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AN EXPERIMENTAL INVESTIGATION ON THE DURABILITY OF CONCRETE BY USE OF AGAVE LECHEGUILLA

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Abstract - ***Fiber reinforced concrete is new structural material which is gaining increasing importance. Addition of fiber reinforcement in discrete form improves many engineering properties of concrete. Fiber reinforced concrete can offer a convenient practical and economical method of overcoming micro-cracks and similar type of deficiencies. Since concrete is weak in tension, some measures must be adopted to overcome this deficiency. Hence sisal fiber is used in concrete to overcome this deficiency. Experiments were conducted on concrete beams, cylinders, cubes with various percent of sisal fiber (i.e) 0.5 % 1% 1.5% and 2% by the volume of concrete. By testing of beams, cubes and cylinders we found that there is an increment in the various properties and strength of concrete by the addition of sisal fiber as fiber reinforcement. Durability tests are yet to be conducted for the above specimens.***

Key Words: *Fiber, sisal, durability etc…*

1. INTRODUCTION

Natural fiber, as reinforcement, has recently attracted the attention of researchers because of their advantages over other established materials. They are environmental friendly, fully biodegradable, abundantly available, renewable, low-priced and have low density. Increasing concern about the global warming, primarily due to deforestation has led to the ban on use of wood in government buildings. Subsequently, a large action plan for the development of wood substitute has resulted in creation of more awareness about the use of natural fiber based building materials. In the past one decade or so the joint efforts by R&D organizations, private industries and funding agencies provided the much needed thrust for the actual transfer of technical know-how and product to the end users.

Concrete is weak in tension and has brittle characters. The concept of using fiber to improve the characteristics of construction materials is very old .It has been recognized that the addition of small ,closely spaced and uniform dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as fiber reinforced concrete. Fiber reinforced concrete and discontinuous, discrete, uniform dispersed suitable fibers continuous meshes, woven fabrics and long wires or codes are not considered not to be discrete fibers. Although every type of fiber has its characteristics properties and limitation some of the fibers that could be used are steel fibers, polypropylene, nylon, asbestos, coir, glass, carbon.

Fiber is a small piece of reinforcing material possessing certain characteristics properties .they can be circular or flat the fiber is often described by a convenient parameter called ‘aspect ratio’. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

Fiber reinforced concrete is the composite material containing fibers in the cement matrix in an orderly manner or randomly distributed manner. Its properties would obviously, depend upon the efficient the efficient transfer of stress between matrix and the fiber, which is largely dependent on the type of fiber, fiber geometry, fiber content, orientation and distribution of the fibers, mixing and compaction techniques of concrete and size and shape of the aggregate .

1.1 Sisal fiber

Agave Lecheguilla or 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 fibersthrough 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.

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

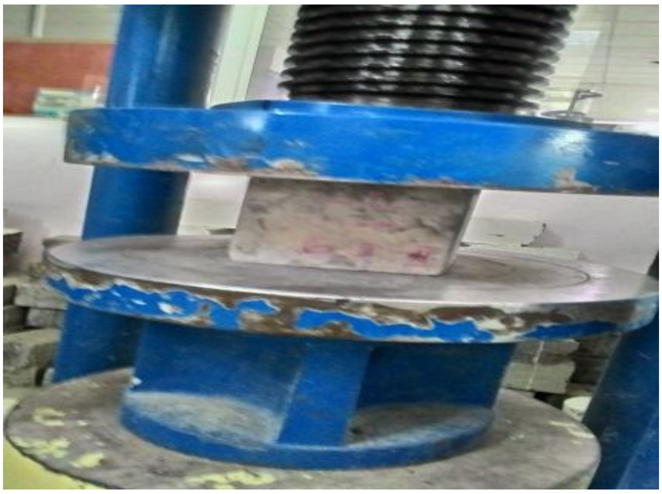
Various tests on Cement, fine aggregate and coarse aggregates were carried out and the results were obtained. In order to do find the merit or demerit of any special concrete, it has to be compared with conventional concrete. Therefore, a set of conventional concrete specimen is required. In order to 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 was 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. Ordinary Portland cement (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. 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. Ordinary Portland cement (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.

Third, Seventh and Twenty Eighth 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

Compressive strength tests (Fig-3) were carried out on a CTM on both conventional concrete and special concrete.



Split tensile strength tests (Fig-4) were carried out on Cylinders of diameter 100 mm and height 200 mm.

Fig-4 Split tensile strength test

Flexural strength test (Fig-5) were carried out on flexure beam specimen of size 500 mm × 100 mm × 100 mm.

Chart-I, II and III shows the compressive strength test results of cubes after 28 days curing.

Chart-1: Compressive strength 28th day results

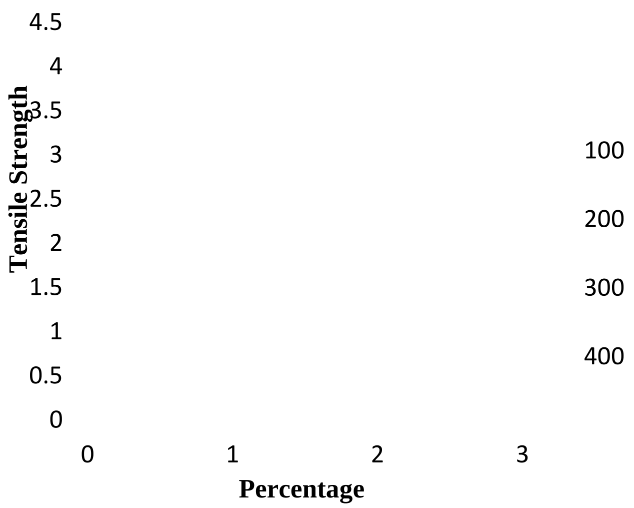


Chart -2: Split tensile strength 28th day results

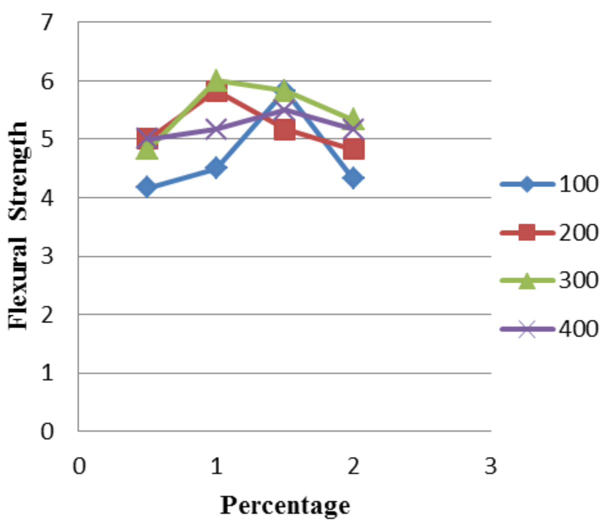


Chart 3: Flexural strength 28th day results

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.
The authors can acknowledge any person/authorities in this section. This is not mandatory.

- 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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