EXPERIMENTAL INVESTIGATION OF STRENGTHING OF RCC BEAM IN FLEXURE USING GFRP SHEET

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ABSTRACT

This paper presents the results of an experimental investigation carried out to study the strength behaviour of glass fibre reinforced polymer in RCC beams. FRP laminates have gained popularity as external reinforcement for the strengthening of reinforced concrete structures. GFRP strengthening exhibits high strength, light in weight, decrease time of construction. Fibre reinforced polymer (FRP) externally bonding with epoxy resin is recently widely used in construction industry to increase the ultimate strength of structures. All strengthened beams give sufficient warning when compared to control beam failure. The load carrying capacity and failure modes are discussed with control beam and GFRP wrapping beams. The purpose of this project is to investigate the flexure behaviour of reinforced concrete beam laminated with GFRP sheets over the whole beam, wrapping on shear zone and wrapping on shorter face top, bottom and two end faces of the beam by M20 grade of concrete of beam size 1200x100x150mm. In this study, flexure in beams includes various parameters like percentage of increase in strength of the member due to the externally bonded fibre reinforced polymer, examining the crack patterns, scaling, convenience of using the fibers, cost effectiveness.

INTRODUCTION

Fiber-reinforced polymer (FRP) application is very effective way to repair and strengthen structures that have become structurally weak over their life span. FRP repair systems provide an economically viable alternative to traditional repair system and materials. Reinforced concrete beams usually involves strengthening in existing members to carry higher ultimate loads or to satisfy certain serviceability requirements. Infrastructure decay caused by premature deterioration of buildings and structures has lead to the investigation of several processes for repairing or strengthening purposes. This increases the beam strength and its stiffness (load required to cause unit deflection), however decreases the deflection capacity and ductility.

FIBER REINFORCEDPOLYMER

Glass fiber also known as fiber glass is made from extremely fine fibers of glass. It GLASS is a light weight, extremely strong and a robust material. Glass fibers, the most popular of the synthetics, are chemically inert, hydrophobic, and light weight. Glass fibers reduce plastic shrinkage cracking and subsidence cracking over steel reinforcement.

MATERIAL PROPERTIES

GLASS FIBRE REINFORCED POLYMER (GFRP)

Glass fibre is made from extremely fine fibres of glass. It is a light weight which extremely strong and a robust material. Glass Fibres the most popular of the synthetics are chemically inert, hydrophobic, and light weight. This composite consist of a number of layers of fibre glass embedded in an epoxy resin. The properties of Glass fiber reinforced polymer is shown in Table

Table 1 Properties of Glass Fibre Sheet

PROPERTIES	VALUES
Yield stress	125Mpa
Elastic modulus	26 Gpa
Poisson's ratio	0.28
Density	1.8 g/cm³

EPOXYRESIN

Epoxy resin is used for wrapping the specimens with GFRP**.**

ACCELERATOR

It is used along with catalyst to harden the resin from liquid states to solid states.

CATALYST

Catalyst increases the rate of a chemical reaction of two or more reactants and helps in rapid hardening of the mix.

PIGMENT

A pigment is a material that changes the colour of mix. White pigment is used for wrapping the specimens with GFRP.

LIST OF MATERIALSUSED

- Cement
- water
- Fine aggregate
- Coarse aggregate
- Glass fibre reinforced polymer
- Epoxy resin, Accelerator, Catalyst, pigment
- Reinforcing bars

Table 2: Properties of Glass Fibre Sheet

PROPERTIES	VALUES
Yield stress	125Mpa
Elastic modulus	26 Gpa
Poisson's ratio	0.28
Density	1.8 g/cm³

Mix proportion

Mix design for M20 grade concrete by Indian Standard recommended method of concrete mix design as per design code IS: 10262- 2009.

Cement (kg/m^3)	**Fine aggregate (kg/m^3)**	**Coarse Aggregate (kg/m^3)**	**Water (Litre)**
394	670	1160	197

4. RESULTS

Table 3: Compressive Strength of concrete cube at 7 days and 28 days

SI.NO.	**Specimen**	**Compressive Strength of Concrete Cubes in N/mm^2**	
		7 Days	**28 Days**
1	C1	17.52	25.21
2	C2	18.5	26.3
3	C3	15.11	25.24

