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Recent Developments in Response Spectrum-Based Modal Combination Rules

by

Vinay K Gupta

IIT Kanpur

The estimation of peak linear response via elastic design (response) spectra continues to form the basis of the earthquake-resistant design of structural systems in various codes of practice all over the world, and it is common to use the design pseudo spectral acceleration (PSA) spectrum characterizing the seismic hazard at the site of the structure together with a response spectrum-based modal combination rule for this purpose. Many response spectrum-based formulations of peak linear response also require the input of the spectral velocity (SV) ordinates consistent with the specified seismic hazard in order to account for modal correlations in a simple manner. To this end, SV ordinates have been conventionally approximated as pseudo spectral velocity (PSV) ordinates. However, the PSV ordinates are known to be close to the SV ordinates only over the intermediate frequency range coinciding with the velocity-sensitive region. The PSV approximation may lead to large overestimation errors when the structure is stiffer to the ground motion. Also, at long periods, PSV ordinates underestimate the SV ordinates. Due to these limitations, the use of PSV approximation for the SV ordinates has been largely avoided and alternative means involving the moments of power spectral density functions have been employed, thus increasing the complexity of the response spectrum-based modal combination rules. It is also quite uncommon to use the relative spectral acceleration (RSA) ordinates in the response spectrum-based modal combination rules, and thus little attention has been paid to the estimation of RSA ordinates consistent with the specified design PSA spectrum. These ordinates may be required in the estimation of peak floor accelerations, which are useful for ensuring the safety of rigid nonstructural components in structural systems.

This lecture focuses on the estimation of the SV and RSA ordinates directly from a design PSA spectrum. It will also be shown how the proposed approximations can be used in the response spectrum-based modal combination rules to estimate peak linear responses while avoiding the tedious calculations of spectral moments and still not ignoring any modal correlations.