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Grantee: Auburn University

Title of Grant: Development of a Soil-Structure-Interaction Framework in Support to Enhance Regulatory Oversight for Small Modular Reactors

Period of Performance: 9/27/2021-9/26/2024 (FY21 Notice of Funding Opportunity NOFO)

Executive Summary

Most small modular reactor (SMR) designs place the critical compartments (e.g., reactor containment) or the entire structure below ground level. This structural layout is advantageous in protecting compartments with critical equipment from natural and man-made external hazards. However, partially or fully burying these structures cause uncertainties related to the performance against earthquakes, where soil-structure-interaction (SSI) and interface behavior are expected to have a significant impact on the structural response; including changes in the energy dissipation, calculated seismic demands, and in-structure response spectra. In order to address some of these uncertainties associated with the performance of new generation SMR designs under seismic loading, this research will aim to develop a framework for conducting nonlinear soil-structure interaction (NLSSI) studies on idealized SMR structures using time-domain finite element models validated against both experimental and field data. The developed NLSSI analysis framework will be applicable for a wide range of structural layout and surface material types by reflecting generic structural attributes of SMRs that are under development. The project will also bridge the gap in large-scale SSI experiments for other researchers to validate their numerical models in the future. The overall goal of this project will be to highlight the importance of SSI on the seismic response of SMR designs while accounting for their distinct features in a generic manner and providing technical basis for improved regulatory oversight for enhanced safety. The experimental data and the modeling framework will be seminal in guiding vendors and researchers to conduct investigations for specific combinations of structure-soil conditions.

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Presentations and Publications

The list of publications was submitted with the final report after grant expiration.

- “Soil-Structure-Interaction Testing and Analysis of Partially Buried Structures for SMR Applications”, Sener K., Montgomery J., Varma A. 12th National Conference in

*Earthquake Engineering, Earthquake Engineering Research Institute, Salt Lake City, UT.
June 2022*

- *“Large Scale Soil-Structure-Interaction Testing of Partially Buried Structures”, Sener K., Montgomery J., Varma A. 26th Structural Mechanics in Reactor Technology Conference (SMiRT26), Berlin, Germany, July 2022.*
- *“Development of a Large Direct Shear Testing Box for Simple Direct and Interface Shear Testing.” McLeod J.*, Montgomery J., Hurley B.K.*, Sener, K.C., Geotechnical Testing Journal, ASTM. (under review, submitted in December 2024)*
- *“Large-scale experiments to evaluate soil-structure-interaction effects for embedded structures” Hurley B.K., McLeod J., Montgomery J., Sener K.C. Geotechnical Frontiers 2025, Louisville, KY March 2-5, 2025 (abstract submitted, awaiting acceptance)*
- *“Lateral Load Behavior of Partially Buried Large-Diameter Caisson under Different Over-Surcharge and Saturation Conditions”, Hurley B.K., McLeod J., Montgomery J., Sener K.C. Nuclear Engineering Design, Toronto, Canada, July 2025. (under review, submitted in February 2025)*

Patents

N/A