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Enhancing the Compressive Strength of Square Cross Sectional Column Using FRP Material

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Abstract: Now a day various material used in civil engineering field for enhancing the strength of structural member in moderate cost .fiber reinforced polymer is one of the modern material used for enhance the strength of structural members. It is composite materials are becoming more frequently used in civil engineering structures. In this work we practically used application of this new material for enhancing the strength of square cross sectional columns by means confinement with fiber sheets. In square cross sectional column confining with fiber reinforced polymer (confinement action) is mostly located at corners. The main aim of this paper to show the most utilized techniques of performing composite confining systems for reinforced concrete columns with their advantages. In this study prepare a square cross sectional (150X150mm) columns and 300mm its length. Its length to width ratio is 2.0 and provided 1.30% longitudinal reinforcement in columns. After 28 days column wrapped with 0,2,4,6 and 8 layers of GFRP outside the surface of the specimens as confinement. The 28 days compressive strength of specimen wrapped with 8 layers of GRRP was increased by 33% as compared to the strength of specimen without any confinement
Keywords: square cross sectional column, compressive strength, fiber reinforced polymer, confinement.

I. INTRODUCTION

Day by day civil engineering converted to very vast science. Various products and material available in market to increasing the structural capacities in all aspects. Fiber reinforced polymer is sheets for the external wrapping of concrete compressed members is today a very popular theme, the external wrapping in external in column is very effective. The role of FRP for strengthening of existing or new reinforced concrete structures is growing at an extremely rapid pace owing mainly to the ease and speed of construction, and the possibility of application without disturbing the existing functionality of the structures. . Fiber reinforced polymers (FRP) composites comprise fibers of high tensile strength within a polymer matrix such as vinyl ester or epoxy. The epoxy resin is used to align the fibers in proper direction and bond the wrap with the structural member. The advantage of the FRP includes high strength to weight ratio, high stiffness, corrosion resistance, high specific strength, and durability. While FRP can be used to strengthen many different structural members such as beams, columns, slabs and chimneys. Confinement is generally applied to member in compression, with the aim of enhancing their load caring capacity on, in cases of seismic upgrading, to increase their ductility. Advanced FRP composites materials have only recently been recognized as reliable confinement devices for reinforced concrete elements.

The concept enhancing the strength of square cross sectional RC column by FRP material: - FRP sheets are wrapped around the columns with fibers oriented perpendicular to the longitudinal axis of column are fixed to the column using epoxy resin. The wrap not only provides passive confinement and increases the concrete strength, but also provides significant strength against shear. FRP composites are different from traditional construction - As concrete is uniaxial compressed due to load, passions effect induces transverse strain that result in radial expansion of the concrete. This increase in transverse strain results in volumetric expansion. By confining the concrete using a continuous FRP jacket, i.e. wrapping of RC columns By high strength low weight fiber wraps to provide passive confinement, the fibers resist the transverse expansion of the concrete and provide passive confinement which increase both strength and ductility.

II. RELATED WORK

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The behaviour of FRP wrapped concrete cylinders with different wrapping materials and bonding dimensions has been studied by Lau and Zhou1 (2001) using the finite element method (FEM) and other analytical method. It was found that the load carrying capacity of the wrapped concrete structure is governed by mechanical properties such as tensile elasticity modulus and Poisson's ratio of the wrapping sheet. Manuel and Carlos2 (2006) have conducted tests on modes of circular cylindrical columns of concrete with GFRP jackets subjected to axial loading for different height of cylinders and it was found that the increase in number of layers led to an increase in the maximum load. Riad, et al3 (2003) conducted tests on square glass fiber composites. It was found that the stiffness of the applied FRP jacket was the key parameter in the design of external jacket retrofits. Shamim, et al4 (2002) have investigated the seismic behaviour of concrete columns confined with steel and FRP. It was concluded that the use of GFRP significantly enhances strength, ductility and energy absorption capacity of columns. Mander et al.5 (1988) proposed a model to calculate the increase in concrete compressive strength due to confining pressure provided by transverse reinforcement in reinforced concrete columns. The model has been extended to the case of FRP-confined circular and square reinforced concrete by sections several researchers Wang and Restrepo6 (2001).

This paper envisages the effect of lateral confinement using GFRP sheets on strength of reinforced concrete compression specimens.

