

Thesis Defense

Monday, June 22, 2015

10:00 am in 100 Powell-Booth

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“Metaconcrete: Engineered aggregates for enhanced dynamic performance”

This work presents the development and investigation of a new type of concrete for the attenuation of waves induced by dynamic excitation. Recent progress in the field of metamaterials science has led to a range of novel composites which display unusual properties when interacting with electromagnetic, acoustic, and elastic waves. A new structural metamaterial with enhanced properties for dynamic loading applications is presented, which is named *metaconcrete*. In this new composite material the standard stone and gravel aggregates of regular concrete are replaced with spherical engineered inclusions. Each metaconcrete aggregate has a layered structure, consisting of a heavy core and a thin compliant outer coating. This structure allows for resonance at or near the eigenfrequencies of the inclusions, and the aggregates can be tuned so that resonant oscillations will be activated by particular frequencies of an applied dynamic loading. The activation of resonance within the aggregates causes the overall system to exhibit negative effective mass, which leads to attenuation of the applied wave motion. To investigate the behavior of metaconcrete slabs under a variety of different loading conditions a finite element slab model containing a periodic array of aggregates is utilized. The frequency dependent nature of metaconcrete is investigated by considering the transmission of wave energy through a slab, which indicates the presence of large attenuation bands near the resonant frequencies of the aggregates. Applying a blast wave loading to both an elastic slab and a slab model that incorporates the fracture characteristics of the mortar matrix reveals that a significant portion of the supplied energy can be absorbed by aggregates which are activated by the chosen blast wave profile. The transfer of energy from the mortar matrix to the metaconcrete aggregates leads to a significant reduction in the maximum longitudinal stress, greatly improving the ability of the material to resist damage induced by a propagating shock wave. The various analyses presented in this work provide the theoretical and numerical background necessary for the informed design and development of metaconcrete aggregates for dynamic loading applications, such as blast shielding, impact protection, and seismic mitigation.