Stability and Dynamic Analysis of A CFST Arch Bridge With Basket Type

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Summary

This paper examines the stability properties and dynamic performances of the Hechang Bridge, which is the CFST arch bridge in Fujian ,China. The differences of stability and dynamic performance between basket type and parallel type are discussed using three-dimensional finite element models. Furthermore, the influence of inclined angle for basket-type arch rib on stability and dynamic performance is also studied. It can be used for reference of similar bridge in selecting the bridge type, its main structures, static and dynamic analyses preformed.

Keywords:

basket-type arch-bridge; stability and dynamic behaviour; inclined angle; finite element.

1. Introduction

Concrete filled steel tubes (CFST) structures have advantages over either steel tubular structures or reinforced concrete structures [1]. The technology of CFST arch bridges has developed rapidly in China since 1990. More than two hundreds CFST arch bridges have been built or are now under construction. However, since the weight of a CFST arch rib is greater than that of a steel rib and the arch action is not effective in the out-of-plane direction, the out-of-plane frequencies of a CFST arch bridge is small than those of a steel arch bridge. Then, in order to improve out-of-plane stability and increase out-of-plane stiffness, the basket type is a good choice for the CFST arch bridge.

The Hechang Bridge(Fig.1) is located in the campus of Yangen University, Quanzhou City, Fujian Province, China. The total length of Hechang Bridge is 153.7m with a pedestrian path of 5m wide. The design live load is 4.5 kN/m^2. The ratio of clear rise to clear span of the arch is 1/5.

The arch rib is a pair of CFST dumbbell rib. Each rib is composed of two steel tubes filled with C40 concrete and welded together by two steel web plates. The diameter of the steel tube is 500mm with a thickness of 10mm in spring segments and 8mm in other segments. In order to prevent the cracks in the weld sealing between steel tube and web plates when concrete fills into the web space, stiffened steel plate is used to reduce stress. Construction began in July 2001 and was completed in Feb. 2002.

Fig.1 Hechang Bridge

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2. Structural analysis

2.1 Static analysis

A three-dimensional finite element model has been developed to analyze the bridge. The arch rib was modeled taking account of all the CFST chord members, each with its own geometric characteristics. Hangers are simulated with truss elements. The other members are modeled by two-node beam elements.

Analyzed by the eigenvalue method, the elastic buckling shape of the structure subjected to dead loads plus live loads was out-of-plane instability, the stability factor of elastic buckling load compared to dead load is 9.298, which is larger than the calculated value of parallel-type arch.

2.2 Seismic actions

Dynamic analysis was performed on the three-dimensional model using finite-element techniques in order to obtain the eigenvalues and eigenvectors of the structure. The first in-plane natural vibration has a frequency of 0.740 Hz, which corresponds to the unique antisymmetric mode of arch bridges. It is larger than the value of the fist natural vibration frequency of parallel-type arch ,which is 0.484 Hz.

2.3 Rational inclined angle of arch ribs

The choice of inclined angle is a very important factor for structure working performance. Based on the different degree of inclined angle respectively ,the stability factor and the natural frequency of lowest order under dead load are calculated .The results show the larger safety factor and natural frequency would be with the inclined angle increasing, especially the values of out of the plane are increasing quickly. But ,we also can find increasing amplitude is reduced gradually with the increasing of inclined angle. The inclined angle with 10 degrees is appropriate for Hechang Bridge.

3. Conclusions

A CFST lift-basket arch bridge has been designed and constructed in Quanzhou City, Fujian Province, China, as a pedestrian bridge to connect the two part of the campus of Yang-En University and has been a landscape of the campus.

The results show the stability factor of elastic buckle and the out-of-plane frequency of basket-type arch is larger than that of parallel-type arch. Meanwhile, with the increasing of inclined angle for basket-type arch rib, the out-of-plane stability is improved and the out-of-plane frequency is also increased. But, the amplitude is deceased.

Because of bridge structural design, the inclined angle should be limited to be not so large. And too large inclined angle will increase the engineering quantity of the substructure and construction difficulty. So, the choice of inclined angle is the very important step in basket-type CFST arch bridge design. The inclined angle with 10 degrees is appropriate for Hechang Bridge.

4. References

[1] Baochun Chen, 1999.Design and Construction of CFST Arch Bridge. Beijing :China Communications Press, China.