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Numerical evaluation and parametric characterization of FE-modeled acoustic metamaterials

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Abstract.

The research performed in the context of this work focuses on the study of composite metamaterials to be employed as possible lightweight insulation systems for noise and vibrations. Going into details, dispersion relations are derived by applying the Bloch-Floquet theory to the unit cell of a periodic microstructure. Advanced beam finite elements based on Carrera Unified Formulation are here extended, for the first time according to the authors' knowledge, to the dynamic characterization of these materials. In addition, transmission curves are computed in order to validate the band gaps encountered in the analysis of the dispersion behavior. The finite element model is first assessed through the evaluation of the dispersion behavior of some metamaterial configurations proposed in the relevant literature; then, its computational efficiency is demonstrated by comparing it with analogous 3D models that are available in commercial codes. In the end, the model is applied to the parametric characterization of a composite metamaterial made of a melamine foam matrix and periodic distribution of cylindrical aluminum inclusions. The results show that it is possible to tune the band gaps of the metamaterial to lower frequencies by simply varying the dimensions of the unit cell and keeping constant its equivalent density.