**Defense Announcement**

The Efficiency of Metamaterial-Based Seismic Isolation Barriers

**Hsuan Wen Huang**

**Degree:** PhD, Civil Engineering
**Date:** 11/09/2020 Time: 3:00 PM – 5:00 PM
**Location:** Zoom, meeting ID: 968 2048 9343
**Password:** Please email hhuang15@uh.edu

| | |
|---|---|
| **Co-advisors:** | Professors Yi-Lung Mo and Kalyana B. Nakshatrala |
| **Other Committee Members:** | Dr. Thomas Hsu |
| | Dr. Kenneth Stokoe |
| | Dr. Shailendra Joshi |

Critical infrastructures are often augmented with seismic isolation systems to mitigate damage from earthquakes. However, there is no effective seismic isolation system that works well for different types of seismic impulses (e.g., P- and S-body waves, surface waves) and for different structures. To fill this critical need, the research objective of this dissertation is to develop a new type of seismic isolation barrier system by utilizing periodic metamaterials. The proposed seismic isolation system—referred to as periodic barrier—and can be tailored to a specific infrastructure and to a specific region's seismic activity. Periodic metamaterials possess a unique frequency-selective property that allows manipulating the propagation of waves. The periodic barrier, designed to mitigate either man-made or naturally caused vibrations, introduces a discontinuity in the soil and is achieved by infilling a trench-type wave barrier with 1D periodic metamaterials.

The research approach can be summarized as follow: (1) derive the analytical frequency band gaps of periodic metamaterial for the Rayleigh wave, (2) establish a finite element model for an extensive parametric study, and (3) conduct passive and active isolation field tests to evaluate the performance of the barriers. First, the analytical frequency band gap of periodic metamaterial for the Rayleigh wave is derived. Second, the dynamic behavior of the periodic metamaterial is simulated with finite element models. The two-dimensional finite element simulations on trench-type wave barriers with various conditions are investigated for their screening effectiveness. The influence of key parameters, including the depth of barriers, infilled material, loading direction, number of barriers, and loading distance, on the screening effectiveness is understood. Third, a series of full-scale field experiments are conducted to investigate the screening effectiveness of both empty trench and periodic barriers. Two state-of-the-art hydraulic mobile shakers (T-Rex and Thumper) were used to generate excitations in the vertical, horizontal inline, and horizontal crossline directions for passive and active isolation tests. In addition to the effect of the barrier dimension, geometrical arrangement, and loading distance, it is found that the excitation direction significantly affects the performance of the barrier. Moreover, the presence of the underground periodic foundation can lead to a wider attenuation zone. The attenuation zones identified through the field tests match the theoretical frequency band gaps with the assumption of the dominant type of wave generated by the excitation in different directions.