Probabilistic Floor Response Spectrum of Nonlinear Nuclear Power Plant Structure using Latin Hypercube Sampling Method

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Abstract: Latin hypercube sampling (LHS) is widely applied to estimate a probabilistic floor response spectrum (FRS) of nonlinear nuclear power plant (NPP) structure. ASCE 4-16 Standards recommend that the minimum number of simulations should be larger than 30 when using LHS. Although this recommendation is commonly used for the minimum number of the simulation, there is no theoretical background. The variability of the estimations may exist according to the number of the simulation. Stated differently, the minimum number of the simulation may be varied depending on the characteristics of the problem (i.e., problem-dependent). In this context, the required sample size of LHS method should be obtained heuristically by evaluating the convergence test. One simple way for obtaining the required sample size is to run independent sampling multiple times by increasing the number of the sample (i.e., brute-force approach). This approach may be limited when the simulator is expensive and time-consuming. To address this limitation, this study proposes a resampling method without additional simulations.

A reactor containment building structure with nonlinear shear wall behavior is considered to evaluate the feasibility of the proposed method. Three parameters related to the hysteretic behavior of the shear wall is considered. The distribution of the FRS is computed as the sample size is increased. 30 simulations are conducted for one sample size and the quantile is checked to evaluate the convergence. The resampling method is then used and feasibility is investigated. The required sample size for constructing the probabilistic FRS of nonlinear NPP structure was shown much larger than the specified in the ASCE 4 standards.

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