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Model updating of lattice structures: A substructure energy approach

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ABSTRACT

Model updating is an inverse problem to identify and correct uncertain modeling parameters, which leads to better predictions of the dynamic behavior of a target structure. This study presents a direct physical property adjustment method and the substructure energy approach, which can accurately update the stiffness and mass matrices of lattice structures using incomplete eigenvectors measured from critical substructures. For validation, the proposed method is applied to update models of a mass-spring system, a two-dimensional, and a three-dimensional lattice structure.

1. Introduction

With scalable geometry and repetition characteristics, lattice structures are widely employed in aerospace, mechanical, marine, and civil systems [1]. Their structural properties depend on the actual size of the unit cell, enabling applications in both the small- and large-scale structural systems [2]. For the purpose of evaluating the mechanical integrity of a lattice structure, numerical (mathematical) model needs to be established via the use of the finite element (FE) method. In order to improve the correlation between the FE model and experimentally measured data, model updating is emerging as one of the most important topics in the area of modal testing [3], and the deduced optimal structural models can be used for structural health monitoring applications [4,5]. In essence, model updating identifies and corrects uncertain modeling parameters, and integrates the information into a FE model that could better evaluate the dynamic behaviors of a target structure. There are two broad approaches for updating the system matrices based on the type of parameters that need updating as well as the available data measured from experiment: (a) updating from modal data and (b) updating directly from the force-response measurements. This study focuses on the first category.

The conventional modal-based updating approaches usually rely on either the matrix adjustment method or the physical property adjustment method [6,7]. The first method computes directly the changes to the mass and stiffness matrices, and the resulting models become "abstract representations" and cannot be interpreted in a physical way [8]. The second method seeks physical quantities for each individual element or associated parameter; this method is closely related to the model-based methods for damage determination, which can be used to quantify the location and extent of damage [9].

With respect to the physical property adjustment method, there are two widely used approaches: (a) iterative methods and (b) non-iterative methods. For iterative methods, spatially complete measured modes are not necessary, but there are

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