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ASSESMENT OF A FULL SCALE PEDESTRIAN BRIDGE BY MODEL UPDATING

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ABSTRACT

In this work, dynamic model updating of a full scale cable stayed pedestrian bridge is carried out. Dynamic data such as natural frequencies and mode shapes were collected by forced excitation of the bridge. Finite element model (FEM) of the bridge was later updated using an evolutionary algorithm particle swarm optimization (PSO). It was found from the updating results that PSO was successful in model updating of the full scale bridge with good computational efficiency and gave meaningful results related to physical condition of the bridge.

Keywords: full scale pedestrian bridge, dynamic testing, particle swarm optimization, model updating, structural assessment.

INTRODUCTION

Due to inherent simplifying assumptions in development of finite element models (FEM), the actual behavior of structures often differs from their analytical model. Finite element updating can be performed to estimate physical properties of the FEM by matching experimental dynamic measurements, such as natural frequencies, mode shapes and damping, with the analytical ones. There is a degree of uncertainty in the assessment of the actual properties of the materials used in the full scale structure as well as the most realistic representation of the element stiffness in the initial FEM. The challenge of finding a set of suitable parameters having physical justification necessitates the use of physically significant updating parameters and suitable optimization tools (Jaishi and Ren 2007).

In this paper, modal identification of a pedestrian footbridge is performed using low amplitude forced vibrations. The bridge is composed of two spans with composite steel concrete deck and a centre steel tower. The bridge was excited using three dynamically synchronized shakers and bridge response was measured with a dense array of sensors for efficient mode mapping. To identify the natural frequencies and mode shapes, the numerical subspace state space identification method was used. The results were cross checked by using pick picking from the power spectra of the acceleration data.

For model updating, sensitivity method is routinely used to update the analytical models but suffers from the risk of being trapped in local minima (Brownjohn et al 2001). In order to overcome this problem, global optimization techniques are worth exploring especially for full scale complex structures. In this research, particle swarm optimization (PSO) has been used for model updating of a full scale cable stayed bridge structure. PSO was used in the study due to its better searching speed and accuracy in finding the solutions. An initial finite element model (FEM) of the bridge was developed using structural analysis software SAP 2000 and later exported to MATLAB for subsequent model updating.

RESULTS AND CONCLUSIONS

The natural frequencies of experimentally identified modes were compared with the normal stepping frequency to check any resonance issues of the bridge under normal operation. The first three vertical frequencies identified for the bridge, at 1.64 Hz, 1.89 Hz and 3.69 Hz, lie within the range of pedestrian walking excitation and are critical for vibration serviceability under frequency tuning approach (Pimentel et al 2001). This indicates that the bridge might have some undesirable vibrations during its service life. However, the first horizontal mode is at 4.86 Hz, which is well above the specified criteria of 1.5Hz.

It has been found that PSO has given improved results after model updating as compared to the initial frequency estimates. A decrease in the stiffness of the bridge deck has been observed which could be mainly attributed to the fact that the initial model considered the cast in-situ concrete slab as fully composite with the steel girder. The updated results revealed that there is only partial composite action between the cast-in slab and the steel girder resulting in lower stiffness of the whole deck. Another important result from updating was that the pre-stressed forces in cables were fund to be less than assumed in design.

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