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Strength Properties of Sisal Fiber Concrete with 30% Partial Replacement of Ground Granulated Blast Furnace Slag

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***Abstract* - Due to the drastic increase in the construction of structures, the usage of concrete is increasing at an alarming rate. Concrete is relatively brittle, and its tensile strength is typically only about one tenths of its compressive strength. Cement, a constituent of concrete releases huge amount of greenhouse gases by manufacturing. To reduce this cement content is reduced by adding other products which satisfies the strength and other needs and are less harmful to the environment. One among such materials is Ground Granulated Blast Furnace Slag (GGBS).**

The use of fibers in concrete improves crack resistance, imparts ductility to concrete and avoids catastrophic nature of failure and their main purpose is to increase the energy absorption capacity and toughness of the material, apart from increasing the tensile and flexural strength of concrete. But using steel fibers in concrete is a costly one, this can be overcome by using Natural fibers.

In this paper sisal fiber at different percentages by weight of concrete is used as a secondary reinforcement to increase the properties of concrete with partial replacement of cement by 30% GGBS. The experimental study involves the strength comparison of fiber concrete with conventional concrete. Prisms and cubes were cast to compare the test results.

Index Terms— Sisal fiber, GGBS, NaOH solution, Compressive, Flexural

I. INTRODUCTION

Reinforced concrete can be used to produce frames, columns, foundation, beams etc. Reinforcement material used should have excellent bonding characteristic, high tensile strength and good thermal compatibility. Reinforcement requires that there shall be smooth transmission of load from the concrete to the interface between concrete and reinforcement material and then on to reinforcement material. Thus the concrete and the material reinforced shall have the same strain.

II. DESCRIPTION OF SISAL FIBER AND GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Sisal Fiber:

Sisal fiber (Agave sisal fiberana) is an agave that yields a stiff fiber traditionally used in making twine rope and also dartboards. The term may refer either to the plant or the fiber, depending on context. It is sometimes incorrectly referred to as sisal fiber hemp because hemp was for centuries a major source for fiber, so other fibers were sometimes named after it.

The length of Sisal fiber is about 1.5 to 2 meters tall. The life-span of sisal fiber plant is 7–10 year and typically produces 200–250 commercially usable leaves. Each leaf contains an average of around 1000 fibers.

Sisal Fiber Extraction:

Fiber is extracted by a process known as Decortication, where leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibers remain. In India, where production is typically on large estates, the leaves are transported to a central decortication plant, where water is used to wash away the waste parts of the leaf. The fiber is then dried, brushed and baled for export. Superior quality sisal fiber is found in East Africa. Proper drying is important as fiber quality depends largely on moisture content.

Sisal Fiber Treatment:

Sisal fiber is treated with NaOH solution of 0.1 normality to attain high performance in crack resistance and durability in sisal fiber concrete. When the treated fibers were incorporated into an epoxy matrix, mechanical characterization of the laminates revealed the importance of two types of interface: one between fiber bundles and the matrix and the other between the ultimate cells. In general, fiber treatments can significantly improve adhesion at the former interface and also lead to ingress of the matrix resin into the fibers, obstructing pull-out of the cells. As a result, the dependence of laminate mechanical properties on treatment methods becomes complicated.

Fig.2.1: Before treating sisal fiber

Fig.2.2: After treated with NaOH solution

Ground Granulated Blast Furnace Slag (GGBS):

It is a hydraulic binder, i.e. cement, which has been known and used for 150 years. It improves the quality and durability of concrete, and its production is virtually CO_2-free. Yet its many advantages in producing sustainable, high-quality concrete remain underappreciated and underused. In an increasingly resource-constrained and environmentally conscious world, all that is about to change.

