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Increasing the Strength Parameters of Beams of M_{30} Grade Concrete by Use of Various FRPs

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***Abstract* - Safety of Civil Engineering structures is of paramount importance. Different methods have been adopted by scientist for stabilizing the concrete structures, but still lack of knowledge of the geography of the region; many structures fail to satisfy. Still instances are there regarding many such structures do not meet to the specified design requirements, thus become unsafe. Completely demolishing an old structure and then reconstructing is too cumbersome and uneconomical besides time consuming and troublesome. One of the most economical, effective materials for rehabilitation and strengthening of RCC beams that has been found and is being used from the last decade is fibre reinforced polymer. (Danraka1, Mahmod and Oluwatosin, 2017) They do have high strength to weight ratio, high stiffness, and corrosion resistance. In these study 15 numbers of RCC beams were casted. M30 grade of concrete mix was used and all beams of same detailing were used. Three beams each were used as control beams without strengthening. The same number of beams were strengthened with Carbon Fibre Reinforced Polymer, Glass Fibre Reinforced polymer, Aramid Fibre Reinforced Polymer and Polyethylene Terephthalate Fibre Reinforced Polymer. Beams wrapped with Carbon Fibre Reinforced Polymer has enhanced the flexural strength of beam by 33.33%, beams wrapped with Aramid Fibre Reinforced polymer improved flexural strength by 26%, beams wrapped with Glass Fibre Reinforced polymer improved flexural strength by 20% and finally wrapped with Polyethylene Terephthalate Fibre Reinforced polymer improved flexural strength by 15%. The overall implications of the above study are to compare the results with the normal RCC beams and justifiable reasons are incorporated with the results about the enhancement of flexural strength without disturbing all the other parameters.**

Keywords: AFRP, CFRP, FRP, PET-FRP.

I. INTRODUCTION

For structures which have become structurally weak over the span of time, use of fibre reinforced polymers is very effective and economical method for increasing their strength and retrofitting unlike traditional methods. The major constituents of FRP are Fibre and Resin. The type of fibre determines mechanical property of FRP and types of resin increase its durability characteristics. (Sterlin, Sam and Sruthi, 2016) For the flexural strengthening of a beam, FRP sheets or plates are applied to the tension face of the beam. Principal tensile fibers are oriented in the beam longitudinally similar to its internal flexural steel reinforcement. This increases the beam strength and its stiffness; however it decreases the deflection capacity and ductility (Meikandaan and Murthy, 2017).

II. MATERIALS USED

Concrete which means compounded has one of the most utilized substances consisting of graded range of aggregates, bonded to cement paste by water. Strength, durability, permeability and other properties of the concrete depend on the properties of materials, mix proportion, compaction method, curing etc. Concrete of Grade M_{30} used in this experiment was used with OPC 43 brand name 'Khyber'. The size of the coarse aggregates was 20mm and fine aggregates passing through sieve 4.75mm. Water which is neutral in nature (pH approximately 7) is used for preparing the mould. Reinforcement bars having 10mm dia and 2 in numbers are used as top and bottom reinforcement. Vertical stirrups of 6mm dia @150mm c/c are used in this experiment. Fibre Reinforced Polymer is a composite material. The word composite is used to refer two constituent materials i.e., Fibres and Matrix. Fibres provide strength and stiffness to the beam while the function of Matrix is to support, protect and maintain the relative position of fibres on beams. Fibres are 20-25 times stiffer and 50 times stronger than matrix. Main function of matrix is that of glue enabling fibre to support applied load, mostly used for strengthening civil structures. Four different types of FRPs were used:

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1. Carbon Fibre Reinforced Polymer: CFRPs have high strength and stiffness, low density and resistance to corrosion.

2. Glass Fibre Reinforced Polymer: GFRPs have ductile behavior making them suitable for seismic retrofitting and possibility to construct building on low bearing capacity.

