Comparison of Direct and Iterative Methods for Model Updating of a Curved Cable-stayed Bridge Using Experimental Modal Data

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Summary

In the paper both a direct method and a sensitivity-based iterative method have been applied to update a finite element model of a curved cable-stayed bridge. The direct method is known as the Douglas-Reid algorithm. The sensitivity-based method is a Trust-Region algorithm. Thirteen experimental modes identified between 0 and 10 Hz under ambient condition have been considered as reference modal data. An a-priori finite element model has been implemented by using the SAP2000 software. The model has been firstly manually tuned and then updated through computational procedures implemented in MATLAB. The results of the direct and the iterative methods have been compared to each other for the specific case study.

Keywords: FE model updating, Curved cable-stayed bridge, Direct method, Sensitivity-based method.

1. Introduction

In design of bridges and structures, Finite Element (FE) modelling is a technique widely used for structural analysis. The FE model is however generally uncertain. Considerable discrepancy of the structural behaviour is very often found between the prediction of the numerical model and the measurements of the structure on-site. The uncertainties come from multiple sources, which include but are not limited to the model-structure errors (assumption made in simplification of the structure, discretion errors inherent in the FE method, etc.) and parameter errors.

FE updating is a technique widely used for calibration and improvement of the preliminary model, which is normally built on technical drawings with assumed materials properties and boundary conditions [1]. Although study of different updating methods have revealed their respective advantages and disadvantages, most of the findings have been found using relatively simple and less accurate experimental results as the target. Today, the maturity of the ambient vibration testing technique has come to provide the researchers and designers with more accurate and reliable modal results for the FE updating procedure. In this paper, two different numerical algorithms were implemented and compared to each other for FE updating of a recently built curved cable-stayed bridge. One was the Douglas-Reid method, which is often used due to its simplicity and numerical efficiency [2]. A system of quadratic functions was introduced to approximate the numerical modal frequencies around the chosen reference values of the structural parameters, which needed to be identified. Then an optimization algorithm was applied to solve the problem to minimize the difference between the numerical and experimental modal frequencies. Since the FE model didn't need to be recalled in the optimization procedure, it could be considered as a direct methods [2]. The other one was a sensitivity-based iterative method [3]. The FE updating was formulated as a least squares problem. A trust region method was implemented to solve the optimization problem, which minimized the difference between the numerical and experimental modal data, including both the natural frequencies and mode shapes.

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