Strengthening of RCC Short Column Using Chopped Strand Mat GFRP

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***Abstract*- The retrofitting is the method of enhancing the strength of existing concrete structure by applying the appropriate composite material such as Fibre Reinforced Polymer (FRP), Steel Jacketing etc. One of these applications are Chopped Strand Mat (CSM), Glass Fibre Reinforced Polymer (GFRP) strengthening and retrofitting of reinforced concrete columns. The objective of this study is to make a comparison between without wrapped reinforced columns and columns wrapped with CSM-GFRP sheet. These reinforced short columns were tested under the compressive axial load monotonically. Results of research work have shown that wrapping of columns with CSM-GFRP sheet enhances the ductile as well as compressive strength when compared with the non-wrapped reinforced columns. CSM-GFRP confinement is a cost effective material than other retrofitting methods. This research work also gives the comparison of strength efficiency with respect to additional cost of CSM-GFRP sheet.**

***Index terms*- CSM-GFRP, Steel Jacketing, Confinement, compressive axial load**

INTRODUCTION

Researches on short RC columns are significantly low in CSM-GFRP comparison to Carbon Fibre Reinforced Polymer (CFRP), which hereby, make it appropriate to carry forward the little work on short columns, ahead. CFRP has proved its ability to improve compressive strength of short columns whereas its merit on delaying the bending failure is yet to be verified comprehensively. As we know concrete is the one of the most preferable construction material because of its versatile properties. Concrete can be cast in the desired shape and size under the economic cost. These all properties make it most preferred building material. Glass Fiber Reinforced Polymer (GFRP) is a fiber reinforced polymer made up of fine fibers of glass. GFRP is a light weight, strong and tough material, due to these outstanding properties; it is used in various industries. Although strength properties of GFRP are lower than CFRP and it is less stiff, but material is typically far less brittle and raw materials are much cost effective. The previous researches have been carried out to retrofit or strength the existing structures in which retrofitting is the process of making changes of present structures to make them strong, durable, most cost-effective and technically superior alternative than the traditional techniques like concrete and steel jacketing. On this case, either in form of steel reinforcement or sheets has given a noteworthy competition to other substitutes.

Riad Benzaid et. al. (2008) has investigated the increment of compressive strength and strain behavior under the axial compressive load when confined with GFRP. Under this study these column samples were prepared in square section with reinforced concrete. Result shows the adequate improvement in strength when made comparison between the samples wrapped with GFRP sheet in single and double layer and without wrapped column.

P. Sangeeta et.al.(2018) has studied the behavior of the circular concrete column under uniaxial compressive load when wrapped with GFRP and without wrap. In this research, the GFRP sheets were used in the form of Surface Mat, Copped Strand Mat, Woven Roving Mat in single and three plies. The strength has been achieved remarkable when wrapped in three layers in 28 days curing period.

Houssan A.Toutanji et.al. (2007), this research work has focused on the aspect ratio (Height/Width) and corner radius of square columns. This work analyzed the compressive strength of large scale and small scale column. This research analysis suggested that rounded corners having some radius gives good

results in strength when confined with the GFRP sheet and also reduces the confinement pressure when provide higher aspect ratio.

K P Jaya, et.al. (2012), under this study the jointed column- beam sample was tested under the seismic load condition. These sample were wrapped with GFRP and CFRP. GFRP wrapped in two, four and six layers and CFRP in single layer and made the comparison with without wrapped samples in seismic condition. GFRP wrapped specimens shows the tremendous performance in ductile strength than CFRP wrapped specimen while carrying capacity recorded remarkably good in CFRP wrapped column than GFRP wrapped specimens.

C. Cui et. al (2010), under this paper, a total 112 cylindrical concrete specimens of size 150mm diameter and having 300mm height were tested under monotonic axial compressive load to study the behavior of stress-strain when wrapped with fibre reinforced polymers and without wrapped column. Result shows the ductility rupture at peak load state make the comparison with 0 percentage wrapped specimens.