3. Aramid Fibre Reinforced Polymer: AFRPs do not rust or corrode, and their strength is unaffected by immersion in water When woven together, they form a good material for mooring lines and other underwater objects. (A.I.T., chikkamagaluru, Dept. of civil engineering, Rehabilitation and Retrofitting of structures)

4. Polyethylene Terephthalate Fibre Reinforced polymer: PET a thermoplast resin has low tensile strength but high fracture strain. PET-FRP has good mechanical property and good chemical resistance. It is also used for production of fibers for very wide range of applications in textile industry.

III. TESTING OF MATERIALS AND EXPERIMENTAL SETUP

Before casting the beams for final testing, the ingredients of mortar used i.e. fine aggregates and course aggregates were tested in the laboratory. For each element specific gravity, fineness modulus and bulk density were calculated whereas for cement specific gravity, normal consistency, initial and final setting time were calculated.

1. Fine aggregates:

The fine aggregates or sand used was normal sand obtained from river bed in the nearby vicinity (Table I).

TABLE-1
Properties of Fine Aggregates

Sl. No.	Physical property	Value
1	Specific gravity	2.70
2	Fineness modulus	6.5
3	Bulk density	1510kg/m^3

2. Coarse aggregates:

The coarse aggregates were brought from nearby river bed (Table II).

TABLE-II
Properties of coarse aggregates

Sl. No.	Physical property	Coarse aggregates
1	Specific gravity	2.65
2	Fineness modulus	2.53
3	Bulk density	1470kg/m

3. Cement:

The cement used was ordinary Portland cement of grade 43 brand name Khyber cements. Number of tests was performed on cement according to IS 4031 –part 1 (Table III).

TABLE-III
Properties of OPC

Sl. No.	Specific gravity	2.90
1	Soundness	2 mm expansion
2	Normal Consistency	35%
3	Initial Setting Time	90 min
4	Final Setting Time	525 min

IV. CASTING OF SPECIMEN

15 no. of beams of dimension 1200 x 200 x 100 mm were prepared using cement, fine and coarse aggregates. Mixing is done with the help of hoe i.e. hand mixing. For hand mixing we use 10% extra cement. Beams were casted without delay, and were covered with gunny bags to minimize loss of evaporation from the surface of the beam. After 24 hrs formwork from the sides of the beam was removed and beams were placed in curing tanks for 28 days.

After 28 days beams were taken out, dried and required region i.e. tension side of beam is rubbed with sand paper to make it rough. Beams were divided in 5 groups in which 3 beams were used as control beams, 3 beams were wrapped with CFRP. 3 beams were wrapped with AFRP beams were wrapped with GFRP and 3 beams were wrapped with PET FRP. Beams were designed to fail in tension and load was applied at specific intervals and deflection was noted with dial gauge. Loads were applied until the failure of beams.

V. RESULTS AND DISCUSSIONS

After the tabulation of results of normal beams it was observed that normal beams failed in flexure when an average of 60kn load was applied on the beam. The failure was brittle in nature (Fig.1).

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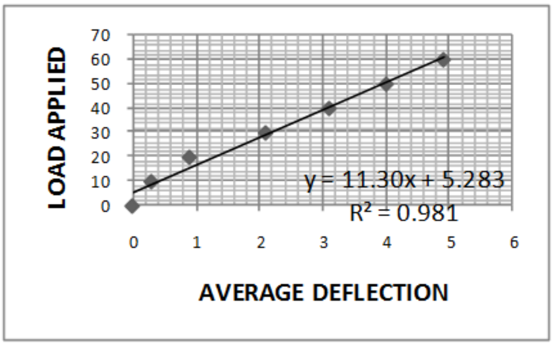

Figure-1: Average load Vs deflection of Normal beams

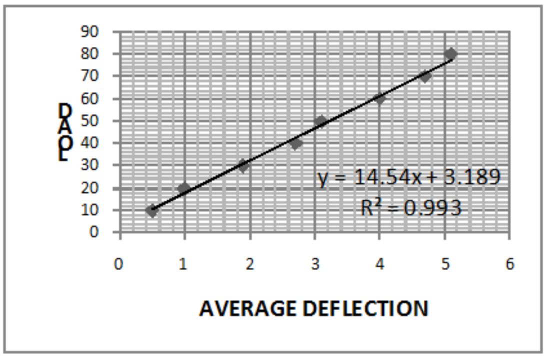

Figure -2: Average curve of load Vs deflection CFRP beams

CFRP beams carried maximum load and failed at an average of 80kn. The failure was flexural in nature (Fig 2).

