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Experimental investigation of sisal fibre reinforced concrete with partial replacement of cement by ground granulated blast furnace slag

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ABSTRACT

The study focuses on the compressive strength, split tensile strength, flexural strength performance of the sisal fibre concrete containing a different percentage of slag as a partial replacement of OPC. The cement in concrete is replaced accordingly with the percentage of 10%, 20% and 30% by weight of slag. And 1% of sisal fibre is added to the concrete. Concrete cubes are tested at the age of 7,14 and 28 days of curing. Finally, the strong performance of slag used fibre reinforced concrete is compared with the performance of conventional concrete. From the experimental investigations, it has been observed that the optimum replacement of Ground Granulated Blast Furnace Slag powder to cement is 20% for M 30 grade. Addition of sisal fibre in the concrete mix significantly influenced the cracking behavior and ultimate strength of beams. Addition of 1% sisal fibre in the RC beams increases both the flexural first cracking strength and flexural toughness of the SFRC beams and leads to an appreciable increase in their ductility and stiffness compared to those conventional RC beams without the addition of sisal fibre.

Keywords— *Sisal fibre, GGBS, Slag used cement, SFRC beams, Replacement*

1. NEED FOR STUDY

The production of concrete has always lead to massive exploitation of natural resources. Manufacturing 1 tonne of Portland cement requires quarrying 1.5 tonnes of limestone and clay. 1.4 tonnes of Ordinary Portland cement being produced yearly around the globe contribute to 5 per cent of greenhouse gas, carbon di oxide, emissions worldwide. Not only burning fuel to heat the kiln emits carbon di oxide, but also the decomposition of limestone emits even more gas. These identified problems clearly, contribute significantly to climate change. The ideal target to partly solve the above phenomenon is to develop a sustainable system loop which can turn resources which are landfilled as waste materials into useful products in the construction industry, thus preserving the natural resources.

The scope of this study is to find out the feasibility of using sisal fibre and ground granulated blast furnace slag in concrete by checking the compressive strength, tensile strength and flexural strength for M 30 concrete. In this study, a comparison has been made between plain cement concrete and sisal and GGBS added to concrete.

2. SISAL FIBRE

Sisal fibre is a species of Agava. It is botanically known as Agave sisalana. The material is chosen to improve the various strength properties of the structure to obtain sustainability and better quality structure. Short discrete vegetable fibre (sisal) was examined for its suitability for incorporation in cement concrete. The physical property of this fibre shown no deterioration in a concrete medium. Leaves are dried, brushed and baled to form a fibre.

2.1 Properties of Sisal Fibre

- Sisal Fibre is exceptionally durable with low maintenance with minimal wear and tear.
- It is Recyclable
- Sisal fibres are obtained from the outer leaf skin, removing the inner pulp.
- It is available as plaid, herringbone and twill
- Sisal fibres are Anti-static, does not attracts or traps dust particles and do not absorb moisture or water easily.
- The fine texture takes dyes easily and offers the largest range of dyed colours of all natural fibres.
- It exhibits good sound and impact absorbing properties.
- Its leaves can be treated with natural borax for fire resistance properties.

2.2 Properties of Cement

Table 1: Properties of cement

Property	**Specific Gravity**	**Fineness**	**Initial setting time**	**Final setting time**	**Standard consistency**
Value	1.76	2%	40 min	450 min	32%

3. FINE AGGREGATE

3.1 Specific gravity of fine aggregate (IS-2386 PART III-1997)

Weight of empty pycnometer (W1) = 640 gm.

Weight of empty pycnometer + Sand (W2) = 1680 gm.

Weight of empty pycnometer + sand + water (W3) = 2150 gm.

