COMPARATIVE STUDY ON MULTISCALE NONLINEAR DYNAMIC ANALYSES OF RC SHEAR WALL BUILDINGS

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ABSTRACT

Reinforced concrete shear wall (RCSW) systems have served as a robust earthquake-resistance mechanism, and been widely used in a large portion of buildings and infrastructure. However, recent extreme earthquakes in Japan and Chile raised significant questions regarding unexpected dynamic behavior and failure mechanisms. In hopes of finding the clues behind the “unexpected” dynamic responses, this research performs a novel "multiscale" dynamic analysis of a typical pre-1980 RCSW building, and compares the responses against those from practical "macroscopic" analyses. Here, "macroscopic analysis" means a dynamic analysis using multi-linear wall models while “multiscale analysis” means a novel analysis that links millimeter length scale's microphysical damage phenomena (e.g., multidirectional cracks, nonlinear shear over cracked surfaces, steel bars' progressive buckling, etc.) to the building-level nonlinear dynamic responses. Results show that the nonlinear dynamic responses from the macroscopic analysis tend to substantially deviate from those of the multiscale analysis from early inelastic regime. Multiscale analysis predicts that building-level dynamic damage occurs in “unexpected” directions and complex patterns. Physical rationales obtained are twofold: (1) multidirectional damage within a complex RCSW system engenders "premature" development of inelasticity in an unexpected direction; (2) The path-dependence of nonlinear responses of RCSW becomes aggravated as more microscopic mechanisms are incorporated. This implies that when exposed to extreme excitations, complex RCSWs and the entire building tend to experience severe damage in "unexpected" locations and directions. Results call for more inclusion of microphysical mechanisms into building-level dynamic analyses as well as further experiments with realistic irregular loading directions and magnitudes.

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