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An Experimental Study on Retrofitting Concrete Subjected to Lateral Loading

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Abstract — **In this research project describes the retrofitting of the structural member by GFRP sheet. Generally, RCC structures fail, due to various factors like seismic loads, deterioration of the concrete, corrosion of RC elements, ageing of the structures etc. Due to that effects, the old structures to be rehabilitated in a cost-effective way. One of the process of this retrofitting technique was used to withstand lateral loading and also increasing the strength of the old structures. The recent retrofitting techniques such as concrete jacketing, steel jacketing, Fiber Reinforced Polymer (FRP) wrapping were used in field. From this study, we identified that the load carrying capacity of retrofitted M30 grade of RCC beams using GFRP sheet was increased gradually when compared to conventional beams.**

Keywords*— *Glass Fiber Reinforced Polymer (GFRP) sheet, RCC beams, M30, retrofitting, load carrying capacity.

I. INTRODUCTION

Rehabilitation and strengthening of old structures using advanced materials is a contemporary research in the field of Structural Engineering. During the past two decades, much research has been carried out on shear and flexural strengthening of reinforced concrete beams using different types of fiber reinforced polymers and adhesives. Strengthening of old structures is necessary to obtain an expected life span.

Life span of Reinforced Concrete (RC) structures may be reduced due to many reasons, such as deterioration of concrete and development of surface cracks due to ingress of chemical agents, improper design and unexpected external lateral loads such as wind or seismic forces acting on a structure, which are also the reasons for failure of structural members. The superior properties of polymer composite materials like high corrosion resistance, high strength, high stiffness, excellent fatigue performance and good resistance to chemical attack etc., has motivated the researchers and practicing engineers to use the polymer composites in the field of rehabilitation of structures.

II. MATERIALS AND METHODS

Cement:

Ordinary Portland Cement (OPC) 43-grade was used for casting of beams. Cement used was confirming as per IS 8112:1989. The specific gravity was 3.15. The initial and final setting time was 30 min and 600 min respectively.

Coarse aggregate:

Locally available crushed stones, basalt stone were used for casting of concrete. Only 20 mm aggregates were used. The material satisfied IS 383-1970. The specific gravity of 20mm aggregate 2.7 respectively. Water absorption was 0.75%.

Fine aggregates:

Locally available river bed sand was used as per IS: 383-1970 provision it was in range of zone II. Specific gravity of FA was 2.81 and water absorption was 1.5%.

Glass Fiber Sheet:

Glass fibers, typical form shown in Fig.1 are isotropic in nature and most widely used filament. Common types of glass fibers are E-Glass, S- Glass and C-Glass. The characteristic properties of glass fibers are high strength, low cost with good water resistance and resistance to chemicals.

Fig. 1 Glass fiber sheet

Table 1. Properties of Glass Fibre Sheet

Tensile strength (MPa)	3400-4800
Modulus of elasticity (GPa)	70-90
Density (kg/m^3)	2200-2500

Epoxy Resin:

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Epoxy resins are relatively low molecular weight pre-polymers. In civil engineering industry, for coating and bonding purpose epoxy resins are used. The epoxy resin is two-part system, resin as adhesive and hardener as catalyst. The resin and hardener used in this our study are Araldite LY. 556. and Hardener HY. 951 shown in fig 2.

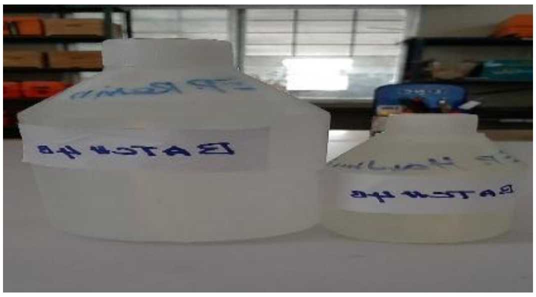

Fig. 2 Epoxy Resin

Table 2. Properties of Araldite Ly. 556

Aspect (visual)	Clear liquid
Viscosity	10000-12000 mPa.s
Density	1.15-1.2 g/cm^3

Table 3. Properties of Hardener Hy 951

Aspect (visual)	Clear liquid
Viscosity	10-20 mPa.s
Density	0.98 g/cm^3

Perma master bond:

Perma master bond (as shown in fig. 3) is two component permanent epoxy adhesive for internal or external bonding or rendering, granolithic toppings, and concrete. The ultimate bond strength is greater than the tensile strength of concrete, master bond does not shrink and provides an even and stress-free bond. The primary use of this bond to bonding old concrete to new concrete.

