Engineering meta-structural plates for the cloaking of flexural waves

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Abstract

Shielding surface waves could be a part of a comprehensive strategy to mitigate the possible destructive effects of seismic waves on existing buildings. A possible way to achieve the goal is to employ an orthotropic meta-structural plate designed according to the recipe provided in [1], where a square geometry has been assumed. However, the mathematical transformation obtained in [1] leads to the presence of an unlikely strong compressive prestress, beyond the buckling threshold for the structure, with in-plane body forces to maintain it in equilibrium. In addition, some of the predicted bending stiffnesses must reach very high values in some parts of the cloak that are difficult to achieve in a real structure. With the aim of establishing design guidelines for the construction of a real meta-structural plate, we have implemented a FE code in Matlab to deal with the cloaking of transient waves in structured flexural plates interacting with a substratum. The tool allowed us to explore some orthotropic plate layouts that can achieve good shielding performance, without the need of prestress, for a wide range of frequencies. A sensitivity analysis of design parameters is performed to highlight the main quantities that should be considered for an optimization of the proposed concept.

Reference

[1] Colquitt, D., Brun, M., Gei, M., Movchan, A.B., Movchan, N.V. and Jones, I.S. (2014). Transformation elastodynamics and cloaking for flexural waves. Journal of the Mechanics and Physics of Solids 72, 131-143.