A Study on Strength Characteristics of Fiber Reinforced Concrete using Basalt Rock Fiber

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***Abstract*—*This paper is to analyse the strength development of FRC with the addition of Basalt Fibre in Concrete. Attempt has been made to study the effect of Basalt Fibre on the performance of M40 grade Concrete. This material may be used in construction industry for the structural elements and Airport runways. Concrete Cubes were casted to study the characteristic compressive strength with different ratios of Basalt Fibres. The fibres were added at percentage of 0.5 to 3 with an increase of 0.5%. Prism specimens were also casted to study the performance of flexural strength of concrete. The specimens were tested after 7, 14, 28 days of curing. The results shows an increase of 12 % in compression and 38 % increase in flexure.*

Keywords*—*Basalt fiber, Compressive strength, Flexural strength, Fiber reinforced concrete

I. INTRODUCTION:

Concrete is the most widely used man-made construction material in the world and is second to water as the most utilized substance on the planet. A major portion of this concrete volume is occupied by coarse and fine aggregate. The demand for aggregate is enormous in liberalization, privatization and globalization, and in the construction of important infrastructure projects like Expressways, Airports, nuclear plants etc. The increased extraction of coarse and fine aggregate from the natural resources is required to meet this high demand. The increasing use of natural fine aggregate creates an ecological imbalance. Thus, partial replacement of fine aggregate is vital in construction industries. Aggregates are the most important constituents in the concrete mix that help in reducing shrinkage and impart economy to concrete production. Most of the aggregate used are naturally occurring aggregates (Ansari et al, 2015).

1.1 Basalt fiber:

Many fibers are used in the construction industry such as glass polyethylene, carbon fiber etc., one of the new fibercalled Basalt rock fiber is added to this list. Basalt is usually brown or dark in color formed from volcanic lava after solidification. It has better strength characteristics of good hardness and thermal properties. Basalt rock fibers give high strength and low cost high performance to solve the problem in the large project like cracking, structural failure of concrete. The structure of Basalt fiber is shown in figure below (Figure 1)

Figure 1 Basalt Fiber

It is generally used for reinforcement in Civil Construction, Road Repairing and infrastructure. It does not get affected by Acid or Base or any organic chemicals. These fibers are heat resistant and not affected by temperature upto 650^{O} C to 700^{O} C. It is very strong & light in weight. One Kg of basalt fibre replaces 9.6 Kg steel reinforcement. The Table below (Table 1)shows the characteristics of Basalt fibre.

Table 1 Characteristics of Basalt Fibre

Characteristics	Basalt Fiber
Tensile strength, M Pa	3000~4840
Elastic modulus, G Pa	79.3~93.1
Elongation at break, %	3.1~6
Specific gravity	2.65-2.8
Diameter of filament, mμ	6~21
Temperature of application, °C	-260~+500
Melting Temperature, °C	1450

II. LITERATURE SURVEY

Ansari et al, (2015) has done an experimental research on high strength concrete of grade M40 using Basalt Rock Fiber. The fiberswere replaced at a percentage from 0 to 1.5% at an interval of 0.5%. The

hardened properties of concrete such as compressive strength and splitting tensile were tested at 28, 56, 90 days. The Compressive strength and splitting tensile strength of concrete increases with increase in the age of curing. The compressive strength of concrete increased with increase in the percentage of Basalt Fibreupto 1% and after that it tends to decrease. The maximum compressive strength was found at 1% of replacement cement as 54.78 (N/mm^2), 55.51 (N/mm^2), 56.53 (N/mm^2) at 28 days, 56 days and 90 days respectively. The split tensile strength of concrete increased with increase in the percentage of Basalt Fibreupto 1% and after that it tends to decrease. The maximum spilt tensile strength was found at 1% of replacement as 4.19 (N/mm^2), 4.48 (N/mm^2), 4.95 (N/mm^2) at 28 days, 56 days and 90 days respectively.

Jaysing et al, (2014) has done an experimental research on High Strength Concrete of grade M40 using Basalt Rock Fibre. The fibres were replaced at a percentage from 0 to 0.75% at an interval of 0.25%. The hardened properties of concrete such as compressive strength, split tensile strength and Flexural Strength are test at 28 days. The Compressive strength of concrete is the percentage of Basalt Fibre is 0.25% and after tends to decrease. The maximum compressive strength of concrete was found at 0.25% of replacement as 63.51 (MPa) at 28 days. The Split tensile strength of concrete is the percentage of Basalt Fibre is 0.25% and after tends to decrease. The maximum split tensile strength of concrete was found at 0.25% of replacement as 5.700 (MPa) at 28 days. The Flexure Strength of concrete is the percentage of basalt fibre is 0.25% and after tends to decrease. The maximum flexure strength of concrete was found at 0.25% of replacement as 6.3 (MPa) at 28 days.

