The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

DESIGN OPTIMIZATION OF A SINGLE-PHASE ELASTIC METAMATERIAL FOR ENHANCING IMPACT RESISTANCE

Ana C. A. Vasconcelos[1*], Dingena Schott[2], Jovana Jovanova[3] and Alejandro M. Aragón[4]

[1] Faculty of Mechanical, Maritime and Materials Engineering, Delft University of Technology, Mekelweg 2, 2628 CD Delft, The Netherlands,
A.C.AzevedoVasconcelos@tudelft.nl
[2] D.L.Schott@tudelft.nl [3] J.Jovanova@tudelft.nl [4] A.M.Aragon@tudelft.nl,
am-aragon.science

Keywords: *Design optimization, Single-phase unit cell, Impact resistance*

Elastic metamaterials (EMMs) are architected materials with unique properties due to the presence of bandgaps – frequency ranges in which the wave propagation is attenuated. Unlike phononic crystals (PnCs), which are periodic structures that exhibit bandgaps due to Bragg scattering, EMMs rely on the use of internal resonators [1]. This type of locally resonant structures have shown promising results for attenuating low-frequency waves as the ones originating from repetitive impact loads [2].

Single-phase EMMs has recently been explored, because their manufacturing requires less complex and low-cost processes. Furthermore, with the trend of circular economy, such EMMs can be manufactured from raw disposal materials or can be easily re-processed for other applications. However, obtaining a low-frequency bandgap by using such single-phase structures requires large masses and thin structures targeting low stiffness, which may result in impractical designs from a mechanical point of view. To avoid such designs, optimization techniques can be used to enhance the mechanical properties of the unit cell.

This work investigates the mechanical behavior of a single-phase EMM. The aim is to filter energy at specific frequencies of an impact signal. The unit cell shows bandgaps at low frequency regions, which are related to the geometric parameters of the internal resonator. It is observed that the EMM fails mechanically due to high-amplitude loads, especially because of the requirement of thin beams and huge masses to obtain low-frequency bandgaps. The proposed scheme optimizes the geometric parameters so that the stresses are minimal. Through such procedure, the metamaterial can be used for vibration suppression and noise control of structures undergoing high amplitude impact loads.

REFERENCES

[1] Z. Liu et al. Locally resonant sonic materials. *Science*, 289(5485):1734–1736, 2000.

[2] M.H. Khan, Bing Li, and K.T. Tan. Impact load wave transmission in elastic metamaterials. *International Journal of Impact Engineering*, 118:50–59, 2018.