A Comparative Study on Mechanical Properties of Basalt Fiber Reinforced Concrete with Partial Replacement of Cement with GGBS

S. Sai Charan[1],
PG Scholar [Structural Engineering],
Gudlavalleru Engineering College,
Gudlavalleru, A.P, India,

CH. L. K Murthy Gupta[2]
Asst.professor [Structural Engineering],
Gudlavalleru Engineering College,
Gudlavalleru, AP, India.

Abstract: **The Present work deals with the addition of Basalt Fibers in to concrete to inspect and compare the Compressive, Split Tensile and Flexural strength of Basalt Fiber Reinforced Concrete [BFRC] with plain M30 Grade concrete. In this experimental work the Basalt Fibers are chosen in four different proportions i.e. 0.5%, 1%, 1.5%, 2% & 2.5% respectively to the volume of concrete. Fibers of length 1.5 to 2cm were used in this study. Typically to improve the Tensile and Flexural strengths of concrete, fibers are introduced in to the concrete and it is named as fiber reinforced concrete. Fibers namely Steel, Carbon, Glass, Coir, Basalt.., are commonly preferred to use in concrete. In this work i have also studied the performance of basalt fiber reinforced concrete when the cement is partially replaced with Ground Granulated Blast Furnace Slag (GGBS).The replacement of cement with GGBS is done in two different percentages i.e. 30%, 40% respectively. The results have declared that the use of basalt fibers has significantly increased the flexural and tensile strength of concrete, but decrease in compressive strength of concrete. When the cement has replaced with GGBS the strength of the concrete has failed at 40 % respectively.**

Key words: Basalt fibers, Concrete, Compressive strength, GGBS, Flexural test, Split tensile test.

1. INTRODUCTION

Recent developments in the concrete technology have established new ways for improving the mechanical and durability properties of concrete. Addition of Natural/Artificial like Basalt, Steel, Glass, Jute, Nylon, polypropylene.., in to concrete Matrix is one of the satisfactory method for improving the properties of concrete. By including the fibers in to concrete structures it may contribute to improve the structural behaviour of the concrete members. By adding the fibers in to concrete we can overcome the problem like Crack resistance, Corrosive resistance.

The name Basalt is originated from a Latin “BASALTES” [Very hard stone].Basalt fibers are originated from the Basalt rock. This Basalt rock is generated with rapid cooling of molten lava on the earth crust. Basically this rock is normally available on the earth surface, beneath of the oceans. Basalt rock is also one type of igneous rock containing 45-60% of Sio_2 [silica] content to its volume. This basalt rock is naturally very hard and dense material having dark brown in colour similar to the normal ballast rock. Sometimes due to oxidation process its changes to rust-red colour. Normally the Basalt rock and Ballast rocks looks similar, but the difference between them can be judged depending up on their mineral admixtures and their Textures.

The Basalt rock is melted at 1500^0 C to 1650^0C for manufacturing the “BASALT FIBERS”. From this Basalt rock various types of secondary materials like Basalt fibers, Basalt Rebar’s, Basalt fiber pins, Basalt fiber geo girds, Basalt Fabric can be produced. First these basalt fibers are produced as continuous Basalt fibers then after they are chopped in to various sizes based on the use of purpose. The main advantage of the basalt fibers is it doesn’t commit any toxic reaction with air and water.

2. EXPERIMENTAL PROGRAM

2.1 Materials Used:

In this research work various materials like Cement, Fine Aggregate ,Coarse Aggregate, water and Basalt fibers were used and their properties are examined by taking the help of IS [INDIAN STANDARD] codes .

2.1.1 Cement:

Ordinary Portland cement of 53 Grade was preferred for this study. The physical properties of cement are categorized in table 1 as per IS 456-2000.

Table 1: Physical Properties of Cement

S.No	Properties	Value
1	Specific Gravity	3.13
2	Initial setting time	43min
3	Final setting time	260 min
4	Fineness test	6% retained

2.1.2 Fine aggregate:

Locally available river sand was preferred as fine aggregate for entire experimental work. The physical properties of sand was carried out by taking the help of IS 383-1970 and IS 2386-1963 code books.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

Table 2: Properties of Fine Aggregate

S.No	Properties	Value
1	Specific Gravity	2.56
2	Density kg/m^3	1580
3	Water absorption	
4	Zone	II

2.1.3 Coarse aggregate:

Crushed Granite stone of sizes 20mm and 10mm were selected for this work. Taking the reference of IS codes the properties of coarse aggregate have been tested.

