FLEXURAL BEHAVIOUR OF RC BEAMS USING GLASS FIBERS

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Abstract

Fibre reinforced polymer material bodies composed of fibre embedded in a polymeric matrix, which exhibit several properties and create the opportunity for their use in structural reinforced elements. They are characterized by good tensile strength in the direction of the fibres FRP composites do not exhibit any yielding, but instead they are good elastic up to failure They are also characterized by relatively low modulus of elasticity in tension and low compressive properties in this study two-directional glass reinforced polymer laminates are using for practical approach. After a curing period of 2 to 3 days, the rehabilitated specimens will be tested until failure. The cracking pattern, ultimate loads and deflected shape of the specimens to be notified and tests will be carried out on 10 simply supported RC beams with 150 X 150mm width and depth and a span of 1000 mm. The beams were strengthened with external U wraps bonded to tension side. The continuous GFRP reinforcement which gives delay in de-bonding of bottom longitudinal GFRP laminates. the most interesting parameter in this experimental study is to determine the load carrying capacity of strengthened RC beam, To evaluate the strength of damaged RC beams with externally bonded GFRP laminates is the target of this project.

1. Introduction

Deterioration and aging of concrete structures are not the only reasons for strengthening beams Other reasons include upgrading design standards committing mistakes in design or construction exposure to unpredicted loads such as truck hits or powerful earthquakes and changing the usage of the structure Moreover, the ever-increasing truck loads are sometimes beyond the design loads of most bridges in North America. The strengthening should ideally minimize the amount of material added to the structure to avoid increasing the dead load or decreasing the clearance requirements. Bonding steel plates might be considered as a very convenient method for strengthening indoor beams. However, the main disadvantage of using steel plates for outdoor applications is corrosion of steel. Fibers can make the concrete more homogenous and can improve the tensile response, particularly the ductility. Bonding of FRP to concrete is faster and less labor intensive. Due to the linear elastic behavior of FRP bars, the flexural behavior of FRP reinforced beams exhibits no ductility as defined in the steel reinforced structures. Li and Wang7 reported that the GFRP re bars reinforced with engineered cementations composite material showed much better flexural behaviors

2. Need of glass fibres

The GRP is used to control corrosion problems in oil fields, marine applications, chemicals and industrial plants. The successful performance of fibre glass reinforced thermo setting plastics have led to its wide use in corrosive services compared to other metallic materials. Also, due to its improved properties such as high specific strength and stiffness to weight ratio, glass fibre reinforced polymers composites are utilized successfully as structural material.

3. Objectives

The main purpose of my work is to

- → study the behavior of the reinforced concrete (RC) beams reinforced with Glass Fiber Reinforced Polymer sheets at different sides
- → understand the failure modes of strengthened and non-strengthened beams
- → Evaluate the effect of Glass Fiber Reinforced Polymer sheets on the strength and deflection of the strengthened and non-strengthened beams.

4. Materials Used

Concrete material

M-30 grade concrete

Mild steel

Zone-II sand

Type E-Glass fibre

5. Properties E-glass fibre

Following are some major properties of glass fibre:

- → Low cost
- → High production rates
- → High strength
- → High stiffness
- → Relatively low density
- → Non-flammable
- → Resistant to heat
- → Good chemical resistance
- → Relatively insensitive to moisture able
- → maintain strength properties over a wide range of conditions
- → Good electrical insulation

property	Density g/cm^3	Youngs modulus Gpa	Tensile strength Gpa	Tensile elongation
High strength	1.8	230	2.48	1.1
High modulus	1.9	370	1.79	0.5
Ultra high modulus	2.0-2.1	520-620	1.03-1.31	0.2

