Evaluation of constant ductility displacement response spectra for near-fault ground motions of the 1999 Chi-Chi earthquake, Taiwan

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This study evaluates the constant ductility displacement response spectra (CDDRS) for near-fault ground motions (NFGMs) of the 1999 Chi-Chi earthquake in Taiwan. The complex source mechanism was mainly caused by a rupture on the Chelungpu fault that spanned about 100 km. A dataset of 63 NFGM records was considered to understand the effects of CDDRS due to hanging wall, foot wall and directivity effects. CDDRS were generated using SeismoSignal tool for the selected ground motions. Significant variation was observed in both elastic and inelastic CDDRS for tall buildings due to the hanging wall effect. In addition, variations in the inelastic spectra were found to be more prominent due to the backward directivity effect. Moreover, the inelastic displacement spectral values for pulse-like ground motions were much higher than those associated with non-pulse ground motions.

Keywords: Constant ductility response spectra, earthquakes, forward and backward rupture, near-fault ground motions, seismic hazard.

earthquake. Severe damage occurred to structures along the length of the fault during the earthquake. The Chelungpu fault trace passed beneath a building in Wufeng, Taiwan (Figure 1). This rupture produced a vertical displacement of about 2 m through the building. The building was severely damaged due to the differential movement of the fault trace. Another spectacular structural failure was the famous Shihkang dam, which was directly uplifted by the fault trace[6]. It was offset by approximately 10 m near its right abutment, primarily due to the dip–slip fault rupture.

In recent years, displacement-based seismic design has been increasingly implemented compared to the traditional lateral forces design. The constant ductility displacement response spectra (CDDRS) play a crucial role in the evaluation of the preliminary design of new structures. Several researchers have examined the influence of ductility requirements for engineering structures under earthquakes[7–11]. Freeman[8] originally developed the capacity spectrum method (CSM) in the 1970s. Later, Newmark and Riddle[10] presented the idea of an inelastic response spectrum based on