iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** V **Month of publication:** May 2016

DOI:

Volume 4 Issue V, May 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Effects on Concrete Filled Stainless Steel Tubular Columns Strengthened By Using GFRP Sheets – A Review

M.Vanitha[1], N.Sakthieswaran[2], G.Shiny Brintha[3], O.Ganesh Babu[4]
[1,2,3,4]Department of Civil Engineering
[1,2,3,4]Anna University Regional Campus, Tirunelveli, TN, India.

Abstract - A set of 11 concrete filled stainless steel tubular (CFSST) columns with a 100 x 45 mm rectangular cross section with 300mm long were cast using 25 MPa concrete mixture. Nine specimens were tested under different percentage (60%, 70% & 80%) of compression loading until failure. Then these existing CFST columns were retrofitted using GFRP wraps of different spacing (20mm, 60mm & without spacing) with the layer width 60mm. The structural response of CFSST columns was investigated under uniaxial compressive stresses in order to determine the effect of protection materials on ultimate load carrying capacity, axial strain and the mode of failure. The ultimate load carrying capacities of retrofitted columns were estimated. The load carrying capacity of strengthened and un-strengthened CFST columns was compared. The models fairly estimated the ultimate load carrying capacity of strengthened CFST columns after subjecting to the partial failure.
Keywords: Concrete filled stainless steel columns (CFST); Strengthening of concrete columns; GFRP.

I. INTRODUCTION

Concrete-filled stainless steel tubular (CFSST) columns have gained popularity for buildings, bridges and other types of structures. CFST columns have also become popular among designers and structural engineers. This is due to the great advantages of CFST columns. CFST columns combine the structural properties and advantages of both steel and concrete materials. They help to accelerate the speed of construction as the steel tube acts as a shoring during the concrete pouring, so this also leads to saving costs in the concrete-pouring process by eliminating the need for formwork. Other advantages are the high strength and the increase of the structural stiffness. CFST columns have a high load-bearing capacity and high seismic resistance. The steel tube provides confinement to the concrete infill, which in turn acts as a support to the steel tube and prevents local inward buckling of the section; also CFST columns have an attractive appearance and a reduced cross-section.

Numerous applications of fibre reinforced polymers (FRPs) have demonstrated good performance in retrofitting and repairing deteriorated reinforced concrete structures, both through research studies and through field applications. Fire is one of the most serious dangers to which reinforced concrete elements may be subjected. The deteriorating effect of accidental load on concrete varies depending on the concrete cement content, type and content of coarse aggregate, fire temperature and exposure time, type of exposure, percentage and layout of reinforcement, ...etc. The use of FRP as externally bonded reinforcement for RC elements is a relatively new technique that is an attractive alternative to classical concrete or steel jackets due to high strength, high strength-to-weight ratio, corrosion resistance and high durability in a wide range of aggressive environment. The use of FRP in retrofitting RC elements plays significant role in extending the lifetime of a concrete element rather than the inconvenient and less effective jacketing methods. The use of FRP is preferable since any alternative retrofitting solution may be lengthy, costly and labour intensive.

In recent years, existing concrete structures in North America have reached a state where many of them can no longer safely resist the loads acting on them. This is due to deterioration caused by electro-chemical corrosion and to increased load requirements, among other factors. Demolishing and rebuilding these structures is not an economically viable option, therefore new repair methods and materials such as fibre reinforced polymers (FRPs) are being used in retrofitting many of these structures. Due to their numerous advantages, which includes high strength-to-weight ratios in comparison to steel and resistance to electro-chemical corrosion, FRP materials have been already successfully used in the rehabilitation of bridges in Canada, such as Champlain Bridge, Webster Parkade etc.

Several protection materials may be used to protect bare RC elements from fire such as gypsum layers or cement mortar. Without reliable experimental results, the use of protection materials in protecting FRP as a retrofitting material from the fire deteriorating

Volume 4 Issue V, May 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

effect is questionable.

The theoretical models used in predicting the behavior of columns with confinement may not be readily applicable to this particular case. This is because the protection materials may protect both of the retrofitting materials and the base concrete. In addition, these models used to predict the ultimate load carrying capacity does not acknowledge the deterioration in the mechanical properties of base concrete after subjecting to fire.

II. LITERATURE REVIEW

Vipulkumar Ishvarbhai Patel et al (2014) presents Nonlinear analysis of axially loaded circular concrete-filled stainless steel tubular short columns, It is demonstrated that the developed fiber element model considering concrete confinement effects predicts well the load–strain behavior and ultimate axial strengths of CFSST short columns tested by independent researchers. The proposed design model for axially loaded CFSST short columns is verified by experimental and numerical results.