6. Methodology

Experimental investigations on the behaviour of RC beams strengthened by using glass Fibre Reinforced Polymer in flexural case have been presented in this paper. The experimental work consisted of tested beams. This study took into account strengthened and repaired cases in using glass Fibre Reinforced Polymer All the RC beams had been tested in a simply supported span and subjected to two-point loading until the failure. The beams included additional anchorage at the ends of the main glass Fibre Reinforced Polymer sheet reinforcement to prevent the de lamination of glass Fibre Reinforced Polymer sheet. The results of experiments show that the use of glass Fibre Reinforced Polymer as external strengthening has significant enhancement on the ultimate load, crack pattern and deflection of the strengthened of beams. It is observed from the work that the use of external glass Fibre Reinforced Polymer in strengthening beams could improve the ultimate load capacity of beam

Fig; 6.1glass fibre

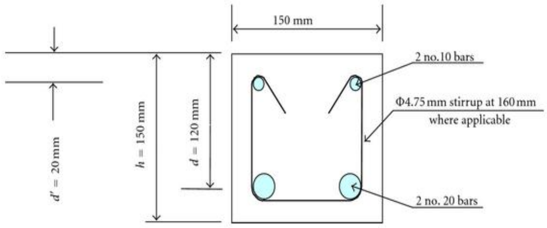
7. Preparation of RC beam with GFRP

In FRP wrap systems, FRPs are bonded on the lateral faces of the beam with the fibers perpendicular or inclined to the longitudinal axis of the beam. The FRPs can also be placed on both lateral faces in a continuous way underneath the beam web resembling U-shaped external stirrups. The performance of the U-shaped bands can be further improved by adding additional longitudinal FRP strips over the ends of the U-shaped bands. Sprayed GFRP was applied either on both lateral faces or on three faces excluding the top Boyd reported a difficulty involving the inability of the fibers to stay in place when bent around sharp corners during the retrofit process. To overcome this problem and to avoid possible failure of the FRP due to stress concentrations at the corners of the beam section, when sprayed or fabric GFRP was applied on three sides of the beam, the corners of the beam section were rounded to a radius of 35 mm. This was also recommended by ISIS Canada Different thicknesses of Sprayed GFRP were applied and studied in this project. For surface preparation, different techniques such as sandblasting, epoxy glue, and hammering the surface were investigated. Through bolts and nuts were also tried with emphasis on concrete-GFRP bond strength enhancement

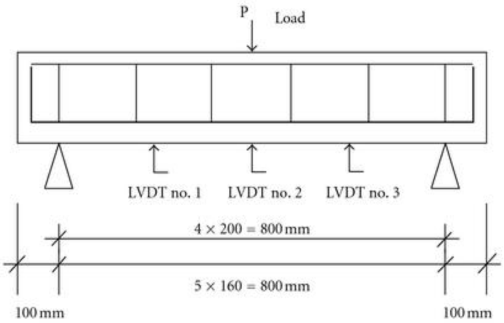
7.1 Details of RC beam

Width of compression face of member	150 mm
Overall depth of beam	150 mm
Distance from extreme compression fiber to centre of tension reinforcement	120 mm
Distance from extreme compression fiber to centre of compression reinforcement	20 mm
Specified compressive strength of concrete	44 mpa
Specified yield strength of tension reinforcement	440 mpa
Specified yield strength of compression reinforcement	474 mpa
Specified yield strength of shear reinforcement	600 mpa

