Metamaterials in Seismic Mitigation

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Abstract

'Metamaterials', or composite structures engineered to have specific properties typically not available from naturally-occurring homogenous materials, have found special application in engineering for wave propagation. Mathematical research on 'cloaking', or design of structures which render objects invisible to waves, typically implies that the material properties in the cloak must be so unusual that only metamaterials can achieve them.

Success in developing metamaterial concepts for electromagnetic and acoustic cloaking has piqued interest in seismic applications. Here, the 'invisibility' of a structure cloaked from earthquake or ground shock is of interest not for the scattering effects, as in electromagnetics and acoustics, but because wave invisibility implies that the structure would not perceive any load at all. A perfect seismic cloak would redirect all waves around the structure, so that the base would not experience any excitation.

Because of the clear potential value of seismic cloaking in buildings and infrastructure, researchers have begun to explore specific theories and concepts that may make seismic cloaking a practical reality. This session will cover the theory of cloaking for elastic waves, metamaterial concepts to realize the theory in practice, and some experimental and numerical results that indicate the promise of the technology.

This talk will focus on several aspects of the problems of applying metamaterial concepts to seismic mitigation. First, we will review existing mitigation concepts, especially seismic impedance barriers, in the physical context of metamaterial alternatives. Second, we will review recent computational and analytical work in acoustic metamaterial technology that bears on the topic of design, assessment and optimization of metamaterials of any mechanical wave-bearing type. Third, we will explore briefly a selection of metamaterial concepts in a practical yet simulated soil/structure environment. Finally, we will discuss some alternative future paths for research and development.