Coir Fiber used as Composite Material in Roofing Tiles and Concrete Structures

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***Abstract*— In order to optimize the cost of construction, engineers have always been on the lookout for efficient and light roofing which requires minimum maintenance and labour to install. Coir is a green building material and has potential as a raw material for the production of roofing materials like corrugated sheets and tiles. The main object of the paper is produce cost effective roofing tiles without compromising their quality by replacing cement upto 15% using coir fibre. On the basis of the results, a composite with a fibre volume of 10% was considered to be the optimum composite. A comparison of material costs indicated that this composite tile was substantially cheaper than ordinary cement concrete tile.**

***Keywords*—Coir Fibre, Roofing tile**

Introduction

Coconut fibre is extracted from the outer shell of a coconut. It is natural fibre of coconut husk where it is a thick and coarse but durable fibre. The common name, scientific name and plant family of coconut fibre is coir, cocos nucifera and Arecaceae (palm) respectively.

Concrete made with Portland cement has certain characteristics: it is strong in compression but weak in tension and tends to be brittle. The weakness in tension can be overcome by the use of conventional steel bar reinforcement and to some extent by the inclusion of a sufficient volume of certain fibres. The use of fibres also alters the behaviour of the fibre-matrix composite after it has cracked, thereby improving its toughness.

The overall goal for this research is to investigate the potential of using waste and low energy materials for domestic construction, principally in Ghana.

Types of Coir fibre:

There are various types of coconut coir in the market and the most popular fiber types are

- Brown fiber
- White fiber
- Bristtle coir
- Buffering coir

i.**Brown Fiber:**

When coconut fiber is extracted from matured coconuts. They are naturally brown in colour having a strong and thick nature and good abrasion resistance. This fiber is called brownfiber.

i) Fig. Brown fibre

ii) White fiber :

When coconut fiber is extracted from immature coconuts. They are naturally white in colour having smooth and fine soft touch properties and it is also weaker than the brown fibre. This fibre is called white fibre.

Chemical composition of coconut/coir Fibre :

1)Lignin…………………………………………...………45.84%
2)cellulose…………………..……………..…………….43.84%
3)Hemi cellulose………………………………..……00.25%
4)Pectin's and related compound………………03.00%
5)Water soluble…………………………………………05.25%

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6)Ash……………………………………………………………0 2.22%

Physical Properties of Coconut / Coir Fiber:
1)Length in inches…………………….……6-8
2)Density (g/cc)…………………….……..1.40
3)Tenacity (g/Tex)…………………...…10.0
4)Breaking elongation%................30%
5)Diameter in mm………………..…….0.1 to 1.5
6)Rigidity of Modulus………………..1.8924 dyne/cm2
7)Swelling in water (diameter).….5%
8)Moisture at 65% RH…………..……10.50%

Tests to be conducted

Conducted tests on concrete cubes :-

1) Compression strength test
2) Efflourence test
3) Water absorption test

Conducted tests on concrete beams : -

1) Tensile strength test
2) Efflourence test
3) Water absorption test

Conducted test on roofing tiles :-

1) Compression stress strength
2) Efflourence test

RESULTS :

Compressive Strength For Concrete Cubes :

For ordinary Portland concrete :

TRAILS	STRENGTH AT 7 DAYS N\mm^2	STRENGTH AT 28 DAYS N\mm^2
1	465	495
2	460	485
3	450	487

For coir reinforced concrete :

COIR %	TRAILS	STRENGTH AT 7 DAYS N\mm2	STRENGTH AT 28 DAYS N\mm2
5%	1	475	504
	2	468	495
	3	464	498
10%	1	485	520
	2	495	516
	3	503	522

Efflorescence test results for ordinary portland concrete :

S.NO	DETERMINATION NO.	1	2	3
1	Weight of saturated concrete cube(A)	2565	2614	2575
2	weight of oven dried concrete cube (B)	2438	2483	2465
3	Water absorbtion =(A-B) / B * 100	5.2	5.27	4.46

Coir fiber reinforced concrete cubes :

Coir 5 % adding in the replacement of cement

S.NO	DETERMINATION NO.	1	2	3
1	Weight of saturated concrete cube(A)	2569	2643	2610
2	weight of oven dried concrete cube (B)	2457	2482	2460
3	Water absorbtion = (A-B) / B * 100	4.55	6.48	6.09

