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COMBINED EFFECT OF GGBS AND BASALT FIBER ON STANDARD GRADE OF CONCRETE

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Combined Effect of GGBS and Basalt Fiber on Standard Grade of Concrete

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Abstract – The second most consumed product in the world is Cement. It contributes nearly 7% of the global carbon dioxide emission. To reduce the effect of carbon dioxide on environment an Industrial waste like GGBS is used. GGBS is considered as a more eco-friendly alternative to Ordinary Portland cement (OPC). Concrete has a good serviceability, but it is failing in some conditions due to the improper mixing which results in cracking. So the concrete is likely to be get mixed by other material like fibers (Basalt Fiber), to get good serviceability The present study carried out on concrete due to the effect of GGBS with Basalt fiber and compared with Normal Concrete In this study we used concrete mixes with GGBS of 0%, 5%, 10%and 15%, with addition of crimped Basalt fibers of diameter 0.5 mm , at various percentages as 0%, 1.0 %, 2.0 % ,3.0 % and 4.0% by the volume in concrete on M25 grade of concrete. The Mechanical properties Such as Compressive strength and Tensile Strength of concrete specimens were determined at 7, 14 and 28 days. The test results shows that 1% BF+ 5% GGBS, 2% BF + 5% GGBS,3% BF + 5% GGBS, 4% BF + 5% GGBS shows the increasing in compressive and tensile Strength. The compressive strength and Tensile strength is been increased from 24.91N/mm^2 and 3.493N/mm^2 for 0 % to 25.41 N/mm^2 and 3.528 N/mm^2. for B.F 4%+GGBS 5%.

Keywords: OPC, GGBS, Basalt Fiber, Compressive Strength, Tensile Strength

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INTRODUCTION

To produce concrete, Ordinary Portland cement (OPC) is used as binder conventionally. Concrete is the most world widely used construction material. The increase in demand of concrete more the new method and materials are being developed for production of concrete. Concrete is a mixture of cement, water, and aggregates with or without chemical admixtures. The most important part of concrete is the cement. Use of cement alone as a binder material produces large heat of hydration. Since the production of this raw material produces lot of CO2 emission. The carbon dioxide emission from the cement raw material is very harmful to the environmental. Nowadays many researchers have been carried out to reduce the CO2. The effective way of reducing CO2 emission from the cement industry. the use the industrial by products such as GGBS, Fly ash , Silica Fume e.t.c. In the present work we are replacing the cement with GGBS to reduce the environmental Problems. And in addition to GGBS we are adding crimped Basalt fibers of diameter 0.5 mm , at various percentages by the volume.

BASALT FIBER

Basalt is a natural, hard, dense, dark brown to black volcanic igneous rock originating at a depth of hundreds of kilometers beneath the earth and resulting the surface as molten magma. And its gray, dark in colour, formed from the molten lava after solidification. The production of basalt fiber consists of melt preparation, extrusion, fiber formation, application of lubricates and finally winding. Method is also known as spinning. A fiber is a material made into a long filament with density generally in the order of 300g/cm2 of 50cm. The aspect ratio of length and diameter can be ranging from thousand to infinity in continuous fibers. It is do not undergo any toxic reaction with water and do not pollute air also. The functions of the fibers are to carry the load and provide stiffness, strength, thermal stability and other structural properties in concrete.

Basalt fiber is a typical ceramic fiber it's easy to disperse when mixed with cement concrete and mortar. Therefore, basalt fiber reinforced concrete serves the functions of reinforcement, crack resistance, and can extend the life of construction in the fields of housing,

Fig: 1.1 Chopped Basalt Fibers

GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground Granulated Blast Furnace is a byproduct from the Blast furnace slag is a solid waste discharged in large quantities by the iron and steel industry in India. These operate at a temperature of about 1500 degree centigrade and are fed with a carefully controlled mixture of iron – ore, coke and limestone. The iron ore is reduced to iron and remaining materials from slag that floats on top of the iron. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has been rapidly quenched in large volumes of water. The quenching optimizes the cementitious properties and produces granules similar to coarse sand. This granulated slag is then dried and ground to a fine powder. The re-cycling of these slag's will become an important measure for the environmental protection. The primary constituents of slag are lime (CaO) and silica (SiO2). Portland cement also contains these constituents. The primary constituent of slag is soluble in water and exhibits an alkalinity like that of cement or concrete. Meanwhile, with the development of steel industry, the disposal of such a material as a waste is definitely a problem and it may cause severe environmental hazards.

