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EXPERIMENTAL INVESTIGATION ON STRENGTHENING OF CONCRETE BY USING SISAL FIBER

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Abstract:

The inclusion of fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. In recent years, a great deal of interest has been created the potential applications of natural fiber reinforced, cement based composite, physical performance and durability of cement based matrices reinforced with naturally occurring fibers including sisal, coconut, jute, bamboo and wood fibers. These fibers have always been considered promising as reinforcement of cement based matrices because of their availability, low cost and low consumption of energy. In this, the general properties of the composites are described in relation to fiber content, length, strength and stiffness. A chronological development of sisal fiber reinforced, cement based matrices is reported and experimental data are provided to illustrate the performance of sisal fiber reinforced cement composites. A brief description on the use of these composite materials as building products has been included. The influence of sisal fibers on the development of plastic shrinkage in the pre-hardened state, on tensile, compressive and bending strength in the hardened state of mortar mixes is discussed. Creep and drying shrinkage of the composite sand the durability of natural fibers in cement based matrices are of particular interest and are also highlighted. The results show that the composites reinforced with sisal fibers are reliable materials to be used in practice for the production of structural elements to be used in rural and civil construction.

Keywords: Sisal Fiber, Workability, Shrinkage, Flexural strength.

I. INTRODUCTION

Concrete is a material made of cement, water, fine aggregate & coarse aggregate, which has very good compressive strength and poor tensile strength. in order to provide tensile to concrete usually steel has provided as reinforcement, which is called reinforced concrete. the use of fibers as reinforcement is as old as human civilization. traces of natural fibers such as flax, cotton, silk, wool and plant fibers have been located in ancient civilizations all over the globe. for example, the recorded usage of flax can be dated back to 5000 bc; it is considered the oldest natural textile fiber. more recently, the use of natural fibers in construction has been limited to thin elements for roofing, cladding, and internal and external partitioning walls. now a day's wide research are being carried out to replace steel reinforcement by some other natural to overcome the various defects in steel and to make reinforced concrete more economical one. processes involved in this project are mix design, preparing samples with and without fiber, testing of cubes and analysis of results. here we have added

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sisal fiber in a weight basis by 0%, 1.5%, 2%, 2.5%, 3%, etc.as we know that concrete is strong in compression and weak in tension, this paper is aimed to reduce the weight of cubes are made with m30 grade as per is10262-1982 after that sisal fiber of aspect ratio 70 is introduced. after 7, 14, 28 days of curing the cubes and cylinders, beams are tested for the compressive strength, split tensile strength and flexural strength of concrete respectively and results are compared.

II. 2. MATERIALS USED AND MATERIAL PROPERTY

III.2.1 CEMENT

The cement used was ordinary Portland cement 53 (OPC 53).All properties of cement were determined by referring IS 12269 - 1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 30%.

2.2 Coarse Aggregate

20mm size aggregates-The coarse aggregates with size of 20mm were tested and the specific gravity value of 2.78 and fineness modulus of 7 was found out. Aggregates were available from local sources.

2.3 Fine Aggregate

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60.

2.4 Water

The water used for experiments was potable water.

2.5 Sisal Fiber

Even though four natural fibers were considered during the preliminary investigation (namely coir, sisal, jute and hibiscus cannebinus only sisal fiber was selected for comprehensive experimental investigations as reported in this only. Hence, a brief review of salient characteristics is focused only with respect to sisal fibers, in this section.

Classification

A great number of fiber plants are exploited for their ability to yield fibers directly from their wild or natural form, particularly in developing countries. While a great number of species are employed in fiber production, relatively few species show high quality, good yield and hence are of commercial importance. Fibers of economic imortance are members of various

botanical families, the more exploited of which include **Amarilidnceae** to which sisal (**Agave *sisalana*)** belongs. Several varieties of sisal exist in different climatic conditions and with different morphological characteristics.

Classification system of vegetable fibers, is based on various major aspects, such as,

- Final uses (end - use of fiber in commercial terms) such as, textile fibers, bags &canvasses etc.,
- Anatomical origin of vegetable fibers, such as, bark fiber, leaf fiber, fruit fiber and root fiber and
- Chemical origin (cellulose - producing fibers, ligno -cellulose - producing fibers).

However, the principal classifications of fibers are based on their origin in the plant**.**

Sisal is a bast fiber which is extracted from the leaves of **Aguvu *sisalana*** and fiber content generally may not be more than 4% of total leaf mass. It is reported that there are 57 species known to date.

