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An Experimental Study of Basalt Chopped Fibers Reinforced Concrete on Compressive, Tensile, and Flexural Behavior

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Abstract - *In this paper an experimental work is carried out to study the behaviour of basalt fibre reinforced concrete containing fibres 0, 0.5, 1.0, 1.5,2.0,2.5,3.0% compressive, flexural and split tensile strength with plain M40 grade concrete. Total 84 No's of specimens are casted for M40 grade concrete (42 cubes, 21 cylinders and 21 prisms). A design mix of M40 is prepared by using the IS 10262:2009. 28 days water curing is adopted for all the testing specimens. From is experimental work, it can be concluded that the optimum dosage for the compressive strength of cubes, split tensile strength is 1.5% and for flexural strength is 2%*

Key words: Basalt fiber, Compressive strength, Split tensile strength, Flexural strength, FRP, Plain concrete.

1. INTRRODUCTION

As the structural use of concrete developed in the second half of the 1800's, interest was focused on reinforced to enhance its low tensile capacity. The concern with the inferior fracture toughness of concrete are alleviated to a large extent by reinforced it with fibers of various materials. The resulting material with a random distribution of short discontinuous fiber is referred as fiber reinforced concrete (FRC)[2].It has been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. It is now established that one of the important properties of Fiber Reinforced Concrete (FRC) is its superior resistance to cracking and crack propagation. Fiber- reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity [1].the vast improvements achieved by the addition of fibers to concrete; there are several applications where fibers Reinforced Concrete (FRC) can be intelligently and beneficially used. These fibers have already been used in many large projects involving the construction of industrial floors, pavements, highway- overlays, etc. in India. These fibers are also used in the production of continuous fibers and are used as a replacement to reinforcing steel [7].

1.1 Basalt Fiber

Basalt rock is a volcanic rock and can be divided into small particles then formed into continues or chopped. Basalt fiber has a higher working temperture and has a good resistance to chemical attack, impact load and fire with less poisonous fumes.It is fine-grained, extrusive, igneous rock composed of plagioclase, feldspar, pyroxene and magnetite, with or without olivine and containing not more than 53 wt% SiO_2 and less than 5 wt% total alkalis.The production of basalt fibers is similar to the production of glass fibers. Basalt is quarried, crushed and washed and then melted at 1500° C. The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber [1 & 3].

2. OBJECTIVES

The main objective of this experimental work is to investigate the behavior of basalt fiber (chopped strand) reinforced concrete compressive strength, tensile strength, flexural strength of concrete using basalt fiber and identify the use of this fibers in regular construction. To study the strength characteristics of basalt fiber concrete are compared with the reference mix (M40 concrete without fiber) and possible use of basalt fiber.

3. EXPERIMENTAL PROGRAMME

3.1 Materials

It is obvious that the performance of the basalt fiber concrete depends upon the various physical properties of the ingredients, proportion of the mix, water cement ratio, compaction effect type and period of curing.

So in order to know the physical properties of the materials, various testes specified by the Indian Standards were conducted and their suitability for use was checked. The detail of the investigation is presented below.

A. Cement

The cement used in all mixtures was Ordinary Portland cement (43Grade) with a specific gravity of 3.15. Initial and final setting times of the cement were 69 min and 195 min, respectively.

Some of the important required experiments conducted on the cement as specific gravity of cement, normal consistency of cement, initial and final setting time of cement, results are shown below table.

Table No-1 Physical Properties of Cement

Sl. No.	Properties	Values
1	Specific Gravity	3.15
2.	Standard consistency	34%
3.	Initial setting time in min.	30
4.	Final setting time in min	480

B. Fine aggregates (sand)

Manufactured sand was used as fine aggregate for the experiments. Various tests were conducted to determine the properties of sand . Grading is the particle-size distribution of an aggregate as determined by a sieve analysis.

Some of the importance tests will be conducted on fine aggregates which is required in mix design of concrete as shown in below table. The test was done according to IS: 2386 (Part 1) – 1963.

Table-2 Properties Of Fine Aggregate

Sl. No.	Properties	Values
1	Specific Gravity	2.65
2.	Fineness modulus	2.963
3.	Water absorption	11%
4.	Zone	II

C. Coarse aggregate

Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete .Maximum size of aggregate affects the workability and strength of concrete. It also influences the water demand for getting a certain workability and fine aggregate content required for achieving a cohesive mix. In this study the natural coarse aggregates are used, which was bought from the nearby quarry. Aggregates of 20 mm and 12.5 mm size were chosen for the experiment which is clean and free from deleterious materials.
The importance tests are to be conducted on the coarse aggregates as per IS 10262:2009. Which the experimental results are required in mix design as shown in below table.