Fig.2.3: GGBS Powder

III. EXPERIMENTAL INVESTIGATIONS ON MATERIALS USED IN CONCRETE

Concrete is a composite material which consists of coarse aggregate, fine aggregate binded together with cement paste which hardens over time. The cement is a binding material, it reacts chemically with water and other materials and form hard matrix. The materials used in the concrete are:

1. Cement 2.Coarse aggregate 3. Fine aggregate 4.GGBS (mineral admixture)

Table 3.1: Properties of cement

S.No.	Properties	Results
1	Specific gravity	3.01
2	Normal consistency	28%
3	Initial setting time	32 min
4	Final setting time	300 min
5	Soundness	2 mm
6	Fineness	3.06%

Table 3.2: Sieve Analysis of coarse aggregate

S. No.	IS Sieve Size (mm)	Cumulative% Passing
1	20	100
2	12.5	94.5
3	10	35.3
4	4.75	2.00
5	pan	1.400

Specific gravity of coarse aggregates=2.83
Bulk density=1.385 mg/cc

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Table 3.3: Sieve Analysis of fine aggregate

S.No.	IS Sieve Size	Cumulative% passing
1	4.75 mm	97.8
2	2.36 mm	92.6
3	1.18 mm	69.1
4	600 mic	45.6
5	300 mic	11.8
6	150 mic	0.3
7	Pan	0

Specific gravity = 2.70 Bulk density = 1.672g/cc

Table 3.4: Properties of GGBS

S.No.	Chemical Constituents	Mass%
1	CaO	40
2	SiO_2	35
3	Al_2O_3	10
4	MgO	8

Specific gravity = 2.85 Fineness modulus = 4%

Table 3.6: Mix details of concrete

Materials	Conventional Concrete	Sisal Fiber Concrete				
		0.5%	1%	1.5%	2%	2.5%
Cement kg/m^3	399.166	313.6	313.6	313.6	313.6	313.6
Sand kg/m^3	690.39	677.23	677.23	677.23	677.23	677.23
Coarse aggregate kg/m^3	1101.30	1082.68	1082.68	1082.68	1082.68	1082.68
Water kg/m^3	191.599	150.528	150.528	150.528	150.528	150.528
GGBS kg/m^3	-	134.4	134.4	134.4	134.4	134.4
Fibers(gms)	-	1.568	3.136	4.705	6.272	7.84

Casting:

The cubes of 150mmx150mmx150mm size are used as specimens to test the compressive strength of concrete and prisms of 500mmx100mmx100mm size are used as specimens to test the flexural strength of the concrete. The materials required for casting the specimens are taken by weigh batching. The materials are weighed according to the mix proportions obtained.

A dry mix is prepared by pouring cement, fine aggregates, and coarse aggregates into a rotary mixer and thoroughly mixed. Then the required amount of water is added to the dry mix and mixed thoroughly. The moulds are cleaned and lightly coated with grease for easy removal of specimens while demoulding. The mix is then placed into the moulds in three layers, each layer compacted by giving 25 blows with the tamping rod of 16mm diameter.

After filling the mould, the top surface is made smooth. The moulds are demoulded after 24 hours when the concrete in it is completely dried and hardened and placed in the curing tank until the day of testing. The testing is done at the age of 3, 7, 28 days and the corresponding results are recorded.

Curing:

Curing is done before testing the specimen. The specimen must be placed in the curing tank immediately after demoulding. The temperature of the water in the curing tank should be maintained at 27^0C – 30^0C. the specimen should be completely immersed in the curing tank to attain perfect curing and strengths.

In order to provide adequate circulation of water, sufficient space should be provided between the specimens and between the specimens and the sides of the curing tank. The curing of specimens is done by ponding method of curing. Specimens are placed in a tank containing water for required number of days of curing immediately after demoulding.

After the required curing period is done the specimens are taken and neatly wiped and dried and then tested for required results.

Fig 3.2: Curing tank

IV. TESTS CONDUCTED ON THE SPECIMENS

A number of tests are conducted on the concrete specimens to check its strength, design mix properties and other criteria in the laboratory. The overall performance of any concrete is measured on the basis of strength and durability of hardened concrete. Strength is the major governing attribute whereas durability is the measure of performance.

