Seismic Performance Reassessment of a Critical Nuclear Facility

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This presentation presents the overall approach of a seismic performance reassessment conducted on a mission critical nuclear facility. The presentation summarizes the key features of the framework for the performance reassessment, which includes capturing nonlinear response at multiple hazard levels and the consideration of realistic ground motions.

Since circa 1990, the U.S. Department of Energy (DOE) has adopted a performance goal based design philosophy for managing the seismic risk to their inventory of plants. Specifically, DOE utilizes design and analysis guidelines which control the level of conservatism in design such that the effects of natural phenomena hazards (including earthquakes) are treated on a consistent and uniform basis. This is accomplished via concepts of usage categories and performance goals: usage categories assigned to structures as a function of their consequence of failure, and performance goals being numerical targets such as acceptable annual probability of failure selected on a graded scale. The performance goal concept is currently maintained in the current version of DOE-STD-1020-2016, "Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities."

Although it is relatively straightforward to implement a performance based philosophy for new facilities, by establishing a design basis and specifying minimum margins of safety necessary to achieve the desired target performance goals, evaluation of existing facilities requires additional complexity. For many existing older facilities, estimates of the seismic hazard has changed, and many times has increased, whereas the physical construction and seismic behavior of the facility has not. The challenge for existing facilities is then to compute the performance achieved given conditions significantly different than facility design criteria. This has been done frequently using probabilistic risk approaches wherein the seismic fragility of a structure system or component is derived based on a response analysis of the structure to a given design-level or review-level ground motion. The risk assessment approach then inherently assumes linear response of the structure for other ground motion levels. This may be unnecessarily conservative for robust structures and/or when beneficial response nonlinearities exist, wherein functional performance is maintained for much larger ground motions than was analyzed. These unintended conservatisms can suggest a need for costly and time-consuming structural strengthening projects.

The alternative seismic performance reassessment framework being undertaken at Los Alamos for a key critical nuclear facility addresses unintended conservatism by explicitly computing the mean probability of failure of the structure to performance at multiple ground motion hazard levels. At larger hazard levels the nonlinear response of the soil and the structure are realistically captured, including uncertainty, and these effects are reflected in the resulting seismic fragility. It is suggested that this new paradigm is appropriate and promising for critical facilities to obtain a more accurate calculation of seismic performance. The framework for the project is presented in detail so that other projects wanting to undertake new seismic risk assessments may learn from lessons on this project.