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Toward the identification of a Cosserat effective continuum for quasi-periodic lattice materials

A. SOMERA^a, M. PONCELET^b, N. AUFFRAY^c, J. RÉTHORÉ^a

a. *Institut de Recherche en Génie Civil et Mécanique (GeM), Centrale Nantes, Université de Nantes, CNRS, UMR 6183, 44321 Nantes, France*

b. *Université Paris-Saclay, CentraleSupélec, ENS Paris-Saclay, CNRS, Laboratoire de Mécanique Paris-Saclay, 91190, Gif-sur-Yvette, France*

c. *MSME, Univ Gustave Eiffel, CNRS UMR 8208, F-77474 Marne-la-Vallée, France*

*audrey.somera@ec-nantes.fr, martin.poncelet@ens-paris-saclay.fr,
nicolas.auffray@univ-eiffel.fr, julien.rethore@ec-nantes.fr*

The recent emergence of new manufacturing processes has led to the increasing use of architected materials in industry. Quasi-periodic architected materials are a class that promises to combine the advantages of random and periodic lattices: they are, at the same time, perfectly ordered structures [1], while being elastically isotropic and having a great toughness [2].

The democratisation of lattice materials for engineering applications requires the ability to perform rapid simulations, which often involves the use of a homogeneous overall continuum. The idea is to consider a fictitious homogeneous material which behaves, for a certain range of external parameters, like the original lattice material. For a weak scale separation, the classical Cauchy continuum model is sometimes unable to describe the effective behaviour [3]. Thus, the nature of the fictitious material to be considered is the first question to be answered. Once the continuum model defined, the second problem consists in obtaining the material parameters of the associated constitutive relation. As lattice behaviours can be classified into at least three categories - bending dominance, stretching dominance and slenderness dominance [4] - a credible hypothesis is that the effective medium depends on the lattice dominance type. In order to numerically and experimentally determine the parameters of the substitution medium, a new experimental setup is proposed. It is inspired of the Brazilian test, with the three-point loading of a ring-shaped specimen.

The objective of this contribution is to validate the proof of concept of the design using numerical simulations. Virtual experimental data are generated by use of digital twin models of the periodic and quasi-periodic architected materials specimens, discretized using beam elements. These simulations are used as references for the identification of Cauchy and Cosserat effective behaviours using a FEMU method. It is shown that the most appropriate behaviour depends on the type of lattice dominance: Cauchy for stretching-dominated structures and Cosserat for bending-dominated ones.

References

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