ABSTRACT

Hong, Sangdo Ph.D., Purdue University, May 2007. Fundamental Behavior and Stability of Concrete Filled Steel Tube (CFT) Members Under Fire Loading. Major Professor: Amit H. Varma.

This dissertation presents: (a) experimental and analytical research of the fundamental force-deformation-temperature (F-δ-T) behavior of concrete filled steel (CFT) members under elevated temperatures from fire loading, and (b) its use to investigate the stability (inelastic buckling) of CFT columns under standard fire loading.

The experimental investigations were conducted using an innovative experimental technique to determine the moment-curvature (M-ϕ) behavior of CFT beam-columns subjected to combined axial, flexural, and thermal loading. The testing technique involved the use of radiation-based heating and control units and digital imaging systems to measure deformations at elevated temperatures. The parameters considered in the experimental investigations were the axial load level, the concrete strength, the steel tube width and b/t ratio, and the duration of heating. Thirteen CFT beam-columns specimens were tested, and the experimental results included the M-ϕ-T responses of the plastic hinge regions.

The analytical investigations focused on the development and verification of 3D finite element models and fiber-based section models for predicting the M-ϕ-T behavior of the tested CFT beam-column specimens. The 3D finite element models accounted for the effects of various complexities of behavior, namely: (i) temperature-dependent thermal properties and constitutive models, (ii) global and local geometric imperfections and nonlinearity, and (iii) composite interaction and local buckling. The fiber-based models used similar temperature-dependent constitutive models. The fiber models were for the section only, i.e. the length effects were not involved. The predictions from the 3D finite element analyses and the fiber analyses compared favorably with the experimental M-ϕ-T measurements. A combined Poh-Lie constitutive model for steel was recommended for these analytical investigations.

A simple analytical approach was developed to investigate the overall stability (inelastic buckling) behavior of CFT columns under fire loading using the fundamental section F-δ-T behavior. This approach was developed by modifying Newmark's method for inelastic column buckling analysis to include: (a) the effects of elevated temperatures,

and (b) temperature-dependent section M-ϕ behavior using fiber models of the sections at the station points. The analytical approach was used to predict the standard fire behavior and stability of several CFT columns tested by researchers around the world. The analytical predictions were verified by comparing with: (a) experimental results, and (b) analytical results (displacement-time and stress states) predicted using 3D finite element models. The comparisons indicated that the simple analytical approach could predict reasonably the standard fire behavior of CFT columns.

The experimental approach for determining the fundamental behavior of structural members under fire loading is recommended for future research. The fiber-based section models for predicting the fundamental behavior of members under fire loading is also recommended for future development of modeling techniques. The simple analytical approach for predicting column stability under fire loading is recommended for future research focusing on the effects of various loading, restraint, and fire parameters on column inelastic behavior and stability under standard or realistic fire loading.