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EXPERIMENTAL STUDIES ON SISAL FIBRE REINFORCED CONCRETE WITH GROUNDNUT SHELL ASH

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ABSTRACT

Fibre reinforcement usually increases the performance of the concrete in many aspects, this paper deal addition of Sisal Fibre Reinforcement (SFR) in concrete to improve the performance at the same time reducing cement consumption by replacing with Groundnut Shell Ash (GSA). These materials not just lessen the emanation of carbon dioxide gas in the climate additionally utilized as a substitute for the bond to take care without bounds demand. In the present work, GSA replacement for cement is 0, 5, 10, 15 and 20%; SFR is added for each set percentage of GSA as 1, 2 and 3% by its weight. Na2CO3 treatment was carried out to reduce the potential deterioration of SF. The compressive strength, flexural bending strength, deflection of the beam and economic consideration for M25 concrete specimen was done. Totally 120 numbers concrete 150 x150 mm cube and 9 number of 100 x 150 x 800mm flexural member cast and tested. It is recommended up to 10% of replacement of cement by GSA and 2 % addition of SF provide optimum values from investigation and economic consideration.

Keywords: sisal fibre, groundnut shell ash, vegetable fibre reinforced concrete, waste material.

1. INTRODUCTION

By utilizing the natural products and wastes is very much helpful to the environmental protection. Sisal fibre (SF) is the natural fibre extracted from the tree leaves (Agave sisalana tree), it is possible to use directly to concrete or in a chopped form. To emphasis durability and corrosion resistance of sisal fibre reinforced concrete (SFRC) the thermal treatment and Na_2CO_3 surface layer treatment is good practicable way on SF [1]. In this research work locally available sisal fibre collected from dharmapuri town, Tamil Nadu, India. Sisal fiber is amazingly sturdy and a low upkeep with ostensible wear and tear, SF is excessively intense for materials and textures. It is a solid fiber routinely utilized as a part of making rope, twine and furthermore dartboards sisal fiber is fabricated from the vascular tissue from the sisal plant. It is utilized as a part of car erosion parts (brakes, grasps), where it gives green quality to performs, and for improving surface with coatings application. GSA is the waste material may be used for incineration purpose in the industries, also used as the sustainable fuel sources in Uganda [2]. Preparation of waste groundnut shell ash was produce by keeping for 550^0C in the furnace. Unidirectional SF matrix reinforced for cement thin mortar panel shows improvement in flexural strength and deflection control, also elastic energy stores 46% higher in the materials for toughness [3]. SFRC used for retrofitting as confinement by wrapping in the reinforced cement concrete [4]. SF provides greater in flexural bending performance. SFRC fracture resistance was lower when comparing to the steel fibre also fracture resistance can be measured1/10 by steel fibre, experimental result shows with the DCB (double cantilever beam) specimen resistance was less and it is found the function of reinforcing parameter as;

$$V_{fx}\, L_f / \phi \text{ (V - Volume, L - Length and - } \phi \text{ - angle)} \qquad (1)$$

Crack opening at which fibre offers no resistance to pull-out is relatively small [5]. Where as in the case of fatigue strength evaluation it is observed that the strength because of the sisal fiber is significantly increase, test was performed for 6 MPa up to one million cycles and the failure is not occur [6].

2. EXPERIMENTAL INVESTIGATION

2.1 Materials properties

Ordinary Portland Cement (OPC) with 53 grade which is satisfies the physical and chemical properties within the range of ASTM C150 [7], Compressive strength of 54.5 MPa was used for complete experimentation process and density of the OPC is 3104 Kg/ m^3. Local river sand is added as Fine aggregate which specific gravity 2.65 and its fineness modulus 2.64. The properties of sand were determined by conducting tests as per IS: 2386 (Part-I) [8]. The results indicate that the sand conforms to Zone III of IS: 383-1970 [9].