MATRIAL USED

Cement

Using Ordinary Portland Cement (grade 43) of specific gravity 3.14 conforming to IS 8112:2013, "ORDINARY PORTLAND CEMENT-SPECIFICATION", has been used.

Aggregates

Fine aggregates conforming to IS383:1970, "SPECIFICATIONS FOR COARSE AND FINE AGGREGATES FROM NATURAL SOURCES FOR CONCRETE" has been used.

Coarse aggregates conforming to IS383:1970, "SPECIFICATIONS FOR COARSE AND FINE AGGREGATES FROM NATURAL SOURCES FOR CONCRETE" has been used

Water

Normal portable water fit for drinking purpose has been used to prepare fresh concrete. Specification confirming to IS 456:2000.

Concrete

The concrete is mixture of four main constituents: cement, water, coarse aggregate, and fine aggregate. The concrete was prepared of M20 for a characteristic compressive strength of 20MPa in 28 days from manufacturing.

Chopped Strand Mat (CSM)-GFRP

The CSM are made up of irregularly woven glass fibres having specification of 2540 kg/m3 density, 1.5 specific gravity, 120Mpa tensile strength and 75 young modulus.

Epoxy Resin and Hardener

Epoxy adhesive is used for high strength bondage in concrete structure having specification of 1.17 specific gravity, 40000 viscosity and handling strength of 8 hrs.

EXPERIMENTAL SETUP

A. Specimen layout

A total of ten reinforced concrete half-scale column specimens were fabricated and tested in the experimental program having the size of 400mm×150mm×150mm. Columns were reinforced longitudinally with four 8mm (50.21 mm2) steel bars and laterally with 6 mm closed steel ties spaced at 100 mm, as per the requirement for axial load design. 8 column specimens were strengthened with GFRP (CSM & WRM) and the other two were used as control specimens (no strengthening). The columns were numbered as SC11,WC11, ,CC11 and so on, where the letter "S" indicates simple and "W" and "C" are indicating WRM and CSM wrapping respectively while "C" indicates column specimens which is the second word in abbreviation and the numeric value indicates the sequence in which they were tested in different group.

Figure 1: Chopped Strand Mat GFRP

The FRP lamina was applied using the "dry layup" method with a resin having 1:0.8 epoxy to hardener matrix. The FRP fabric was applied to form different lamina on the smoothened and cured concrete surface. First the fabrics, either as WRM or CSM sheets, were cut to desired widths and lengths. Epoxy resin was then applied to the entire portion of the column surface. Whether longitudinal or transverse (or bi-directional), the fabric was wrapped around the column, allowing at least 10 mm thickness to ensure strong epoxy-to-epoxy bond.

Figure 2: Specimen Preparation

Figure 3: Prepared Specimen

B. Testing Programme

RC specimens were subjected to axial compressive load using compressive testing machine of 2000KN capacity. Ultimate load readings were taken to study the compression performance of the specimens. Prior to testing, all specimens were wiped off the water by a cloth and cleaned the surfaces of column and then applied the fiberglass sheets on surface. After all these actions, putting the specimen by possessed a thick layer of paper fixed at the top and bottom surface of the column in order to ensure that the contact surface remained parallel and that the applied load remained concentric.

Figure 4: Single Layered CSM-GFRP Wrapped Column Setup

Figure 5: Failure of Single Layered CSM-GFRP Wrapped Column

Figure 6: Failure of Double Layered CSM-GFRP Wrapped Column

EXPERIMENTAL RESULT

Table 1: Results obtained of Short Columns

Specimen Name	Percentage wrapping	P_{ult}(KN)	σult(Pult/A) (MPa)	σult Considered (MPa)
SC_{11}	0	430	19.11	17.78
SC_{12}		400	17.78	
SC_{13}		420	18.66	
CC_{21}	100	550	24.45	23.11
CC_{22}		520	23.11	
CC_{23}		540	24	
CC_{31}	200	550	24.45	24.45
CC_{32}		580	25.78	
CC_{33}		570	25.33	

