Probabilistic Multi-Hazard Assessment of Dry Cask Structures

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Program: Used Nuclear Fuel Disposition

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ABSTRACT

There are 65,000 tons of spent nuclear fuel (SNF) in the United States (more than in any other nation), and this amount grows by 2,200 tons each year. The fuel removed from the reactor core is initially stored in spent fuel pools. Once the capacity of these pools is reached, used fuel assemblies are inserted into canisters that enclose bundles of used fuel rods to be stored in Dry Cask Storage Systems (DCSS). In the absence of a long-term nationwide storage facility, it is expected that Independent Spent Fuel Storage Installations (ISFSI) will be used in the interim, which has two main implications: the number of DCSS will increase drastically in the near future; and DCSS will be used for extended periods of time. DCSS are cylindrical structures, approximately 20 ft in height and 11 ft in diameter, with typically 2 feet of concrete shielding walls, placed on concrete pads in an upright position or can be horizontally stacked. We need to fully comprehend the long-term performance of DCSS under multiple hazards (e.g. earthquakes, tornados combined with aging effects) before relying on them for interim storage (~100 years) of used nuclear fuel. *The proposed project has two main objectives for DCSS: (1) develop a probabilistic multi-hazard assessment framework, and (2) through experimental and numerical research, perform a comprehensive assessment under combined earthquake loads and aging-induced deterioration, which will also provide data for the development and validation of the probabilistic framework.*

Earlier studies showed that material aging effects coupled with sudden events like an earthquake, can lead to potential catastrophic failures. As an example, DCSS at Dominion Virginia Power's North Anna nuclear power plant moved as much as 4.5 inches during the 2011 Virginia earthquake, demonstrating the susceptibility of these structures to seismic forces. A Nuclear Regulatory Commission (NRC) spokesperson called the dry cask movement "unexpected and unprecedented". One can ask such questions as: What kind of damage would these 100-200 ton casks have sustained due to tip-over had they been aging for 50 or 300 years? In the case of extreme events, it is important to take into account the state of the cask at the time of the event in order to judge the potential failures due to external loads.

In light of the danger associated with multiple hazards, a probabilistic study on the performance of casks of different ages under a combination of earthquakes or other extreme events is deemed necessary. Earlier research studies on seismic behavior of DCSS did not systematically consider the risk associated with the variability in ground motion records and material behavior. A multi-hazard analysis that takes into account the effect of aging and corrosion when analyzing the impact of seismic events has not been conducted for DCSS; nor has the uncertainty in their performance been quantified. This study will complement ongoing work under NEUP to characterize material properties of components of DCSS over time and under severe load scenarios.