The strength of the concrete is measured from

1. Compressive strength on cubes.
2. Flexural strength for prisms.

The compressive strength test is carried out on specimens blended with various percentage of fibers added by the weight of cement along with 30% partial replacement of OPC by GGBS at 3, 7 and 28 days of curing in compressive testing machine.

The cube was tested in a compression testing machine of capacity 2000kN at a loading rate of 5.5 kN/min. The compressive strength is calculated as:

Compressive strength of cube (Fc) =ultimate load / cross section of cube

Fig 4.1: compressive test machine

Fig 4.2: Cubes after compressive test

The flexural strength is found to increase by the addition of the fine grained particle and fibers due to increase in bond strength as they form a rigid structure comparatively. The specimen is cleaned to remove any sand or other material from the surface of the specimen. The specimens are placed on the machine in contact with the rollers in such a way that is specified according to IS: 516-1959.

The axis of the specimen is aligned carefully with the axis of the loading device and the load is applied uniformly on the prism. The maximum load at which the specimen fails is recorded. The flexural strength is calculated as –

Flexural strength of prism (Fb) =Pl/bd Where, P = ultimate load, l= effective span, b=Breadth

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Fig 4.3: Prisms after flexural testing

V. RESULTS

In this paper, the observations were recorded for compressive and flexural Strength by varying the different percentage of sisal fiber with the constant percent of GGBS.

Compressive Strength Test for Cubes:

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. In this paper we are varying percentage of fibers as 0.5%, 1.0%, 1.5%, 2% & 2.5% respectively.

Fig.5.1: Testing of cubes in compressive strength machine

Table 5.1: Results

Trial	Area(mm^2)	3 Day Compressive strength (MPa)	7 Day Compressive strength (MPa)	28 Day Compressive strength (MPa)
1	150x150	14.26	18.04	28.44
2	150x150	13.06	19.60	30.13
3	150x150	13.02	19.33	27.73
		Avg=13.44	Avg=18.98	Avg=28.76

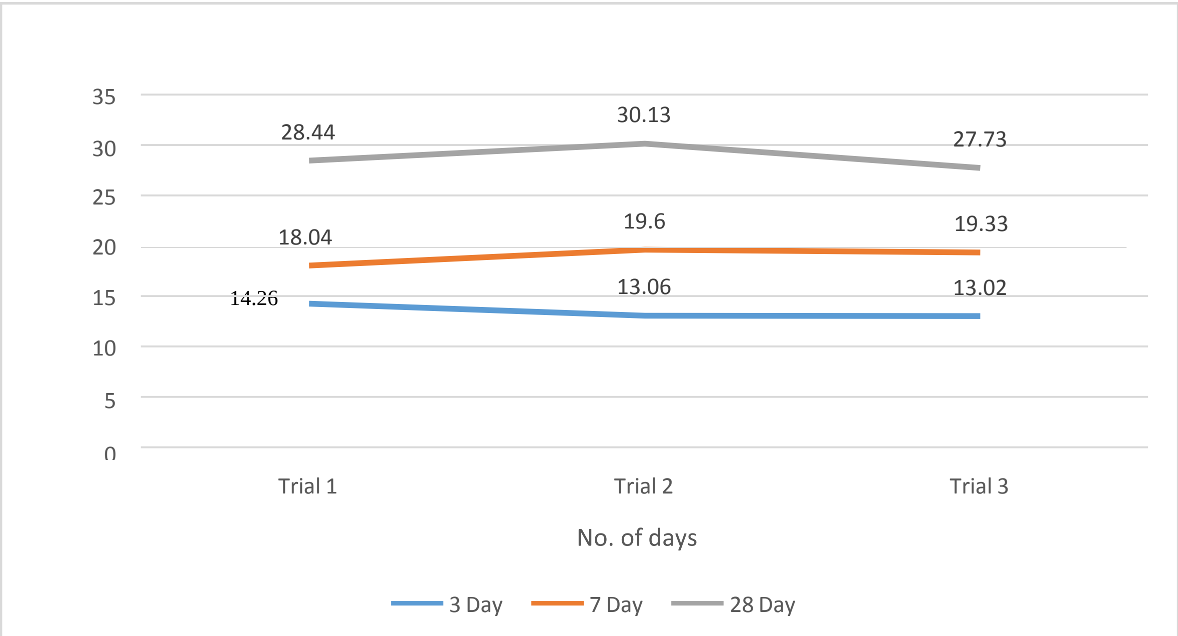

Fig 5.2: compressive strength results of conventional concrete

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Flexural Strength of Concrete:

