Mechanical Properties of Concrete on Addition of Sisal Fiber

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Abstract - *Sisal fiber is a promising reinforcement for use in composites on account of its low cost, low density, high specific strength and modulus, no health risk, easy availability in some countries and renewability. In recent years, there has been an increasing interest in finding new applications for sisal-fiber-reinforced composites that are traditionally used for making ropes, mats, carpets, fancy articles and others. This review presents a summary of recent developments of sisal fiber and its composites. The properties of sisal fibre itself, interface between sisal fiber and matrix, properties of sisal-fibre- reinforced composites and their hybrid composites have been reviewed. Concrete is strong in compressive and weak in tension. So we will provide the reinforcement to the concrete. Majorly steel is used as the reinforcement. Many of the researches are in progress to find a substitute to this material. Many investigation proposed artificial fibers. Sisal fibre is obtained from the leaves of the plant Agave sisalama. It is grouped under the broad heading of the "hard fibres" among which sisal is placed second to manila in durability and strength. They also found that impact resistance can be enhanced by the addition of sisal fibres. They produced corrugated sheets in different ways to optimize the processing technique. The production of sisal fibres as compared with synthetic fibre or even with mineral asbestos fibre needs much less energy in addition to the ecological, social and economical benefits.*

Key words: **Durability, mechanical properties, sisal fibre, M40**

1. INTRODUCTION

For the fast 30 years, a great concern is created worldwide on the potential applications of natural fiber cement based composites. Investigations have been carried out in many countries on various mechanical properties, physical performance and durability of cement based matrices reinforced with naturally occurring fibers including sisal, coconut, jute, bamboo and wood fiber. The general properties of the composites are described in relation to fiber content, length, strength and stiffness in this work. The development of sisal fiber reinforced, cement based matrices is discussed here and studied of experimental works of different investigators on performance of sisal fiber reinforced cement composite. A brief description on the use of these composite materials as building products have been included. The influence of sisal fiber on tensile, compressive and bending strength in the harden state of mortar mixes is discussed. The durability of natural fibers in cement based matrices is of particular interest and is also highlighted. Concrete is the most commonly used construction material. Customarily, concrete is produced by using the Ordinary Portland Cement as the binder.. Production of one ton of Portland cement requires about 2.8 tons of raw materials, including fuel and other materials and hence it is well known that cement production depletes significant amount of natural resources. As a result of de-carbonation of lime, manufacturing of one ton of cement generates about one ton of carbon dioxide. Nowadays, there is a big concern about the development of alternative materials to Portland cement. Therefore, there are efforts to develop the other form of cementitious materials for producing concrete. Concrete is a mixture of glue and fillers, cement and water act as glue and coarse and fine aggregate are the fillers. This concrete is strong in compression and 8-10 % weaker in tension. Reinforcement is introduced in concrete to improve its property and fiber have always been co Sisal Fiber is a species of Agava. It is potentially known as Agavasisalana. The material is chosen to improve the various strength properties of the structure to obtain sustainability and better quality structure. Short discrete vegetable fiber (sisal) was examined for its suitability for incorporation in cement concrete.

1.1 ADVANTAGES OF SISAL FIBER

- It is exceptionally durable with a low maintenance with minimal wear and tear.
- It is recyclable.
- Sisal is sustainable and 100% Bio-degradable.
- It is Anti static, does not attract or trap dust particles and does not absorb moisture or water easily
- It exhibits good sound and impact absorbing properties.

1.2 DISADVANTAGES OF SISAL FIBER

- The cost of fiber is very high.

- ❖ In the concrete, addition of fiber reduces workability.

1.3 PROPERTIES OF SISAL FIBER

- ❖ Sisal Fiber is exceptionally durable with a low maintenance with minimal wear and tear.
- ❖ It is Recyclable.
- ❖ Sisal fiber are obtained from the outer leaf skin, removing the inner pulp.
- ❖ It is available as plaid, herringbone and twill.
- ❖ Sisal fiber are anti-static
- ❖ It exhibits good sound and impact absorbing properties.
- ❖ It leaves can be treated with natural borax for fire resistance properties.

2. LITERATURE REVIEW

2.1 Properties of Sisal Fibre Reinforced concrete

Sisal fibre contain some gelatinous chemical reagents which may affect the chemical properties of cement in concrete. When the percentage fibre is increased by more than 1% reduction in mechanical properties is observed. The addition of the fibre in small amounts will increased the tensile strength. Addition of fibres not increased tensile strength but also increases bond strength but also increased bond strength, but decreases permeability.

