EXPERIMENTAL STUDY ON STRENGTHENING OF RC BEAM USING FIBRE WRAPPING

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ABSTRACT
Repair and strengthening of RC beam is now becoming more and more important in the field of structural strengthening and retrofitting. This paper presents the Repair and strengthening of reinforced concrete RC beams of M30 grade of concrete using E-glass fiber and its comparative study with basalt fiber for flexural behavior using both experimental and analytical method. The beam size is 700x150x150mm designated as per IS456-2000. In this study , experimental investigation of the strengthening and flexural behavior has been studied by wrapping E-glass fiber and basalt fiber with epoxy resins. Reinforced concrete beam externally bonded with E-glass fiber and basalt fiber sheets were tested to failure using symmetrical four point load system . Six reinforced concrete beams have been cast for this experimental test. The experimental results shows, that full bottom E-glass fiber, basalt fiber wrapping beam can increases strengthening and flexural capacity of the beam compared with controlled beam

1. INTRODUCTION

Unfortunately, there is no single solution that offers a simple, straight forward method for all repair and strengthening projects However, success can be achieved. Reinforced cement concrete is an extremely popular construction material used for structural components of a building like beam, columns, slab etc. The repair of structurally deteriorated RC structures became necessary since the structural element ceases to provide satisfactory strength and serviceability. some of the structures are in such a bad condition that they need to be replaced. The use of fibers to improve the post strength of concrete behavior is very popular nowadays. For the flexural strength of beam E-glass fiber and basalt fibers are used to the member. Since last 48 years, several different fiber types and materials have been used to improve the durability of concrete and also its physical properties. Most of RCC structures, have suffered severe degradation since their construction due to the combined effects of aggressive environments, significantly increased live loads. This includes casting RCC beams, with various degree of damping, number of layer of applying the E-glass fiber and basalt fiber sheets and testing them under two point loading on a universal Testing machine of capacity 1000 KN. The shear stress and strain parameters of the control beams and the retrofitted beams were observed and noted. Also, the stress strain curve of the beams was studied. It was found that the strength of beams improved with the addition of E-glass fiber, basalt fiber

BASALT FIBER: Basalt is a type of igneous rock formed by the rapid cooling of lava at the surface of a planet. It is the most common rock in the Earth ‘s crust.[1] Basalt rock characteristics vary from the sources of lava, cooling rate, and historical exposure to the elements. High quality fibers are made from basalt deposits with uniform chemical makeup

E-GLASS FIBER or ELECTRICAL GRADE GLASS was originally developed for strand off insulator for electrical wire. Glass fiber are generally produced using melt spinning techniques. Properties that have made E- glass so popular in fiber glass and other glass fiber reinforced composite include low cost , high strength, high stiffness, non- flammable, good chemical resistant, good electrical insulation.

2.OBJECTIVES AND SCOPE

2.1 OBJECTIVES

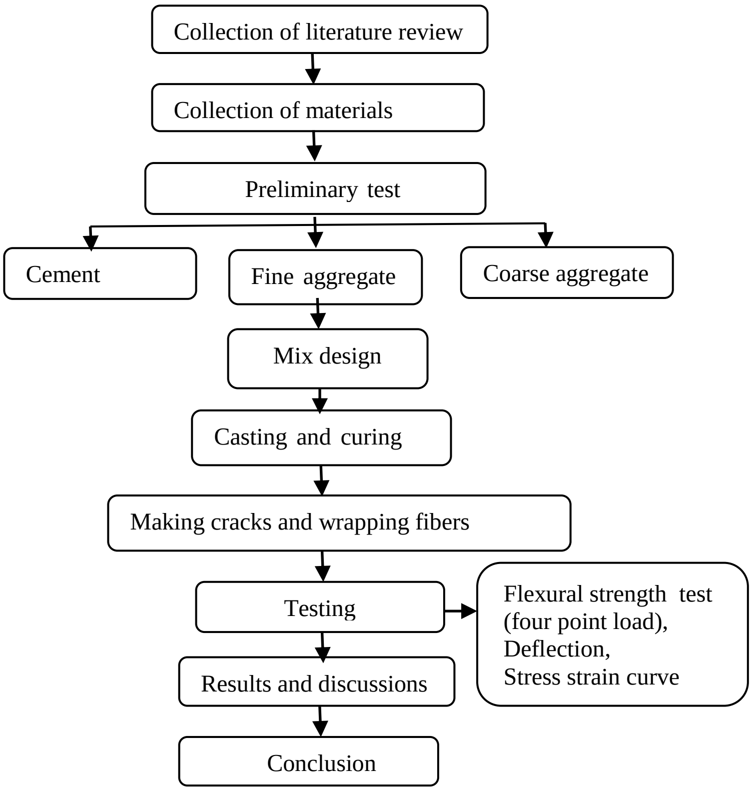
- To study the ultimate load bearing capacity and failure pattern in the rehabilitated RC beam.
- To investigate the structural behavior of RC beams under four point loading .
- To evaluate the ultimate load carrying capacity for the Flexural strength of the strengthened RC beams retrofitted by fiber wrapping technique.
- To increase the strength and durability of a structure because of wrapping.
- To provide maximum lifetime capacity and serviceability.
- To study the effect of different sized layers of fiber, which can be wrapped on shear deficient beams.