Table 4. Properties of Perma Master Bond

Colour	Pale yellow
Specific gravity	1.60 at 25°C
Tack free time	Within approx.6 hours
Pot life	Approx. 1 hour
Bond strength	In concrete 3 N/mm^2 In steel 15 N/mm^2

Fig. 3 Perma Master Bond

Mix proportion:

Design mix of M 30 concrete is done by IS 10262 2009.

- Cement Content = 394 kg/ m3
- Water content = 197 kg/ m3
- Coarse aggregate = 1113 kg/ m3
- Fine aggregate = 725.496 kg/ m3

MIX RATIO: 1: 1.8: 2.8

III. SPECIMEN LAYOUT

Two beams were cast using M30 concrete grade and Fe 415 grade of steel. The dimensions of all the beams were same. Beam is 1500 mm long and having area of cross- section 100 mm x 150 mm as shown in fig. 4.

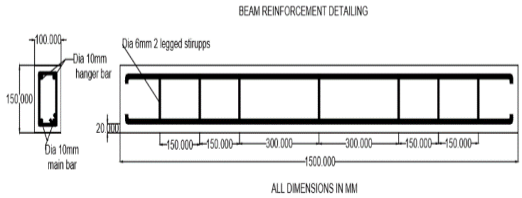

Fig. 4 Reinforcement Details of RCC Beam

IV. EXPERIMENTAL INVESTIGATION

First step before application of GFRP sheets on surface of beam, the area on which GFRP sheet was to be bonded was made rough using sand paper. After making surface ready for application of GFRP sheet, epoxy resin was mixed as per the manufacturer's instructions. Mixing was done in jug with Araldite LY. 556 – 100 parts by weight and Hardener HY 951 - 7.5 parts by weight.

It was mixed till uniformed texture. On other side fiber sheets were cut as per the requirement. Ready epoxy resin was applied on the surface of beam with help of paint brush as shown Fig 5.

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Fig. 5 Application of epoxy resin on glass fiber sheet.

Beams were cured for 14 days and then they were cleaned with water so that cracks should be visible. Two-point loading arrangement was used for testing of beams. The beam was placed over the two steel rollers bearings leaving 50 mm from the both sides of beam. Rest of the part was equally divided in to three equal parts. Load was applied by loading cell of 1000 kN. Two dial gauges were used for recording deflection. One dial gauge was placed at center and other was placed under 1/3rd distance of beam as shown in fig. 6.

Fig. 6 Experimental setup of beam.

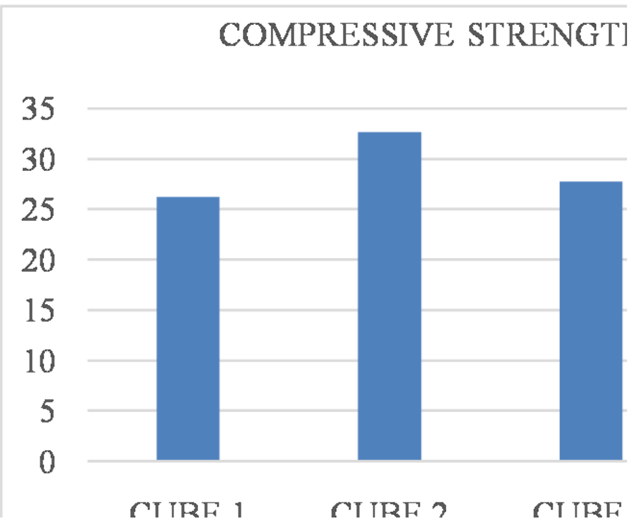
V. RESULTS AND DISCUSSION

Compressive strength of concrete:

