Journal of Advances in Science and Technology

Vol. 11, Issue No. 22, May-2016, ISSN 2230-9659

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AN INTERNATIONALLY INDEXED PEER REVIEWED & REFEREED JOURNAL

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Journal of Advances in Science and Technology
Vol. 11, Issue No. 22, May-2016, ISSN 2230-9659

Experimental Investigation for the Effect of Agave Fiber on the Properties of Concrete

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Abstract – Concrete is the most widely used construction material in the world, with about two Billion tons of utilization worldwide during each year. Concrete is widely used in all types of infrastructural applications because it offers considerable strength. Concrete is strong in compression and weak in tension in order to overcome the weakness steel reinforcement is being provided. Researches attempted to inherit the tensile property by introducing synthetic fibres such as poly propylene, asbestos and steel fibres, but they are expensive. Hence they are attempting to use the natural fibres such as agave, straw, elephant grass, palm leaf, coconut coir etc., to incorporate tensile strength in conventional concrete. So that the traditional steel reinforcement on concrete can be reduced.

In this research, agave fiber is being used in concrete. Thereby, the mechanical properties such as compressive strength, split-tensile strength were determined for M25 grade concrete and by varying the dosage of fibre content from 1%, 2%, 3%, and 4%, by volume of cement with optimum length of 40mm.. The mechanical properties such as compressive strength and split tensile with % agave fibre were compared with conventional concrete properties of M25 grade. It is observed that increasing % of fiber in concrete increases the compressive and split tensile strength of concrete compared to Normal concrete

Keywords: Concrete, Agave Fiber, Compressive Strength, Split-Tensile Strength.

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INTRODUCTION

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape from a cylindrical water storage tank to are rectangular beam or column in a high-rise building. The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. The disadvantages of using concrete include poor tensile strength, low strain of fracture and formwork requirement. The major disadvantage is that concrete develops micro cracks during curing. It is the rapid propagation of these micro cracks under applied stress that is responsible for the low tensile strength of the material.

The science of incorporating one or more materials in concrete to improve strength and satisfy design requirements is not new. Since the 17th Century, man has been known to make composite materials to achieve the desired design strengths Mostly concrete is reinforced with steel bars .Over the years scientists have been doing research on reinforcing concrete with fibers. The approach of replacing steel by incorporating the natural fibers in concrete is termed as Natural Fiber Reinforced Concrete (NFRC).The use of fiber reinforced concrete can be dated back since 1870‘s .Since then researchers have been working on concrete reinforced with wood fiber, waste glass, sisal fibers and vegetable fibers such as elephant grass, and many more. In particular, the natural fibers are sometimes used as reinforcement together with steel in concrete so as to reduce cracking and spelling of the structures.

1.1 FIBER

Fibers or fibres are a class of hair-like materials that are continuous '"filaments"' or are in discrete elongated pieces, similar to pieces of thread. They can be used as a component of composite materials. They can also be matted into sheets to make products such as paper or felt. Fibers are of two types.

A) **Natural fiber:** Which consists of animal and plant fibers.

B) **Man-made fiber:** Which consists of synthetic fibers and regenerated fibers

1.2 Agave Fiber

There are plenty of renewable resources obtainable from the plant kingdom, and a vast resource for different natural fibers viz. Jute, Banana, Coir, *etc.*, which are abundantly available in many parts of world. However, there are still a number of other vegetable fibers which have not been used as textile fibers. From the plant kingdom, one of the abundant sources of strong natural fiber is “Agave Americana”. Agave Americana fibers are also called “Pita Fibers”. These fibers are cellulosic in nature

Fig: Agave Plant

Effect of Different Chemicals on Agave Fibers

Agave fibers are stable in weak acids and weak alkalis, and have no effect on structure and tenacity of Agave Americana fibers. Therefore these fibers can be safely treated with bleaches, detergents and dyes which are weak basic or weak acidic in nature. However, in strong acids and strong bases, fibers were dissolved or distorted. The bonds connecting the subunits (*i.e.*, ultimate fibers) are unstable to acid, which leads to loss in tensile strength of fibers. Reaction with concentrated sodium hypochlorite results in the bleaching of fibers, but after prolonged exposure, the fiber loses its strength and disintegrates. This indicates that oxidizing solutions like sodium hypochlorite should only be used when cold, diluted and according to instructions given by the manufacturer. Therefore, chlorine bleaches should be used for a short period of time and must be rinsed out thoroughly to avoid further damage to the fiber.