Area of tension reinforcement	600 mm2
Area of compression reinforcement	200 mm2



Fig; 7.1 cross-sectional details of RC beams

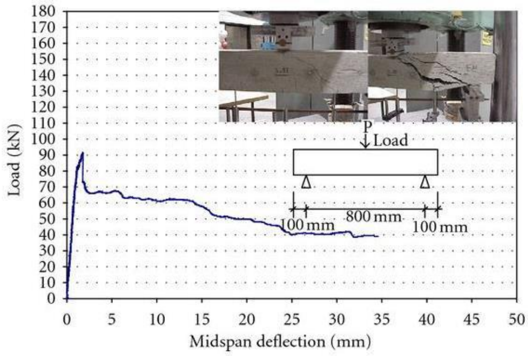


Fig; 7.2 Load configuration of RC beam

Fig; 7.3 Beam test setup under quasi-static loading

8. Preparation of RC beam without GFRP

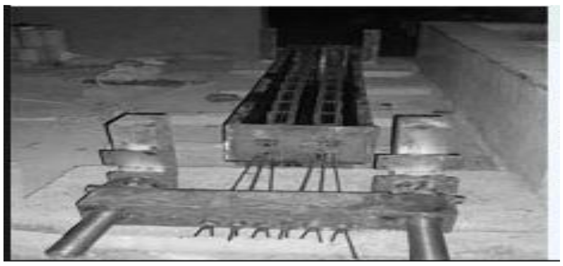
Six beams were tested under quasi-static loading without the GFRP coating. Results are reported here and will be used later as bench marks for comparison. One beam (beam C-NS in was tested under quasi-static loading with no stirrups and no GFRP. The result of this test is shown in Figure A typical shear failure was observed in this beam with a crack of about 45°. This shear crack became flatter at the load point as shown in. Load carrying capacity was in good agreement with the predicted value



Fig; 8.1 Load versus mid span deflection of control RC beam C-S-1

9. Flexural strengthening of beam

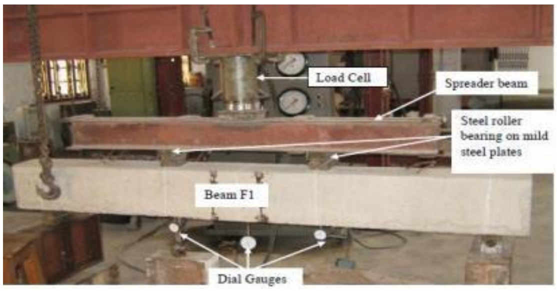
The beams were tested for their ultimate strengths. In SET I three beams (F1, F2 and F3) weak in flexure are tested. The beam F1 is taken as controlled beam. It has less load carrying capacity when compared to that of the externally strengthened beams using GFRP sheets. In SET I beams F2 is strengthened only at the soffit of the beam and F3 is strengthened up to the neutral axis of the beam along with the soffit of the beam.



Fig; 9.1 fixing of GFRP on beam

10. Testing of specimen

The GFRP strengthened beam and the control beams were tested to find out their ultimate load carrying capacity. It was found that the control beams F1 is failed in flexure and showing that the beams were deficient in flexure In SET I beam F2 failed due to fracture of GFRP sheet in two pieces and then flexural-shear failure of the beam took place. Beam F3 failed due to de lamination of the GFRP sheet after that fracture of GFRP sheet took place and then flexural-shear failure of the beam. In SET I beams F2 and F3, GFRP rupture and flexural-shear kind of failure was prominent when strengthening was done using both the wrapping schemes



Fig; 10.1 testing of specimen

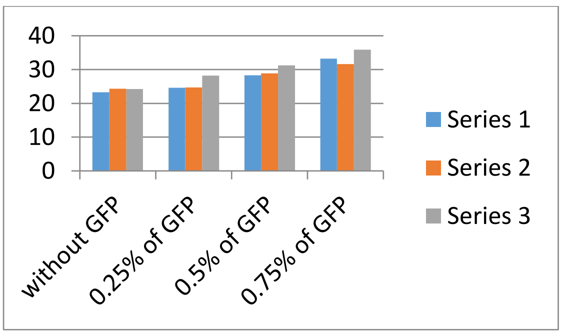
11. Results

11.1- Compressive strength:

Compressive strength is the capacity of a material or the ability of a structure to withstand load tending to reduce size .For compression test cube specimen of concrete and 150 mm x 150 mm were used respectively. Totally 21 cubes were cast for determination of compressive strength After 24 hours the moulds were demoded and subjected to water curing. Before testing the cubes were dried for 2 hours. All the cubes were tested in saturated conditions after wiping out surface moisture. The load was applied without shock and increased continuously until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen was then recorded; three cubes each were tested at the age 7 days 21 days and 28 days of curing for concrete compression testing

