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Durability Study on Coir Fibre Reinforced Concrete

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***Abstract*— The use of fibres in concrete has demonstrated excellent structural performance, there still exists the need for understanding the durability of fibre reinforced concrete in the environment to which concrete structures are generally exposed. The aim of this study is to evaluate the durability properties of coir fibres in the structural concrete. Experimental investigation explores durability properties such as water absorption, acid resistance and sulphate resistance. The fibre volume fraction ranges from 0 to 3% for a length of 1.5 and 3cm. From the experimental investigation, it was found that there is improvement in durability properties for coir fibre reinforced concrete when compared to plain cement concrete. Also coir reinforced concrete improves the cracking resistance compared to plain cement concrete.**

Keywords*— *Fibre, Durability, Coir Fibre Reinforced Concrete, Crack

I. INTRODUCTION

Fibre reinforced concrete (FRC) is a promising material in direction possessing higher durability under extreme environments. It is a composite matrix containing a random distribution of minor natural or artificial fibres having higher tensile strength compared to normal concrete. Due to the presence of these homogeneously dispersed fibres, the cracking strength of FRC will be increased. The fibres act as crack arresters, enhancing the crack resistance of FRC. The fibers are being used in structural applications with conventional reinforcement. Because of the flexibility in methods of fabrication, fiber reinforced concrete can be an economic and useful construction material.

There are numerous fiber reinforced concrete types available for commercial and experimental use.

Types of FRC are: steel, glass, synthetic, and natural fiber reinforced concretes.

- Steel fiber reinforced concrete.
- Glass fiber reinforced concrete.
- Synthetic fiber reinforced concrete.
- Natural fiber reinforced concrete.

In this paper, coir fibre is considered which is the natural fiber of the coconut husk where it is thick, coarse and durable fiber. The common name, scientific name and plant family of coconut fiber is Coir, Cocos nucifera and Arecaceae (Palm), respectively. There are two types of coconut fibers, brown fiber extracted from matured coconuts and white fibers extracted from immature coconuts. Brown fibers are thick, strong and have high abrasion resistance. White fibers are smoother and finer, and also weaker. Both brown and white coir consist of fibers ranging in length from 4-12 in (10-30 cm). Those that are atleast 8 in (20 cm) long are called bristle fiber. Shorter fibers, which are also finer in texture, are called mattress fiber. A 10-oz (300-g) coconut husk yields about 3 oz (80 g) of fiber, one-third of which is bristle fiber. Industries based on coir have developed in many coconut producing countries especially India, Tanzania, Kenya, Bangladesh, Burma, Thailand, Sri Lanka, Nigeria, Ghana etc.

The concrete reinforced with fibres have been investigated in the past few years with different proportions in order improve the durability, mechanical properties and toughness of concrete. Presently, fibre having good tensile strength is becoming popular

Shreeshail. B H, et al. [1] conducted a study on concrete reinforced with coir fibre. The coir fibres of different proportions and lengths are studied. The proportions of 1, 2, 3 and 4 % weight of cement and length of 1.7 and 2.8 cm were used and considered the mix design of M30. From the study it was concluded that, 1% and 3% coconut fibre has given lesser compressive strength when compared to 2%. Higher fibre content in CFRC might have caused voids resulting in decreased compressive strength.

Thandavamoorthy, et al. [2] conducted a study on the concrete reinforced with steel fibre (4%), polypropylene fibre (4%), hybrid fibre that enclose (2% steel fibre and 2% polypropylene fibre). The results of those fibres were compared with standard concrete. The test results showed that the addition of steel and polypropylene fibres to concrete reveal better concert. Result of water absorption test for SFRC and hybrid specimen were same as that of normal concrete. But in the case of polypropylene fibre reinforced concrete, it was 4% booster than normal concrete.

Srinivasa Rao et al.[3] investigated the durability studies on glass fibre reinforced concrete (GFRC). The results showed that there was an increase in the durability of the concrete by adding together these glass fibres in concrete. Addition of glass fibres in concrete gave a reduction in bleeding, and also enhanced the resistance of concrete to the assault of acids. Maximum improvement in durability of concrete with different percentage of glass fibres was observed at 28days and 90 days at 0.1% for all grades of concrete. Chloride permeability of glass fibre reinforced concrete showed less permeability of chlorides into concrete when compared with ordinary concrete.

