ANALYSIS ON THE BAND-GAP PROPERTY OF THE LIGHT-WEIGHT PERIODIC STRUCTURE BY THE SPECTRAL ELEMENT METHOD

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ABSTRACT

The band-gap property is a very significant dynamic behavior of periodic structures in view of its structural and/or material periodicities. The elastic waves that can propagate in the structure in some frequency ranges are referred to as the pass band. However, sound and vibration propagation is forbidden for certain other frequency ranges, called stop bands. This property endows periodic structures with the potential to control wave propagation. In this study, we focus on the periodic structure as shown in Fig. (1). These kinds of periodic structures have unique characteristics. They are constructed by plentiful basic structure such as rods, beams and plants. They not only have the band-gap property but also possess the light weight feature due to the abundant interspaces.

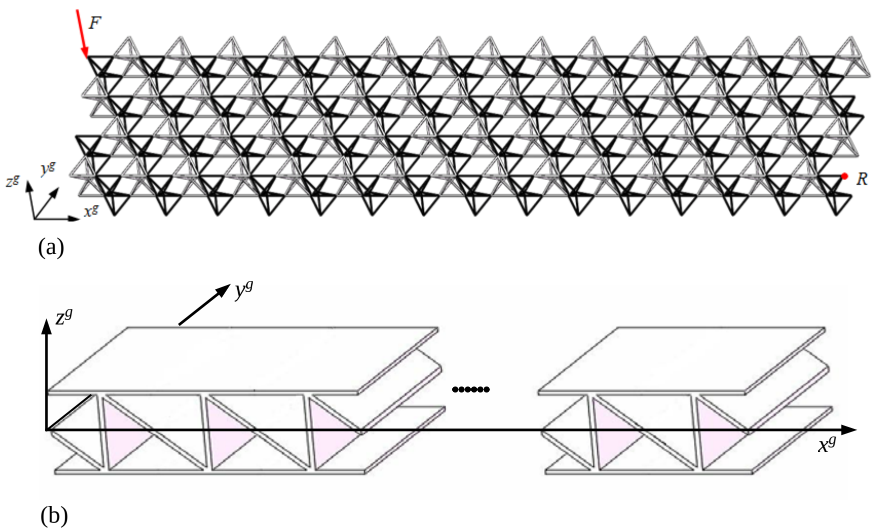

Fig.1 Two kinds of light-weight periodic structures such as (a) 3D Kagome lattice and (b) sandwich panels with corrugated cores.

In recent years, with the increasing attention on the investigation of elastic wave propagation in periodic structures, several methods have been developed to analyze the band-gap characteristics [1-4]. For the kinds of complicated light-weight periodic structures as shown in Fig. (1), it is difficult to use the traditional method in the modeling. Although they can be treated numerically by the finite element method (FEM), the computational cost will be substantially increased with the increasing size or number of the sub-structures. Moreover, the accuracy of the numerical solutions will be deteriorated when the frequency becomes higher. So a suitable and efficient method should be developed and applied to study the dynamic behaviors of this kind of light-weight periodic structures. In this study, the spectral element method (SEM) is adopted for dynamic modeling of the light-weight periodic structures. The interpolation function used in SEM is based on an Eigen function of the equation of motion that can provide exact solutions in the frequency domain [5, 6]. If the structure has uniform geometry and material properties, it can be considered as only one spectral element, which means that the element number and the degree of freedom (DOF) can be reduced significantly. High solution accuracy in the frequency domain and assuring the minimum DOF are the two main benefits derivable from SEM during a periodic structure analysis.

The spectral stiffness matrices of beam and plate elements are established. The spectral equations of the whole structures are further assembled. The frequency responses of the lattices are calculated, and the results are compared with those calculated by the FEM. It can be observed that the SEM is more accurate, especially in high frequency ranges. The frequency band gap properties are also analyzed. Furthermore, the effects of the material and structure parameters on the band gap properties are investigated.

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