Seismic Fluid-Structure Interaction Analysis of Molten Fuel Advanced Reactor Vessels using MASTODON

Som L. Dhulipala, Chandrakanth Bolisetti, Lynn B. Munday

Many advanced reactor concepts propose the use of molten fuels in their reactor technology. Seismic analysis of these advanced reactors entails assessing the demands on their reactor vessels during earthquakes while considering fluid-structure interaction effects. A fluid-structure interaction module is developed in the Multihazard Analysis for Stochastic Time DOmaiN phenomenon (MASTODON) software, which is an open source, seismic analysis and risk assessment software developed at INL. In this module the fluid behavior is modeled using acoustics, which is a linear version of the Navier-Stokes equation. Interaction between the structure and the fluid is modeled by enforcing displacement continuity across the boundaries as well as the stress-pressure continuity. After developing the module, a verification and validation study is performed using models of fluid-filled tanks that are representative of reactor vessels. The tanks are subjected to uni-directional, bi-directional, and rotational accelerations at the base. Peak pressures on the tank wall and peak wave heights over the fluid surface are recorded and compared to benchmark solutions calculated using analytical calculations as well as another finite-element software, LS-DYNA, and data recorded from experiments performed at University at Buffalo. The seismic demand quantities calculated using MASTODON match well with the benchmark solutions and experimental data up to a peak base acceleration of 0.5g. Future work will be focused on performing fluid-structure interaction analyses of seismically isolated reactor vessels.