Applications of Agave Fibers

Agave fibers exhibit high tensile strength and have low density. Because of this, historically, they were used in manufacturing twines and ropes for fishing and agricultural purposes. Further, these fibers can be used for the production of nets, carpets, rugs, doormats, bags, sacks, fish stringers, furniture webbing, drapes, upholstery padding, saddle pads, cushion stuffing, brush brittles, baskets, bracelets, headbands, sandals, decorative items, clothing and other woven objects. Papers also have been made from lower grade Agave fibers. Agave fibers are also used for embroidery of leather in a technique known as piteado

Research findings showed that Agave fiber can also be utilized for other industrial purposes. There can be a potential application of Agave Americana fibers in composites as well as in nonwovens. Bio-plastics, geotextiles, carpets, fiber boards, dart boards and molded furniture can also be manufactured using Agave fibers.

Environmental Benefits of Agave Plant and Fibers

Agave plants have four times more cellulose than the fastest growing eucalyptus tree, and it effectively captures CO2 from the atmosphere. When properly maintained, it requires irrigation only three to four times per year. Agave Americana fibers have minimal environmental impact. The production does not need agricultural chemicals. During processing of Agave Americana fibers, only organic waste is produced which can often be reused. The by-products after the processing of the agave takes the form of bio-degradable organic matter which can be used as “compost” or as an organic material to be returned to the land and as fuel for biogas production. In this way, they enhance soil fertility. Unlike synthetic fibers, Agave Americana fiber is 100% biodegradable during its lifetime and Agave Americana ropes and other products can be recycled as paper. The plants can be also used as an effective hedge to protect crops and land from predators and the extensive root system helps to reduce soil erosion in arid areas. This is truly a “no waste” plant. The “zero-waste” utilization of the plant would enable its production and processing to be translated into a viable and sustainable industry

SCOPE OF STUDY

In the present Experimental study we are adding Agave Fiber in Percentages of 1%, 2%, 3%, and 4%, by volume of cement with optimum length of 40mm for M25 Grade concrete and casted cubes and cylinders and tested for Compressive strength and tensile strength at 7,14,28 Days.

2. MATERIALS USED

The basic materials for mixing concrete are required such as

1. Cement
2. Fine aggregate

3. Coarse aggregate

4. Agave fibres

5. Water

Cement

The cement used was OPC 53 grade cement. The following Table 2.1 is the various tests conducted as per Indian Standards to determine the properties of this cement. For initial & final setting time IS: 8112-1989 is used and for standard consistency of cement IS: 4031(part-4) 1988. For specific gravity of cement (IS: 2720- part 3) is used.

S. no	Properties	Values obtained
1	Specific gravity	3.15
2	Standard consistency	35%
3	Initial setting time	65 min
4	Final setting time	300 min

Table 2.1: Results of Tests on Cement

Fine aggregate

Sand was used as fine aggregate for the experiment. Various tests were conducted to determine the properties of sand which are shown in the Table 2.2. Grading is the particle- size distribution of an aggregate as determined by a sieve analysis. The tests were done according to IS: 2386 (Part-1) – 1963.

S. no	Properties	Values
1	Specific gravity	2.6
2	Water absorption	0.82%
3	Zone	II

Table 2.2: Results of Tests on Fine Aggregate

Coarse aggregate

Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Maximum size of aggregate affects the workability and strength of concrete. It also influences the water demand for getting a certain workability and fine aggregate content required for achieving a cohesive mix. In this study the natural coarse aggregates are used, which was bought from the nearby quarry. Aggregates of 20 mm passed and 12.5 mm retained size were chosen for the experiment which is clean and free from deleterious materials. The following Table 2.3 shows the tests conducted in order to determine the properties of this aggregate.