Fig: 1.2 GGBS

2. MATERIALS USED

The basic materials for mixing concrete are required such as

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Basalt fibres
5. GGBS
6. Water

Cement

The cement used was OPC 53 grade cement. The following Table 2.1 is the various tests conducted as per Indian Standards to determine the properties of this cement. For initial & final setting time IS: 8112-1989 is used and for standard consistency of cement IS: 4031(part-4) 1988. For specific gravity of cement (IS: 2720- part 3) is used.

S. No	Properties	Values Obtained
1	Specific gravity	3.15
2	Standard consistency	35%
3	Initial setting time	65 min
4	Final setting time	300 min

Table 2.1: Results of Tests on Cement

Fine aggregate

Sand was used as fine aggregate for the experiment. Various tests were conducted to determine the properties of sand which are shown in the Table 2.2. Grading is the particle- size distribution of an aggregate as determined by a sieve analysis. The tests were done according to IS: 2386 (Part-1) – 1963.

S. No.	Properties	Values
1	Specific gravity	2.6
2	Water absorption	0.82%
3	Zone	II

Table 2.2: Results of Tests on Fine Aggregate

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 passed and 12.5 mm retained size were chosen for the experiment which is clean and free from deleterious materials. The following Table 2.3 shows the tests conducted in order to determine the properties of this aggregate.

S. No	Properties	Values
1	Specific gravity	2.65
2	Fineness modulus	2.2
3	Water absorption	0.19%

Table 2.3: Results of Tests on Coarse Aggregate

Basalt fibre

The fibres used were chopped basalt fibre, which are uniformly and randomly distributed in the concrete matrix. Six different fibre contents were chosen 1%, 2%, 3% and 4% for each mix. Chopped basalt fibres are shown in Figure 2.4. The chemical composition of basalt fibre is mentioned in below Table6.

Oxide	Chemical Composition (%)
Sio_2	69.51
Al_2o_3	14.18
Fe_3o_3	3.92
Cao	5.62
Mgo	2.41
K_2o	1.01
Na_2o_3	2.74

Table 2.4. Chemical Composition of Cement

GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

The Properties of GGBS used in the present work

PROPERTIES	GGBS
Specific Gravity	2.86
Water Absorption	0.14%

Table 2.5. Properties of GGBS

Water

Water used in concrete is free from sewage, oil, acid, strong alkalis or vegetable matter, clay and loam and is satisfactory to use in concrete.

3. Experimental Procedure

It is carried out to study the properties of M25 grade of concrete. Cement is replaced by GGBS of 0%, 5%, 10% and15% with addition of 0.5 diameters of crimped Basalt Fiber with various percentage as 0%, 1.0%, 2%,3% &4% by the volume of concrete. The mix proportion was (1:1:2) with W/C Ratio 0.45. The 150 X 150 X 150 mm cubes and cylinders were casted. The compressive strength and tensile strength was carried out at the age of 7, 14 and 28 days, at various % of GGBS and Basalt fibers.

Basalt Fiber (%)	Cement is Replaced by GGBS	
BF	GGBS	CEMENT
0	Normal Concrete	
1%	5%	95%
	10%	90%
	15%	85%
2%	5%	95%
	10%	90%
	15%	85%
3%	5%	95%
	10%	90%
	15%	85%
4%	5%	95%
	10%	90%

	15%	85%

Table 3.1. % GGBS and BF used in concrete

4. TESTS RESULTS AND DISCUSSION

Workability

The workability of GGBS with Basalt fiber with different percentages in concrete has found to decrease than normal concrete.

Compressive Strength

The cube specimen was placed in the machine, of 2000kN capacity. The load was applied at a rate of approximately 140 kg/sq.cm/min until the resistance of the specimen to the increasing load can be sustained. The specimens were tested at 7 days,14 days and 28 days.

