Dynamic Characteristics of an Ultra-long Cable-stayed Bridge

Jianfeng Liu
Lecturer
Dept. of Bridge Eng.
Tongji University
Shanghai, 200092, China
liujf@tongji.edu.cn

Jianfeng Liu, born 1979, received his MS. degree from Tongji Univ. in 2004. He has worked in Tongji Univ. for 6 years.

Qiwei Zhang
Professor
State Key Lab for Disaster Reduction in Civil Eng.
Tongji University
Shanghai, 200092, China
Zhangqw@tongji.edu.cn

Qiwei Zhang, born 1966, received his Ph.D degree from Tongji Univ. in 1999. He is currently the dean of Bridge Laboratory.

Summary

This paper describes the experimental and numerical modal analysis performed on the Sutong Bridge in China, the first-built large cable-stayed bridge with over one kilometer main span in the world. Theoretical analysis is conducted on the 3D finite element model developed from the design drawings combined with some measured material properties. Ambient vibration tests are carried out and the acceleration responses of the deck and the towers are obtained. 18 vibration modes of the deck and the towers are identified in the frequency range 0-1.0Hz using both the peak-picking method and the random decrement technique combined with Ibrahim time domain method. Moreover, modal damping ratios of all modes are estimated and their scattering ranges are narrow. A good correlation is achieved between the finite element analysis and experimental analysis. The main assumption adopted in the FE model for dynamic analysis are assessed and summarized. The identified results can be used to validate and update the finite element model.

Keywords: Modal analysis, dynamic characteristics, cable-stayed bridge, parameter identification, finite element analysis.

1. Introduction

Recently, more and more cable-stayed bridges with ultra-long span were built all over the world, such as the Tatara Ohashi Bridge in Japan, the Normandy Bridge in France and the Sutong Bridge in China. It is the most significant issue to ensure the bridges‟ safety no matter when they are under construction or under operation. Some dynamic topics of the large structures, such as anti-seismic and anti-wind ability, vibration control and condition assessment, have become of increasing concern. However, precise dynamic properties such as natural frequencies, mode shapes and damping ratios are the foundation to solve these problems. Nowadays, the theoretical and experimental methods are the two ways often used to identify dynamic parameters. The finite element (FE) method is a commonly used theoretical way to analyze the dynamic characteristics of cable-stayed bridges with ultra-long span. The established FE model is usually developed from design drawings. But as a rule, obvious difference exists because of the uncertainties between drawings and actual structures, such as the material and geometric properties and the simplification of the boundary conditions and so on. Therefore, the analysis results of the FE model usually depend on the experimental verification for the subsequent application. Furthermore, structural modal damping cannot be gained by theoretical analysis by reason of the complexity of damping mechanism of large bridges. At present, there are two main types of on-site vibration testing, forced vibration testing and ambient vibration testing. Because of the limitation of the excitation equipments and high spending, forced vibration testing is often used for small structures. For large cable-stayed bridges like the Sutong Bridge, dynamic characteristics are usually identified and confirmed by way of on-site ambient vibration testing and modal parameter identification technique[1]~[5].

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