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Research Article

Experimental Study on Influence of Confinement by CFRP Wrapping on Concrete Columns

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Abstract

Columns are the most important structural element of the building. The overall performance of the structure depends on stability of the column plays a important role under different loading conations. The column should be provided with adequate strength for the entire design life of the structure. Any deficiency occur in the column will affect the smooth function of the structural members and in turn the structure gets collapse. The column will be subjected to additional load due to earthquake and blast which is of higher magnitude than design load and there by failure happened in the column. The columns are then retrofitted to meet the expected design life. An experimental work was carried out to study the CFRP wrapped column. The load carrying capacity of conventional concrete columns compared with the carbon fibre reinforced polymer wrapped columns. Three different cross sections of the column like circular, square and rectangular were tested. The result of the study demonstrated the CFRP wrapped circular column has high percentage increase in load carrying capacity compared to the conventional circular column than the rectangular and square column due to the influence of confinement.

Keywords: Fibre, CFRP, Column, Confinement, Axial Load, Deflection

Introduction

Rehabilitation of concrete structures increases rapidly in the recent years due to the environmental condition, improper design, poor quality of construction and irregular maintenance. The ductility and energy absorption capacity are the two important factor depends on inelastic deformation of the structure during the severe earthquake to avoid collapse. Some advanced composite materials are used in the construction industries which behaves in excellent way and increase the engineering properties such as strength , stiffness , durability , low density , corrosion resistance and fatigue endurance , low thermal coefficient and good strength –to-weight.

The excellent properties of resistance to corrosion , more stiffness, high strength, low density and improved fatigue performance are the more important parameter to use of the carbon fiber reinforced composites than metallic components in many industries. The polymer matrix combination and carbon fibers develops excellent properties than all fiber reinforced composites. Retrofitting of old masonry structures , that are damaged due to earth quake , chemical reaction and due environment degradation are usually done by carbon fiber reinforced polymer. In many filed as such as marine and air filed pavements and automobile industries CFRP are used than any conventional materials due to its stiffest and lightest composite materials. The matrix as Polymer resin like epoxy were used to give strength and stiffness for carbon fiber in CFRP.

The Carbon fibers is of extremely thin 5-10μm in diameter, embedded in polyester resin. The structures are damaged due to ageing are repaired with CFRP.

The tensile strength of concrete can be improved by CFRP by replacing steel thus avoid steel corrosion. Seismic resistance of the column can be improved by wrapping with CFRP there by increase the strength and stiffness of the concrete element. The fibers are good resistant to chemical action and does not absorb water. Carbon fibres have a high modulus of elasticity 200 – 800 GPa. The ultimate elongation is 0.3-2.5% where the lower elongation corresponds to the higher stiffness.

Riad Babba (1) discussed the experimental study on plain concrete cylinders of diameter 160 mm and 320 mm provided with CFRP layers. From the experimental work it was concluded the use of optimum utilization of CFRP to get ultimate strength. Y.Wu. Youyi wei (2) studied the behaviour short rectangular column provided with CFRP wraps. Different aspect ratio, depth to width of the cross section and the number of CFRP layers were considered as the parameter . The study concluded that the confined column shows better performance than the unconfined column. XianLi .J.Lu et .al., (3) investigated the axial behaviour of rectangular reinforced concrete (RC) columns with large cross-sectional aspect ratios (section depth to width ratios) confined by carbon-fibre-reinforced polymer (CFRP). It was observed that CFRP wraps enhanced the compressive strength of CFRP-confined rectangular RC columns even with a large aspect ratio of 2·25; however, the strength enhancement levels decreased with an increase in aspect ratio. CFRP anchors were effective in restraining concrete from bulging out and thus improved the confinement effectiveness of the CFRP wraps. J. Zeng, Guan Lin et.al., (4) experimented nine large-scale rectangular RC columns, with and without FRP jacketing. The test results were used to examined the validity of large scale column. Guan Lin .j. Zeng et.al., (5) Studied an experimental investigation on eight large-scale FRP-confined rectangular RC columns subjected to eccentric loading. A theoretical column model is then analysed for predicting the responses of the test columns. L. Huang, Tianling Yu et.al., (6) investigated the first-ever experimental study on the behaviour of slender FCCSCs. Test results showed that both the load carrying capacity and deformation ability of CBM in FTSS have been significantly enhanced attributed to the confinement provided by exterior FRP container.

2.0 EXPERIMENTAL INVESTIGATIONS

2.1 Properties of the Materials:

The constituent materials for making concrete were tested in the laboratory . The mix design was carried out using IS method . The mix ratio and workability of concrete were tested and presented in the Table.1.