2.2 SCOPE

The scope of this project is to investigations as well as studies conducted on the retrofitting of the RC beam using fibers wrapping. So it is essential to study the shear capacity, flexural carrying capacity and ductility of flexural beams by retrofitting with fibers.

3. METHODOLOGY

In this study initially the preliminary tests for cement, fine aggregate, coarse aggregate, and the properties of the materials are determined. A concrete mix design for M-30 grade of concrete was developed by Indian Standard codes IS 383-1970, IS 10262-1982, IS 15658: 2000. Test on Flexural Strength of concrete for M30grade at 28 days curing were conducted.



4. MATERIAL COLLECTION

Cement: Ordinary Portland cement of 53 grades is used in this project Cement is the most important ingredient and act as a binding material. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be confirming to various specifications of are IS 12269-1987.

Table 1: Physical Properties of cement

S.No	Properties	Results
1.	Standard Consistency	31 %
2.	Initial Setting Time	35 minutes
3.	Fineness Modulus	9%
4.	Specific gravity	2.92

Fine Aggregate: The most important function of the fine aggregate to assist in producing workability and uniformity in mixture. The fine aggregate also exists the cement paste to hold the coarse aggregate particles in suspension.

Table 2: physical properties of fine aggregate

S.No	Properties	Results
1.	Specific gravity	2.58
2.	Water absorption	1.5%
3.	Fineness modulus	3.90%

Coarse Aggregate:

The coarse aggregate is the strongest and least porous component of concrete. It is chemically stable material. The presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring an account of movement moisture. In this study hard broken stone passing through 20mm sieve is used as a coarse aggregate

Table 3: Physical properties of coarse aggregate

S.No	Properties	Results
1.	Specific gravity	2.61
2.	Water absorption	0.5%
3.	Impact value	12.16%
4.	Fineness modulus	6.02%

Water: Ordinary potable water without acidity and alkaniety was used. It is the most important and least expensive ingredient of concrete. A part of the mixing is utilizing in the hydration of cement to from the building matrix in which the inert aggregate are held in suspension until the matrix has hardened

RESIN :

Epoxy resin is used for wrapping the specimens.

Epoxy adhesive:

Epoxy resin is a adhesive mortar, based on a two component solvent free epoxy resin. The mix ratio was 3:1 of component A(Resin) and component B(hardener) by weight.

Accelerator:

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

Table 4: Physical properties of Accelerator

CHEMICAL NAME	CAS No	Wt%	PEL	TLV	OTHER LIMITS
Aclkyltoluidines	99-97-8	1-20	NE	NE	NE
Acetone	67-64-1	80-100	750ppm	750ppm	1000ppm

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

Table 5: Physical properties of catalyst

Chemical name	Wt.%	CAS	ENIECS
Hexamine	20-40%	100-97-0	202-905-8

Table 6: Physical properties of liquid resin

S.No	Properties	Results
1	Appearance	Light yellow
2	Specific gravity at 29°c	1.12
3	Acid value mg KOH/G	10.4
4	Viscosity at 29’C cps	80/280
5	Non-volatile content %	34.7
6	Get time at 29’C min	7.15

E-GLASS FIBER: Glass also available as thin sheets, called mats. The width of the such mats is variable between 5cm and 2m, their density being roughly 0.5 Kg/m^2. E-Glass fibers typically have a young modulus of elasticity is 70GPa.

