Abstract

EARTHQUAKE-INDUCED RANDOM VIBRATION ANALYSIS OF CABLE-STAYED BRIDGE WITH FINITE STRIP ELEMENTS

This dissertation deals with some problems in structural modeling and dynamic analysis existing in design of cable-stayed bridges and some rational methods for solving above problems were suggested.

A compound modeling for structural analysis of cable-stayed bridges using the flat shell strip from finite strip method to model the deck, three dimensional beam element and three dimensional rod element to model the pylons and cables is presented. The three-dimensional rod elements of cable being connected between the deck and pylon of bridge could satisfy the compatibility conditions of the substructures of the bridge for analysis. But the nonlinear effect of sag of cables and prestress of cables were not taken into account.

The investigation was carried out the structural reliability analysis of the cable-stayed bridges being excited by seismic force. A linear dynamic response spectral analysis of cable-stayed bridges for earthquake response was established. The well-know Kanai-Kajimi model was used to simulate the power spectral density of seismic ground motion. The orthogonality properties of normal modes was used to simplify the coupled equations of motion of the MDOF system into SDOF system and the superposition of the effects of normal modes was utilized. The Fourier transformation of frequency domain method was used for response analysis in this investigation. Finally, the power spectral density of response and auto-correlation function of response had been evaluated by establishing a general three-dimensional theory for analyzing the random vibration of cable-stayed bridges with the assumption of a gaussian, normal distribution for random processes.

Good agreement was obtained by comparison the frequencies between calibrated test results and result from free vibration analysis. The numerical results had showed that they were good and converge very fast in the first few modes as the numbers of shape functions of strips and the modes increase. Moreover, all the shape of response modes coincided with those of the actual response modes.

The power spectra of the displacement have peaks at the natural frequencies of the bridge structure and a significant proportion of the mean square response is from the values around these peaks. The first few modes have significant contribution of total responses. Furthermore, the effects of power spectral density and the auto correlation function are determined with different parameters of natural frequency, damping ratio and white noise which can be adjusted according to the earthquake magnitude, ground resonance frequency and attenuation of seismic wares in the ground. It was found that the most sensitive variable for the response of power spectral density is the damping ratio of ground but the most sensitive variable for the response of auto correlation function is the magnitude of white noise. The power spectral density and auto correlation of response increases are proportionate to the decreases in damping ratio of ground and the natural frequency of ground but the white noise of ground is proportional to both the power spectral density and auto correlation of response.

Keyword :

Finite strip method : It is a special form of finite element method for analysis of structures, which have complex geometry, material properties and loading conditions. However, with relatively simply support conditions, such as bridges, this method has been extensively applied in the static and dynamic analysis of bridge structures for many years.

Cable-stayed bridge : The bridge is suspended by multiple cables that run down to the main girder from one or more towers.

Random vibration : The value of the excitation at a given time cannot be predicted and the excitation is random, such as ground motion during earthquakes, the resulting vibration is called random vibration.