SEISMIC RESPONSE OF CABLE-SUPPORTED BRIDGES

by

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DEDICATED TO

MY PARENTS, MY WIFE AND MY DAUGHTER "DINA"

CERTIFICATE

This is to certify that the thesis entitled, "Seismic Response of Cable-Supported Bridges", being submitted by Mr. Said Mohamed Abdel Kader Allam, to the Indian Institute of Technology, Delhi, for the award of the Degree of 'DOCTOR OF PHILOSOPHY' in Civil Engineering is a record of the bonafide research work carried out by him under my supervision and guidance. He has fulfilled the requirements for submission of this thesis, which to the best of my Knowledge, has reached the requisite standard.

The material contained in this thesis has not been submitted in part or full to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The present study deals with the seismic analysis and investigation of the influence of different important parameters on the response of cable-supported bridges (suspension and cable-stayed bridges) to multi-component stationary and non-stationary random ground motions. The study includes the following:

A frequency domain spectral analysis is presented for seismic analysis of both suspension and cable-stayed bridges under multi-component stationary random ground motion at an angle with the longitudinal axis of the bridge. The seismic analysis is considered as a three component stationary random ground motion. These components are uncorrelated and directed along the principal axes such that the major axis is directed towards the expected epicentre. The ground motion is assumed to be a homogeneous stochastic process which is represented by Glough and Penzien double filter power spectral density function and represented by ratios along the principal axes. The spatial variability of the ground motion along any direction is represented by a coherence function as given by Hindy and Novak [1980]. The continuum approach is used to obtain the mode shapes and natural frequencies. The analysis duly takes into account the spatial correlation of ground motions between the supports, the modal correlation between different modes of vibration and quasi-static excitation. With the help of the proposed method of analysis, an extensive parametric study is conducted to investigate the behaviour of both suspension and cable-stayed bridges under the seismic excitation. The parameters include the spatial

correlation of ground motion, the angle of incidence of the earthquake, the ratio between the three components of the ground motion, the number and nature of mode shapes, the nature of the power spectral density function of the ground motion as modified by soil conditions, the span ratio (for suspension bridge), and the tower-deck inertia ratio (for cable-stayed bridge). The numerical study shows that the above parameters have considerable influences on the responses of these bridges.

A response spectrum method for the seismic analysis of both suspension and cable-stayed bridges is presented for partially correlated multi- component stationary random ground motion. The method takes into account the contributions of the quasi-static component and the relative component to the expected mean peak response. The analysis also takes into account the fluctuation of the cable tension, the modal correlation between different modes of vibration and the relative movements of supports and towers in obtaining the expected peak value of the response of the bridge deck. The responses of the bridge deck as obtained by the response spectrum method are compared with those obtained by the frequency domain spectral analysis in order to verify the applicability and the accuracy of the response spectrum method for the analysis of the cable-supported bridges. The numerical results indicate that the response spectrum method provides nearly the same responses as those obtained by the frequency domain spectral analysis.

A time domain Markov analysis using state space formulation for obtaining the time history of the r.m.s response of both suspension and cable-stayed bridges to non-stationary random ground motion is presented. The non-stationary random ground motion is obtained by multiplying the maximum r.m.s of ground acceleration by a modulating function. The method duly considers the spatial correlation of ground motions between the supports, multi-component of ground motion and the quasi-static excitation. A comparison between the maximum r.m.s responses obtained by the time histories and the r.m.s responses obtained by the frequency domain spectral analysis is carried out under a set of parametric variations. The numerical studies show that the frequency domain spectral analysis gives higher responses and the nature of modulating function plays a significant role in the difference between the two responses.

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