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Venkat Rao et al, [4] carried out an investigational study on durability of high strength self-compacting concrete (HSSCC). The sulphate attack effect on concrete and confrontation of concrete to the attack had been experienced in the laboratory, by immersing specimens of concrete cubes in the solution which encloses 5% sodium sulphate. The chemical attack effect had been estimated by taking adjustment of mass in to consideration. The sulphate attack effect on performance and properties of concrete were acknowledged. Even from the optical surveillance, the intensity of sulphate attack on cracking and the impact of breakdown were noticed.

VijayaSekhar Reddy et al,[5].The test specimens of 15 cm×15 cm×15 cm cubes were immersed in 5 % of sodium hydroxide solution over a period of 90 days. The effect of alkali attack on performance and properties of concrete were found out. Percentage decrease in weight after 28 days was found to be 10.32 %.

Desai et al. [6] conducted a study on durability properties of fibre reinforced concrete on marine structures. In this study the properties of fibre reinforced concrete were compared with those of conventional concrete and also its environmental effects on durability of concrete. Results showed that the addition of polypropylene triangular fibres improved the durability of concrete. Compressive strength of concrete increases with increase in fibre dosage up to 0.3%, then it starts diminishing. So the best possible percentage fibre found from experiment was 0.3%.

Kokseng Chia et al. [7] accomplished an investigational study on the water permeability and chloride permeability of high strength light weight concrete (LWC) in comparison to that of normal strength concrete with or without silica. Results were compared with LWC and NWC (Normal Weight Concrete) at a normal strength of about 30-40MPa. The water penetrability of the LWC with a w/c of 0.55 was lower than that of the equivalent NWC, when the concrete was subject to a pressure of 4MPa when the strength level reached 30-40MPa. The water penetrability of the high-strength LWC and NWC with a w/c of 0.35 was of the same order regardless whether silica fume was incorporated. The results point out that the resistance to the chloride dissemination does not seem to be concurrent to the water permeability of the concrete.

The objective of this paper is to:

1. Study the durability properties of concrete made with coir fibres.
2. Compare the properties with normal concrete.

In this paper, methodology consists of 2 parts:

- Material testing
- Durability test

II. MATERIAL TESTING

The materials used for this study are normal fine aggregate, normal coarse aggregate, coir fibre and PPC of 53 grade. The properties of each of these materials contribute to the quality of produced concrete. The mechanical properties of the aggregates as obtained from various tests are shown in Fig1 and Fig2. Sieve analysis was done based on IS: 2386–1963. Sieves of size 80mm, 40mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600micron, 300 micron, and150 micron were used.

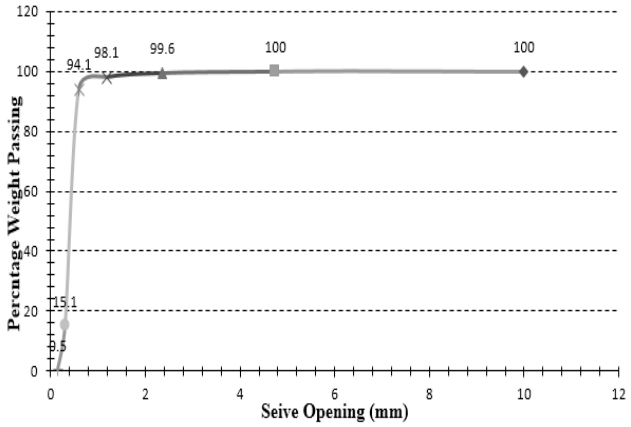

Fig 1: Grain Size Analysis of Fine Aggregate

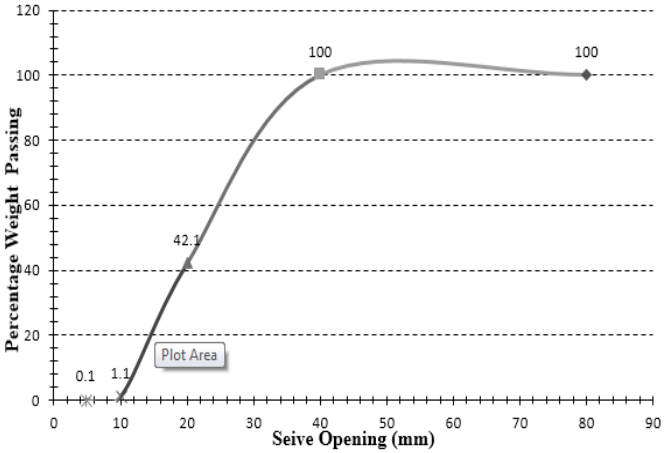

Fig 2: Grain Size Analysis of Coarse Aggregate

The graph indicates that the tested fine aggregate is uniformly graded. From the sieve analysis the sum of cumulative percentage weight retained was obtained to be 292. Therefore the fineness modulus is equal to 2.92.

