An Experimental Study on Partial Replacement of Cement by GGBS and with addition Coconut fibers in Concrete

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***ABSTRACT*: Wastes generated by industrial and agricultural processes have created disposal and management problems which pose serious challenges to efforts towards environmental conservation. A considerable amount of coconut fiber and GGBS remain in the environment as waste, so utilization of these materials for construction will be an important step to improve sustainability and eco-friendly construction. This paper describes the feasibility of using waste in concrete production as a partial replacement of cement with GGBS and addition of coconut fibers. The cement has been replaced by GGBS in the range of 30% and 40% by weight of cement, Coconut fibers in the range of 1.5%, 2.0% and 2.5% by weight of binder for M20 grade mix and compare with plain cement concrete. The cubes and Prisms are tested for compressive and tensile strengths. It is found that by the partial replacement of cement with GGBS and with addition of coconut fibers helped in improving the strength of the concrete substantially compared to normal mix concrete. The results shows that the cement composite with 2% of coconut fiber and 30% of GGBS gives highest compressive strength and split tensile strength.**

***Keywords*: Coconut fiber, compressive strength and split tensile strength.**

I. INTRODUCTION

Concrete is the most widely used construction material in the world, and is second only to water as the most utilized substance on the planet. It is obtained by mixing cementing materials, water, and aggregates, and sometimes admixtures in required proportions. It has high compressive strength. But it is very brittle due to weak in tensile, flexure, impact strength and has low resistance against cracking. One method to improve the brittle behavior of the concrete is the addition of small fibers in concrete with randomly distributed. Such reinforced concrete is called Fiber Reinforced Concrete (FRC). The main reason for incorporating fibers into the cement matrix is to increase the tensile strength, the energy absorption capacity, toughness, flexural strength of concrete and also it improves the cracking deformation characteristics of the concrete composite. Today, the industrial waste by products such as Ground Granulated Blast – furnace Slag (GGBS), fly ash, silica fume, etc. are used as supplementary cementitious materials in concrete. The incorporation of Supplementary cementitious materials improves the mechanical properties of concrete and also reduces the cement consumption by replacing part of cement with these pozzolonic materials. The present experimental investigation is to study the Mechanical Properties of concrete with partial replacement of Ordinary Portland Cement by different percentage of GGBS. Also coconut Fibers are used in different percentage by weight of binder content.

II. METHODS AND MATERIAL

Cement

The cement used in is Birla A-1 53 grade Ordinary Portland Cement. The specific gravity of the cement is 2.9. Standard consistency of cement is 33%. Initial setting time and Final setting time of cement is 40min and 500min respectively. Soundness of cement was found to be 6%.

Fine aggregates

Locally available sand is used in this study which is passing from 4.75 mm sieve and specific gravity and fineness modulus was found to be 2.645 and 2.7, Water absorption calculated as 1.2%.

Coarse aggregates

Aggregate of size 20 mm and 10 mm down available from the local source are used. Specific gravity of course aggregate is 2.72, fineness modulus is 6.1, and Water absorption found to be 0.6%.

Ground Granulated Blast Furnace Slag (GGBS)

The GGBS used in present study was obtained from Jindal Steel Ltd. The properties of GGBS obtained has follows

Table 1. Properties of GGBS

Fineness modulus	378 m^2/kg
Specific gravity	2.9
Glass content	92%
Moisture content	0.10%

Figure 1.0 GGBS

Chemical Composition

Table 2. Composition of GGBS

CaO	30-45
SiO_2	30-38
Al_2O_3	15-25
Fe_2O_3	0.5-2
M_gO	4-17
M_nO_2	1-15

Coconut Fibers (Coir)

Coconut fibers were brought from RK Private ltd., Tumkur and used in study with following Details.

