Ph.D. THESIS DEFENSE ANNOUNCEMENT

NONLINEAR FINITE ELEMENT ANALYSIS OF REINFORCED CONCRETE EXTERIOR BEAM-COLUMN JOINTS WITH NONSEISMIC DETAILING

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Abstract:

This research investigated the behavior of nonseismically detailed reinforced concrete exterior beam-column joints subjected to bidirectional lateral cyclic loading using nonlinear finite element analysis (NLFEA).

Beam-column joints constitute a critical component in the load path of reinforced concrete buildings due to their fundamental role in integrating the overall structural system. Earthquake reconnaissance reports reveal that failure of joints has contributed to partial or complete collapse of reinforced concrete buildings designed without consideration for large lateral loads, resulting in significant economic impact and loss of life. Such infrastructure exists throughout seismically active regions worldwide, and the large-scale risk associated with such deficiencies is not fully known. Computational strategies provide a useful complement to the existing experimental literature on joint behavior and are needed to more fully characterize the failure processes in seismically deficient beam-column joints subjected to realistic failure conditions.

The first part of this research focused on identification and validation of a constitutive modeling strategy capable of simulating the behaviors known to dominate failure of beam-column joints under cyclic lateral load using NLFEA. A rotating smeared crack concrete constitutive model--together with a reinforcing bar plasticity model and nonlinear bond-slip formulation--was systematically validated against experimental data. Parametric studies were conducted to determine the sensitivity of the response to various material properties. This prototype model was then used to simulate the cyclic response of four seismically deficient beam-column joints which had been previously evaluated experimentally. The simulated joints included: a one-way exterior joint, a two-way beam-column exterior corner joint, and a series of two-way beam-column-slab exterior corner joints with varying degrees of seismic vulnerability. The two-way corner joint specimens were evaluated under simultaneous cyclic bidirectional lateral and cyclic column axial loading. For each specimen, the ability of the prototype model to capture the strength, stiffness degradation, energy dissipation, joint shear strength, and progressive failure mechanisms (e.g. cracking) was demonstrated. The successes and limitations of the prototype model were systematically evaluated.