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Experimental study on CFST members strengthened by CFRP composites under compression

M.C. Sundarraja [a,*], G. Ganesh Prabhu [b]

[a] Thiagarajar College of Engineering, Madurai, Tamilnadu, India
[b] Department of Civil Engineering, Thiagarajar College of Engineering, Madurai, Tamilnadu, India

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ABSTRACT

The concrete filled steel tubular (CFST) members become very popular in the construction industry and, at the same time, aging of structures and member deterioration are often reported. The actions like implementation of new materials and strengthening techniques become essential to combat this problem. This research work aimed to investigate the structural improvements of CFST sections with normal strength concrete externally bonded with fibre reinforced polymer (FRP) composites. For this study, compact mild steel tubes were used with the main variable being FRP characteristics. Carbon fibre reinforced polymer (CFRP) fabrics were used as horizontal strips (lateral ties) with several other parameters such as the number of layers, width and spacing of strips. Among thirty specimens, twenty seven were externally bonded with 50 mm width of CFRP strips with a spacing of 20 mm, 30 mm and 40 mm and the remaining three specimens were unbonded. Experiments were undertaken until column failure to fully understand the influence of FRP characteristics on the compressive behaviour of square CFST sections including their failure modes, axial stress–strain behaviour, and load carrying capapcity. From the test results, it was found that the external bonding of CFRP strips provides external confinement pressure effectively and delays the local buckling of steel tube and also improves the load carrying capacity further. Finally, an analytical model was proposed herein for predicting the axial load carrying capacity of strengthened CFST sections under compression.

1. Introduction

Composite construction may be considered as a reliable choice of attaining proper balance between the advantages it offers and the cost. An extensive variety of composite columns are available nowadays, but the concrete filled steel tubular (CFST) sections are most commonly used one. Due to their excellent earthquake resistant properties such as high ductility, large energy absorption and high-strength capacity, they are used in various applications. Furthermore, steel tube lie in the outer limits provides good confinement to the concrete and thus increases its ductility and also the local inward buckling commonly observed in bare steel tube columns is effectively prevented and eliminated. But the deterioration of above metallic structures due to corrosion is often reported. Various strengthening or rehabilitation techniques such as section enlargement, external bonding of steel plates and fibers etc. has been proposed to overcome these problems. Among all the methods, plate bonding technique provides a practical and cost effective solution. The earliest investigators utilized steel plates for external strengthening. Though the technique was successful in practice, it posed some harms such as addition of self weight, required heavy lifting equipment to place the plates in position, difficulty in shaping and fitting in complex profiles and complication in bonding/welding and furthermore added plates are susceptible to corrosion which leads to an increase in future maintenance costs. In contrast, rehabilitation using fibre reinforced polymer (FRP) composites do not exhibit any of these drawbacks.

Though the composite materials were introduced in the year 1909, the composite industry began to bloom only after 1930s [1]. Glass fibre reinforced polymers (GFRP) were first used in aircraft radar covers at the end of 1930s [3] and boat hulls and car bodies were developed with glass fibres as the major reinforcement [11]. Glass was also used as an insulator to prevent galvanic corrosion of metals since it is a non-conductive material [15]. Under certain conditions of exposure, glass fibres proved to be sensitive to alkaline environments and moisture attack [16]. At the end of 1960s, Royal Aircraft Establishment had developed the carbon fibre reinforced polymer (CFRP) for special applications [3]. Unlike glass, carbon is an electrical conductor and hence galvanic corrosion could take place if carbon fibres are placed in direct contact with metals [13] but such fibres behave very well against creep deformation and relaxation [1]. After introduction of advanced composite materials in construction industry, the second generation utilized those materials in external strengthening technique. The application of CFRP with reinforced concrete structures has been widely carried out and reported in the past few decades. However, research

* Corresponding author.
E-mail addresses: mcsciv@tce.edu (M.C. Sundarraja), gganeshprabhu@gmail.com (G.G. Prabhu).

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