2.2 Strength and durability evaluation of sisal fibre reinforced concrete

The addition of natural sisal fibre composites the workability about 29% without polymer. Early gain of compressive strength for sisal fibre reinforced concrete with polymer modification will proves to be a better option for repair works. The increase of compressive strength, split tensile strength and flexural strength is about 13%, 15.5% and 12% for sisal fibre concrete. When the percentage of fibre is increased by more than 1% reduction in mechanical properties is observed. Reduction is strength is due the increase in the fibre percentage and that may leads to porous structure by the agglomeration .Increase in strength up to 1 % is due to utilization of water present in the fibre for chemical reaction at time of curing and less concentration of fibre created densely compacted medium in cement concrete. The addition of fibre in small amount will increase the tensile strength. Addition of fibre not only increases tensile strength but also increases bond strength, decrease permeability .Toughness of concrete also increases by the addition of the fibre.

3. MATERIALS

3.1 CEMENT

Cement is a binder, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement is seldom used on its own, but rather to bind sand and gravel together. Cement is used with fine aggregate to produce mortar for masonry, or with sand gravel aggregates to produce concrete.

Table 3.1 Properties of Cement

S.no	Properties	Cement
1	Specific Gravity	3
2	Normal Consistency	30%
3	Initial Setting Time	55 min

3.2 Fine Aggregate

Aggregate whose size is 4.75mm and less considered as fine aggregate. Local aggregates, comprising Natural sand and M. sand in saturated surface dry condition were used as fine aggregates.

3.3 COARSE AGGREGATE

Aggregates having the size bigger than 4.75mm are considered as coarse aggregate. Local aggregates obtained and comprising 12.5mm and 20 mm coarse aggregates, in saturated surface dry condition, were used. The coarse aggregates were crushed granite-type aggregates. The tests on the aggregates were carried out as per IS 2386: 1968 part III. The coarse aggregate used for the experiments are tested for the following and their properties are listed as in table 4.1.

Table 3.2 Properties of Coarse aggregate

Properties	12.5mm	20mm
Crushing strength	24.89%	24.89%
Dry Density	1451kg/m^3	1453kg/m^3
Flakiness Index	14.68	12.16
Elongation Index	14.42	11.93
Impact value	19.03%	19.03%
Specific gravity	2.79	2.797
Water absorption	0.56%	0.56%
Fineness Modulus	2.72	3.08

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

3.4 M.SAND

M-sand is crushed fine aggregates produced from hard granite stone which is cubically shaped with grounded edges, washed and graded with consistency to be used as a substitute for river sand. The M.Sand was obtained from Chettipalyam and its properties are tabulated below:

Table 3.3 Properties of M.Sand

Properties	M. Sand
Dry Density	1603kg/m^3
Specific gravity	2.627
Water Absorption	2.46%
Fineness Modulus	5.127

3.5 MIX PROPORTION

The mix proportions for the sisal fiber concrete mix are given in table below:

- Target strength = 48.25 N/mm^2
- Cement = 350kg/m^3
- Fine Aggregate = 896kg/m^3
- Coarse Aggregate = 1140kg/m^3
- Water = 140kg/m^3
- W/C = 0.40
- Sisal Fibre for 2% = 2379kg
- Sisal Fibre for 4% = 2377kg

M40 = 1:2.56:3.26

4. FRESH CONCRETE TEST

Workability is defined as the ease with which concrete can be compacted hundred percent having regard to mode of compaction and place of deposition.

4.1 SLUMP CONE TEST

To measure the consistency of concrete by using slump cone. The slump test result is a measure of the behavior of a compacted inverted cone of the concrete. Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It does not measure all factors contributing to workability, nor is it always representative of the placability of the concrete. Additional information on workability and quality of concrete can be obtained by observing the manner in concrete slumps.

Fig 4.1 Slump cone Test

Table 4.1 Slump test Results

Water cement ratio	% of sisal fiber	Slump in mm
0.40	0%	65
0.40	2%	68
0.40	4%	69
0.40	6%	69
0.40	8%	72

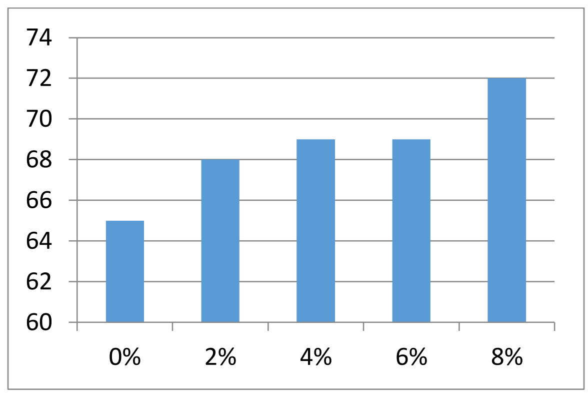

Chart 4.1 Variation of Slump with Sisal

4.2 COMPACTION FACTOR

To measure the workability of concrete by compaction factor test. Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus used is Compacting factor apparatus.

