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Strengthening of Reinforced Concrete using Basalt Fiber

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Abstract: Concrete is most widely used construction material in the world. Fiber reinforced concrete (FRC) is a concrete in which small and discontinuous fibers are dispersed uniformly. The fibers used in FRC may be of different materials like Basalt, steel, G.I., carbon, glass, polypropylene, etc. The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. FRC has found many applications in civil engineering field. Here basalt fiber is used as a strengthening agent in normal plain cement concrete to find the compressive strength, Tensile strength and flexural strength. Based on the laboratory experiment on fiber reinforced concrete (FRC), cube, cylinder and beam specimens have been designed with Basalt fiber reinforced concrete (BFRC) containing fibres of 0%, 1%, 2%, and 3% by total weight of cement in specimen of 18mm cut length were used without admixture. Then the compressive strength, Tensile strength and flexural strength result of FRC is compared with plain M_{20} grade concrete.
Keywords: Compressive Strength, Tensile strength, flexural strength, Basalt Fiber, Fiber Reinforced Concrete.

I. OBJECTIVE

This project to increase the strength of the concrete by addition of fibers in 0%,1%,2%,3% to the weight of cement and to find the compression and flexural strength of concrete. Then the compressive strength, Tensile strength and flexural strength result of FRC is compared with plain M_{20} grade The concrete.

II. INTRODUCTION

Industry is always trying to find new, better and economical material to manufacture new product, which is very beneficial to the industry. Today a significant growth is observed in the manufacture of composite material. With this in mind energy conservation, corrosion risk, the sustainability and environment are important when a product is changed or new product is manufactures.

Basalt fiber is a high performance non-metallic fiber made from basalt rock melted at high temperature. Basalt rock can also make basalt rock, chopped basalt fiber, basalt fabrics and continous filament wire. Basalt fiber originates from volcanic magama and volcanoes, a very hot fluid or semi fluid material under the earth's crust, solidified in the open air.

When in contact with other chemicals they produce no chemical reaction that may damage health or the environment. Basalt fiber has good hardness and thermal properties. Basalt fibers have been successfully used for foundation such as slabs on ground concrete.[4-6] The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. It is now established that one of the important properties of Fiber Reinforced Concrete (FRC) is its superior resistance to cracking and crack propagation.

A. Basalt Fiber

Basalt fiber are melted from volcanic basalt stone, thin basalt threads are pulled to form continuous filaments at a specified diameter which are coated by a sizing suitable for the concrete applications. These fibres are assembled into basalt strands which are chopped to length as determined by the application. Basalt has a fine-grained mineral texture due to the molten rock cooling too quickly for large mineral crystals to grow, although it is often porphyritic, containing the larger crystals formed prior to the extrusion that brought the lava to the surface, embedded in a finer-grained matrix. Basalt fiber is a high performance non-metallic fiber made from basalt rock melted at high temperature. Basalt rock can also make basalt rock, chopped basalt fiber, basalt fabrics and continuous filament wire.

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B. Properties of Basalt Fiber

Diameter – 13to20μm, Specific Gravity – 2.68 g/cm3, Color – Bronze, Thermal Operating Range – -260 to+700C, Electrical Conductivity – None ,Resistance to Corrosion – Non Corrosive.

III. MATERIALS USED

The materials used in this experiment are cement , fine aggregate , coarse aggregate , water and basalt fiber.

IV. EXPERIMENTAL TESTS

A. Concrete

The grade of concrete chosen is M20 Grade and the proportion of the mix is calculated as per the mix design. The concrete selection criteria tests performed are mentioned below.