S. No.	Percentage Basalt fiber % +GGBS %	Compressive Strength (N/mm^2)		
		7 Days	14 Days	28 Days
1	BF 0% +GGBS 0%	15.12	20.06	24.91
2	BF 1%+ GGBS 5%	14.78	21.10	25.18
3	BF1%+GGBS 10%	15.09	20.86	24.95
4	BF1%+GGBS 15%	14.98	20.26	23.97
5	BF 2%+ GGBS 5%	15.41	21.12	25.31
6	BF2%+GGBS 10%	15.30	20.98	24.99
7	BF2%+GGBS 15%	14.98	20.44	23.76
8	BF 3%+ GGBS 5%	15.38	22.18	25.39
9	BF3%+GGBS 10%	15.11	20.02	24.98
10	BF3%+GGBS 15%	14.77	20.02	24.12
11	BF 4%+ GGBS 5%	15.34	22.12	25.41
12	BF4%+GGBS 10%	15.18	20.53	24.88
13	BF4%+GGBS 15%	14.50	20.66	24.42

Table 4.1 Compressive strength of concrete for 7,14 & 28 Days

Tensile Strength

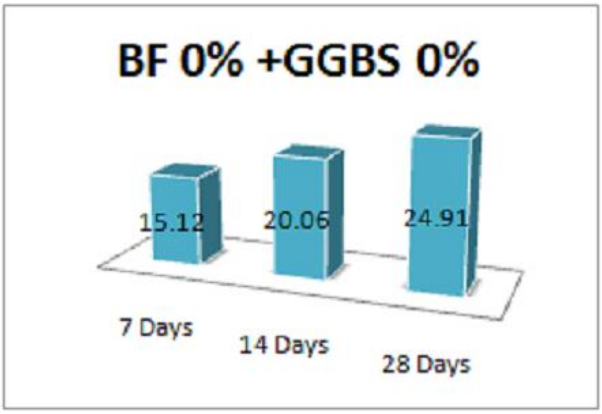
Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to the various kinds of effect and applied loading it self,how ever tesile strength of concrete is very low in compared with compressive strength of concrete.

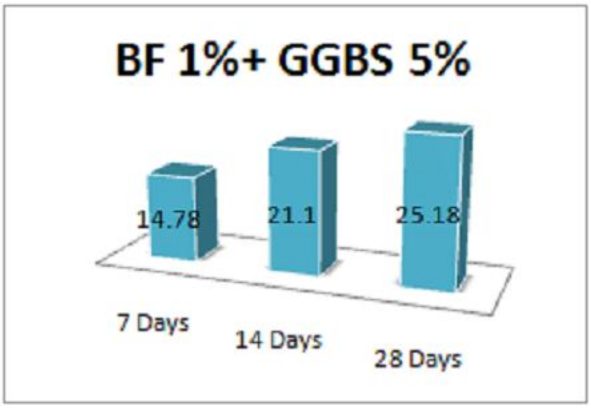
S. No.	Percentage Basalt fiber% +GGBS %	Tensile Strength (N/mm^2)		
		7 Days	14 Days	28 Days
1	BF 0% +GGBS 0%	2.72	3.135	3.493
2	BF 1%+ GGBS 5%	2.692	3.215	3.512
3	BF1%+GGBS 10%	2.719	3.197	3.496
4	BF1%+GGBS 15%	2.709	3.15	3.427
5	BF 2%+ GGBS 5%	2.747	3.216	3.521
6	BF2%+GGBS 10%	2.738	3.206	3.499
7	BF2%+GGBS 15%	2.709	3.164	3.412
8	BF 3%+ GGBS 5%	2.745	3.296	3.527
9	BF3%+GGBS 10%	2.721	3.132	3.498
10	BF3%+GGBS 15%	2.69	3.132	3.437
11	BF 4%+ GGBS 5%	2.741	3.292	3.528
12	BF4%+GGBS 10%	2.727	3.171	3.491
13	BF4%+GGBS 15%	2.665	3.181	3.459