Weight of empty pycnometer + water (W4) = 1510 gm.

$$\text{Specific gravity for sand} = \frac{(W2-W1)}{(W2-W1)-(W3-W4)}$$

$$= \frac{(1680-640)}{(1680-640)-(2150-1510)}$$

= 2.60

4. COARSE AGGREGATE

4.1 Specific gravity test on coarse aggregates

Specific gravity on Coarse aggregate (IS-2386 PART III-1997)

Weight of empty pycnometer (W1) = 640 gm

Weight of empty pycnometer + Coarse aggregate (W2) = 982 gm

Weight of empty pycnometer + sand + water (W3) = 1574 gm

Weight of empty pycnometer + water (W4) = 1353 gm

$$\text{Specific gravity for sand} = \frac{(W2-W1)}{(W2-W1)-(W3-W4)}$$

$$= \frac{(982-640)}{(982-640)\_(1574-1353)}$$

= 2.82

5. CASTING AND TESTING DETAILS

A total number of 36 cubes, 24 cylinders and 12 beams were cast. GGBS were added in concrete in different percentage starting from 10%, and raised the mixing of GGBS up to 30%, at an interval of 10%. And also sisal fibre was added in the concrete at a constant rate of about 1%. For each per cent of GGBS addition 3 cubes, 3 cylinders were cast. The final strength of cube was tested after 7 days, 14 days and 28 days curing. And final strength of cylinder was tested after 14 days and 28 days curing. The beam was tested after 28 days curing. Compression testing machine is used for testing the compressive strength of cube and split tensile strength of cylinder. The crushing loads were noted an average compressive strength and tensile strength for three specimens is determined respectively.

5.1 Details of the test specimen

Table 2: Details of moulds

S no.	**Specimen**	**Size of specimen**
1	Cube	150 X 150 X 150 mm
2	Cylinder	Dia- 150 mm, Height- 300 mm
3	Beam	150 X 150 X 1000 mm

5.2 Compressive strength results

Table 3: Compressive strength of Normal Concrete and sisal fibre and GGBS Added

S no.	**Name of the specimen**	**Percentage of replacement(sisal fibre +GGBS)**	**Compressive strength (N/mm^2)**		
			7 Days	**14 Days**	**28 Days**
1	Cube 1	0% +0%	22.12	25.34	33.85
	Cube 2		22	25.17	34.22
	Cube 3		22.2	24.8	34.05
2	Cube 1	1% + 10%	23.12	25.9	35.42
	Cube 2		23.74	26.36	34.95
	Cube 3		23.45	26.72	35.8
3	Cube 1	1% + 20%	24.93	27.2	36.88
	Cube 2		24.62	27.8	36.2
	Cube 3		24.15	28.1	35.8
4	Cube 1	1% + 30%	22.75	24.63	34.17
	Cube 2		22.48	24.9	34.8
	Cube 3		22.45	25.1	34.6

