EXPERIMENTAL INVESTIGATION OF GFRC EFFECTS ON FLEXURAL BEHAVIOUR OF CONCRETE

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Abstract - This article is focused on the flexural behavior of the simply supported beam strengthened with GFRC plate with different layer GFRC plate length. The experimental program is to be done to access the flexural behavior of the strengthened conventional and GFRC. The flexural behavior is to be analyzed by two- point loading test. The objective of the test was also gain better understanding of the failure mode and the flexural behavior of RC beams strengthened with GFRC plates taking into account the different strengthening method, initial damage, and the dead load before strengthening. Workability, compressive and splittensile strength were also investigated.

Key words: Fiber Reinforced concrete, Glass fiber reinforced concrete, coarse aggregate

1. INTRODUCTION

Retrofitting is modification of existing structure to make it more resistant to external forces like seismic forces, wind forces and vibrational forces. In case of increase in live load, accidental load or impact load and in excessive server environmental condition we need to redesign building as per new combination. Generally we have to take decision that whether to demolish the building or retrofit it. It will depend upon the stressing level of the structure. Also it is to be checked that retrofitting system is capable of taking increased loads or not.

Typical strengthening techniques such a section enlargement externally bonded reinforcement, post-tensioning, supplemental support may be used to achieve improved strength and serviceability.

From the past studies conducted it has been shown that externally bonded glass fiber reinforced concrete can be used to enhance the flexural, shear and torsional capacity of RC beam. Due to the flexible nature and ease of handling and application, combined with high tensile strength-weight ratio and stiffness, the flexible glass fibre plate are found to be highly effective for strengthening of RC beam.

The laminates are stiff plates or shells that come procured and are installed by bonding them to the concrete surface with a thermo setting resin. These fibers are available in market in form of laminate and they can be bonded with epoxy resin to get hardened material which possesses a good tensile strength.

In this study set of beams, weak in flexure were cast a tested up to failure. Set beam were cast, in which one was control beam and others three were retrofitted by using GFRC laminated in bottom middle of beam. The retrofitting of beams is done with different amount and configuration of GRFC laminate.

Experimental data of load, deflection, failure modes and crack pattern of each beam was obtained. Hand wet layup method of application of export was included the effect of different GFRC orientation of ultimate load caring deflection and failure mode of the beam were investigated.

1.1 Glass Fibre Reinforced Concrete

Several manufacturing processes for producing glass fiber reinforced concrete premix products have been developed, such as casting, spray premix, press molding, extrusion, and pultrusion. Glass fiber-reinforced concrete premix is a mixture of AR glass fiber, sand, cement, water, chemical and mineral admixtures, and aggregate. These fibers reduce crack width and spacing between cracks. They are very high temperature resistant as they absorb high energy thereby providing the property of ductility. Their light weight property makes them very popular for concrete mix. They have found varied use in industry today. They are used as sound reducers when used in thickness of 10 mm and surface mass of 20 kg/m2. They are used for repair material for historical buildings and also for extension of old buildings. Any shape product can be formed with good binding strength due to their excellent design flexibility. They are used in sewer relining, earth retaining walls, architectural product as building facades, claddings, cable troughs and noise protection barrier.

1.2. Advantage of GFRC

The GFRC is

1. Light weight

2. They have better shrinkage properties over plain concrete.

3. GRC are environmental friendly.

4. GFRC used in precast manufacturing.

5. They are Anti-corrosive, highly resistant to chemicals, High flexural strength, Impact strength and tensile strength.

6. Very good design flexibility.

7. GFRC have low thermal conductivity because of that heat saving is achieved.

8. Can be used to manufacture strands since they have specific resistance of glass is higher.

9. The thickness of glass filament varies between 10 micron to 20 micron.

1.3 OBJECTIVE

- The main objective is to study the flexural behaviour of reinforced concrete beams with glass fibre plate.
- To study the effect of glass fibre strengthening of RC beams on ultimate load carrying capacity and failure pattern.
- Comparative study of the crack pattern and flexural behaviour between controlled beam and strengthened GRFC beams.

1.4 SCOPE

- For all the strengthened RC beams GFRC plate not only can significantly improve serviceability of reinforced concrete beam by increasing member stiffness because of increase and delay of first cracking and steel yielding load, but also enhance the flexural loading capacity of reinforced concrete beams compare to an strengthened concrete beam.
- Attempts can be made to study the flexural behaviour of GFRC laminate
- The work can be extended by using reinforcement bars.
- Attempts can be made to study the GFRC laminate specimen with more number of layers.

