

# Experimental Investigation of Natural Fiber Reinforced Concrete in Construction Industry

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*Abstract - Concrete made with Portland cement has certain characteristics: it is relatively strong in compression but weak in tension and tends to be breakable. The deficiency in tension can be defeated by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers. Change in the performance of the fiber-matrix composite after it has cracked, is due to The addition of fibers, thereby improving its toughness. On account of its low density, less cost, increased specific strength and modulus, zero health risk, sisal fiber is a promising reinforcement for use in composites and it is easy procured in some countries. 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..The purpose of this research is based on the investigation of the use of sisal fibers in structural concrete to enhance the mechanical characteristics of concrete. To find and compare the differences in properties of concrete containing no fibers and special concrete with fibers, as well as the correlation on the effects of different type and geometry of fibers to the concrete is the aim of the study. This scrutiny was carried out using several tests, which contained workability test, compressive test, split tensile test, flexural test. A total of ten mix batches of concrete containing 0%, 0.5%, 1%, 2% dosage of fiber were cast. With the best results from the mix, torsion beam elements are cast and torsion testing is to be done.*

*Key Words: Fiber, workability, torsion.*

## 1. INTRODUCTION

Fiber is a natural or synthetic string. It is also used as a component of concrete, or when made into sheets. It is used to make products such as paper or felt. Fibers are often used in the manufacture of other materials. The strongest engineering materials often incorporate fibers. Fibers are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to

pieces of thread. Concrete made with Portland cement has certain characteristics: it is relatively strong in compression but weak in tension and tends to be brittle. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers. The use of fibers also alters the behavior of the fiber-matrix composite after it has cracked, thereby improving its toughness.

Since the advent of fiber reinforcing of concrete in the 1940's, a great deal of testing has been conducted on the various fibrous materials to determine the characteristics and advantages for each product. Fibers produced by plants (vegetable, leaves and wood), animals and geological processes are known as natural fibers. Natural fibers possess the advantages like easy availability, light weight, renewability of raw materials, low cost, high specific strength and stiffness.

Natural fibers are cheap and locally available in many countries. Fibers are thread like materials which can be used for different purposes. The use of natural fibers reduces weight by 10% and lowers the energy needed for production by 80%, while the cost of the component is 5% lower than the comparable fiber glass-reinforced component.

### 1.1 Sisal fiber

Agave sisalana Perrine (Agavaceae), popularly known as sisal in is a monocotyledonous plant from Mexico. Sisal derives its name from a small port in the Yucatan peninsula of Mexico through which the earliest supplies of Agave fibers were exported and it became known to commerce as Sisal or 'sisal hemp'. The plants look like giant pineapples, and during harvest the leaves are cut as close to the ground as possible. Sisal represents the first natural fiber in commercial application, in which it is estimated in more than half of the total of all natural fibers used. The Sisal plant is a monocotyledonous, whose roots are fibrous, emerging from the base of pseudo stem.

Sisal can be cultivated in most soil types except clay and has low tolerance to very moist and saline soil conditions. Husbandry is relatively simple as it is resilient to disease and its input requirement is low compared to other crops. These are mainly cultivated for fibers which are highly suited for ropes of all kinds Sisal fibers are extracted from

an agave plant. Sisal fibers are stiff, straight, smooth and yellow in color. Strength, durability and ability to stretch are some of the important properties of sisal fibers. Sisal fiber is one of the most widely used natural fibers and it can be easily harvested. Sisal plant produces over 200-250 leaves during its life time of 7 to 8 years and each leaf contains 1000-1200 fiber bundles.



Fig -1 sisal fiber plant

The size of sisal fibers vary between 60 -100 mm in width and 500 - 2500 mm in length, depending on species, climate and soil in the plantation. The diameter of the fiber is about 100 to 300 μm. According to producer's classification, sisal fibers are divided into three categories depending on their length as:

- Short fibers with length 3 600mm;
- Medium sized fibers with length in the range 600 - 700mm;
- Long - sized fibers with length in the range greater than 700mm. The fiber diameter is generally reported to be less than 0.2m.