Table 4.1 Split tensile strength of concrete for 7, 14 & 28 Days

Graphs

Compressive strength

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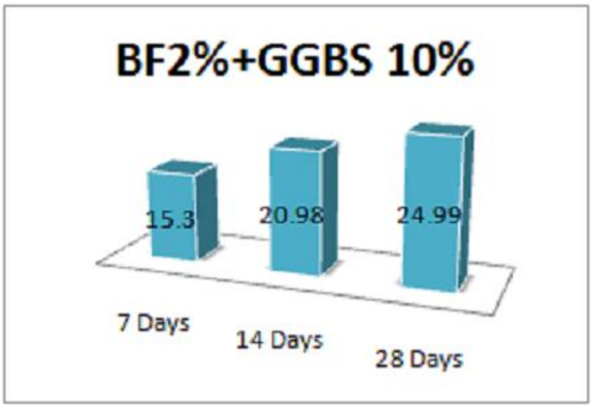
14 Days
28 Days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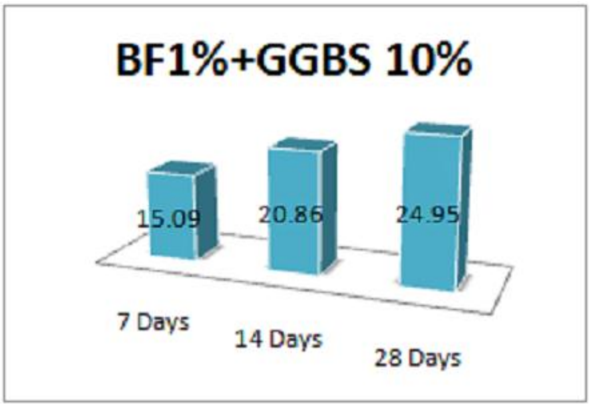
28 Days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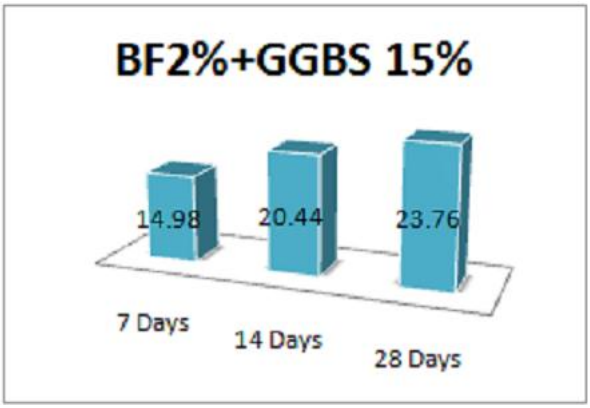
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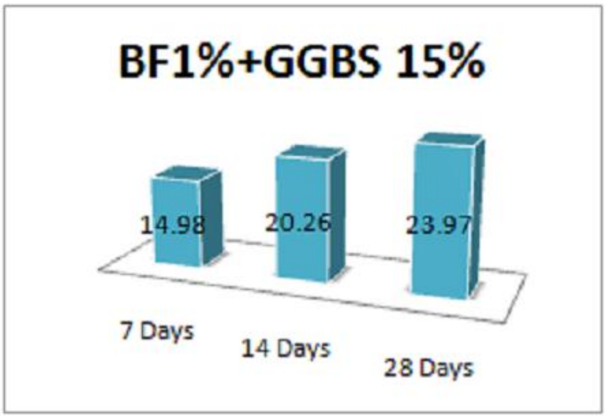
