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Damping Optimal Design of Sandwich Beams Partially Covered with Damping Patches

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Abstract : The application of viscoelastic materials in the form of constrained layers in mechanical structures is an efficient and cost-effective technique for solving noise and vibration problems. This technique requires a design tool to select the best location, type, and thickness of the damping treatment. This paper presents a finite element model for the vibration of beams partially or fully covered with a constrained viscoelastic damping material. The model is based on Bernoulli-Euler theory for the faces and Timoshenko beam theory for the core. It uses four variables: the through-thickness constant deflection, the axial displacements of the faces, and the bending rotation of the beam. The sandwich beam finite element is compatible with the conventional C1 finite element for homogenous beams. To validate the proposed model, several free vibration analyses of fully or partially covered beams, with different locations of the damping patches and different percent coverage, are studied. The results show that the proposed approach can be used as an effective tool to study the influence of the location and treatment size on the natural frequencies and the associated modal loss factors. Then, a parametric study regarding the variation in the damping characteristics of partially covered beams has been conducted. In these studies, the effect of core shear modulus value, the effect of patch size variation, the thickness of constraining layer, and the core and the locations of the patches are considered. In partial coverage, the spatial distribution of additive damping by using viscoelastic material is as important as the thickness and material properties of the viscoelastic layer and the constraining layer. Indeed, to limit added mass and to attain maximum damping, the damping patches should be placed at optimum locations. These locations are often selected using the modal strain energy indicator. Following this approach, the damping patches are applied over regions of the base structure with the highest modal strain energy to target specific modes of vibration. In the present study, a more efficient indicator is proposed, which consists of placing the damping patches over regions of high energy dissipation through the viscoelastic layer of the fully covered sandwich beam. The presented approach is used in an optimization method to select the best location for the damping patches as well as the material thicknesses and material properties of the layers that will yield optimal damping with the minimum area of coverage.

Keywords : finite element model, damping treatment, viscoelastic materials, sandwich beam
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