu (2007). The above series of bridge collapse accidents show that the main cause of bridge collapse is not only caused by the structural damage of the bridge and the strength failure, but also the vehicles and ships under the bridge. Impact on bridge piers, main girder, and excessive sand mining at the bridge location can also affect the safety of the bridge by natural or human factors that cannot be ignored. Therefore, the current code based on the structural level of the carrying capacity appraisal is far from meeting the requirements of bridge safety assessment. It is necessary to rise to the height of the safety of the bridge system, and comprehensively consider the safety status of the bridge structure itself, the safety of traffic operations on and under the bridge, and the abnormal erosion of the foundation. The safety of the bridge structure and the public safety (referring to cars, pedestrians) The comprehensive evaluation of the safety of use), the comprehensive evaluation of the safety of use, in which the evaluation criteria of the public safety evaluation should be specifically formulated in conjunction with the social importance of the bridge to be evaluated, the severity of the consequences of bridge damage, and the public’s psychological tolerance for bridge damage.

According to the above, due to the huge number of dilapidated and old bridges in the country and the frequent occurrence of bridge collapse accidents, my country's highway management departments have paid great attention. The Ministry of Transport has ordered all localities to immediately carry out quality surveys of distressed and old bridges. Based on this background, there is an urgent need to find a simple, fast and systematic bridge safety assessment method. Based on the appraisal of the bridge structure's bearing capacity, the system safety of the bridge to be appraised can be accurately assessed to ensure the safety and smooth flow of road traffic. In response to this project, the Highway Bureau of the Shandong Provincial Department of Communications, in 2005, combined with the Shandong Provincial Highway and Bridge Inspection Center, the Transportation Science Research Institute of the Ministry of Communications, Shandong University of Science and Technology and other scientific research units to form a special research team to formally carry out the "Highway and Bridge Inspection Evaluation The subject research work of "Research on Comprehensive Technology of Reinforcement and Reinforcement", which aims to combine the specific actual situation of Shandong Province to investigate and study the periodic inspection and quality inspection methods of bridges that can guide the bridge maintenance work in Shandong Province, the assessment standards of bridge technical conditions, and the inspection of bridge bearing capacity Evaluation methods and complete sets of bridge maintenance and reinforcement technologies to achieve the goal of comprehensively improving the technical level of bridge maintenance in Shandong Province. This subject involves 5 sub-topics, of which "Research on Highway Bridge Carrying Capacity Evaluation Technology" belongs to the fourth topic. In May 2006, the research team organized a special survey on the safety of dilapidated bridges in accordance with the requirements of the research outline. The results of the survey showed that there are three main reasons for the reduction of the load-bearing capacity of reinforced concrete bridges. The first is due to changes in bridge functions such as increased load. Grades lead to insufficient load-bearing capacity of the original structure and reduced safety reserves; second, actual overload caused by low bridge design standards or too many overloaded vehicles; third, structural damage caused by corrosion of reinforced steel bars, cross-section defects, and concrete deterioration The safety of the bridge is reduced. The above factors all lead to the relatively insufficient bearing capacity of the bridge structure level, and the safety margin of the bridge structure is reduced. At the same time, based on the results of the bridge inspection and evaluation, the reinforcement technology can be economically and rationally decided in order to achieve the best balance between reinforcement economy and safety, so as to
maximize the load-bearing potential of our existing bridge structures and achieve the best Optimizing economic benefits is an urgent task facing experts, scholars and engineers. A reasonable approach should be to have a correct evaluation of the existing bridge’s operating conditions, damage degree, bearing potential and remaining life and other issues, and then take corresponding reinforcement and maintenance countermeasures on this basis, and strive to tap the existing bridge’s bearing capacity potential. Therefore, the bridge as a highway throat will gradually shift from the period of large-scale construction to the period of evaluating, improving and improving its performance.

In summary, the topic selection of this topic is reasonable, has strong engineering pertinence, and contributes to the overall improvement of the technical level of my country's bridge safety assessment.

