Author: Abdullah Alghossoon

Title: Analysis And Design Of High-Strength Steel And Composite Members

Committee Chair: Professor Amit Varma

The increasing desire to adopt high-strength materials in building structures is driven by perceived economic benefits and architectural demands of using lighter-weight members. In general, the adoption of new materials in the construction industry has occurred at a slow pace as compared to the automotive or aerospace industries due to the constraints placed in design codes and standards. Limited experimental and numerical research have been conducted on the use of high-strength steel and concrete materials in steel and composite structural members and systems due to the constraints placed by the AISC 360 Specification.

The AISC 360-16 Specifications limits the use of steel and concrete materials in filled composite members to concrete strength (f'_c) less than or equal to 10 ksi and steel yield strength (F_y) less than or equal 75 ksi. In addition, experimental results on the high-strength steel beams' behavior are somewhat inconsistent, requiring further investigations. The current design equations of the filled composite members are based on experimental tests conducted on short members with conventional material strengths. Recent experimental and numerical studies have demonstrated reductions in the axial-moment (P-M) interaction strength as the member slenderness increases. The new high-strength steels have different stress-strain characteristics than conventional steel, making the current design equations and limiting section slenderness ratios questionable. Prior experimental research has also concluded the need for new slenderness limitations for high-strength steel beams.

This dissertation directly addresses these limitations and summarizes the results of numerical parametric studies conducted to evaluate the behavior and design of rectangular filled composite members and steel beams made from high-strength materials. The research builds upon prior studies by using their recommended effective stress-strain relationships for the high-strength steel tube and concrete infill while conducting parametric studies. These phenomenological stress-strain relationships implicitly accounted for the effects of local buckling, yielding, concrete confinement, and crushing failure. The dissertation proposes simplified and accurate

stress blocks and design equations for high-strength CFT members to be used in everyday practice. A phenomenological effective stress-strain relationship is proposed for the high-strength steel beams, which serves as a starting point for extensive parametric studies on the behavior and design of high-strength steel beams.

The numerical models developed and benchmarked in this dissertation for: (a) high strength rectangular CFT beam-columns, and (b) high strength steel beams will be used in the future to conduct comprehensive investigations on the behavior of structural frames designed using these elements. The eventual goal will be to enable the use of these high-strength elements in the design of high-rise buildings governed by wind or seismic loading combinations.