Towards the design of a feasible seismic metabarrier using multi-mass resonators

Antonio Palermo[1], Matteo Vitali[1], Alessandro Marzani[1]

[1]DICAM, University of Bologna, Italy

*** Correspondence:**
Alessandro Marzani
alessandro.marzani@unibo.it

Abstract

Artificially engineered soils, also referred as "seismic metamaterials", have been recently investigated as novel isolation devices for earthquake engineering applications. Their design is inspired by concepts well established for acoustic and mechanical vibration applications where periodic and locally resonant media, i.e. the metamaterials, are used to control and attenuate the propagation of acoustic and elastic waves in the high infrasonic-ultrasonic range (100 to 100.000 Hz). However, in a seismic event, low frequency (1-10 Hz) long wavelength (10-1000 m) elastic waves are generated, posing significant complexity to the design of effective and feasible metamaterial based isolation devices.

Recently, we have proposed the use of an array of resonant structures, each made of a steel mass suspended by elastic bearings encased in a concrete pipe, buried at the soil surface to interact with incoming seismic surface waves. These surface resonators can realize a seismic metabarrier which converts harmful surface waves into shear bulk waves, redirecting part of the elastic energy traveling on the surface into the bulk.

Building on these results, in this talk we investigate the use of multi-mass resonators to enhance the ground motion attenuation of a seismic metabarrier and achieve broadband wave filtering properties with more compact structures. To this aim, we first review the performance of a single mass metabarrier, investigating the required dimensions (mass and length of the barrier) to obtain a significant ground motion attenuation. Then, we describe the dynamic of a multi-mass metabarrier using analytical and numerical approaches. In particular, we provide a detailed study of a double-mass resonator which shows the superior performance of multi-mass resonators, either when specific frequencies are targeted and when a rainbow trapping arrangement is exploited. Finally, we exploit an optimization strategy based on the use of Genetic Algorithms to design a multi-mass resonator with minimal mass able to target selected frequency ranges at will. The optimization strategy is applied to design a structure to protect two concrete frame buildings of known dynamic properties, showing significant ground motion reduction with a more compact metabarrier design.