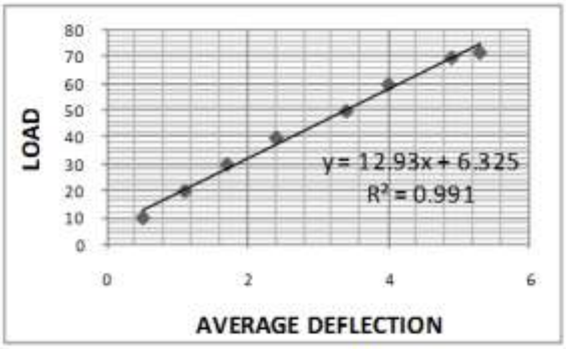

Figure-3: Average load Vs deflection curve of AFRP beams

The nature of failure was flexural (Fig. 3).

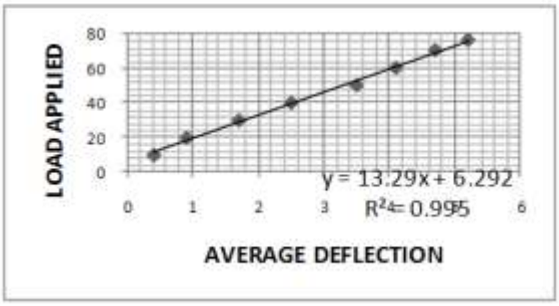

Figure-4: Average load Vs deflection GFRP beams

The nature of failure was flexural (Fig.4).

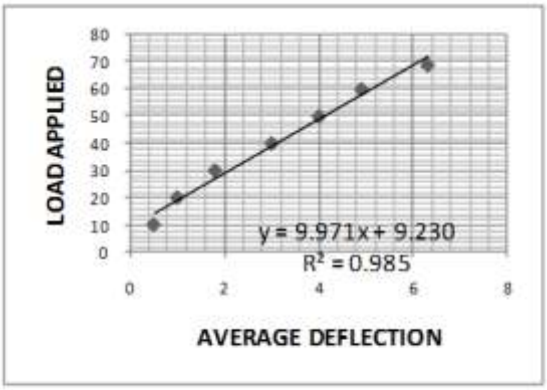

Figure-5: Average load Vs deflection of pet –FRP beams

Nature of failure was Flexure and the load applied is shown above (Fig.5).

It is observed that in control beams cracks are widely spread and visible whereas in beams strengthened with FRPS no cracks are visible initially. These beams failed in flexure and cracks were closely spaced. Beams strengthened with FRPs gave sufficient warning before failure, de-bonding of fibre taking place at first and then crushing if concrete. Beam which had lowest load carrying capacity were control beams which failed at 60KN and highest load carrying capacity was of beams wrapped with CFRP which failed at 80KN (Table IV).

TABLE-IV

Results of ultimate loads and type of beams

S.NO.	ULTIMATE LOAD	BEAM TYPE
1	60	NORMAL BEAM
2	69	PET FRP
3	72	GFRP
4	76	AFRP
5	80	CFRP

VI. CONCLUSION

From the study it is clearly depicted that instead of casting a beam with concrete if the same is wrapped with different fibre reinforced polymers provide massive strength as far as flexural strength parameters are considered. In each graph the R2 values show a positive trend, that implies more the load is applied more the deflection is achieved. It hardly matters what type of polymers are used. In all the cases the failure is too high as shown in the figures.

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