Comparison of Random Vibration Theory and Time Series Seismic Site Response Analyses

PEER Lifelines Program

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Introduction

One-dimensional seismic site response analysis is used to assess the effects of ground motion on buildings and structures. In a conventional analysis, the input rock motions are specified by recorded, modified, or simulated rock motions. The input rock motions are propagated through a deterministic ground motion prediction equation to obtain motions at the ground surface.

An alternative to conventional site response analysis is a Random Vibration Theory (RVT) approach. In the RVT approach, time domain input motions are not required; rather, a single input motion is specified as a Fourier Amplitude Spectrum (FAS), the FAS is propagated through the soil column using the site response equation, and the results are used to predict peak time domain estimates of motion (e.g., peak ground acceleration, spectral acceleration) at the ground surface.

This paper presents a comparison of time series and RVT site response analysis results. Three separate suites of input ground motions were generated for the site response analyses for a hypothetical magnitude 6.5 earthquake at a site in Sutter County, CA. The first suite consisted of artificially generated motions that were randomly generated and not correlated with a specific earthquake. The second suite consisted of recorded motions selected and scaled to fit a response spectrum from a ground motion prediction equation. The third suite consisted of spectral matching the selected motions to the same response spectrum.

Electromechanical Time Series

Using the random-soil method for the mechanism, one random soil time series was generated to satisfy the FAS input spectrum. This FAS was scaled to the site index of 1.0.

Stochastic Time Series

Input motion time series was scaled to the site index of 1.0 and scaled to fit a standard response spectrum of the site. For the stochastic time series, the RVT approach was used to predict the peak response spectrum.

Spectrally Matched Time Series

Spectrally matched time series was created through spectral matching to the input motion response spectrum. The RVT approach was used to predict the spectral matched motion.

Time Series Results

Frequency Results

Equivalent Linear Results

Results

In the figures to the left, the input response spectrum, the profiles of maximum shear strain, ratio of surface response spectrum to input response spectrum, and the peak ground acceleration are shown. Additionally, the maximum horizontal peak acceleration is shown. The FAS is shown on the top row and the response spectrum is shown on the bottom row.