Table 3. Properties of Coir

Length	6-8 inches
Density	1.40 g/cc
Diameter	0.1-1.5 mm
Swelling in water	5%
Moisture absorption	10.5%

Fig 2 Coconut fiber

Concrete Mixes

Three concrete mixes were prepared. The control mix (CM) A consisted of 100% OPC. In mixes B and C, the cement was partially substituted with 30% and 40% of GGBS by weight respectively. In mixes D, E, and F, the cement was partially substituted with 30% of GGBS with addition of coir fibers 1.5%, 2.0% and 2.5% respectively. In mixes G, H and I, the cement was partially substituted with 40% of GGBS with addition of coir fibers 1.5%, 2.0% and 2.5% respectively. The fine aggregate and coarse aggregate content was kept constant for all mixes. The Indian Slandered method was used for the mix design process. The target strength of all mixes was 27.0 N/mm^2 and the target slump was 135-155 mm. The mix proportion used is 1:2:3.3 with w/c 0.55. The proportions of materials for each concrete mix are shown in Table 4.

Table 4 - Mix Proportions of Mixes

Materials Kg/m^3	Cement (kg)	C.A (kg)	F.A (kg)	GGBS
A	358.1	1171.1	717.8	-
30% GGBS(B)	250.72			107.45
40% GGBS(C)	214.90			143.27
D 1.5%fiber	250.72			30% GGBS
E 2.0%fiber	250.72			30% GGBS
F 2.5%fiber	250.72			30% GGBS
G 1.5%fiber	214.90			40% GGBS
H 2.0%fiber	214.90			40% GGBS
I 2.5%fiber	214.90			40% GGBS

Casting and Curing

For each mix, six 150mm×150mm×150mm cube, and 150 mm diameter x 300 mm long cylindrical test specimens were cast. After 24 hours, the specimens were de-moulded and cured in water at room temperature until they were tested.

III. RESULTS AND DISCUSSION

TESTING

Compressive Strength

The compressive strengths of three 100mm x 100mmx100mm test cubes were determined in accordance with IS516:1959: Testing hardened concrete: Compressive strength of test specimens. The specimens were tested for 7 and 28 day strengths.

Fig. 3 Cube specimens

Fig. 4 Testing of Cube specimen under CTM

Table 5.Comparison between normal concrete and GGBS concrete

Sl. No.	Type of design	Compressive strength (N/mm^2)	
		7 days	28 days
1	M 20 A	19.7	28.4
2	B 30% GGBS	19.9	30.75
3	C 40% GGBS	20.84	26.95

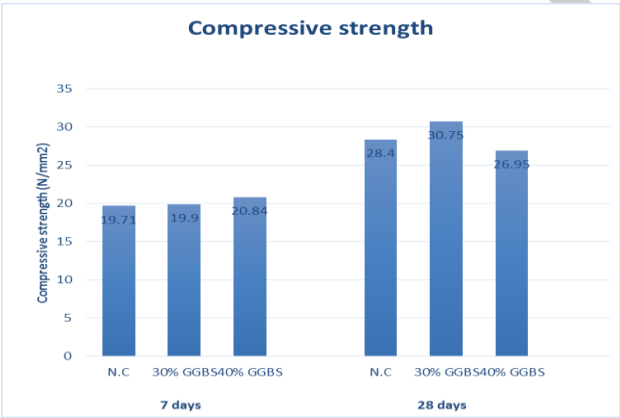

Fig 5 Comparison between normal concrete and GGBS concrete of compressive strength

The samples were tested by applying increasing compressive load until failure. Fig. 6 and 7 shows the comparison of compressive strength of different percentages of GGBS and Coir fibers at 7 and 28 days. The compressive strength of concrete at 28 days increases as percentage of GGBS(30%) and coir fiber increases but decreases at 28 days strength for 40% GGBS replacement.

