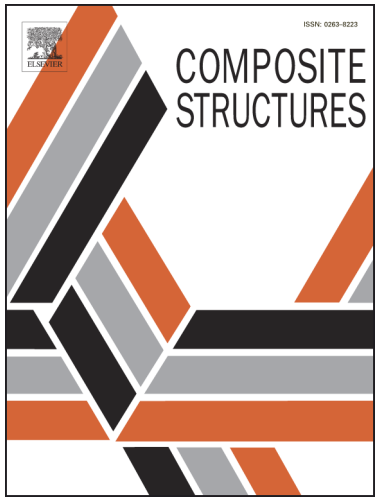

Bending dominated response of layered mechanical metamaterials alternating pentamode lattices and confinement plates

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VBENDING DOMINATED RESPONSE OF LAYERED MECHANICAL METAMATERIALS ALTERNATING PENTAMODE LATTICES AND CONFINEMENT PLATES

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Abstract

A numerical study on the elastic response of single- and multi-layer systems formed by alternating pentamode lattices and stiffening plates is presented. Finite element simulations are conducted to analyze the dependence of the effective elastic moduli of such structures upon suitable aspect ratios, which characterize the geometry of the generic pentamode layer at the micro- and macro-scale, and the lamination scheme of the layered structure. The given numerical results highlight that the examined structures exhibit bending-dominated response, and are able to achieve low values of the effective shear modulus and, contemporarily, high values of the effective compression modulus. We are lead to conclude that confined pentamode lattices can be regarded as novel metamaterials that are well suited for seismic isolation and impact protection purposes. Their elastic response can be finely tuned by playing with several geometrical and mechanical design variables.

1. INTRODUCTION

Pentamode lattices are mechanical metamaterials with unconventional mechanical properties induced by the peculiar geometry of the primitive unit cell, which is formed by four rods meeting at a point. The repetition over the three dimensional space of such a cell gives rise to a diamond-like structure that supports five soft-modes of deformation (zero-energy modes), and one single rigid mode in the stretch-dominated limit [1]. Physical models of pentamode lattices have been obtained through additive manufacturing techniques at different scales, employing both metallic and polymeric materials [2][3][4].

Practical applications of pentamode metamaterials have been proposed for the realization of shear waves band-gap materials [5][6], and graded structures that make defined regions of space invisibly isolated from mechanical waves (elasto-mechanical cloak) [7][8]. More recently, pentamode lattices confined between stiffening plates have been proposed for the realization of tunable seismic isolation and impact protection devices, which show soft modes controlled through the tuning of the bending moduli of members and junctions [4][9]. It has been recognized that the mechanical response of such metamaterials features some analogies with that of elastomeric bearings obtained by bonding layers of synthetic or natural rubber to stiffening plates made of steel or fiber-reinforced composites [10]-[15].

The present study aims at extending the research initiated in Refs. [4][9], through a numerical investigation on the elastic response of single- and multi-layered confined pentamode lattices