The cement used for the study is PPC of 53grade. The properties of the cement determined from various tests are shown in Table 1.

Table1: Properties of PPC

Standard consistency	35%
Initial setting time	90mins
Final setting time	270mins
Specific gravity	2.80
Soundness	0.5mm
Fineness	1%

The physical and chemical properties of coir fibre used in the project were taken from the journal "*coconut fibre –a versatile material and its applications in engineering"* by *Majid Ali.*

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The properties are:

Chemical Composition of Coconut / Coir Fiber:

- Lignin…….....……..45.84%
- Cellulose…….....……..43.44%
- Hemi-Cellulose…….....00.25%
- Pectin's and related Compound...……03.00%
- Water soluble…….....05.25%
- Ash…….....02.22%

Physical Properties of Coconut / Coir Fiber:

- Length in inches……...6-8
- Density (g/cc)……...1.40
- Tenacity (g/Tex)……10.0
- Breaking elongation%.....30%
- Diameter in mm……0.1 to 1.5
- Rigidity of Modulus……1.8924 dyne/cm2
- Swelling in water (diameter)...……5%
- Moisture at 65% RH…….10.50%

The trial mix proportions for M30 grade concrete were prepared and tabulated based on IS 10262 -2009. After conducting trial mixes with water cement ratio 0.45, the mix proportion ratio selected was 1: 1.32: 2.63.

III. DURABILITY TEST

To determine the durability of the FRC, various tests such as acid attack, sulphate attack, and water absorption test were conducted.

i. Acid attack test

The Acid attack test is conducted as per ASTM C 267. For determining the resistance to acid, the cubes are to be immersed in sulphuric acid (H_2SO_4) solution for 28 and 56 days. Concrete in proportion of 0%, 1%, 2%, and 3% of fibres by weight of cement and length of 1.5cm and 3cm of coir fibre cubes were casted. The results obtained for the weight loss and strength loss of the concrete are shown in Table2 and Table 3 respectively.

Table 2: Loss in Weight after Immersion in Sulphuric Acid
For length 1.5 cm

Percentage of Coir Fibre	% Mass Reduction	
	28th day	56th day
0	2.857	7.058
1	0.87	3.2
2	1.53	3.9
3	2.7	4.4

For length 3 cm

Percentage of Coir Fibre	% Mass Reduction	
	28th day	56th day
0	2.857	7.058
1	0.72	2.8
2	1.2	3.4
3	2.2	3.98

It was observed that there is a slight increase in the strength reduction as the fibre content is increased from 1%. From the above values, it was observed that the optimum percentage and length of coir fibre is 1% and 3cm respectively.

Table 3: Loss in Strength after Immersion in Sulphuric Acid
For length 1.5cm

Percentage of Coir Fibre	Strength Reduction	
	28th day	56th day
0	23.7	36.98
1	21.4	26.86
2	24.69	31.53
3	29.7	35.13

For length 3cm

Percentage of Coir Fibre	Strength Reduction	
	28th day	56th day
0	23.7	36.98
1	13.49	24.41
2	16.79	27.22
3	19.9	32.41

From the above tables, it was observed that the optimum percentage and length of coir fibre are 1% and 3cm respectively.

ii. Sulphate attack test

The sulphate attack test is based on ASTM C 1012. This test was conducted on 150 × 150 ×150 mm concrete specimens for loss in mass and reduction in compressive strength. For determining the resistance to sulphate, the cubes are to be immersed in a 5% sodium sulphate solution for 28 and 56days.The effect of sulphate attack on the properties of concrete was identified in terms of weight loss and strength loss and is shown in Table 4 and Table 5 respectively.