Table-3 Properties of Coarse Aggregate

Sl. No.	Properties	Values
1	Specific Gravity	2.90
2.	Fineness modulus	2.596
3.	Water absorption	0.5%

D. Super plasticizer

In modern concrete practice, it is essentially impossible to make high performance concrete at adequate workability in the field without the use of super plasticizers. The super plasticizer used in the study was build plast 150.

Benefits:

- Increase the workability.
- Increase the compressive strength by reducing water content.
- Reduces the cement content without altering workability and strength.

- Increases durability of concrete by reducing water permeability.
- Minimize the risk of segregation, cracks and bleeding by forming a dense, close textured surface.
- Chloride free, hence safe for reinforced concrete.

E. Basalt Fiber

The fibers used were chopped basalt fibers which are uniformly and randomly distributed in the concrete matrix. For the experimental work 12mm size and the fiber diameter 13μ basalt chopped fiber were used. Chopped basalt fibers are shown in figure

3.1.2 Properties of Basalt Fibers

Capability	Basalt fiber
Tensile strength, M Pa	3000~4840
Tensile strength, M Pa	79.3~93.1
Elastic modulus, G Pa	3.1~6
Elongation at break, %	2.65-2.8
Specific gravity	6~21
Diameter of filament, mμ	-260~+500
Temperature of application, °C	1450
Price, Rs./kg	150

3.1.3 Chemical Composition of Basalt Rock

Chemical Composition of Basalt rocks	%
SiO2	52.8
Al_2O_3	17.5
Fe^2O_3	10.3
MgO	4.63
CaO	8.59
Na_2O	3.34
K_2O	1.46
TiO_2	1.38
P_2O_5	0.28
MnO	0.16
Cr_2O_3	0.06

3.2 Methodology

The mixture proportioning was done according the Indian Standard Recommended Method IS 10262-2009.The target mean strength was 40 MPa for the control mixture, the total cement content was 443.25 kg/m3, fine aggregate is taken 684.85 kg/m3 and coarse aggregate is taken 1213.65kg/m3, the water to cement ratio was kept as 0.40, the Super plasticizer content was taken as 8.8kg/m^3 for all mixtures.

The Cement, sand, Basalt fiber and fine and coarse aggregate were properly mixed together in accordance with IS code before water was added and was properly mixed together to achieve homogenous material. Water absorption capacity and moisture content were taken into consideration and appropriately subtracted from the water/cement ratio used for mixing.150 × 150 × 150mm cubes, 500mm × 100 mm× 100mm Beam and 150 mm diameter and 300 mm height Cylinder moulds were used for casting. The concrete specimens were cured in the tank for 7, 28 days.

Table No-4 : For Cubes

Sl. No	Mix id	Percentage of basalt fiber	Numbers	
			7 days	28 days
1	CUBES	0	3	3
2		0.5	3	3
3		1.0	3	3
4		1.5	3	3
5		2.0	3	3
6		2.5	3	3
7		3.0	3	3
	Total		**21**	**21**

Table No-5 : For Cylinders

Sl. No.	Mix id	Percentage of basalt fiber	Numbers 28 days
1	CYLINDERS	0	3
2		0.5	3
3		1.0	3
4		1.5	3
5		2.0	3
6		2.5	3
7		3.0	3
		TOTAL	**21**

Table No-6 : For Prisms

Sl. No.	Mix id	Percentage of basalt fiber	Numbers 28 days
1	PRISM	0	3
2		0.5	3
3		1.0	3
4		1.5	3
5		2.0	3
6		2.5	3
7		3.0	3
		TOTAL	**21**

Fig -2 Specimens are Kept For Curing in Curing Pond

Fig -2 Moulds After Filling of Concrete

Fig -3 Testing of prism in flexural Testing Machine

4. RESULTS AND DISCUSSION

Test results conducted of M40 mix concrete. All plain concrete mix with different proportion of basalt chopped fiber were cast and tested under suitable testing apparatus. The tests like compressive strength, spite tensile strength and flexural strength were studied. Their test results and related discussions are given in tables in detail.

4.1 Workability test results:

Table-7 gives the various workability test results of basalt fibre reinforced concrete for different percentages of fibres. The variation is represented in the form of graphs.

