Propagation of elastic waves in microporous materials employing an energetically-equivalent non-classical continuum

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Abstract. The elastodynamic response of engineered porous materials depends on their microstructural features. The presence of internal structure, here accounted for by an implicit non-local/non-classical continuum[1], gives rise to a dynamic response due to an additional degree of freedom, different from the linear elastic behaviour of Cauchy continuum. In this work, a two-scale modelling is applied, based on the energetic equivalence between a lattice at the microscale and a non-classical continuum at the macroscale. This model can represent the material non-linearity, due to porosity, through additional state of strain and stress (autoforces) instead of altering the system stiffness as in classical internal variable models. The response of a microporous plate described with the equivalent model to a monochromatic wave is compared to the original fine texture. The results prove the effectiveness of the approach in describing the wave response and also observing dispersion in wave propagation.

Introduction

Novel microporous materials have gained attention in a broad range of engineering applications since their internal texture can be tailored to meet desired requirements. The engineered materials include lightweight structures, bio-engineered tissues, and vibration or acoustic control devices. The efficient design of such materials requires reliable mechanical models to describe their macroscopic behaviour. A proper model must take into account the microstructural texture. For microporous structures excited at wavelengths of the same order of magnitude of the internal lengths, the classical Cauchy theory fails to accurately homogenize the discrete nature of the material [2,3,4]. In such cases, the use of non-classical continua is motivated by the presence of additional kinematical descriptors, which enable the preservation of the material's underlying structure at a fine level [1]. In the current work, a two-scale discrete-continuum procedure is employed to describe a microporous material based on micro/macro energy equivalence. For the continuum description, a non-classical theory is adopted with an additional degree of freedom to implicitly account for the internal structure. Furthermore, the nonlinear response, in the static and dynamic framework, of a 2D microporous material subjected to a plane-wavefront monochromatic wave is investigated.

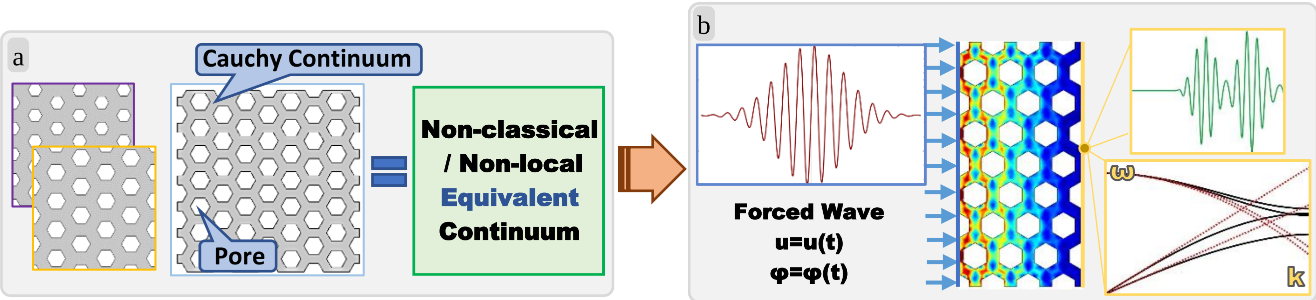

Figure 1: A graphical abstract of the work: developing an equivalent non-classical continuum for various microporous material textures **(a)**; employing the model to study wave propagation **(b)**.

Results and Discussion

The non-local theory was implemented to provide a continuum description of a microporous material, based on energy equivalence. A parametric study was carried out by varying pattern, size and density of pores (**Fig. 1a**), and compared to available experimental results [5]. In order to verify the ability of the equivalent model to account for the presence of the microstructure, the non-classical elastodynamic behaviour of porous material was studied (**Fig. 1b**). The results showed the ability of the proposed model to describe the occurrence of dispersion in wave propagation as well as the existence of different propagation modes tied to the microporosity, which cannot be described by the classical (Cauchy) theory.

References

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