Ordered Peak Response under Multicomponent Ground Motion via Modal Combination Rule and Its Correlation with Nonlinear Response
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The present earthquake-resistant design philosophy is based on the use of elastic design response spectrum and on the suitable reduction of peak linear response for dissipation of hysteretic energy during the inelastic response. In case of multi-degree-of-freedom systems, modal combination rules play an important role in obtaining the peak response in a simple manner. The modal combination rules typically used by the profession are meant just to estimate the largest response peaks as the second largest, third largest, ... peaks are assumed to play no role. With a view to correlate the structural damage in the post-yield regime with these higher order peaks, this study looks at developing a new modal combination rule for the multistoried buildings excited by multi-component ground motion. The proposed modal combination rule is developed by using the stationary random vibration theory and by making suitable approximations regarding the peak factors and nonstationarity factors. A numerical study has shown that the proposed rule performs better than the CQC3 rule in all those cases where the building is stiffer with respect to the ground motion. The level of accuracy for the higher order peaks is comparable to that for the largest peak in case of the largest 10 peaks and is reasonably good in case of the next 10 peaks. This study also proposes a functional of those higher order peaks in the linear response that exceed the yield level. This functional can be estimated directly from the response spectrum and is found to be well-correlated with the ductility demand in the case of elasto-plastic and Riddell-Newmark oscillators. It has been shown that ductility demand can indeed be estimated from the proposed functional with a period-independent parameter for the oscillators having periods greater than 0.8 sec irrespective of their type of nonlinearity.