2.2 Groundnut Shell Ash (GSA)

Groundnut shell used for this research was obtained from Groundnut mill. The shells ash was collected in bags and transported to site, where the burning and grinding were carried out. The fiery remains was gotten by consuming the groundnut shells on an iron sheet in the outdoors under typical temperature. Figure-1 shows GSA once the burning process was done. Table-1 shows the physical and chemical properties of GSA. Fineness modulus of GSA is evaluated 2.27 by sieve analysis.

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Figure-1. Groundnut shell ash.

Figure-2. Sisal fibre chopped.

Table-1. Physical and chemical properties of GSA.

Parameter	Composition (GSA)	Composition (OPC)
Fineness	17.45%	-
Specific gravity	1.81	-
consistency	33%	-
Fe_2O_3	1.82	4.60
SiO_2	16.31	22.00
C_aO	8.77	62.00
Al_2O_3	6.1	5.03
M_gO	6.76	2.06
Oxide	9.03	0.19
K_2O	15.13	0.40
SO_3	6.97	1.43

2.3 Sisal fibre (SF)

Figure-2 shows treated with Na_2So_4 SF is used for this research, diameter of sisal fibre is varies from 2.25 to 3.75mm and length varies from 640 mm to 890 mm. Chemical composition of SF mentioned in Table-2.

Table-2. Chemical composition of SF.

Composition	Percentages %
Cellulose	65
Hemi cellulose	12
Lignin	9.9
waxes	2

2.4 Specimen details

The mix proportion was provided as per the provisions given by ACI method ACI 211.1-91, for target compressive strength 25 MPa by the proportion 1:1.218:2.835 (Cement: sand: aggregate) [10]. Workability slump test was done as per the procedures given in ASTM C143 [11]. Table-3 shows different combination of mix proportion set used in this research. 44 numbers of 150 x 150 x 150 mm size standard concrete cubes specimens are made and tested to find compressive strength. 2000kN Compression testing machine used capacity at a rate of 150 kN per minute conforming to BIS 516:2004 [12]. 12 numbers of 100 x 150 x 800 mm size reinforced concrete prism casted and tested in the Universal testing machine 1000kN capacity as per the guidelines given by BIS 9399: 2013 [13-14].

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Table-3. Combination of Mix sets used in this research.

Description	Designation	% of GSA replacement for cement	% of SF Addition by weight of cement
Conventional concrete M25	CCM25	-	-
GSA with cement replacement	GSA- alone	5,10,15 & 20	-
SF addition with CCM25	SF- alone	-	1,2 & 3
GSA with5% and SF addition	GSA5+SF	5	1,2 & 3
GSA with10% and SF addition	GSA10+SF	10	1,2 & 3
GSA with15% and SF addition	GSA15+SF	15	1,2 & 3
GSA with20% and SF addition	GSA20+SF	20	1,2 & 3

3. RESULTS

3.1 Compressive strength

Experiment was carried out as mentioned in Table-3. Combination of mix sets, the 28 days water cured specimen, results of the experimental investigation shown in Table-4. Figure-3 shows the experimental set-up for compressive strength and Figures 5, 6, 7, 8, 9 & 10 showing the comparison charts between conventional concrete and GSA+SF influence concrete.

Figure-3. Compressive test set-up.

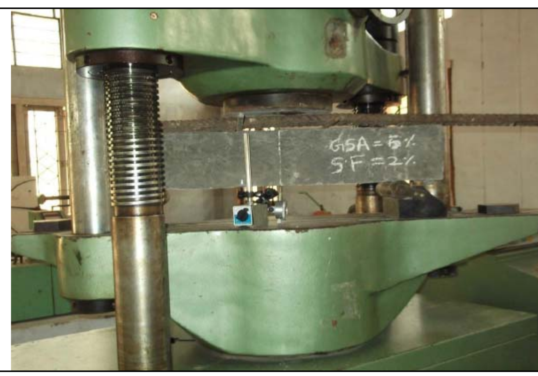

Figure-4. Flexural strength set-up.

