Impact of Chopped Basalt Fiber on Mechanical properties of Concrete: An Experimental Investigation

Raviteja P[1], Vishnu P[2], Sasi P[3], John P.J[4], Naveen G[5], Yaswanth G[6], Ramsagar B[7]

[1.2,3,4,5,6] UG Students, Department of Civil Engineering, Aditya Engineering College, Surampalem, A.P, India
[7] Assistant Professor, Department of Civil Engineering ,Aditya Engineering College , Surampalem, A.P, India

---***---

Abstract - Fibre reinforced concrete (FRC) is well known for its high flexural strength, ductility and sufficient durability. This research aim to develop high strength Fibre reinforced concrete along with ductility and durability. In this present study, effect of the different percentage volume fraction of Chopped Basalt Fibres of length 24 mm on the mechanical properties of FRC were analyzed. Cubes, cylinder and prisms are prepared with 0%, 0.5%, 1.0% and 2.0% of volume fraction of basalt fibres. The results shows that adding of basalt fibres significantly improves the tensile strength, Flexural strength and compressive strength of the concrete but as the BF content increase the slump value decrease. compared with conventional concrete, the compressive strength, splitting tensile strength and Flexural Strength of concrete reinforced with basalt fibre increases by 2.55% – 6.24%, 5.58%-17.58%, 6.79% – 23.28% respectively. From the results of the experiments, it is concluded that an optimum dosage of basalt fibre for Compressive strength is 1.5%, for Splitting tensile and Flexural strength is 1.0%.

KeyWords**:** Tensile strength, Flexural strength, Ductility, Compressive strength and Basalt Fibers.

1.INTRODUCTION

During the latter half of the 19th century, concrete was developed as a structural material, which led to a focus on reinforcing it to address its low tensile capacity. The addition of fibers made from various materials was found to alleviate concerns about its inferior fracture toughness. This led to the creation of fiber reinforced concrete (FRC), which is comprised of a random distribution of short, discontinuous fibers and is commonly referred to as FRC [2]. Adding fibers in different percentages has been shown to enhance the mechanical properties, durability, and serviceability of FRC structures. One of the key benefits of FRC [1] is its significant improvement in resistance against cracking and crack development. FRC contains fibrous material, which improves its structural integrity. The significant changes achieved by incorporating fibers into concrete have made FRC a viable option for various applications, including industrial floors, pavements, and highway overlays, among others. In India, FRC has been utilized in many large-scale projects involving these applications. Continuous fibers can also be produced and used as a replacement for reinforcing steel in some applications [7].

1.1 Basalt Fibers

In this present study, Basalt fibres of length 24 mm and 10 micro meter diameter. Basalt fibers are a type of synthetic fiber that are made from basalt rock. Basalt is a common extrusive igneous rock that is formed from the rapid cooling of lava on the earth's surface. Basalt fibers have several properties that make them desirable for use in various industries. The basalt rock is first quarried, crushed, and washed to remove impurities. The crushed rock is then melted at a temperature of around 1500°C in a furnace. The molten materials is formed and made into thin sheets whicj are then chopped into different lengths. basalt fibers are used as a reinforcement material to improve the strength and stiffness of the material. In textiles, basalt fibers are used to make fabrics that are lightweight, durable, and resistant to heat and chemicals. In construction materials, basalt fibers are used to reinforce concrete and to make insulation materials for buildings

2. OBJECTIVES

The primary objective of this experimental study is to examine the impact of various fluence levels on the behavior of chopped strand basalt fibers with a length of 24 mm, as they reinforce the compressive strength, tensile strength and flexural strength of concrete. The objective is to identify the potential application of basalt fibers in regular construction. The strength properties of basalt fiber concrete will be analyzed by comparing them to a reference mix of M40 concrete without any fibers, at varying fluence levels.

3. EXPERIMENT PROGRAMME

3.1 Materials

The Strength of the concrete was largely dependent on several factors, including the physical properties of its ingredients, mix proportion, W/C ratio, Compaction effect, and Period of curing. Therefore, it is essential to conduct various preliminary tests to identify the properties of the materials and verify their suitability for use. A detailed description of the materials utilized in the experiment is provided below.

