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Recent Advances

Hedayati, Reza; Bodaghi, Mahdi

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Editorial

Acoustic Metamaterials and Acoustic Foams: Recent Advances

Reza Hedayati [1,*] and Mahdi Bodaghi [2]

1 Department of Aerospace Structures and Materials (ASM), Faculty of Aerospace Engineering, Delft University of Technology, 2600 AA Delft, The Netherlands
2 Department of Engineering, School of Science and Technology, Nottingham Trent University, Nottingham NG11 8NS, UK; mahdi.bodaghi@ntu.ac.uk
* Correspondence: rezahedayati@gmail.com

1. Introduction

Acoustic metamaterials are synthetic materials, made of repeating unit cells that are designed to address an acoustic problem, through the rational design of their micro-features. The characteristics of acoustic metamaterials are dominated by their rationally designed microarchitecture, rather than the base material. Particularly, acoustic metamaterials can manipulate sound and elastic waves, both spatially and spectrally, in unprecedented ways. Such properties include super-focusing [1], super-lensing, cloaking [2,3], active membrane structures, phononic plates [4], fluid cavities, separated by piezoelectric boundaries [5], and tunable noise attenuation, based on Helmholtz resonators [6].

This class of materials did not exist until recently, as manufacturing their complex features was either impossible or prohibitively expensive. Recent advances in additive manufacturing (3D printing) have made it possible to manufacture such constructions, with complex internal geometries, and at significantly lower cost [7]. Even though acoustic metamaterials are becoming more and more prevalent in academic and industrial sectors, acoustic foams have still kept their importance in addressing noise issues [8,9], due to their relatively low cost and high noise mitigation performance.

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2. Acoustic Metamaterials and Acoustic Foams

This Special Issue, considering three papers, explores the latest advances in the development of acoustic metamaterials, as well as recent advances in acoustic foams, in the fields of seismic isolation, outdoor noise control, and permeable noise reducing metamaterials.

The paper by Liu et al. [10] implements layered periodic foundations (LPFs), a well-known seismic metamaterial, to construct combined layered periodic foundations (CLPFs). The challenge in the development of these traditional metamaterials, is that it is very difficult to design LPFs with attenuation zones, which are both broadband and are of low starting frequencies. They simulate CLPFs with up to four-story frames to address this problem. The results of their study demonstrate that the attenuation zone of CLPFs is the union of the attenuation zones of individual LPFs. Their proposed design is able to have a broadband attenuation zone with low starting frequency ($f > 2.5$ Hz).

In the paper by Fusaro et al. [11], a metawindow—with the aim of high noise control capability—accompanied with suitable natural ventilation is introduced. Their paper studies the acoustic performance, numerically and experimentally, and the ventilation performance numerically. For the numerical simulations, the finite element method is implemented, and for the experimental tests, additive manufacturing is used to fabricate the samples; the acoustic tests are performed in an anechoic chamber. The results demonstrate an overall mean sound attenuation of 15 dB in the bandwidth of 380–5000 Hz. The noise reduction capability is improved even further in the frequency range of 50–500 Hz.

Analytical approaches provide convenient and quick predictions for the performance of different types of physical systems. That is why, despite huge recent advances in numerical techniques and computational tools, the derivation of analytical relationships has maintained their importance in academia and industry. The challenge is that there are small to huge differences between the results of numerical, experimental, and analytical approaches [12]. Improved analytical approaches that are able to address these discrepancies and provide a means to decrease them are, therefore, exceedingly beneficial. The goal of the paper by Hedayati et al. [13] is to improve the accuracy of the already-existing analytical solutions, by presenting a handy and easy-to-use methodology, which is capable of converting analytical relationships, based on Euler–Bernoulli beam theory, to equivalent analytical relationships, based on Timoshenko beam theory. They apply the proposed technique to six unit cells, for which analytical relationships—based on Euler–Bernoulli beam theory—are already available in the literature: body-centered cubic (BCC), diamond cubic, truncated octahedron, hexagonal packing, rhombicuboctahedron, and truncated cube. The results demonstrate that applying the proposed methodology can decrease the analytical/numerical discrepancy by one order of magnitude.

3. Summary

We would like to express our appreciation to the authors, the reviewers, and the Editorial office of *Applied Sciences*, who have all contributed greatly to this Special Issue. We hope that the papers published in this Special Issue open new avenues in the field of designer acoustic metamaterials and acoustic foams.

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