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Strengthening of reinforced concrete beam with polyester resin bonded basalt fiber fabric

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ABSTRACT

Fiber reinforced polymer is a beneficial technique to repair and strengthen reinforced concrete members as a externally bonded reinforcement. This technique is used in a number of applications to increase the shear capacity of structural members. An experimental investigation was conducted to evaluate the structural behavior of rectangular concrete beams that is externally strengthened by wrapping basalt fiber fabric at the bottom of the beam with polyester resin as a bonding agent. Basalt fabric is a natural based fiber material originated from volcanic rocks. The rectangular beam is designed for the size of 1000mmx400mmx300mm. The structural behavior such as ultimate load, Stiffness factor were determined. From the experimental investigation we found that wrapping of basalt fiber fabric at bottom of beam controls the deflection of beams. Hence it is best technique to repair and retrofitting of damaged structures. This technique can also be used when there is a need of more strength than its natural strength.

Keywords: *Retrofitting, Reinforced Concrete Beam, Basalt Fiber Fabric*

1. INTRODUCTION

Concrete as the most commonly used construction material that is going towards high performance, i.e., high strength, high toughness, high durability and good workability. Shrinkage and permeability resistance of concrete are two important properties relating to durability. An important measure of improving concrete impermeability is to improve the capability of resisting shrinkage and cracking. Concrete can be modified to perform in a more ductility form by the addition of randomly distributed discrete fibers in the concrete matrix. Specialized technique of strengthening, stiffening and repair are needed to deal with damaged produced by unusual events such as fire, earthquake, foundation movement impact and overload. In this research various tests were conducted to detect the structural behavior of beam with basalt fiber fabric. Here three reinforced concrete beams are externally reinforced with Basalt fiber fabric to examine.

2. BASALT FIBERS

Basalt is a type of igneous rock formed by a rapid cooling of lava at the surface of planet. It is the most common rock in the earth crust. Basalt rock characteristics vary from the source of lava, cooling rate, and historical exposure to the elements. High quality fibers are made from basalt deposits with uniform chemical makeup. Though the temperature required to produce fibers from basalt is higher than glass, It is reported by some researches that production of fibers made from basalt requires less energy by due to the uniformity of its heating. Though the temperature required to produce fibers from basalt is higher than glass, it is reported by some researchers that production of fibers made from basalt requires less energy by due to the uniformity of its heating specification.

Basalt as a fiber used in FRPs and structural composites has high potential and is getting a lot of attention due to its high temperature and abrasion resistance. Compared to FRPs made from glass, aramid and carbon fiber, its use in the civil infrastructure market is very low. The most widely used FRP strengthening technique is the manual application of wet layup. The main and the important feature of this technique is that the fibers of externally bonded FRP composites are in parallel as practicable with the direction of principal tensile stresses.

3. MATERIALS AND MIX PROPORTION

A. Materials: Raw materials required for the concreting operations of present work are cement, fine aggregate and coarse aggregate

B. Cement: Cement is used as binding material in the concrete where the strength and durability are significant important. The

ordinary portland cement of 53 Grades conforming to IS 12269-1987 is used to manufacture the concrete. Also some test were content such as consistency test, setting time test and Specific Gravity test.

Table 1: Properties of Cement

S no.	Properties	Observed
1	Standard Consistency Test	31%
2	Fineness Test	6%
3	Specific Gravity	3.17
4	Initial setting time	32 min
5	Final setting time	582 min

A. Fine Aggregate

The fine aggregate was used clean dry river sand conforming to IS 383:1970. The sand was sieved to remove pebbles. The total fines content of the mix is the function of both the binder (and filler) content and the fine aggregate content with the grading of fine aggregate being particularly important. The grading of fine aggregate in the mortar should be important such that both workability and stability are simultaneously maintained. Sand fineness modulus is 2.87.

Table 2: Properties of Fine Aggregate

S no.	Test for Fine Aggregate	Observed Values
1	Fineness Modulus	2.87
2	Specific Gravity	2.67
3	Bulk Density (Kg/m^3)	1589.30
4	Moisture content	2.50
5	Water absorption(%)	0.90

B. Coarse Aggregate

Hard granite broken stones of 20mm size were used as coarse aggregate conforming to IS: 383-1970. However, the influence of the grading of coarse aggregate has also to be considered if the spacing of the obstacles is very close to the maximum size of coarse aggregate. The specific gravity is found to be 2.81. The physical properties of coarse aggregate are shown in table

Table 3: Properties of Coarse Aggregate

S no.	Test of Coarse Aggregate	Result
1	Water Absorption	4%
2	Specific Gravity	2.81
3	Moisture Content	0.26
4	Bulk density	1452

C. Water

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salt, sugar, organic or other substance that may be deleterious to concrete. Potable water generally considered satisfactory for mixing and curing.

