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Variability of dynamic responses of frequency dependent visco-elastic sandwich beams with material and physical properties modeled by spatial random fields

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Abstract

Probabilistic engineering mechanics aims to take into account uncertainties of input parameters of models and evaluating their impact onto the model responses. For frequency dependent visco-elastic sandwich structures, used in many industrial applications such as for vibration damping, the computation of the stochastic response can lead to a prohibitive computational costs. In this paper, an efficient methodology is proposed here to analyze the output variability by a stochastic method based on fast Monte Carlo simulation using a specific formulation obtained with the modal stability assumption. Geometrical and mechanical properties of a three-layered sandwich beam with a visco-elastic core made of 3M ISD112 damping polymer are represented by random fields to model the spatial variability. The validation of the formulation is studied, then the variability of the frequency response is evaluated for moderate and high variability levels. The benefits of the approach are also discussed.

1. Introduction

The mechanical behavior of structures made of visco-elastic materials is of great interest to industrial domains specially in the framework of vibration damping [1]. The complexity of frequency dependent visco-elastic sandwich structures and systems can be modeled as it is proposed by Bilasse et al. [2], Assaf et al. [3] and Adhikari et al. [4]. More recently, a detailed review of generalized damping models used for structural dynamics has been proposed by Adhikari [5]. However, it is also necessary to assess the impact of non negligible fluctuations of model features and parameters, especially due to manufacturing processes [6], on model's outputs. Indeed, neglecting uncertainty means ignoring robustness assessment. Uncertainty can be modeled by random variables or random fields following a given probabilistic distribution. The resolution of the problem under uncertainty provides output quantities with random nature. Our aim is thus to propose an effective vibration analysis with the finite element method by taking into account stochastic parameters to evaluate stochastic dynamic responses. Spectral methods are often used to obtain stochastic responses: several complete overviews were devoted to spectral stochastic finite element methods such as the works by Adhikari et al. [7] and Stefanou [8]. Recently, Adhikari et al. developed a novel Galerkin subspace method for dynamic analysis of stochastic structural systems in the frequency domain [9]. An original approach is also proposed by Kundu et al. [10] who evaluated the stochastic vibration response of a randomly parameterized structural dynamic system with a hybrid spectral and meta-modeling approach. Fabro et al. [11] developed a method providing an automated approach to the characterization of spatial variability and hence the prediction of the statistical features of vibration responses for chopped fibre composites. A modal