Accepted Manuscript

Dynamic homogenization of composite and locally resonant flexural systems

René Pernas-Salomón, Gal Shmuel

PII: S0022-5096(18)30250-3
DOI: 10.1016/j.jmps.2018.06.011
Reference: MPS 3368

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 26 March 2018
Revised date: 30 May 2018
Accepted date: 10 June 2018

Please cite this article as: René Pernas-Salomón, Gal Shmuel, Dynamic homogenization of composite and locally resonant flexural systems, *Journal of the Mechanics and Physics of Solids* (2018), doi: 10.1016/j.jmps.2018.06.011

Dynamic homogenization of composite and locally resonant flexural systems

René Pernas-Salomón and Gal Shmuel*

Faculty of Mechanical Engineering, Technion–Israel Institute of Technology, Haifa 32000, Israel

Abstract

Dynamic homogenization aims at describing the macroscopic characteristics of wave propagation in microstructured systems. Using a simple method, we derive frequency-dependent homogenized parameters that reproduce the exact dispersion relations of infinitely periodic flexural systems. Our scheme evades the need to calculate field variables at each point, yet capable of recovering them, if wanted. Through reflected energy analysis in scattering problems, we quantify the applicability of the homogenized approximation. We show that at low frequencies, our model replicates the transmission characteristics of semi-infinite and finite periodic media. We quantify the decline in the approximation as frequency increases, having certain characteristics sensitive to microscale details. We observe that the homogenized model captures the dynamic response of locally resonant media more accurately and across a wider range of frequencies than the dynamic response of media without local resonance.

Keywords: Composite, Phononic crystal, metamaterial, Local resonator, Band gap, Flexural wave propagation, Bloch-Floquet analysis, Dynamic homogenization

1 Introduction

The physics of systems with microstructure is governed by complex differential equations with spatially varying coefficients, leading to fields that exhibit rapid fluctuations at the microscale. Homogenization theory aims at describing such systems in terms of simpler *effective* or *macroscopic* equations, assuming these microscale variations can be averaged out (Hashin, 1983, Nemat-Nasser and Hori, 1999, Milton, 2002). In turn, the homogenized models—ordinarily developed when analyzing infinite media—are employed in investigating the physics of microstructured systems

*Corresponding author. Tel.: +1 972 778871613. *E-mail address*: meshmuel@technion.ac.il (G. Shmuel).