BASALT FIBER: Basalt fiber is a type of igneous rock formed by the rapid cooling of lava at the surface of a planet. It is the most common rock in the Earth ‘s crust. Their density being roughly 2.7 Kg/m^2. Basalt fiber typically have a young modulus of elasticity is 89GPa.

5.EXPERIMENTAL PROCEDURE

5.1FORM WORK

Fresh concrete, being plastic requires some kind of form work to mould it to the required shape and also to hold it till its sets. The form work has, therefore, got to be suitably designed. It should be strong enough to take the dead load and live load, during construction and also it must be right enough so mat any bulging, twisting or sagging due ton load if minimized, wooden beams, mild steel sheets, wood and several material can be used.

Figure 1: Reinforcement and mould setup

5.2MIXING

Mixing of ingredients is done by Hand mixing for this study. The cementitious materials are thoroughly blended and then the aggregates is added and mixed followed by gradual addition of water. Wet mixing is done until a mixture of uniform colour and consistency are achieved which is then ready for casting. Before casting of the specimens, workability of the different concrete mixes was found by Slump cone test for each mixer.

Figure 2: Mixing of concrete

5.3 CASTING

The beam were designed by limit state method and moulds of 150x150x700 mm size were prepared by using plywood sheets. Concrete of M30 grade was designed as per IS10262-2009, the mix proportion is 1:1.7:1.9 ratio(cement, sand and coarse aggregate), and the concrete was hand mixed . First the entire mould was oiled. Cover block of size 20mm are used to provide uniform cover to the reinforcement, when the bar have been placed in position. Concrete mix was poured in layers and compacted using tamping rod &vibrator, the compaction is done until the mould is completely filled and there is no voids. The beams were them removed from the mould after 24 hours.

Figure 3: Casting of beam

5.4 CURING

The specimens are left in the moulds undisturbed at room temperature for about 24 hours after casting. The specimens are then removed from the moulds and immediately transferred to the curing tank with fresh water. The operation of curing is to overcome the problem of loss of hydration. The prepared specimens are cured in a curing tank for a period of 28 days

Figure 5: Curing of beams

5.5 FIBER WRAPPING PROCESS:

While doing the wrapping process, first the beams were made clean. The surfaces of the beams were rubbed with paper to make the surface rough. After that the epoxy adhesive was applied to both the fibers and the concrete surface. Finally Then wrapping of different type of fibers on the surface of the beams such as E-glass fiber and basalt fiber were done. The wet lay up or hard layup technique will be adopted. Concrete beams are strengthened with fibers were cured for 48hours at room temperature before testing.

Figure 6: wrapping of beam

6.TESTING

6.1EXPERIMENTAL TEST CONDUCTED ON FRESH CONCRETE

It is discussed earlier that workability of concrete is a complex property. The following test is commonly employed to measure workability.

6.1.1 SLUMP CONE TEST

Slump test is used to determine the workability of fresh concrete. The test is carried out using a metal mould in the shape of a conical frustum known as abrams cone. The tool typically has an internal diameter of 10 cm at the top and 20 cm at the bottom with a height of 30cm. The cone is placed on a hard non- absorbent surface. This cone is filled with fresh concrete in three stages. Each time, each layer is tamped 25 times nosed tamping rod with diameter of 16mm. The mould is carefully lifted vertically upwards and the concrete subsides. The slump of the cone is measured by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone.

Figure 7: slump cone test

6.2EXPERMENTAL TEST CONDUCTED ON HARDENED STATE

6.2.1FLEXURAL TEST

The determination of flexure strength is essential to estimate the load at which the concrete member may crack. The flexure tests were carried out on beam specimens under standard four point loading was done conforming to IS516-1959. The flexure strength determine by testing standard test specimens of 150mmx150mmx700mm under four point loading. Load vs deflections measurements are observed. The ultimate load at failure was noted.