1) *Slump Test:* The aim of this test is to determine the workability of the cement concrete to be used. The mix is prepared and placed in a clean slump cone mould and tamped by three layers of about 25 stokes each layer and the top of the cone is levelled off. Then the mould is lifted up vertically and the nature of slump is analyzed to get the workability of the given cement concrete . For the water cement ratio of 0.5 the slump obtained for each % of fiber concrete and conventional concrete are given below (in mm)

Table 4.1. slump value of concrete

FIBER CONTENT (%)	SLUMP VALUE (MM)
0	27
1%	25
2%	22
3%	15

2) *Compressive Strength Of Concrete*

The Compressive strength of concrete is determined by the crushing strength of 150mm x 150mmx150mm, at an age of 7 ,14 and 28days.Steel mould made of cast iron dimension 150mm x 150mmx150mm used for casting of concrete cubes filled with Basalt fibers 0%, 1% , 2% and 3% by total weight of cement. The mould and its base rigidly damped together so as to reduce leakages during casting. The cube was then stored for 24 hours undisturbed at temperature of l8°C to 22°C and a relative humidity of not less than 90% (IS 516-1959).

3) *Mixing Of Concrete:* Mixing of concrete for cubes is done by hand mixing and the mixing is done according to the design mix of m20 concrete at 1 : 1.78 : 3.1 and first the cement and fine aggregate is mixed well then the coarse aggregate is added with 2/3 of water and mixed well the the fiber is added to concrete with remaining water.

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4) Placing Of Concrete

The concrete is placed in mould of 150 x 150 x 150 mm in three layers and each layers is damped with damping rod for 25 strokes and the top layer is finished with trowel.


5) Testing Of Cubes

The cubes are tested after placing the cubes in curing tank till the curing time. after the curing time the mould is removed from tank and dryed and then placed in compression testing machine. then the load was applied without shock and increased continuously at the rate of approximately 140 Kg/sq cm/ min until the resistance of specimen to the increasing loads breaks down and no greater load can be sustained. The maximum load applied to the specimen was then recorded as per IS: 516-1959.

The compressive strength was calculated as follows:

Compressive strength = Failure load / cross sectional area.

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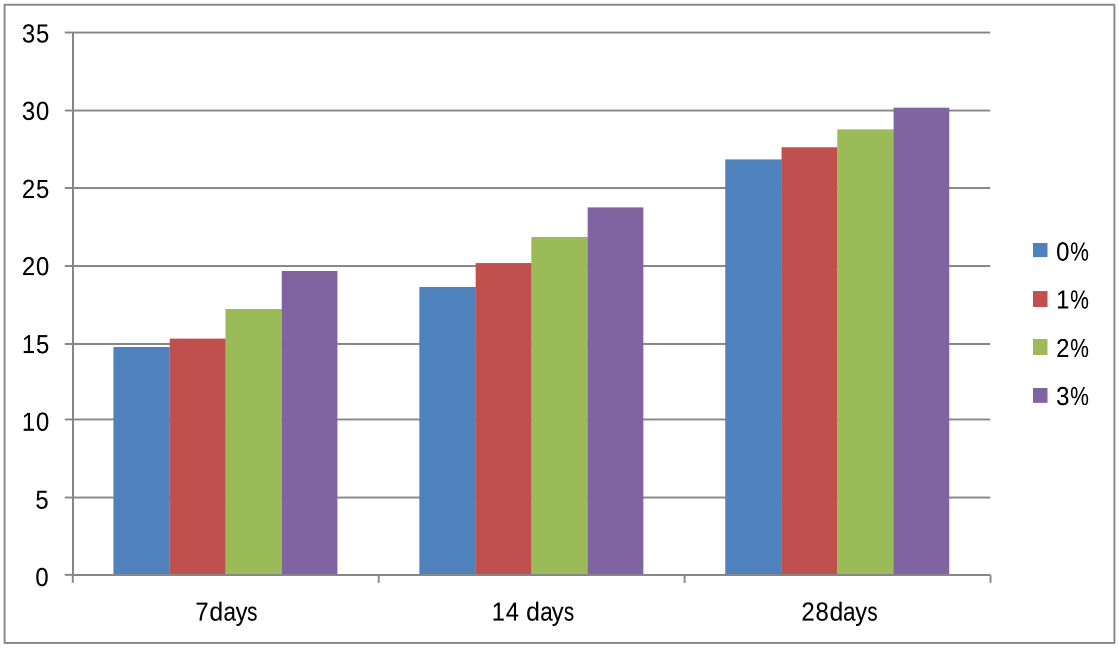
6) Results On Compression Strength Of Concrete

