EXPERIMENTAL INVESTIGATION ON THE INFLUENCE OF SISAL FIBRES ON THE MECHANICAL PROPERTIES OF CONCRETE

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Abstract

The natural fibres are easily available, and the usage of natural fibres are attractive considering their environmental aspect. In this work the Sisal Fibre [SF] act as reinforcement, to improve the tensile strength in concrete. They are eco-friendly materials in the construction industry since they prove that depleting the natural and non-renewable resources without compromising the desirable properties of the concrete. The additions of [SF] in concrete relevantly improve its performance in the study of compression, split, tensile and flexural on concrete specimens. The experimental investigation has been conducted on fresh and hardened concrete with and without SF at different proportions (0.25%, 0.50%, 0.75%, 1% and 1.25% with the weight of binder) and getting optimum result at 1%.

Keywords: Eco friendly Concrete, Sisal Fibre, Compressive Strength.

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1. Introduction

Natural Fibres [NF] in concrete have shown yield with beneficial results when used as reinforcement and it has proved to be a best alternative for steel fibre. The use of NF is not a new concept to the concrete industry. The big capacity of plant Fibre may be charity to get a numerous cracking of compound. In concrete various types of natural fibres are used such as Coconut Fibre**,** Sisal Fibre, Sugar cane bagasse Fibre**,** Bamboo Fibre**,** Jute Fibre and other vegetable Fibres**.**

Tolêdo Filho *et al.*,[1] they investigated the use of SF as reinforcement in cement based composites. The SF reinforced concrete improved the engineering properties, like fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. It becomes evident that cement-based matrices reinforced with SF were on the horizon, thus bringing new movements in compound materials. Their fibres were used to reduce cracking in concrete and to increase its strength. This experimental research effort was carried out to assess mechanical and durability possessions of concrete made of 1% SF and 1% steel fibre for M20 grade concrete. They conclude that after performing an experiment on sisal and steel fibre and also by comparison those with control block, we can conclude that SF and steel fibre not only give better compressive and split tensile strength but it helps to reduce the cracking on the surface.

Aruna [2] conducted on the study of mechanical behavior of SF reinforced concrete composites. In this study the SF has building material in terms of reinforcement. Fibre Reinforced Concrete (FRC) were high strength composite concrete. SF was obtained in the hot areas and has been used to reinforce civil structures.

Barra *et al.,* [3] their experiment conducted to improve the durability on OPC. In this study the concrete matrix was added with Metakaolin in proportion of 10% and 20% with natural aggregate. They concluded that the SF cement composites had increased mechanical strength. The concrete matrix or composites used recycled fine aggregate did not affect the mechanical properties.

Priyadharshini and Ramakrishna [4] their research was conducted on the strength and durability of latex modified sisal FRC. Normally SF were easy to available, cost consumption is very low, cost of fibers is less. So, in this study analysis the different mix proportions, the mechanical properties of concrete. Showing the result gives better performance when both sisal fibre and polymer are utilized in unique precise concrete specimen. Complete the strength then durability limits are originated to have optimistic influence on sisal fibre mixtures in the attendance of usual rubber liquid polymers.

Maya *et al.,* [5] conducted mechanical properties of SF reinforced phenol formaldehyde eco-friendly composites. In this study deals with the SF and the composites how to react with concrete. The mechanical strength of the concrete has been increased when SF length 40 mm and fibre loading 54% by weight. The better fibre matrix interaction is shown by sisal-PF containing 54 % by weight. They concluded that the SF length up to 50 mm the impact strength increased. If the fibre loading were density, hardness and electrical properties of the concrete were increased.

Midhuna and Chandrasekeran [6] their experiment conducted on Mechanical and Durability properties of MS concrete with SF. If MS adds to the concrete at the fresh and hardened concrete has to better qualities. The MS added to concrete it was avoided to corrosive with the effect of chemical environment and increased mechanical and durable properties. They conclude that the MS was o is 10% replacement with cement and SF is 0.75% addition in M40 grade of concrete, solving of disposal problem and reducing global warming.

