# A Validated Framework for Seismic Risk Assessment of Spent Fuel Storage Facilities

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**ABSTRACT:**

Spent nuclear reactor fuel is first stored in spent pools for several years to thermally control the fuel assemblies; then assemblies are transferred to dry storage casks (DSCs) at sites known as Interim Spent Fuel Storage Installations. Most dry storage facilities are free-standing structures resting vertically or horizontally on a reinforced concrete pad and are usually licensed for short-term storage of the spent fuel. However, due to the suspension of the licensing process of the Yucca Mountain permanent nuclear waste repository, DSCs have been reevaluated as a necessary longer-term storage solution, which, in turn, has raised questions about long-term earthquake exposure and the seismic design adequacy of the DSCs at the breadth of sites in the United States. Although both numerical and shake table studies have been used to determine the seismic performance of dry storage facilities, the understanding of the long-term seismic safety of storage facilities and how real-world complexities can alter their response is limited. Previous studies did not properly investigate how the dynamic response of a cask and its instability or chaotic behavior as a free-standing body translates into stresses and strains in the internal elements. Moreover, the existing numerical studies on modeling soil-structure interaction (SSI) effects have only focused on vertically propagating waves in horizontally layered media. On the other hand, most of the previous studies were deterministic despite the existing uncertainties, limiting their applicability for risk analysis and management of dry storage facilities.

The main objective of this research program is to develop a validated numerical framework for seismic risk assessment of spent fuel storage facilities from the global cask behavior to the localized behavior of internal spent fuel assemblies. The primary tasks of the project are analysis and interpretation of the shake table testing data, numerical model development and calibration of the tested storage facilities, SSI analysis coupled with large-scale earthquake simulations, and risk analysis of the tested storage facilities. In building and validating this framework, advanced data analysis, data assimilation, and forward and inverse modeling techniques will be utilized to achieve the synergy of data analytics and computational modeling that can advance the state of knowledge and modeling capabilities. The scope of work is designed carefully to (1) determine whether the stresses and strains on all structural components of the tested storage facilities remain within allowable ranges taking the problem uncertainties into account, (2) identify the causes of large response quantities, potential damages, and global instabilities and how they impact the performance of all structural components including the spent fuel assemblies, and (3) determine whether the SSI effects can drastically impact the seismic performance of the storage facilities. Based on the outcome of the proposed research program, quantitatively supported recommendations will be provided on the need for any future shake table testing and soil box dedicated SSI testing or new computational and reduced-order modeling capabilities in realizing a reliable and predictive toolbox for seismic risk analysis of spent fuel storage facilities. The contents of such a toolbox can also advance knowledge and modeling capabilities in seismic risk analysis of other critical infrastructure.