# Probabilistic Soil-Structure Interaction Analysis of Nuclear Power Plant Structures for Seismic Probabilistic Risk Assessment

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As a partial response to post-Fukushima Near-Term Task Force (NTTF) Recommendation 2.1 from the Nuclear Regulatory Commission (NRC), several operating nuclear power plants commissioned seismic probabilistic risk assessment (SPRA) studies to evaluate the impact of modern seismic hazard estimates on seismic safety. The current study focuses on the structural response analysis performed for various structures at a single-unit General Electric (GE) Boiling Water Reactor (BWR) power plant in the Central and Eastern United States (CEUS). The structures considered include the Reactor Building, Turbine Building, Radwaste Building, and Emergency Diesel Generator Building.

Seismic structural response analysis, especially when involving Soil-Structure Interaction (SSI), can be one of the largest sources of unintended conservatism in seismic risk assessment. For the subject site, the relatively high re-evaluated seismic hazard combined with challenging and influential site geotechnical characteristics, especially deep embedment in soft soils with multiple structures in close proximity to each other, presented an opportunity where refinement could pay large dividends on demonstrating risk reduction. For these reasons, detailed probabilistic SSI analysis was performed for the Reactor Building complex structures using an integrated 3D Finite Element (FE) model and considering soil embedment and structure-soil-structure interaction (SSSI) effects.

Probabilistic SSI analysis for the subject site involved four major steps: (1) development of median-centered structural 3D FE and SSI models; (2) development of a suite of earthquake ground motions and randomization of soil and structure model properties; (3) SSI analysis with comparative, confirmatory, and sensitivity studies/assessments; and (4) results post-processing to quantify local seismic demands, especially in-structure response spectra (ISRS). The focus of the presentation is on development of the median-centered SSI models and the treatment of variability in the soil and structure model properties for probabilistic analysis. Thirty probabilistic SSI analyses were performed for the combined Reactor Building complex using the software SC-SASSI, which allows for efficient probabilistic analysis of large SSI models through the use of high performance computing. It is demonstrated that detailed probabilistic SSI analysis is a feasible alternative to traditional deterministic analysis, even when considering the combination of key challenges involving embedment, soft soils, high-frequency hazard, and coupled buildings.