S. no	Properties	Values
1	Specific gravity	2.65
2	Fineness modulus	2.2
3	Water absorption	0.19%

Table 2.3: Results of Tests on Coarse Aggregate

Agave fibre

The Agave Fibers were extracted from the agave plants .The leafs of the plant were cutted and soaked in the water for 20 days for easy removal of fiber. The soaked leafs were taken and Extract the fiber after that they were dried and cutted to optimum length of 40mm, which are uniformly and randomly distributed in the concrete matrix. The different fibre contents were chosen 0%,1%, 2%, 3% and 4% for each mix.

Composition	Amount(%)
Cellulose	68-80
Hemicellulose	15
Lagnin	17
wax	0.26
Moisture	8

Table 2.4. Chemical Composition of Agave

Water

Water used in concrete is free from sewage, oil, acid, strong alkalis or vegetable matter, clay and loam and is satisfactory to use in concrete.

3. EXPERIMENTAL PROCEDURE

It is carried out to study the properties of M25 grade of concrete by adding Agave Fiber in Percentages of 1%, 2%, 3%, and 4%, by volume of cement with optimum length of 40mm. The mix proportion was (1:1:2) with W/C Ratio 0.45. The 150 X 150 X 150 mm cubes and cylinders were casted. The compressive strength and tensile strength was carried out at the age of 7, 14 and 28 days, at various % of Agave fibers.

The experimental program for cubes and cylinders are mentioned in the table below. To achieve the objectives of the investigation the experimental program was planned to cast around 36 cubes of 150mm x 150mm x150mm and 150 x 300mm cylinders and they were tested

4. TESTS RESULTS AND DISCUSSION

Workability

The workability of agave fiber with different percentages in concrete has found to decrease than normal concrete.

Compressive Strength

The cube specimen was placed in the machine, of 2000kN capacity. The load was applied at a rate of approximately 140 kg/sq.cm/min until the resistance of the specimen to the increasing load can be sustained.

The specimens were tested at 7 days,14 days and 28 days.

Table 4.1 Compressive strength of concrete for 7,14 & 28 Days

S. No	% of Agave Fiber	Compressive Strength (N/mm2)		
		7th Day	14th Day	28th Day
1	0% Normal Concrete	18.1	23.44	25.77
2	1%	18.52	24.11	25.44
3	2%	19.31	24.77	25.85
4	3%	19.55	25.22	26.46
5	4%	19.86	25.81	26.74

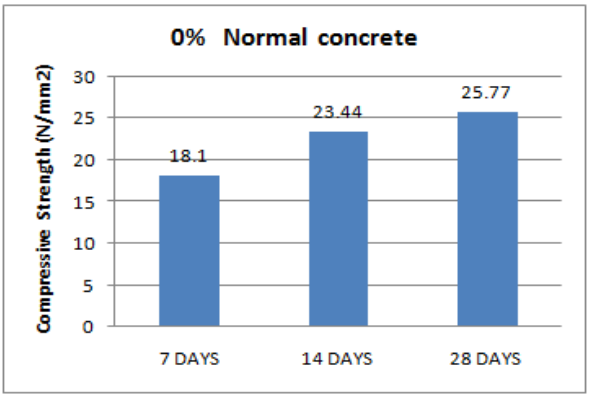
Tensile Strength

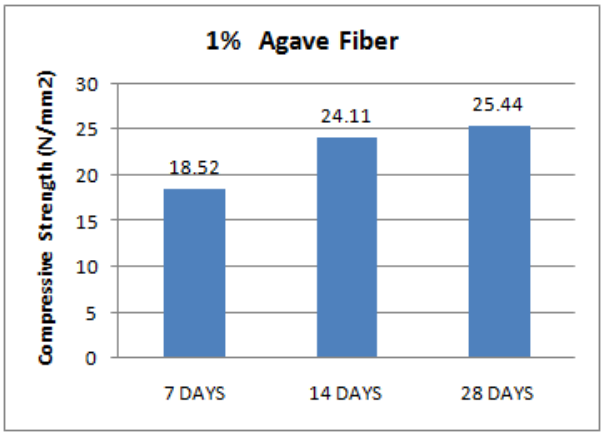
Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to the various kinds of effect and applied loading itself, however tensile strength of concrete is very low in compared with compressive strength of concrete.