Table 6 Comparison between normal concrete and GGBS with coconut fibre of compressive strength

Sl. No.	mixes	Compressive strength (N/mm^2)	
		7 days	28 days
1	A	19.7	28.4
2	D 1.5%fiber	15.55	26.43
3	E 2.0%fiber	19.73	29.80
4	F 2.5%fiber	19.95	24.50
5	G 1.5%fiber	17.24	24.50
6	H 2.0%fiber	15.51	22.70
7	I 2.5%fiber	13.99	19.8

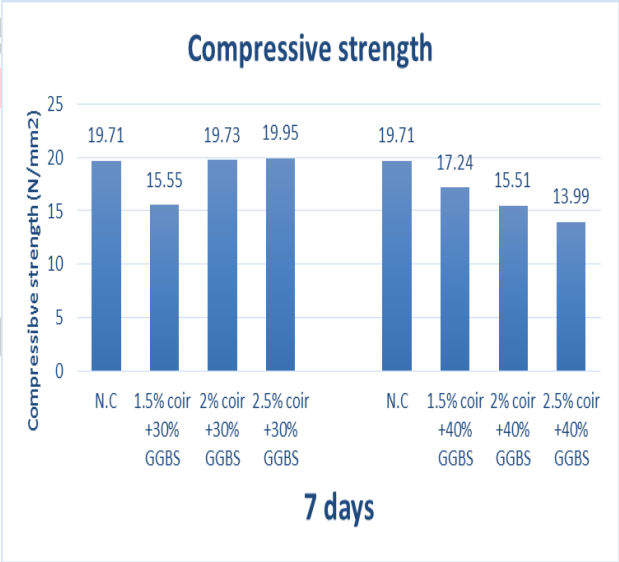

Fig 6 Comparison between normal concrete and GGBS with coir for 7 days of compressive strength

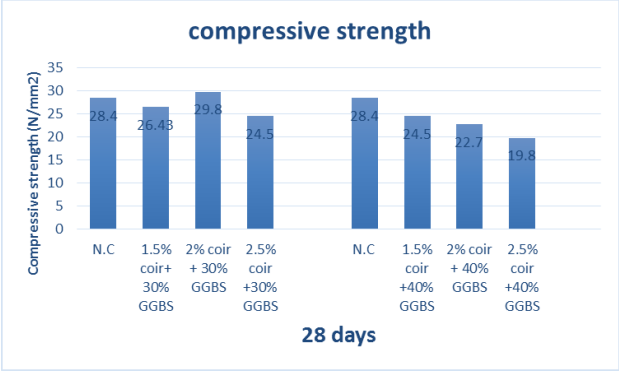

Fig. 7 Comparison between normal concrete and GGBS with coir for 28 days of compressive strength

It can be seen from Fig. 7, that the concrete 'E' specimen as the highest compressive strength (29.80N/mm^2) and the lowest strength is concrete 'I' (15.51N/mm^2) at 28 days but in case of 7 days compressive strength, the concrete 'F'(2.5%coir+30%GGBS) as highest strength and percentage increase is around 1.20% as compared to Control specimen.

Tensile Splitting Strength Test

The tensile splitting strength of the three 150mm diameter, 300mm long cylinders was determined according to IS 516:1959 Testing hardened concrete: Tensile splitting strength of test specimens after 28 days of curing.

Fig. 8 Tensile Test of Cylinder

Table 7 Comparison between normal concrete and GGBS concrete of tensile strength

Sl. No.	Type of designee	Tensile strength (N/mm^2)	
		7 days	28 days
1	A M 20 (N.C)	1.70	2.50
2	B 30% GGBS	2.00	2.90
3	c 40% GGBS	1.40	2.10