Silva F. d. A., et al., [7] In this work sisal fiber [SF] reinforced cement composites were experimentally characterized in three different levels: reinforcement, interface, and bulk composite. The sisal fiber presented an average elastic modulus of 19 GPa and ultimate tensile strength of 400 MPa. Pull-out test results showed that the bond strength reaches its maximum capacity at 14 days and the further curing of the matrix shows no effect on ages of 21 and 28 days. The average adhesional bond strength after 15 days ranged from 0.59 to 0.67 MPa. It was found that increasing the embedded length the pull-out force increased from approximately 2 to 8 N. At an embedded length of 40 mm no significant increase was observed in the pull-out force related to adhesional and frictional bond. No improvement in the bond strength was observed by increasing the embedded length.The use of sisal fiber as continuous reinforcement in multi layered cementitious composites resulted in a material with multiple cracking behavior under tensile loading. The high tensile strength of the sisal fiber together with its adequate bond strength resulted in a material with high ductility and ultimate tensile strength in the order of 12 MPa.

Pallavi K. Pasnur [8] From the investigational work and test results, it was studied that the optimum percentage of sisal fibre and silica fume for maximum strengths (compressive) was found to be at AM4 and BM7 concrete mix. The optimum percentage of sisal fibre for maximum strengths (split tensile) was found to be 0.3% for M40 grade (BM6) of concrete and 0.5% for M30 grade (AM2). It is concluded that 10% replacement of Micro silica induces higher strength properties and good workability properties. This may be due to the filling effect of micro silica. At 15% replacement, the strength of concrete decreases due to excess fines and lesser cement content.

2. Materials and Methods

For the experimental analysis, grade 43 OPC cement was used conforming to IS 8112(2013), throughout this investigation. The specific gravity of the cement was 3.15. In this work the type of stone utilized was Basalt, with normal size of 20mm coarse aggregate. The fine aggregate is used in concrete passing through 4.75mm sieve size. River sand is taken as fine aggregate for conducting experiments. The major use of fine aggregate is to fill the voids. The specific gravity of the coarse and fine aggregate was 2.8 and 2.62 respectively. The drinking water was fit for mixing concrete, which produce a good result in the experimental work. The characteristic compressive strength of concrete used for the study was 25 MPa. The mix ratio adopted was 1: 1.42: 2.75: 0.5 (Cement: Fine aggregate: Coarse aggregate: Water). The compressive strength of conventional cubes after 28 days water curing was 35.33 MPa. The SF were added in various proportions of 0.25%, 0.50%, 0.75%, 1% and 1.25% (by the weight of binder).

3. Results and Discussions

Workability of concrete using Sisal Fibre

The test was performed in accordance with IS: 1199 - 1959 (Reaffirmed 2004) clause no 5. The experiment was conducted on the investigation of fresh concrete mix with SF at different proportions ranging from 0.25%, 0.50%, 0.75%, 1% and 1.25% with the weight of binding material. Table 3.1 presents the workability of concrete mixes with the investigated SF with different proportions.

Table 4.1 Workability of concrete with SF

SF %	Slump value (mm)
0.00	120
0.25	112
0.50	105
0.75	95
1.00	80
1.25	75

This experimental result shows the workability in the fresh concrete decreases from 120mm to 75mm when the percentage of SF increases from 0 to 1.25 %.

Compressive strength of concrete using Sisal Fibre

In accordance with IS: 516 – 1959 (Reaffirmed 1999) the compressive strength was conducted. In case of SF included mixes, a total of 36 concrete cubes were tested with addition of different proportions ranging from 0.25%, 0.50%, 0.75%, 1% and 1.25% with the weight of binder and subjected to testing after 7 and 28 days of curing. Table 3.2 denotes the concrete cube compressive strength with addition of SF at different proportions.

Table 4.2 Compressive strength of concrete

SF %	Compressive strength (N/mm^2)	
	After 7 days	**After 28 days**
0.00	24.02	35.33
0.25	25.34	36.94
0.50	26.22	38.26
0.75	28.02	39.84
1.00	28.76	40.02
1.25	27.63	39.53