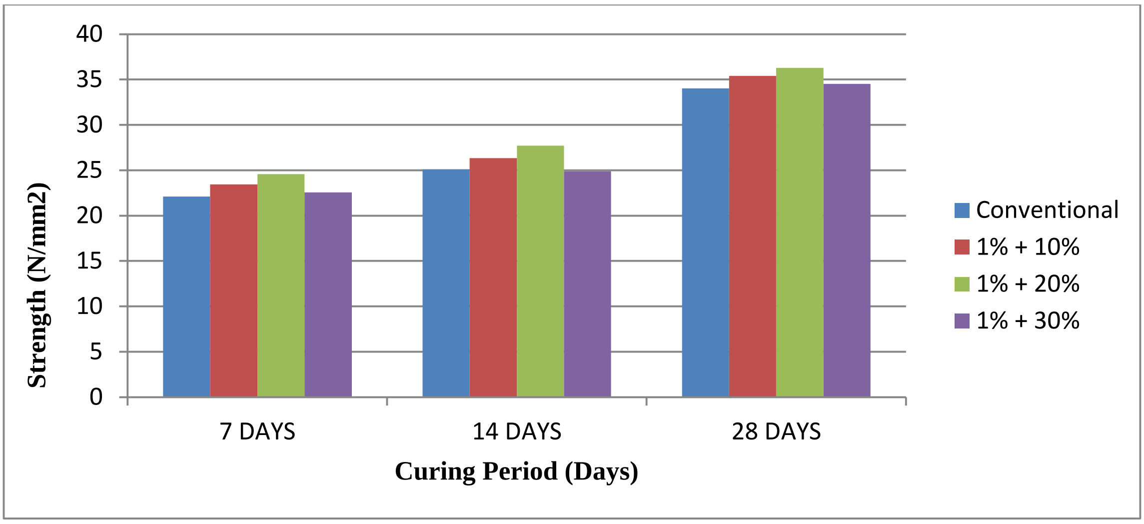

Fig. 1: Graphical representation of M30 Compressive strength

5.3 Split tensile strength results

Table 4: Split tensile strength of Normal concrete and sisal and GGBS Added concrete- 14, 28 days (Mean value)

S no.	Name of the specimen	Percentage of replacement(sisal fibre +GGBS)	Split tensile strength (N/mm^2)			
			14 Days	Mean value	28 Days	Mean value
1	Cylinder1	0% +0%	2.41	2.38	3.3	3.32
	Cylinder 2		2.36		3.39	
	Cylinder 3		2.38		3.28	
2	Cylinder 1	1% + 10%	2.49	2.47	3.44	3.46
	Cylinder 2		2.5		3.49	
	Cylinder 3		2.42		3.45	
3	Cylinder 1	1% + 20%	2.62	2.60	3.59	3.59
	Cylinder 2		2.58		3.61	
	Cylinder 3		2.61		3.58	
4	Cylinder 1	1% + 30%	2.43	2.41	3.39	3.39
	Cylinder 2		2.39		3.41	
	Cylinder 3		2.40		3.36	

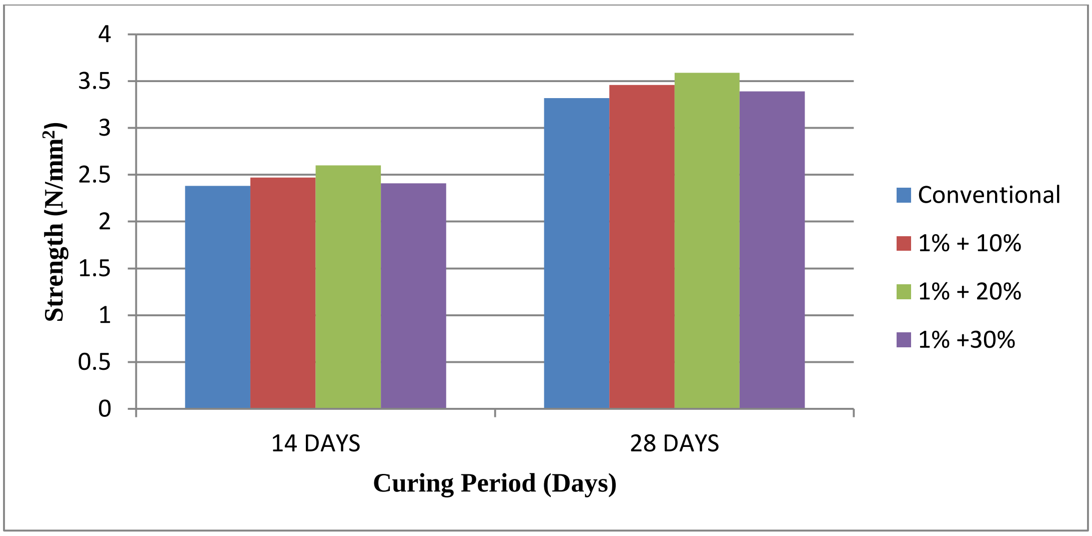

Fig. 2: Graphical representation of M30 Split Tensile strength

5.4 First crack load and deflection

The static load was applied to all the beam specimens. The mid-point load deflection was noted using the dial gauge. The figure shows the variation of the first crack load and the ultimate load. The SFRC reinforced concrete shows a 48% increase in first crack load this is due to the effect of GGBS and sisal fibre reinforced concrete which increase the first crack and also resist their propagation.

