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Experimental Study on Partial Replacement of Cement with Silica Fume with Addition of Agave Fiber on M_{20} Grade Concrete

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Abstract – The concrete is widely used construction material in the world. In conventional concrete, micro-cracks develop before structure is loaded because of drying shrinkage and other causes of volume change. When the structure is loaded, the micro cracks open up and propagate because of development of such micro-cracks, results in inelastic deformation in concrete. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to the concrete would act as crack arrester and would substantially improve its compressive and split tensile strength properties.

In this research, Natural available Agave fiber is being used in concrete. Thereby, the mechanical properties such as compressive strength, split-tensile strength were determined for M20 grade concrete and by varying percentage of fiber content from 1%, 2%, 3%, 4%and 5% by volume of cement and 10% Cement is replaced by silica fume. The optimum length of fiber 40mm.. The mechanical properties such as compressive strength and split tensile strength with % agave fiber were compared with conventional concrete properties of M20 grade. From the results it is observed that increasing % of fiber in concrete increases the compressive and split tensile strength of concrete.

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

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1. INTRODUCTION

Concrete is one of the most versatile building materials, 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. It can be cast to fit any structural shape in 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.

Concrete is strong in compression and weak in tension in order to overcome the weakness steel reinforcement is being provided. However usage of steel reinforcement is expensive. Considerable efforts have been made world-wide to add various types of fibers to concrete so to make it more strong, durable and economical. Natural fiber such as agave, coconut, sisal fiber has certain physical and mechanical characteristics that can be utilized effectively in the development of reinforced concrete material. Concrete consumes more cement which lead to increase in cost and environmental problems .to reduce it effect an alternate industrial waste materials like silica fume, ggbs, flyash can be used in production of concrete.

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. Fibers are classified in to Natural fiber, which consists of animal and plant fiber and 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

Uses 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.

1.3 Silica Fume

Silica fume, also known as micro silica, (CAS number 69012-64-2, EINECS number 273-761-1) is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete.

Scope of study

In the present study we are adding Agave Fiber in Percentages of 1%, 2%, 3%, 4% and 5%, by volume of cement and 10% of cement is replaced by silica fume in concrete .The optimum length of 40mm fiber were used for casting M20 Grade concrete 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. Silica fume
6. Water

Cement

The cement used was OPC 53 grade cement. The different tests were 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. The Table 2.1 shows the results

S. no	Properties	Values obtained
1	Specific gravity	3.15
2	Standard consistency	34%
3	Initial setting time	60 min
4	Final setting time	300 min

Table 2.1: Results of Tests on Cement

Fine aggregate

The sand is used as fine aggregate is used in the concrete. Various tests were conducted to determine the properties of fine aggregate which are shown in the Table 2.2. Grading is the particle- size distribution

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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. 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	Water absorption	0.2%

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% ,4% and 5% for each mix.

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

Table 2.4. Chemical Composition of Agave

3. SILICA FUME

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy

production and consists of spherical particles with an average particle diameter of 150 nm.

Figure 1: Silica Fume

Properties	Values
Specific Gravity	2.2
Bulk Density	576, (kg/m^3)
Surface Area	20,000 (m^2/kg)
Sio2	(90-96)%
Al_2O_3	(0.5-0.8)%
Size (macron)	0.1

Table 2.5: Properties of Silica Fume

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.

1. Experimental Procedure

It is carried out to study the properties of M20 grade of concrete by adding Agave Fiber in Percentages of 1%, 2%, 3% ,4% and 5% by volume of cement and cement with silica fume 10 %. The optimum length of fiber is 40mm . The mix proportion was (1:1.5:3) with W/C Ratio 0.5. 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 specimens 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.

% of Agave Fiber	Silica fume	Compressive Strength (N/mm2)		
		7th Day	14th Day	28th Day
0% Normal Concrete	0%	14.184	19.81	23.12
1%	10%	13.91	16.981	20.821
2%	10%	13.98	17.124	21.432
3%	10%	13.662	17.761	21.972.
4%	10%	13.811	18.223	22.621
5%	10%	13.651	18.912	23.466

Table 4.1 Compressive strength for 7,14 & 28 Days

Tensile Strength

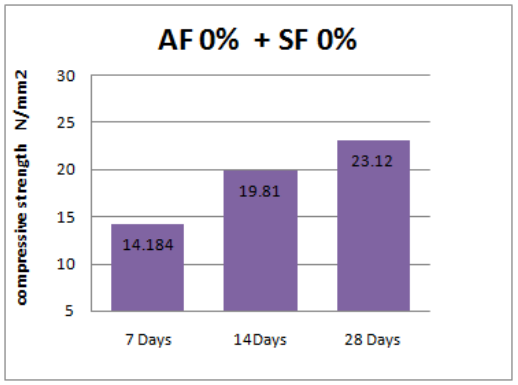
Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to the various kinds of effect and applied loading itself, however tensile strength of concrete is very low in compared with compressive strength

