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ABSTRACT

Coupled RC Walls with Unbonded Post-Tensioned Precast Coupling Beams: Analytical Evaluation of Lateral Load Behavior

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The results from eight half-scale experiments of floor-level RC coupled wall subassemblies with unbonded post-tensioned precast concrete coupling beams are used to develop and validate an analytical subassembly model. The validated subassembly model is then used to develop models of multi-story coupled walls with unbonded post-tensioned precast coupling beams. As shown in Fig. 1, the lateral resistance of this new type of coupled wall system is achieved by post-tensioning precast concrete beams to the wall piers at each floor and roof level. Steel top and seat angles are used at the beam-to-wall connections to yield and provide energy dissipation during a large earthquake. The post-tensioning force is provided by a multi-strand tendon that runs through the center of each beam and the wall piers. The post-tensioning tendons are placed inside ungrouted ducts and are anchored to the structure only at the outer ends of the wall piers. Thus, the post-tensioning steel is intentionally not bonded to the concrete over its length.

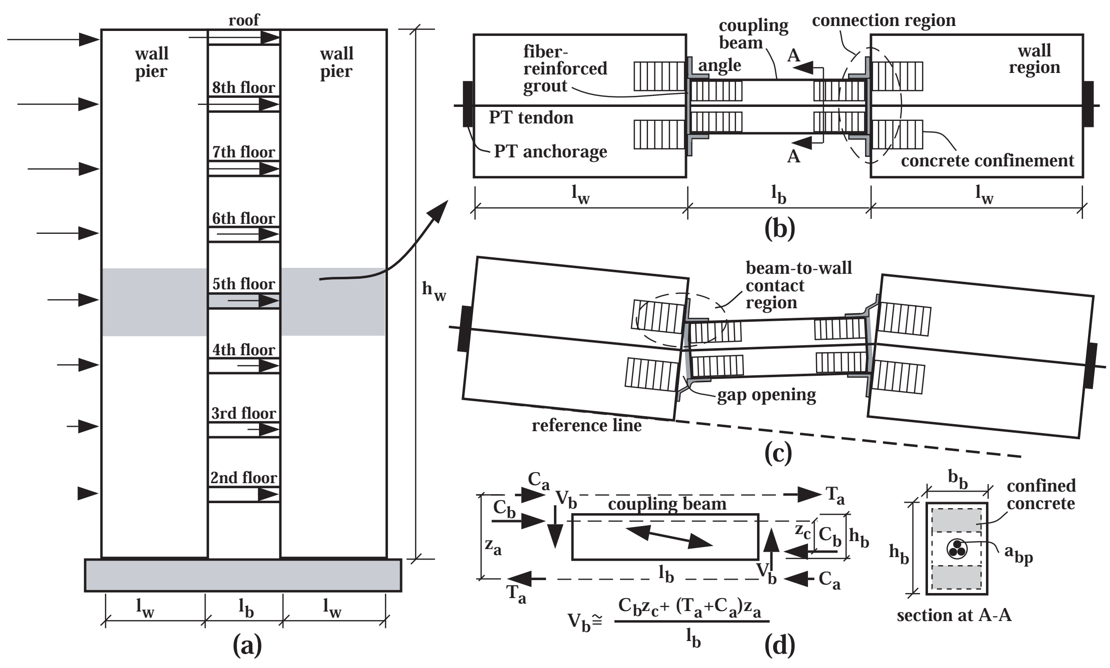

Fig. 1: Coupled wall system: (a) multi-story structure; (b) floor-level subassembly; (c) idealized exaggerated displaced shape; and (d) coupling forces.

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The multi-story analytical model is used to conduct a parametric investigation on the lateral load behavior of unbonded post-tensioned coupled walls. For this purpose, static analyses of a series of wall structures are conducted under monotonic and cyclic lateral loads. The effects of the following design parameters on the lateral stiffness, strength, ductility capacity, and hysteretic characteristics of the walls are investigated: (1) wall pier length; (2) wall pier thickness; (3) coupling beam length; (4) coupling beam depth; (5) coupling beam thickness; (6) top and seat angle strength; (7) coupling beam post-tensioning area; (8) initial stress in the post-tensioning steel; and (9) wall pier reinforcement area. Coupled wall systems with 8 and 14 stories, as well as uncoupled walls, are included in the investigation. In addition, wall piers with monolithic cast-in-place reinforcement details as well as with precast concrete details are considered to allow for a more comprehensive comparative investigation.

The results from the parametric analyses are used to identify important limit states for unbonded post-tensioned coupled wall structures and develop seismic design recommendations to control the expected behavior of the system under lateral loads. For example, the effect of the beam post-tensioning steel area on the lateral strength of the coupled wall system is quantified. It is shown that unbonded post-tensioned precast coupling beams having lateral stiffness and strength similar to monolithic cast-in-place RC coupling beams can be designed to provide stable levels of coupling between concrete walls with reduced damage in the coupling beams and in the regions of the walls near the beams. As compared with monolithic cast-in-place coupling beams, post-tensioned beams provide a significant restoring force to the entire structure, reducing the residual lateral displacements upon unloading from a nonlinear displacement and resulting in a large self-centering capability.