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CHEMICALLY TREATED COIR FIBER REINFORCED CONCRETE

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Abstract - *The study of adding coir fiber (coconut fiber) into the concrete structure differs in many engineering properties. Concrete is having a low tensile and also a flexural property. However, conventional steel reinforced concrete structures are the most popular method developed to reduce such problem and it is rather to becoming expensive for construction in terms of its costs and sustainability issues also, because of these problems in many constructions industry they reduce the strength of steel there by decreasing the strength to overcome these problem, by adding of coir fiber to the concrete structure increases the tensile and also the flexural properties and coir fiber are normally available in nature and it is also eco-friendly. This experiment was conducted on high strength concrete with addition of coir fiber with a 4 mix proportions (0, 0.1%,0.2% and 0.3%) and the compressive strength and tensile strength of cured concrete is evaluated for 28days. Stem of dissemination of information about the flood will bring a peaceful mind to the households leaving in the flood prone zones, hence can save their lives and avoid huge damages which is occurring from the natural disasters.*

Key Words: *Fiber-reinforced concrete, coir fibers, chemical treatment, interfacial bond, mechanical properties, sustainable construction.*

1.INTRODUCTION

Natural fibers are organic fibers are plant sources and animal products. They are used by humans for thousands of years for wide range of applications to their abundance, versatility, and desirable properties. Fibers are extracted from the plants like sisal, coir, jute, and from animal sources like wool and silk. Natural fibers possess several advantageous properties are suitable for various applications. They are renewable and biodegradable, making them environmentally friendly alternatives to synthetic fibers. They also have excellent breathability, moisture absorption, and thermal insulation properties, making them comfortable to wear in clothing and textiles. In addition to their textile applications, plant fibers are largely used as reinforcement materials in composites, including in construction materials like concrete and plastics. Which increase the engineering properties of composites by providing strength, stiffness, and impact resistance.

1.1 Coconut Fiber (Coir Fiber)

Coconut fiber (coir fibers) are natural fibers derived from the husk of coconuts, which are the fruits of the coconut palm tree (Cocos nucifera). Fibers are extensively used in other properties due to their unique properties and versatility. Coconut fibers are obtained from the innermost layer of coconut husk, known as the mesocarp. The process typically involves soaking the husks in water to soften them, followed by mechanical processes such as beating or retting to separate the fibers from the rest of the husk. The fibers are then cleaned, dried, and further processed for different applications.

1.2 Types of Coir Fiber

Coconut fibers are obtained from the outer husk of coconut shells and are largely used in various industries. There are classified into two types of coir fibers based on their extraction process and physical characteristics:

1. Brown coir fiber
2. White coir fiber

Brown Coir Fibers: Brown coconut fibers are obtained from mature coconut husks. These fibers are thick, strong, and have a brownish color. They are naturally used in applications that require durability and strength, such as mattresses, ropes, carpets, and geotextiles. Brown coir fibers are also used for erosion control and landscaping purposes.

White Coir Fibers: White coir fibers are derived from immature or green coconut husks. They are softer, finer, and have a lighter color compared to brown coir fibers. White coir is primarily used in the production of products that require a finer texture, such as upholstery padding, cushioning materials, and decorative items. It is also used for making brushes, doormats, and filling material.

1.3 Test conducted

Several tests are conducted on concrete to assess its quality, strength, durability, and other properties. Here are some commonly performed tests on concrete:

1. Compressive Strength Test: This is the most common and important test for concrete. It determines the

maximum compressive load a concrete sample can bear before failure. The test involves applying a gradually increasing load to a cylindrical or cubical concrete specimen until it fails.

2. Flexural Strength Test: Also known as the modulus of rupture test, it measures the tensile strength of concrete. A beam specimen is subjected to a bending force until it fractures. This test helps assess the concrete's ability to resist bending or cracking under load.

3. Splitting Tensile Strength Test: This test measures the tensile strength of concrete perpendicular to the applied compressive force. A cylindrical or cubical concrete specimen is subjected to a diametrical compressive force until it cracks. The splitting tensile strength is then calculated based on the applied load.