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Production And Use

The main producers of .sisal fibers, in general, are: Brazil, Indonesia and East African countries (like Tanzania). It has been reported that the annuai production of sisal fibers is about 600 million tonnes (M.T.), out of which Brazil alone accounts for nearly 220 M.T. However, the production of sisal fibers in India is reported to be about 3 M.T. only.

Generally, the fibers are used in the fabrication of cordage, strings, twines and ropes and the fibers of low-quality are used as fillings in furniture and in the manufacture of paper. Sisal is among the hard fibers of the World and represents around 70% of the World's market in fibers. Its principal use is in the manufacture of sacks and its special use is in the manufacture of marine strings due to its resistance to salinity.

Size, Structure, Chemical Composition And Properties Size

Sisal fibres vary in size, between 6 -10 cm in width and 50 - 250 cm in length, depending on species, climate and soil in the plantation. According to producer's classification, sisal firbes are divided into three categories depending on their length as:

Short fibres with length <600mm

Medium sized fibres with length in the range 600 -700mm

Long - sized fibres with length in the range greater than 700mm the diameter is generally reported to be less than 0.2m

Structure:

In general, fibers from different sources, age and parts of plant, have different structure e and hence different properties. Sisal fibers are built - up of about 100 fiber cells (with a length of 2- 5 mm) in cross section. The fiber cells are linked together by means of middle lamellae.

The fiber cells consist of a number of walls built - up of fibrillae. In the outer wall (primary wall) the fibrillae have a reticulated structure. In the outer secondary wall (Sl), which is located inside the primary wall, the fibrillae are arranged in a spiral with a spilal angle of 40°, in relation to the longitudinal axis of the cell. 'fhe iibrillae in the inner secondary wail (S2) have a sharper dope, 18'.

The innermost wall (the tertiary) wall is thln and has *2* reticulated arrangement of fibriiiate. The fibrillae are, in turn, built - up of micro - fibrillae with a thickness of about 20 nm.

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Figure presents a schematic sketch of a fiber cell.

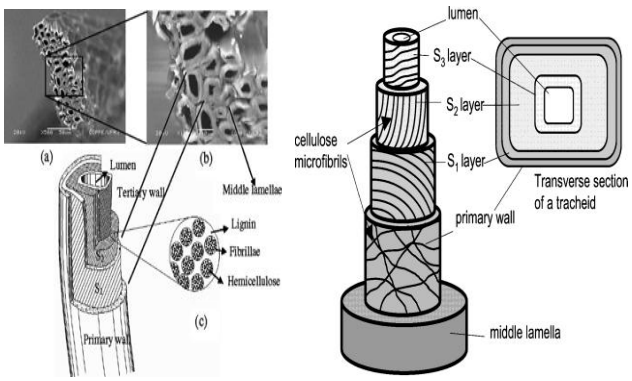

Fig. 2.1 Sisal Fiber Cells

Fig. 2.2 Sisal Plant

Properties:

It is well known that the physical and mechanical properties of these fibers are affected by environmental changes, e.g., soil, time of harvesting, process of fiber separation, treatment, air - humidity, temperature etc. Various physical and mechanical properties of sisal fibers, as reported in the literature are summarized. Vegetable fibers in dry state have a tendency to absorb very high percentages of water.

When they are actually immersed in water. Sisal fibers are no exception to the above behavior. Moreover, such a behavior becomes critical as it may affect the performance of cement – based Composites, due to the artificial inducement of lower effective water - cement ratio in the matrix. Data as published in the literature on the water absorption of sisal fibers (of Brazil origin) during 24 hr of immersion of water. It can be seen that the first 15-30 minutes after immersion of fibers, are crucial. as the water absorbed is very high, than in subsequent periods.

PRODUCTION TECHNOLOGY

The production technologies available include (Bentur & Mindess, 1990):

- Combining fibers with matrix in a pan mixer as if the fibers were an extra ingredient in the common method of producing a cementitious mi
- Simultaneously spraying fibers and cement slurry onto the forming surface to produce thin products

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- Fiber-reinforced concrete
- Dispersal of fibers in a cement slurry which is then dewatered to produce thin products
- Hand-laying fibers, in the form of mats or fabrics, in moulds, impregnating them with Cement slurry and then vibrating or compressing the mix to produce a dense material with high fiber content
- Impregnating continuous fiber mats and fabrics with a cement slurry by passing them through a cement bath in a continuous process

