ROTATIONAL COMPONENTS AND THEIR IMPACTS ON STRUCTURAL SYSTEMS

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ABSTRACT

Rotational and vertical components of earthquake ground motion are almost always ignored in design or assessment of structures since current practice, which has long been established based on far-fault earthquake recordings, dictates that rotational components are small so as not to add significantly to seismic loads, and structures have sufficient over-strength against vertical motion since they have already been designed against gravitational acceleration. Despite this common perception, the databases of near-fault records reveal that vertical motion could be as twice much as horizontal and may exceed 2g level, while rotational excitation may reach few degrees in the near-fault zone. Coupling of different components of ground excitation may significantly amplify the seismic demand by introducing additional lateral forces and enhanced P-Δ effects. In this study, a governing equation of motion is postulated to compute the response of a SDOF oscillator under multi-component excitation. Expanded equation includes secondary P-Δ components associated with combined impacts of tilt and vertical excitations in addition to inertial forcing terms due to angular and translational accelerations. The elastic and inelastic spectral ordinates traditionally generated considering uni-axial input motion are compared at the end with those of multi-component response spectra of coupled horizontal, vertical and tilting motions. Possible impacts of multi-component coupling including rotational and translational components of ground motion are exemplified on the existing highway overpass. The results of this study confirm that higher ductility demand (or dynamic collapse) may ensue due to the effects of vertical and rotational motions when they are coupled with horizontal excitation. Unlike conventional spectrum, the proposed multi-component response spectrum (elastic or inelastic) is capable of capturing the enhanced seismic demands associated with multi-component coupling effects.

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