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COMPRESSION BEHAVIOR OF CIRCULAR AND RECTANGULAR RC COLUMNS RETROFITTED BY GFRP LAMINATES: AN EXPERIMENTAL STUDY

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ABSTRACT

The study aims at evaluating the effect of retrofitting by GFRP on circular and rectangular columns. Both control and retrofitted columns of circular and rectangular shapes were tested on CTM and UTM to determine the compressive strength after 7 and 28 days. From the experimental data, it is observed that there is increase in compressive strength in the retrofitted specimens, both in circular and rectangular columns. For retrofitted circular columns, there is 20.36% increase in compressive strength. Also, there is an increase of 19.23% of compressive strength in rectangular retrofitted columns. Strictly from the experimental study, it is observed that retrofitting by GFRP is most efficient in circular columns. Retrofitting by GFRP can be employed in case when the structures are subjected to severe load combinations.

Keywords-*Circular and Rectangular Columns, Compressive strength, GFRP,Retrofitting*

I. INTRODUCTION

There are a number of reasons that lead to retrofitting of RC structures, which are: seismic activity, higher load demand, higher strength demand, constructional errors, deterioration caused by environmental factors, change in use of the structures, etc. Due to the formation of cracks, there is decrease in strength of a structure. So to regain its strength, a structure needs to be retrofitted[1]. So to sum up, retrofitting is modification of existing structures to make them more resistant towards the external loadings. Some of the retrofitting methods that has been applied in the past are steel plate bonding, jacketing, external post tensioning, addition of new structural elements, use of different types of FRP's, etc and these methods were successful[2]. According to literature available, use of FRP for retrofitting proves to be more efficient and economical. Glass Fiber-reinforced polymers (GFRP) are light weight in nature,

easy for implementation and have high tensile strength and also are corrosion resistance[3]. Due to these reasons, FRP composites are preferred solutions for strengthening of various reinforced concrete structural elements and are now extensively being used all over the world. Physical properties and mechanical properties of FRPs are governed by its basic properties and the structure at micro level[4]. In FRP's, the main load bearing component are the fibers. FRP products that are used in retrofitting of structures can be in the form of strips, sheets and laminates[5]. In our experimental study, FRP provides strength and stiffness to the structural component on which it will be wrapped[6].

II.MATERIALS AND METHODOLOGY

For the casting of columns, various construction materials are used like cement, fine aggregates and coarse aggregates and water. GFRP laminates are used for the purpose of retrofitting.

Cement: Portland pozzolana cement (PPC) was used for the casting of the columns. The cement has been checked for various properties and they are accurate taking IS:4031-1968 into consideration.

Coarse aggregates: Size of the aggregates which will be used in the making of concrete are 10mm and 20mm. This material has to satisfy IS:383-1970. Locally available aggregates and some basalt stone chips was used in this study.

Fine aggregates: Locally available riverbed sand was used and it should be confirming some zone which depends upon the sieve analysis of the sand[6].

Glass fibers: These fibers are generally made up of silicon. Their main characteristic is high strength. After retrofitting, glass fibers enhance various properties of the structure. Table 1 gives the properties of glass.

Table 1: Properties of glass

Thickness	0.32 mm
Weight	935 g/m^2
Tensile strength	2290 MPa
Tensile modulus	74632 MPa
Ultimate elongation	0.025

Epoxy: Epoxy is used as a resin and it will act as a binder for the purpose of wrapping of GFRP. Tensile strength and flexural modulus of epoxy is 37 MPa and 3680 MPa respectively, with elongation of 1.2%.

Steel: HYSD bars of 8mm were used for main reinforcement and stirrups of 6mm were used for both circular and rectangular columns with a minimum cover of 10mm for main reinforcement.

Mix proportion: Design mix of M20 concrete and was done taking IS:10262-2009 into consideration as given in table 2.

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Table 2: Mix Proportion

Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (kg/m^3)
387.5	608.79	1181.50	186
1	1.570	3.049	0.48

Therefore; ratio of concrete= 1:1.570:3.049

III. EXPERIMRNTAL SETUP

Total number of 24 columns were casted and were cured in a curing tank. Among these samples, 12 columns were rectangular and rest were circular. The diameter of circular column was 150mm and its height was 350mm. Cross-section of rectangular columns was 150mm×150mm and their height was 350mm. The columns were tested after 7 days and 28 days. All these samples were tested under compression testing machine CTM and UTM. After application of load, cracks were developed in the sample and load at failure was determined. The rate of loading was kept constant at 0.01mm/sec. To regain the strength in the columns, epoxy resin was coated on the surface for the purpose of bonding and then GFRP was wrapped around the specimen. Again the retrofitted specimens were tested under the same rate of loading and their strength was determined. The details of rectangular and circular specimens are given below in FIG I-V.