1.4 Chemical treatment

The recent trends in the development of the newer materials have led in replacing materials like glass and carbon reinforced composites with the natural fibers reinforced composites. However, the main drawback of natural fibers as reinforcement is that they are incompatible with thermoplastics due to their hydrophilic nature which results in the poor interfacial interaction between the fibers and matrix. This result in poor mechanical properties of the composites. Therefore, the modification of natural fibers is required to make them less hydrophilic. Here an attempt is made to brief about various chemical treatment on natural fibers.

ALKALINE TREATMENT

The alkaline treatment is a chemical treatment in which the natural fibers are immersed in a known concentration of aqueous sodium hydroxide (NaOH) 1N for a given temperature and a period of time.

2. MATERIALS AND METHODOLOGY

2.1 Materials

The materials used in this study are:

1. **Cement (PPC):** UltraTech Cements - 43 Grade
2. **Fine Aggregate:** M-Sand
3. **Coarse Aggregate:** Aggregates passing through 20mm IS sieve
4. **Coir fibre:** Fibre of length 1.5cm, 2.5cm and 3cm
5. **Water:** Collected from local fresh water sources

Tests conducted on cement: Various tests are conducted to evaluate the quality and performance of cement. These tests help assess properties such as fineness, setting time, compressive strength, soundness, and chemical composition.

Here are some common tests conducted on cement:

1. Fineness test
2. Setting time test
3. Soundness test
4. Specific gravity test

Table -1: Test results on cement

SL NO.	PROPERTY	VALUE	STANDARD VALUES (IS8112-1989)
1	Specific gravity of cement	2.9	Not specified
2	Normal consistency (%)	33	Not specified
3	Initial setting time of cement (minutes)	130	30 (minimum)
4	Final setting time of cement (minutes)	360	600 (maximum)

Test conducted on fine aggregate: Several tests are conducted on fine aggregates to assess their quality, suitability, and conformity to specifications. These tests help determine important characteristics such as particle size distribution, shape, cleanliness, strength, and durability. Here are some common tests conducted on fine aggregates:

1. Sieve analysis
2. Specific gravity
3. Water absorption

Table -2: Test results on fine aggregate

SL NO.	PROPERTY	RESULTS		
1	Specific Gravity	2.5		
2	Water absorption	1%		
3	Sieve analysis	IS Sieve	% passing	Conforming to grading zone II of IS 383:1970
		4.75 mm	94	
		2.36 mm	86	
		1.18 mm	68	
		600 µ	48	
		300 µ	14	
		150 µ	2	
		Pan	0.4	

Test conducted on coarse aggregate: Coarse aggregate undergoes testing to ensure its compliance with relevant standards and specifications. Tests such as sieve analysis, specific gravity, water absorption, and abrasion resistance help assess the quality and suitability of the aggregate for concrete production. It's important to note that local standards, construction practices, and regional availability of materials may influence the specific use and characteristics of coarse aggregate in different areas. Several tests are conducted on coarse aggregate to assess its quality and suitability for use in concrete.

Here are some common tests conducted on fine aggregates:

1. Sieve analysis
2. Specific gravity
3. Water absorption

Table -3: Test results on coarse aggregate

Sl. No.	PROPERTY	RESULTS		
1	Specific Gravity	2.8		
2	Water absorption	0.25%		
3	Sieve analysis (passing through IS 20mm Sieve)			
	IS Sieve	Weight retained	Cumulative % Weight retained	% passing
	40mm	0	0	100
	20mm	362.5	14.5	85.5
	10mm	2060.82	96.53	3.07
	4.75mm	31.40	98.18	1.82
	Pan	0	100	0

2.2 Methodology

MIX DESIGN

Most of the researches have studied the influence of coconut waste on M20 grade concrete. M20 concrete is a 1:1.5:3 mixture of cement, sand, and aggregate, where cement makes up one part, sand makes up 1.5 parts, and aggregate or stone makes up the remaining three parts.