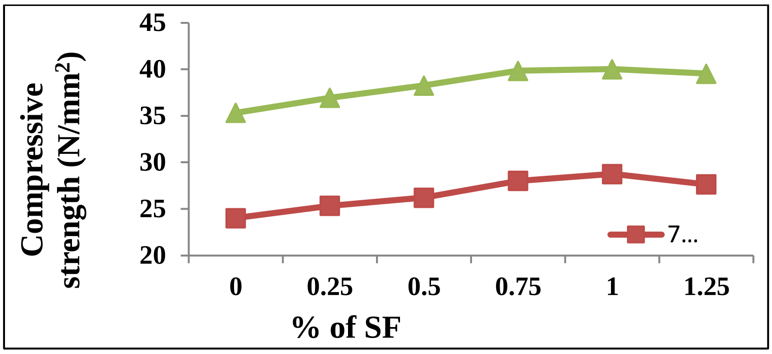

Figure 4.1 Effect of SF on the compressive strength of concrete cubes

The results of the compressive strength improved up to a fibre content of 1.00%. The improvement is contributed by the increase in toughness of concrete with the inclusion of fibres. Further, the compressive strength values were observed to decrease. This is due to the clubbing of fibres at higher volumes resulting in an even spreading of fibres which ultimately causes premature failure of specimen at lower compressive loads. Figure 3.1 display the variation of compressive strength of concrete specimens due to inclusion of fibres assessed after 7 and 28 days of curing of water.

- Compressive strength of concrete cubes assessed after 7 days of water curing was observed to be 5.49%, 9.15%, 16.66%, 19.73% and 15.02% higher than the control specimens for inclusion of SF at 0.25%, 0.50%, 0.75%, 1% and 1.25% respectively.
- Similarly, Compressive strength of concrete cubes assessed after 28 days of water curing was observed to be 4.57%, 8.29%, 12.76%, 13.27% and 11.88% higher than the control specimens for inclusion of SF at 0.25%, 0.50%, 0.75%, 1% and 1.25% respectively.

Split tensile strength of concrete using Sisal Fibre

In accordance with IS: 5816 - 1999 clause no 7 the split tensile strength was conducted. In this work the cylinder was used 300 mm length and 150 mm diameter. The SF included mixes, with addition of SF at different proportions ranging from 0.25%, to 1.25% with the weight of binder and subjected to testing after 7 and 28 days of curing. Table 3.3 denotes the split tensile strength of different mixes with addition of fibres at varying proportions.

Table 4.3 Split tensile strength of concrete cylinders with SF

Percentage of sisal fibre	Split tensile strength(N/mm^2)	
	7 days	28 days
0.00	3.44	4.16
0.25	3.72	4.54
0.50	3.86	4.76
0.75	4.13	4.88
1.00	4.56	4.92
1.25	3.92	4.84

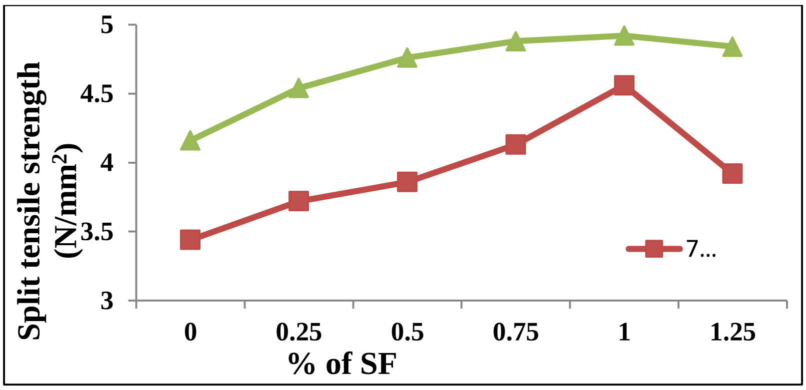

Figure 4.2 Effect of SF on the split tensile strength

The result of the above experiment indicated that inclusion of fibres in concrete mixes causes substantial improvement in split tensile strength. The SF were added to the concrete the split tensile strength improved up to a fibre content of 1.0 %. The Figure 3.2 display the variation of split tensile strength of concrete specimens due to inclusion of fibres assessed after 7 and 28 days of curing of water.

- Split tensile strength of concrete cylinders assessed after 7 days of water curing was observed to be 8.13%, 12.20%, 20.05%, 32.55%, and 13.95% higher than the control specimens for inclusion of SF at 0.25%, 0.50%, 0.75%, 1% and 1.25% respectively.
- Split tensile strength of concrete cylinders assessed after 28 days of water curing was observed to be 6.13%, 14.42%, 17.30%, 20.67%, and 18.75% higher than the control specimens for inclusion of SF at 0.25%, 0.50%, 0.75%, 1% and 1.25% respectively.

