Wave propagation in phononic-crystal composites plates

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ABSTRACT

Composite structures have been introduced in the transportation industry to reduce vehicle mass and energy consumption. Composites have low internal damping which leads to higher levels of vibration and induced noise. To reduce the vibrations amplitude and thus the acoustic discomfort, damping elements placed in specific locations of the structure [1-2] are sometimes used. In this paper, the anti-vibration function is obtained by the introduction of periodic effect. This arrangement constitutes a phononic crystal that generates frequency ranges without free wave propagation [3-4], called band gap. The vibro-acoustic properties of the structure are thus improved.

This study focuses on periodic composite plates of glass/epoxy by defining elementary cells.

In a first part, when the periodicity is very smaller than the dimensions of the plate a finite element approach is proceed using Comsol Multiphysics ®4.4 software, to obtain the dispersion curves of an infinite periodic structure. The frequency associated to each wave vector which propagates through the elementary cell is calculating using Bloch-Floquet periodicity conditions on the boundaries. The dispersion curves around the edge of the irreducible Brillouin zone are obtained.

The study is focuses on the bidirectional periodic structures. One of the configurations studied is a plate composed of a periodic square of rubber inclusions embedded in a composite material with eight-layer of fiber glass. Unlike the band diagram of a composite reference plate, the band diagram obtained (Fig.1) shows that waves are blocked for frequencies around 2600 Hz, in all directions of the wave vector.

The second parts of the study concern the fabrication and characterization of unidirectional periodic plates, in order to take into account the technical limits of the production of periodic plates with composite materials. These plates are composed of a succession of strips, with a number of layers of glass fibers varying from one strip to another. This succession of strips provides directional bands gaps. To test these plates, an experimental protocol is chosen to

impose unidirectional wave propagation: the plate is attached in the middle between two aluminum beams enough rigid at low frequency. The lower beam is connected to a vibration exciter for exciting the structure. Several plates will be tested and compared to the numerical results.

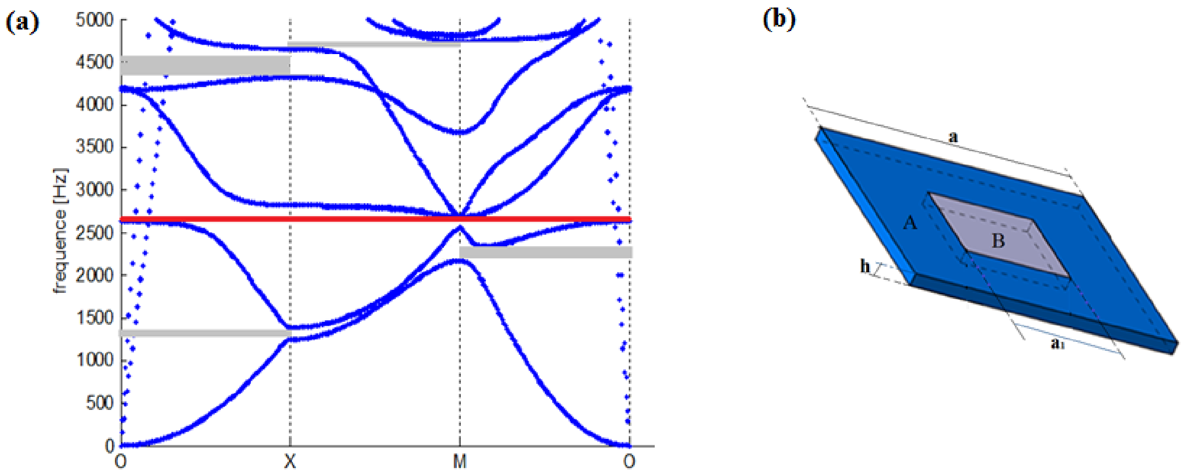

Figure 1. (a) Band diagram of a periodic composite plate with rubber inclusions, (b) Unit cell with inclusion.

REFERENCES

[1] M. Assarar, A. El Mahi, J-M. Berthelot, "Damping Analysis of Sandwich Composite Materials", Journal of Composite Materials - J COMPOS MATER, vol. 43, no. 13, pp. 1461-1485, 2009.

[2] S. Assaf, "Finite element vibration analysis of damped composite sandwich beams", International Journal of Acoustics and Vibration, Vol. 16, n°4, pp. 163-172, 2011.

[3] L. Brillouin, "Wave propagation in periodic structures", McGraw-Hill Book Company, New York, 1946.

[4] C. Claeys, K. Vergote, P. Sas, W. Desmet, "On the potential of tuned resonators to obtain low-frequency vibrational stop bands in periodic panels", Journal of Sound and Vibration 332, pp. 1418–1436, 2013.

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