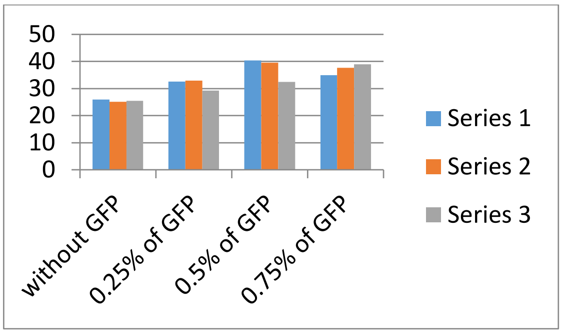
7-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
23.24	24.57	28.27	33.21
24.3	24.67	28.89	31.62
24.25	28.18	31.25	35.89



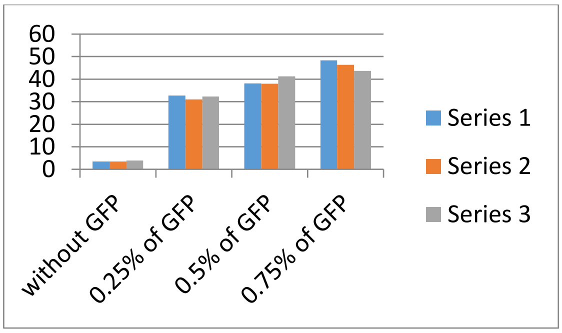
21-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
25.9	32.56	40.38	34.98
25.12	32.92	39.60	37.62
25.44	29.3	32.4	39



28-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
3.5	32.8	38.2	48.39
3.42	31.82	37.96	46.4
3.9	32.3	41.25	43.6

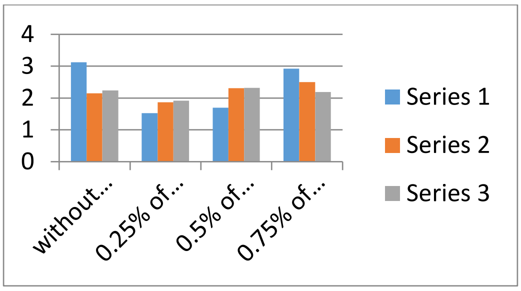


11.2-Split tensile strength:

Split Tensile strength of concrete is usually found by testing concrete cubes mould of size 150 mm x 300mm. The tensile strength of concrete as compared to its compressive strength is very low and is found to be only 10-15 % of the compressive strength. There are various factors which influence the tensile strength of concrete like aggregates, age, curing, air entrainment and method of test.

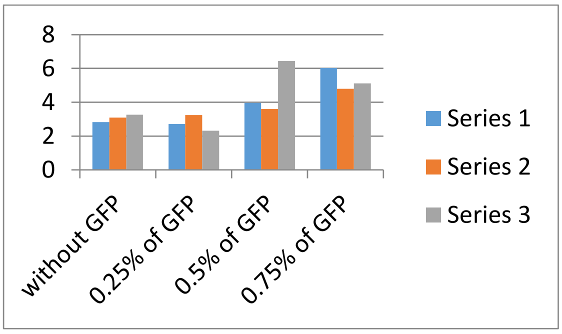
7-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
3.12	1.52	1.70	2.92
2.15	1.87	2.31	2.50
2.24	1.92	2.32	2.19



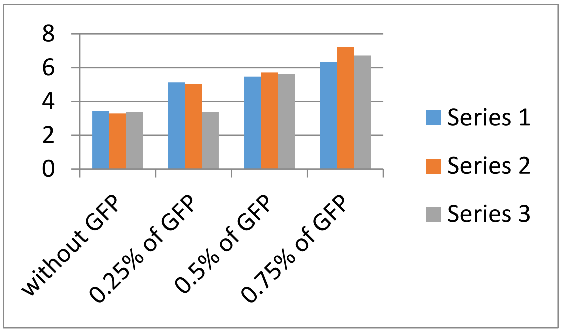
21-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
2.83	2.72	3.96	6.02
3.10	3.25	3.6	4.80
3.26	2.32	3.45	5.12