Fig.2.3 Sisal Fiber bars

EXTRACTION OF SISAL FIBER

Sisal fiber is extracted from the leaves of sisal plant. The fibers are extracted through hand extraction machine composed of either or non serrated knives. The peel is clamped between the wood plank and knife and hand-pulled through, removing the resinous material. The extracted fibers are sun-dried which whitens the fiber once dried the fibers are ready for knotting. A bunch of fibers are mounted or clamped on a stick to facilitate segregation. Each fiber is separated according to fiber sizes and grouped accordingly. To knot the fiber, each is separated and knotted to the end of another fiber manually. The separation a knotting is repeated until bunches of unknotted fibers are finished to form a long continuous. This sisal fiber can be used for making variety of products

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Fig. 2.4 Sisal Fiber Extraction

3. MIX PROPOTION

In this project the mix design ratio used as 1:1.29:2.66 M30 grade concrete.

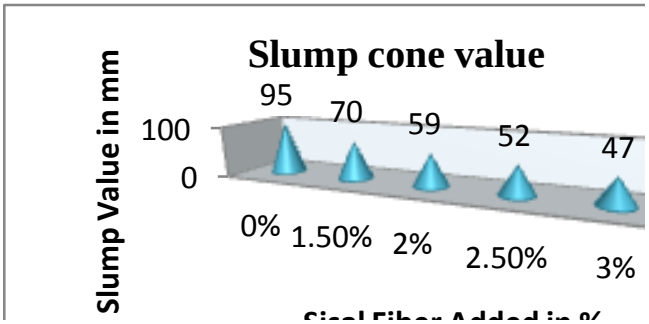
4. FRESH CONCRETE

4.1. Slump test

The slump value decreased with increase in percentage of sisal fiber.

Table 5 Slump value

MIX (Sisal Fiber)	SLUMP(MM)
0%	95
1.5%	70
2%	59
2.5%	52
3%	47



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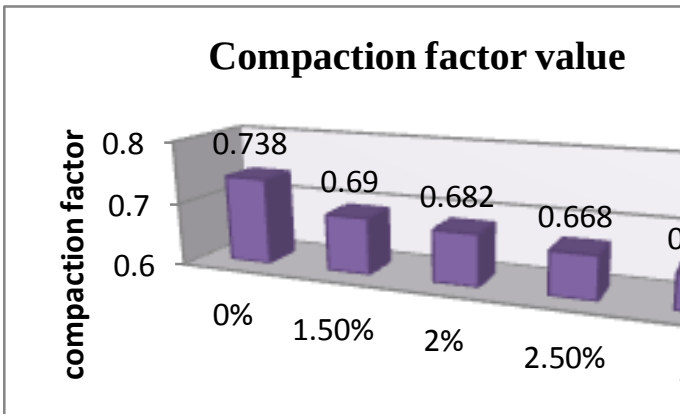
4.2. Compaction factor test

There was no much variation in compaction factor was very minute after addition of sisal fibre

Table 6 Compaction factor value

MIX (Sisal Fiber)	COMPACTION FACTOR
0%	0.738
1.5%	0.690
2%	0.682
2.5%	0.668
3%	0.654



5.HARDENED CONCRETE

5.1. Compressive strength

The compressive strength result obtained for 7days , 14 days and 28days it was observed that the compressive strength increased by adding 0%,1.5%,2%,2.5%,3% of sisal fibre and it decrease in strength by adding of sisal fibre.

Fig.5.1 Compressive Strength Test

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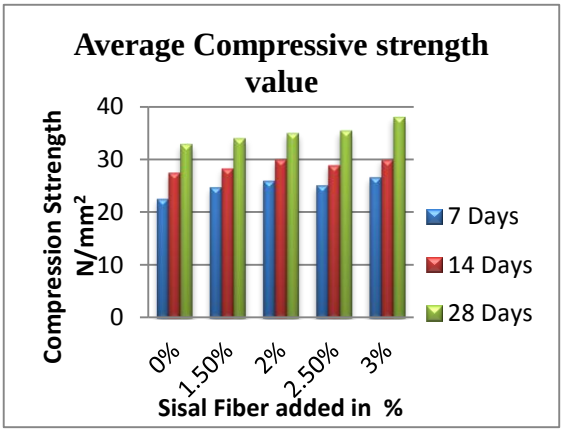
Table 7 Compressive Strength Value

Sl.no	*Mix of Sisal Fiber*	*Avg. Compressive Strength Value N/mm²*		
		7 Days	*14 Days*	*28 Days*
1	*0%*	*22.5*	*27.39*	*32.82*
2	*1.5%*	*24.65*	*28.20*	*33.92*
3	*2%*	*25.92*	*29.93*	*34.88*
4	*2.5%*	*25.06*	*28.82*	*35.36*
5	*3%*	*26.55*	*29.87*	*37.92*



5.2. Split Tensile strength

The Split tensile strength also can be increase by addition of sisal fiber to the concrete.

