Accepted Manuscript

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PII: S0263-8223(18)31827-0
DOI: https://doi.org/10.1016/j.compstruct.2018.07.115
Reference: COST 10033

To appear in: *Composite Structures*

Received Date: 19 May 2018
Revised Date: 25 July 2018
Accepted Date: 30 July 2018

Elastic Wave Propagation in 3-D Periodic Composites: Band Gaps Incorporating Microstructure Effects

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Abstract

A new model for determining band gaps for elastic wave propagation in three-dimensional (3-D) periodic two-phase composites is developed using a modified couple stress theory that accounts for microstructure effects. Three types of composites, each containing a different kind of inclusion – spherical, cubic, and cube with square-rod connections, are considered, with the third one representing a co-continuous composite. The plane wave expansion method and the Bloch theorem for periodic media are employed to solve the elastic wave equations in each case, which are converted to an eigenvalue problem. The band gaps are determined from solving the characteristic equation and plotting the resulting eigen-frequencies. The new non-classical model reduces to the classical elasticity-based model when microstructure effects are suppressed. To quantitatively illustrate the newly developed model, a parametric study is conducted for 3-D periodic composites with the three kinds of inclusions. The numerical results reveal that the first band gap values predicted by the current non-classical model are smaller than those predicted by the classical elasticity-based model, and the difference between the two sets of band gap values is large when the unit cell size is very small. Also, it is seen that the volume fraction and inclusion shape have significant effects on the band gap size. These indicate that large band gaps can be attained by tailoring microstructural parameters including the unit cell size, volume fraction and inclusion shape.

Keywords: Band gaps; Wave propagation; Bloch theorem; Plane wave expansion method;

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