TOWARDS THE DESIGN OF HIGHLY DISSIPATIVE LOW-FREQUENCY METAMATERIALS: THE K-DAMPING CONCEPT

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Abstract

The terms “acoustic/elastic meta-materials” describe a class of periodic structures with unit cells exhibiting local resonance. An intuitive description of such designs is by using a simple “mass-in-mass” lumped parameter model. This localized resonant structure has been shown to result to negative effective stiffness and/or mass at certain frequency ranges close to the local resonances. As a result, these structures present unusual wave propagation properties at wavelengths well below the regime corresponding to band-gap generation based on spatial periodicity, (i.e. “Bragg scattering”). Therefore, acoustic/elastic meta-materials can lead to applications, especially suitable in the low-frequency range.

However, low frequency range applications of such meta-materials require very heavy internal moving masses, as well as additional constraints at the amplitudes of the internally oscillating locally resonating structures, which may prohibit their practical implementation.

In order to resolve this disadvantage, the KDamping concept will be analyzed. According to this concept, the acoustic/elastic meta-materials are designed to include negative stiffness elements instead of internally resonating added masses. This concept removes the need for the heavy locally added heavy masses, while it simultaneously exploits the negative stiffness damping phenomenon.

Application of both Bloch’s theory and the classical vibration analysis at the one-dimensional mass-in-mass lattice is analyzed and corresponding dispersion relations are derived. The results indicate significant advantages over the conventional mass-in-a mass lattice, such as broader band-gaps, as well as increased damping ratio and reveal significant potential in the proposed solution, encouraging further investigation.