Table 3: Properties of Coarse Aggregate

S.No	Properties	Value
1	Specific Gravity	2.70
2	Crushing value	14.21%
3	Impact value	2.5%
4	Density kg/m^3	1560
5	Water absorption	0.6%

2.1.4 Basalt Fibers:

The basalt fibers which I have been choosed were chopped uniformly of 1.5 to 2cm in length. The properties and chemical composition of basalt rock fiber are tabulated in 4 & 5 tables respectively.

Fig 1: BASALT FIBERS

Table 4: Physical Properties of Basalt Fibers

S.No	Physical properties	Suggested values by supplier
1	Length (cm)	2-6
2	Yield strength (Mpa)	>1000
3	Density (g/cm^3)	2.63
4	Tensile strength (Mpa)	3200-3850
5	Working temperature (^{o}C)	260^{0}C-700^{0}C

Table 5: Chemical Composition of Basalt Rock Fiber

S.No	Major components	% present in basalt rock fiber
1	Silicon Dioxide SiO_2	51.6-65%
2	Aluminium Oxide Al_2O_3	17-18.5%
3	Ferric Oxide Fe_2O_3	3-8%
4	Calcium oxide CaO	5.4-7.8%
5	Magnesium Oxide MgO	2-3.5%

2.1.5 Ground Granulated Blast Furnace Slag (GGBS):

GGBS is generated by rapid Chilling of molten iron slag from a blast-furnace in a steam or water to yield a Granular material. This outcome granular material is dried and turned in to a fine power that is termed as GGBS.GGBS is one of the material which holding the properties similar to the Cement.

Table 6: Properties of GGBS

S.No	Chemical Constitution	% Percentage in GGBS
1	Calcium oxide CaO	42
2	Silicon Di-oxide SiO_2	37
3	Aluminium oxideAl_2O_3	9-12
4	Magnesium oxide MgO	7

2.2 CONCRETE MIX PROPORTION:

The mix design has carried out by following the specifications and limitations of Indian Standard Code (IS 10262-2009). The target meant strength was inspected as 38.25N/mm^2 for the following mix proportion, the cement content was observed as 425kg/m^3, amount of 603.5kg/m^3 was noted as a fine aggregate content, coarse aggregate content was observed as kg/m^3 and the water to cement ratio is taken as 0.45. Firstly the fine aggregate, cement and basalt fiber were mixed thoroughly for 1minute then after coarse aggregate and water are added and mixed thoroughly up to 4minutes to get a homogeneous mix. At last the specimens (cubes, cylinders and beams) were casted and soon after 24hours the specimens are remoulded.

3. RESULTS AND DISCUSSIONS

3.1 Cube compressive strength:

The capacity of a material or structure to resist the loads disposed to reduce the size is termed as compressive strength of concrete. The compressive strength test is done for cube specimen of sizes 150*150*150mm for 7 and 28 days of curing. The compressive strength results are mentioned in table 7.

Table 7: Compressive Strength of BFRC

Mix details	`Strength in Mpa	
	7 days	28 days
Conventional	27.12	40.3
Basalt fibers 0.5%	27.68	41.52
Basalt fibers 1%	28.35	42.53
Basalt fibers 1.5%	28.42	42.64
Basalt fibers 2%	25.62	38.40
Basalt fibers 2.5%	24.29	36.44

Fig 2: Graph for Compressive strength results of Basalt fiber reinforced concrete (BFRC)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

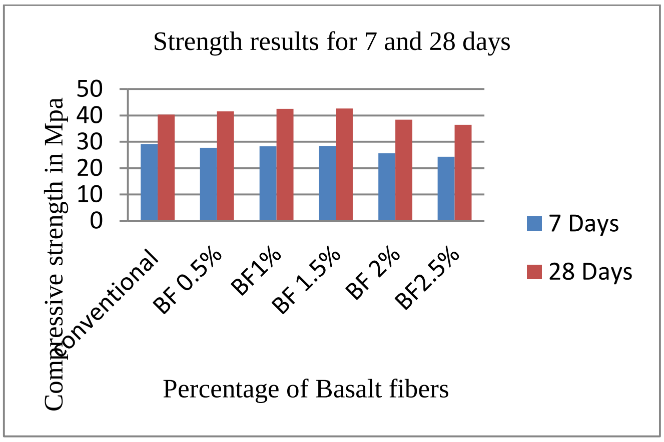


Fig 3: Test for compressive strength.