2. LITERATURE REVIEW

2.1 General

A literature review is carried out on the glass fiber reinforced concrete. A number of literatures are available on the strength aspects of the glass fiber concrete. This section presents a brief report on the literatures reviewed as part of this project.

2.2 REVIEW

2.2.1. Surendra P. Shah (1987)

He has discussed about strength and durability properties of M20 and M30 grade of glass fibre reinforced concrete. They concluded that improved behaviour of glass fibre reinforced concretes over ordinary concrete and discussed about the effect of glass fibres on durability properties of glass fibres reinforced concrete.

2.2.2. J.A.O. Barros et al. (2002)

He has studied fracture energy of cement-based materials is significantly increased by adding glass fibre to the mix composition. The tensile strength is largely determined by the fibre orientation which depends on the mixing method. A tensile strength of about 11MPa is found when a spray up technique is used for the PGFRC. Fracture energy of cement based materials is significantly increased by adding glass fibre to the mix composition. A tensile strength between 4.5 and 5.5 MPa is found for GFRC mixes made with the premix method.

2.2.3. Greednhalgh, John (2003)

The use of glass fibres in segmental linings with reinforced concretes is discussed. Glass fibres impart toughness, or ductility, to the otherwise brittle concrete. This minimizes cracking and spalling due to demoulding, handling, transportation and construction underground.

2.2.4. Homan.K.A et al (2004)

He observed that reduction of both water absorption and chlorine ion permeability in the specimen showed that natural pozzolana is not only suitable for high performance concrete but also results in better properties than through concrete causing damage. The ability of concrete to resist chemical attack is characterized by permeability and diffusivity which are considered as “durability indicators” .

2.2.5. Strobach claus Peter, et al (2006)

They performed on precast concrete using glass fibre reinforced made of self- compacting concrete. Four experimental beams were manufactured with various types of glass fibres and those beams were examined. Results show that prestresses Glass-fibre-reinforced beams made of PMFRC can be manufactured without conventional reinforcement, both for shear resistance and for resisting the bursting stresses in the area where the prestressing forces are introduced. Load tests showed a nearly linear elastic response to a maximum of 2.2 times the service load.

2.2.6. Ferrara, LiberatoMeda, Alberto (2006)

A series of 40 precast prestressed roof elements was cast, employing a modified polymer glass fibre reinforced concrete. They are being used in an industrial building. The fibre distribution within the roof elements was investigated by means of a suitable test procedure and correlated with results obtained from cube samples drawn from the batches and tested in the fresh state. Companion slabs were also cast and tested under four-point bending, in order to study the correlation between fibre distribution and the mechanical properties of the composite.

2.3. CONCLUSIONS

The above literature study denotes the risks occurred in the construction industry. In phase I the literature are collected and the detailed study has been completed. The further process in the project are carried out in the future. We have to study about When GFRC panels used in the beams and columns what will be the changes the various parameters of concrete. The different literatures are collected and the deep study has been done. By the deep study, the methodology has been framed for the phase II of the project.

3. EXPERIMENTAL INVESTIGATION

3.1 Casting of Beam

The moulds were prepared using plywood. The dimensions of all the specimens were identical. The length of beams was 1800 mm and the cross section were 100 150 mm. the deign mix ratio was adopted for designing the beam. One under reinforced beam were cast there as a control specimen and three beams for retrofitting. Two bars of 10mm diameter were provided as tension reinforcement at the soffit of the beam and two bars of 8 mm diameter were provided as reinforcement at the top of the beam.

3.2 Retrofitting Beams

The glass fiber plate can be placed at bottom surface. At the time of bonding of fiber, the concrete surface is made rough using a wire brush and then cleaned with water to remove all dirt and debris. The beams are allowed to dry for 24 hours. The fiber plate is cut according to their size. After that, the epoxy resin primer is mixed in accordance with manufacture's instruction. The mixing is carried out in a plastic container. After uniform mixing, to the concrete surface. The epoxy matrix is mixed in a plastic container in accordance with the manufacture's instruction to produce a uniform mix of base and hardener. The coating is applied on the beam and fiber plate for effective bonding of the plate with the concrete surface. Then the fiber plate is placed on top of epoxy resin coating and the resin is squeezed through the roving of the fabric air bubbles entrapped at the epoxy concrete or epoxy fabric interface are eliminated. During hardening of the epoxy, a pressure is applied on the composite fabric surface in order to extrude the excess of epoxy resin and to ensure good contact between the epoxy, the concrete and the fabric. This operation is carried out at room temperature. Concrete beams strengthened with fiber plate are cured for 2 days at room temperature before testing.