2. Classification and methods of commonly used bridge assessment techniques

2.1. Basic classification of commonly used bridge assessment techniques

Bridge inspection and evaluation is the process of understanding the technical status of a certain part or the whole of the bridge. The result is an objective description of the status of the bridge to be tested. This description involves factors such as material defects, deterioration, and structural forces. This information as a whole is vague, which needs to be quantified by mathematical means to achieve the purpose of evaluating its reliability or reliability, such as safety or durability. Therefore, the so-called bridge evaluation is to use a series of evaluation indicators and evaluation models to evaluate the reliability of the in-service bridge or the technical level of a certain aspect of the reliability according to the collected bridge technical condition data, thereby judging that the in-service bridge meets the specified use. The degree of requirements and functional requirements, and the process of making engineering decisions accordingly. Based on the actual situation of highway bridge assessment at home and abroad, and for different assessment content and assessment purposes, the assessment of in-service bridges can be divided into three categories, namely, comprehensive assessment methods based on condition assessment based on bridge appearance surveys, and oriented to small and medium spans. Appraisal and assessment of the bearing capacity of bridges and condition assessment for large bridges. The first category can be considered to be a comprehensive assessment method based on condition assessment based on the appearance of the bridge. It is a preliminary judgment of the overall technical condition of the bridge structure. It belongs to the category of fuzzy classification. The assessment result can be used as a special inspection of the bridge structure. The basis of suitability assessment. Countries have formulated national standards for grading and sorting based on specific conditions. The basic methods are similar. First, experts will vaguely classify the indicators of interest, and the rights of indicators will be given by experts, which are used as industry, region or bridge standards; practical. At the time, the specified indicators of the real bridge were scored by fuzzy classification, and the weighted sum was used to obtain the evaluation conclusion. This is the evaluation method adopted by my country's highway and urban bridge maintenance specifications and foreign standards. The second category is an assessment method focusing on the appraisal of the bearing capacity for small and medium-span bridges. The domestic "Appraisal Method for the Bearing Capacity of Old Highway Bridges" (Trial) or the "Regulations for Testing and Evaluation of the Bearing Capacity of Highway Bridges" provide the basis for such assessments. However, in the assessment, some bridges that have passed the load-bearing capacity check but have large stress cracks or deflection are required. This requires that the bridge inspection and evaluation must take into account the load-bearing capacity check items and the load-bearing state observation items, and only meet the requirements of the specification. The bridge structure is reliable. For example, the actual degraded reinforced concrete hollow slab test data shows that although the degree of steel corrosion is different, the bearing capacity of the hollow slab is not significantly reduced. However, from the perspective of durability, it has reached the limit state, and severely corroded bridges will face failure at any time. danger. At the same time, with the development of bridge evaluation technology, bridge inspection makes it possible to comprehensively consider the carrying capacity check calculation and the carrying state.
The third category is condition assessment for large-scale bridges, that is, using the data obtained by monitoring systems and manual inspections to comprehensively assess the current status of large-scale bridges to determine the working status of the structure and guide daily maintenance and repair. The condition assessment of the bridge includes not only the safety of the stress state of the bridge, but also the applicability of the stress process and the durability of the structure. It is a comprehensive reflection of the safety, applicability and durability of the bridge operation.

2.2. Basic steps of the comprehensive evaluation method

Comprehensive evaluation is to make a general evaluation of the data obtained from different aspects of objective things. In actual work, the evaluation (or evaluation) of a thing often involves multiple factors or multiple indicators. It is a typical multi-index evaluation problem. You can’t just evaluate things from a single factor, but based on multiple factors or Indicators make a comprehensive evaluation of things, that is, comprehensive evaluation. Obviously, judging refers to comparing and judging the pros and cons of objective things according to given conditions or standards; comprehensive refers to the systematic analysis and judging conditions that contain multiple factors or multiple indicators. Therefore, comprehensive evaluation (evaluation) is to make a comprehensive evaluation of things or projects involving multiple factors. Comprehensive evaluation generally solves the following three types of problems.

The third type of assessment problem is mainly solved in the assessment of bridge technical condition. In view of the diversity and complexity of assessment indicators, the comprehensive assessment of bridge structure can generally be divided into four steps:

1. Build an indicator model

In the multi-index comprehensive evaluation, a hierarchical multi-level index system model should be established first according to the evaluation object and evaluation objective. For comprehensive assessment of bridge safety, an index system model should be constructed first. The index system is hierarchized according to the force transmission path of the bridge structure, which is divided into first-level indicators and second-level indicators. According to the complexity of the assessment project, three-level indicators can even be selected. The lowest level indicators are divided into qualitative and quantitative.

2. Determination of index importance weight

When using multiple indicators to comprehensively evaluate things, weights are usually used to reflect the importance of each evaluation indicator to the evaluation object. The larger the weight, the more important it is, and vice versa. For example, in the assessment of the overall technical condition of the bridge, the degree of influence of the bridge superstructure and the tapered slope and other protective structures on the technical condition of the bridge is different. For the scientific and reasonable evaluation, it is usually necessary to assign indicators with different degrees of importance to the evaluation target. Different weights. The weight determination methods include Delphi method (expert method), analytic hierarchy process, binomial coefficient weighting method and adjacent index comparison method, among which Delphi method and analytic hierarchy process are the most commonly used and important methods.

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