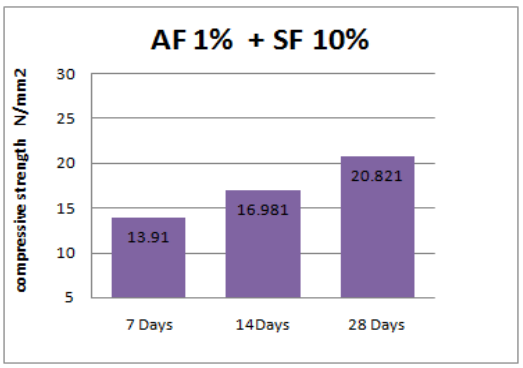
% of Agave Fiber	Silica fume	Tensile Strength (N/mm2)		
		7th Day	14th Day	28th Day
0%	0%	2.636	3.116	3.366
1%	10%	2.611	2.885	3.194
2%	10%	2.617	2.897	3.241
3%	10%	2.587	2.950	3.281
4%	10%	2.601	2.988	3.329
5%	10%	2.586	3.044	3.391

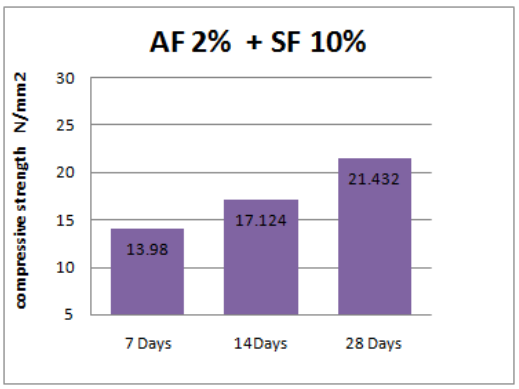
Table 4.2 Tensile strength of concrete.