Table-4. Compressive strength comparison of GSA replaced and SF added concrete.

S. No.	Description	Designation	% of GSA replacement for cement	% of SF addition by weight of cement	Avg. Compressive strength in MPa	
					7 days	28 days
01	Set- 01	CCM25	-	-	22.64	29.7
02	Set- 01	CCM25	-	-	21.80	28.19
03	Set- 01	CCM25	-	-	24.20	30.51
04	Set- 02	GSA- alone	5	-	22.07	29.18
05	Set- 02	GSA- alone	10	-	21.95	29.84
06	Set- 02	GSA- alone	15	-	21.53	26.98
07	Set- 02	GSA- alone	20	-	19.88	25.16
08	Set- 03	SF- alone	-	1	26.83	33.97
09	Set- 03	SF- alone	-	2	25.24	31.62
10	Set- 03	SF- alone	-	3	24.80	30.05
11	Set- 04	GSA5+SF	5	1	25.07	30.80
12	Set- 04	GSA5+SF	5	2	27.66	33.95
13	Set- 04	GSA5+SF	5	3	27.20	33.38
14	Set- 05	GSA10+SF	10	1	24.89	30.57
15	Set- 05	GSA10+SF	10	2	26.40	32.22
16	Set- 05	GSA10+SF	10	3	24.13	29.21
17	Set- 06	GSA15+SF	15	1	23.02	28.05
18	Set- 06	GSA15+SF	15	2	21.01	26.33
19	Set- 06	GSA15+SF	15	3	21.95	26.95
20	Set- 07	GSA20+SF	20	1	18.76	21.91
21	Set- 07	GSA20+SF	20	2	14.13	19.43
22	Set- 07	GSA20+SF	20	3	15.74	22.67

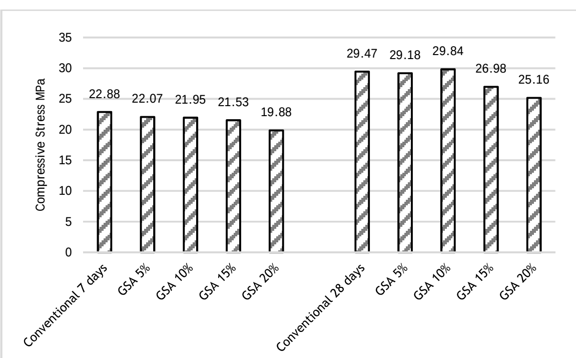

Figure 5. Comparison of conventional - GSA alone replacement concrete.

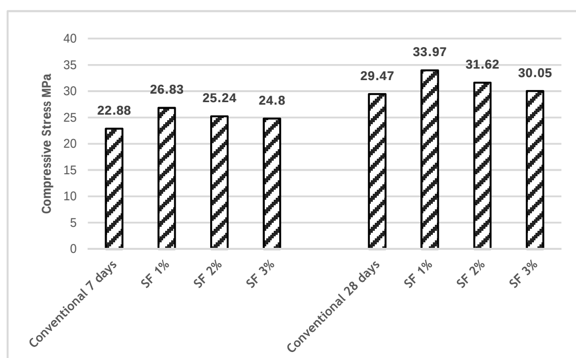

Figure-6. Comparison of conventional - SF alone added concrete.

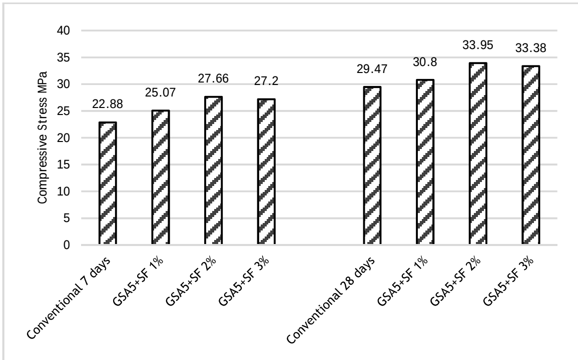

Figure-7. Comparison of conventional - 5%GSA+SF replacement concrete.