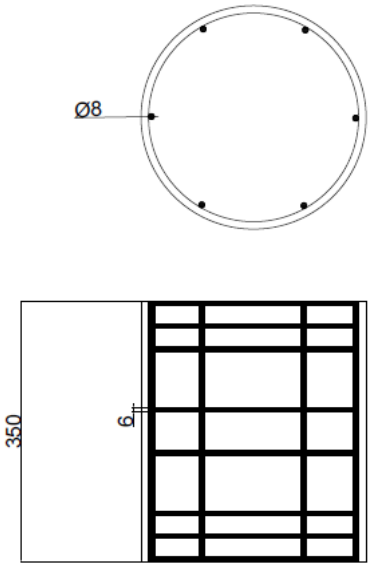

FIG I: Circular Specimen

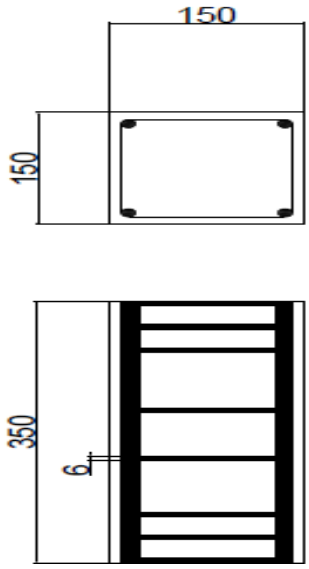

FIG II: Rectangular Specimen

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FIG III: Circular Column **FIG IV: Rectangular column** **FIG V: Retrofitted column**

IV. RESULTS AND DISCUSSION

The testing of specimens has been performed after 7 days and 28 days for both control and retrofitted columns. From the experimental findings, it is clear that there is increase in load carrying capacity in retrofitted specimens. There is increase of 20.36% of compressive strength in circular retrofitted specimens after 28 days. Also there is increase of 19.23% of compressive strength in retrofitted rectangular specimens as given in Table 3.

Table 3: Compressive Strength after 7 and 28 days of different specimens.

Specimen		Diameter/height (mm)	Number of samples	Average strength (MPa), 7 days	Average strength (MPa), 28 days
Circular	Control specimen	150/350	03	18.26	33.91
	Retrofitted specimen	150/350	03	23.05	42.58
Rectangular	Control specimen	150/350	03	17.89	32.41
	Retrofitted specimen	150/350	03	22.83	40.13

From FIG VI and FIG VII, it is shown that circular retrofitted columns are having higher capacity to carry loads effectively than retrofitted rectangular columns. It is because of air entrapped in case of rectangular columns while wrapping the GFRP sheets, usually at the corners.

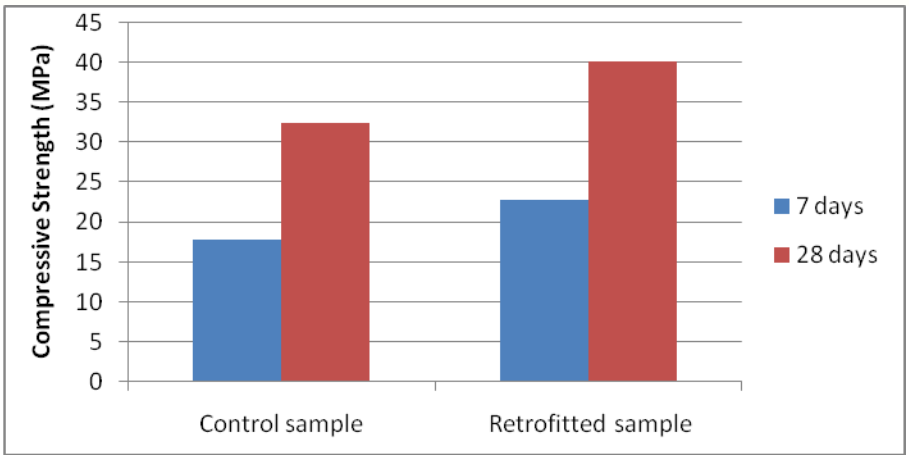

FIG VI: variation of compressive strength of Rectangular specimens after 7 and 28 days

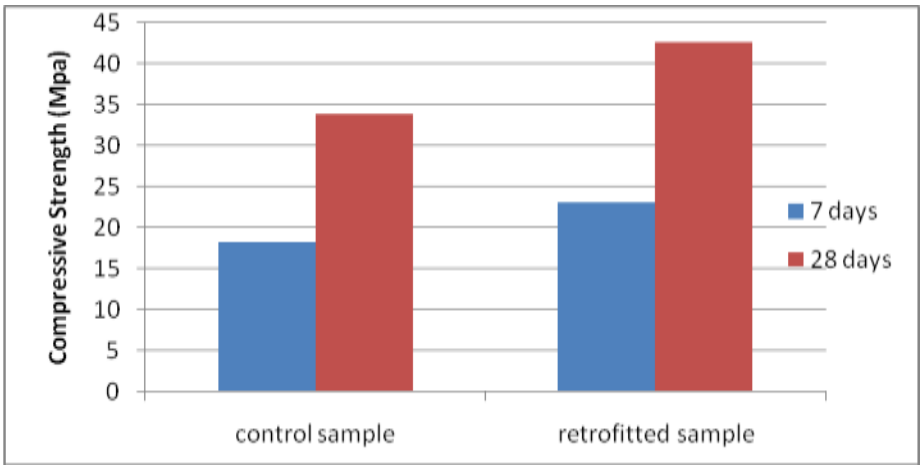

FIG VII: Variation of compressive strength of circular specimens after 7 and 28 days

V. CONCLUSIONS

The retrofitting plays an important role in enhancing the overall strength, stiffness, ductility and load carrying capacity of the structure. Approximately, there is around 20% increase in the strength of retrofitted columns. Therefore this exploration can be quite useful for the structures damaged by natural calamities like seismic actions, to modify and regain their strength. Also the retrofitting proves to be most efficient in case of circular specimens. Therefore, shape of the cross section contributes to the increase in strength. If there are more number of layers of GFRP, significant increase in strength is observed. Thus number of layers and type of binder (epoxy) also influence the strength increase in retrofitted specimens.

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