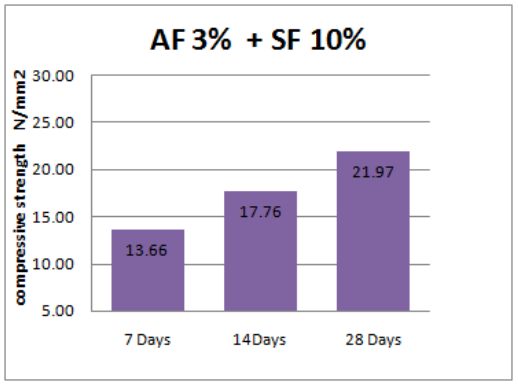
Graphs

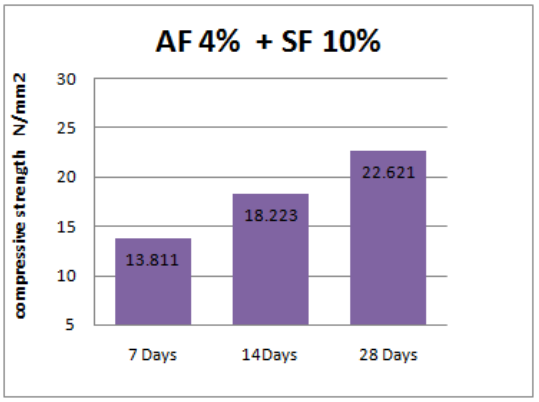
Compressive strength

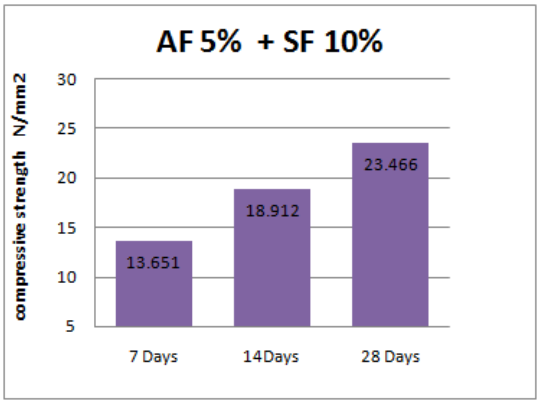




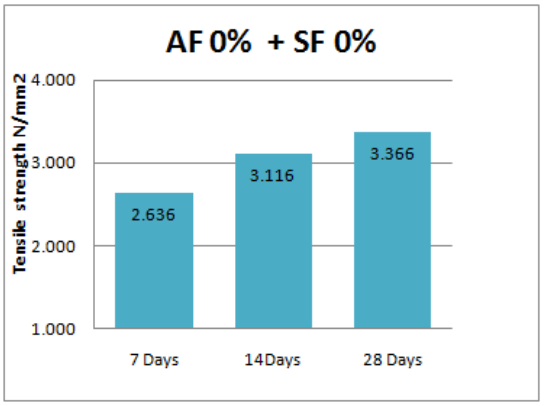


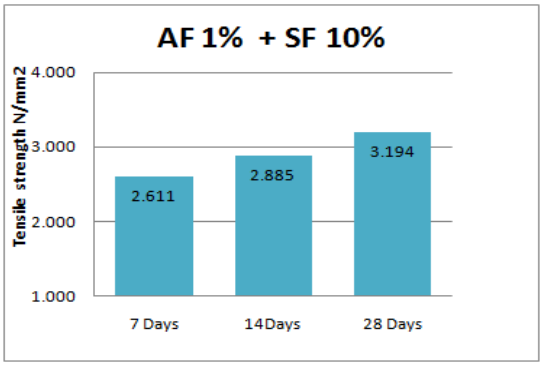


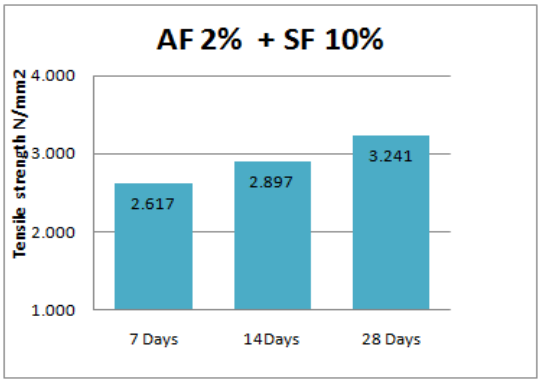


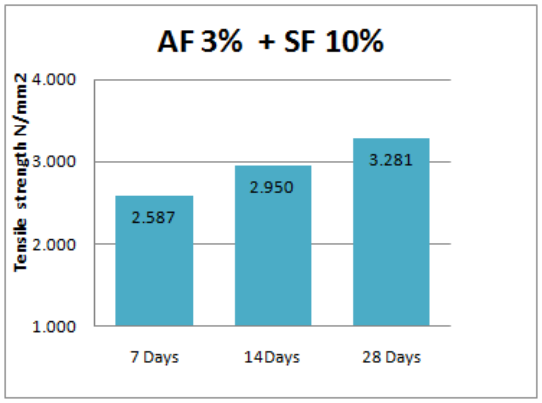


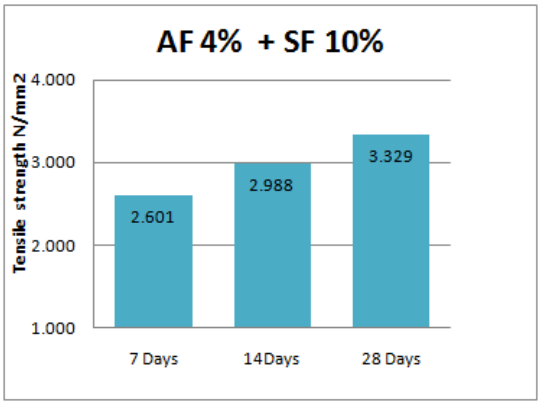
Tensile Strength

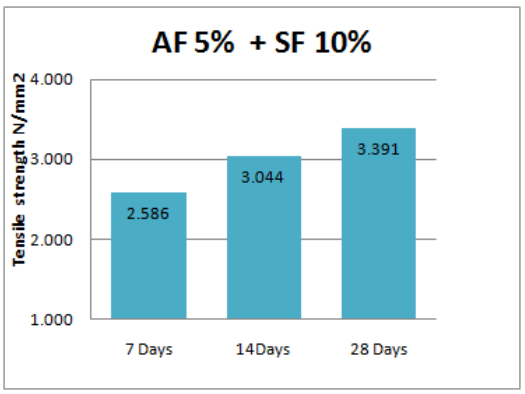












CONCLUSION

- The test results shows that 0% , 1% ,2% ,3% 4% and 5% of Agave Fiber With addition 10% silica fume shows the increasing in compressive and tensile Strength.
- The compressive strength and Tensile is been increased From 23.12 N/mm2 and 3.36 N/mm2 for 0% to 23.466 N/mm2 and 3.391 N/mm2 for 5 % Agave fiber.
- It has been observed that the workability of concrete decreases with the addition Agave Fibres 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.

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