Table -4: M20 Mix design

CEMENT	383.0Kg/m3
WATER	191.6kg/m3
FINE AGGREGATES	727kg/m3
COARSE AGGREGATES	1103kg/m3
WATER CEMENT RATIO (W/C)	0.50
RATIO	1:1.5:3

Calculation Of Quantity of Coir Fiber

Volume of mould (V) = 0.15 x 0.15 x 0.15 = 0.003375 m3

Fiber volume = 0.003375 m3

Fraction (VF) = 0

Fiber (D) = 1140 kg/ m3

No. of specimens (N) = 3

1) Wt. of 0.1 % coir fiber = VF x V x D x N
= (0.1 / 100) x 0.003375 x 1140 x 3
= 0.011 kg
2) Wt. of 0.2 % coir fiber = VF x V x D x N
= (0.2 / 100) x 0.003375 x 1140 x 3
= 0.023 kg
3) Wt. of 0.3 % coir fiber = VF x V x D x N
= (0.3 / 100) x 0.003375 x 1140 x 3
= 0.034 kg

2.3 Chemical Treatment of Fiber

Prepare the NaOH Solution:

Measure the appropriate amount of solid sodium hydroxide (NaOH) pellets. Add the NaOH pellets to distilled water in a container, while stirring continuously to dissolve the pellets.

Continue stirring until all the NaOH is dissolved and a homogeneous 1N NaOH solution is obtained. Ensure proper safety precautions while handling NaOH, such as wearing protective gloves and eyewear, as it is a caustic substance.

Fig 1: Weighing of NaOH Pellets

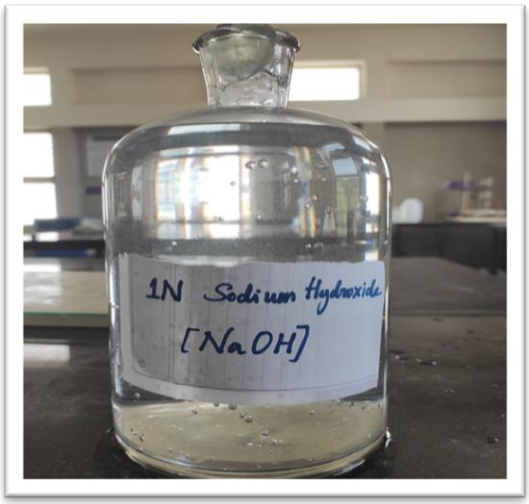

Fig 2: 1N NaOH Solution

Fiber Preparation:

Obtain natural coir fibers extracted from mature coconut husks. Cut the coir fibers into suitable lengths of 1.5cm, 2.5cm and 3cm, depending on the desired reinforcement length in the concrete.

Fig 4: Extraction of Coir Fiber From Matured Coconut Husks

Fig 5: Coir Fibers in Different Length

Immerse the coir fibers in the prepared 1N NaOH solution for 2hours. Ensure that the fibers are completely submerged in the solution and provide sufficient space for them to expand.

Fig 6: Coir Fiber During Treatment

Fiber Treatment:

During the immersion period, gently agitate or stir the fibers at regular intervals to ensure proper penetration and contact with the NaOH solution. The NaOH solution reacts with the lignin present in the coir fibers, removing impurities and enhancing fiber-matrix bonding properties. After the required immersion time, remove the fibers from the NaOH solution.

Fig 7: Treated Coir Fiber

Drying:

Allow the fibers to air-dry in room temperature or a well-ventilated area for 24 hours, such as natural sun-drying or mechanical drying, to remove excess moisture. Ensure that the fibers are completely dry before incorporating them into the concrete mix to prevent excess water absorption during mixing.

Fig 8: Treated Coir Fiber in Dry Condition After 24 Hours

Incorporation into Concrete Mix:

Mix the chemically treated and dried coir fibers with the other concrete ingredients according to the desired mix proportions of 0.1%, 0.2% and 0.3% and mixing methodology.

Fig 9: Weight of Treated Coir Fiber For 3 Different Mix Proportion

Gradually add the fibers into the concrete mixer during the mixing process to ensure even distribution and proper bonding between the fibers and the concrete matrix. Continue mixing until the fibers are uniformly dispersed throughout the concrete mixture.

Fig 10: Treated Coir Fiber Mixed with Concrete

It is important to note that the specific treatment duration, concentration of NaOH solution, and other parameters may vary based on research findings, project requirements, and available resources. It is advisable to refer to relevant literature, expert guidance, and conduct preliminary trials to optimize the chemical treatment process for 1N NaOH chemically treated coir fiber reinforced concrete.