A. Cement

Portland Slag Cement (33 Grade) with a specific gravity of 2.95 was utilized in all experiments as the cementitious material. The Initial and Final Setting time of the cement used in the study were 60 minutes and 540 minutes. Other crucial properties of the cement, such as normal consistency, fineness, and soundness, are listed in the table - 1 below.

Table- 1: Properties of 33 Grade PSC Cement

S. No	Properties	Values
1	Fineness Of Cement	4.3%
2	Specific Gravity of Cement	2.95
3	Normal Consistency	32%
5	initial Setting Time (Min)	40
6	final Setting Time (Min)	540
7	Compressive Strength	34.63 N/Mm^2
8	Soundness	2 mm

B. Fine Aggregate (Sand)

The present study utilized sand as the fine aggregate, and several tests were conducted to analyze its properties. One of these tests involved the grading of the sand and was determined through a sieve analysis. The importance of conducting various tests on fine aggregates is highlighted in the table below, which outlines the required tests for concrete mix design. These tests were conducted in accordance with the IS: 2386–1963 (Part 1) standard. Table - 2 contains different physical Properties of Fine aggregate.

Table-2: Properties of Fine Aggregates

Sl. No.	Properties	Values
1	Specific Gravity	2.65
2.	Fineness modulus	3.66
3.	Bulking of Sand	4%
4.	Zone	III

C. Coarse Aggregates

Aggregate is typically considered as an inert filler that makes up a significant portion of the volume and weight of Concrete. The Nominal size of Aggregate can affect the Workability and strength of concrete, as well as the water demand necessary to achieve a desired workability and In this particular study, Natural Coarse Aggregates were utilized, Which were sourced from a Local building materials shops. Clean, deleterious-free Aggregates with a size of 20mm and 10mm are chosen for the experiment. The importance of conducting various tests on the coarse aggregates is outlined in the table below, which specifies the required tests for concrete mix design in accordance with IS 10262 - 2019. Properties of Coarse aggregate are shown in the below Table - 3.

Table - 3 Properties of Coarse Aggregate

S. No.	Properties	Values
1.	Specific gravity	2.74
2.	Fineness modulus	7.14
3.	Water absorption	0.5%
4.	Nominal Size	20 mm

C. Basalt Fibers

The experimental work utilized 24mm size chopped basalt fibers, with a diameter of 13µm, which were uniformly and randomly distributed within the concrete matrix. A visual representation of the chopped basalt fibers is provided in a corresponding figure.

Table- 4: Technical Specification of basalt fibers

S. No	Properties	Units	Value
1.	Length	mm	24
2.	Diameter	µm	10
3.	Aspect ratio	---	2400

Table- 5: Physical properties of basalt fibers

S. No	Properties	Units	Value
1.	Density	Kg/m3	2100
2.	Specific Gravity	---	2.1
3.	Melting Point	°C	1350
4.	Moisture content	%	<0.30

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 04 | April - 2023 Impact Factor: 8.176 ISSN: 2582-3930

3.2. METHODOLOGY

Mix design was Calculated according to the Indian Standard Recommended Method IS 10262 - 2019. The mix design for Normal concrete and conventional concrete was designed with different slump values. For normal plain concrete the mix was designed for 75 mm slump and for Basalt fibre reinforced concrete the mix was designed for 125 mm slump. This is because the PSC cement delaying setting time if plasticizer is used in concrete mix but it is necessary to increase workability for Basalt Fibre Reinforced concrete so workability of BFRC is increase of increase the slump value. Mix proportions for all mixes are mention in the below table.