3.3 Testing of beam

This section deals with analysis of result of the experimental investigations on the RCC beam of control specimen and the retrofitting beams. Experimental investigation was carried out to determine the ultimate load, deflection of specimen. Two point load was applied on the specimen. A universal testing machine was used to obtain the ultimate load and deflection. Deflection of beam is noted when initial cracks appears on the beam. Dial gauge is used to determine the deflection oh the beams.

Control beam were failed in flexural. It is obtained that the control beam had less load carrying capacity and high deflection values compared to that the externally strengthened beams using GFRC plate. Since the glass plate is used for retrofitting, initial cracks are delay. Further with increase in loading, propagation of the cracks took place. The beams retrofitted with glass fiber plate had maximum deflection and lower ultimate load carrying capacity. From the graph it is clear that all the retrofitted beams have better load deflection characteristic than the control specimen.

Fig .1. Testing set up for GFRC

Table 4.3.1. Conventional Beam

Sl.no	Sl.no Load (KN)	Deflection1 (mm)	Deflection2 (mm)	Deflection3 (mm)
1	1	0	0	0
2	2	0.1	0	0.8
3	3	0.19	0	0.12
4	4	0.29	0.3	0.21
5	5	0.4	0.15	0.33
6	6	0.49	0.25	0.42
7	7	0.62	0.4	0.54
8	8	0.84	0.67	0.77
9	9	1.15	1.03	1.07
10	10	1.54	1.48	1.44
11	11	2.07	2.09	1.95
12	12	2.49	2.59	2.42
13	13	2.94	3.13	2.94
14	14	3.34	3.6	3.37
15	15	3.82	4.11	3.89
16	16	4.2	4.5	4.3

17	17	4.68	5.04	4.86
18	18	5.06	5.38	5.27
19	19	5.39	5.53	5.67
20	20	5.8	6.04	6.12
21	21	6.2	6.63	6.58
22	22	6.53	7.18	7.03
23	23	6.88	7.77	7.44
24	24	7.3	8.4	7.97
25	25	7.73	9.14	8.5
26	26	8.17	9.76	9.06
27	27	8.58	10.3	9.48
28	28	8.9	10.55	9.92
29	29	-	-	-
30	30	-	-	-
31	31	-	-	-
32	32.2(ultimateload)	-	-	-

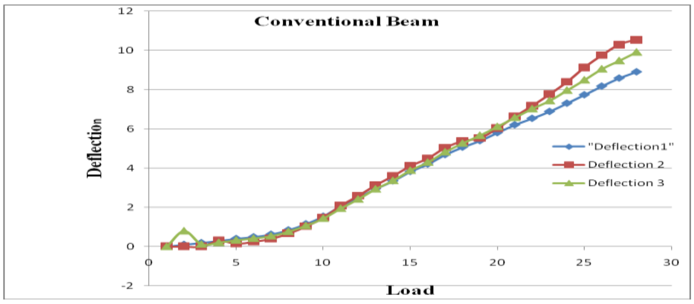

Fig.2.graph for conventional beam

Length of the glass fiber plate = 0.8 m

Table 4.3.2 GFRC Beam-0.8 m

Sl.no	Sl.no Load (KN)	Deflection1 (mm)	Deflection2 (mm)	Deflection3 (mm)
1	1	0	0	0
2	2	0.13	0.14	0.22
3	3	0.25	0.29	0.3
4	4	0.35	0.4	0.55
5	5	0.45	0.53	0.62
6	6	0.59	0.69	0.73
7	7	0.73	0.83	0.89
8	8	0.83	1.07	1.1
9	9	1.160	1.350	1.38
10	10	1.42	1.64	1.63
11	11	1.72	1.97	1.95
12	12	2.02	2.3	2.23
13	13	2.31	2.66	2.55
14	14	2.57	2.95	2.82
15	15	2.87	3.36	3.11
16	16	3.23	3.72	3.46
17	17	3.54	4.03	3.8
18	18	3.8	4.37	4.08
19	19	4.11	4.72	4.3
20	20	4.47	5.15	4.72
21	21	4.83	5.54	5.11
22	22	5.24	6.01	5.5
23	23	5.52	6.29	5.8
24	24	6.26	7.1	6.45
25	25	6.66	7.57	6.89
26	26	7.06	8.05	7.29
27	27	7.67	8.72	8.01
28	28	8.52	9.34	8.58
29	29	9.34	9.72	8.99
30	30	10.4	10.23	9.59