Baskar K et al (2012) investigated the bond stress characteristics of circular concrete filled steel tubular columns using mineral admixture metakaoline presents the bond carrying capacity of conventional concrete and metakaoline in concrete filled steel columns. The bond carrying capacity is interrelated with slip between the steel and concrete interface.

Brain uy et al (2011) conducted a series of tests on short and slender stainless steel tubular columns to explore their performance under axial compression or combined actions of axial force and bending moment. Empty short steel hollow sections were tested for comparison. The test results showed the performance of the composite columns was quite good and have the potential to be used extensively as structural members.

Riad et al (2008) conducted tests on square prismatic concrete column, strengthened with external glass fibre composite. It was found that the stiffness of the applied FRP jacket was the key parameter in the design of external jacket retrofits.

OlivovaK &BilcikJ (2008) presented the results of an experiment at study on the structural behavior of reinforced concrete columns strengthened with carbon fiber sheets and strips in pre-cut grooves.The observed behavior of the confined columns was similar to the unconfined columns up to the peak load of the unconfined columns. Increase in the lateral deflection of the confined columns resulted in the concrete failing in compression and rupturing the FRP confining jacket at approximately mid-height. The deflected shape of the columns at peak load was symmetrical, and there was no local buckling in the columns.

Hadi,(2007); Hadi,(2003); Yong et al (1998) conducted an investigation on behaviour of high strength concrete columns with FRP confinement. The specimens were confined using carbon, glass and Kevlar fibre reinforced polymer of varying thicknesses and subjected to concentric as well as eccentric loading. The authors concluded that all columns failed in a brittle manner. The failure of unconfined columns was highly explosive. Under concentric loading conditions, confinement using Kevlar FRP resulted in some increase of deflection and ductility over the unconfined specimens. Carbon fibre wrapped specimens with single layer failed explosively, while those with three layers seemed to appear integral without any damage to the wrap even after failure of the column. Under eccentric loading, carbon FRP confined columns failed explosively, while kevlar and glass FRP confined specimens showed adequate warning in the form of white patches on FRPsurface at the time of initiation of failure.

Nagaradjane et al (2007) presented on a sensitivity study and design procedure for FRP wrapped RC circular columns, subjected to an axial load and equal end moments. The parameters used in the study include the unconfined concrete strength, steel ratio, thickness of FRP wraps and the section diameter. Interaction equations were also developed in this work to provide a simplified and practical tool for engineers to evaluate the ultimate strength of the FRP wrapped columns. The author concluded that FRP wraps significantly increase the ultimate strength of RC columns. The rate of increase in strength increases proportionally to the increase in FRP layer thickness.

Prota A et al (2006) conducted the test on Ultimate behavior of axially loaded RC wall-like columns confined with GFRP," It was found that actual failure mode did not change by confinement but it was able to delay bars buckling and to resultantly compressive concrete strains attain higher values, thus resulting in higher load carrying capacity of the column (strength improvement is about 15%) and significantly in ductility enhancement.

Bisby et al (2005) reported on fire endurance tests on insulated FRP confined reinforced concrete circular columns, which also endured a standard fire for more than four hours in some cases. The temperature of the steel reinforcement and concrete for the columns was maintained below 200°C in some cases, and therefore the column was able to maintain essentially all of its original room temperature strength during the fire test. This was evident in the fact that the column failed after more than five hours of fire exposure at a higher axial load than its predicted nominal (unfactored) compressive strength for the unwrapped condition. In this study, the insulation protecting the FRP confined reinforced concrete column was able to maintain the temperature of the FRP below 100°C, which was higher than the glass transition temperature of 91°C, for up to four hours during fire. However, without any supplemental fire protection, the FRP begin to combust within minutes of exposure to fire, thus raising the surface temperature of the structural member above the surrounding temperature. This effect could potentially create a more severe fire exposure than the un-strengthened reinforced concrete member.

Iraj h.p. mamaghani (2004) investigated seismic design and retrofit of thin-walled steel tubular columns. This paper deals with seismic design and retrofit of thin-walled steel tubular columns supporting superstructures in highway bridges. The important characteristics of the thin-walled steel tubular columns are noted and the basic seismic design and retrofitting concepts of such structures are presented. Three seismic retrofitting techniques of the thin-walled steel tubular columns, namely, stiffeners strengthening technique, partially concrete-filled columns technique, and energy absorption segment technique are outlined.

Richard D lacobucci et al (2003) investigated the retrofit of square concrete columns with Carbon Fibre Reinforced Polymer (CFRP) for seismic resistance. It was found that added confinement with CFRP at critical locations enhanced ductility, energy dissipation capacity and strength of all substandard members.