Concrete as we know is relatively week in tension and strong in compression. In reinforced concrete members, little dependence is placed on the tensile strength of concrete since sisal reinforcing bars are provided to resist all tensile forces. However, tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of sisal reinforcement, temperature gradients and many other reasons. Therefore, the knowledge of tensile strength of concrete is of importance.

Fig 5.3: Failure of prisms after testing

Table 5.2: 3 Day flexural strength Test Results

Trial	Area(mm^2)	Flexural strength (N/mm^2)	Flexural strength(N/mm^2)	Flexural strength(N/mm^2)
1	10x10x50	2.790	2.834	2.892
2	10x10x50	2.801	2.851	3.015
3	10x10x50	2.801	2.834	2.987

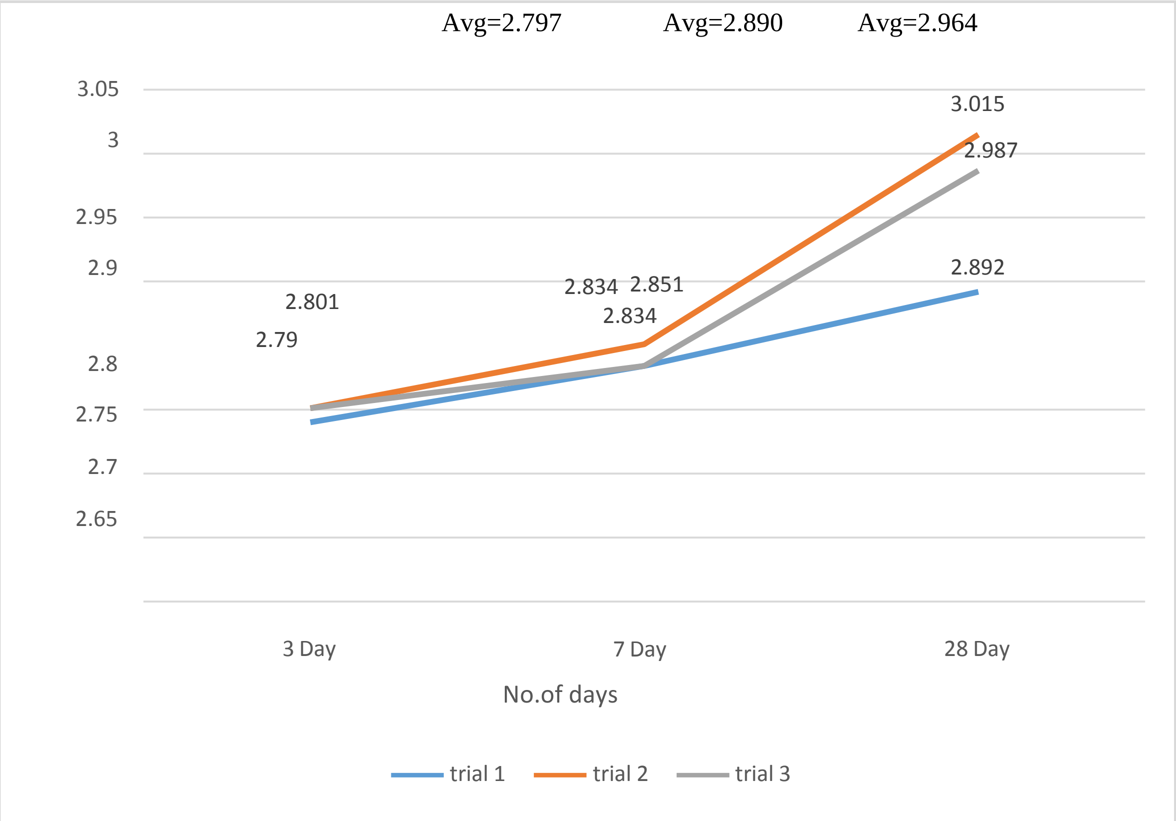

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Fig 5.4: Prism after testing