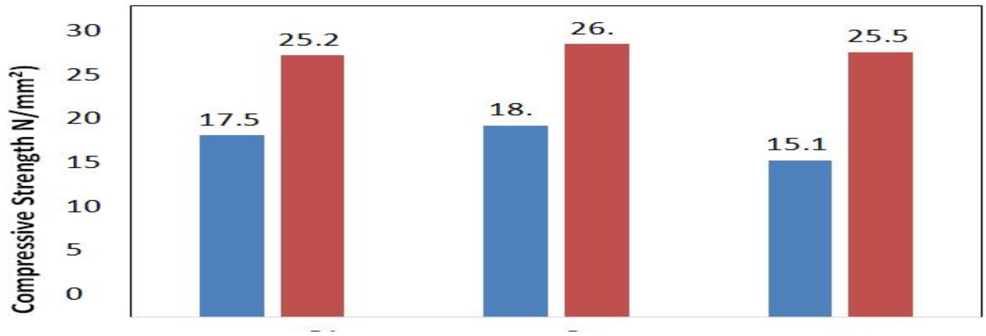

Figure 1 : Compressive strength of concrete cubes for 7 days & 28 days curing

Table 4: Split tensile Strength of concrete cylinder at 7 days and 28 days

SI.NO	Specimen	Split tensile Strength of Concrete Cylinder in N/mm^2	
		7 Days	28 Days
1	CY1	2.61	5.10
2	CY2	2.50	5.30
3	CY3	2.55	5.28

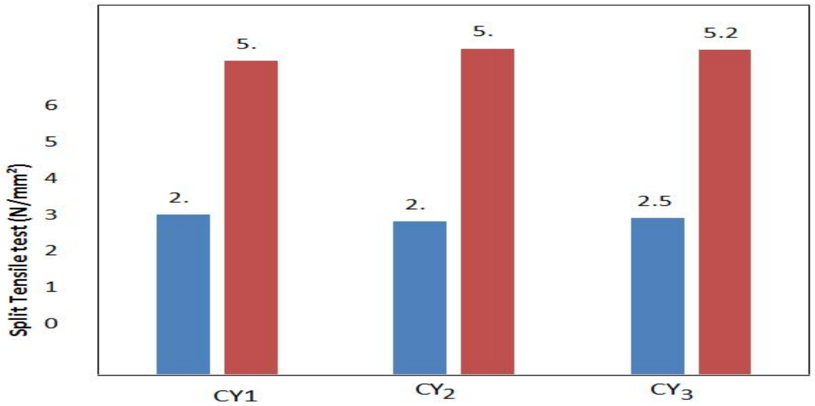

Figure 2:Split tensile strength of concrete cylinders for 7 days & 28 days curing

Table 5: Details of the test specimens

S. No	Designation of beams	Ultimate Load (kN)	Deflection (mm)	% increase in Load
1	Control Beam (B1)	47.5	5.6	-
2	Fully wrapped Beam (B2)	79.7	4.1	67.78%
3	Wrapping on shear zone (B3)	57.75	2.7	21.05%
4	Wrapping on shorter face top, bottom & two end faces of the Beam (B4)	78.35	4.1	64.94%

Table 6:Results of Load Vs Deflection for Initial Crack Load

Parameters	Initial crack load (kN)	Deflection (mm)	
		Experimental	Theoretical
B1	12	1.5	0.953
B2	No crack	-	-
B3	18.21	2.25	1.440
B4	22	1.12	1.740

Table 7: Results of Load Vs Deflection for Ultimate Crack Load

Parameters	Ultimate crack load (kN)	Deflection (mm)
		Experimental
B1	47.5	5.6
B2	79.7	4.1
B3	57.5	2.7
B4	78.35	4.1

Table 13: Results of Ductility

Parameters	Ductility
Control Beam (B1)	**70**
Fully wrapped Beam (B2)	**91.1**
Wrapping on shear zone (B3)	**77.14**
Wrapping on shorter face top, bottom and two end faces of the Beam (B4)	**82**

CONCLUSIONS

Based on the experimental investigation the following conclusions are calculated,

- In this study, the behaviour of properties of materials used in the investigation weretested.
- Compressive strength test and split tensile strength of control concrete cube and cylinder shows higher strength at 28 days when compared to 7days.
- The ultimate strength of fully wrapped beam was obtained as 79.7 kN and of control beam as 47.5 kN.The Ultimate strength of fully wrapped beam was 67.78% more than to that of the control beam.
- The ultimate strength of wrapping on shear zone was obtained as 57.5 kN and of control beam as 47.5 kN. The Ultimate strength of wrapping on shear zone was 21.05% more than to that of the control beam.
- The ultimate strength of wrapping only on shorter face top, bottom & two end faces of the beam was obtained as 78.35 kN and of control beam as 47.5 kN. The Ultimate strength of wrapping only on shorter face top, bottom & two end faces of the beam is 64.94% more than to that of the control beam.
- It was observed that the load and deflection was increased with wrapping of GFRP Sheets and also it is feasible to provide the maximum strength shows the enhancement of strength andductility.
- Fully wrapped beam and beam wrapping with on shorter side face top, bottom and two end faces of the beam carries maximum load carrying capacity when compared to beam with wrapping on shear zone only and controlbeam.
- The energy absorption and ductility increases for beam wrapped with GFRP Sheets when compared to controlbeam.
- Use of GFRP sheets improves load carrying capacity, delays crack formation and energy absorption capability of beam reinforced with GFRPSheets.
- The overall performance of Wrapping of GFRP Sheets over the beam is increased when compared to that of the control beam.

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