

A Modern Computational Framework for the Nonlinear Seismic Analysis of Nuclear Facilities and Systems

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The U.S. Department of Energy (DOE) has stewardship responsibility for a large inventory of mission critical facilities ranging from experimental science to nuclear operations facilities. Ensuring an appropriate characterization of seismic hazard and seismic risk for critical facilities is essential to the economical and safe management of the DOE enterprise. The DOE has developed a rigorous foundation for risk-informed, performance-based design for natural hazards through DOE standard 1020. To fully realize the potential of standard 1020 for ensuring earthquake safety, there must be a supporting computational capability that can accurately assess seismic demands and perform reliable simulations of facility limit states.

In support of the ability to execute performance-based analyses, a modern computational framework for the nonlinear analysis of nuclear facilities and systems is being developed under the auspices of the DOE. The major activities underway are focused on three main tasks:

- Development of a nonlinear, time domain finite element program for high performance computational simulations of earthquake soil-structure-interaction (SSI) for nuclear facilities including the effects of superstructure and soil nonlinearities
- Development of a large-scale laminar soil box experimental testbed for performing validation tests for nonlinear wave propagation in soils and for validating computational simulations of dynamic soil-structure-interaction
- Development of a systematic approach (procedures and technologies) for nonlinear, time domain modeling and simulation of nuclear facility structures, systems and components.

Fully nonlinear treatment of soil, contact surfaces and structures using high fidelity models will allow designers to optimize a nuclear facility soil-structure system for safety and economy, and provide an ability to execute risk-informed, performance-based design simulations as framed in DOE Standard 1020.

Recent advancements and progress in this project will be presented with a focus on the development of the earthquake simulation testing facility at the University of Nevada, Reno, as well as the advancements in nonlinear modeling and simulation using the ESSI implicit nonlinear finite element program. The ultimate objective is to make verified and validated computational tools for performance-based simulations widely available throughout the DOE complex.