The Table. 5 shows the characteristics compressive strength of concrete specimens at 28 days

Table 5 Characteristics Compressive Strength of Concrete

Test Specimen	Age Of Concrete = 28 Days		
	Load (Kn)	Compression Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
CUBE 1	660	29.32	31.106
CUBE 2	730	32.45	
CUBE 3	710	31.55	

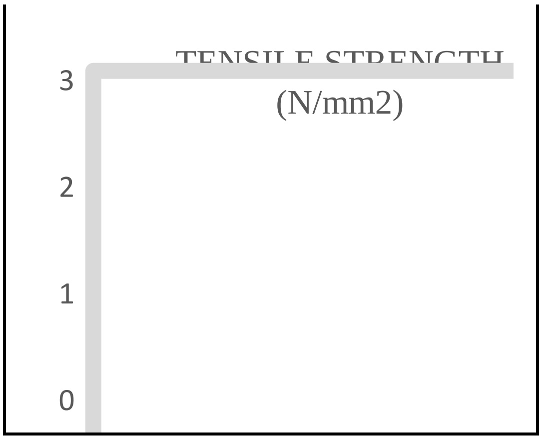


Split tensile strength of concrete:

The Table. 6 shows the characteristics Split tensile strength of concrete specimens at 28 days

Table 6 Characteristics Tensile Strength of Concrete

Test Specimen	Age Of Concrete = 28 Days		
	Load (Kn)	Split Tensile Strength (N/mm^2)	Average Tensile Strength (N/mm^2)
Cylinder 1	130	1.84	2.026
Cylinder 2	140	1.99	
Cylinder 3	160	2.25	

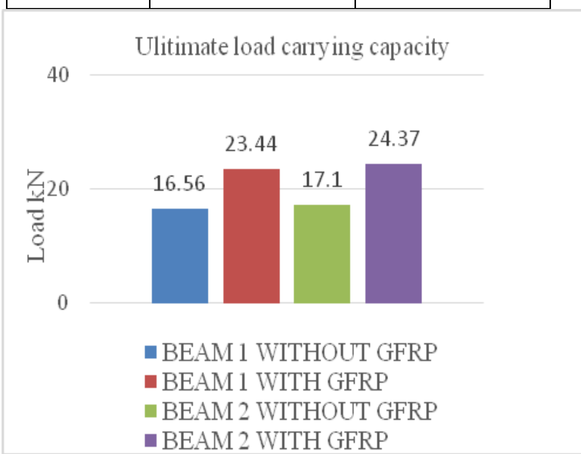


Ultimate Load Carried by Beams:

The Table. 7 shows the ultimate load carried by the normal and GFRP specimens

Table 7 Load Carrying Capacity Beams

Ultimate Load Carried by Beams		
Beam No.	Without GFRP KN	With GFRP KN
1	16.56	23.44
2	17.1	24.37



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- The above results show the cast specimens achieved the target mean strength in both compression and split tensile test.
- The flexural strength of the beam is achieved as per the mix design for the size of 0.15m x 0.1m x 1.5 m.
- By using GFRP sheet, there is a certain increment in load carrying capacity of a beam and also deflection is decreased.
- Finally, on the basis of an above results while using GFRP sheet there is a 30% increment of load carrying capacity when compared to conventional beams.

VI. CONCLUSION

- From this study we found that, to extend the life span of the existing structures Sheet retrofitting technique by using GFRP to be used in RCC beams.
- From the experimental results, it has been observed that the retrofitting of beam using GFRP sheet has produced higher strength when comparted to ordinary RCC beam and also it resist the deflection.
- The ultimate load carrying capacity of a beam while using GFRP sheet retrofitted beam is increased 30% when compared to conventional beams.

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