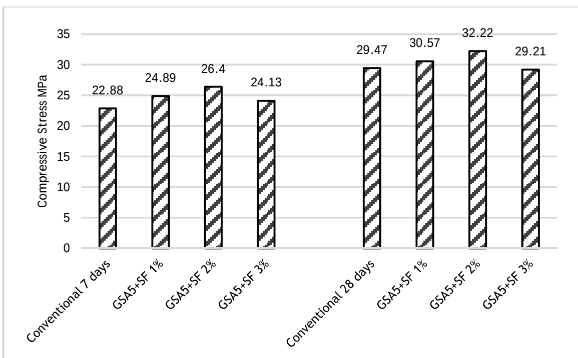

Figure-8. Comparison of conventional - 10%GSA+SF replacement concrete.

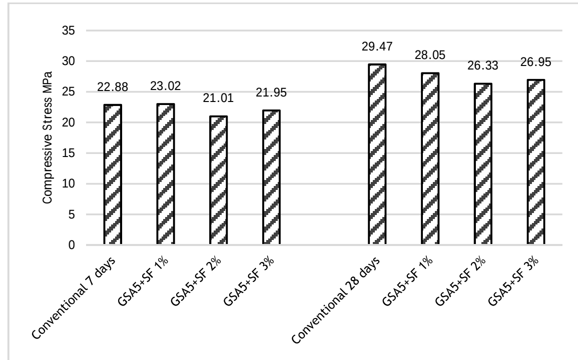

Figure-9. Comparison of conventional - 15%GSA+SF replacement concrete.

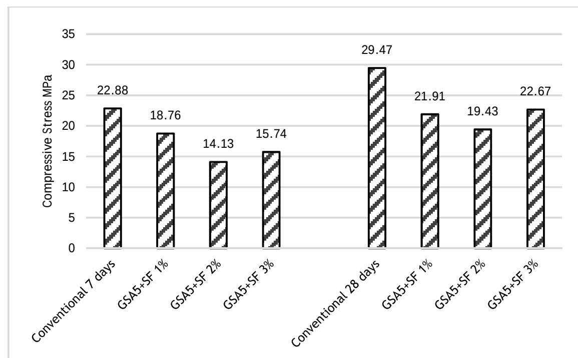

Figure-10. Comparison of conventional - 20%GSA+SF replacement concrete.

3.2 Flexural strength of concrete

This test is carried out in Universal testing machine with a capacity of 1000 kN. Two point load setup was done for evaluating the flexural strength and deflections in beams is calculated by Demountable dial gauge. Figure-4 shows the flexural strength test set-up.

Table-5. Flexural strength of the member.

S. No.	Designation	Flexural strength in MPa	Maximum deflection at mid span in 'mm'
01	CCM25 + minimum reinforcement	19.61	9.02
02	CCM25 + minimum reinforcement	18.72	8.79
03	CCM25 + minimum reinforcement	18.63	9.56
04	GSA5+SF + minimum reinforcement	19.16	10.14
05	GSA5+SF + minimum reinforcement	20.43	8.35
06	GSA5+SF + minimum reinforcement	21.79	9.19
07	GSA10+SF + minimum reinforcement	17.74	10.99
08	GSA10+SF + minimum reinforcement	16.98	7.10
09	GSA10+SF + minimum reinforcement	17.55	9.25