III.EXPERIMENTAL INVESTIGATION

Test specimen details: - Experiments were conducted on rectangular specimen. The specimen of height 300 mm and 150 mm x 150mm in cross section were used. Reinforcement used for the column is shown in fig.1 and the details of the specimens tested are given in table 1. The ingredient used in concrete was OPC of 43 grade (JP cement), Local River sand confirming to zone II (specific gravity 2.61) and clean portable water. A design mix of M-40 (1:1.65:2.92) were used to prepare the specimens. Fe 415 grade steel is used as longitudinal reinforcement and lateral ties. Specimen was wrapped externally by 2, 4, 6 and 8 layers of GFRP sheets. Before strengthening the specimens with GFRP sheets, a surface preparation was carried out, which included cleaning, and then epoxy adhesive was used for bonding GFRP sheets on the specimens. Additional layers of epoxy adhesive were applied between GFRP sheets.

A. Reinforcement And Confinement Details

Experiments were conducted on square cross sectional column specimen. The cross section of specimens 150 mm x 150mm and 300mm height used Reinforcement used for the column is shown in fig.1 and the details of the specimens tested are given in table 1. . The ingredient used in concrete was OPC of 43 grade (JP cement), Local River sand confirming to zone II (specific gravity 2.61) and clean portable water. A design mix of M-40 (1:1.65:2.92) were used to prepare the specimens. Fe 415 grade steel is used as longitudinal reinforcement and lateral ties.

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Table-1 reinforcement and confinement details

No.	No of GFRP Layers	Specimen Size (mm x mm)	Longitudinal reinforcement	Stirrups
R-1	0	150x150	4 Nos of 10mm dia.	8mm dia at 90mm c/c
R-2	2	150x150	4 Nos of 10mm dia.	8mm dia at 90mm c/c
R-3	4	150x150	4 Nos of 10mm dia.	8mm dia at 90mm c/c
R-4	6	150x150	4 Nos of 10mm dia.	8mm dia at 90mm c/c
R-5	8	150x150	4 Nos of 10mm dia.	8mm dia at 90mm c/c

Strengthening of columns before bonding the composite fabric on to the concrete surface the required region of concrete surface was made rough using a coarse. Sand paper texture and cleaned with an air blower to remove all dirt and debris. One the surface was prepared to the required standard, the epoxy resin was mixed in accordance with manufacturer's instructions mixing was carried out in a plastic container and was continued until the mixture was in uniform color. When this was completed and the fabrics had been cut to size, the epoxy resin was applied to the concrete surface. The composite fabric was then placed on top of epoxy resin coating and the resin was squeezed through the roving of the fabric with the roller. Air bubbles entrapped at the epoxy/concrete or epoxy/fabric interface were to be eliminated. Then the second layer of the epoxy resin was applied and GFRP sheet was then placed on top of epoxy resin coating and the resin was squeezed thorough the roving of the fabric with the roller and the above process was repeated. This operation was carried out at room temperature. Concrete specimens strengthened with glass fiber fabric were tested after 24 hours at room temperature. Strengthening process of specimens is shown in figure 2, 3 and 4 .