SujeevaSetunge (2002) observed behavior of the confined columns was similar to the unconfined columns up to the peak load of the unconfined columns. Increases in the lateral deflection of the confined columns resulted in the concrete failing in compression and rupturing the FRP confining jacket at approximately mid-height. The deflected shape of the columns at peak load was symmetrical, and there was no local buckling in the columns.

Pantelides&Gergely (2002) presented analysis and design procedures for a CFRP composite seismic retrofit of a reinforced concrete three-column bridge bent. In situ test results showed that the seismic retrofit was successful, and the bridge bent strengthened with CFRP composite reached a displacement ductility level and doubled the hysteretic energy dissipation of the as-built bent.

Mirmiran A et al (2002) investigated that Fiber reinforced composites, due to their high strength-to-weight and stiffness-to-weight ratios, large deformation capacity, corrosion resistance to environmental degradation, and tailorability, present an attractive option as an alternative and extremely efficient retrofitting technique in such cases through the use of composite jackets or wraps around a deteriorated column.

Bogdanovic A (2002) showed that Carbon sheets have been applied to increase the concrete confinement and loading resistance of reinforced concrete columns. The confinement effectiveness of externally bonded FRP jackets depends on different parameters, namely, the type of concrete, steel reinforcement, thickness of the FRP jackets (number of layers)and stiffness (type of FRP) and loading conditions.

de Paula R F& de Silva (2002) The shape of the cross sections and sharp edges in the cross sections of columns can directly affect the confinement effectiveness of externally bonded concrete. The efficiency of FRP confinement is higher for circular than square sections. The mitigation of the effect of this shape is achieved by rounding the corners of rectangular sections with the effectiveness increasing with the rounding radius, until a certain threshold is reached. The ultimate strength of the confined concrete is closely related to the failure strength of the FRP wraps. The CFRP strain at the rupture of the confined columns is usually lower than the ultimate strain obtained by tensile testing of the CFRP coupons.

Shamim et al (2002) have investigated the seismic behavior of concrete columns confined with steel and FRP. It was concluded that the use of FRP significantly enhances strength, ductility, and energy absorption capacity of columns.

Shahawyet al (1999) assessed the effectiveness of external reinforcement in terms of the cracking moment, maximum moment, deflection, and crack patterns. The deflection and cracking patterns showed results similar to experiments previously discussed. The deflection decreased inversely with the number of CFR Players on each beam. This, alternatively, caused the stiffness to increase. The control had wider cracks while the repaired beams showed smaller cracks at relatively close spacing. This shows an enhanced concrete refinement due to the CFRP sheets.

JessyMathai&K.P.Jeya (1999) presents an experimental and analytical investigation conducted to assess the behaviour of beam-column wrapped with GFRP and CFRP. One specimen without FRP wrapping, three specimens with 2, 4 and 6 layers of GFRP and two specimens with one layer of CFRP were tested.The column specimens wrapped with two layers, four layers and six layers of GFRP shows 8%, 28% and 32% increase in the load carrying capacity respectively compared to the specimen without wrapping. The specimen jacketed with 6 layers of GFRP has the highest load carrying capacity and there is 32% increase in the strength compared with the specimen without GFRP wrapping. The column specimens wrapped with two layers, four layers and six layers of GFRP shows 25%, 54% and 70% increase in ductility respectively compared to the specimen without wrapping. The specimen jacketed with 6 layers of GFRP has the highest ductility and there is 70 % increase in the ductility compared with the specimen without GFRP wrapping. The specimens jacketed with CFRP have an average of 98.3% increase in the strength capacity compared to the specimen without CFRP wrapping.

III. NEED FOR THE STUDY

A. The FRP wrapping can improve the load carrying capacity of columns.
B. The rate of increase in strength increases proportionally to the increase in FRP layer thickness.
C. Percentage reduction in stress and strain due to wrapping are 50.3% and 77.02% respectively compared to unwrapped column.
D. Percentage increase in stiffness and energy absorption in wrapped are 38.88% and 20.32% respectively compared to unwrapped column.
E. The specimen jacketed with 6 layers of GFRP has the highest ductility and there is 70 % increase in the ductility compared with the specimen without GFRP wrapping.
F. The specimens jacketed with CFRP have an average of 98.3% increase in the strength capacity compared to the specimen without CFRP wrapping
G. The use of FRP materials restores or improves the column original design strength for possible axial, shear, or flexure.
H. GFRP wrapping can increase the seismic capacity of the columns in increasing their strength and ductility
I. It is feasible to add GFRP to improve the mechanical properties of CFST columns.
J. FRPs are being effectively used in various research works which remarkably improves the mechanical properties of concrete member, when added into it.