The compression strength of concrete for m20 grade concrete with different fiber % are shown below

Table.4.2. compression strength of concrete

BASALT FIBER(%)	COMPRESSION STRENGTH (N/MM^2)		
	7 days	14 days	28 days
0	14.8	18.6	26.8
1%	15.3	20.2	27.6
2%	17.2	21.8	28.8
3%	19.6	23.8	30.2



Bar chart: 4.1.compression strength

From the above chart it is clear that the percentage fiber increases the compression strength of concrete increases.

7) Tensile Strength Of Concrete

The cylinder is placed in a horizontal position and the load is applied gradually and value is recorded if the cylinder splits into two half or if the cylinder fails while applying the load on it.

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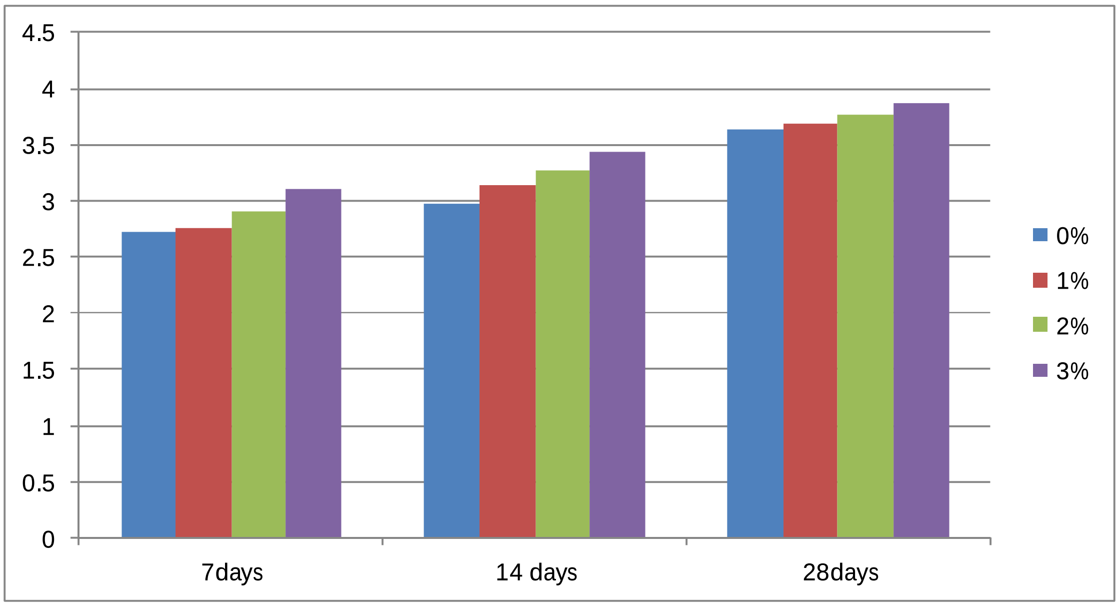
This test is done to determine the tensile strength of the cylinders. The test is conducted on the 7day , 14th day and the 28th day and its observation are listed below in the form of a graph.