Table 4: Loss in Weight after Immersion in Sodium Sulphate solution

(Length of fibre – 1.5cm)

Percentage of coir Fibre	Percentage Mass Reduction	
	28th day	56th day
0	1.2	2.4
1	0.865	1.6
2	0.89	1.9
3	0.95	2.1

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(Length of fibre – 3cm)

Percentage of coir Fibre	Percentage Mass Reduction	
	28th day	56th day
0	1.2	2.4
1	0.85	1.4
2	0.87	1.7
3	0.93	1.96

From the above tables, it was observed that the optimum percentage and length of coir fibre are 1% and 3cm respectively.

Table 5: Loss in Strength after Immersion in Sodium Sulphate solution

(Length of fibre – 1.5 cm)

Percentage of coir Fibre	Percentage Strength Reduction	
	28th day	56th day
0	4.14	6.03
1	1.94	2.2
2	2.01	2.8
3	2.12	3.4

(Length of fibre – 3 cm)

Percentage of coir Fibre	Percentage Strength Reduction	
	28th day	56th day
0	4.14	6.03
1	1.71	2.05
2	1.8	2.6
3	2.09	3.1

From the above tables, it was observed that the optimum percentage and length of coir fibre are 1% and 3cm respectively.

iii. Water absorption test

The water absorption is based upon IS 1124-1974. The water absorption of different percentages of coir fibre reinforced with normal concrete was studied and is shown in Table 6. Based on the test conducted the following results were obtained.

Table 6: Water Absorption of Concrete with different Percentages of Coir Fibres

Length 1.5cm

Grade of Concrete	Percentage of Coir Fibres	Water Absorption
M30	0%	3.681
M30	1%	3.586
M30	2%	4.227
M30	3%	4.321

Length 3cm

Grade of Concrete	Percentage of Coir Fibres	Water Absorption
M30	0%	3.681
M30	1%	3.35
M30	2%	3.66
M30	3%	4.01

The minimum water absorption rate is found on 1% of fibre content by weight of cement on both the lengths. The maximum water absorption is seen on normal concrete with 3.681%. While increase in the content of the fibre from 1%, it was observed that, there is increase in the rate of water absorption. The graphical representation of percentage of water absorption with different percentage of coir fibre content is shown in the Figure 4.

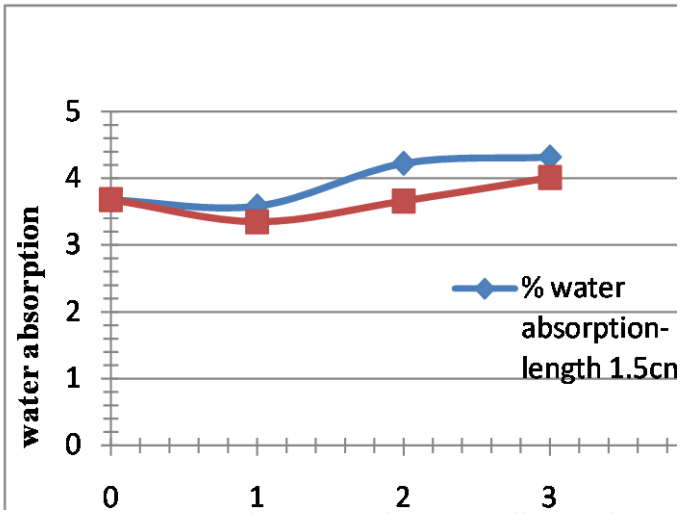

Fig 4: Water Absorption of Concrete Reinforced With Different % of Fibre

Concrete reinforced with different percentage of coir fibres had shown lesser value than the normal concrete. The minimum water absorption rate was found on 1% fibre content by weight of cement on both the lengths. The maximum water absorption is seen on normal concrete with 3.681%. While increase in the content of the fibre from 1% to more, it is clearly seen that, the water absorption rate is being increased.

V. CONCLUSION

Experimental investigation was done to evaluate the durability properties of concrete reinforced with coir fibre. The durability study includes acid attack, sulphate attack, and water absorption test. The tests were conducted for 28, and 56 days after the curing period. The coir fibres in concrete with length 1.5 and 3cm and proportion of 1%, 2%, and 3% by weight of cement were used in this investigation. From the present study, it is concluded that the concrete reinforced with coir fibres shows improved durability properties when compared to concrete with no fibre content

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