D. Basalt fiber

Basalt as a fiber used in FRPs and structural composites has high potential and is getting a lot of attention due to its high temperature and abrasion resistance. Compared to FRPs made from glass, aramid and carbon fiber, its use in the civil infrastructure market is very low.

Table 4: Mechanical properties of Basalt fiber

Fiber	Tensile strength (MPa)	Modulus of elasticity (GPa)	Ultimate tensile strain (%)	Unit weight (g/cm^3)
Basalt	2500	84	3.15	2.6

E. Mix proportion

Mix design is a process of selecting suitable ingredients and determining their relative proportion with the objective of producing concrete of having certain minimum workability, strength durability as economically as possible. In this method water content and proportion of fine aggregate corresponding to the maximum size of aggregate are first determined fromthe reference values of workability, water-cement ratio, and the grading of fine aggregate is given in table5.

Table 5: M30 Concrete Mix Proportion

Mix	Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	W/C
M30	490	594	1121	0.4

4. RESULT

The compressive strength test, Split tensile strength test and Flexural Strength test were tested for Conventional concrete. The deflection test was carried out on beam, the beams are casted and wrapped with basalt fiber fabric the deflection values against different loads were measured by using a load cell and deflectometers. For beams, Deflection test was conducted at the curing age of 28 days, beam dimension of (300x400x1000) mm at the centre point load should be given at L/3 distance these beams are casted with Conventional Concrete and beam with basalt fiber fabric.

A. Compressive Strength of Concrete

Compressive strength of concrete is tested on cube of size (150×150×150) mm. The strength of concrete has been tested on cube at 7 and 28 days. Compression testing machine is used for testing the compressive strength test on concrete.

Table 6: Compressive strength

Cube	7 days	28 days
1	22.89	34.67
2	22.11	34.22
3	22.67	34.00

B. Flexural Strength of Concrete

This test was carried out in UTM by two point loading method of specimen of (500 x100 x 100) mm and tested for maximum load.

Table 7: Flexural Strength

Prism	7 days	28 days
1	2.95	3.85
2	3.01	3.79
3	2.99	3.89

C. Split Tensile Strength of Concrete

Splitting tensile tests were carried out on 150mm diameter and 300mm height cylinder specimens at an age of 7 and 28 days using compression testing machine.

Table 8: Split Tensile Strength

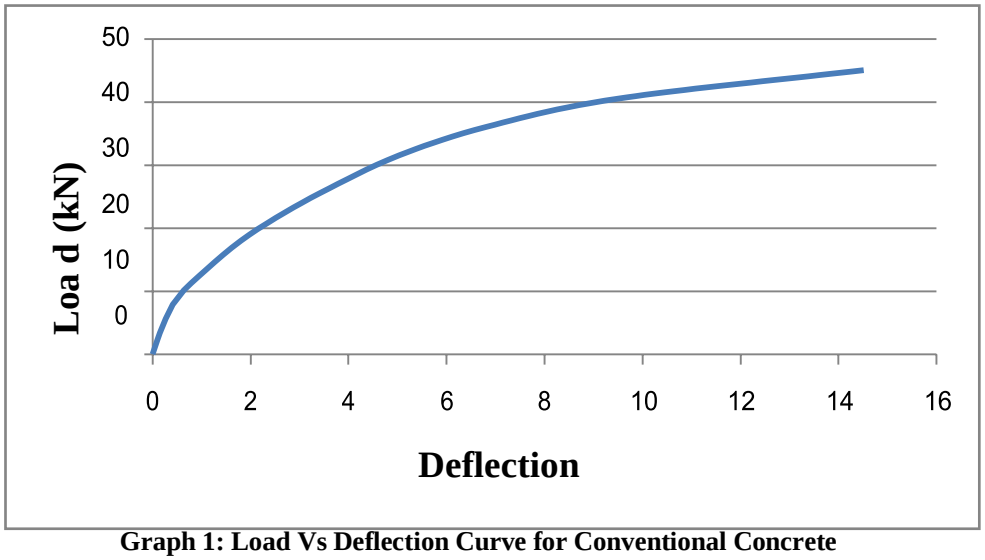
Prism	7 days	28 days
1	3.07	4.14
2	2.98	4.37
3	3.11	4.43

D. Deflection test

The load test was carried out on beam, the beams are casted and wrapped with basalt fiber fabric the deflection values against different loads were measured by using a load cell and deflectometers. For beams, Deflection test was conducted at the curing age of 28 days, beam dimension of (300x400x1000) mm at the centre point load should be given at L/3 distance these beams are casted with Conventional Concrete and beam with basalt fiber fabric .

