Nuclear Power Reactor Seismic Siting Methodology

Mory DIANÉ[1], Alex RENNER[1], Natalie DOULGERAKIS[2]

[1] Oklo Inc., [2] SC Solutions, Inc.

Commercial nuclear power reactors are required to undergo an onerous design and licensing process prior to fabrication, construction, and operation. Both the existing licensing pathways (i.e., 10 CFR Part 50 and 10 CFR Part 52) and the proposed licensing pathway (i.e., 10 CFR Part 53) require seismic site characterization and development of ground motion response spectra (GMRS), with the only NRC-endorsed method for generating GMRS defined in Regulatory Guide (RG) 1.208. However, the site investigation, seismic source characterization, and GMRS development methods defined in RG 1.208 were inherently developed for large light water reactors and are incongruous with the risk profile of many advanced non-light water reactors. More specifically, while RG 1.208 endorses the performance-based ground motion development method defined in ASCE/SEI 43-05, it requires use of the parameters established for the most stringent seismic design category (SDC) 5.

As a performance-based approach, ASCE 43-05 offers graded seismic design criteria: "More stringent design criteria are used to achieve better seismic performance for structures, systems, and components that have more serious failure consequences." While SDC 5 may be appropriate for traditional large light water reactors, some advanced reactors contain very small hazardous inventory such that the potential unmitigated radiation dose resulting from postulated accidents meets the criteria for an SDC 2 facility according to ANS 2.26. The performance-based approach of ASCE 43-05 is illustrated in the below comparison of failure consequences and seismic performance criteria for SDC 2 and SDC 5 facilities.

SDC	Unmitigated consequence of failure	Frequency of MCE/GMRS	Annual probability of unacceptable performance
SDC 2	< 5 rem to the public [1] < 25 rem to facility worker [1]	1 in 2,500 yrs [2]	2×10^{-4} (1 in 5,000 yrs) [2]
SDC 5	> 100 rem to the public [1] > 500 rem to facility worker [1]	< 1 in 10,000 yrs [3]	1×10^{-5} (1 in 100,000 yrs) [4]

[1] ANS 2.26
[2] ASCE 7-16
[3] RG 1.208
[4] ASCE 43-05

To achieve the technology-inclusive and performance-based goals of the Nuclear Energy Innovation and Modernization Act, it is proposed to consider the seismic design and analysis approach of ASCE 43-05 for SDC 2 facilities when designing commercial reactors with equivalent or lower failure consequences. This proposed approach is consistent with the approach applied for similar Department of Energy nuclear facilities, as defined in ANS 2.26, DOE-STD-1020-2016, and ASCE 43-05. From ANS 2.26 and consistent with DOE-STD-1020-2016, and ASCE 43-05, "the risks [associated with SDC 1 and SDC 2 facilities] are dominated by damage to the facility and occupants, and it is appropriate to apply the IBC design methods." The proposed approach implements the seismic design and analysis approach of the IBC and by reference ASCE 7, providing the option to use publicly available USGS profiles for most of the United States and simplifying seismic characterization and ground motion development. A seismic siting and ground motion characterization approach, which ensures NRC key safety requirements are addressed where applicable, is proposed herein to meet the global need for the rapid deployment of clean and safe advanced reactors.