2.4 Casting of chemically treated coir fibre reinforced concrete

The calculated amount of cement and fine aggregate are mixed together until a uniform mix is obtained. Fibres at varying amounts of 0.1%, 0.2% and 0.3% to that of weight

of cement are taken. Coir fibre strands are cut into a length of 1.5,2.5 and 3cm. Then the fibers are immersed in 1N NaOH solution for 2 hours and dried for 24hours in room temperature. It is then added to the mix. Coarse aggregates are then added to the same and mixed, followed by addition of water. Care should be taken to add water slowly in stages so as to prevent bleeding which may affect the strength formation of concrete. It is placed in the moulds of standard dimensions, compacted and finished. Casting of mould size 150 x 150 x 150 mm is also same for different percentages (i.e., 0.1%, 0.2% and 0.3%). Three cubes are casted for each percentage for compressive test. Estimation of split tensile strength for cylinder is 150 x 300 mm long using CTM machine of the capacity 300T. Flexural strength test for beam is 150 x 150 x 170 mm length using CTM machine of its capacity 300T.

Fig 11: Chemically Treated Coir Fiber Reinforced Concrete are Moulded

Fig 12: Chemically Treated Coir Fiber Reinforced Concrete are Unmoulded

3. RESULTS AND DISCUSSION

COMPRESSIVE STRENGTH TEST:

The compressive strength test is a fundamental test conducted on hardened concrete to determine its ability to withstand axial compressive loads. It is one of the most important tests for assessing the quality and performance of concrete. when conducting compressive strength tests to ensure accuracy, consistency, and comparability of the results. The compressive strength test helps assess the concrete's ability to resist compression and is critical for evaluating the structural performance of concrete elements in various applications.

Table -5: 28 Days Compressive Strength Test Result (N/Mm ^{2})

% OF FIBER ADDED	28 DAYS COMPRESSIVE STRENGTH TEST RESULT (N/mm ^{2})		
	15mm	25mm	30mm
0	22	22.03	23.04
0.1	25.03	26.7	29.01
0.2	25.13	26.9	29.89
0.3	25.7	27.03	30.02

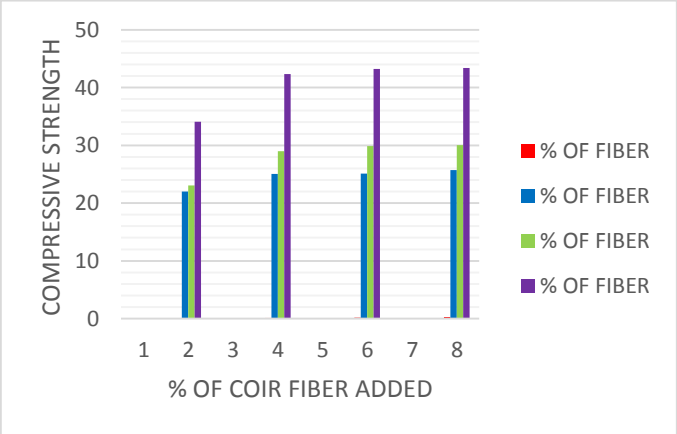

Chart -1: Compressive Strength Test 28days Result

Split Tensile Strength Test:

Determination of split tensile strength for cylinder 150X300mm long using CTM machine of capacity 300T, this is for each cube as per IS516-1959. Tensile strength is the capacity of a material or structure to withstand tension. It is measured on concrete cylinders of standard dimensions using a Universal Testing machine. Both conventional and fibre reinforced specimens were tested at varying percentages of fibre and the average value was obtained.