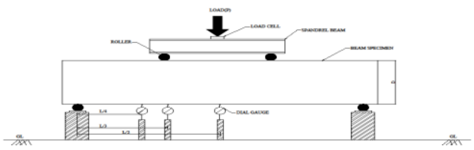


Figure 8: Experimental setup

Figure 9: Control Beam Setup

Figure 10: Wrapped Beam Setup

Figure 11: E-glass Wrapped Beam

Figure 12: Failure pattern of E-glass wrapped beam

Figure 13: Basalt fiber wrapped beam

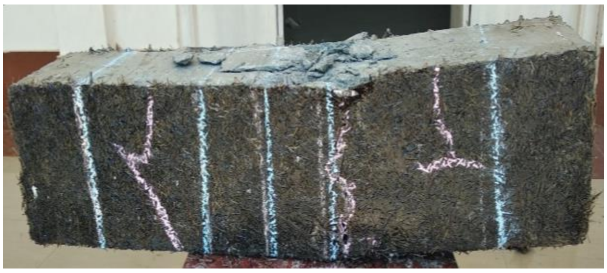


Figure 14:Failure pattern of basalt fiber wrapped beam

6.3 EXPERIMENTAL PROCEDURE

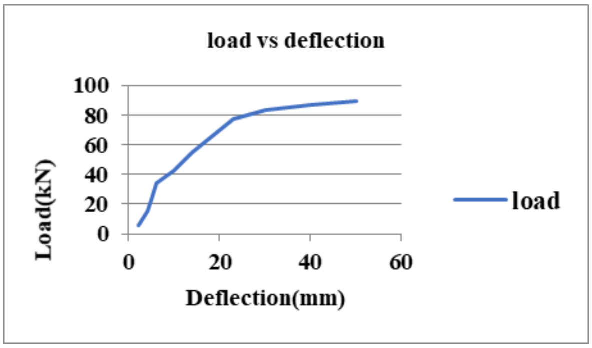
Before testing the members was checked dimensionally, and a detailed visual inspection made with all information carefully recorded. After setting and reading all gauges, the load was increased incrementally up to the calculated working load, with load and deflection recorded at each stage. Load will them normally be increased again in similar increment up to failure, with deflection gauges replaced by a suitably mounted scale as failure approaches.

Table 7: Experimental result for control Beam

Beam no	Specimen 2
Initial crack load	14kN

Ultimate load	89.5Kn			
Sl.no	Deflection (mm)	Load (kN)	Stress (N/mm^2)	strain
1	2	6	0.26	0.004
2	4	15	0.66	0.008
3	5	23	1.02	0.01
4	6	34	1.51	0.012
5	10	43	1.91	0.02
6	14	55	2.44	0.028
7	17	63	2.8	0.034
8	23	77.5	3.44	0.046
9	30	83	3.68	0.06
10	40	88	3.86	0.08
11	50	89.5	3.97	0.1

Graph 1: Load vs deflection graph for control beam



Graph 2: Stress Vs strain graph for control beam

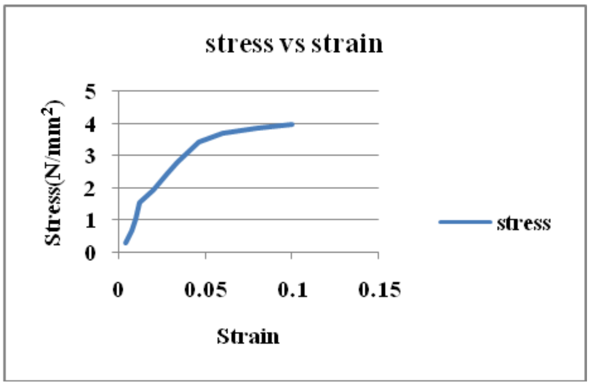
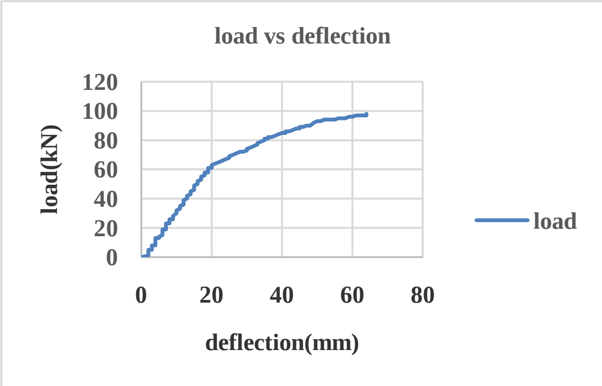