Results for Sisal Fiber Concrete with Different Percentages:

Sl No.	% of GGBS	0.5%	1%	1.5%	2%	2.5%	Day
1	30	14.61	15.25	17.89	15.07	13.24	3
2	30	18.59	18.98	19.86	17.16	16.03	7
3	30	25.20	28.45	35.94	33.18	30.36	28

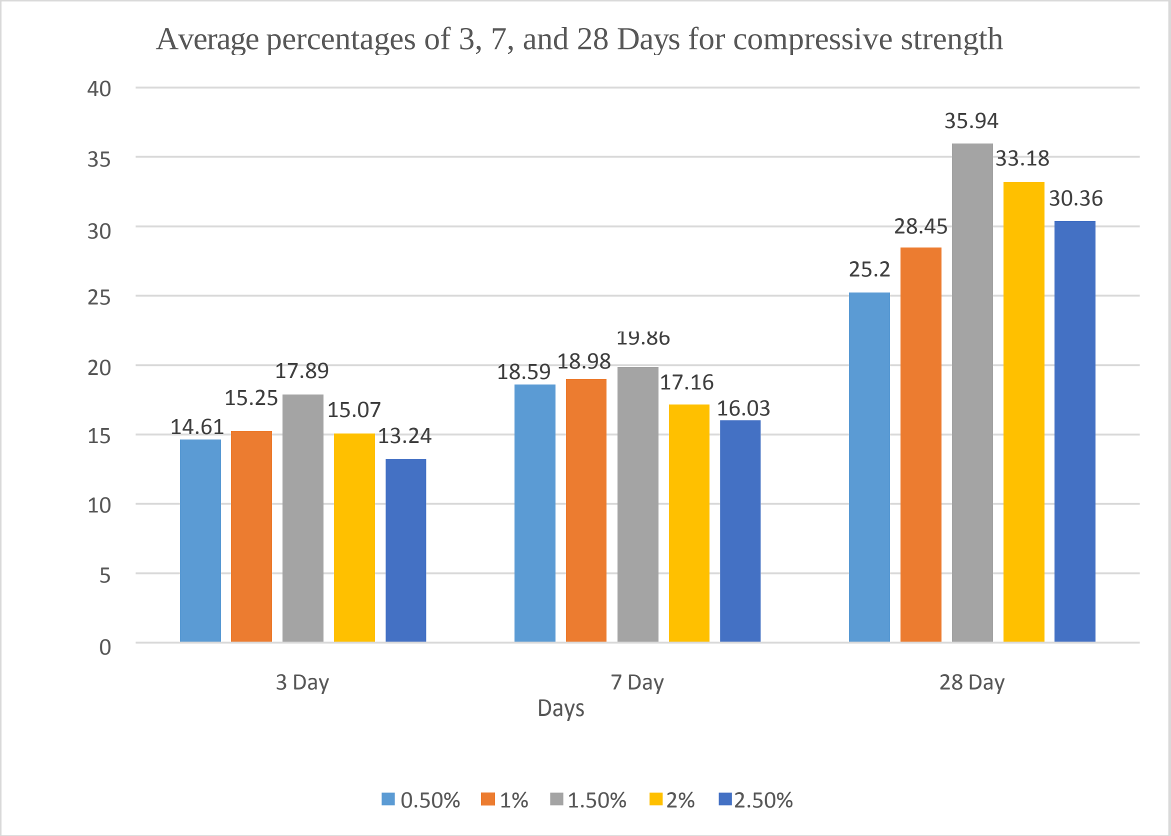

Fig.5.5 Average Percentages of 3,7 and 28 days for compressive strength

Flexural Strength Results:

Table 5.3: Average Flexural Strength Results of Sisal Fiber Concrete for 3,7,28 days:

