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Analytical Study of the Structural Response to Near-Field Earthquakes

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Abstract : Numerous earthquakes, which have taken place across the world, led to catastrophic damage and collapse of structures (e.g., 1971 San Fernando; 1995 Kobe-Japan; and 2010 Chile earthquakes). Engineers are constantly studying methods to moderate the effect this phenomenon has on structures to further reduce damage, costs, and ultimately to provide life safety to occupants. However, there are regions where structures, cities, or water reservoirs are built near fault lines. When an earthquake occurs near the fault lines, they can be categorized as near-field earthquakes. In contrary, a far-field earthquake occurs when the region is further away from the seismic source. A near-field earthquake generally has a higher initial peak resulting in a larger seismic response, when compared to a far-field earthquake ground motion. These larger responses may result in serious consequences in terms of structural damage which can result in a high risk for the public's safety. Unfortunately, the response of structures subjected to near-field records are not properly reflected in the current building design specifications. For example, in ASCE 7-10, the design response spectrum is mostly based on the far-field design-level earthquakes. This may result in the catastrophic damage of structures that are not properly designed for near-field earthquakes. This research investigates the knowledge that the effect of near-field earthquakes has on the response of structures. To fully examine this topic, a structure was designed following the current seismic building design specifications, e.g. ASCE 7-10 and ACI 318-14, being analytically modeled, utilizing the SAP2000 software. Next, utilizing the FEMA P695 report, several near-field and far-field earthquakes were selected, and the near-field earthquake records were scaled to represent the design-level ground motions. Upon doing this, the prototype structural model, created using SAP2000, was subjected to the scaled ground motions. A Linear Time History Analysis and Pushover analysis were conducted on SAP2000 for evaluation of the structural seismic responses. On average, the structure experienced an 8% and 1% increase in story drift and absolute acceleration, respectively, when subjected to the near-field earthquake ground motions. The pushover analysis was ran to find and aid in properly defining the hinge formation in the structure when conducting the nonlinear time history analysis. A near-field ground motion is characterized by a high-energy pulse, making it unique to other earthquake ground motions. Therefore, pulse extraction methods were used in this research to estimate the maximum response of structures subjected to near-field motions. The results will be utilized in the generation of a design spectrum for the estimation of design forces for buildings subjected to NF ground motions.

Keywords : near-field, pulse, pushover, time-history
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