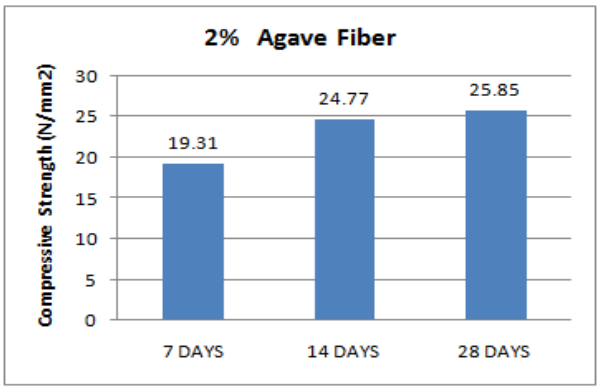
S.No	% of Agave Fiber	Tensile Strength (N/mm2)		
		7th Day	14th Day	28th Day
1	0% Normal Concrete	2.98	3.39	3.55
2	1%	3.01	3.44	3.53
3	2%	3.08	3.48	3.56
4	3%	3.10	3.52	3.60
5	4%	3.12	3.56	3.62

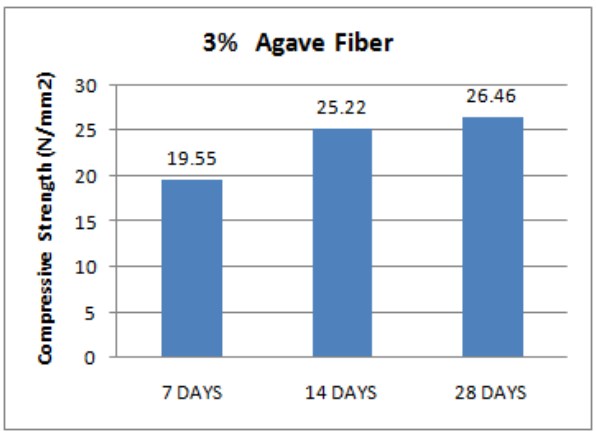
Graphs

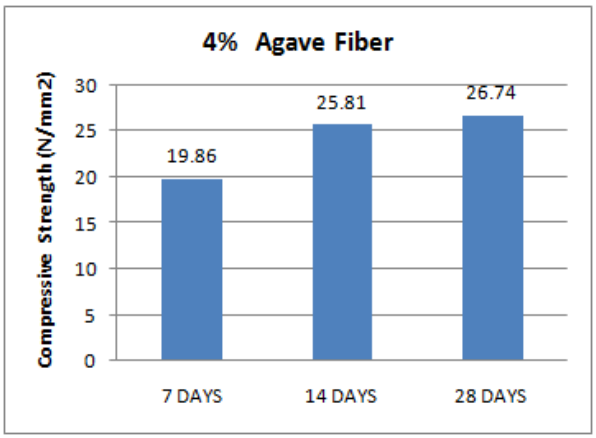
Compressive strength (0%, 1%,2%, 3% ,4%)



