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Experimental Observation of a Large Low-Frequency Band Gap in a Polymer Waveguide

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The quest for large and low-frequency band gaps is one of the principal objectives pursued in a number of engineering applications, ranging from noise absorption to vibration control, and to seismic wave abatement. For this purpose, a plethora of complex architectures (including multiphase materials) and multiphysics approaches have been proposed in the past, often involving difficulties in their practical realization. To address the issue of proposing a material design that enables large band gaps using a simple configuration, in this study we propose an easy-to-manufacture design able to open large, low-frequency complete Lamb band gaps exploiting a suitable arrangement of masses and stiffnesses produced by cavities in a monolithic material. The performance of the designed structure is evaluated by numerical simulations and confirmed by scanning laser Doppler vibrometer (SLDV) measurements on an isotropic polyvinyl chloride plate in which a square ring region of cross-like cavities is fabricated. The full wave field reconstruction clearly confirms the ability of even a limited number of unit cell rows of the proposed design to efficiently attenuate Lamb waves. In addition, numerical simulations show that the structure allows to shift the central frequency of the BG through geometrical modifications. The design may be of interest for applications in which large BGs at low frequencies are required.

Keywords: phononic crystals and metamaterials, Lamb band gap, guided waves, finite element simulations, scanning laser Doppler vibrometer

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1. INTRODUCTION

One of the main problems facing physicists and engineers working in the field of metamaterials is to achieve vibration damping and control over large, low-frequency ranges. This is true in fields ranging from noise absorption (Aurégan et al., 2016; Jiménez et al., 2016; Li and Assouar, 2016; Morandi et al., 2016) to seismic wave abatement (Colombi et al., 2016; Miniaci et al., 2016). Phononic crystals (PCs) and acoustic metamaterials (AMMs), generally made of periodically distributed inclusions in a matrix (or hosting material), are of particular interest because of their ability to act as stop-band filters, i.e., attenuate mechanical waves over entire frequency bands, commonly known as band gaps (BGs) (Pennec et al., 2010; Craster and Guenneau, 2012; Hussein et al., 2014).