Table-7: Workability test results

% of basalt fibre by volume fraction	Slump (mm)	Compaction factor	Vee-Bee degree (Sec)
0.00%	60	0.95	37
0.50%	57	0.94	43

1.00%	53	0.93	47
1.50%	48	0.92	49
2.00%	45	0.92	53
2.50%	40	0.91	57
3.0%	35	0.89	54

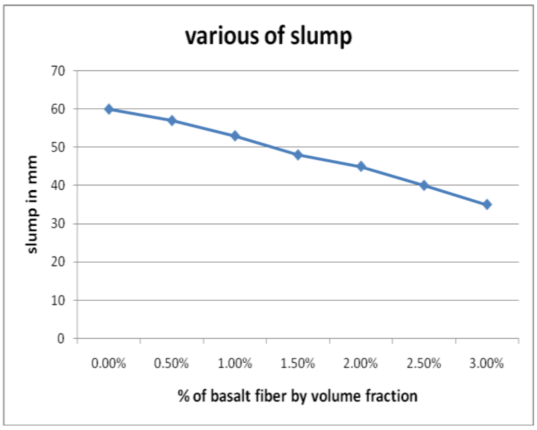

Fig-4: Variation of slump

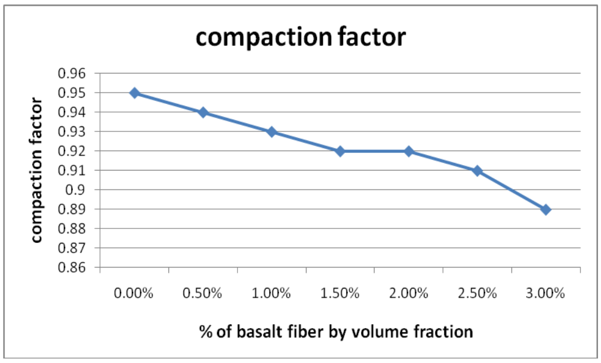

Fig-5: Variation of compaction factor

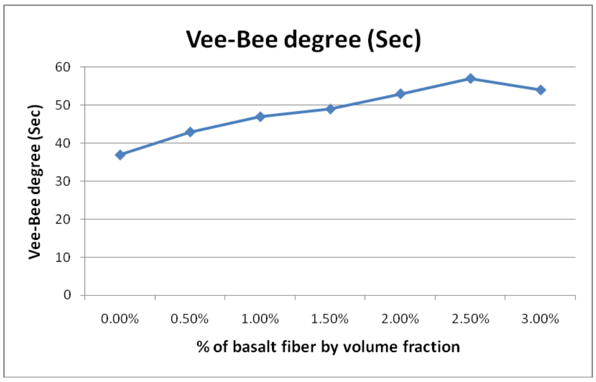

Fig-6: vee – Bee degree (sec)

4.2 Compressive Strength Test

Tests results of compressive test and its comparison with controlled concrete cube are as shown in the below table.

Table No- 8: 28 Days Compressive Strength

Si No	Shape of concrete (controlled specimen)	Compressive strength of concrete for 28 days curing period in n/mm²
1	CUBE	41.61
2	CYLINDER	2.76
3	PRISM	5.33

Table- 9 Compressive Strength of 7 Days Curing (Cube)

SI NO	Percentage of basalt chopped fiber (%)	Compressive strength of concrete in n/mm²	Percentage of increase in strength over controlled concrete cube (%)
1	0	31.29	-
2	0.5	32.22	2.97
3	1.0	33.26	6.29
4	1.5	34.21	9.65
5	2.0	33.73	7.79
6	2.5	33.20	6.10
7	3.0	31.92	2.01

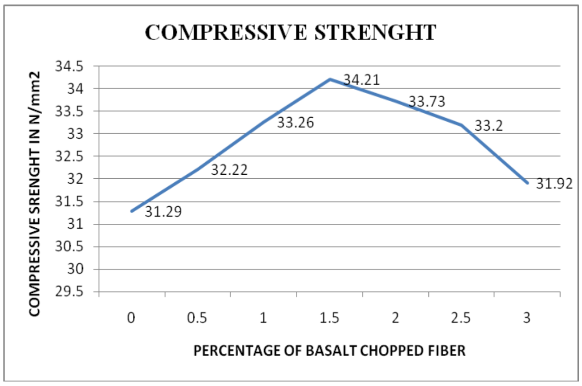

Fig-7: Compress Strength for 7 days

Table-10 Compressive Strength Of 28 Days Curing (Cube)

Sl. No	Percentage of basalt chopped fiber (%)	Compressive strength of concrete in N/mm²	Percentage of increase in strength over controlled concrete cube (%)
1	0	41.61	-
2	0.5	44.70	7.42
3	1.0	45.45	9.22
4	1.5	46.27	11.20
5	2.0	45.86	10.21
6	2.5	43.54	4.64
7	3.0	42.48	2.10

