Evaluating Soil-Structure Interaction Effects in Seismic Risk Assessment for Spent Fuel Storage Systems

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This presentation focuses on the development and verification of the domain reduction method (DRM) model (Bielak et al., 2003) for dynamic soil-structure interaction (SSI) analysis of dry storage casks (DSCs) to provide insights into how near-field motions may affect their response. To this end, the responses of the DSC under a three-dimensional (3D) earthquake field, taking SSI effects into account, are evaluated. To reduce computational costs, the DRM model is employed to couple the results of physics-based earthquake simulations with the near-field model in LS-DYNA, including the DSC and the surrounding soil. We used SW4 (Sjogreen and Petersson, 2012) to perform earthquake simulations and LS-DYNA to model the soil-cask system.

Verification tests were conducted to assess the accuracy of the DRM model in LS-DYNA software. In the first step, a geophysical model representing the earthquake source and path effects is developed and analyzed using SW4. In the second step, a small section of the SW4 model is selected and simulated in LS-DYNA. A Python script is used to extract the input motions from the SW4 model and apply them to the LS-DYNA model at the DRM layer. These analyses show that the DRM model can successfully replicate the results obtained from SW4, indicating the effectiveness of this approach in both near- and far-field scenarios for layered soil. In the subsequent phase of the analysis, accelerations obtained from 1 km and 25 km away from the fault are implemented and applied as DRM forces and as free-field motions at the base of the concrete pad. Then, the responses of the DSC to earthquake-induced forces are assessed to evaluate the seismic performance and structural behavior under realistic seismic conditions with and without SSI effects.

Bielak, J., Loukakis, K., Hisada, Y., Yoshimura, C., 2003. Domain reduction method for three-dimensional earthquake modeling in localized regions, part i: Theory. Bulletin of the Seismological Society of America 93, 817–824.

Sjogreen, B., Petersson, N.A., 2012. A fourth-order accurate finite difference scheme for the elastic wave equation in second-order formulation. Journal of Scientific Computing 52, 17–48.