

Numerical Investigation Of Structured Materials For Vibration Control

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Abstract

Periodical architected structures comprising reticulated beams or trusses have proven capable of controlling wave propagation at different frequency scales. Moreover, recent progress in 3D printing techniques has paved the way to their actionable application in various fields, i.e., aerospace or acoustic. In this work we aim at leveraging the dynamic properties of an octet lattice, made of elastomeric material, to attenuate the effects of man-induced vibrations on the structural components of existing buildings. Vibrations generated by railway and car traffic, construction works or industrial activity are often cause of nuisance and non-structural damage (e.g. facades).

To design the structured material we develop a 3D solid model of a modified octet unit cell, consisting of 48 struts, by means of COMSOL Multiphysics® Structural Mechanics Module. We initially assume an infinitely periodic lattice by applying Floquet boundary conditions to the edges of the cell. We then perform an eigenvalue analysis with parametric sweep to compute the dispersion relation of the lattice, namely the relationship between wave frequency and wavenumber, and infer its dynamic behavior. This study shows that the flexural resonance of the struts can be exploited to obtain a frequency region, known as bandgap or stop band, in which elastic waves are strongly attenuated. This exotic property bestows the designed cell with the potential to serve for vibration mitigation.

In order to engineer a compact, yet efficient, tool we analyse the attenuation performance of a finite lattice obtained by periodically repeating the basic unit cell in the horizontal and vertical directions. Via frequency domain analysis we evaluate the response of this structure when subjected to a prescribed base displacement acting over a broad range of frequencies. The result of this study indicates that the bandgap formerly estimated via the infinitely periodic model can be effectively achieved with a limited number of cells. Finally, with the perspective of practically implementing and testing this structure, we run a static analysis to verify the static stability of the lattice under its own weight.

This numerical investigation demonstrates the potential for adoption of reticulated structures for the purpose of vibration isolation. A modified octet cell is shown to offer protection at the range of frequencies typically affected by ground vibration. The study further investigates the geometric and material parameters influencing the position of the bandgap and lays the foundation for further in-depth studies, including nonlinear effects, such as buckling.

Figures used in the abstract

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Figure 1 : Periodic lattice structure for groundborne vibration mitigation. (a) Unit cell design: framed octet. (b) Tetrahedral mesh close-up.

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Figure 2 : Dispersion relation of the framed octet cell where the bandgap is emphasized by the

light blue region.

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Figure 3 : Mode shapes which delimit respectively the lower (a) and upper (b) bounds of the bandgap.