EFFECTS OF COCONUT FIBERS ON THE PROPERTIES OF CONCRETE

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Abstract

The materials chosen for structural up gradation should not pollute the environment and endanger bioreserves. They should be accessible to the ordinary people and be low in monetary cost. Coconut fiber is an abundant, versatile, renewable, cheap, lignocellulosic fiber and more resistant to thermal conductivity. The aim of investigation is to study the possibilities to use the coconut fiber in addition to the other constituents of concrete and to study the strength properties. A literature survey was carried out, which indicates that the detailed investigation of coconut fiber concrete is necessary. In the present study the deformation properties of concrete beams with fibers under static loading condition and the behavior of structural components in terms of compressive strength for plain concrete(PC) and coconut fiber reinforced concrete(CFRC) has been studied.

The testing of various material constituents of concrete was carried out according to the Indian Standard specifications. To identify the effects on workability and mechanical strength properties due to the addition of these coconut fibres, workability tests such slump, vee – bee, compaction factor test, Flow table tests, and the mechanical strength tests on standard specimens such as compressive strength, split tensile strength, modulus of rupture were conducted on the different aspect ratio. The standard cubes, cylinders and beams for conventional concrete and coconut fiber reinforced concrete were prepared and tested under compression testing machine and flexure testing machine respectively. The suitability of CFRC as a structural material is studied, in comparison with conventional concrete.

Keywords: *CFRC1, Concrete properties2, Coir3.*

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1. INTRODUCTION

1.1 General

Plain concrete is a brittle material. Concrete without any fibers will develop cracks due to plastic shrinkage, drying shrinkage and changes in volume of concrete. Development of these micro cracks causes elastic deformation of concrete. In order to meet the required values of flexural strength, fibers are used in normal concrete. The addition of fibers in plain concrete will control the cracking due shrinkage and also reduce the bleeding of water. Not much importance is given to the use of coconut fibers (coir) in concrete. Some of the researchers have used coconut shells as a partial replacement of coarse aggregates.

To overcome the brittle response of the concrete. Micro structural properties of natural fibers as composites in terms of flexibility, ductility and energy absorption improve seismic resistance. Fibers in concrete serve as crack arrestor which can create a stage of slow crack propagation and gradual failure. The use of natural Fibers is economical as compared to synthetic fibers.

Coconut fiber is used in many ways. Some of them are floor mats, floor tiles, sackings. A small amount is used in making twine. The major use is in rope industry. White coir is used in making fishing nets due to high resilience to salt water. However, the use of *coconut fibers in concrete* has to be investigated.

1.2 Material constituents of CFRC

Coconut fiber - Fibres are strong, light in weight. The addition of coconut fiber can reduce the thermal conductivity of the composite specimens. Cement- Ordinary Portland cement of 43 grade. Sand- Passing through 4.75mm sieve Coarse aggregate- 20mm and downsize. Water- potable water

2. EXPERIMENTAL PROGRAMME

2.1 General

To accomplish the objectives of the study, the experimental program was carried out on cubes, cylinders and beams. The details of the materials used for these specimens and testing procedure incorporated in the test program are presented in the subsequent sections.

2.2 Tests on coarse aggregate

The coarse aggregate passing through 20mm size sieve and retaining on 10mm sieve is tested as per IS:2386-1963 and properties are listed below

Table 2.1 Properties of Aggregate

Sl. No.	Property	Value
1	Crushing value	14.86%
2	Impact value	2.75%
3	Abrasion value	11.4%
4	Specific gravity	2.75
5	Water absorption	1.2%

2.3 Tests on fine aggregate

The fine aggregate passing through 4.75mm sieve is tested as per IS: 2386(part III) and the properties are listed below

Table 2.2 Properties of Sand

Sl. No.	Property	Value
1	Sieve analysis	Zone II
2	Specific gravity	2.52

2.4 Tests on cement

The cement is tested as per IS: 431(part IV)-1988 and the properties are listed below

Table 2.3 Properties of Cement

Sl. No.	Property	Value
1	Fineness test	5.5%
2	Setting time a)initial b)final	 45 min 165 min
3	Specific gravity	3.15
4	Soundness test	3.5 mm

2.5 Preparation of coir

- The Coconut fibre (Coir) is Collected from rope industry , Hosadurga,
- Average diameter of fiber measured from Vernier caliper is 0.0226cm
- Average length of fiber measured is 19.43cm
- According to fixed Aspect ratio is 75 and 125, fibers were cut to the length of 1.7cm and 2.8cm respectively.