S. No.	% of GGBS	0.5%	1%	1.5%	2%	2.5%	Day
1	30	2.709	2.815	2.851	2.815	2.801	3
2	30	2.815	2.851	2.982	2.873	2.834	7
3	30	2.984	3.248	3.846	3.422	3.162	28

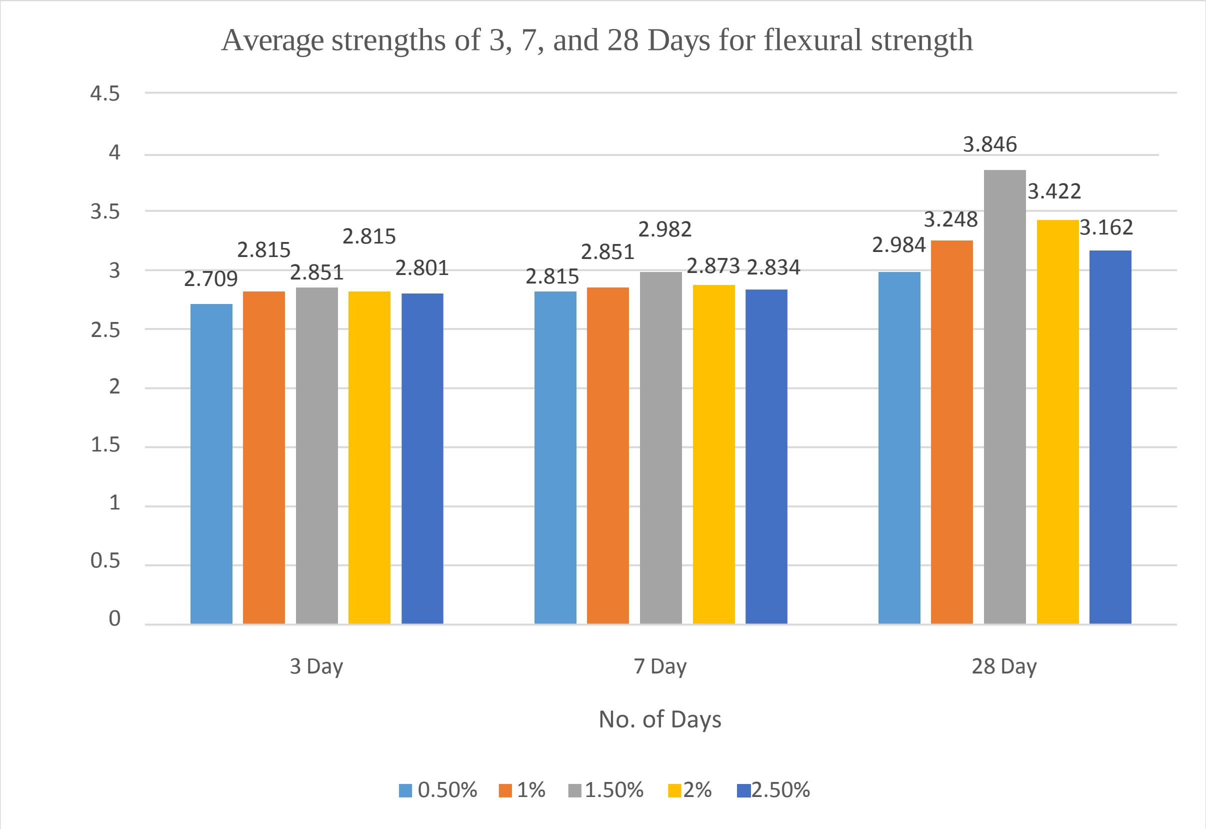

Fig.5.6 Average strengths of 3,7 and 28 days for flexural

V. CONCLUSIONS

Based on the experimental study conducted the conclusions that are drawn are as follows:-

