Ain Shams University
Faculty of Engineering

Behavior of High-Strength Concrete Filled Steel Tubes for Long Columns

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STATEMENT

This thesis is submitted to Ain Shams University in partial fulfillment of the requirements for the degree of Master of Science in Structural Engineering.

The work included was carried out by the author at Reinforced Concrete Laboratory of the Faculty of Engineering, Ain Shams University.

No part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

TITLE: "Behavior of High-Strength Concrete Filled Steel Tubes for Long Columns"

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Composite columns consisting of concrete-filled steel tubes have become increasingly popular in structural applications around the world. Today's possibility to produce concrete with higher compressive strength allows the design of more slender columns, which leads to greater profits. It is of great practical and economic interest not to have any mechanical shear connectors at the interface between the concrete core and the steel tube, and no additional reinforcement in the concrete core besides the surrounding steel tube. By using composite columns consisting of concrete-filled steel tubes instead of traditional reinforced concrete columns the problem of concrete cover spalling can be avoided. Furthermore, inward buckling of the steel tube is prevented by the concrete core, thus increasing the stability and the strength of the column as a system. The structural behaviour of short concrete filled steel tube system and the beneficial effect of confinement has been investigated by many researchers over the past decades. It was of interest to investigate the structural behaviour of concrete filled tubes for columns with higher slenderness ratios.

The research program included in this thesis evaluates the structural performance of concrete filled steel tubes as long columns. The main variables in the study were to investigate how the structural behavior of the column was affected by: the filling concrete strength, the steel tube thickness,

adding reinforcing steel bars and applying initial load eccentricity. In order to achieve this, experiments and non-linear finite element analyses were used in combination. A total of sixteen columns were tested up to failure under static loading conditions. The tested concrete filled steel tubes were compared to traditional reinforced concrete columns.

The analytical program considered in this study includes performing nonlinear finite element models using ABAQUS v6.7 program. These models are performed to simulate the columns behaviour and to extend study of the behaviour of such columns. The FE results were compared to those obtained from the experiments and the results agreed in a satisfactory way. Also an extended study was held using the program to extend understanding of the effect of column slenderness ratio on achieving the beneficial effect of confinement in composite columns. The effect of slenderness ratio on the column ultimate capacity is investigated as well. Comparison between the ultimate column capacities obtained from the finite element program and those calculated using Euro code 4 and AISC LRFD specifications is also introduced.

Research findings indicate that for all tested CFST columns the load bearing capacities were guided by the combined effect of the column's lateral deflection and the compression yielding of the outer steel tube with signs of tube local buckling. The additional moment due to high slenderness played an effective role in accelerating the column failure and affected in general the column response. In general utilizing CFST system enhances the column ultimate strength and ductility as compared to traditional reinforced concrete columns. Utilizing high strength concrete in combination with CFST system enhances the column stiffness in the elastic zone and increase column

strength. The extended study results showed that the column strength enhancement provided by confinement effect is better achieved in short columns rather than long columns. Strength enhancement in normal strength concrete is higher than high strength concrete. Increasing column slenderness ratio reduces column ultimate capacity significantly. The implemented design codes were found to be conservative in calculating the ultimate column strengths in most cases.

Keyword: Composite columns, High-strength concrete, nonlinear finite element models, Confinement effect.

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