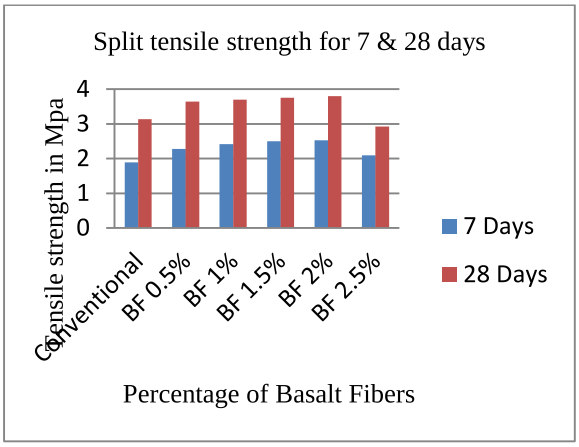
3.2 Split Tensile Strength:

The split tensile strength of BFRC is observed at 7 and 28 days and values are mentioned in table No: 8. for finding out the tensile strength cylinders of height 300mm * 150mm in diameter are used in this project. Fig 3 shows the graphical representation of split tensile strength of BFRC.

Table 8: Split Tensile strength of BFRC

Mix details	Split Tensile Strength in Mpa	
	7 days	28 days
Conventional	1.89	2.24
BF 0.5%	2.28	3.64
BF 1%	2.42	3.70
BF 1.5%	2.5	3.75
BF 2%	2.53	3.80
BF 2.5%	2.09	2.92

Fig 3: Graph for Split Tensile Strength of Basalt Fiber Reinforced concrete (BFRC)



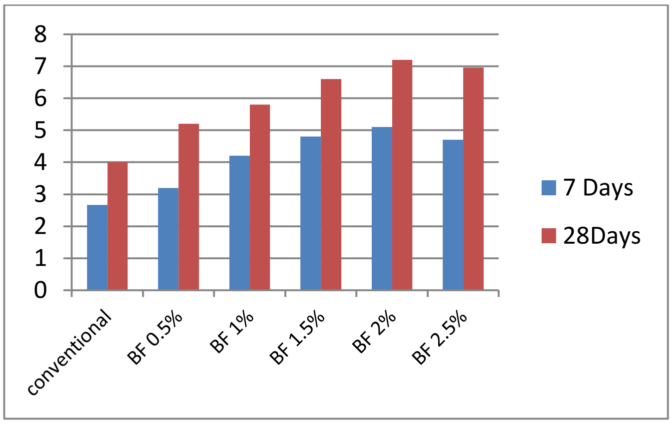
3.3 Flexural strength:

The flexural strength of Basalt fiber reinforced concrete was carried out after 7 and 28 days of curing on the beam specimen of size 500mm*100mm*100mm.the test was done according to the IS:516-1959 code book. The strength values of flexural strength were mentioned in table No 9.Graphical representation of flexural strength are shown in fig 4.

Table 9: Flexural strength of BFRC

Mix details	Flexural Strength in Mpa	
	7 days	28 days
Conventional	2.67	4.0
BF 0.5%	3.2	5.2
BF 1%	4.2	5.8
BF 1.5%	4.8	6.6
BF 2%	5.1	7.2
BF 2.5%	4.7	6.96

Fig 4: Graph for Flexural strength of BFRC



International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

3.4 Test results when cement is partially replaced with Ground Granular Blast Furnace Slag (GGBS):

Case i: 30% of cement is replaced with GGBS.

Case ii: 40% of cement is replaced with GGBS.

Case i: 30% of cement replaced with GGBS

3.4.1 Compressive strength results when 30% of cement is replaced with GGBS

Mix details:

M1=Conventional

M2=30%GGBS+70% cement

M3=M2+BF 0.5%

M4=M2+BF 1%

M5=M2+BF 1.5%

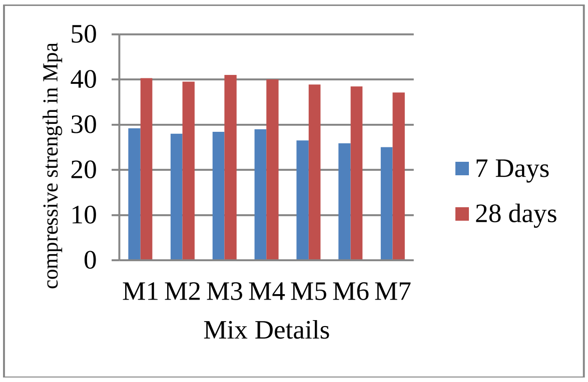
M6=M2+BF 2%

M7=M2+BF 2.5%

Table 9: Compressive strength of BFRC when 30% of cement is replaced with GGBS

Mix details	Compressive strength in Mpa	
	7 days	28 days
M1	29.2	40.3
M2	28	39.5
M3	28.45	41.02
M4	29.01	40
M5	26.52	38.85
M6	25.84	38.42
M7	25	37.10

