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Faculty of Engineering
Department of Structural Engineering

Behavior of RC Columns with Different Tie Configurations

**A Thesis submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy**

In

Structural Engineering

Presented by

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ABSTRACT

Reinforced concrete columns are considered one of the most important structural elements in different construction systems. It should, therefore, be studied to improve its behavior and performance. Reinforced concrete columns consume large quantities of ties, especially the inner ties in columns with large dimensions, and in some cases nesting of the pillars occurs as a result of the cross-ties. Standard code requirements include the type of reinforcement used for ties, the quantity and the maximum spacing between the transverse reinforcement and the middle bars are treated with the same manner as the corner bars, in order to prevent the buckling of longitudinal reinforcing bars.

The main objective of this thesis is to develop new methods for transverse reinforcement in RC columns and investigate their effect on the behavior of the columns. The proposed V-ties as transverse reinforcement replacing the ordinary and cross-ties details are economically feasible. They facilitate shorter construction periods and decrease materials and labor costs.

For this purpose, experimental and numerical studies are carried out. In the experimental program, nine reinforced concrete columns with identical concrete dimensions (1300 x 250 x 250 mm) and longitudinal reinforcing bars are prepared and tested under concentric axial load with different tie configurations. The specimens are divided into two groups according to the parameter being investigated. The main parameters are the tie configurations and the length (l_v) of V-tie legs. Two lengths of V-tie legs are considered in group 1; 32 mm and 85 mm. On the other hand, three lengths of V-tie legs are considered in group 2; 32 mm, 56 mm and 85 mm.

As part of the numerical study, a numerical analysis using ABAQUS software program is conducted by modelling the nine RC columns with different tie configurations. The finite element models could accurately predict the load capacities for the simulated RC columns subjected to concentric load and reinforced with different tie configurations. The results obtained using ABAQUS finite element were in good agreement with the experimental ones. To extending the results, a numerical parametric study is carried out to study the influence of concrete compressive strength, longitudinal reinforcement ratio, spacing between ties and aspect ratios of cross-section on the behavior of RC columns with the considered tie configurations.

Based on the experimental and numerical results, it is found that using V-ties instead of traditional ties could increase the axial load capacity of RC columns, restrain early local buckling of the longitudinal reinforcing bars and improve the concrete core confinement of RC columns. Finally, this highlights the need for designing codes to consider the effect of V-ties to be used as a transverse reinforcement for RC columns.

Keywords: RC columns; transverse reinforcement; confinement effect; finite element analysis; concrete damage plasticity model; rebar buckling.

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