2.6. Concrete Mix Design

The proportioning of ingredients of concrete is governed by the required performance of two states namely; the plastic state and the hardened state. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes important.

The Mix Design for concrete was carried out with the guidelines from IS:10262- 2009 for M30 grade concrete with the water cement ratio of 0.5.

1) Water= 185 kg/m^3
2) Cement= 375 kg/m^3
3) w/c ratio= 0.5
4) Aggregates:
- Coarse aggregate fraction= 0.58
- Fine aggregate fraction= 1-0.58=0.42

5) a) Volume of concrete= 1m^3
b) Volume of cement= (375/2.92)*(1/1000)
= 0.128m^3
c) Volume of water= (185/1)*(1/1000)
= 0.185m^3
d) Volume of aggregates in all= 1-0.128-0.185
= 0.687m^3
e) Coarse aggregate= 0.695*0.58*2.75*1000
= 1095.765 kg/m^3
f) Fine aggregate= 0.695*0.42*2.52*1000
= 727.1208 kg/m^3

Proportions for 1m^3

Water	cement	Fine aggregates	Course aggregates
185 kg	375 kg	727.1208 kg	1095.654kg

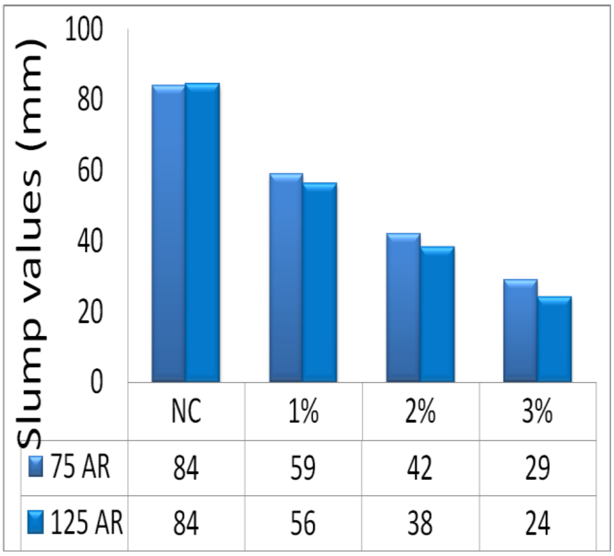
Mix proportion is 1:1.94:2.92
(cement: fine aggregate: coarse aggregate)