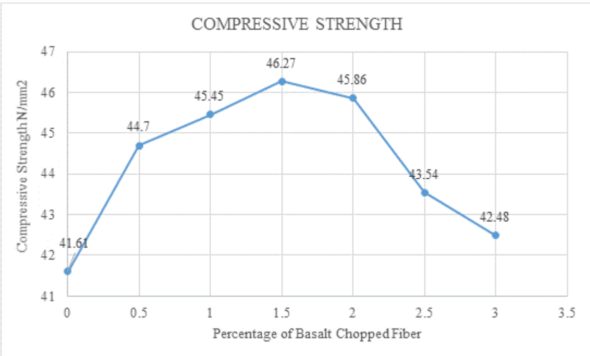

Fig-8: Compress Strength for 28 days

4.3 Tensile Strength Test:

Tests results of tensile strength test and its comparison with controlled concrete cube are as shown in the below table.

Table-11: Split Tensile Strength Of 28 Days Curing (Cylinders)

Sl. No.	Percentage of basalt chopped fiber (%)	Tensile strength of concrete in n/mm²	Percentage of increase in strength over controlled concrete cube (%)
1	0	2.76	-
2	0.5	2.87	3.99
3	1.0	2.95	6.88
4	1.5	3.10	12.31
5	2.0	3.00	8.7
6	2.5	2.94	6.52
7	3.0	2.84	2.89

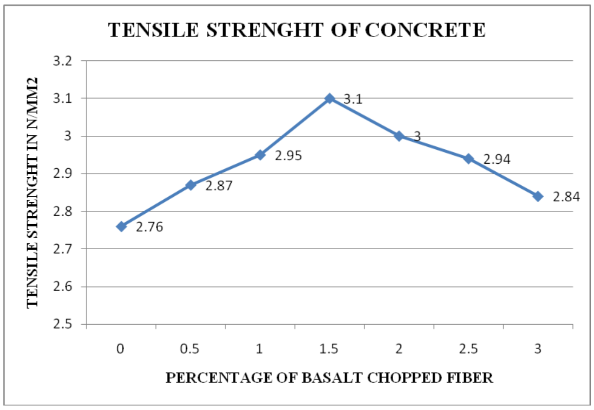

Fig-9: Split tensile strength of concrete

4.4 Flexural Strength :

Tests results of tensile strength test and its comparison with controlled concrete cube are as shown in the below table.

Table-12: Flexure strength of concrete (prism)

Sl. No	Percentage of basalt chopped fiber (%)	Flexure strength of concrete in n/mm²	Percentage of increase in strength over controlled concrete cube (%)
1	0	5.33	-
2	0.5	6.53	22.51
3	1.0	6.74	26.45
4	1.5	7.06	32.46
5	2.0	7.90	48.22
6	2.5	7.29	36.77
7	3.0	6.72	26.07