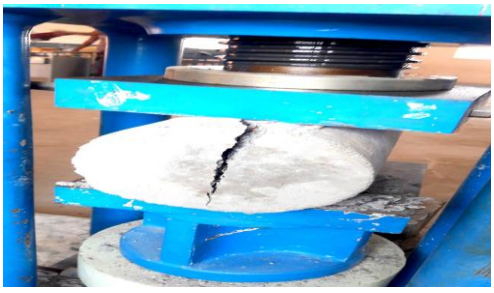


Fig. 5.2 Split Tensile Test

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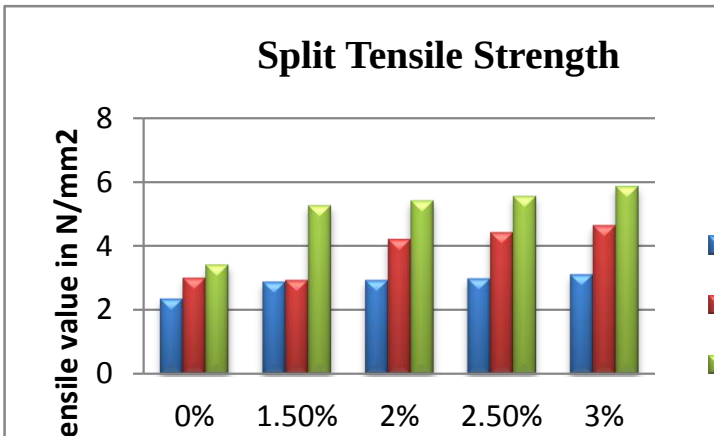
Table 8 Split Tensile Strength

S. No	Mix (Sisal Fiber)	Spilt Tensile Strength in KN/mm^2		
		7 Days	14 Days	28 Days
1	0%	2.36	3.01	3.42
2	1.5%	2.898	4.06	5.28
3	2%	2.945	4.22	5.43
4	2.5%	2.995	4.43	5.57
5	3%	3.123	4.65	5.88



5.3.Flexural Strength Test

The flexural strength test is a measure of the intensity of a beam or slab resisting against tensile forces due to bending. This experiment inferences the capacity of the bonding strength of the sisal fibers in concrete. The flexure strength test was carried out on beam specimens with varying fiber volume fraction such as 0%, 1.5%. 2%, 2.5% and 3% for M30 grades of concrete. The test was conducted using standard Universal Testing Machine with single point loading. The test procedure was used as per IS: 5816-1959. Figure 4 shows a beam specimen tested for flexural strength. The test results of the flexural strength test are tabulated as shown in the Table .

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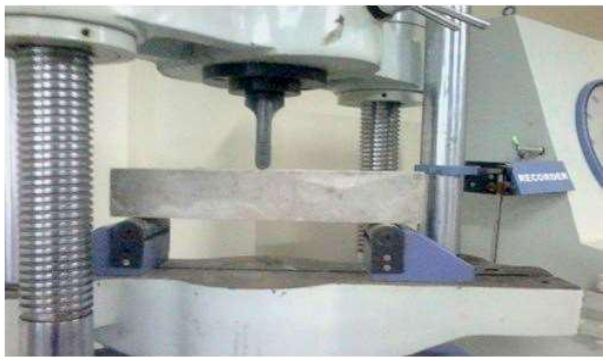

Fig.5.3 Flexural Strength Test

Table 9 Flextural Strength

S. No	***Samples of slab***	***7 Days (N/mm^2) Pl/bd^2***	***14 Days (N/mm^2) Pl/bd^2***	***28 Days (N/mm^2) Pl/bd^2***
1	*Normal R.C Beam*	*3.23*	*3.56*	*4.11*
2	*1.5% of SFRC Beam*	*3.38*	*3.69*	*4.22*
3	*2% of SFRC Beam*	*3.53*	*3.79*	*4.27*
4	*2.5% of SFRC Beam*	*3.55*	*3.83*	*4.32*
5	*3% of SFRC Beam*	*3.61*	*3.87*	*4.48*

