

Uncertainties in In-Structural Response Spectra Due to Uncertainties in Input Motion Amplitude Spectra

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To estimate the mean seismic responses of linear structural systems, a common practice is to use multiple response-spectrum-matched input acceleration time histories to obtain stable estimates of the responses. However, in our presentation at the 2020 DOE-NRC Natural Phenomena Hazards Meeting, we demonstrated that the uncertainties in phase spectra of the input motions alone, which are considered irreducible, could result in a coefficient of variation (COV) in ISRS around 40%, with which four or five input motions in the current practice were found not able to lead to stable ISRS estimates with reasonable confidence levels. In that work, the amplitude spectra of the input time histories remained constant and their uncertainties were not considered. The uncertainties in the amplitude spectra are expected to increase the uncertainty in ISRS. For example, Reference 1 indicates that COV in ISRS can reach as high as 70% based on analyses using several hundreds of input time histories that matched to the same input response spectra.

The uncertainties in amplitude spectra can be strongly influenced by the method used for response spectrum matching, and are often not separable from those of the phase spectra. In this presentation, we will explore how one popular response spectrum matching algorithm can affect the COV in ISRS, and compare that with what is reported in Reference 1. If this algorithm produces a level of COV in ISRS equal to or greater than 70%, it further affirms the current practice of using 4 or 5 input time histories may not be sufficient to attain stable ISRS estimates. The methods in this study and Reference 1 include uncertainties in both phase spectra and amplitude spectra of the input motions.

This study intends to show that a check of power spectral density (PSD) functions is necessary even using multiple input time histories. Reference 2 reasons that because PSD checks ensure the input time histories have sufficient power over the entire frequency range of interest, the mean ISRS using 4 or 5 input time histories, although not as stable as necessarily required for reasonable levels of confidence, would tend to vary on the conservative side.

References:

1. Houston, T.W., G.E. Mertz, M.C. Costantino, and C.J. Costantino (2010). "Investigation of the Impact of Seed Record Selection on Structural Response," American Society of Mechanical Engineers Pressure Vessels and Piping Conference (PVP2010-25919), Bellevue, WA
2. Nie, J., J. Xu, V. Graizer, and D. Seber (2020). "Estimating Stable Mean Responses for Linear Structural Systems by Using a Limited Number of Acceleration Time Histories," American Society of Mechanical Engineers Pressure Vessels and Piping Conference (PVP2020-21132), Virtual, Minneapolis, MN.