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Abstract

Combining lightweight characteristics with favourable noise and vibration behaviour, locally resonant metamaterials with vibro-acoustic stopband behaviour are gaining increasingly more attention. In view of applicability of metamaterials, this paper investigates the effects of curvature on stopband behaviour. Through derivation of curved unit cell models, dispersion curves for cylindrically curved infinite periodic structures are derived. The effect of curvature on metamaterials is investigated through both an academic example of an infinite cylindrically curved panel with added spring-mass systems and a realizable curved panel with resonant structures. It is shown that, whenever pure flexural motion exists in the host structure, the stopband mechanism can be applied to achieve flexural stopbands.

Keywords**:** metamaterial; Bloch-Floquet; wave propagation; cylindrically curved panels; complex wavenumber; periodic structures.

1. Introduction

In recent years, increasingly restrictive emission regulations forced the transportation industry to look at lightweight design to increase fuel efficiency of their vehicles. However, since generally structures with low mass and high stiffness suffer from unfavourable noise, vibration and harshness (NVH) behaviour, this leads to vehicles with possibly poor NVH behaviour. Therefore, considering the increasing awareness regarding the negative impact of unwanted noise on human health , post-treatment of lightweight vehicles seems to be a necessity. Albeit, only the example of automotive is given, these two often contradictory criteria of favourable NVH behaviour and lightweight design, hold for various sectors of industry and ask for new and innovative solutions which should be kept as simple, cheap and easy to apply as possible.

As one of these innovative and efficient lightweight NVH solutions, vibro-acoustic metamaterials are becoming of more interest. Metamaterials have shown a promising potential in efficiently insulating noise and vibration in a host structure, at least in targeted frequency ranges. These targeted frequency ranges are commonly referred to as stopbands and they are defined as zones in frequency in which no free wave propagation can occur. It has been shown that metamaterials can be designed to have multiple stopbands . The stopband phenomenon in metamaterials is the result of resonances of resonant cells distributed on a subwavelength scale (i.e. on a scale smaller than the governing wavelength in the host structure at the frequency