Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 2, No. 8, August, 2016

Finite Element Modeling of Axially Loaded CFRP-Confined Rectangular Reinforced Concrete Columns

Hamed Akbarpour [a*], Masoumeh Akbarpour [b]

[a] Department of Civil and Environmental Engineering, The Pennsylvania State University, University Park, USA

[b] Department of Civil Engineering, K.N. Toosi University of Technology, Tehran, Iran

Received 2 May 2016; Accepted 10 July 2016

Abstract

This paper investigates numerically the behaviour of rectangular RC columns strengthened with carbon fiber reinforced polymer (CFRP) composites under uniaxial loading. For this a reason, a parametric study is conducted and the effects of CFRP layers number, compressive strength of unconfined concrete, and fiber orientation on the behaviour of such columns have been studied. The number of CFRP layers has been changed from one to five layers while the fibers are oriented transversely. Compressive strength of unconfined concrete has been increased from 26 MPa to 45 MPa. In addition, three different fiber orientations are considered. The results show that an increase in the number of CFRP layers would enhance the ultimate strength of specimens. Although increasing the number of layers would not increase the ultimate strength of specimens exponentially, but the rate of strength gain would also decrease. Moreover, it is shown that lateral strains increase as the layer number increases. The effect of unconfined concrete strength on the ultimate strength is less for low strength concrete than high strength concrete. Evaluating the effect of fiber orientation shows that the maximum ultimate strength is obtained from transverse orientation and as the angle of orientation increases, the ultimate strength decreases.

Keywords: Axial Load; Rectangular Concrete Columns; Carbon Fiber Reinforced Polymer; Strength; Ductility.

1. Introduction

In recent years, fiber-reinforced polymers (FRPs) are used widely for strengthening reinforced concrete (RC) columns to achieve more strength and ductility. Under the lateral confining pressure provided by FRPs, such columns are subjected to a tri-axial stress state and consequently the total strength and ductility increase [1, 2].

Most of studies reported in the literature are devoted to the investigation on the behavior of circular RC columns under axial load, but fewer attempts are made on square/rectangular RC columns. In non-circular RC columns, the compressive strength of confined concrete is a function of the cross-sectional aspect ratio, the height, the corner radius, the unconfined concrete strength, the longitudinal and transverse reinforcement ratio, and the mechanical properties of FRPs.

Wu et al. [3] presented the results of an experimental study on the behavior of axially loaded rectangular columns. 45 specimens were tested under uniaxial compression where the effects of the cross-sectional aspect ratio and the number of CFRP layers were studied. The test results indicated that the strength gain in the confined columns decreased as the aspect ratio increased, but the aspect ratio of 2 was a limit point where its effect became insignificant. It is also showed that an increase in the FRP layers lead to increase the strength and ductility of specimens.

El-Hacha et al. [4] investigated the slenderness effects of confined concrete with CFRP. 18 specimens with varying slenderness ratio tested under axial loading up to failure. The results showed that increasing the height of columns reduced the ultimate axial strength where this reduction is more significant for the wrapped columns.

* Corresponding author: hqa5124@psu.edu