Postprint: Low-Frequency Wide Band Gap Seismic Metamaterials for Vibration Reduction Based on Soil Layering

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Abstract

To investigate the influence of soil stratification on the vibration mitigation performance of seismic metamaterials, numerical simulations were conducted to calculate the band structures and transmission spectra of seismic metamaterials under four different soil stratification conditions. The influence of geometric parameters, such as the height and thickness of steel pipes and concrete, on the complete bandgap width of seismic metamaterials was analyzed for the case of four-layer soil stratification. By coupling seismic metamaterials with isolation trenches, the ability of the structure to attenuate seismic surface waves along the ΓX direction was examined. The results demonstrate that as the bottom constraint of the soil layer strengthens, each band gradually shifts upward. Therefore, in practical engineering applications, the desired complete bandgap width can be achieved by enhancing the bottom constraint of seismic metamaterials. Geometric parameter analysis reveals that the unit cell height and steel pipe thickness exert significant influences on the complete bandgap width of seismic metamaterials. Through proper design of steel pipe dimensions, a complete bandgap with a width of up to 7.132 Hz can be obtained, which holds significant importance for the seismic protection of high-rise and super high-rise buildings with resonance fundamental frequencies within 10 Hz. The coupling of isolation trenches with seismic metamaterials can attenuate seismic surface waves in the 0.1–20 Hz range along the ΓX direction, thereby facilitating the achievement of omnidirectional control of seismic surface waves.

Full Text

Preamble

This preamble section introduces the fundamental mathematical relationships and definitions that form the theoretical foundation of this work. These equa-

tions establish the core notation, variables, and relationships that will be utilized throughout the subsequent analysis and discussion. The mathematical framework presented here provides the necessary context for understanding the methodologies and results described in later sections.

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Note: Figure translations are in progress. See original paper for figures.