Fig.1 – detail of reinforcement

Fig.2- reinforcement with mould

Fig.3 – Columns after 28 days curing

Fig.4 fiber reinforced

Fig.5 – cuttings of FRP material

Fig.6 - using epoxy resin

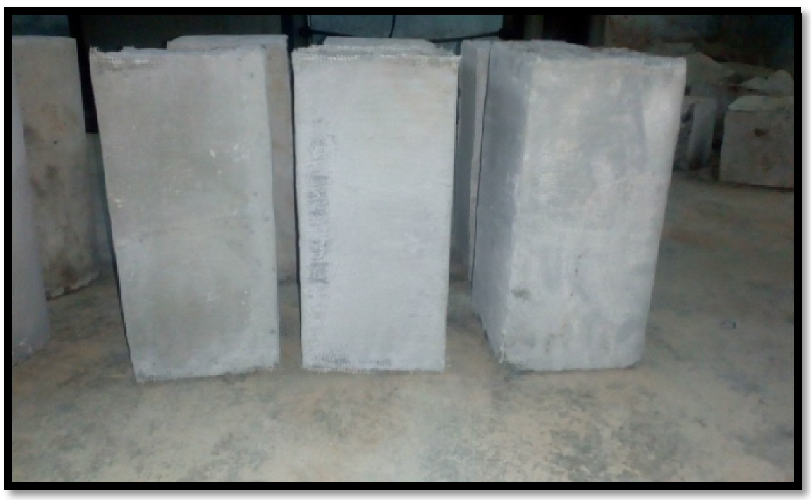

Fig.7-Columns after strengthening with GFRP

Fig.8-Columns after strengthening with GFRP

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IV. EXPERIMENTAL RESULTS

A. Experimental Results And Discussion

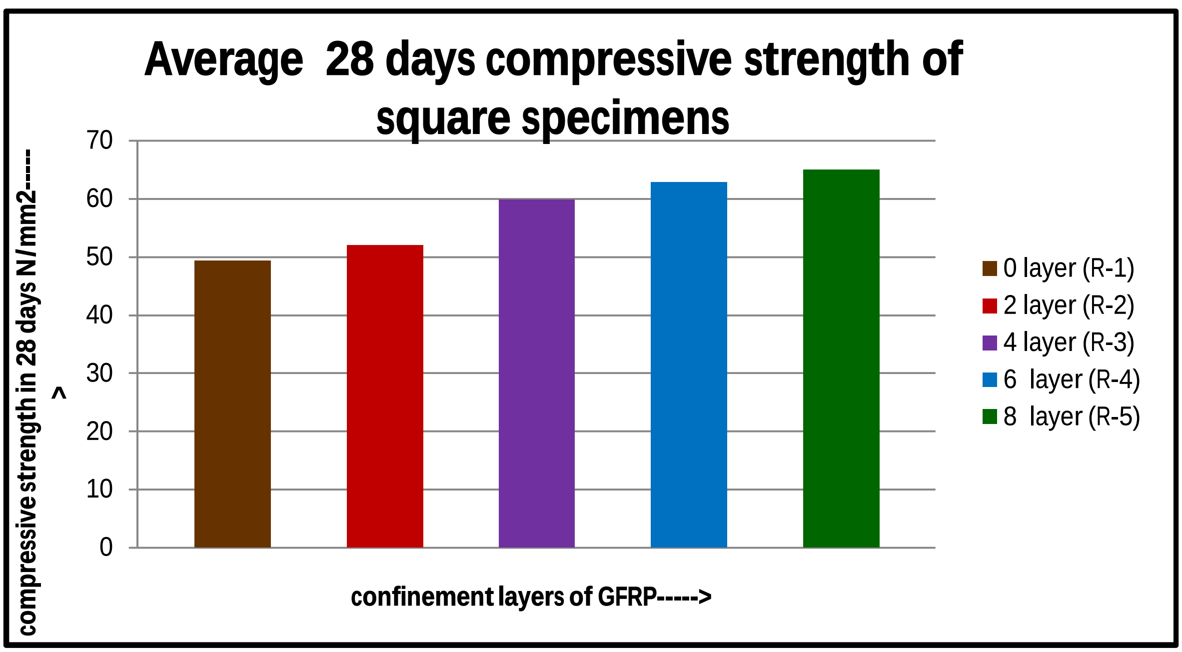
The specimens were tested for compressive strength on a machine having 2000KN capacity show in fig.7. In rectangular specimen total five sets of specimen R-1, R-2, R-3, R-4 and R-5 tested for compressive strength for different layer of GFRP i.e. 0,2,4,6 and 8 layers respectively. It was observed that the specimen R-5 has maximum strength when compared to that of the specimen R-1, which has zero layers GFRP.

B. Results

In the specimen without GFRP wrapping R-1, failure was due to concrete crushing at the specimen and cracks were noticed along the height of the column, for the other Glass fiber wrapped specimens, failure occurred due to the fracture of GFRP composites at the columns due to the stress concentration in those regions. In all cases, the columns failure was the results of the rupture of the FRP jacket, associated with concrete crushing of the specimen. The failure was started at edges of specimen and then progressed towards center of specimen. The test results are summarized in table-2.

TABLE-2 TEST RESULTS

S. No.	Specimen designation (sets)	No. of GFRP layer	Average compressive strength of specimen) N/mm2
1	R-1	0	48.88
2	R-2	2	52.03
3	R-3	4	59.85
4	R-4	6	62.95
5	R-5	8	65.03



V. CONCLUSIONS

From the series of tests conducted on the concrete specimens with different degree of confinement the following conclusions are drawn:

The confinement in the form of GFRP sheets increases the compressive strength of the square cross sectional column specimens remarkably.