Table 4.1 Compaction factor Results

Water cement ratio	% of sisal fiber	Compaction factor
0.40	0%	0.745
0.40	2%	0.76
0.40	4%	0.76
0.40	6%	0.773
0.40	8%	0.79
0.40	10%	0.791

5. PROPERTIES OF HARDENED CONCRETE

Testing of hardened concrete plays an important role in controlling and confirming the quality of cement concrete works. Systematic testing of raw materials, fresh concrete and hardened concrete are inseparable part of any quality control program of concrete.

5.1COMPRESSION TEST

Compression test is the most common test conducted on concrete, partly because it is easy to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. Compressive strength of cubes was tested in accordance with IS 516:1959 in this study. The cube specimen of size 150mm x 150mm x 150mm was casted for testing the compressive strength. Compressive strength of cubes was tested using Compression Testing Machine (CTM). The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area.

$$\text{Compressive strength of the cube} = \frac{\text{maximum load applied}}{\text{cross sectional area of cube}}$$

Fig 5.1 Compressive Test

5.1.1 COMPRESSION TEST TABLE OF CUBE

S.no	Type of Specimen	Strength in 7days (N/mm^2)	Strength in 28 days (N/mm^2)
1	Conventional	26.68	39.25
2	2%	25.64	40.5
3	4%	6.41	40.63
4	6%	24.99	38.45
5	8%	24.92	38.34

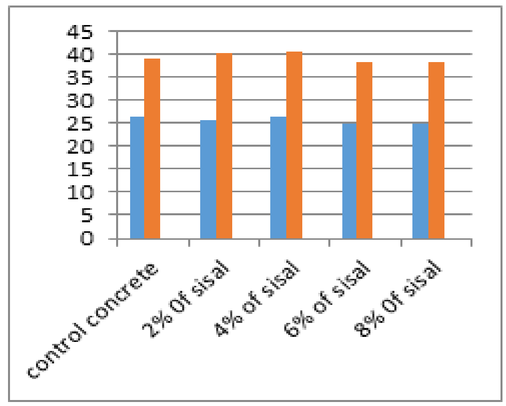

Chart 5.1 Compressive Test Results

5.2 SPLIT TENSILE STRENGTH

Concrete is strong in compression, but it is weak in tension. The low tensile strength is due to the presence of numerous micro cracks. At least three specimens shall be tested for each age of tests. The specimens shall be tested immediately after curing. The dimensions of the specimens and their weight shall be noted before testing. For cylindrical specimen it shall be ensured that the upper platen is parallel with the lower platen.. The maximum

Fig 5.2 Split Tensile Test

load applied shall then be recorded. The measured splitting tensile strength (f_{ct}), of the specimen shall be calculated to the nearest 0.05 N/mm² using the following formula:

$$f_{ct} = \frac{2P}{\pi l d}$$

Where, P = maximum load applied to the specimen in Newton,

l = length of the specimen

d = diameter of the specimen

Average of three values shall be taken as the representative of the batch provided the individual variation is not more than ± 15 percent of the average.

5.2 SPLIT TENSLE TEST TABLE

S.no	Type of Specimen	Strength in 7days (N/mm²)	Strength in 28 days (N/mm²)
1	Conventional	1.869	3.064
2	2%	2.061	3.272
3	4%	3.015	4.417
4	6%	3.946	5.431
5	8%	4.630	6.023

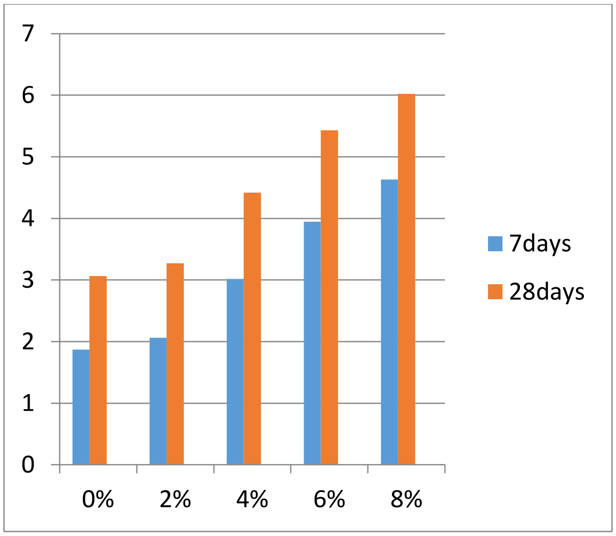

Chart 5.2 Split Tensile Test Results

5.3 FLEXURAL STRENGTH OF CONCRETE

It is generally determined by testing prisms of size 500mm x100mm x 100mm that was done in the lab. In this test, the prisms are subjected by applying the load of 1.8kN (180kg/min). Flexural test is intended to give the flexural strength of concrete in tension. The modulus of rupture is determined by testing prisms with four point loading in N/mm².