The ultimate load carrying capacity of RC beam and SFRC beam was 42 and 46.1KN respectively. There is an increase of ultimate load of 10% as compared to the conventional RC beam. The importance of using GGBS and sisal fibre reinforced concrete to have a ductile failure rather than a brittle failure of the specimen and all the specimens were observed to fail in a ductile manner. All the beams failed in flexural mode, there is any shear failure in the beam.

Table 5: Load and Deflection results for conventional beam and SFRC beam

S no.	Designation	% GGBS Replacement of cement	Load (KN)	Deflection (mm)	Remarks
1	Conventional beam	0	18.3	2.51	First crack load and deflection
			42	8.15	Ultimate load and deflection
2	SFRC Beam	20%	22.8	3.72	First crack load and deflection
			46.1	8.99	Ultimate load and deflection

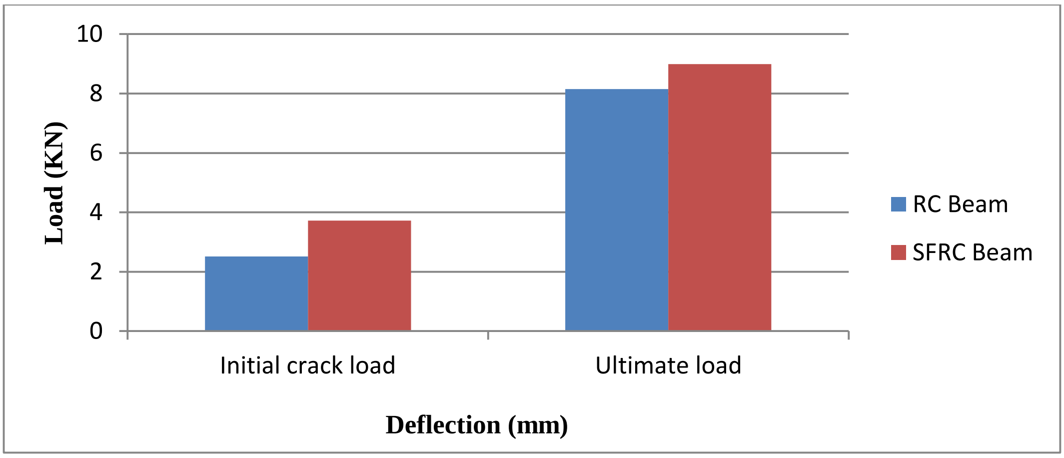

Fig. 3: Load vs Deflection

6. CONCLUSION

This study was carried to obtain the results, tests conducted on blast furnace slag powder modified cement concrete mix, in order to ascertain the influence of blast furnace slag powder and sisal fibre on the characteristic strength of concrete.

- The optimum dosage for partial replacement of cement by ground granulated blast furnace slag is 20%.
- The rate of gain of compressive strength of GGBS concrete is slow in the initial stage up to 14 days and as the curing period increases strength also increases.
- The compressive strength, tensile strength and flexural strength of sisal and GGBS added concrete increases with increase in GGBS content.
- The compressive strength, tensile strength and flexural strength of concrete decreased at the dosage of 30% replacement of cement by GGBS.
- Addition of sisal fibres in the concrete mix significantly influenced the cracking behaviour and ultimate strength of beams.
- Addition of 1% sisal fibre in the RC beams increases both the flexural first cracking strength and flexural toughness of the SFRC beams and leads to an appreciable increase in their ductility and stiffness compared to those conventional RC beams without the addition of sisal fibre.

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