28 Days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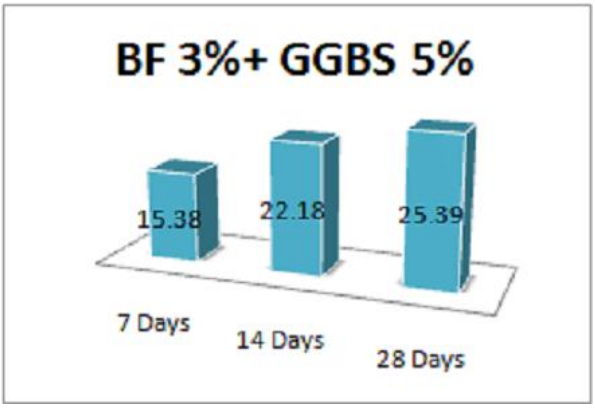
28 Days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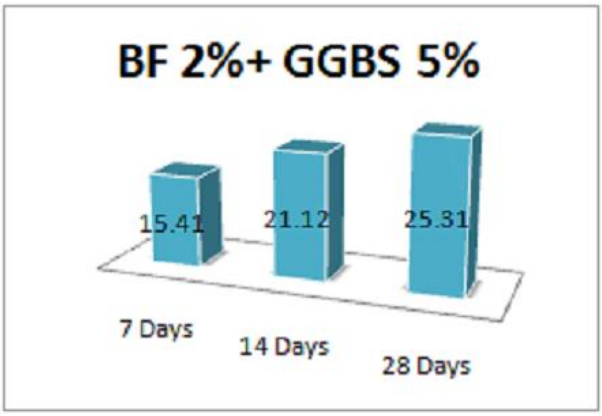
28 Days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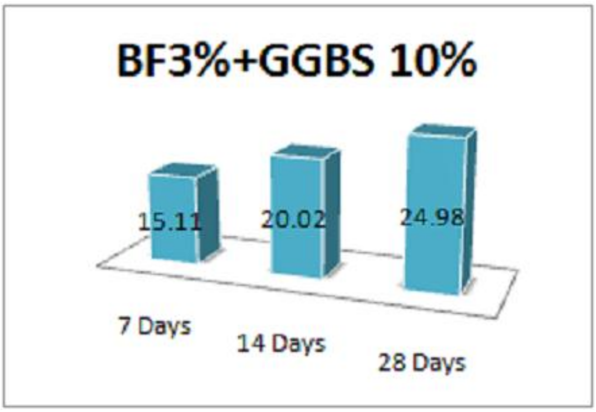
14 Days
28 Days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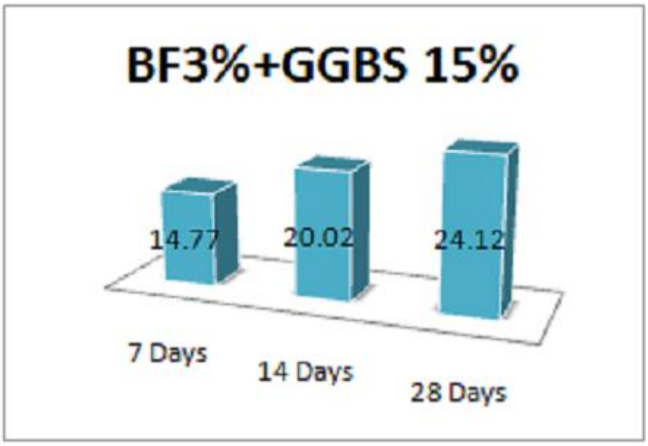
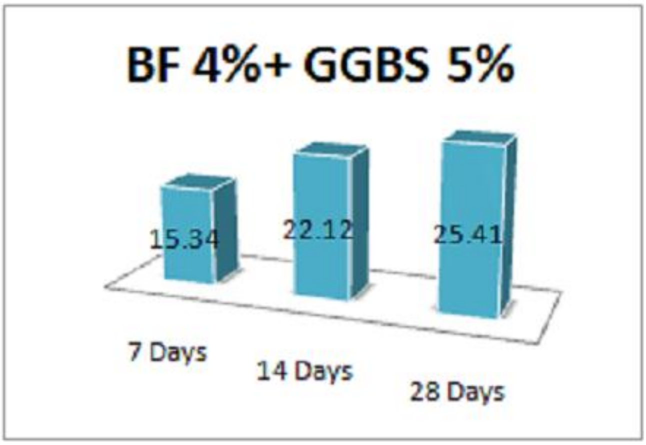
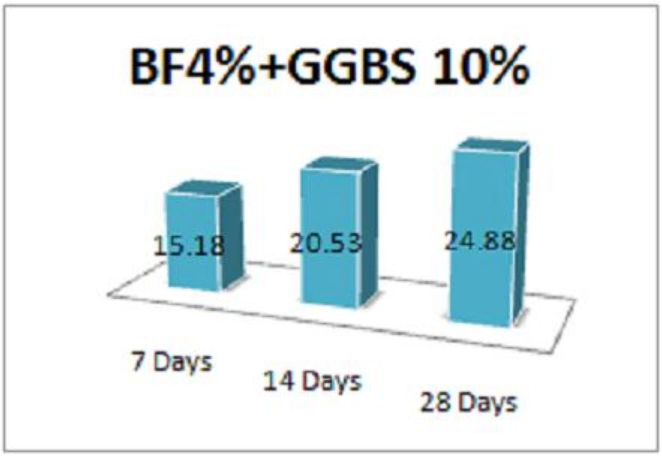
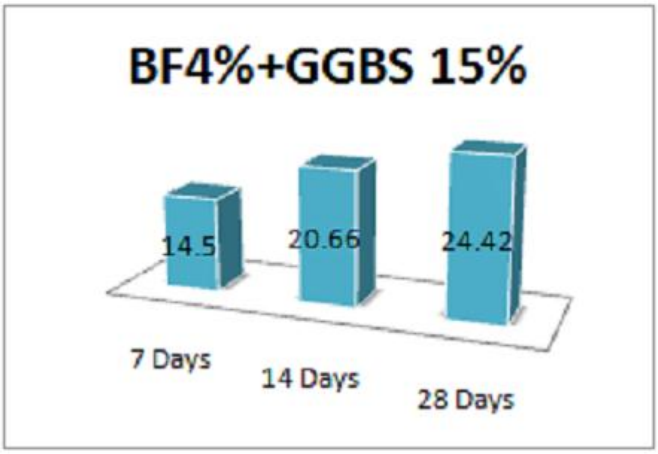
28 Days