Flexural strength of concrete using Sisal fibres.
In accordance with IS 516:1959 (Reaffirmed 1999) clause no. 7 the flexural strength test was conducted. This study was used as the prism standard size was100x100x500 mm. The concrete prism was loaded at one-third span points and the prism supporting span was kept as 400 mm. The SF included mixes, with addition of SF at different proportions ranging from 0.25% to 1.25% with the weight of binder and subjected to testing after 7 and 28 days of prisms. Table 3.4 denotes the flexural strength of different mixes with addition of fibres at varying proportions.

Table 4.4 Flexural strength of concrete

SF %	Flexural strength (N/mm^2)	
	After 7 days	After 28 days
0.00	3.46	4.22
0.25	3.75	4.62
0.50	3.82	4.71
0.75	4.12	4.90
1.00	4.26	4.98
1.25	4.05	4.73

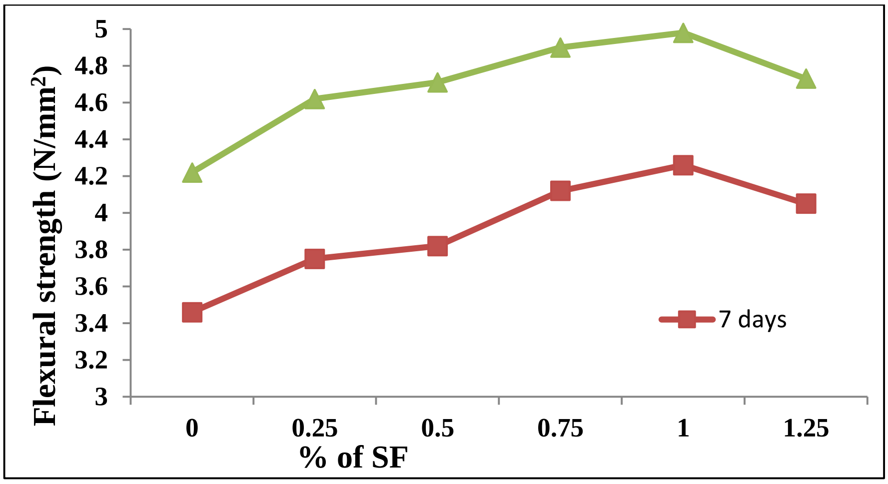

Figure 4.3 Effect of SF on the flexural strength

The experimental results indicated that inclusion of fibres in concrete mixes causes major improvement in flexural strength. In case of SF the flexural strength improved up to a fibre content of 1.0% , Figure 3.3 display the variation of flexural strength of concrete specimens due to inclusion of fibres assessed after 7 and 28 days of curing of water.

- Flexural strength of concrete prisms assessed after 7 days of water curing was observed to be 8.38%, 10.40%, 19.07%, 23.12% and 17.05% higher than the control specimens for inclusion of SF at 0.25%, 0.50%, 0.75%, 1% and 1.25% respectively. Similarly, flexural strength of concrete prisms assessed after 28 days of water curing was observed to be 9.47%, 11.61%, 16.11%, 18.00% and 12.08% higher than the control specimens for inclusion of SF at 0.25%, 0.50%, 0.75%, 1% and 1.25% respectively.

4. Conclusion

The experimental investigation has been conducted on fresh and hardened concrete with and without SF at different proportions (0.25%, 0.50%, 0.75%, 1% and 1.25% with the weight of binder). The experimental results show that the workability of fresh concrete decreases with the increase of SF in concrete. The experimental results show that the compressive strength of concrete cubes increases with the increase of SF in concrete up to 1%. Beyond that there is a decrease in compressive strength.

- The compressive strength of concrete specimens after 7 and 28 days water curing were 28.76 N/mm ^{2} and 40.02 N/mm^2 respectively.
- The percentage increase in split tensile strength of concrete specimens after 7 and 28 days water curing were 4.56 N/mm ^{2} and 4.92 N/mm^2 respectively.
- The flexural strength of concrete specimens after 7 and 28 days water curing were 4.26 N/mm ^{2} and 4.98 N/mm^2 respectively.

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