- GGBS concrete gives more strength when compared to conventional concrete.
- The addition of fibers by weight of cementitious material ranged from 0.5% to 2.5%. The optimum percentage of fiber at which strength increment was significant was observed to be at 1.5%.
- The compressive strength of sisal fiber reinforced concrete increases up to 1.5% addition of fibers to the concrete by weight of the cementitious material and beyond it a significant fall in the strength values is observed.
- There is also an increase in the flexural strength also up to 1.5% addition and beyond that a significant decrease in the strength is observed.
- The compression strength test results at 3 days curing period with 30% GGBS replacement along with fibers at 1.5% addition increased by 33.11% when compared with conventional concrete.
- The compression strength test results at 7 days curing period with 30% GGBS replacement along with fibers at 1.5% addition increased by 25.71% when compared with conventional concrete.
- The compression strength test results at 28 days curing period with 30% GGBS replacement along with fibers at 1.5% addition increased by 24.96% when compared with conventional concrete.
- The flexural strength test results at 3 days curing period with 30% GGBS replacement along with fibers at 1.5% addition increased by 1.93% when compared with conventional concrete.
- The flexural strength test results at 7 days curing period with 30% GGBS replacement along with fibers at 1.5% addition increased by 2.99% when compared with conventional concrete.
- The flexural strength test results at 28 days curing period with 30% GGBS replacement along with fibers at 1.5% addition increased by 29.75% when compared with conventional concrete.
- Workability of M25 grade concrete increased with the addition of fibers till 1.5% along with 30% partial replacement of cement by GGBS and later on as the fiber conctent increased workability decreased.
- It can be concluded that concrete mix with cement replacement by GGBS and fiber addition improves the strength properties, crack resistance and is eco-friendly.

REFERENCES

[1] Santosh Kumar Karri, G.V. Rama Rao and P. Markandeya Raju, "Strength and Duribility Studies on GGBS Concrete", SSRG International Journal of Civil Engineering(SSRG-IJCE), Vol. 2, Issue 10, October 2015, pp. 34-41, ISSN: 2348-8352

[2] Thejaskumar HM and Dr. V. Ramesh, "Experimental Study on Strength and Durability of Concrete with Partial Replacement of Blast Furnace Slag", Vol. 3, Issue 1, Sep.

2015, pp. 134- 140, e-ISSN: 2348-7607

[3] Magandeep, Ravi Kant Pareek and Varinder Singh, "Utilization of Ground Granulated Blast Furnace Slag to Improve Properties of Concrete", International Journal on Emerging Technologies, Vol. 6, Issue 2, Aug. 2015, pp. 72-79, e-ISSN: 2249-3255

[4] T. Vijaya Gowri, P. Sravana and P. Srinivasa Rao, "Studies on Strength Behaviour of High Volumes of Slag Concrete", International Journal of Research in Engineering and Technology(IJRET), Vol. 3, Issue 4, Apr. 2014, pp. 227-238, e-ISSN: 2319-1163

[5] M. Ramalekshmi, R. Sheeja and R. Gopinath, "Experimental Behaviour of Reinforced Concrete with Partial Replacement of Cement with Ground Granulated Blast Furnace Slag", International Journal of Engineering Research & Technology(IJERT), Vol. 3, Issue 3, Mar. 2014, pp. 525-534, ISSN: 2278-0181

[6] S. Arivalagan, "Sustainable Studies on Concrete with GGBS as a Replacement Material in Cement", Jordan Journal of Civil Engineering, Vol. 8, Issue 3, Feb 2014, pp. 263-270

[7] Reshma Rughooputh and Jaylina Rana, "Partial Replacement of Cement by Ground Granulated Blast Furnace Slag in Concrete", Journal of Emerging Trends in Engineering and Applied Sciences(JETEAS), Vol. 5, Issue 5, 2014, pp. 340-343, ISSN: 2141-7016

[8] Yogendra O. Patil, Prof. P.N. Patil and Dr. Arun Kumar Dwivedi, "GGBS as Partial Replacement of OPC in Cement Concrete – An Experimental Study", International Journal of Scientific Research(IJSR), Vol. 2, Issue 11, Nov. 2013, pp. 189-191, ISSN: 2277-8179.