ABSTRACT

Coupled Composite Plate Shear Walls / Concrete Filled (CC-PSW/CFs) are being employed as a seismic lateral force resisting system for the design and construction of mid- to high-rise buildings around the world. The coupled system consists of two or more Composite Plate Shear Walls – Concrete Filled (C-PSW/CFs) connected to each other using composite coupling beams located at the story heights. The CC-PSW/CF system can provide higher overturning moment capacity, lateral stiffness, and ductility than uncoupled walls. Concrete-filled steel box sections are typically used for the composite coupling beams, which are designed to be flexure critical members. When the CC-PSW/CF system is subjected to lateral seismic forces, plastic hinge formation and inelastic deformations (energy dissipation) occur near the ends of most of coupling beams along the structure's height, followed by flexural hinging of the C-PSW/CFs, typically at the base.

This work presents the details and design of four composite coupling beam-to-C-PSW/CF connection configurations. Six scaled connection specimens, representing the four connection configurations, with beam clear span-to-section depth, L_b/d, ratios of 3.5 and 5.1, were designed, fabricated, and tested. The experimental program focused on the force-displacement and moment-rotation responses, behavioral observations, limit states, and flexural capacities of the tested specimens. Major limit states and events included yielding of the steel plates comprising the coupling beam, followed by local inelastic buckling, fracture initiation in the base metal (near the weld toes) in the connection region, and fracture propagation through the beam flange and web plates leading to loss of flexural strength and failure. All specimens developed and exceeded the capacity and chord rotation requirements, in accordance with ANSI/AISC 341-22 guidelines.

Detailed nonlinear 3D finite element models of the tested specimens were developed and verified using experimental results. The 3D finite element models accurately simulate the stiffness, flexural capacities, and monotonic responses of tested specimens. Nonlinear fiber-based models of the tested coupling beam-to-C-PSW/CF specimens were developed and verified using experimental results. The nonlinear fiber-based models can accurately simulate the stiffness, flexural capacities, and cyclic responses of tested specimens. The benchmarked fiber models were used to estimate the moment-rotation response of full-scale archetype connections.