If the specimen is wrapped with 8 layers of GFRP sheets the strength increases to 33% of the strength without confinement

From the study it can be concluded that the column can be confined with GFRP sheets to increase their strength to a great extent. This material (GFRP) may be used in seismic retrofitting or RCC compression members.

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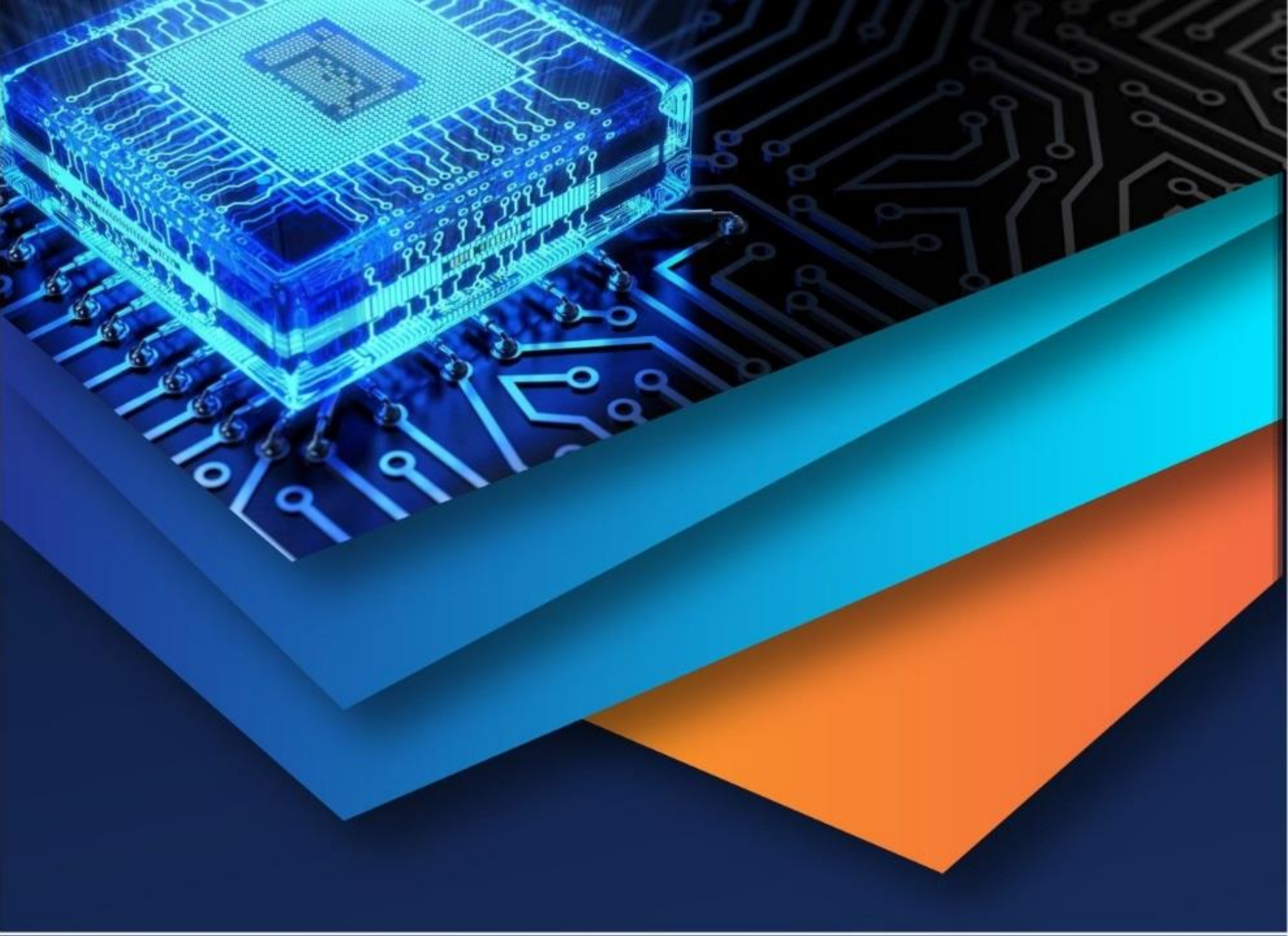

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