Abstract

Concrete filled composite plate shear walls (C-PSW/CF) effectively combine the advantages of steel construction with concrete material to result in a composite wall system that has excellent structural performance and efficient constructability. The performance and adoption of these walls in commercial construction are influenced by their connections, including wall to base and wall to wall connections. Although traditional connection techniques are structurally efficient, they present constructability challenges. To address these limitations, this study evaluated cost-effective and constructible alternatives. Specifically, non-contact lap-splice connections were investigated for wall-to-base connections and bolted splice connections were developed for wall-to-wall connections.

Large scale specimens using non-contact dowel bar lap splice connections were designed and detailed using prior recommendations on embedment length, arrangement of dowel bars, and interfacial shear strength. Three specimens with varying connection details were designed, constructed, and tested to failure. A cyclic loading protocol representative of wind and seismic loading was used. The specimens had linear elastic response during the elastic wind cycles and minimal loss in stiffness during the inelastic wind cycles. During the seismic cycles, the specimens exhibited significant ductility before failure which occurred due to tensile rupture of dowel rebars. Finite element models developed and validated using experimental results indicated extensive yielding of the dowel rebars prior to failure. Experimental and numerical results were used to develop design recommendations and methods to estimate the flexural stiffness, flexural capacity and shear capacity of wall-to-base connections.

Novel bolted splice connection techniques were proposed and evaluated. Empty module specimens incorporating splice connections were designed and tested to verify the connection techniques and assess the shear behavior of individual fasteners. The specimens exhibited a predictable response both in terms of capacities and failure modes. Two techniques were selected to design large-scale specimens which were tested under monotonic lateral and cyclic lateral loading. A wind and seismic loading protocol was used to apply the cyclic loading. The large-scale tests indicated that response of the bolted splice response was primarily governed by fasteners - their shear strength and shear-deformation relationship. The moment-rotation (M-θ) response of the splice was linear elastic until flexural cracking of the concrete infill occurred in the composite section at M_{cr}, followed by an almost parabolic relationship up to its ultimate moment capacity (M_u). Failure occurred due to shear fracture of the fasteners in the flexure induced tension region of the splice. Finite element models were developed and used to gain additional insights into behavior. The models showed excellent agreement with experimental results and can be used for future parametric studies. The experimental and numerical results were used to develop and verify design methods for estimating the moment capacity and ultimate rotation of bolted splice connection: (i) the instantaneous center of rotation method (ICM), and (ii) a less accurate but simpler method (SM). The effects of the connection flexibility on the lateral stiffness of the overall C-PSW/CF wall system were evaluated, and design recommendations were proposed to limit reductions in system lateral stiffness.