Sisal leaf contains three types of fibers. They are mechanical, ribbon and xylem fibers. Mechanical fibers have a roughly thickened horseshoe shape and hardly divide during extraction process. It is present in the periphery of the leaf. Ribbon fiber occurs in association with the conduction. Xylem fibers have an irregular shape and occur opposite to ribbon fibers through the connection o vascular bundles.

Table 1: Chemical composition of sisal fiber

CHEMICALS	PERCENTAGE
Cellulose	71.5%
Hemicelluloses	18.1%
Lignin	5.1%
Pectin	2.3%
Waxes	0.5%
Total	100%

Generally, the strength and stiffness of plant fibers depend on the cellulose content and the spiral angle which the bands of micro fibrils in the inner secondary cell wall make with the fiber axis.

Fiber can be extracted in two methods, the retting process and the mechanical process. The fiber yield in retting process is about 5.5% and in the mechanical process is about 3-4% based on the weight of green leaves. Hand extraction machine is used to extract the fibers through serrated or non-serrated knives. The fiber extracted is dried under the sun till it turns into white color and then it is made ready for knotting. Water is used to wash away the waste parts of the leaf. The fiber is then dried, brushed and baled for export. Proper drying is important as fiber quality depends largely on moisture content. Artificial drying has been found to result in generally better grades of fiber than sun drying, Fiber is separated to various sizes and knotting is done on the other side to form long continuous strands. It is mainly used for mats, carpets and many other reinforcement materials.



Fig -2 Hand Extraction

## 2. METHODOLOGY

Concept of using sisal fiber in concrete was conceived. Based on the concept, various journals where referred and an idea about the natural fiber known as the sisal fiber being used in concrete was obtained. The knowledge on fiber reinforced concrete was also obtained by referring various journals. Literature review was done and the concept was finalized

Various tests on Cement, fine aggregate and coarse aggregates were carried out and the results were obtained. In order to do find the merit or demerit of any special concrete, it has to be compared with conventional concrete. Therefore, a set of conventional concrete specimen is required. In order to cast a set of conventional concrete, initially the mix design for M40 grade of concrete has to be done. Tests on fresh concrete were carried out. Workability was checked by carrying out slump test. The water cement ratio and the percentage of super plasticizer to be added was also determined based on three different designs of trail mix. The mix with optimum results were considered for casting conventional concrete.

The same mix ratio which was used to cast conventional concrete specimen, was used to cast special

concrete specimens. Special concrete specimens are fiber reinforced specimens. Four different aspect ratios are considered. Fiber was cut for each aspect ratio. For each aspect ratio, four different percentage of amount of fiber were added to concrete mix. Special concrete specimens consist of cubes, cylinders and beams. OPC grade 53 cement was used in casting. The coarse aggregate added to the mix was divided into two portions. 60% of 20mm aggregate and 40% of 12.5mm aggregate was used. 16 mixes of special concrete specimens were cast and cured.

3<sup>rd</sup>, 7<sup>th</sup> and 28<sup>th</sup> day testing were carried out to find the compressive strength, split tensile strength and flexural strength for the special concrete. With the results obtained, the optimum result was found. With the optimum result, the aspect ratio and the percentage which gives us the optimum result is found. With this aspect ratio and percentage, the research to carried forward by conducting torsion and durability tests.

### 3.RESULTS AND DISCUSSION



Fig -3 compressive strength test

Compressive strength tests were carried out on a CTM on both conventional concrete and special concrete .



Fig -4 Split tensile strength test

Split tensile strength test were carried out on Cylinders of diameter 100 mm and height 200 mm.



Fig -5 Flexural strength test

Flexural strength test were carried out on flexure beam specimen of size 500 mm × 100 mm × 100 mm.