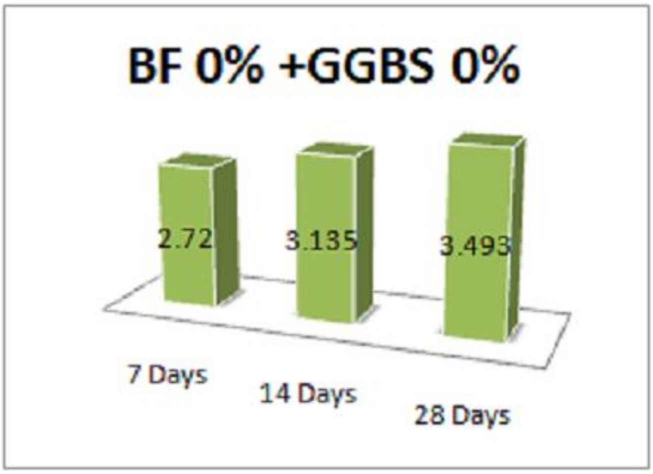


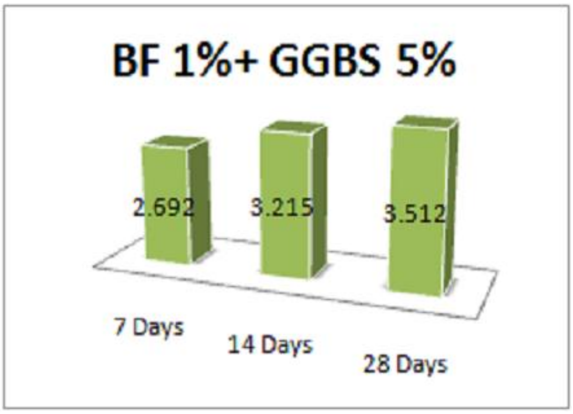


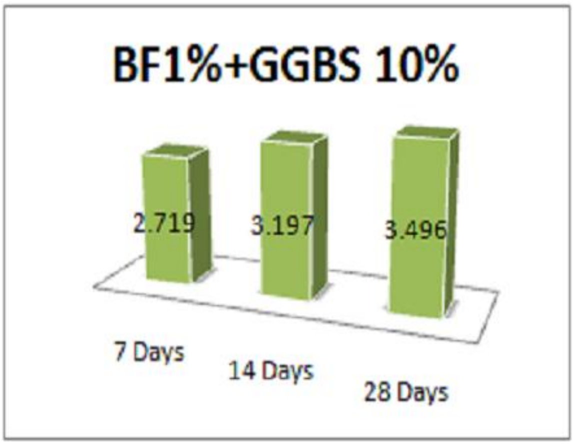


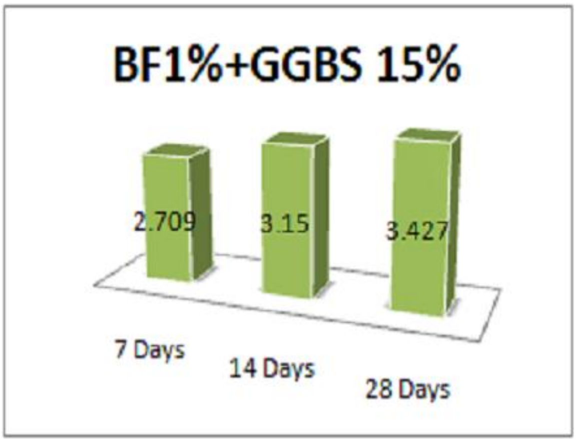


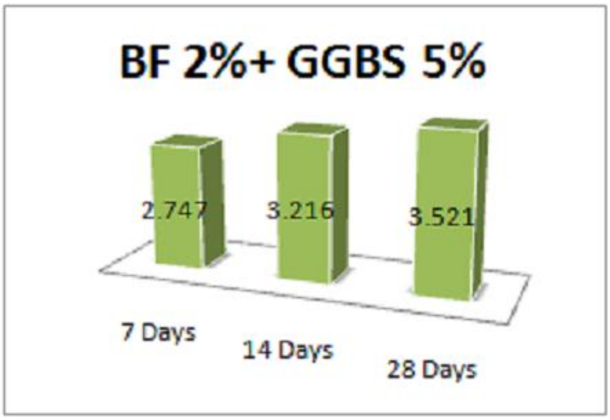
Graphs of Tensile Strength







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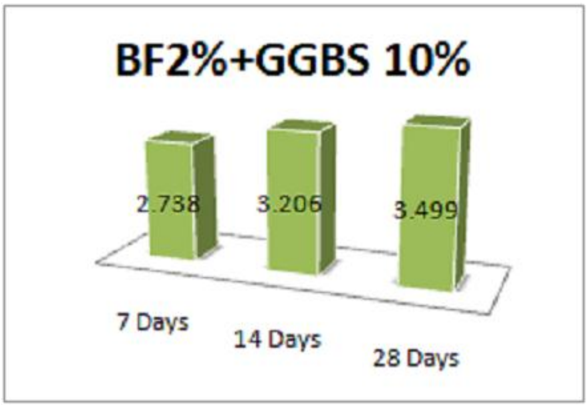
3.216
3.521
7 Days
14 Days
28 Days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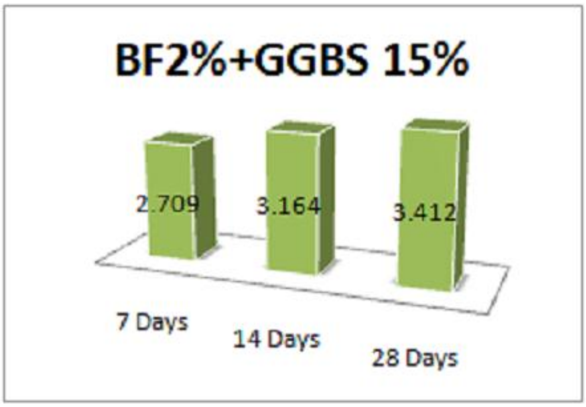
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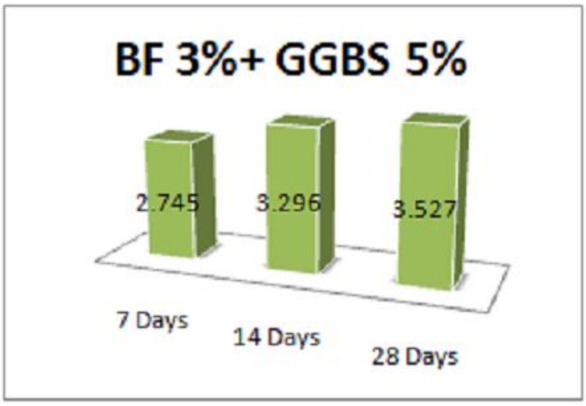
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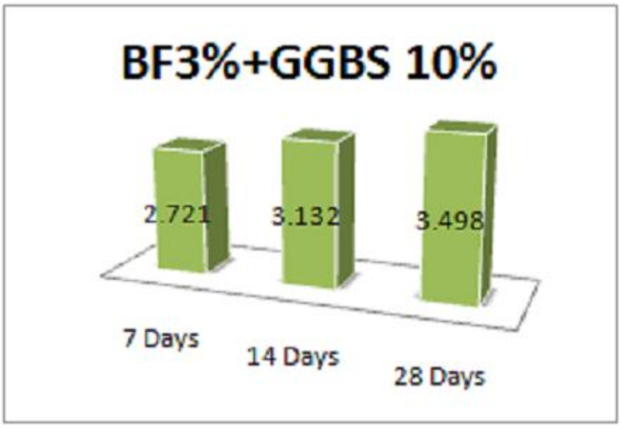
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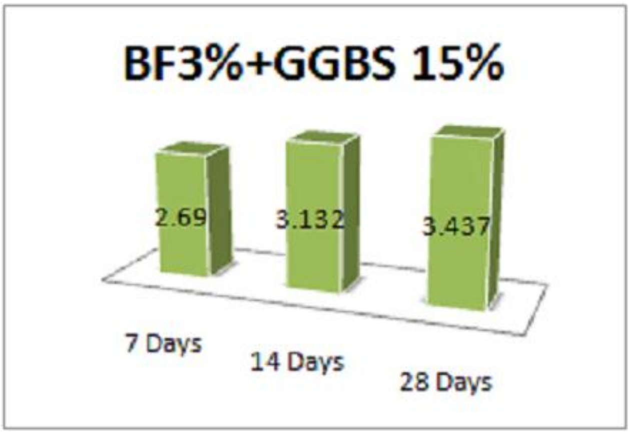