Table.4.3. Tensile strength of concrete

BASALT FIBER(%)	TENSILE STRENGTH (N/MM^2)		
	7 days	14 days	28 days
0	2.72	2.98	3.64
1%	2.76	3.14	3.68
2%	2.90	3.27	3.77
3%	3.10	3.43	3.86

Bar chart: 4.2.Tensile strength of concrete



B. Reinforcement Of R.C Beams

Reinforcement of R.C beams is done with 10mm and 8mm dia rods , 10mm dia of 2nos is used in tension side for the length of 1950mm with 25mm cover on both sides and 8mm dia rods of 2nos are used as hanging bars with 8mm stripps at 100mm c/c spacing. Totally 12 beams are reinforced at 3beams for every percentage of fiber , initially the bars are straighten and then the bars are cutted for 1950mm length and the stripps are bended and the the stripps are tied with tension bar and hanging bar .Before tie of stripps the spacing of stripps at 100mm c/c is marked on tension bars and hanging bar.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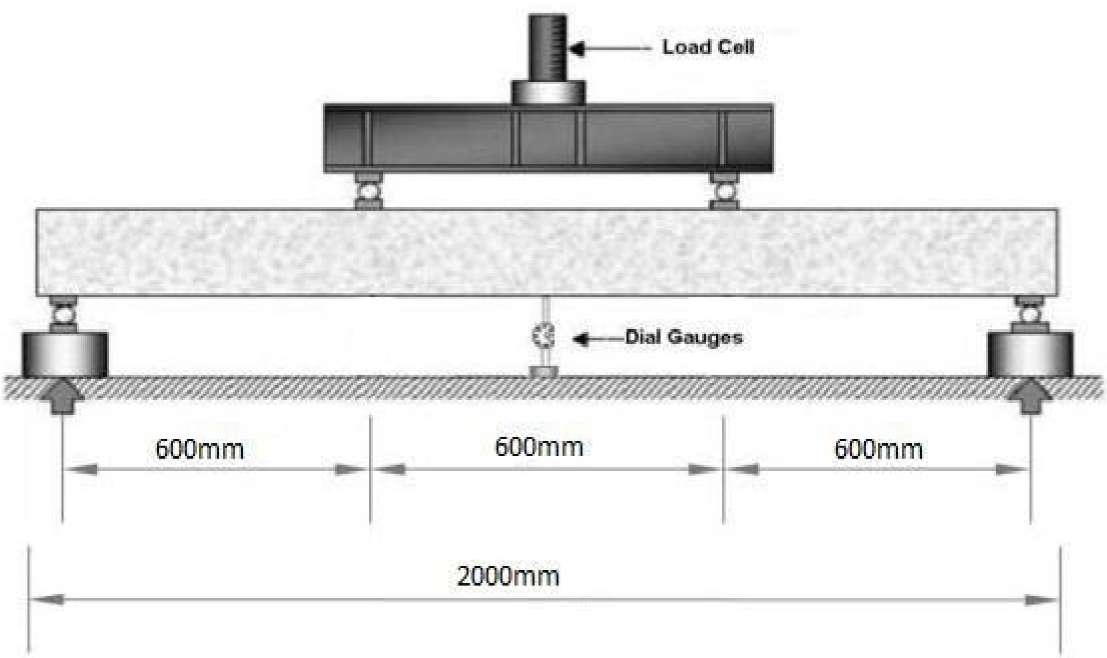
A. Mixing of Concrete

Mixing of concrete should be done thoroughly to ensure that concrete of uniform quantity is obtained . Hand mixing is done in small works , while machine mixing is done for all big and important works although a machine generally does the mixing , hand mixing sometimes may be necessary surface is needed for this purpose even , paved surface or a wood platform , having tight joints to prevent paste loss .

B. Experimental Setup

All the specimens were tested in the loading frame of the " Structural Engineering Laboratory" of Arulmigu Meenakshi Amman College Of Engineering. The tesing procedure for the entire specimen was same . After the curing period of 28 days was over , the beams as washed and its surface was cleaned for clear visibility of cracks . the most commonly used load arrangement for testing of beams will consist of two point loading . this has the advantage of a substantial region of nearly uniform moment coupled with very small shears , enabling the bending capacity of the central portion to be assessed . if the shear capacity of the members is to be assessed , the load will normally be concentrated at a suitable shorter distance from support.