Fig 5: Graphical representation for compressive strength of BFRC when cement is replaced with GGBS

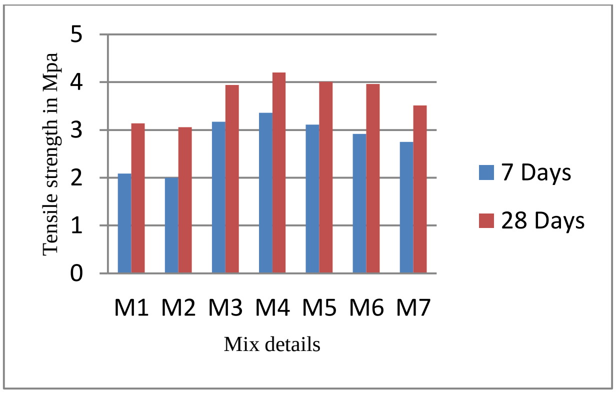


3.4.2 Tensile strength results when 30% of cement is replaced with GGBS

Table 10: Tensile strength of BFRC when 30% of cement is replaced with GGBS

Mix details	Split tensile strength in Mpa	
	7 Days	28 Days
M1	2.09	3.14
M2	2.00	3.06
M3	3.17	3.94
M4	3.36	4.20
M5	3.11	4.01
M6	2.92	3.96
M7	2.75	3.51

Fig 6: Graphical representation for split tensile strength of BFRC when cement is replaced with GGBS



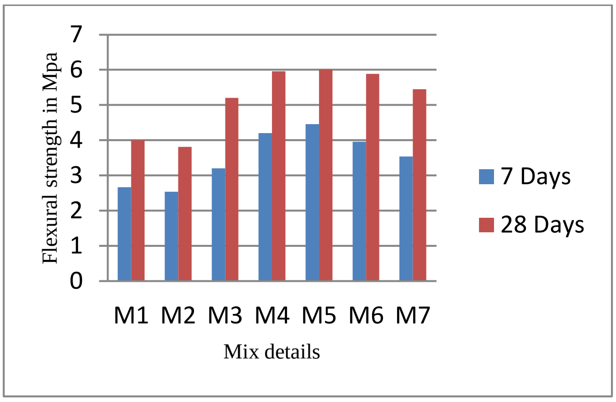
***3.4.3** Flexural strength results when 30% of cement is replaced with GGBS*

Table 11: Flexural strength of BFRC when 30% of cement is replaced with GGBS

Mix details	Flexural strength in Mpa	
	7 Days	28 Days
M1	2.67	4.0
M2	2.54	3.81
M3	3.2	5.2
M4	4.2	5.96
M5	4.46	6.01
M6	3.96	5.89
M7	3.54	5.45

Fig 7: Graphical representation for Flexural strength of BFRC when cement is replaced with GGBS

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016



Case ii: 40% of Cement is replaced with GGBS

3.4.4 Compressive Strength results of BFRC when 40% of cement is replaced with GGBS

Mix details:

V1=Conventional Concrete

V2=60% Cement +40% GGBS

V3=V2+BF 0.5%

V4=V2+BF 1%

V5=V2+BF 1.5%

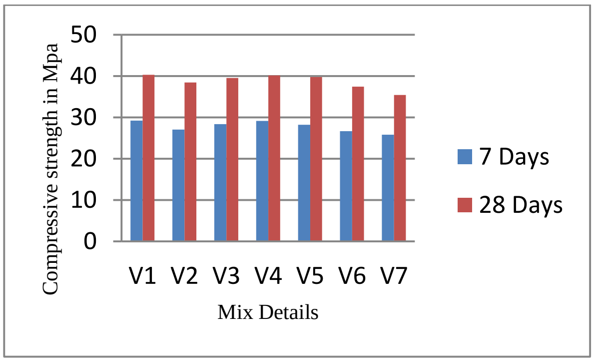
V6=V2+BF 2%

V7=V2+BF 2.5%

Table 12: Compressive strength of BFRC when 40% of cement is replaced with GGBS

Mix details	Compressive Strength in Mpa	
	7 Days	28 Days
V1	29.2	40.3
V2	27	38.42
V3	28.36	39.5
V4	29.12	40.12
V5	28.21	39.75
V6	26.65	37.36
V7	25.82	35.42