Table 1.0 Mix ratio

Properties	Value
Mix Ratio	1:1.12:2.69
Sump value	80 mm to 150 mm
Compressive Strength of Concrete	36.07 MPa
Split Tensile Strength of Concrete	4.7 MPa
Flexural Strength	5.97 MPa

2.2 Designation of Specimens:

Totally eighteen column specimens were cast in this experimental investigation. Specimens composed of three groups. Each group confined with three cross section named as circular, Square Rectangular specimens. Nine specimens were considered as conventional specimens. The specimens named as two terms. The first term mentioned for the cross section and the second term describes for Retrofitting such as

CR, SR and RR as circular section of Retrofitting , Square section of Retrofitting and Rectangular section of retrofitting specimens . The Conventional specimens designated as CC, SC and RC describes as circular section of conventional specimens , Square section of conventional specimens and Rectangular section of conventional specimens.

2.3 Casting of Specimens

The materials are weighed and machine mixer was used. The casting of column specimens was carried out in steel mould. After twenty four hours from the casting time all the specimens were submerged in water for twenty eight days curing. Mechanical properties (7) such as compressive strength , split tensile strength and flexural strength were determined and presented in the Table 1.0 . Figure.1 Shows the casting of specimens and Figure.2 shows the specimens after 28 days curing process..

Figure.1 Casting of the Speimens and Curing of the Specimens

Figure. 2 Specimens after 28 days curing.

2.4 Process of CFRP Wrapping

Before the process of wrapping some surface preparation of the concrete specimens has to be carryout in effective manner. The surface must be cleaned , free from oil residues and the holes, depressions and imperfections shall be filled with renderoc mortars or by using Epoxy grouting, Nitocote VF/ Nitomortar FC, and epoxy putty. The primer consist of base and hardener. Due to long storage the solid settles at the bottom. It has to be thoroughly stirred for at least 3 minutes. Mechanical mixing using a heavy-duty slow speed (300 - 500 rpm), drill, fitted with a mixing paddle is recommended. With the help of brush the liquid mixed materials named Nitowrap 30 epoxy primer is coated over the prepared concrete specimens. The coated specimens is allowed to dry for twenty four hours. The saturant named Nitowrap 410 is then applied over the primer to a thickness of about 250 microns. The Nitowrap CF fabric is cut to the specimen size and pasted over the saturant. Care to be taken there should not any air bubbles, which can be removed with the help of surface rollers. Figure.3 Shows the process of CFRP wrapping. One more coat of Nitowrap 410is then applied over the fabric to a thickness of about 250 microns. The second layer of Nitowrap CF fabric was laid after 30 minutes. At any time the orientation of fiber should not get disturbed during the application of saturant. Finally Nitowrap 512 is applied in two coats for the UV resistance to a thickness of 100 microns per coat as a top coat. The coatings will become tack free in approximately 4 – 6 hours and be fully cured in 7 days.

Figure. 3 Process of the CFRP Wrapping

3.0 RESULTS AND DSICUSSION

3.1 Axial Load Test

All the specimens were tested under monotonically increasing concentric compressive load in the 2000kN capcity compression testing machine(8)(9). The load was applied gradually at a constant rate till failure. The deformations were measured using deflectometer .Test set up is shown in Figure.4 and Figure 5. Crack were observed on the column as load progress. The ultimate load carrying capacity of different specimens are plotted in Figure. 6. From the result it was observed that the percentage increase of load in CR specimens is 79% higher when compared to the CC specimen. The percentage increase in SR specimen is 42 % higher than the SC specimen. The Percentage increase in RR specimen is 28% higher than the RC specimen. Carbon fibre wrapped circular column is more effective compared to carbon fibre wrapped rectangular column and square column because while applying the axial load to columns unconfined area in the rectangular column and square column reduces the load carrying capacity of columns, In circular column confined area is more it take up more load. So, the load carrying capacity of circular column is higher and the section is economical. Figure .7 shows the confinement area of the circular , square and rectangular column. In the case of conventional column, the percentage increase of load in RC specimen is 54.6% higher than CC and 29 % higher than SC, whereas 20 percentage increase was noted when RC compared with SC. In the case of retrofitting column, the percentage increase of load in RR specimen is 11% higher than CR and 3 % higher than SR, whereas 13 percentage increase was noted when RR compared with SR. The energy absorption capacity of SR column is 29 % higher than SC specimens, whereas 3% increase was noted when RR compared to RC specimens and 45 % increase was noted when CR specimens compared with CC specimens.