Table- 6: M40 grade Mix Proportions for 1m^3

Mix Name	Cement	Water	Fine aggregates	Coarse aggregates		Basalt fibers Volume percentage (%)
				20 mm	10 mm	
CC	534	192	545	599	599	0
BF0.5	564	203	524	545	545	0.5
BF1.0	564	203	524	545	545	1.0
BF1.5	564	203	524	545	545	1.5
BF2.0	564	203	524	545	545	2.0

In accordance with the IS code, the Cement, sand, Basalt Fiber, and Fine and Coarse Aggregate were thoroughly Mixed together before adding of water to the mix. The aim was to achieve a homogeneous material with consistent properties. The water/cement ratio used for mixing was adjusted to account for the water absorption capacity and Moisture content of the materials used. 150 mm × 150 mm × 150 mm cubes, 500 mm × 100 mm × 100 mm Prisms, and 150 mm diameter and 300 mm height cylinder moulds were casted. These Concrete Specimens were then cured in a tank for a period of 7 and 28 days to ensure adequate strength development and stability of the concrete. The curing process was carefully monitored to ensure that the specimens were kept at the appropriate temperature and moisture levels to promote optimal curing.

4. RESULTS AND DISCUSSIONS

Suitable testing apparatus was employed to conduct tests on the M40 mix concrete specimens, which were cast with varying proportions of basalt chopped fiber. Tests were conducted to study the compressive strength, split tensile strength, and flexural strength of the concrete. Experiment results and related discussions are presented in below table – 7, 8, 9, 10, 11, highlighting the impact of the incorporation of Basalt chopped fiber on the strength properties of the concrete.

Fig-1: Casting of 100 x 100 x 500mm Prisms

Fig-2: Curing of concrete Specimens

4.1 Workability Test results:

The results of the slump cone test for basalt fiber reinforced concrete for different fiber percentages are displayed in Table-7. It was observed that the workability of the concrete decreased as the basalt fiber content increased.

Table- 7: Slump cone test results

Mix Name	**Slump Value in mm**		**Volume Fraction of Basalt fibers (%)**
	Designed	**Actual**	
CC	75	78	0
BF0.5	125	122	0.5
BF1.0	125	118	1.0
BF1.5	125	115	1.5
BF2.0	125	113	2.0

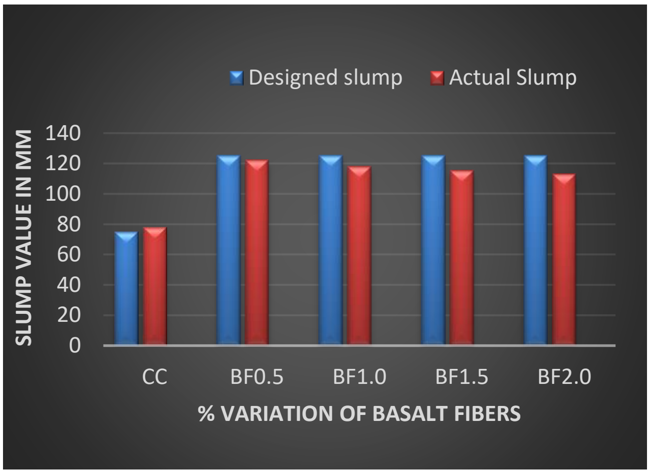

Fig- 3: Slump Variations

4.2 Compressive Strength Test

The test results of the Compressive strength test on all cube specimens and its percentage increase of basalt fibre reinforced concrete with conventional Concrete are presented in the tables and graphs below.

Table – 8: 7 days Compressive strength of specimens

Mix Name	Compressive strength of concrete in N/mm²	Percentage of increase in strength over controlled concrete cube (%)
CC	32.29	--
BF0.5	33.22	2.88
BF1.0	34.26	6.10
BF1.5	35.21	9.04
BF2.0	34.73	7.55