FIG 8: Graphical representation for compressive strength of BFRC when 40% of cement is replaced with GGBS



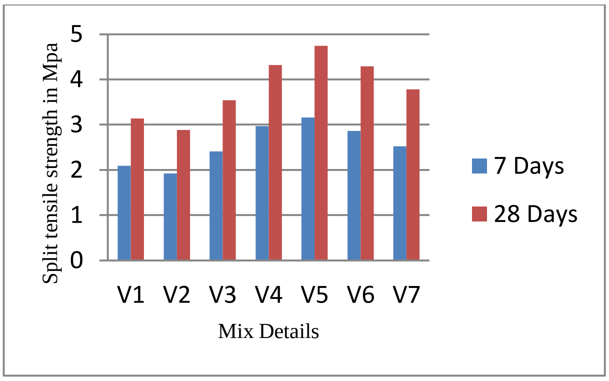
3.4.5 Split Tensile strength results for BFRC when 40% of cement is replaced with GGBS

Fig 9: Test for Tensile strength

Table 13: Split tensile strength for BFRC when cement is replaced with GGBS

Mix details	Split tensile Strength in Mpa	
	7 Days	28 Days
V1	2.09	3.14
V2	1.92	2.88
V3	2.41	3.54
V4	2.97	4.32
V5	3.16	4.74
V6	2.86	4.29
V7	2.52	3.78

Fig 10: Graphical representation for tensile strength of BFRC when 40% of cement is replaced with GGBS



3.4.6 Flexural strength results for BFRC when 40% of cement is replaced with GGBS

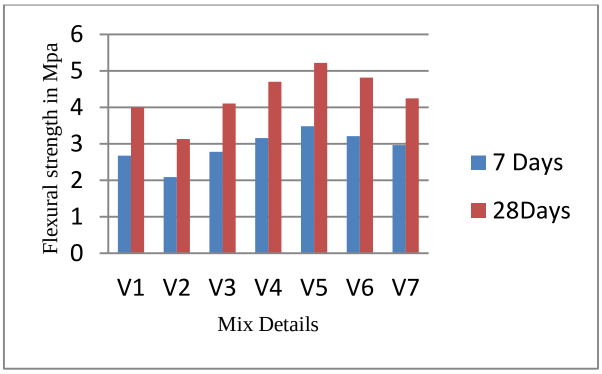
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 06, June-2016

Fig 11: Test for Flexural strength

Table 14: Flexural strength for BFRC when 40% of cement is replaced with GGBS

Mix Details	Flexural Strength in Mpa	
	7 Days	28 Days
V1	2.67	4.0
V2	2.09	3.13
V3	2.78	4.10
V4	3.16	4.70
V5	3.48	5.22
V6	3.21	4.81
V7	2.96	4.24

Fig 12: Graphical representation of Flexural strength of BFRC when 40% of cement is replaced with GGBS



4. CONCLUSION

- The study of experimental results has specified that effect of Basalt fibers on compressive strength is not significant comparing to Tensile and flexural strengths of concrete.
- It was observed that 35% of compressive strength has increased for Basalt fiber reinforced concrete over plain concrete.
- 69% of split tensile strength has increased when it was compared with plain concrete.
- Flexural strength has also significantly increased up to 65% when it was correlated with plain concrete.
- But whenever the cement has replaced with GGBS the compressive strength has noted as only increase of 2 to 4% only.
- Only a slight increase has examined in Split Tensile strength and flexural strength of BFRC when cement has replaced with GGBS.
- We can arrest the sudden and brittle failures in concrete structures by using these Basalt fibers.

5. REFERNCES

[1] FarhadAslani and BijanSamali, "High Strength Polypropylene Fibre Reinforcement Concrete at High Temperature", University Of Technology Sydney, Ultimo, NSW, Australia. 4 March 2013.

[2] Kunal Singha, "A short Review on Basalt fibers", international journal of textile science 2012, 1(4):19-28

[3] M.C Nataraja, "Fiber Reinforced Concrete-behaviour properties and applications.

[4] Nihat Kabay,"Abrasion resistance and fracture energy of concretes with Basalt fiber", construction and building Materials 50(2014) 95-101.

[5] Tumadhir M "Thermal and Mechanical properties of Basalt fiber Reinforced concrete", world Academy of science, Engineering and Technology, Vol: 2013-04-26.

[6] IS: 12269-1987 Specifications of 53 Grade OPC.

[7] IS: 2386-1963 Methods of testing Aggregates fir Concrete

[8] IS:10262-2009 Recommend Guidelines for concrete Mix Design.