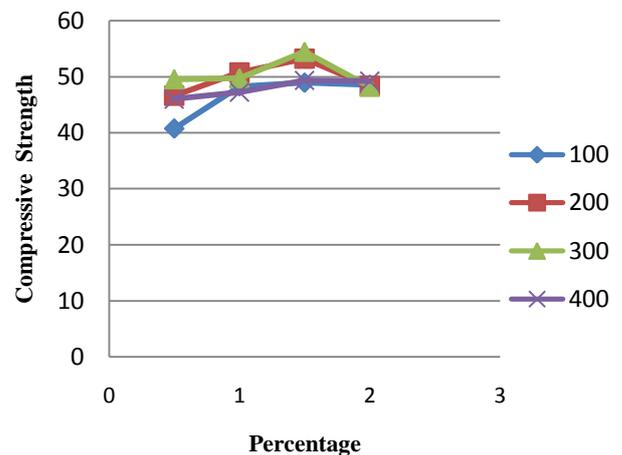


Chart -1: Compressive strength 28th day results

Compressive strength test results of cubes after 28 days curing.

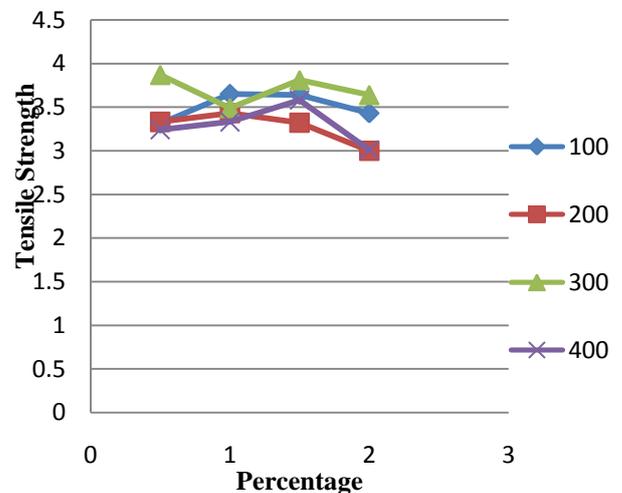


Chart -2: Split tensile strength 28th day results

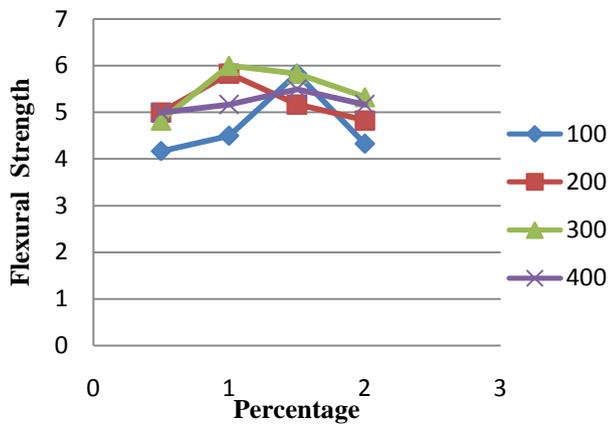


Chart 3: Flexural strength 28th day results

### 3. CONCLUSION

Concrete made with Portland cement has certain characteristics; it is relatively strong in compression but weak in tension and tends to be brittle. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers. The use of fibers also alters the behavior of the fiber-matrix composite after it has cracked, thereby improving its toughness.

By adding this sisal fiber it has been found that there is an increase in properties of both fresh and hardened concrete.

- Addition of fibers of aspect ratio 300 by dosage of 1.5% shows an increase in compressive strength as compared to conventional concrete.
- Addition of fibers of aspect ratio 300 by dosage of 0.5% shows an increase in split tensile strength as compared to conventional concrete.
- Addition of fibers of aspect ratio 300 by dosage of 1% shows an increase in flexural strength as compared to conventional concrete.

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