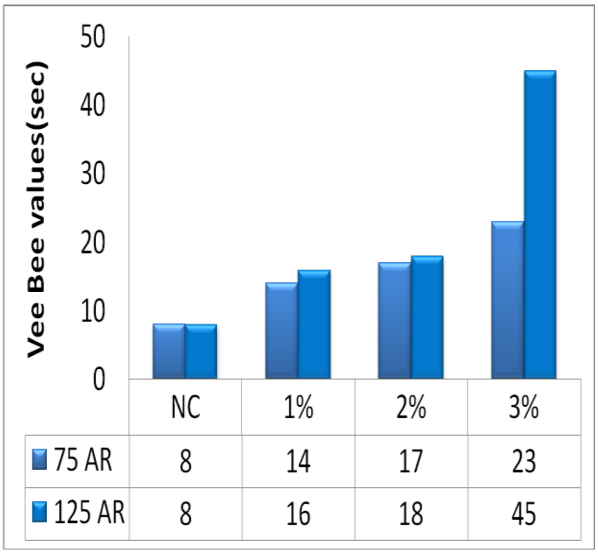
3. TESTS ON FRESH CONCRETE

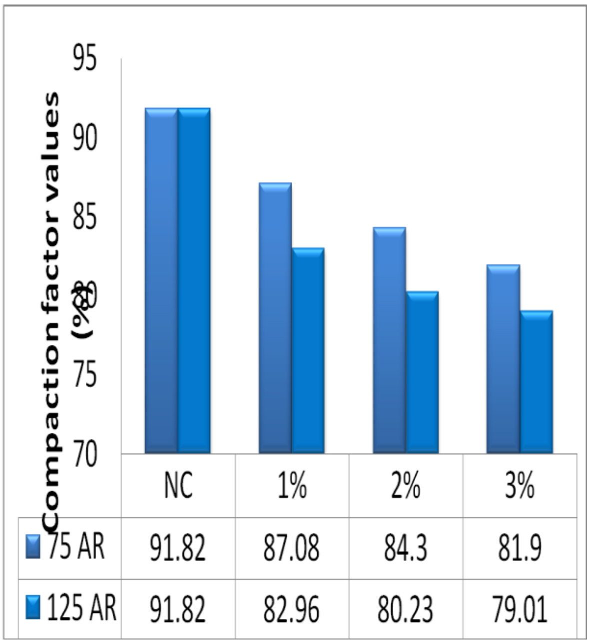
Tests on fresh concrete were carried out determine the workability of normal concrete as well as CFRC as per IS:1199-1959. The properties of the tests are listed in the table 3.4

Table 3.1 Properties of fresh concrete

	Slump value	Compaction factor	Vee bee test	Flow table test
Normal concrete	84mm	91.82%	8 sec	80.13%
with 1% fibre a)75 AR b)125 AR	 59mm 56mm	 87.08% 82.96%	 14 16	 60.00% 58.26%
with 2% fibre a)75 AR b)125 AR	 42mm 38mm	 84.30% 80.23%	 17 18	 58.67% 53.23%
with 3% fibre a)75 AR b)125 AR	 29mm 24mm	 81.90% 79.01%	 23 45	 55.14% 49.98%







Graphical representation of slump values, vee-Bee value, compaction factor values.

Materials Used

Cement: Ordinary Portland cement of 43-grade.
Sand: Locally available river sand passing through 4.75mm sieve.
Aggregate: Well graded crushed aggregate passing through 20mm sieve and retaining on 10mm sieve.
Water: potable water.
1st mix: Aspect Ratio-75
Mix proportion- **1:1.94:2.92**
Fibers added-1%, 2%, 3% by weight of cement
2nd mix: Aspect Ratio-125
Mix proportion- **1:1.94:2.92**
Fibers added-1%, 2%, 3% by weight of cement

4. CASTING

1st a layer of coarse aggregates were spread on clean tray. Then the fibers were separated manually and spread. Over the fibers fine aggregates were spread and dry mixed for 2 minutes. Then cement was added and dry mixed again. 50% of the water was added first and mixed properly. Then by adding remaining water the concrete was mixed.

Then 21 cubes of 150*150*150mm , 21 beams of 100*100*500mm and 21 cylinders of 150mm dia*300mm height were cast for 7 days strength and were demoulded after 24 hours of casting and were subsequently cured in water bath for 3 days.

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Then 21 cubes of 150*150*150mm , 21 beams of 100*100*500mm and 21 cylinders of 150mm dia*300mm height were cast for 28 days strength and were demoulded after 24 hours of casting and were subsequently cured in water bath for 28 days.

