Title: Oblique shear wave propagation in finitely deformed layered composites

Authors: Jian Li, Viacheslav Slesarenko, Pavel I. Galich, Stephan Rudykh

PII: S0093-6413(17)30454-8
DOI: https://doi.org/10.1016/j.mechrescom.2017.12.002
Reference: MRC 3237

To appear in:

Received date: 21-8-2017
Revised date: 5-12-2017
Accepted date: 5-12-2017

Mechanics Research Communications. Year	Publication Office: **Elsevier UK**
Editor-in-Chief: A. Rosato New Jersey Institute of Technology, Newark, New Jersey, USA Anthony.Rosato@njit.edu	

Oblique shear wave propagation in finitely deformed layered composites

Jian Li, Viacheslav Slesarenko, Pavel I. Galich, Stephan Rudykh*

Department of Aerospace Engineering, Technion – Israel Institute of Technology, Haifa 32000, Israel

*Corresponding author: rudykh@technion.ac.il (S. Rudykh)
Tel.: +972-4-829-2547; fax: +972-4-829-2547
Accepted:

Abstract

In this paper, we study the influence of deformation on shear waves propagating at various angles in hyperelastic layered composites (LCs). In periodic laminates, shear wave band gaps (forbidden frequency ranges) exist only for waves propagating perpendicular to the layers, and the band gaps close suddenly if the incidence angle changes even slightly. However, the attenuation in the frequency ranges corresponding to band gap decreases gradually with a change in the angle. We find that the dispersion curves are significantly influenced by deformation for shear waves propagating at oblique angles. We show the evaluation of the dispersion from the case of waves propagating perpendicular to the layers to the case of waves propagating along the layers in finitely deformed LCs. We observe significant influence of deformation on the dispersion curves of shear waves propagating at angles different from the normal case. For waves propagating at angles close to the normal case, the dispersion curves are highly nonlinear, and the applied deformation changes the location of the local minima and maxima, and further transforms them. For oblique waves propagating at significantly different from normal case angles, we find that the dispersion curves possess "bi-linear" behavior, and the applied tensile deformation shifts the dispersion curves towards higher frequency in both linear short and long wave ranges. For long wave ranges, however, the effect of deformation becomes less significant after some level of applied deformation.

Keywords: Layered composite, finite deformation, wave propagation, dispersion relation, attenuation

1. Introduction

Elastic wave propagation in solids has been an active topic of research due to its importance for many applications, such as seismology, nondestructive testing, acoustic filters, vibration damper, biomedical imaging and acoustic cloaking. Recently, the field of architected microstructured metamaterials for manipulating elastic wave propagation has attracted significant attention [1–18]. Moreover, soft materials provide an opportunity to control elastic waves by deformation. This can be achieved through different effects of applied deformation – changes in microstructural geometry [19,20] and local material properties [21–25], or by a combination of these effects [26–28]. Furthermore, the influence of deformation can be further magnified by utilizing the elastic instability phenomenon. Buckling induced microstructure transformations can lead to formations of new periodic microstructures, thus, significantly influencing elastic wave propagation [29–32]. Experimental realization of such microstructured materials significantly depends on the development in material fabrications such as layer-by-layer fabricating and 3D printing techniques; these recently emerged techniques already allow manufacturing of

0093-6413© 2015 The Authors. Published by Elsevier Ltd.