Table -6: 28 Days Split Tensile Strength Test Result (N/Mm²)

% OF FIBER ADDED	28 DAYS SPLIT TENSILE STRENGTH TEST RESULT (N/mm²)		
	15mm	25mm	30mm
0	3.41	3.58	3.64
0.1	3.52	3.77	3.91
0.2	3.64	3.85	4.01
0.3	3.52	3.7	3.68

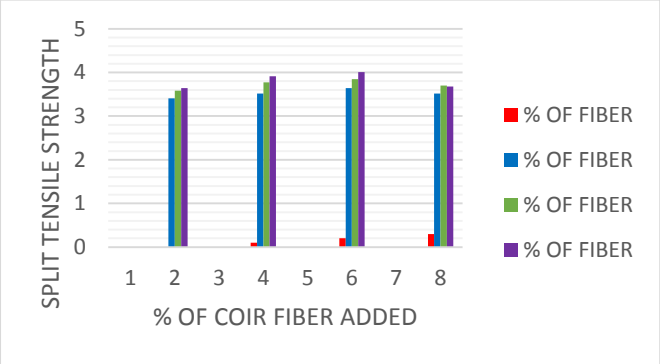

Chart -2: Split Tensile Strength Test 28days Result

Flexural Strength Test:

Flexure strength test for beam 150X150X170mm length using CTM machine of capacity 300T, this is for each cube as per IS516-1959. Flexural strength of concrete is considered as an index of tensile strength of concrete. Tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons. Beam tests are conducted to determine flexural strength of concrete. In flexural tests on beam theoretical maximum tensile strength is obtained at bottom of beam and is called modulus of rupture, which depends on dimension of beam and position of loading.

Table -7: 28 Days Flexural Strength Test Result (N/Mm ²)

% OF FIBER ADDED	28 DAYS FLEXURAL STRENGTH TEST RESULT (N/mm²)		
	15mm	25mm	30mm
0	3.82	4.16	5.03
0.1	3.96	4.29	5.67
0.2	4.32	4.53	4.79
0.3	4.35	4.42	4.57

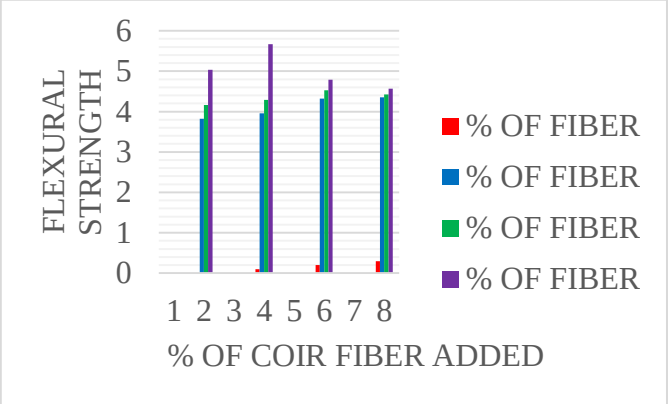

Chart -3: Flexural Strength Test 28days Result

RESULT:

The addition of 0.3% of treated coir fiber at length of 15mm, 25mm and 30mm improve in the result of compression strength test, split tensile strength test and flexural strength test, with best outcome observed for 30mm length chemically treated coir fiber reinforced concrete.

4. CONCLUSIONS

1. The concrete can be reinforced as coir fiber, which has been proven to be a successful material.

2. Test were carried out in labs all around the world to see the performance of concrete would be impacted by coconut fibers.

3. Coconut fiber is the perfect material for creating a lightweight version of concrete. Coir fibers are less dense than concrete and so the total weight of construction.

4. The coir fibers increase concrete specifications and aid in lowering environmental pollution. The study findings support the idea that no more than 1% of the fiber fraction should be used. Coir fibers has low heat conductivity hence it promotes natural cooling.

5. Improved Fiber-Matrix Bond: Chemical treatment of coir fiber with 1N NaOH can enhance the adhesion between the fiber and the concrete matrix. This treatment helps remove impurities and surface contaminants from the fibers, allowing for better bonding and improved mechanical properties of the reinforced concrete.

6. Enhanced Mechanical Properties: The addition of chemically treated coir fibers to concrete can lead to improvements in mechanical properties such as tensile strength, flexural strength, and impact resistance. The

treated fibers act as reinforcement, effectively distributing stresses within the concrete and enhancing its overall performance.

7. Reduction in Cracking and Shrinkage: The presence of coir fibers, especially when chemically treated, can help mitigate cracking and shrinkage in concrete. The fibers act as internal reinforcement, providing additional tensile strength and controlling the development of cracks, thereby improving the durability and longevity of the concrete structures.

8. It is important to note that these conclusions are generalized and based on the potential benefits associated with chemically treated coir fiber reinforced concrete.

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