Table 8: Experimental result for E-glass fiber wrapped Beam

Beam no	Specimen 2			
Initial crack load	30kN			
Ultimate load	98kN			
Sl.no	Deflection (mm)	Load (kN)	Stress(N/mm^2)	Strain
1	2	3	0.133	0.004
2	2	5	0.22	0.004
3	3	6	0.266	0.006
4	3	7	0.31	0.006
5	4	8	0.35	0.008
6	4	10	0.44	0.008
7	4	11	0.48	0.008
8	4	13	0.57	0.008
9	5	13	0.57	0.01
10	6	15	0.66	0.012
11	6	18	0.8	0.012
12	7	19	0.84	0.014
13	7	21	0.93	0.014
14	8	23	1.02	0.016
15	8	25	1.11	0.016
16	9	27	1.2	0.018
17	10	30	1.33	0.02
18	10	32	1.42	0.02
19	11	34	1.51	0.022
20	12	36	1.6	0.024
21	12	38	1.68	0.024
22	13	41	1.82	0.026
23	14	44	1.95	0.028
24	15	46	2.04	0.03
25	15	49	2.17	0.03
26	16	51	2.26	0.032
27	17	54	2.4	0.034
28	18	56	2.48	0.036
29	19	58	2.62	0.038
30	20	61	2.75	0.04
31	24	67	2.88	0.044
32	26	70	3.02	0.05
33	30	73	3.2	0.056
34	32	76	3.33	0.062
35	34	79	3.46	0.066
36	36	82	3.6	0.07
37	39	84	3.68	0.076
38	42	86	3.77	0.082
39	45	88	3.86	0.086
40	47	90	3.95	0.092

41	50	93	4	0.096
42	56	95	4.17	0.104
43	60	96	4.22	0.116
44	64	98	4.31	0.122

Graph 3: Load vs deflection graph for E-glass fiber wrapped beam



Graph 4: Stress Vs Strain Graph For E-glass fiber wrapped Beam

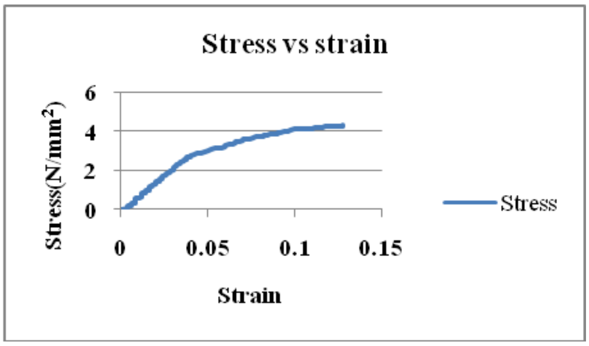
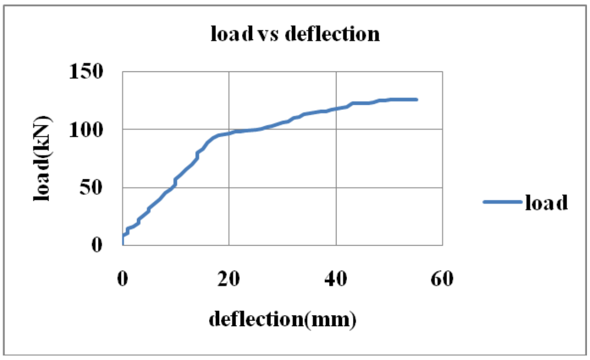