5. TESTING AND RESULTS

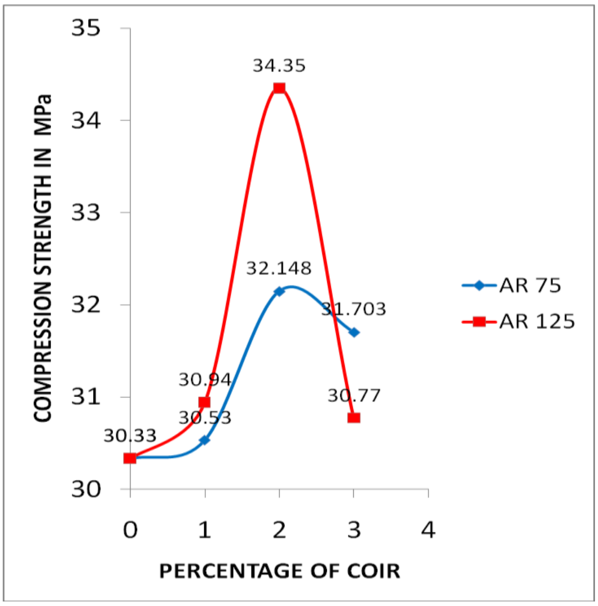
5.1 Compressive Strength

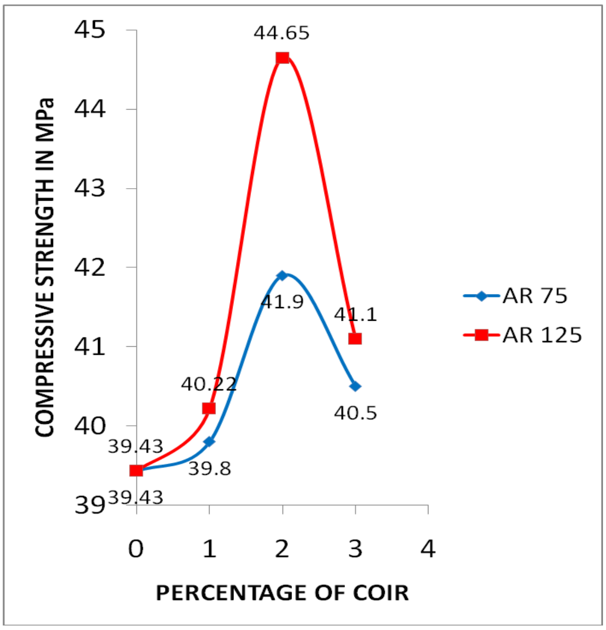
All the cubes were tested in a 'Compressive Testing Machine' to determine the compressive strength of the cubes. The procedure is as follows.

Compression test of cube specimen are made as soon as practicable after removal from curing pond. Place the specimen centrally on the location marks of the compression testing machine and load is applied continuously, uniformly and without shock. The rate loading is 2kN/Sec continuously. The load is increased until the specimen fails and record maximum load carried by the each specimen during the test. Also note the type of failure and appearance of cracks.

Compressive Strength =Average load/Area of cross section. Compressive strength has also a decreasing trend with increasing fibre content in CFRC. But CFRC with 2% fiber content has higher compressive strength as compared to that of PC. In comparison to compressive strength of Plain Concrete, Compressive strength is increased up to 1% for 75 aspect ratio and 2% for 125 aspect ratio with 1% fibre.

Compressive strength is increased up to 6% for 75 aspect ratio and 13% for 125 aspect ratio with 2% fibre. Compressive strength is increased up to 3 % for 75 aspect ratio and 4% for 125 aspect ratio with 3 % fibre. As compared to 2% coconut fibre 1% and 3% coconut fibre has given the lesser compressive value. Higher fibre content in CFRC might have caused voids resulting in decreased compressive strength.





Graphical representation of compression strength for 7days, 28 days and picture showing failure specimen