Irine, (2014) done an experimental research on Normal Strength Concrete of grade M30 using Basalt Rock Fibre. Based on the laboratory experimental on basalt fibre reinforced concrete, cube, beam and cylindrical specimens have been designed with basalt fibre reinforced concrete containing $1kg/m^3$, $2kg/m^3$ and $4kg/m^3$ basalt fibbers'. The experimental test results demonstrated considerable increases in compression, flexural and splitting of specimen at 3, 7 and 28 days with addition of basalt fibres. The fibrewere replaced from 0 to 4 (kg/m^3) at an interval of 1 kg/m^3. The hardened properties of concrete such as compressive strength, split tensile strength and Flexural strength were tested at 3, 7, 28 days. The compressive strength, split tensile strength and flexural strength of concrete increases with increase in the age of curing. The maximum compressive strength of concrete was found at 4 kg/m3 of Basalt fibre is 22.2 (N/mm^2), 28.89 (n/mm^2), 40.2 (N/mm^2) at 3, 7, 28 days respectively. The maximum split tensile strength of concrete was found at 4 kg/m^3 of basalt fibre is 2.87 (N/mm^2), 3.64 (N/mm^2) at 7, 28 days respectively. The flexural strength of concrete was found at 4 kg/m^3 of basalt fibre is 6.2 (N/mm^2), 8 (N/mm^2) at 7, 28 days respectively.

Rathod et al, (2015) has done an experimental research on normal strength cone of grade M25 using basalt fibre. The fibres were replaced at a percentage of 0 to 2% at an interval of 1%. The Test conducted on this research are compressive strength and flexural strength at 14 days and 28 days. In the 14 days average strength was maximum when 2% fibre is used. About 40% to 50% increase in strength is observed. In the 28 days average compressive strength is maximum when 2% fibres' are used. About 83% & 92% increase in compressive strength than the design strength, when the basalt fibres are introduce in concrete.

An experimental research on high strength concrete of grade M40 using basalt fibre was carried out. The fibres were replaced at a percentage from 0 to 1% at an interval of 1%. The hardened properties of concrete such as compressive strength, slit tensile and flexural strength were tested at 7 and 14 days. As far from the work done that initial when adding fibre in high strength concrete the strength of high strength concrete is decreasing on 7 days and 14 days. But as far from study of research paper that the strength of basalt fibre will gain more than the design mix after 28days was studied by Ketan et al, (2013).

III. EXPERIMENTAL INVESTIGATION

3.1 Materials Used:

In this the various materials used for the study, their properties, test conducted and results are discussed. This section also explains the mix proportions used for the study.

3.1.1 Cement:

Ordinary Portland cement of 43 grades confirming to IS 8112:1989 was used in this study. The Table 2below shows the properties of Fine aggregate.

Table 2 Properties of Cement

PROPERTY	RESULTS	STANDARD VALUE
Fineness	5%	Less Than 10%
Normal Consistency	28%	30%
Initial Setting Time	45 min	30 min
Final Setting Time	360 min	600 min
Specific Gravity	3.077	3.15

3.1.2 FINE AGGREGATE

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. As with

coarse aggregates these can be from Primary, Secondary or Recycled sources. Good quality River sand was used as a fine aggregate. Locally available River Sand to zone II I.S. 383-197 Test conducted for Fine Aggregates. The Table 3 below showsthe properties of Fine aggregate.

Table 3 Properties of Fine aggregate

PROPERTY	RESULTS	STANDARD VALUE
Fineness Modulus	2.49	3
Specific Gravity	2.5	2.6
Water Absorption	0.65%	1%
Bulk Density	1.625 Kg/m^3	1.520-1.680 Kg/m^3

3.1.3 COARSE AGGREGATE

The crushed granite stone passing on IS 20mm sieve and retaining on IS 4.75mm sieve is taken as coarseaggregate.The Table 4 below shows the properties of Fine aggregate.

Table 4 Properties of Coarse aggregate

PROPERTY	RESULTS	STANDARD VALUE
Fineness Modulus	8.045	7.5-8
Specific Gravity	2.78	2.7
Water Absorption	0.63%	1%
Bulk Density	1.503 Kg/m^3	1.520-1.680 kg/m^3

3.1.4. Basalt Fiber:

Basalt fiber is usually brown or dark in colorformed from volcanic lava after solidification. It's generally used for reinforcement in civil construction, repair work and many other application and also high performance nan metallic fiber. It can replace easily almost all application. Basalt fiber is very economical than other raw material. The table 5 below shows the properties of Basalt fiber.

Table 5 Properties of Basalt Fiber

SL.NO.	BASALTFIBER	PROPERTIES
1	Length (mm)	13
2	Diameter	0.14*0.80
3	Aspect ratio	16.6
4	Specific Gravity	2.60
5	Tensile Strength	3100
6	Young's modulus	73

3.1.5. Mix Proportions:

Mix design is a process of selecting suitable ingredients and determining their relative proportions with the objective of producing concrete of having certain minimum workability, strength and durability as economically as possible. The M40 grade concrete Mix design is made as per IS 10262:2009. The table 6 below shows the mix design.