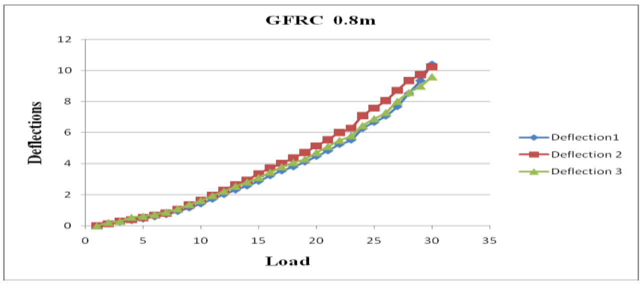

Fig.3. graph for GFRC beam

Length of the glass fiber plate = 1.2 m

Table 4.3.3 GFRC Beam-1.2 m

Sl.no	Sl.no Load (KN)	D eflection1 (mm)	Deflection2 (mm)	Deflection3 (mm)
1	1	0	0	0
2	2	0	0	0
3	3	0	0	0
4	4	0	0.1	0.05
5	5	0.08	0.2	0.15
6	6	0.18	0.32	0.25
7	7	0.35	0.5	0.4
8	8	1.48	0.62	0.6

9	9	1.63	0.76	0.75
10	10	1.75	.85	1.10
11	11	1.9	1.09	1.33
12	12	2.02	1.29	1.5
13	13	2.22	1.56	1.76
14	14	2.41	1.83	2.02
15	15	2.56	2.09	2.28
16	16	2.73	2.26	2.5
17	17	3.87	2.50	2.76
18	18	3.99	2.68	2.99
19	19	4.1	2.87	3.25
20	20	4.18	3.09	3.5
21	21	4.22	3.30	3.85
22	22	4.3	3.51	4.2
23	23	4.54	3.65	4.48
24	24	4.62	3.75	4.8

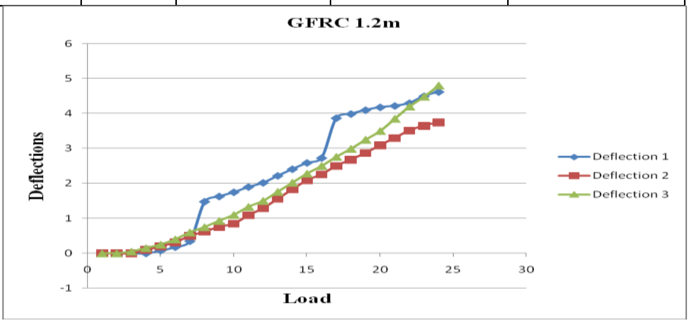

Fig 4 graph for GFRC beam

Length of the glass fiber plate = 1.6 m

Table 4.3.4 GFRC Beam- 1.6 m

Sl.no	Sl.no Load (KN)	D eflection1 (mm)	Deflection2 (mm)	Deflection3 (mm)
1	1	0	0	0
2	2	0.11	0	0.3
3	3	0.23	0.04	0.44
4	4	0.33	0.11	0.54
5	5	0.43	0.23	0.64
6	6	0.53	0.33	0.75
7	7	0.62	0.42	0.83
8	8	0.7	0.52	0.92
9	9	0.79	0.63	1.01
10	10	0.91	0.78	1.12
11	11	1.08	0.98	1.3
12	12	1.24	1.12	1.44
13	13	1.48	1.33	1.62
14	14	1.65	1.55	1.79
15	15	1.83	1.76	1.95
16	16	2.08	2.06	2.18
17	17	2.33	2.33	2.46
18	18	2.51	2.55	2.58
19	19	2.72	2.81	2.81
20	20	2.94	3.08	3.01
21	21	3.18	3.33	3.35
22	22	3.38	3.56	3.59
23	23	3.59	3.83	3.81
24	24	3.89	4.15	4.15
25	25	4.12	4.44	4.44
26	26	4.33	4.64	4.83
27	27	4.56	4.97	4.89
28	28	4.8	4.26	5.12
29	29	5.01	4.48	5.32
30	30	5.19	4.72	5.54
31	31	5.45	4.94	5.82
32	32	5.67	5.2	6.1
33	33	5.93	5.47	6.4
34	34	6.12	5.74	6.67
35	35	6.35	5.98	6.92
36	36	6.53	6.21	7.13
37	37	6.72	6.44	7.35
38	38	6.96	6.77	7.66
39	39	7.17	7.04	7.9
40	40	7.38	7.29	8.14
41	41	7.62	7.61	8.44
42	42	7.83	7.92	8.69
43	43	8.04	8.2	8.94
44	44	8.25	8.49	9.2
45	45	8.48	8.77	9.45
46	46	8.7	9.04	9.72

Fig.5.GFRC Beam

5. RESULTS

In present study flexural strength, compressive strength and tensile strength of M25 grade concrete was to be found out. In that RC beam is used for flexural study and cubes, cylinder, small beams and large beams are to be used for compressive, tensile and flexural strength.

