Study on Fatigue Resistance Optimum Design of Steel-concrete Composite Beam Cable-stayed Bridge Deck

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Abstract: Under the background of social and economic development, steel-concrete composite girder cable-stayed bridge, as a new building structure, greatly improves the public's traffic convenience. Based on bridge engineering design and construction, combined with the characteristics of steel-concrete composite girder cable-stayed bridge deck, this paper draws a fatigue-resistant plan of steel-concrete composite girder cable-stayed bridge deck, which can avoid bridge cracking, improve the shortcoming of difficult deck pavement and shorten the construction period.

1. Background of the study

1.1 Literature review

In the corresponding construction field, in order to study the influence of creep and shrinkage on the stress of integral cable-stayed bridges, Li Faxiong et al. based on ABAQUS platform, selected typical experimental results, compared and verified different concrete creep and shrinkage modules, and found that the creep and shrinkage of cable-stayed bridges occurred and were affected by different compressive stresses (Li et al,2013). He Yaobei et al. are based on the problems of traditional steel-concrete composite beams. One Zishui Bridge in Hunan Province, China, is the main research object. By establishing the model of main girder segments and whole bridge, and then carrying out corresponding bending tests, the concrete fatigue resistance of steel-concrete composite beams is obtained, which can provide reference for engineering construction (He et al,2019). Su Haicheng summarized the types and causes of cracks in composite girder cable-stayed bridge deck, analyzed the influence of cracks on fatigue resistance of bridge deck from different connection degrees, and then put forward three feasible connection modes (Su,2017). Under the background of social development, this paper studies the engineering process of composite girder cable-stayed bridge, discusses the influence of wet joint construction technology on bridge structure, and explains the specific application of related technology, which is conducive to improving construction quality and efficiency (Wang,2018). As a new type of cable-stayed bridge, the composite beam-concrete beam hybrid cable-stayed bridge is analyzed in detail by using finite element software, and the methods to improve the stability of the bridge structure are put forward (Luo et al,2012).

1.2 Purpose of research

In recent years, a large number of cable-stayed bridges have been built in the construction industry, and combined with different construction schemes, the high cost of bridge construction has been avoided. However, after construction, it is found that bridge cracks occur in the operation of different bridges. Through the analysis of the causes, it is found that bridge cracks are mainly caused by the restraint of steel bars in the deck, resulting in great tensile stress, and the overall structural fatigue resistance is reduced because of the insufficient reinforcement of the deck. Therefore, in view of the advantages and disadvantages of steel-concrete composite girder cable-stayed bridge deck, this paper analyses the fatigue problems of steel-concrete composite

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girder cable-stayed bridge deck, and then puts forward concrete optimization measures from two aspects of control of welding connection technology and construction control of high-strength bolt connection, which are of great importance to improve bridge stability.

2. Characteristics of steel-concrete composite beam cable-stayed bridge deck

In the field of construction engineering, steel-concrete composite beam cable-stayed bridge deck is a new type of structure developed on the basis of reinforced concrete structure. Generally, it is widely used in railway bridges, urban overpasses, civil buildings and large-span industrial buildings (Ding et al, 2018). In the practical application process, the steel-concrete composite girder cable-stayed bridge deck has the characteristics of novelty, beautiful shape, smooth structure, vivid artistic conception and smooth lines, which can effectively realize the coordination and unity between architecture and aesthetics.

In the deck structure of cable-stayed bridge with steel-concrete composite beams, two steel beams are mainly composed of upper and lower parts (Shi et al, 2015). Seamless butt joint is realized between two beams and slabs through shear shear connectors. In the steel-concrete composite beam cable-stayed bridge deck structure, the reinforced concrete slab is mainly responsible for compressive stress, which can give full play to the related properties of materials. In related fields, besides utilizing the mechanical characteristics of concrete and steel, the steel-concrete composite girder cable-stayed bridge deck has the following advantages.

First, the anti-fatigue performance is high. The steel-concrete composite girder cable-stayed bridge deck has greater stiffness, can reduce the flange stress on the steel girder, can significantly increase the distribution length of wheel pressure on the steel girder, and then improve the stress state of the overall steel girder.

Second, save steel. Practical research results show that steel can be saved about 20%-40% compared with steel structure in steel-concrete composite girder cable-stayed bridge deck structure, which greatly reduces the production cost of construction department.

Third, improve the seismic performance of the structure. On the related buildings, the overall structure design of steel-concrete composite girder cable-stayed bridge deck is more reasonable and has good fatigue resistance. Therefore, in the actual application process, the steel-concrete composite beam cable-stayed bridge deck can show good seismic performance.

Fourthly, it has high reliability of bearing capacity. In the related fields at home and abroad, the steel-concrete composite girder cable-stayed bridge deck is tested, and it is found that the steel-concrete composite girder cable-stayed bridge deck has high bearing capacity in a certain period of time when it receives a greater force locally.

Fifth, it is beneficial to enhance the stiffness of the structure and reduce the overall beam height. The steel-concrete composite beam cable-stayed bridge deck structure can effectively increase the stiffness of the beam in the structure when participating in the corresponding beam work. Moreover, compared with the steel plate beam structure, the deflection of the beam in the structure can be reduced by half under the condition of using the same amount of steel in the structure. For the steel-concrete composite beam cable-stayed bridge deck structure with the same stiffness in the material, compared with the steel structure, the section height can be reduced by 25% - 30%.