Table 6 Mix Design

SL.NO	MATERIAL	QUANTITY(kg/m^3)
1	Cement	370
2	Fine Aggregate	655
3	Coarse Aggregate	1295
4	Water	148
5	Super Plasticizer	4
6	W/C Ratio	0.4

IV. TEST RESULTS AND DISCUSSIONS:

4.1 Compressive Strength Test:

Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. The Figure 2 below shows the Compressive Strength test.

Figure 2 Compressive Strength Test

Compressive strength is often measured on a universal testing machine; these range from very small table-top systems to ones with over 53 MN capacity. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compressive strengths are usually

reported in relationship to a specific technical standard.

The percentage increases in compressive strength of Basalt fiber concrete mix compared with 28 days compressive strength of plain concrete is observed as 12%. The Table 7 below shows the compressive strength test results. The values are plotted in the graph shown in Figure 3.

Table 7 Compressive strength of Concrete after 7 days, 14 days and 28 days on Basalt fibre

Cube	7 Days	14 Days	28 Days
0%	20.44	29.78	50.22
0.50%	22.22	34.22	53.78
1%	26.67	37.78	56.89
1.50%	24	35.11	53.56
2%	23.11	34.67	52.67
2.50%	21.78	33.33	51.78
3%	20.89	32.44	51.11

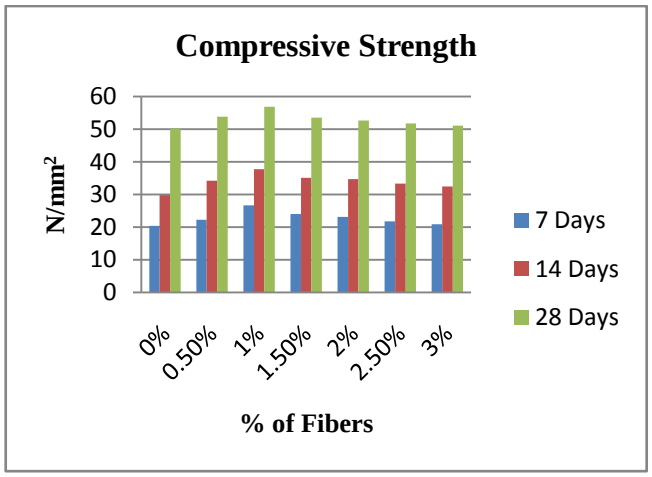

Figure 3 Compressive Strength of concrete

4.2 Flexural Strength Test:

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural testtechnique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measure in terms of stress, here given the symbol σ. The Figure 4 below shows the Flexural strength test.

Figure4 Flexural Strength Test

The percentage increases in Flexural strength of Basalt fiber concrete mix compared with 28 days Flexural strength of plain concrete is observed as 38%. The Table 8below shows the Flexural strength test results. The values are plotted in graph shown in Figure 5.

Table 8 Flexural strength of Concrete after 14 days and 28 days on Basalt fibre

Prism	14 Days	28 Days
0%	2.88	4.2
0.50%	3.72	5.16
1%	3.96	6.72
1.50%	3.84	6.12
2%	3.6	5.76
2.50%	3.48	5.4
3%	3.24	4.92

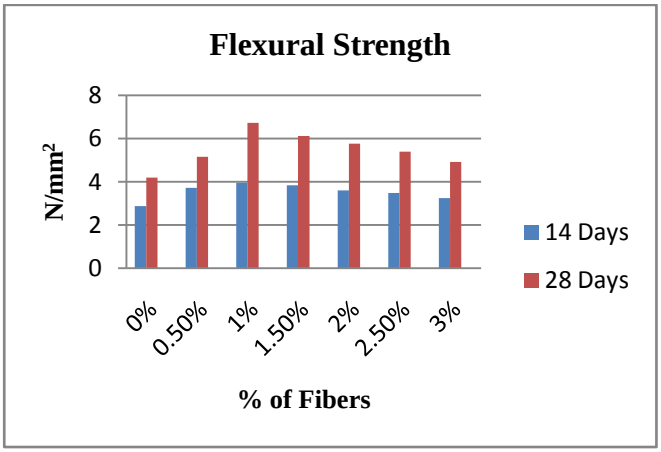

Fig 5 Flexural Strength of concrete

- Adding Basalt fiber during mixing with concrete it should mixed with the fixed

minute of 1.5, otherwise it will get isolated or segregated.

V. Conclusion:

Fibre Reinforced concrete has a great demand in Construction Industry. Basalt fibremay be effectively utilized in FRC since it is a non-corrosive, good flexural strength and high heat resistant material. It has no toxic reaction with air or water and can get high strength at 28 days. From the result it is very clear that the compressive strength and flexural strength is comparatively increasing than any other traditional Fibre Reinforces Concrete. Since the compressive strength is increased by 12 % and Flexure by 38 %, this material may be used in structural members like Beam Column joints and also in all kinds of tension and compression members.

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