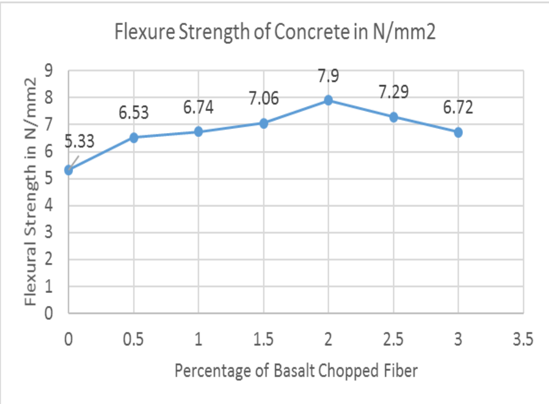

Fig-10: Flexure strength of concrete

5. CONCLUSION

1. The compressive strength at 1.5 percentages was 34.31 N/mm2. The increase percentage of strength at 1.5 percentage basalt chopped fiber was 9.65 % over controlled concrete cube strength 31.29 N/mm2, which was an optimum percentage of basalt chopped fiber content (1.5 %) for 7 days curing period.
2. The compressive strength at 1.5 percentages was 46.27 N/mm2. The increase percentage of strength at 1.5 percentage basalt chopped fiber was 11.20 % over controlled concrete cube strength 41.61 N/mm2, which was an optimum percentage of basalt chopped fiber content (1.5 %) for 28 days curing period.
3. The split tensile strength at 1.5 percentages was 3.1 N/mm2. The increase percentage of strength at 1.5 percentage basalt chopped fiber was 12.32 % over controlled concrete cylinder strength 2.76 N/mm2, which was an optimum percentage of basalt chopped fiber content (1.5 %) for 28 days curing period.
4. The flexural strength at 2.0 percentages was 7.9 N/mm2. The increase percentage of strength at 2.0 percentage basalt chopped fiber was 48.21 % over controlled concrete prism strength 5.33 N/mm2, which was an optimum percentage of basalt chopped fiber content (2.0 %) for 28 days curing period.
5. These strength values were increased in percentage of basalt chopped fiber up to 1.5 % for cubes and cylinders, 2 % for prisms. There was optimum percentage basalt chopped fiber content in concrete to increase in strength.
6. The achievable strength can be obtained by adding basalt chopped fibers from 0.5 to 1.5 % further increase in basalt chopped fibers in concrete decrease in strength. The desired percentage of fiber content in concrete would be 0.5 to 1.5%.

REFERANCE

[1] Dr. Patnaik Anil, “Applications of Basalt Fibers Reinforced Polymer (BFRP) Reinforcement for Transportation Infrastructure”, Developing a Research Agenda for Transportation Infrastructure – TRB, November 2009, 1-5.

[2] Clarke, J. L, Volume, R. L.,Swwannel, N. et al. "Guidance for the Design of Steel-Fiber-Reinforced Concrete". Technical Report No. 63, Report of a Concrete Society Working Group. UK , 2007.

[3] Murray Allan D.,” Basalt Fibers for high-performance composites”, Allied composite Technologies LLC, 1-4.

[4] Saravanan D., “Spinning of rocks – Basalt fibers”, Institute of Engineers (India) Journal, volume 82, February 2006, 39-45.

[5] Sheldon G. L., “Forming fibers from basalt rock”, platinum metal review, 1977, 18-24.

[6] SinghaKunal “A Short Review on Basalt Fiber”, International Journal of Textile Science, volume 1 (4), 2012, 19-28.

[7] M. C. Nataraja, "Fiber Reinforced Concrete-Behaviours Properties and Application".

[8] Basalt information, “Aketoma – Basalt fabrics, tubes, Mesh, rods etc.”, (www.laseroptronix.se/exoma/ basaltinformation.pdf).

[9]. Gore Ketan R, Suhasini M. Kulkarni, “The performance of basalt fibre in high strength concrete” Journal of Information, Knowledge and Research in Civil Engineering, Nov 2012 to Oct 2013/ volume 2, issue 2, pp 117 -124.

[10]. Singaravadivelan R, Chinnadurai P, Muthuramu KL and Vincent P. “Flexural behaviour of basalt chopped strands fibre reinforced concrete beams” 2nd International Conference on Chemical, Ecology

and Environmental Science. June 17 -18, 2013 London (UK), pp 237 - 241.

[11]. Dymlar Penteado Dias, Clelio Thaumaturgo, "Fracture toughness of geo polymeric concretes reinforced with basalt fibre" Cement and Concrete Composites 27(2005),pp 49-54.

[12]. NihatKabay. "Abrasion resistance and fracture energy of concretes with basalt fibre" Construction and Building Materials, 50 (2014) pp 95 – 101.

[13]. Anandakumar R, Selvamony C, Kunnan S.U "Retrofitting of concrete specimens and reinforced concrete Piles Using Basalt fibres" International Journal of Engineering Science Invention ISSN: 2319 – 6734, ISSN:2319 – 6726 Volume 2 Issue 8 August 2013,pp01-05.

[14]. Singaravadivelan R, Chinnadurai P, Muthuramu KL and Ramamoorthy N.V, "An experimental study to Evaluate the Behaviour of Concrete Elements using Basalt Chopped Strands Fibre" International Conference on Chemical, Bio-chemical and Environmental Sciences,(ICBEE' 2012) December 14-15,2012 Singapore. PP 31 - 34.

[15]. IS: 10262 – 2009, "Concrete mix proportioning – Guidelines" (First revision), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi, July2009.

[16]. IS: 456 – 2000, "Plain and reinforced concrete – Code of practice" (Fourth revision), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi, October 2000.

[17]. IS: 8112 – 1989, "43 Grade ordinary Portland cement—Specifications" (First revision), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi, May 1990.

[18]. IS: 383 – 1970, "Specifications for coarse and fine aggregate from natural sources for concrete" (Second revision), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi, April 1971.

[19]. IS: 3812 (Part 1) – 2003, "Pulverized fuel ash – Specification" (Second revision), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi, October 2003.

[20]. IS: 5816 – 1999, "Splitting tensile strength of concrete – Method of test" (First revision), Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi, July 1999.