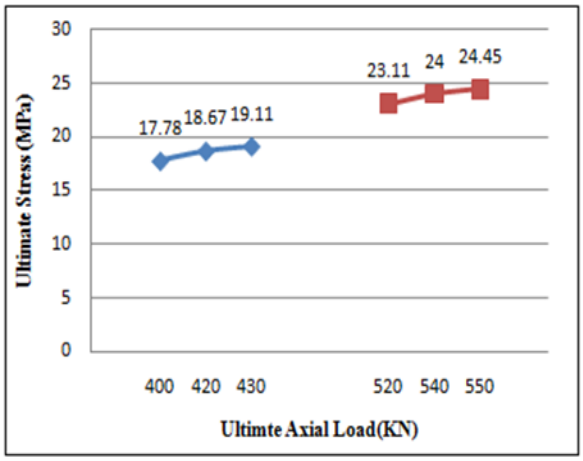

Figure 7: Ultimate Load VS Ultimate Stress for Single Wrapped Column

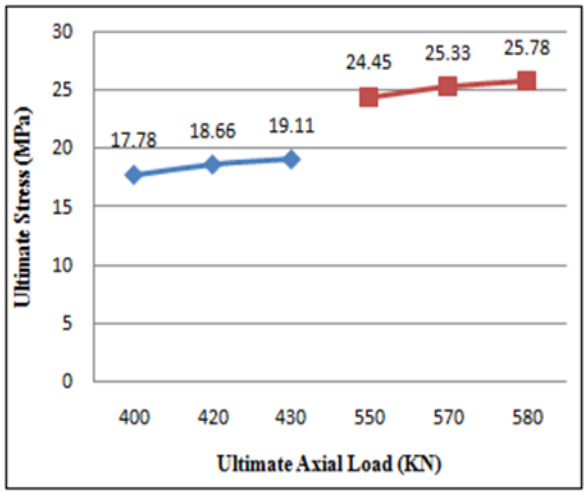

Figure 8: Ultimate Load VS Ultimate Stress for Double Wrapped Column

Generally the 100% wrapped column (CC21, CC22 & CC23) showed an increase of 29.98% in the ultimate load/stress resistance with respect to without GFRP wrapped (SC11, SC12 & SC13) column specimen.

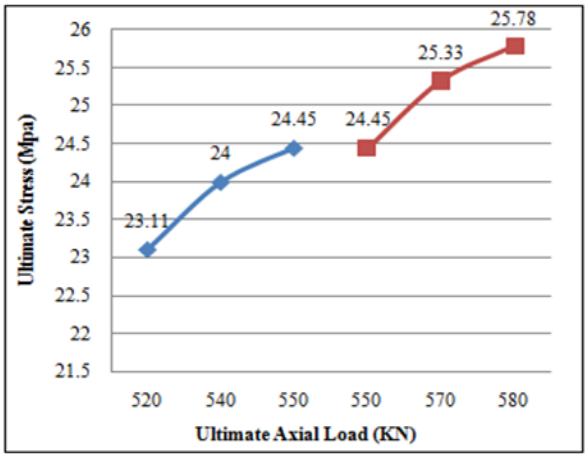

Figure 9: Ultimate Load VS Ultimate Stress for CSM Single & Double Wrapped Column

The column specimen CC31,CC32 & CC33 which were 200% wrapped (continuous double layer) with GFRP showed a growth of 37.51% in the ultimate load/stress with respect to 0% wrapped column specimen and 7.53% with respect to 100% wrapped specimen.

CONCLUSION

Nine columns designated as SC11, SC12, SC13, CC21, CC22, CC23, CC31, CC32 and CC33 were tested under axial compressive loading in compression testing machine of 2000KN capacity. Comparative study has been carried out between simple column and CSM-GFRP wrapped column (SC & CC). This research work shows the following results

- The compressive strength of CSM-GFRP single layer wrapped columns is enhanced by 29.98% than without wrapped RC columns.
- Increment of axial compressive strength in double layer CSM-GFRP wrapped is 37.51% compare with control column.
- When comparison carried out between CSM-GFRP single and double layer wrapped column, the results shows CSM-GFRP wrapped column has greater strength than single layered.

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