Fayoum University

Faculty of Engineering

Civil Engineering Department

Innovative Strengthening Method of Slender Reinforced Concrete Columns with FRP Composites (Finite Element Simulation)

By:

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Master Degree of Science

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ABSTRACT

In recent years, long (slender) columns have been widely used due to the requirements of modern advanced architecture. In a historic country like Egypt, significant government budget is regularly directed to rehabilitation of old structures such as administrative buildings, schools, hospitals, etc. Also, increased loads arising from changing of building use or adding new stories are an important cause for increasing the number of strengthening projects. Strengthening of these slender columns by using the advanced fiber-reinforced polymer (FRP) jacketing has acquired a wide popularity in recent years. Most researchers investigated the behavior of RC short columns strengthened with FRP under several loads but few studies have emerged for the analysis of slender RC columns. This thesis presents a full assessment of strengthening and rehabilitation of RC slender columns with FRP composites jacket.

A 3D non-linear finite element model of reinforced concrete columns externally strengthened with FRP using ANSYS, a commercial Finite Element Modeling software was used to investigate the behavior of RC slender columns strengthened with FRP under eccentric compression load. The finite element models' results were verified and evaluated by comparing them with experimental ones. The numerical results revealed good agreement with available experimental measurements.

Fifty-eight (58) 3-D numerical models of RC slender columns were created by using the common finite element package ANSYS14. This large number of models is aimed to investigate the structural behavior of RC slender columns strengthened with CFRP under various parameters to complete a full image of these strengthened columns. All the columns models were exposed to a concentric axial load to determine the column capacity under the previous parameters. Various parameters were studied,

such as column cross-section, slenderness ratio, type of FRP, thickness of FRP, number of layers, orientation of FRP and the required length of FRP wrapping.

The numerical models are divided into two main groups according to the column cross-section, i.e. square and rectangular. Each group consists of 29 models and includes three series depending on the slenderness ratio (λ=15, 22 and 35). Every group series has a number of models that differs in the number of strengthening layers and FRP orientation. Series (A) includes 11 models, while series (B) and series (C) have 9 models for each one. The highest advantage for using the numerical study is that every column is studied as built without any scale factor for the column dimensions and a second advantage is to study all the various parameters without any large cost. The ultimate loads computed using these models are compared with the theoretical ultimate loads and the design is calculated according to the Egyptian code of RC concrete design.

The results indicate that FRP composites can be successfully used in strengthening of RC slender columns which improve the structural behavior, e.g. strength, stiffness and ductility. Also, the ultimate load capacity has higher increasing ratios in the case of strengthening square columns with FRP layers than strengthening rectangular column and the effect of FRP strengthening is reducing by increasing the column slenderness ratio. The best strengthening pattern to increase the ultimate load capacity is using CFRP layers in the longitudinal direction to reduce the buckling moment. From the previous results, an equation is estimated to calculate the column capacity for both square and rectangular columns.