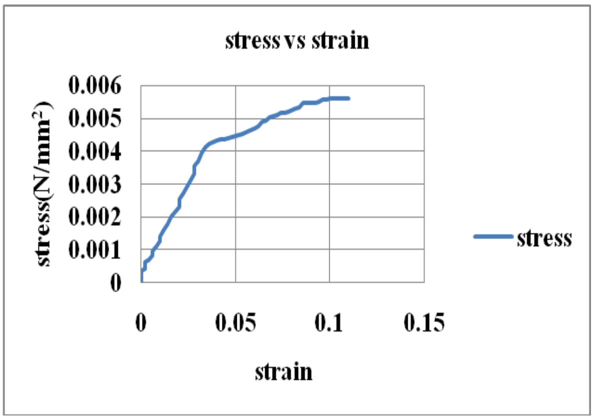
Table 9: Experimental result for Basalt fiber wrapped Beam

Beam no	Specimen 3			
Initial crack load	22kN			
Ultimate load	126kN			
Sl.no	Deflection (mm)	Load (kN)	Stress (N/mm^2)	Strain
1	0	0	0	0
2	0	0	0	0
3	0	2	0.000088	0
4	0	6	0.00026	0
5	0	8	0.00035	0
6	1	10	0.00044	0.002
7	1	14	0.00062	0.002
8	3	19	0.00084	0.006
9	4	25	0.0011	0.008
10	5	32	0.0014	0.01
11	7	40	0.0017	0.014
12	9	48	0.0021	0.018
13	10	57	0.0025	0.02
14	12	66	0.0029	0.024
15	14	75	0.0033	0.028
16	15	83	0.0036	0.03
17	17	93	0.0041	0.034
18	20	97	0.0043	0.04
19	22	98	0.0043	0.044
20	25	100	0.0044	0.05
21	27	102	0.0045	0.054
22	30	106	0.0047	0.06
23	32	110	0.0048	0.064
24	34	113	0.0050	0.068
25	37	116	0.0051	0.074
26	39	117	0.0052	0.078
27	42	120	0.0053	0.08
28	44	123	0.0054	0.088
29	47	124	0.0055	0.094
30	49	125	0.0055	0.098
31	50	126	0.0056	0.104
32	55	126	0.0056	0.11

Graph 5: Load vs deflection graph for basalt fiber wrapped beam



Graph 6: Stress Vs Strain Graph For basalt fiber wrapped Beam



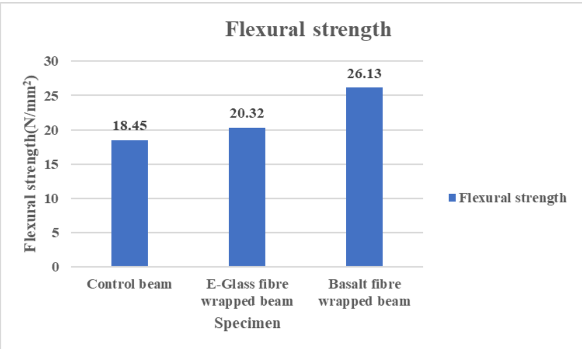
6.4 COMPARISION OF RESULTS

The results of the two set of beam are shown in graph

Table 10: Comparison of Flexural strength of beam

S.NO	TYPE OF BEAM	FLEXURAL STRENGTH(N/mm^2)
1	Control beam	18.45
2	E-glass wrapped beam	20.32
3	Basalt wrapped beam	26.13

Graph 7: Flexural strength of beam



7. CONCLUSIONS

In this experimental investigation the flexural behavior of RC beam strengthened by E-glass and Basalt fiber are studied. From the test results and calculated strength value, the following conclusions are drawn:

1. Initial flexural cracks appear at a higher load by strengthening the beam.
2. The maximum flexural strength is obtained for the beam strengthened by basalt fiber which is 26.13 kN/mm^2.
3. The ultimate load carrying capacity of the beam strengthened by Basalt fiber is 126 kN is obtained with deflection 55mm.
4. Use of Basalt fiber wrapping over the beam improves load carrying capacity and delays cracks formation compared to the controlled beam and beam wrapped with E-glass fiber.
5. Stress strain curve shows the point of modulus of elasticity.

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