5.1 compressive strength values of cubes

TABLE: 5.1.1 Compressive Strength

Sl .n o	Spe cim en	Grade ofconc rete	Mix rati o	Area ofspeci men(m m)	Loa d(k N)	Compressiv estrengthN /mm²
1	1	M25	1:1. 7:2. 95	22500	121 6	54
2	2	M25	1:1. 7:2. 95	22500	125 4	55.73
3	3	M25	1:1. 7:2. 95	22500	130 4	57.9

5.2 Flexural strength test result

Table: 5.2.1 Flexural Strength

Sl .no	Specimen	Grade of concrete	Mix ratio	Load (KN)	Compressive strength N/mm²
1	1	M25	1:1.7:2.95	6.2	3.1
2	2	M25	1:1.7:2.95	6.6	3.3
3	3	M25	1:1.7:2.95	6	3

10.3 Split Tensile Strength Test Result

Table:10.3.1 Split Tensile Strength

Sl .no	Specimen	Grade of concrete	Mix ratio	Load (KN)	Compressive strength N/mm²
1	1	M25	1:1.7:2.95	251	3.55
2	2	M25	1:1.7:2.95	256	3.6
3	3	M25	1:1.7:2.95	222	3.142

10.4 Flexural Strength Test for Long Beams

The beam casted was de moulded after 48 hrs and water curing was done up to 28 days. The beams just before using gunny bags. The beams were tested 28th day. The beams just before testing were white washed and the support position were measured and marked. Mainly four beams are casted for Flexural study in that one is for control specimen and other three is for fiber specimen. The flexural study calculation is done by taking the ultimate load of beam. In fiber beam testing the load carrying of fiber beam is more as compare to normal beam and it is also have high deflection.

Table 10.4.1 Specimen details

Sl no	Beam	UltimateLoad(KN)	Maximumdeflection 1(mm)	Maximumdeflection 2(mm)	Maximumdeflection 3 (mm)
1	conventional	32.2	8.9	10.55	9.92
2	GFRC 0.8mm	44.8	10.4	10.23	9.59
3	GFRC 1.2 mm	46	4.62	3.75	4.8
4	GFRC 1.6 mm	60.6	8.7	9.04	9.72

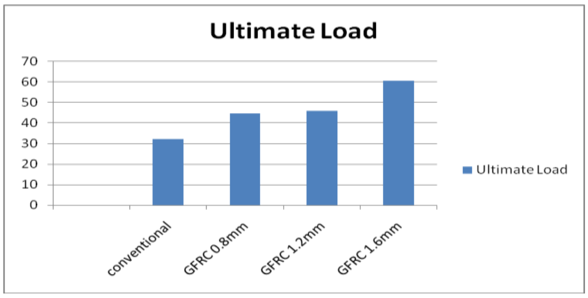

Fig.6. graph for ultimate load

Initial cracks appear is taken more loads as compared to normal beams.

Table: 5.4.2 Cracks Details

Sl o	Beams	Initial crack(KN)	Second crack(KN)	Third crack(KN)
1	Conventional	13	18	19
2	GFRC 0.8mm	16	17	20
3	GFRC 0.8mm	20	21	23
4	GFRC 0.8mm	24	26	28

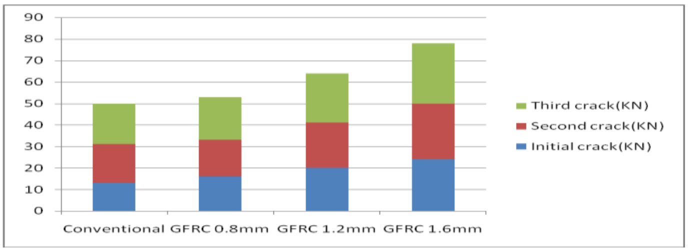

Fig .7. Graph for crack details

6. CONCLUSIONS

1. Flexural load carrying capacity of retrofitted beam increases with GFRClaminate than the conventional beam.
2. The GFRC laminate specimen showed improvement in ultimate load. As the increases the glass fiber laminate length was increased the ultimate load carried by the specimen also increased.
3. The initial cracks in the strengthened beams appear at a higher load compared to the ultimate strengthened conventional beam.
4. The flexural strength and ultimate load capacity of the beams improved due to external strengthening of beams.
5. The strengthening of beam using glass fiber plate is found to be more effective in improving the flexural strength and ultimate load capacity.
6. Retrofitting beams gives more strength comparing to conventional beam.

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