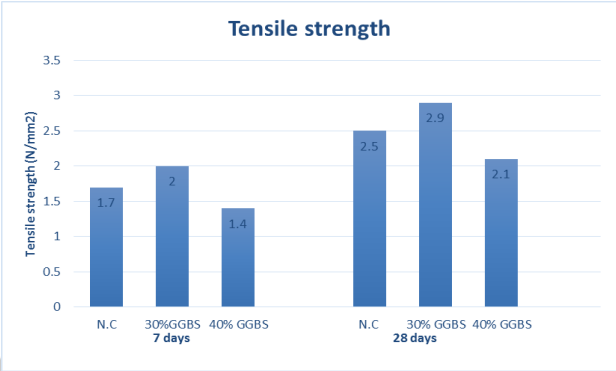

Fig. 9 Comparison between normal concrete and GGBS concrete of Tensile strength

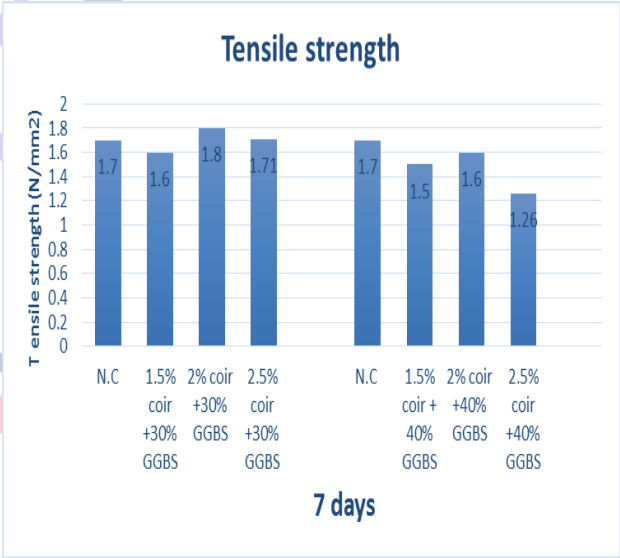

Fig. 10 Comparison between normal concrete and GGBS with coir for 7 days of tensile strength

Table 8 Comparison between normal concrete and coconut fibre reinforced coir for split tensile strength

Sl. No.	mixes	Tensile strength (N/mm^2)	
		7 days	28 days
1	M20 (N.C)	1.70	2.50
2	1.5% Coir 30 % GGBS	1.60	2.69
3	2% Coir 30% GGBS	1.80	2.90
4	2.5% Coir 30% GGBS	1.71	2.80
5	1.5% Coir 40% GGBS	1.50	2.40
6	2% Coir 40% GGBS	1.60	2.57
7	2.5% Coir 40% GGBS	1.26	2.01

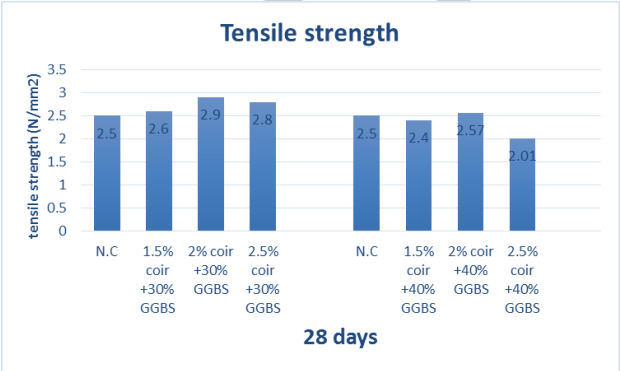

Fig. 11 Comparison between normal concrete and GGBS with coir for 28 days of tensile strength

The optimum percentage level of 30% GGBS replacement to the weight of the cement is taken with the M20 mix with addition of 2% fibres gave better results when compared to the control mix.

The splitting tensile strength results are shown in Fig. 10 and 11. The recorded splitting tensile strength for all mixes with addition of GGBS (30%) and Coir fibers shows higher strength compared to the control concrete. One can be observed in compressive strength and flexural strength, it could be said that increase in the strength upto percentages of 30% GGBS with addition fibers, also increase the tensile strength. The increase at age 7 days was found to be up to 5.80% from control mix. It can be easily observed that 'F' specimen as (30% GGBS + 2% coir) addition had given the highest splitting tensile strength amongst all the samples tested.

IV. CONCLUSION

Based on limited study carried out on performance of GGBS and coconut fibre concrete in comparison with normal concrete of design strength of M20 following conclusion are drawn.

- 30% GGBS replacement had more compressive strength than 40% of GGBS replacement when compared with normal concrete.
- The concrete mixture with 30% GGBS and 2% coconut fibre has the highest compressive strength and split tensile strength performance at all ages in comparison with all variations including non-fibers control Concrete.
- Compressive Strength and Spilt tensile strength of concrete 'F' is around 3% and 6% increase than strength of normal concrete.

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