Where,

b=width of the depth d=failure of the depth

L= supported length P= maximum load

Fig 5.3 Testing of prism

5.3 FLEXURAL STRENGTH TEST TABLE

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International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

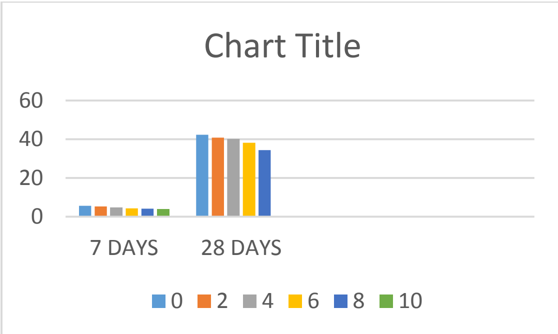

Chart 5.3 Flexural Strength Test

5.4CORROSIONTEST: IMPRESSED VOLTAGE TEST

Corrosion process was accelerated by impressing a constant 3-V DC to RC cylinders immersed in 3% NaCl solution. The setup was configured such that the positive terminal of power supply is connected to the embedded rebar (anode) and the negative terminals to cylindrical stainless steel (cathode) of size 8-1/2 in high, and 6 in diameter. To prevent entry of oxygen to rebar-concrete junction, an epoxy coating has been applied on the said location. A 10-ohm resistor was also soldered somewhere in the protruded part of each rebar to act as the primary load of the circuit. The current flowing through the bars was recorded using an external ammeter connected across the resistor that can measure one current reading per second.

6. TEST RESULTS OF HARDENED CONCRETE

6.1 DENSITY

Average density values of sisal fiber concrete range from 2394 to 2447kg/m³. The density of sisal fiber concrete was found approximately equivalent to that of conventional concrete.

Table 6.1 Density of Concrete

Specimen	% of Sisal	Density (kg/m^3)
A1	8	2391
A2	6	2394
A3	4	2397
A4	2	2399
A5	0	2441

7. DURABILITY TESTING

7.1 ACID ATTACK

The casted cubes of size 150mm x 150mm x 150mm were demouled after one day. All specimens were placed in water for seven days. In the end of curing period all specimens were placed in atmosphere for two days. All the sample specimens were weighed and submerged in 5% H_2SO_4 solution .following sixty days of submerging in corrosive environment, the cubes were washed in running water and allow drying for two days. The specimen weight was taken and the loss of weight was calculated.

Table 7.1 Loss of weight

Addition of sisal fibres	Weight of Specimen (W1)	Weight of Specimen after immensed in H_2SO_4(W2)	% of weight reduction
0%	8.564	8.487	3.003
2%	8.531	8.482	1.738
4%	7.483	2.472	0.443
6%	8.42	8.38	1.652
8%	6.39	6.32	2.928
10%	8.36	8.34	0.847

Table 7.2 Loss of Strength

Additional of Sisal fibres	Strength of cubes cured in water after 28days	Strength of cubes cured in water after 60days	% of weight reduction
0%	33.5	28.2	15.8
2%	33.7	27.7	17.8
4%	33.1	26.8	19
6%	32.2	25.7	20.1
8%	31.1	23.7	23.7
10%	29.1	20.4	29.8

CONCLUSION

From the analytical and experimental investigation on sisal fiber composites the following conclusion have been arrived at. The study has concluded that there was an increase in slump value from 4mm t0 53mm after addition of super plasticizer, Degree of workability for concrete mixture with 0.2% super plasticizer and water cement ratio 0.4 provided good workability. It is concluded that 4% addition of fiber will give better strength. It is observed that bonding between concrete and fiber is excellent and no sign of delamination is noted. Concrete is strong in compression but weak in tension. The tensile property of concrete can be improved by the addition of small volume of fibers, Addition of fibers not only increase tensile strength but also increases bond only increases tensile strength but also increases bond strength, decreases permeability, also resist seismic loading as well through its ductility. Toughness of concrete also increases. Properties of fiber reinforced concrete are affected by type of fiber reinforced concrete are affected by type of fiber, fiber geometry, fiber volume, orientation and distribution of fibers.

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