Highway bridges provide a critical lifeline during extreme seismic events and must maintain serviceability under a large range of earthquake intensities. Consequently, the advent of more computational power has allowed more advanced analysis approaches for predicting performance and vulnerability of highway bridges under these seismic loads. In traditional two-dimensional finite element analyses, it has been demonstrated that the incidence angle of the ground motion can play a significant role in structural response. As three-dimensional nonlinear time history analyses are used more frequently in practice, ground motions are still usually applied along a single bridge axis. It is unknown how three orthogonal components of ground motion excitation should be applied to the structure to best represent the true response.

In this study, the fundamental behavior of three-dimensional ground motion was studied using single-degree-of-freedom elastic spectra. Mean spectra computed from various orientation techniques were found indistinguishable when the orthogonal components were combined. The effect of incidence angle on the nonlinear structural response of highway bridges was then investigated through extensive statistical simulation. Three different bridge models were employed for this study implementing a suite of 180 multi-component ground motion records of various magnitude-distance-soil bins. Probabilistic seismic demand models for various response parameters are presented comparing the effects of random incidence angle to that of recorded directions. Although there are instances where the angle of incidence can significantly amplify response, results indicated that incidence angle had negligible effect on average ensemble response. This is consistent with results from the spectral analysis, although existing literature has emphasized incidence angle as a significant parameter of multi-component analysis.

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The public is welcome to attend.