Fayoum University

Faculty of Engineering

Civil Engineering Department

Strengthening of Tubular Steel Compression Members

with Fiber-Reinforced Polymer (FRP)

By:

ENG.: Yomna Ahmed Mohammed

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B.SC, CIVIL ENGINEERING, MAY 2011
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Master Degree of Science

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ABSTRACT

Although fiber reinforced polymers (FRP) have been widely used in strengthening of concrete structures, there are few applications to steel structures, especially to tubular sections. Thin-walled tubular steel members may exhibit local buckling such as elephant foot mode or overall buckling under extreme compression load. Recently, external bonding of fiber reinforced polymer (FRP) sheets for strengthening steel tubular compression members has been explored through gradually increasing experimental research.

This research presents three-dimensional nonlinear finite element analysis to investigate the buckling behavior of tubular steel members strengthened with FRP under uniaxial compression. Imperfections were introduced to the model to simulate elephant's foot and overall buckling modes. Both material and geometric nonlinearities were considered in this research. The imperfection was introduced as half-wave sine curve for one model and initial out-of-straightness for another model. The finite element models' results were verified and evaluated by comparing them with the experimental ones. The numerical results revealed good agreement with available experimental measurements.

The parametric study consists of 35 simulations of tubular steel members under axial compression. The elephant's foot buckling mode has been investigated through 17 of these models and the overall buckling mode has been studied on the remaining models. The developed models have been implemented in this study to investigate the influence of cross section area, length, slenderness ratio, fiber type, fiber orientation and fiber layers number on buckling behavior. The ultimate loads which were computed using these models were compared with the theoretical ultimate loads and the design calculated according to the Egyptian and American codes of steel (Allowable Stress Design and Load and Resistance Factor

Design). The results demonstrated that strengthening tubular steel compression members with FRP provides significant increase in strength, stiffness and ductility. For the models susceptible to elephant's foot buckling, the glass fiber enhanced the ductility with slight improvement in strength and reduced the outward elephant's foot buckling. For the models susceptible to overall buckling, the carbon fiber improves the strength of the tube without compromising the ductility.