Computational Design of Acoustic Metamaterials with Volumetric Locking and Uncertainty Issues

[*]Eric Li[1], ZC He[2]

[1] School of Science, Engineering & Design, Teesside University

[2]State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, Hunan University, Changsha, 410082 PR China

*Presenting and corresponding author: ericsg2012@gmail.com

Abstract

A nonlinear interval perturbation hybrid node-based smoothed finite element method (NIPH- NS/FEM) using triangular elements is proposed to study the physical response of LRAMs with uncertainty parameters. The employment of triangular elements is useful to capture the complicated boundary in the earlier design stage. The numerical results have clearly indicated that standard FEM using linear triangular elements suffers from the volumetric locking severely for incompressible rubber, which gives very wrong solutions in the analysis of physical response of LRAMs. With selective integration approach, the hybrid NS/FEM has balanced the smoothed stiffness and mass very well. Based on the theoretical analysis and numerical results conducted in this work, it is confirmed that the volumetric locking issue in the LRAMs has been alleviated successfully in the hybrid NS/FEM model using simple triangular element. In addition, the uncertainty model with the interval parameters has been established in this work. It is found that the Poisson's ratio of the incompressible rubber v is very sensitive to the band gap of LRAMs with ternary structure. The numerical results have strongly confirmed that the NIPH-NS/FEM is able to predict the upper and lower bounds solutions of mechanical response of LRAMs. The implementation of NIPH-NS/FEM in the simulation of LRAMs is very straightforward, which offers a great help in the design of LRAMs for additive manufacturing to suppress the noise and vibration of engineering structure. It is expected that the proposed algorithm developed in this work can be extended to analyze more complicated cases of metamaterials with uncertainty parameters.

Keywords: Volumetric locking; locally resonant acoustic metamaterials; Uncertainty effect; Softened stiffness; Interval model

Reference

[1] Eric Li, ZC He, G Wang, GR Liu. An ultra-accurate numerical method in the design of liquid phononic crystals with hard inclusion. Computational Mechanics DOI 10.1007/s00466-017-1451-y

[2] Eric Li, ZC He, JY Hu, XY Long. Volumetric locking issue with uncertainty in the design of locally resonant acoustic metamaterials. Computer Methods in Applied Mechanics and Engineering 324 (2017) 128-148.
[3] Eric Li, ZC He, G Wang. An exact solution to compute the band gap in phononic crystals. Computational Materials Science 122(2016) 72-85.
[4] ZC He, X Xiao, Eric Li. Design for structural vibration suppression in laminate acoustic metamaterials. Composites Part B: Engineering 2017 (131), 237-252