Parametric analysis of a triple core periodic unit cell including a middle random core

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ABSTRACT

In the last decades, the development of lightweight structures for transportation and aerospace applications have been a key scientific and technical challenge. Composites and sandwich panels are a well-known solution. Nevertheless, it seems that nowadays a special effort is being dedicated to develop metamaterials for these applications. In terms of vibroacoustic performances, the classical honeycomb structures exhibit a high stiffness-to-weight ratio leading to poor acoustic properties. Consequently, some new designs can be imagined to obtain better acoustic indicators. In this context, this paper proposes to study a new kind of periodic structures using multi-layer core topology systems consisting in a stacking of core layers made of different geometries (auxetic, hexagonal, rectangular…). Several new parameters should be considered to fully understand the dynamic and acoustic behaviour of these structures. The three core topologies of interest are: hexagonal, rectangular and auxetic cores surrounding a middle core made of random topology. Consequently, 3 layers are stacked: Hex-Random-Hex, Aux-Random-Aux, Rect-Random-Rect.

The main objective of this study is to analyse the results of the parametric survey. All configurations are constrained to have the same surface density. The chosen acoustic indicator is the Sound Transmission Loss (STL). The transition frequency will be also investigated as well as the compression and shear modulus and the bending stiffness. Modelling these structures is possible using either Wave Finite Element Method (WFEM) only or combining WFEM and the Transfer Matrix Method (TMM). We assume an infinite panel, real wavenumbers and that the structure is excited by plane waves with the angles of incidence and reflection equal. The model is implemented using MATLAB and ANSYS apdl. The proposed designs can typically be made by a 3D printer.

From the parametric study, it turns out that multi-layer core systems can considerably improve the STL performances without any alteration of the weight. Moreover, it is possible to find out an optimized design giving the best STL within a targeted bandwidth. However, as it will be shown, it goes along with less efficiency in terms of mechanical properties and thus such configurations should be tailored for certain applications.

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