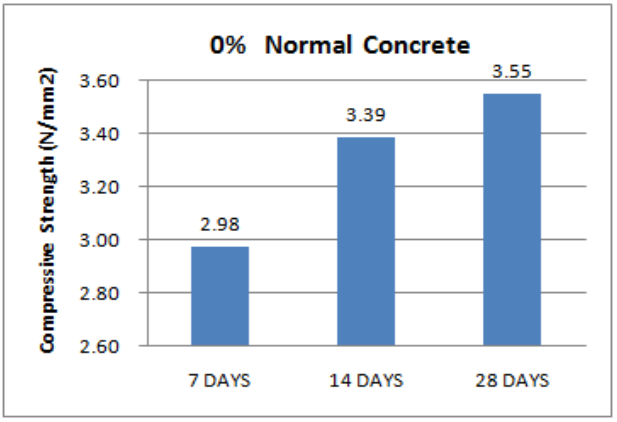


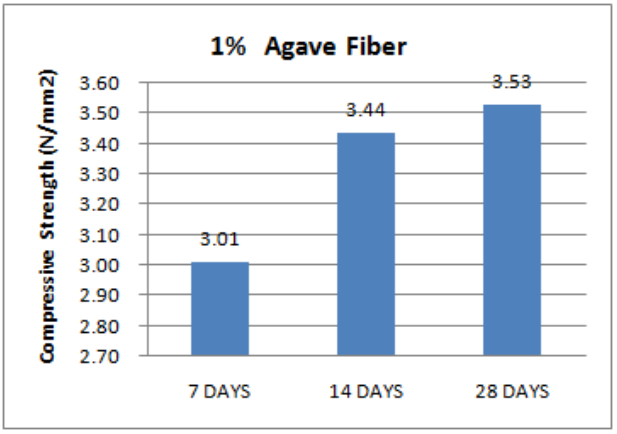


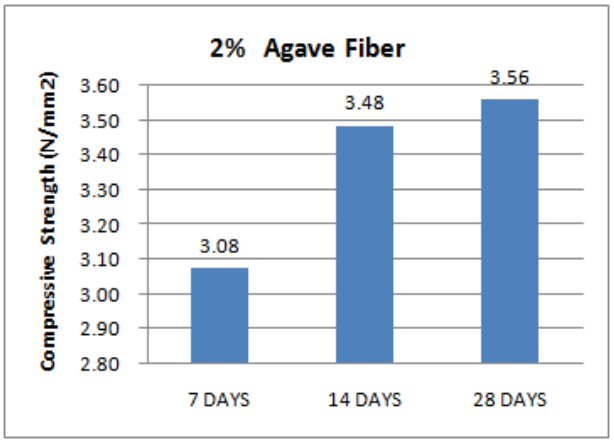


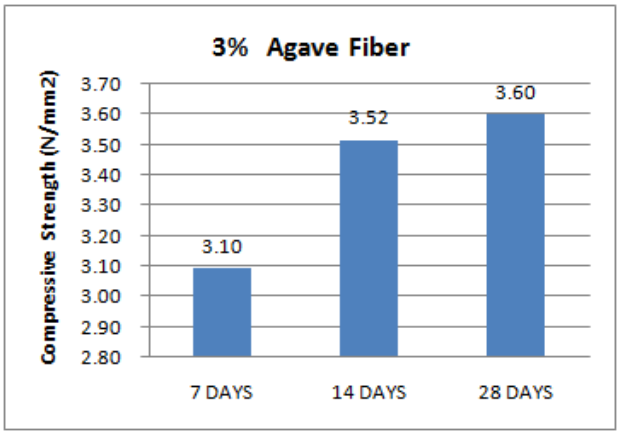


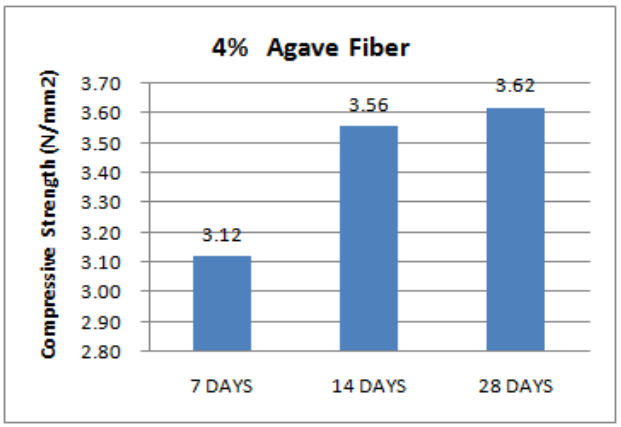
Tensile Strength (0%, 1%,2%, 3% ,4%)











CONCLUSION

- The test results shows that 0% , 1% ,2% ,3% and 4% of Agave Fiber shows the increasing in compressive and tensile Strength.
- The compressive strength and Tensile is been increased From 25.77 N/mm2 and 3.55 N/mm2 for 0 % to 26.74 N/mm2 and 3.62 N/mm2 for 4 % Agave fiber.
- It has been observed that the workability of concrete decreases with the addition Agave Fibers with normal concrete
- The compressive strength of specimens gradually increased with the increase percentage of Agave fibre in concrete
- It shows that the presence of fibres in the concrete acts as the crack arrestors. The ductility characteristics have improved with the addition of Agave fibres.
- It was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibres than the Agave fibre concrete.

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