Coir adding 10% in the replacement of cement :

S.NO	DETERMINATION NO.	1	2	3
1	Weight of saturated concrete cube(A)	2546	2713	2657
2	weight of oven dried concrete cube (B)	2437	2487	2463
3	Water absorbtion =(A-B) / B * 100	4.47	9.08	7.87

Tests On Concrete Beams :

1) **Tensile strength test:**
   For opc concrete-

TRAILS	BREAKING LOAD FOR 7 DAYS	BREAKING LOAD FOR 28 DAYS
1	950 kN	1050 kN
2	920 kN	1025 kN
3	940 kN	1075 kN

For coir fibere concrete :

coir %	Trails	breaking load for 7 days	breaking load for 28 days
5	1	985 KN	1200 KN
	2	997 KN	1245 KN
	3	1020 KN	1250 KN

COIR %	TRAILS	BREAKING LOAD FOR 7 DAYS	BREAKING LOAD FOR 28 DAYS
10	1	1120 KN	1290 KN
	2	1080KN	1265 KN
	3	1095 KN	1310 KN

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Tests For Roofing Tiles :

Compressive Strength Test

TRAILS	STRENGTH AT 7DAY N\mm^2	STRENGTH AT 28 DAYS N\mm2
1	140 kN	180 kN
2	150 kN	175 kN
3	135 kN	175 kN

COIR %	TRAILS	STRENGTH AT 7 DAYS N\mm2	STRENGTH AT 28 DAYS N\mm2
5%	1	160	185
	2	170	185
	3	175	190
10%	1	190	200
	2	200	220
	3	200	225

CONCLUSIONS:

Coconut fibre is available in abundance at the test site, which makes it quite viable as a reinforcement material in concrete. Further, it acts as a source of income for the coconut producer who gets the benefits of the new demand generated by the construction industry. In addition to this, it is an efficient method for the disposal of coir mattress waste which will reduce the demand for additional waste disposal infrastructure and decrease .

on existing landfills and incinerators. Coconut fibres being natural in origin, is ecologically sustainable and can bring down the global carbon footprint quite effectively.

The objectives of this work were:

1) To find out variation in compressive, tensile and flexural strengths of CFRC using processed fibre strands and raw fibre

The effect of coconut fibres on high strength concrete should be studied and thus the use of CFRC can be extended to industrial and commercial buildings. Since the corrosion study is not done, the applicability of CFRC in reinforced constructions could be tested.

Coconut fibre is a good insulator in itself and as such it can improve the thermal properties of concrete. This is particularly useful in a tropical country like India where the mercury levels are quite high for most part of the year, so as to maintain the room temperatures within comfort levels of its inhabitants. It can also reduce the load on air conditioning systems thus reducing the power consumption.

meshes at varying fibre contents and to compare it with that of conventional concrete

2). To determine the influence of shape of fibres on strength of concrete The scope of this project was limited to rural residential constructions.

The major conclusions from this study are

3) At 5% addition of coconut fibre with a water cement ratio of 0.5, compressive strength tests yielded best results. However, the compressive strength decreased on further fibre addition. This must be due to the fact that when the fibres are initially added to concrete, the finer sized fine aggregates enter into the surface pores in the fibre creating a better bonding between the fibre and mix,

4) However further addition of fibres resulted in formation of bulk fibre in the mix which will lead to decrease in bonding. Hence there is an optimum value of fibre to cement ratio, beyond which the compressive strength decreases. Hence 0.5 was taken as the optimum water cement ratio and optimum fibre content was taken as 5% .

5)When the fibre content is increased there is an increase in split tensile strength with a maximum at 5%. However when the fibre content is increased beyond this value a reduction in tensile strength is observed.

6)This is due to the fact that tensile failure occurs due to the dislocation of atoms and molecules present in concrete. However when the fibre is added it acts as a binder holding them together.

7) When fibre content is increased there is an increase in flexural strength with a maximum at 5% of fibre. However when the fibre content is increased beyond this value a downward slope of the graph is observed. This is also due to the binding properties of coconut fibre owing to its high tensile strength of 21.5 MPa.

FUTURE SCOPE:

The acoustic properties of concrete reinforced with other natural fibres have been studied in the past using an impedance tube apparatus and the results are fair enough to justify the use of coconut fibres as an alternative which is a good absorbent due to the presence of surface pores.

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