FUNDAMENTAL BEHAVIOR OF COMPOSITE AXIAL MEMBERS UNDER FIRE LOADING

ABSTRACT

Composite axial members [Concrete-filled Steel Tube (CFT) columns and Composite-Plate Shear Walls (C-PSWs)] may be subjected to a combination of loading conditions, such as gravity, wind, seismic or fire. Under fire loading, the member would experience degradation of material properties and non-uniform temperature distribution through the cross-section. A time-temperature study is necessary to determine the member capacity and stability under fire loading.

This thesis presents (a) the development and validation of a 2D fiber-based numerical analysis tool for modeling composite axial members under fire loading and (b) the results of benchmarked numerical studies conducted on composite axial members (CFTs and C-PSWs). The studies involved simulating fire conditions by exposing steel faceplates to elevated temperatures (ASTM E119 Time-Temperature Curve) while maintaining a constant axial load. The fiber model was benchmarked using experimental results and further validated with benchmarked Finite Element (FE) models.

The parametric study on CFTs involved analyzing the effect column slenderness, column aspect ratio, section slenderness, and material properties on the behavior of columns at elevated temperatures. Section slenderness and concrete strength were seen to have a significant effect on column capacity, while aspect ratio and steel yield strength had a minor influence. A layer of fire protection was modeled to understand its effect on stability (failure time and critical load). It was observed that a layer of fire protection delayed the time to failure (Fire Rating) but caused the member to fail at marginally lower axial loads. The parametric study results are used to develop equations for calculating the compression strength of CFTs at elevated temperatures.

The studies on CPSWs involved modeling the walls using two methods, which are analyzing the entire wall section and analyzing a strip of the wall section. Results from both methods are compared with finite-element and experimental data and proposed equations for axial capacity are validated. One-sided heating of walls is also explored and validated.