Uncertainties in In-Structural Response Spectra Estimated by Using Multiple Acceleration Time Histories

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We have previously identified the necessity of assessing the power spectral density (PSD) functions of the input acceleration time histories if a single set of acceleration time histories are used in seismic analysis and design of safety-related structures, systems, and components (SSCs) in nuclear power plants. For an option using multiple acceleration time histories to estimate the mean seismic responses of linear structural systems, some current practices use as few as four or five time histories without assessing their PSD functions. The premise is that when multiple time histories are used, the peaks and valleys in their PSD functions will average out, so the chance of having power deficiencies in the ensemble would be small. However, a recent PVP2010 paper by Houston, et al. indicates that with several hundreds of input time histories, the estimated in-structure response spectra (ISRS) can have a coefficient of variation (COV) as high as 70%. Given this level of large uncertainty, we raise a concern on the use of four or five time histories to achieve a stable estimate of the ISRS that is sufficiently close to the true mean ISRS.

In this presentation, we will explicitly use the ISRS COV to assess the number of input time histories required to achieve an estimate of the mean ISRS that falls in ±10% of the true mean ISRS, with a preselected confidence level. Also, for simplicity, we will only consider the uncertainties in the phase spectra of the input time histories while maintaining constant PSD functions. Of course, consideration of uncertainty in the PSD functions will only increase the ISRS COV, and will need to be explored in another study. Nonetheless, the insights gained in studying the effect of the random phase spectra can be used to evaluate the adequacy of the current practice using four or five input time histories.