All the Twelve beams are tested under simply supported end conditions. Two point loading is adopted for testing and spacing between two concentrated loads. The testing of beams is done with the help of hydraulic operated jack connected to load cell. The load is applied to the beam with the help of hydraulic jack and the data is recorded from the data acquisition system, which is attached with the load cell. One LVDT (Linear Variable Deflection Transformer) is placed at the center of the specimen. The value of deflection is obtained from LVDT.

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V. RESULTS AND DISCUSSION

A. Result analysis

The deflection per unit loaded in noted and the initial and final crack of beams are noted and the results are tabulated below.

Table.5.1. Result on 0% of basalt fiber Beam

<table>
<tr><th>S.no</th><th>Deflection(mm)</th><th>Load(kN)</th><td rowspan="11">Initial crack = 20 kN
Final crack = 48.2kN</td></tr>
<tr><td>1</td><td>0.25</td><td>5</td></tr>
<tr><td>2</td><td>0.57</td><td>10</td></tr>
<tr><td>3</td><td>1.08</td><td>15</td></tr>
<tr><td>4</td><td>1.66</td><td>20</td></tr>
<tr><td>5</td><td>2.50</td><td>25</td></tr>
<tr><td>6</td><td>3.43</td><td>30</td></tr>
<tr><td>7</td><td>4.23</td><td>35</td></tr>
<tr><td>8</td><td>5.35</td><td>40</td></tr>
<tr><td>9</td><td>5.45</td><td>45</td></tr>
<tr><td>10</td><td>6.42</td><td>48.2</td></tr>
</table>

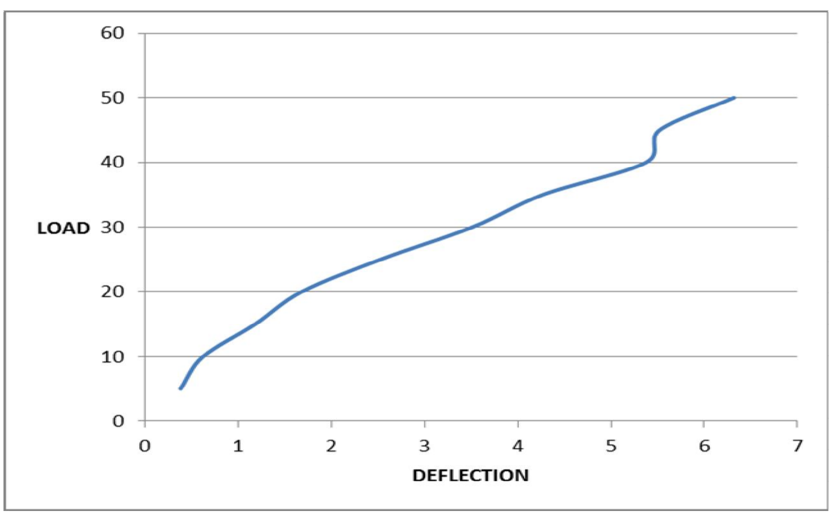

Fig.5.1 Load vs Deflection for 0% BFRB

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Table.5.2. Result on 1% of basalt fiber Beam

S.no	Deflection(mm)	Load(kN)	
1	0.38	5	Initial crack = 25 kN Final crack = 52.8kN
2	0.62	10	
3	1.18	15	
4	1.68	20	
5	2.52	25	
6	3.51	30	
7	4.27	35	
8	5.38	40	
9	5.52	45	
10	6.32	50	
11	7.60	52.8	