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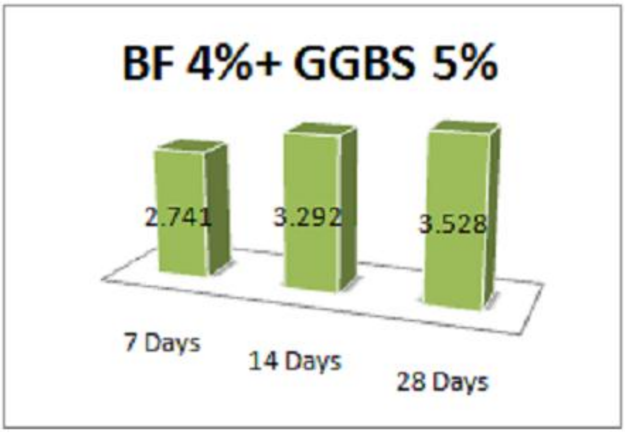
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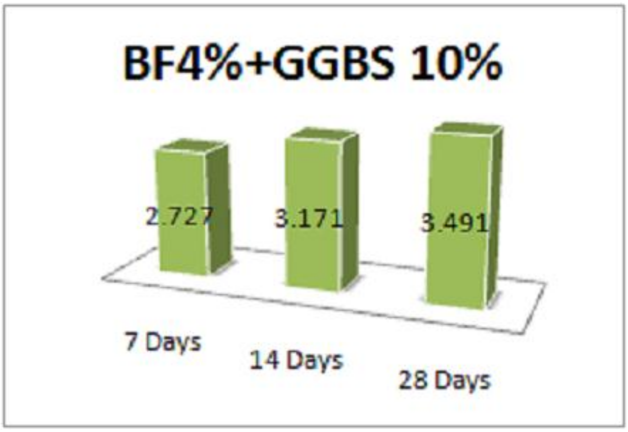
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7 Days
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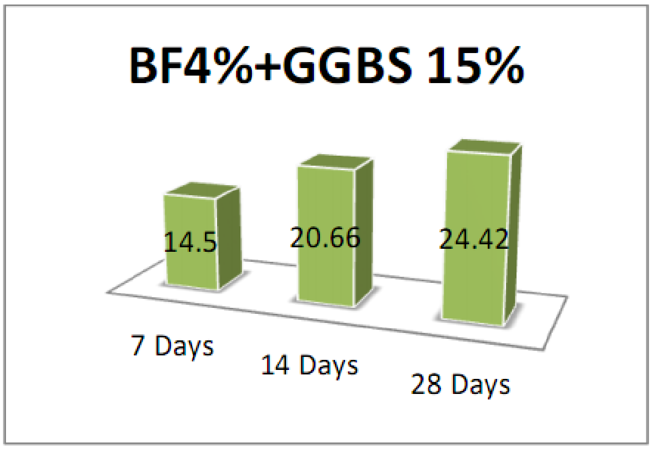

CONCLUSION

Based on the investigation studies the following conclusions can be made:

- It has been observed that the workability of concrete decreases with the addition of GGBS and Basalt Fibres with normal concrete
- The test results shows that 1% BF+ 5% GGBS,2% BF + 5% GGBS,3% BF + 5% GGBS, 4% BF + 5% GGBS shows the increasing in compressive and tensile Strength
- The compressive strength and Tensile strength is been increased from 24.91N/mm^2 and 3.493N/mm^2 for 0 % to 25.41 N/mm^2 and 3.528 N/mm^2. for B.F 4%+GGBS 5% .
- The compressive strength of specimens gradually increased with the increase of basalt fibre in concrete
- The concrete mix containing of GGBS and Basalt Fiber it observed that, if the increasing percentage of GGBS results in decreasing the strength.
- Also it was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibres than the basalt fibre concrete.
- It shows that the presence of fibres in the concrete acts as the crack arrestors. The ductility characteristics have improved with the addition of basalt fibres. The failure of fibre concrete is gradual as compared to that of brittle failure of plain concrete.

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