University of Tehran
Faculty of Engineering
Civil Engineering Department

Soil-Buried Wave Barriers for Vibration Control of Structures Subjected to Vertically Incident Shear Waves

By
Amir Rezaie

Supervised by
Dr. Seyed Rasoul Mirghaderi, Reza Rafiee-Dehkharghani, Kiarash.M. Dolatshahi

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Abstract:

Traditionally, the effects of seismic forces on structures have been mitigated by installing supplemental energy dissipation systems and controlling the energy inserted to the structures. In this paper, a new approach is explored for the mitigation of the earthquake-induced vibrations by obstructing the entrance of the seismic energy to the structure through the insertion of some concrete wave barriers within the soil domain. To do so, a specific part of the ground in the vicinity of the structure and the inserted wave barriers are considered as a manipulated zone, and it is focused to find the optimal layout of the barriers that maximizes the potential of the buried barriers for scattering the seismic waves. This is performed by developing a genetic algorithm (GA) based adaptive optimization methodology that is capable of finding the most efficient layout of the concrete barriers in a manipulated soil zone around the structure. The optimization methodology is coupled with finite element (FE) method for analyzing the complex wave propagation phenomenon in the medium. As each trial solution can have a different geometry, the developed methodology is able to update the FE model during the optimization process. To investigate the effect of frequency, three single-degree-of-freedom (SDOF) structures with the natural frequencies of 1, 2, and 3 Hz are subjected to the time history ground motions with the predominant frequency up to 8 Hz. The analyses are performed in the frequency domain, and the efficiency of the obtained solutions is examined by applying time history ground motions to the medium in the time domain. The results show that the performance of the buried wave barriers is a complex function of the wave barriers layout, natural frequency of the structure, and the frequency content of the loading. It is observed that some optimal layouts of limited volume can attenuate the elastic demands of the structures to the extent of 30 to 80 percent.

Key words: Wave Barrier; Vibration control; Wave propagation; Genetic algorithm.