Figure. 4. Testing of the Circular Square and Rectangular conventional Specimens

Figure. 5 Testing of the Circular Square and Rectangular CFRP wrapped Specimens

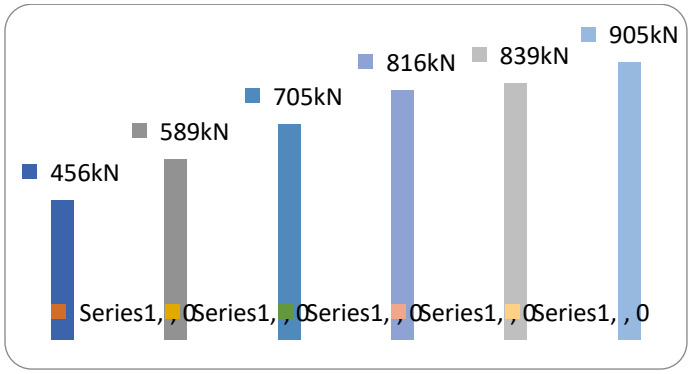

Figure.6 Comparison of Load Carrying Capacity of Specimens

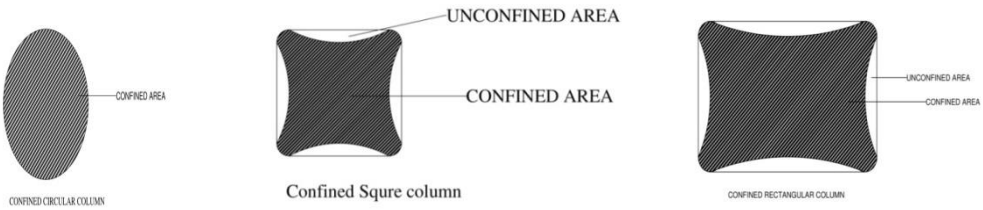

Figure.7 Confinement of all Specimens

3.2 Stress-Strain Response and energy absorption capacity

From the experimental observation of corroded and conventional specimen a graph is plotted between stress versus strain as shown in Figure.8. The axial strain were noted at eighty percentage of loading and energy absorption capacity was calculated for area under stress-strain curve.(10) as shown in Figure .9. the From the result it was observed that the percentage increase energy absorption capacity in CR specimens is 13% higher when compared to the CC specimen. The percentage increase in SR specimen is 29 % higher than the SC specimen. The Percentage increase in RR specimen is 3% higher than the RC specimen. In the case of conventional column, the percentage increase energy absorption capacity in SC specimen is 19.62% higher than RC and 13% higher than CC, whereas 7 percentage increase was noted when CC compared with RC. In the case of retrofitting column, the percentage increase in energy absorption capacity in SR specimen is 36% higher than RR and 24 % higher than CR, whereas 16 percentage increase was noted when CR compared with RR.

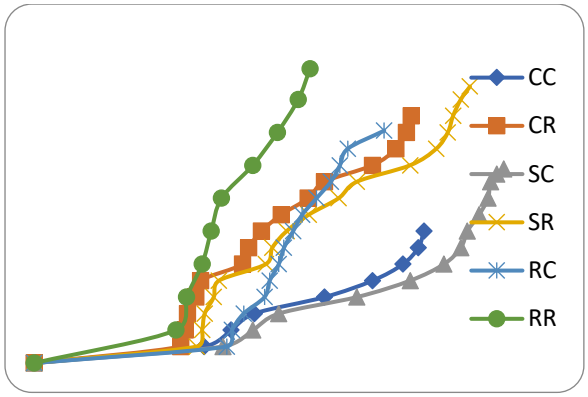

Figure .8 Comparison of Load Vs Deflection of all Specimens

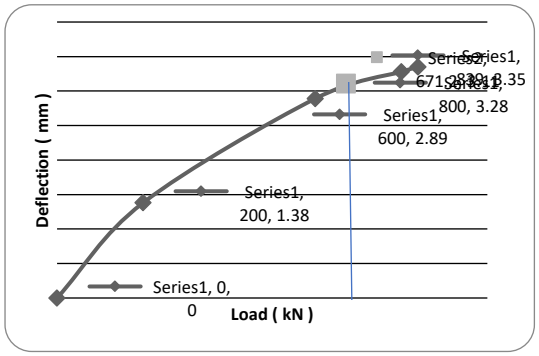

Figure .9. Energy Absorption Capacity of the Specimen.

4.0 CONCLUSION

- The percentage increase in ultimate load carrying capacity of CFRP wrapped circular column is higher than the conventional circular column.
- Carbon fibre wrapped circular column is more effective compared to carbon fibre wrapped rectangular column and square column because while applying the axial load to columns unconfined area in the rectangular column and square column reduces the load carrying capacity of columns, In circular column confined area is more it take up more load. So, the load carrying capacity of circular column is higher and the section is economical.
- .This test result concluded that energy absorption capacity of column get increased while column is externally wrapped with carbon fibre reinforced polymer and also concluded that square has more seismic resistance compared to the rectangular column.
- CFRP material becomes a notable material in construction industry it increases the strength of the structural members , seismic resistivity , retrofitting of old structures even though the carbon fibre rate is high it replace the parts rather additional reinforcing the structures.

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