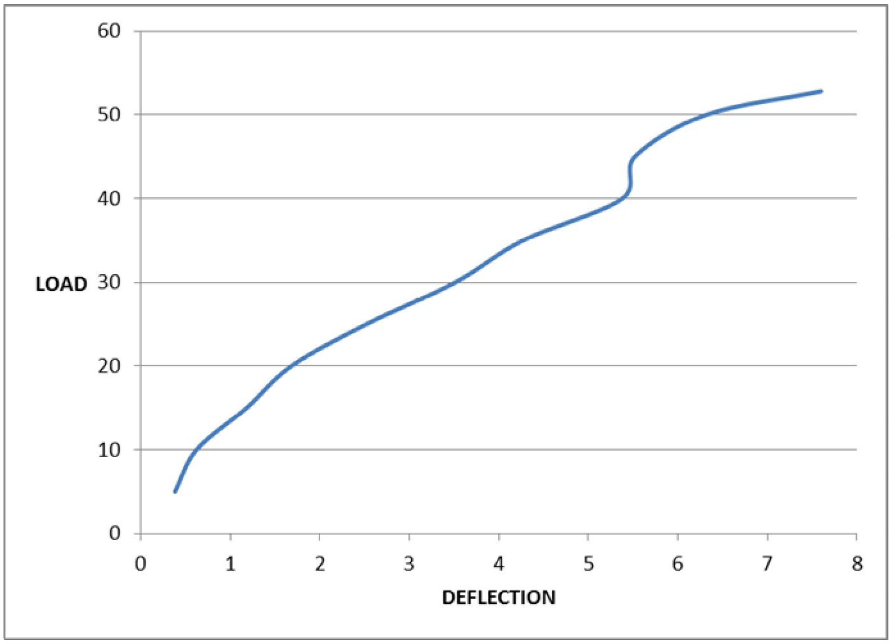

Fig.5.2. Load vs Deflection for 1% BFRB

S.no	Deflection(mm)	Load(kN)	
1	0.32	5	Initial crack = 25 kN Final crack = 54.6kN
2	0.51	10	
3	1.20	15	
4	1.68	20	
5	2.62	25	
6	3.48	30	
7	4.31	35	
8	5.42	40	
9	5.62	45	
10	6.33	50	
11	7.55	54.6	

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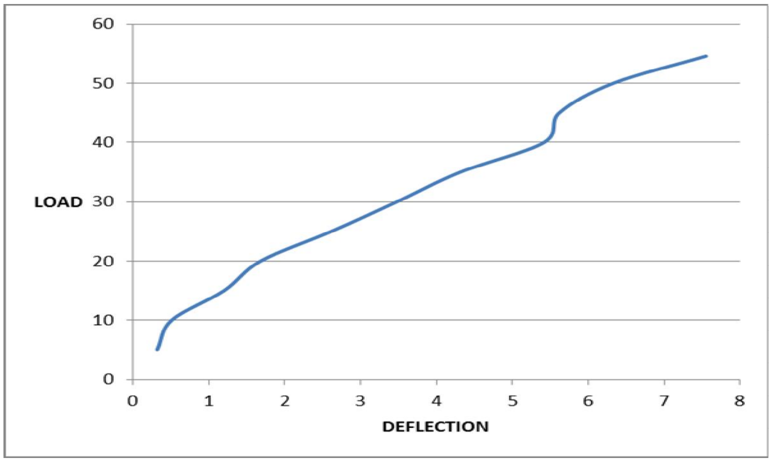

Fig.5.3. Load vs Deflection for 2% BFRB

Table.4.4 Result on 3% of basalt fiber Beam

S.no	Deflection(mm)	Load(kN)	
1	0.38	5	Initial crack = 30kN Final crack = 58.2kN
2	0.52	10	
3	1.18	15	
4	1.75	20	
5	2.72	25	
6	3.51	30	
7	4.42	35	
8	5.48	40	
9	5.65	45	
10	6.21	50	
11	6.42	55	
12	7.30	58.2	