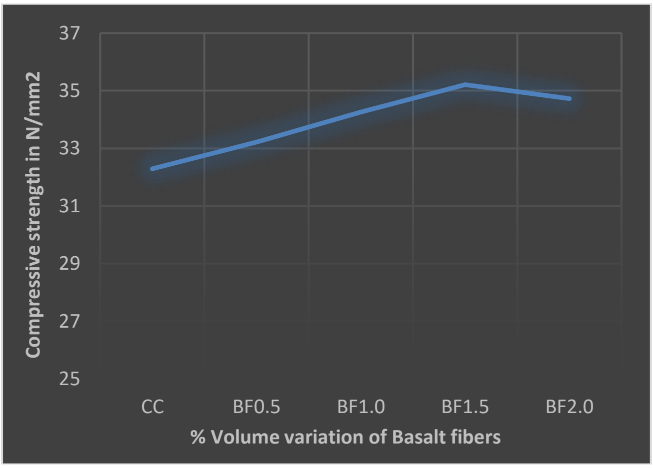

Fig- 4: Compressive strength for 7 days

Table – 9: 28 days Compressive strength of specimens

Mix Name	Compressive strength of concrete in N/mm²	Increase in Percentage of strength over controlled concrete cube (%)
CC	42.61	--
BF0.5	43.72	2.60
BF1.0	44.45	4.31
BF1.5	45.27	6.24
BF2.0	44.86	5.26

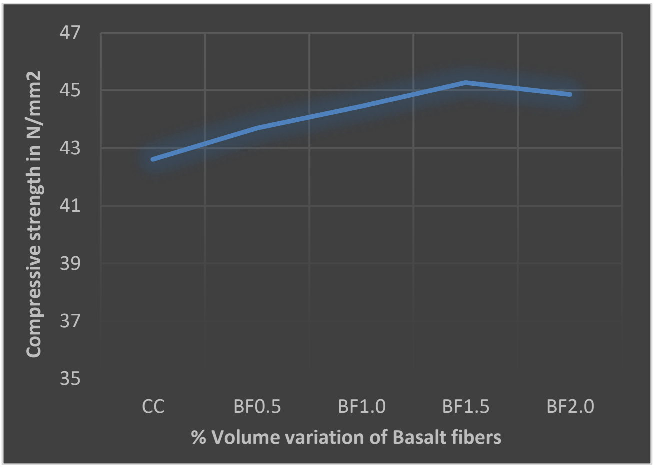

Fig- 5: Compressive strength for 28 days

4.3 Spitting Tensile Strength test

The table below shows the test results of the tensile strength test on cylindrical specimens and its variation with the controlled concrete Cylinders.

Table – 10: 28 days Tensile strength of specimens

Mix Name	Tensile Strength of concrete in N/mm²	Percentage of increase in strength over controlled concrete cube (%)
CC	3.76	--
BF0.5	3.97	5.58
BF1.0	4.42	17.55
BF1.5	4.12	9.57
BF2.0	3.88	3.19

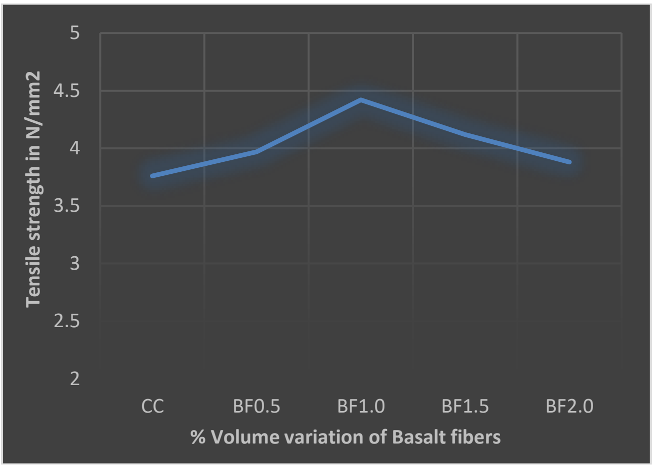

Fig- 6: Tensile strength for 28 days

4.4 Flexural Test

The table below presents the test results of the strength test on all prisms and its comparison with the controlled concrete Prisms.