IV. CONCLUSION

As a part of preliminary work, the various material needed to be used for the further study, were obtained and their physical properties were determined. A study on stainless steel and fibre reinforced polymers were done which are proposed to be used in this experimental work. A review of literature was done which was helpful in getting a better idea on the topic. The properties of the material and testing methods have been discussed in this phase I project.

The experimentation will be performed for rectangular cross section of CFST columns with M25. The specimens of size 100mm x 45 x 300mm are being prepared. Then the specimen is to be tested subjected to different percentage (60%, 70% & 80%) of compression loading until failure. After the partial application of load the CFSST columns were retrofitted using GFRP wraps of different spacing (2mm, 6mm & without spacing) with the layer width 60mm. The effect of wrapping, axial strain and the load carrying capacity of specimen was investigated.

REFERENCES

[1] Bisby, L.A. et al.,(2005), "Modeling the Behavior of Fiber Reinforced Polymer-Confined Concrete Columns Exposed to Fire." Journal of Composites for Construction, ASCE,(January – February 2005): pp. 15-24
[2] Bogdanovic, A., (2002),"Strengthening of Circular Concrete Columns Using FRP Sheets-Applications". The University of Manitoba, Composite Materials in Civil Engineering.
[3] Brain uy et al.,(2011),"Behaviour of short and slender concrete-filled stainless steel tubular columns", March 2011,Vol.67(3):360-378.
[4] de Paula et al.,(2002),"Sharp Edge Effects on FRP Confinement of RC Square Columns", 3rd International Conference on Composites in Infrastructure, ICCI 2002.
[5] Hadi, M.N.S.,(2007)," The Behaviour of FRP Wrapped HSC Columns Under Different Eccentric Loads", Elsevier Science Ltd, 78(4), 560-566.
[6] Hadi. M.N.S. &Li. J.,(2003)," External Reinforcement of High Strength Concrete Columns", Elsevier Science Ltd, 65 (3-4), 279-287.
[7] Iraj h.p. mamaghani., (2004),"Seismic design and retrofit of thin-walled steel tubular columns", Page No:271.
[8] K. Olivova and J. Bilcik.,(2008)," Strengthening Of Concrete Columns With CFRP" 2009/1 Pages 1-9.
[9] Mirmiran, A. et al., (2002),"Design for Slenderness in Concrete Columns Internally Reinforced with Fiber-Reinforced Polymer Bars",ACI Structural Journal, January– February 2002, pp. 116-125
[10] Nagaradjane et al.,(2007),"ANN Model for the Effect of Slenderness on Concentrically Loaded Concrete Cylinders Confined by GFRP", Indian Concrete Journal, 81(7), 43-50.
[11] Pantelides C P &GregleyJ.,(2002),"Carbon Fibre Reinforced Polymer Seismic Retrofit of RC Bridge Bent Design and In-situ Validation",ASCE,6(1,52-60).
[12] Prota A et al.,(2006), "Ultimate behavior of axially loaded RC wall-like columns confined with GFRP," Composites: Part B, Elsevier2006;37:670–8.
[13] Baskar.K et al.,(2012),"Bond stree characteristics on circular concrete filled steel tubular columns using mineral admixture metakaoline",International journal of civil and structural Engineering, Volume 3, No1.
[14] Richard D. Lacobucci et al.,(2003), "Retrofit of square concrete columns with carbon fibre reinforced polymer for seismic resistance", ACI Structural Journal. 100 (6). 785-794.
[15] Riad Benzaid et al., (2008), "Behaviour of square concrete column confined with GFRP composite wrap", Journal of Civil Engineering and Management. 14(2). 115–120.
[16] Shahawy, M.A. & Beitelman, T.,(1999), "Static and Fatigue Performance of RC Beams Strengthened with CFRP Laminates," Journal of Composites for Construction, Vol. 125, No. 6, 1999, pp. 613-621.
[17] Shamim, A. Sheikh & Grace Yau., (2002), "Seismic behaviour of concrete columns confined with steel and fibre reinforced polymers",ACI Structural Journal,

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

99 (1). 72-80.

[18] SujeevaSetunge.,(2002)," Project report on “Review Of Strengthening Techniques Using Externally Bonded Fiber Reinforced Polymer Composites” Report 2002-005-C-01.

[19] Vipulkumar Ishvarbhai Patel et al., (2014),"Nonlinear analysis of axially loaded circular concrete-filled stainless steel tubular short columns”, Journal of Constructional Steel Research, 101 (October), 9-18.

[20] Yong, Y.K.,(1998)," Behavior of Laterally Confined High strength Concrete Under Axial Loads”, ASCE J. Strut. Engg.,114(2), 332-351.