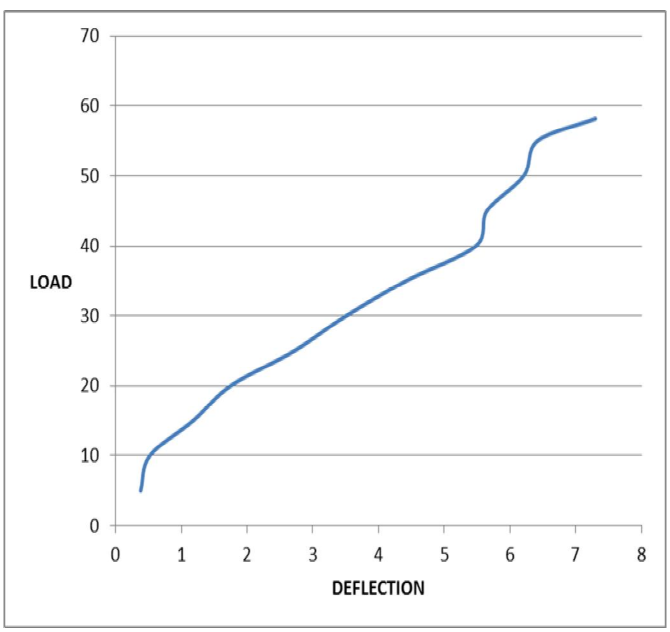

Fig.5.4. Load vs Deflection for 3%BFRB

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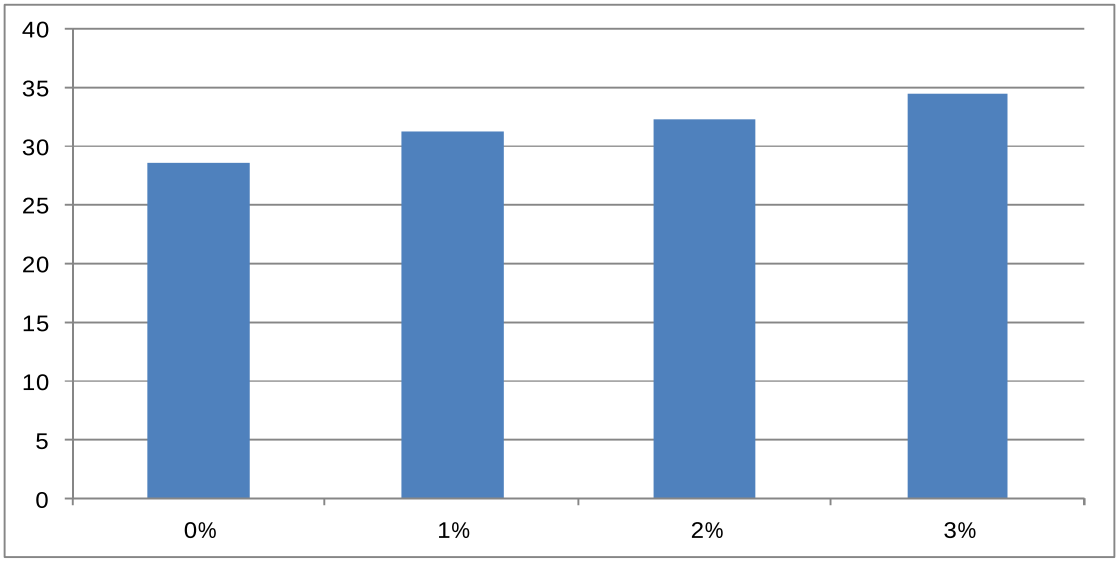
Table.4.5 Flexural Strength of Beams

Sl.no	% of Fiber	Ultimate load KN	Flexural strength(N/mm2)
1.	0	48.2	28.57
2.	1	52.8	31.28
3.	2	54.6	32.36
4.	3	58.2	34.49



Bar chart: 5.1. Flexural strength of Beams

VI. CONCLUSIONS

Based upon the results of experimental study carried out the following conclusions can be drawn. The addition of Basalt fiber has improved the compressive strength, split tensile strength and flexural strength of concrete. The strength difference between basalt fibre concrete specimens and control concrete specimens became high distinct in the beginning age of curing itself.

VII. ACKNOWLEDGEMENT

The research work would not have been possible without my guide and my soul motivation Mrs. R. Suganya, M.E, Also the facts and works provided in this paper is dedicated to all the civil engineers to look world in a smart way. And lastly I want to thank my parents for their unconditional support.