Table – 11: 28 days Flexural strength of specimens

Mix Name	Flexural Strength of Concrete in N/mm^2	Percentage of increase in strengthover controlled concrete cube (%)
CC	4.56	--
BF0.5	4.87	6.79
BF1.0	5.64	23.68
BF1.5	4.76	4.38
BF2.0	4.33	-5.04

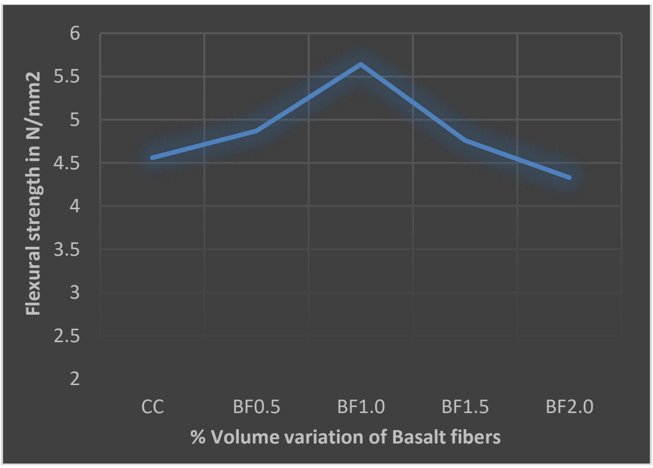

Fig- 7: Flexural strength for 28 days

5. CONCLUSIONS

From the Experimental results it was concluded that the maximum compressive strength is obtained at 1.5% of volume fraction of basalt fibres. the percentage increase of compressive Strength at 1.5% of chopped basalt fibres has 6.24% more strength with that of conventional concrete cubes. Which was an optimum Content (1.5%) of basalt fibres for Compressive Strength. the maximum Tensile Strength and Flexural Strength is obtained at 1.0% of basalt fibres the percentage increase in Tensile Strength and Flexural Strength at 1.0 percentage basalt fibres was 17.55% and 23.68% over conventional concrete specimens. Which was an optimum content (1.0%) for tenisle strength and flexural strength. overall 1.5% is optimal Basalt fiber quantity for Compressive Strength and 1% is optimal Basalt fibre content for tensile strength and flexural strength.

ACKNOWLEDGEMENT

The authors acknowledge the support from Aditya engineering college for providing all the necessary materials and equipment for preparation of concrete sample and testing of sample.

REFERENCES

1. Anil Patnaik.: Application of Basalt fibres reinforced polymer (BFRP) reinforcement for transportation infrastructure, (November 2009), 1-5.
2. V Loresto, C Leone, and De Lorio.: Mechanical Characterization of basalt fibers reinforced plastic. Compos B Eng (2011), 717-23.
3. T Deak and Czigany.: Chemical Composition and mechanical properties of basalt and glass fibres: a comparison. Text Res J (2009) 645- 51.
4. TM Borhan.: Properties of glass concrete reinforced with short basalt fibre Mater, Des (2012), 265-71.
5. BE Ramachandran, V Velpari, and N Balasubramanian.: Chemical durability study on basalt fibers, J Mater Sci (1987).
6. J Sim, C Park, and D Moon.: Characteristics of basalt fibre as a strengthening material for concrete structures, Compos B Eng (2005).
7. M.C. Nataraja. Fiber reinforced concrete Behaviors Properties and Application, Compos B Eng (2011).
8. V Manikandan, JT Winowalin Jappes, SM Suresh Kumar, P Amuthakkannam.: Investigation of the effect of surface modifications on the mechanical properties of basalt fibre reinforced polymer composites, Compos B Eng (2012).
9. D Yeboah, S Taylor, D McPolin, and R Gilfillan.: Pullout behaviour of axially loaded basalt fibre reinforced polymer (BFRP) rods bonded perpendicular to the grain of glulam elements, Construct Build Mater (2012).

10. V Fiore, G Di Bella, and A Valena.: Glass-Basalt/epoxy hybrid composites for marine applications, Mater Des (2011).
11. IS 10262-2019.: Concrete mix proportion guide line, (2019).
12. IS 456-2000.: Plain and Reinforced concrete – code of practice, Bureau of Indian Standards (2000).
13. IS 1237-2012.: Cement concrete flooring tile specification (2012).
14. IS 383-1970.: Guidelines for Coarse and Fine Aggregate from Natural Source for Concrete (1970).
15. IS 5816-1999.: Splitting tensile strength of concrete -method of test, Bureau of Indian Standards (July 1999).