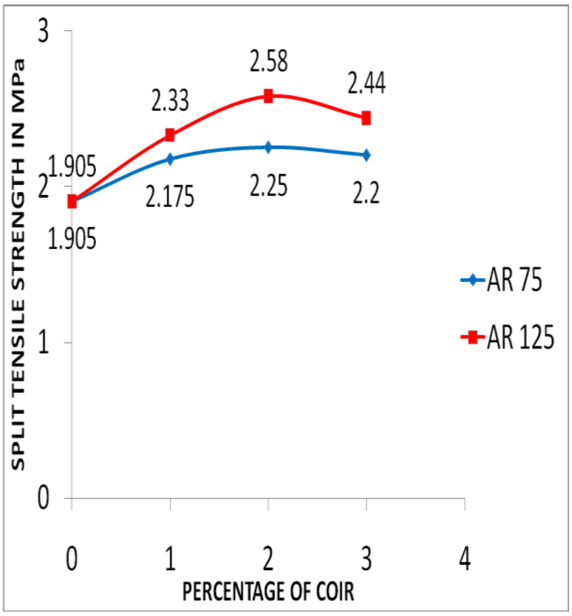
5.2 Splite Tensile Strength

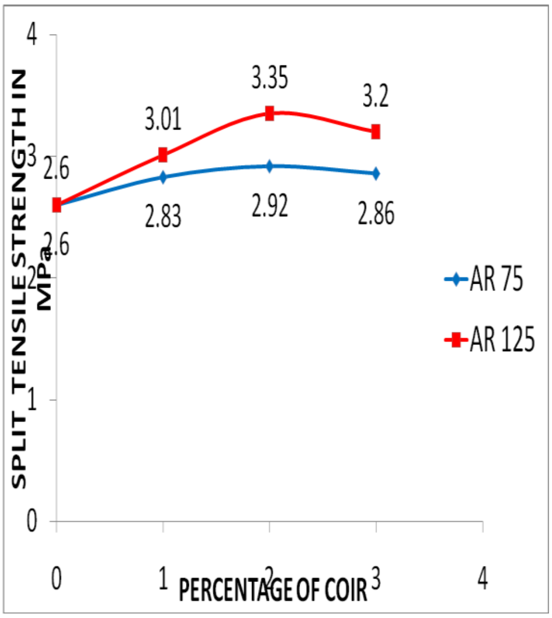
All the cylinders will be tested in a ‘Compressive Testing Machine’ to determine the split tensile strength of the cylinders. The procedure is as follows.

Split tensile test of cylinder specimen are made as soon as practicable after removal from curing pit. Centre one of the plywood strip along the centre of the lower platen. Place the specimen on the plywood strip and align so that line mark on the specimen are vertically and centered over the plywood strip. The second plywood strip is placed lengthwise on the cylinder centered on the lines marked on ends of the cylinder. Then Load is applied continuously, uniformly and without shock. The rate loading is 2kN/Second continuously. The load is increased until the specimen fails and record max load carried by the each specimen during the test. Also note the type of failure and appearance of cracks. Split tensile strength can be calculated by

Split tensile Strength = $2P/\pi Dl$, where P= Average applied load, D= Diameter of specimen, l = Length of specimen.

It has decreasing trend with increasing fibre content in CFRC. But CFRC with 2 % fibre content has higher Split Tensile Strength as compared to that of PC. In comparison to STS of Plain Concrete, Split tensile strength is increased up to 9% for 75 aspect ratio & 16% for 125 aspect ratio with 1% fibre. Split tensile strength is increased up to 12% for 75 aspect ratio & 29% for 125 aspect ratio with 2% fibre. Split tensile strength is increased up to 10% for 75 aspect ratio & 23% for 125 aspect ratio with 3% fibre.





Graphical representation of split tensile strength for 7days, 28 days and picture showing failure specimen

Flexural Strength

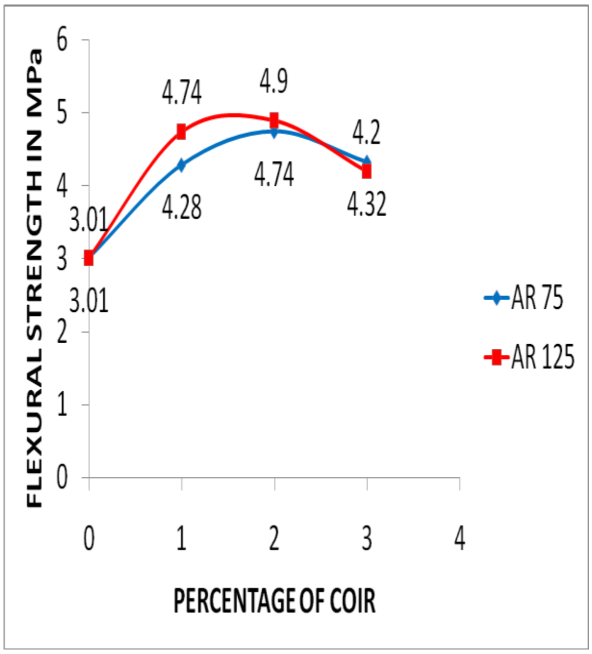
All the beams will be tested in 'Universal Testing Machine' under two point loading to obtain the Flexural strength of the beams. Flexural strength of beam specimens are made as soon as practicable after removal from curing pond.