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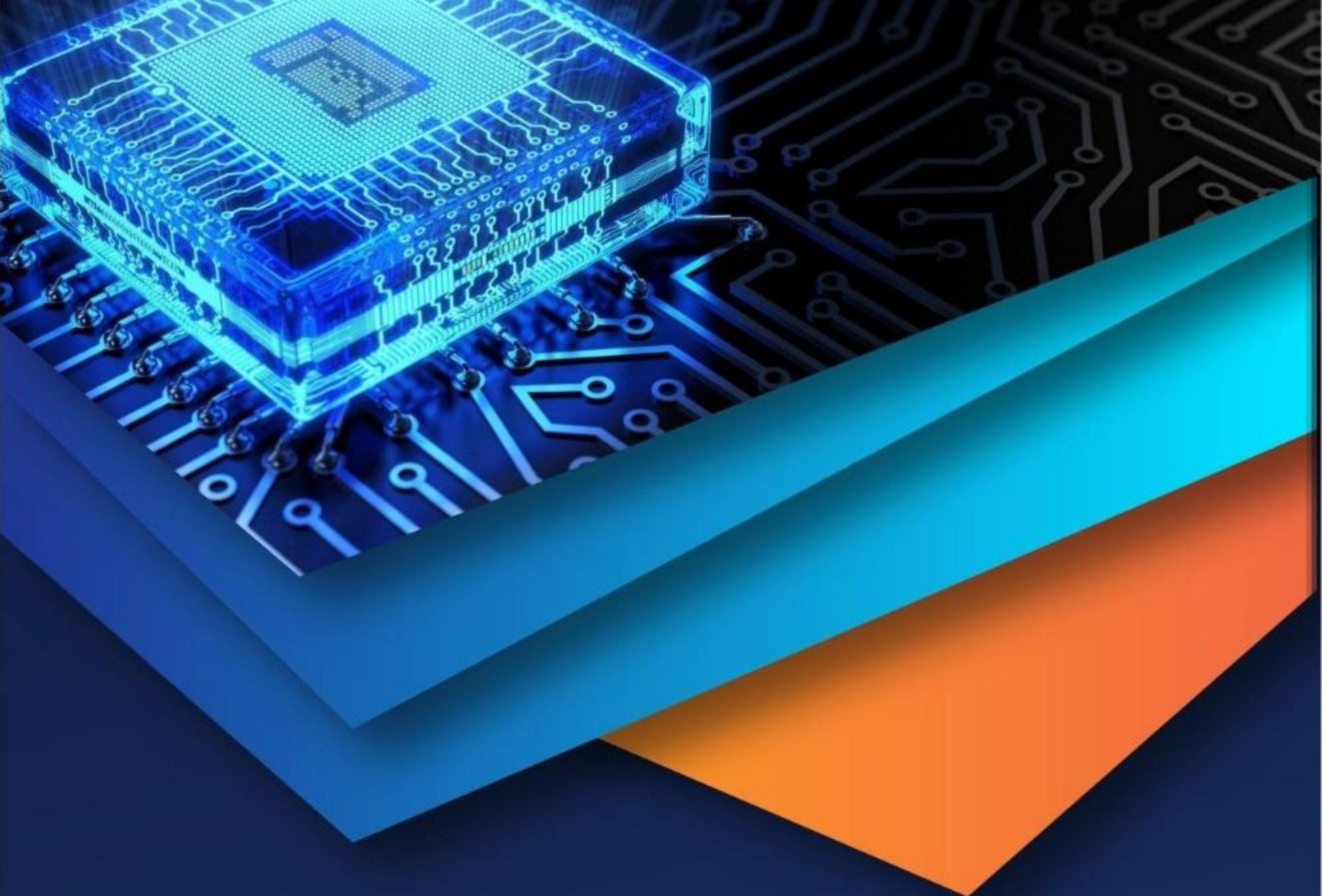

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