28-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
3.42	5.13	5.48	6.32
3.29	5.03	5.71	7.24
3.37	3.37	5.63	6.72

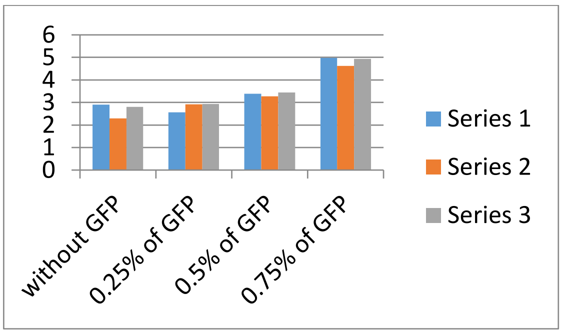


11.3-Flexural strength test:

Flexural strength is also referred to as modulus of rupture, Flexural strength of concrete is usually found by testing plain concrete prisms of size 500 mm x 100x 100mm were casting using M30 grade concrete. Specimens with Conventional Concrete and glass fiber concrete of different percentage were casted. After curing, the specimens were tested for flexural strength

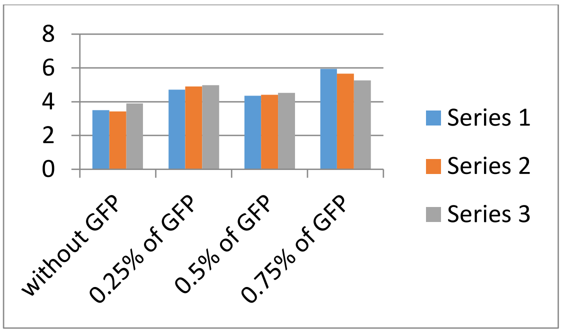
7-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
2.9	2.56	3.38	4.98
2.3	2.92	3.28	4.62
2.8	2.93	3.45	4.94



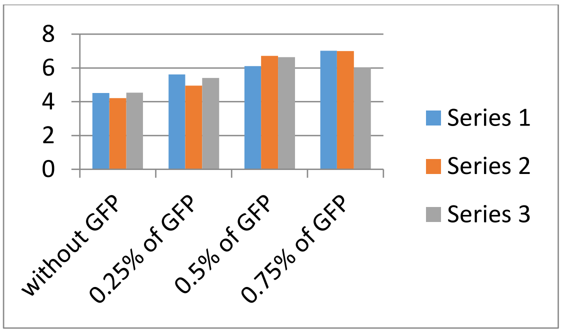
21-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
3.5	4.72	4.36	5.95
3.42	4.90	4.41	5.66
3.9	4.97	4.52	5.27



28-days results

Without fibre	0.25% of fibre	0.5% of fibre	0.75% of fibre
4.52	5.61	6.11	7.02
4.22	4.96	6.72	6.99
4.53	5.41	6.64	6.02



12. Conclusion

The following conclusions are made from the experimental study of addition of glass fibers of two lengths with same diameter and properties into the concrete mix. In this study of addition of combinational glass fibers greater strength and stiffness than the conventional concrete and also possesses good binding and strength to weight ratio. The compressive strength of concrete are increased with the addition of glass fibers to 0.50% by weight of concrete and further any addition of the glass fiber shows in decreases compressive strength (it is been evaluated by studying research paper and journals on this addition).

• Split tensile strength tends to improve for Material Concrete compared to plain concrete.

• Flexural strength shows tremendous increases from 0.5 to 0.75 % in Material Concrete compared to plain concrete. Whereas by using single fiber addition it gives max strength at 1%.

• Optimum combination of is 0 .75% is obtained as higher properties.

• The overall performance of glass fiber concrete increased strength compared to plain concrete.

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