Full title: Metamaterials for increased sound insulation

Abstract: The importance of sound insulation has increased in the last few decades. More people are living in densely populated areas, resulting in noisier environments. However, this fact has been accompanied with more dwellings being built utilizing lightweight constructions, which are less costly and easier to build. The downside of lightweight constructions is that they provide less sound insulation. Noise pollution is a health risk to humans, thus the importance of developing better sound insulation solutions.

Firstly, the thesis studies the possibility of using acoustic metamaterials for increased sound insulation at constant mass per unit area. An analytical model is developed to understand the mechanisms with which acoustic metamaterials provide enhanced sound transmission loss for single-panels, especially looking into the coincidence effect problem. Furthermore, the analytical model shows that metamaterials can provide enhanced sound insulation in a limited frequency range. Experimental validations of the analytical model are carried out.

Secondly, the thesis focuses in the developing of modeling and design tools for the creation of application-specific acoustic metamamterials. This aims to make the design process more efficient, helping the industry in the application of acoustic metamaterial theory in commercial applications. A hybrid analytical-numerical approach is developed for the efficient computation of the sound transmission loss of single-panel realizable acoustic metamaterials. This allows for the practical application of the optimization design methodology in three-dimensional numerical resonator designs.

Lastly, the hybrid analytical-numerical approach is extended for double-panel constructions. The objective is to develop new acoustic metamaterials to enhance the sound insulation of double-panels, especially looking into the mass-spring-mass resonance sound transmission loss dip and the coincidence effect problem. A mechano-acoustic metamaterial is proposed and optimized for sound insulation utilizing the hybrid analytical-numerical approach. Enhanced sound insulation is achieved between 50 Hz and 4000 Hz.