ABSTRACT

Composite Plate Shear Wall/ Concrete Filled (C-PSW/CF), also referred to as SpeedCore walls, are being used as innovative shear wall commercial high-rise buildings. These walls offer advantages such as modularity and construction schedule contraction. The cross-section of C-PSWs/CF consists of concrete-infill sandwiched between the steel faceplates, where the steel plates are tied together by steel tie bars. Elevated temperatures will result in a deterioration in the mechanical properties of steel and concrete during a fire event in buildings. Such degradation can lead to stability-related failure of structural components. Composite floors are connected to these walls through simple shear connections. The floor-to-wall connections will be exposed to elevated temperatures, which may result in connection failure and progressive collapse of structures.

Designing SpeedCore walls without fire protection raises concerns regarding the performance of other structural components connected to SpeedCore walls under fire loading including composite floor systems and wall-to-floor connections. Numerical studies conducted on the connections and the floor systems indicated that these structural components undergo thermal compression forces during heating and tensile forces during the cooling phases of a fire event. The goal of this research was to develop an approach for performance-based fire resistance design of complete floor systems consisting of SpeedCore walls, composite floor slabs, and wall-to-floor connections.

This research includes experimental and numerical analyses to gain insight into the behavior of the floor-to-SpeedCore wall connections under fire and gravity loading. The specimens included steel beams connected to SpeedCore walls through simple shear connections. Three types of floor-to-wall connections were tested including connections with through-plate, reinforcing plate, and unreinforced plate. The parameters considered in the test matrix included: connection type, temperature, loading angle, and loading direction. These parameters in the test matrix were based on results obtained from previous numerical and experimental studies in the literature. The experimental results can fill the existing knowledge gap on floor-to-wall connections for steel-concrete composite members, develop design recommendations, and benchmark numerical models.

Numerical models were developed to simulate the behavior of the connections (member level) and whole structures (structure level) at ambient and elevated temperatures. Finite Element (FE) analysis and Component-based Models (CB) were utilized to develop the numerical models. The developed models were benchmarked by comparing the obtained numerical results with experimental data reported in the literature. FE models have been validated at two different levels, namely member level, and system level. The performance of the designed connection for the archetype structures was studied using benchmarked FE and CB models. The behavior of various wall-to-floor connections with different steel plate (C-PSW/CF) detailing was investigated.

Benchmarked numerical models were used to perform a parametric study to evaluate the performance of these connections. UP connection detail was used to perform the study due to its promising experimental performance, which does not need any special detail or plate reinforcement. The study was performed by evaluating the effects of critical parameters on the connection behavior namely, bolt size, target temperature, loading angles, and loading direction.