The deck structure of steel-concrete composite girder cable-stayed bridge has the above five main advantages, but there are still two shortcomings in practical application. On the one hand, the fire resistance of steel-concrete composite beam cable-stayed bridge deck is poor. For some buildings with high fire-resistant grade, steel-concrete composite girder cable-stayed bridge deck is required to be coated with a thick layer of refractory material in practical use to further improve the safety performance of related structures. On the other hand, when using steel-concrete composite beam cable-stayed bridge deck structure, shear connectors need to be added, so corresponding procedures need to be added. If some construction projects with high requirements are involved, special welding technology is needed. Some steel-concrete composite girder cable-stayed bridge deck structures need to be corrected on site, which greatly increases the construction time. In addition, after the completion of the connecting parts of the structure, because the structure is

unsTable, the relevant personnel cannot walk when hoisting, which greatly increases the difficulty of construction.

3. Fatigue analysis of steel-concrete composite beam cable-stayed bridge deck

As the fatigue resistance of steel-concrete composite girder cable-stayed bridge deck is an economical and applicable bearing component, it is widely used in relevant civil buildings. Especially, the fatigue resistance of steel-concrete composite beam cable-stayed bridge deck reflects good seismic performance and extensibility in application, and gradually becomes an important structural form in bridge structure. For bridge construction, the main purpose of this structure is to carry the dynamic load of vehicles. Therefore, fatigue design of steel-concrete composite girder cable-stayed bridge deck is needed to ensure that no fatigue damage occurs in the concrete application process. In the early stage of composite beam use, the fatigue structure of steel-concrete composite beam cable-stayed bridge deck has not been deeply studied in relevant fields, but the relative safe static calculation method is used to calculate the fatigue structure, which greatly reduces the accuracy of calculation.

At the same time, in the field of engineering and construction, the fatigue loading of steel-concrete composite girder cable-stayed bridge deck is generally in the initial stage, has not reached the ultimate fatigue life, and the impact on the structure has not been highlighted. However, with the deepening of fatigue load calculation methods and theoretical research in related fields, a clear anti-fatigue scheme of steel-concrete composite girder cable-stayed bridge deck structure has been established abroad. However, in China, there are relatively few studies on fatigue of steel-concrete composite girder cable-stayed bridge deck structure, and the research on this structure mainly focuses on static aspects. For the application of steel-concrete composite girder cable-stayed bridge deck under dynamic load, there is no explicit regulation, and there is little research on structural fatigue resistance, which seriously restricts the development of the related construction industry to a certain extent. For example, China has adopted the steel-concrete composite girder cable-stayed bridge deck structure of Nanpu Bridge in Shanghai. In order to avoid structural fatigue problems, the relevant foreign codes have to be adopted for bridge design in concrete construction, and there is still no code to follow in use.

In addition, there are still some bridge projects in China. In the early stage of construction, the fatigue problem of the structure has not been analyzed. In the specific construction process, the relevant personnel did not consider the corresponding anti-fatigue scheme, but implemented the corresponding construction work according to the requirements of the industry. To a certain extent, after the completion of the project, after a certain period of time, there are a lot of fatigue problems in the steel-concrete composite beam cable-stayed bridge deck structure, which seriously reduces the stability and safety of the structure, and is not conducive to the development of the construction industry.

4. Anti-fatigue optimization of steel-concrete composite beam cable-stayed bridge deck

At present, due to the fatigue problem of steel-concrete composite girder cable-stayed bridge deck structure in China, it is not conducive to the safety control of the structure in the relevant construction industry, and seriously affects the safety of the people. Therefore, by analyzing the specific advantages of steel-concrete composite beam cable-stayed bridge deck, in order to solve the fatigue problem of the structure, and according to the specific operation of the construction personnel in different construction links, the anti-fatigue optimization scheme of steel-concrete composite beam cable-stayed bridge deck is proposed from two aspects of welding connection technology and high-strength bolt connection construction. It provides important reference suggestions for related construction projects.

On the one hand, the control of welding process. Welding connection technology is the most common connection method in steel-concrete composite beam cable-stayed bridge deck structure. It has the advantages of convenient construction, simple structure, convenient application and high

operability, and is conducive to improving the overall stability of steel-concrete composite beam cable-stayed bridge deck structure. However, the construction personnel in the implementation of welding operations, constrained by construction conditions, the corresponding welding process regrets the existence of residual stress deformation and other issues, and after the completion of welding, there will be poor structural solidity and plasticity. In the aspect of steel-concrete composite girder cable-stayed bridge deck structure, the relevant construction departments, on the premise of guaranteeing the overall safety of the structure, try to reduce the number of stiffening ribs at the welded joints and increase the number of stiffening ribs, which can avoid the reduction of structural stability due to the large concentration of stiffening ribs. At the same time, due to the phenomenon of stress concentration in the structure, the fatigue of the structure decreases gradually. When the structure is subjected to certain dynamic loads, the construction department should adopt corresponding measures through analysis, such as changing the construction section in appropriate transition area, to ensure the stability of the structure and improve the fatigue resistance.

On the other hand, construction control of high-strength bolt connection. The high-strength bolts in the deck of steel-concrete composite girder cable-stayed bridge mainly rely on the friction force of the surrounding components to transfer the tension and shear force in the process of movement. Generally speaking, there are two types of strong bolt connections in steel-concrete composite girder cable-stayed bridge deck. One is through the shear transmission and friction of the strong bolt to realize the connection in the course of movement. The other is to connect with high-strength friction bolts by transferring friction force between components. In the field of architecture, the former is relatively suiTable for static load components which allow a slip, and can be connected in a short time. Relevant constructors should strictly control the slippage of components in the concrete construction process to avoid the influence of the deck structure of the cable-stayed bridge with integral steel-concrete composite beams, and then affect the stress state of the structure. The latter mainly relies on the performance of the high-strength bolt itself to realize the connection. Therefore, this kind of connection technology has the characteristics of strong anti-fatigue ability and strong bearing capacity, so it is difficult to produce deformation problems in concrete work.

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