Bayesian model updating of a large-span steel tied arch bridge: an experimental study

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Abstract

In this paper, a large-span steel tied arch bridge's Bayesian FEMU is carried out based on the ambient vibration data. Firstly, the ERA method is used for modal identification. Then, the benchmark FE model of this bridge is established. Based on the sensitivity analysis, six updating parameters significantly affecting the natural frequency are selected. Subsequently, the objective function of the FEMU is established, and the DRAM algorithm is utilized to simulate the parameter samples conforming to the posterior distribution. Finally, the uncertainty analysis of the updated items is carried out. After FEMU, the results show that the model's frequency uncertainty is reduced, and the theoretical frequencies are highly consistent with the identified frequencies.

Keywords: Bayesian FEMU, MCMC, DRAM, ambient data, Large-span arch bridge.

1 Introduction

Finite element model updating (FEMU) is a critical technology in bridge health monitoring. A benchmark model that can describe the structure's actual state is vital for calculating the structure's real-time response and evaluating its performance [1].

The Bayesian FEMU method is a kind of stochastic method. It has a strong ability to deal with uncertainty problems and give the probabilistic distribution of the updating parameters. Beck proposed a framework for Bayesian model modification [2-3]. To overcome high-dimensional integration problems, Beck introduced the MCMC (Markov chain Monte Carlo) sampling method to obtain the posterior distribution samples of the updating parameters [4]. which indirectly solved the posterior distribution problem. Subsequently, Yuen explored the Bayesian FEMU based on modal characteristics and proved its applicability and feasibility in structural health monitoring [5].

MCMC method contains a large number of simulation algorithms, including Metropolis-Hastings algorithm (MH) [6], Transitional Markov Chain Monte Carlo (TMCMC) [7], Hybrid Monte Carlo algorithm (HMC) [8], Delayed Rejection Adaptive Metropolis (DRAM) [9].

In this paper, a large-span steel tied arch bridge is selected as the updating object. The bridge's dynamic characteristics are complex. The

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