Mark the distance 50mm of supporting rollers on each side of the specimen and mark the distance 133.33mm of loading roller from the supporting rollers. Then 2 point loading is applied continuously, uniformly and without shock. The rate loading is 180kg/Minute continuously. The load is increased until the specimen fails and record max load carried by the each specimen during the test. Also note the type of failure and appearance of cracks. The following formula were used depending upon distance of line of fracture(a) from nearest support.

i. Flexural Strength $=Pl/bd^2$ When 'a'>13.3cm
ii. Flexural Strength $=3Pa/bd^2$ When 'a'<13.3cm and > 11cm.

Where P= Average applied load, d= Depth of specimen, b= Breadth of specimen, a= Cracking distance from nearest support, l = Length of specimen.

As compared to 2% coconut fibre 1% & 3% coconut fibre has given the lesser tensile value. Flexural strength is increased up to 32% for 75 aspect ratio & 47% for 125 aspect ratio with 1% fibre. Flexural strength is increased up to 45% for 75 aspect ratio & 50% for 125 aspect ratio with 2% fibre. Flexural strength is increased up to 34% for 75 aspect ratio & 31% for 125 aspect ratio with 3% fibre. As compared to 2% coconut fibre 1% & 3% coconut fibre has give the lesser Tensile value.



Graphical representation of Flexural strength for 7days, 28 days and pictures showing failure specimen

6. CONCLUSION

Based on the objectives set in the present study and the experimental work carried out in the laboratory, the following conclusions are drawn.

6.1 Properties of fresh concrete:

As the fiber content was increased, the mix became more cohesive. Workability decreased as the fiber content increased.

6.1.1 Slump test

- As compared to normal concrete, slump decreased 30% for 75 AR and 33% for 125AR for 1% fiber content.

Similarly slump value decreased for 2% and 3% fiber content.

6.1.2 Compaction factor test

- As compared to normal concrete, compaction factor value decreased 5% for 75 AR and 10% for 125AR for 1% fiber content.

Similarly workability decreased for 2% and 3% fiber content.

6.1.3 Vee-bee test

- As compared to normal concrete, time taken to change the shape from cone to cylinder increased 75% for 75 AR and 100% for 125AR for 1% fiber content.

Similarly there was increase in time for 2% and 3% fiber content.

6.1.4 Flow table test

- As compared to normal concrete, flow was decreased 25% for 75AR and 27% for 125AR for 1% fiber content.
- There was decrease in flow for 2% and 3% fiber content.

6.2 Properties of hardened concrete:

The compressive strength, Split tensile strength and Flexural strength has a increasing trend upto 2%. Later, strength decreased with the increase in fiber content. CFRC with 2% fiber content has higher compressive strength, Split tensile strength and Flexural strength as compared to that of PC.

6.2.1 Compressive strength

- Optimum results were found when 2% of coir by weight of cement fibers were used, there was 6% and 13% increase in compressive strength as compared to normal concrete for 75AR and 125 AR respectively.

6.2.2 Split tensile strength

- Split Tensile Strength increased up to 12% for 75 aspect ratio and 29% for 125 aspect ratio with 2% fibre.

6.2.3 Flexural strength

- Modulus of Rupture increased up to 45% for 75 aspect ratio and 50% for 125 aspect ratio with 2% fibre.

Cement content can be reduced by using 125AR fibers. This reduces total production of cement content there by resulting in less emission of CO_2.Thus the coir is found effective in reducing environmental pollution.

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