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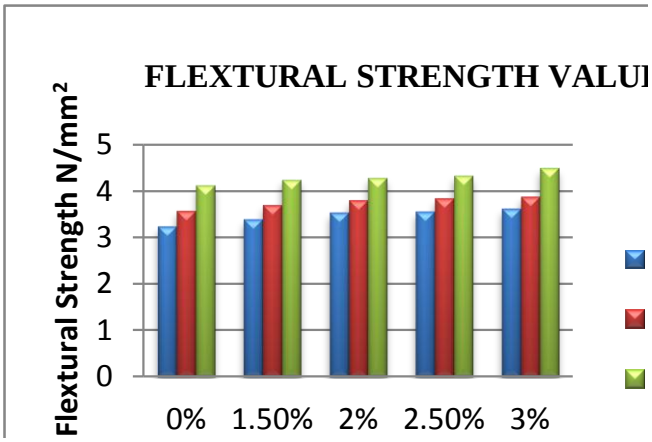

Materials

M30 grade concrete was used for casting beams, 20mm coarse aggregate and fine sand as fine aggregate. The reinforced beam consist of 3 nos. of 10 mm diameter bars in tension side and 2 nos. of 10 mm diameter bars in compression side with 8 mm diameter stirrups over the length of beam at 150 mm spacing.

Specimens

The rectangular cross section of the beams was 150mm width, 150mm depth and 2440mm length. It is shown in figure.

Test setup

The beams were tested in the loading frame of 1000 kN capacity under two point loading. The load was applied gradually by means of hydraulic jack until the beam failed. The test set up is shown in figure. The deflection in the mid span and center of the opening was recorded. Testing arrangement of beam with opening is shown in figure.

FIG.5.4 LOADING FRAME TEST SETUP

SL.N	SPECIMEN	INIIAL CRACK LOAD (KN)	FINAL CRACK LOAD (KN)	DEFLECTION (mm)
1	NORAML CONCRETE	41	166	9.2
2	CONCRETE WITH 1.5% OF SISAL FIBER ADDED	46	172	10.7
3	CONCRETE WITH 2% OF SISAL FIBER ADDED	51	178	11.6
4	CONCRETE WITH 2.5% OF SISAL FIBER ADDED	55	185	12.5
5	CONCRETE WITH 3.5% OF SISAL FIBER ADDED	62	197	13.3

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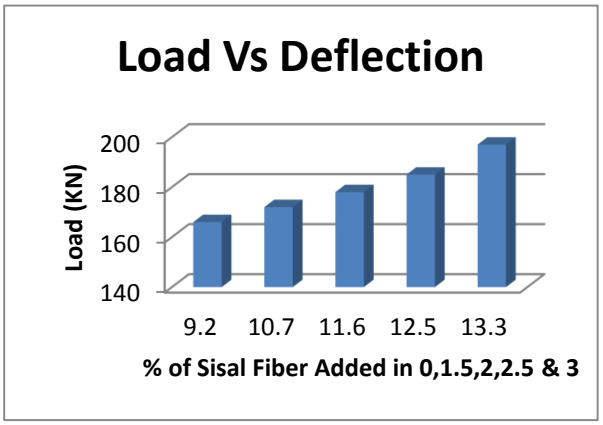

Load Vs Deflecion graph

IV. CONCLUSION

The following Conclusions are made from these experimental studies and laboratory investigations:

- The inclusion of fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic construction materials.
- A Chromological development of sisal fiber reinforced cement based matrices is reported and experimental data are provided to illustrate the performance of sisal fibre
- To utilize the natural sisal fibres to the concrete and it is a reliable material.
- Fibre is added in percentage by weight of cement for various proportions.
- The basic test were carried out, cubes, cylinders and Beams were caste for 7,14 and 28 days strength test.
- It was observed that the addition of fibres increased the compressive strength of concrete, considerably and the maximum compressive strength of concrete was found to be for a fiber volume fraction of 3% in optimum mix proportion.
- As the grade of concrete increases, the compressive strength also increases which indicates that the grade of concrete has a significant influence over the compressive strength of sisal fiber reinforced concrete. For concrete specimen the tensile strength increased as the percentage of fibers increased indicating an increase in ductility of concrete.
- The flexural strength increased with the increase in fiber volume fraction. This concludes that the increased amount of fibers in concrete makes the concrete effective in withstanding the greater flexural loads.

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BIOGRAPHY

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