Table 9: Test Result of Load Vs Deflection for Conventional Concrete

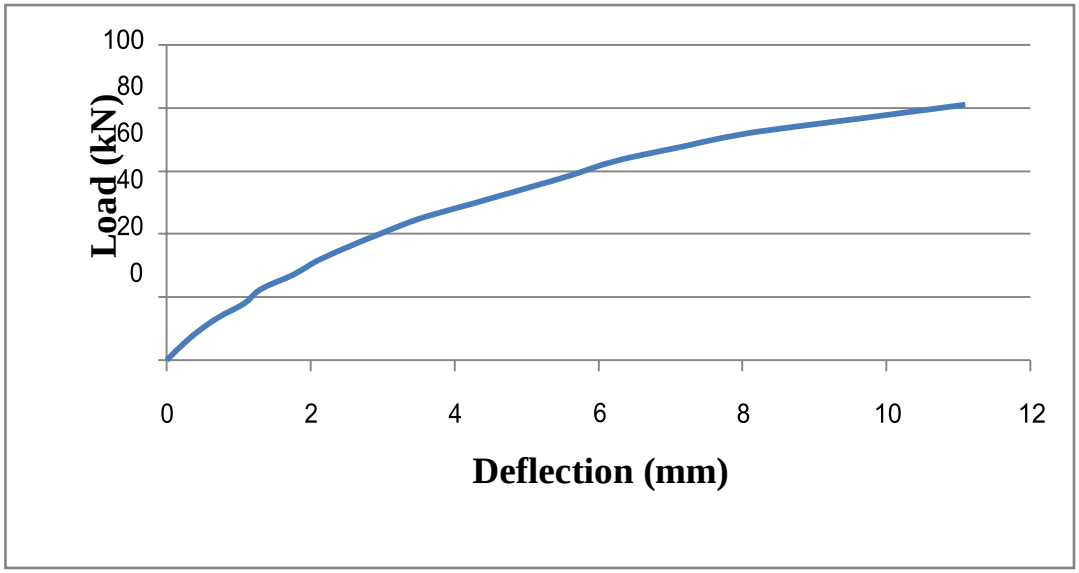
Load (kN)	Deflection (mm)	Stiffness (N/mm)
0.00	0	0
4.50	0.207	21.74
9.00	0.512	17.57
13.50	1.109	12.17
18.00	1.807	9.96
22.50	2.712	8.29
27.00	3.790	7.124
31.50	5.035	6.26
36.00	6.808	5.28
40.50	9.513	4.26
45.00	14.519	3.11



Graph 1: Load Vs Deflection Curve for Conventional Concrete

Table 9: Test Result of Load Vs Deflection for beam wrapped with basalt fiber fabric

Load (kN)	Deflection (mm)	Stiffness (N/mm)
0.00	0.00	0.00
4.50	0.201	22.39
9.00	0.429	20.98
13.50	0.712	18.90
18.00	1.079	16.68
22.50	1.306	17.22
27.00	1.751	15.42
31.50	2.090	15.07
36.00	2.529	14.23
40.50	3.012	13.44
45.00	3.529	12.75
49.50	4.228	11.71
54.00	4.920	10.97
58.50	5.601	10.45
63.00	6.213	10.14
67.50	7.120	9.48
72.00	8.090	8.90
76.50	9.590	7.98
81.00	11.090	7.30
85.50	13.500	6.34



Graph 2: Load Vs Deflection Curve for beam wrapped with basalt fiber fabric

5. CONCLUSION

- The beam which was strengthened by basalt Fiber wrapping up at the bottom shown good performance characteristics compared to conventional beam.
- The stiffness value for the Basalt wrapped beam specimen by the test result its shows that the basalt fabric wrapped concrete increases the stiffness value of the beam.
- From this work it was derived that natural based fiber fabric shown good structural behavior characteristics when compared to control concrete.
- So this wrapping may be used in strengthening of existing structures in the seismic prone areas.

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