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Design and Experimental Verification of a Seismic Isolation System for Fuel Storage Tanks based on Metamaterial Concepts

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Large vibrations induced by strong earthquakes can cause fluid-filled tanks in tank farms to experience severe damages and trigger cascading effects in neighboring tanks. These events fall into the category of natural technological (NaTech) events that pose significant threats to the community and the environment, and therefore, need to be prevented with highest priority. Thus, in order to mitigate the risk of NaTech events, a novel type of foundation for fuel storage tanks is aspired. In recent years metamaterials have entered the field of earthquake engineering, due to their exceptional wave propagation properties. In line with this development, we conceived the Metafoundation; it is based on locally resonant metamaterials and acts as a seismic shield for fuel storage tanks. The present work describes the validation of this foundation through analytical and numerical analyses both in the frequency and in the time domain. Furthermore, in order to capture the non-linear response of the coupled tank-piping system, we conducted a hybrid (numerical-physical) simulation on the conceived foundation as a numerical substructure and a piping system as a physical substructure. As a result, we found a significant reduction in the seismic demand of the investigated tanks and that the piping system remains in the elastic range for the investigated seismic records covering both operational bases and safe shutdown earthquakes.