Seismic metamaterials for the filtering of S-waves

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Abstract

Researchers started to study metamaterials in the electromagnetic field investigating the material properties like negative permittivity and negative magnetic permeability[1,2]. Similarly, elastic metamaterials are designed to have negative mass density and/or negative Young's modulus in order to control elastic wave propagation for a target frequency. Recently, Huang et al [3] have employed a simple one-dimensional model to introduce the concept of negative effective mass density and negative Young's modulus. Xiang et al [4] focused on one dimensional periodic structure with two different materials, such as rubber and reinforced concrete, to influence seismic waves by defining the concept of periodic foundation. Concerning this concept, it has been shown experimentally how a 2D periodic foundation can effectively work as wave filter within the frequency of a well defined bandgap [5]. In our previous work [6], we have shown that the presence of material with low stiffness is the key feature to work with a bandgap at low frequency (useable for seismic waves) when designing a 2D periodic foundation for seismic waves. Here we present our recent advances on the topic. In particular, we have designed, fabricated and tested on a laboratory scale a composite foundation integrating a seismic metamaterial based on the idea of periodic mass-in-mass systems that is capable of reducing the energy of seismic S-waves propagating across it. Our experiments show the presence of a bandgap with an initial frequency of 5 Hz and, within the bandgap, a reduction of the wave energy more than 50% is observed.

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