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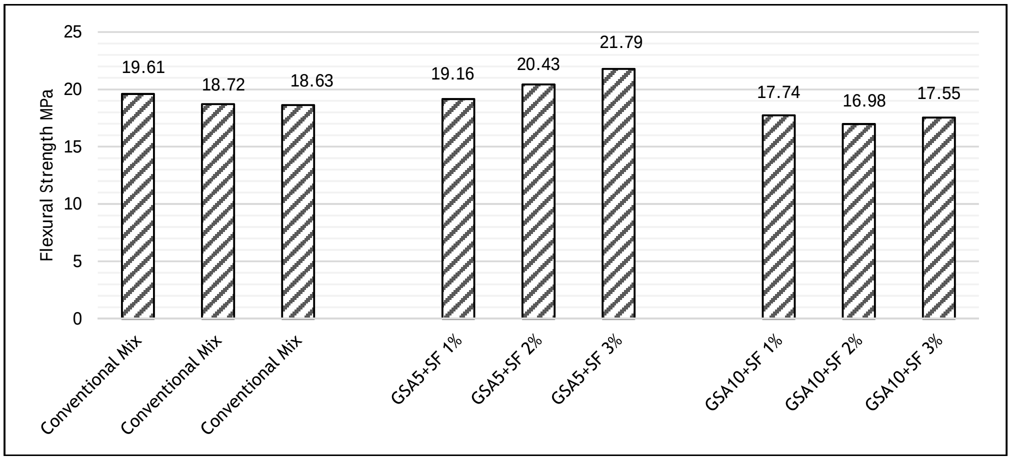

Figure-11. Flexural strength curve.

4. CALCULATION OF ECONOMIC CONSIDERATION

The consideration of cost analysis is important for this research work [15], for optimum results correlation between percentage of cement reduction by GSA and SF addition was noted in Table-6, suitable percentage was observed economy index that is GSA5+SF, GSA10+SF and SA15+SF. GSA and SF is the cheapest material and ecofriendly.

Table-6.

Description	Mass in kg				Total Cost per Cu.m cement In USD $	Compressive strength MPa	Economy index (strength/ cost)
	Cement	GSA	FA	CA			
CCM25	392	-	477	1353	40.40	30.51	0.76
GSA- alone	372	20	477	1353	38.40	29.18	0.76
GSA- alone	353	39	477	1353	36.38	29.84	0.82
GSA- alone	333	59	477	1353	34.34	26.98	0.79
GSA- alone	314	78	477	1353	32.38	25.16	0.78
SF- alone	392	-	477	1353	40.40	33.97	0.84
SF- alone	392	-	477	1353	40.40	31.62	0.78
SF- alone	392	-	477	1353	40.40	30.05	0.74
GSA5+SF	372	20	477	1353	38.40	30.80	0.80
GSA5+SF	372	20	477	1353	38.40	33.95	0.88
GSA5+SF	372	20	477	1353	38.40	33.38	0.87
GSA10+SF	353	39	477	1353	36.38	30.57	0.84
GSA10+SF	353	39	477	1353	36.38	32.22	0.89
GSA10+SF	353	39	477	1353	36.38	29.21	0.80
GSA15+SF	333	59	477	1353	34.34	28.05	0.82
GSA15+SF	333	59	477	1353	34.34	26.33	0.77
GSA15+SF	333	59	477	1353	34.34	26.95	0.78
GSA20+SF	314	78	477	1353	32.38	21.91	0.68
GSA20+SF	314	78	477	1353	32.38	19.43	0.60
GSA20+SF	314	78	477	1353	32.38	22.67	0.70

5. CONCLUSIONS

From experimental and statistical analysis for selected combination of partially replaced cement by GSA and to overcome the strength reduction because of cement replacement we added SF with limited percentage to the M25 concrete. This research was made materials characterization, compressive strength, flexural strength and statistical cost analysis. The accompanying conclusion was made

- Utilization of GSA as substitution to bond was made conceivable and has improved the compressive and flexural quality with including SF.
- The most extreme compressive quality of cement with GSA was almost accomplished the ideal incentive at 28 days. Substitute of bond with GSA past 15% did not yield the prominent change in execution.
- Among the distinctive sets utilized, concrete with GSA10+2%SF was observed to be ideal regarding quality and financial thought. Solid sets made with substitution GSA 5, GSA 10, GSA15 performs better for typical and mass concrete region

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