Coir Fibres: A best use of waste material

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ABSTRACT

This paper is an attempt to make the best use of the waste material obtained from the coconut trees. The coconut husk which is assumed to be of no use; actually is very much useful in day to day life because of its physical, chemical and mechanical properties. The coconut husk is widely adopted as an engineering material also due to its high tensile strength and elasticity. The results obtained from various tests have also been shown which gives us a clear idea about variation of different properties depending upon different fibre composition. The components, advantages, disadvantages as well as application of fibers of the coconut husk are discussed in this paper so that it spreads awareness of using coconut fiber as construction material in civil engineering.

INTRODUCTION

Natural fibers were used in construction between 3000 and 5000 B.C. when dwellings were built of mud or clay bricks reinforced with reeds or straw. The use of natural fibers was widely adopted in ancient period due to the eco-friendly behavior of natural fiber though they had less strength. Now-a-days proper use of natural fibers like coconut husk can give strength along with elasticity. Coconut fibers are obtained from the exterior solid shell of coconut and its scientific name is "COIR". Different types of fibers are available from coconut; matured coconut gives the brown fiber and immature coconut give white fiber. Depending upon the requirement any of them can be used, but brown fiber are thick, strong and provide more resistance to abrasion as compare to white fibers. Coir fibers are 1mm long and 10-20 micrometer in dia. The individual fiber cells are narrow and hollow with thick walls made of cellulose. They are pale when immature but later become hard and yellow as a layer of lignin is deposited on their walls. Various other parts of coconut palm can also be used for one or another purpose. Moreover coir fibers are used to make geo-textiles as it is a bio-degradable material.

LITERATURE REVIEW

It was said by Abrahams P. Mwasha (2009) that "Coconut fibers have excellent characteristics that could be used in construction industry for drainage, filtration, and reinforcement. Coir fibers are having higher tensile strength compare to other fibers and environmentally friendly qualities."
Majid Ali (2012) gave the useful overview. "He discussed that coir fibers have not only excellent physical, chemical, mechanical properties but it has also properties of composites (cement paste etc...)"
G.ramkrishna (2007) investigated that the "Tensile strength increases with increase in percentage of fiber content up to 4% by volume. After that if coconut fiber percentage is still increased than the tensile strength will reduce significantly."
Slate F.O (1976) gave the overview of impact energy of coir fiber. He said that "Coir fibers can absorb more impact energy compare to Plain concrete and it has a high energy absorption capability in comparison with other fibers."
K.M.Rao (2007) discussed that "Coir fibers can also be used as light weight composites for load carrying structure and it is also economical."

CHARACTERISTICS OF COCONUT FIBER

The physical and mechanical properties for the coconut fibers were studied and it was observed that the properties differ for the fibers having same length and diameter, because of this variation in the properties it is necessary to adopt some standards for its use in the construction field, as we have standards for sand and aggregates. The species, location and maturity of the plant are the factors that govern fiber dimensions of various individual cells. The density of the coconut fibers vary from 0.67 – 1.00 gm. /cm^3. It is observed from the stress- strain curve showed below that the coconut fibers are used to take strain 4-6 time more as compared to any other fiber. As L/D ratio of fiber varies, the flexibility & rupture parameters are also changed. The inner hollow cavity, lumen acts as acoustics and thermal insulator so, the bulk density of the fibers decreases because of the cavity. The outer coconut fiber has high elasticity which enables it to absorb or resist higher stretching energy as compare to inner coconut fibers.

Fig: 1 Longitudinal and Cross-section of a Fibre Cell ***[Afa Austin Waif elate Bolarinma Oluseun Abiola (2008)]***

Moreover, the chemical properties of the coir fiber vary depending upon the chemical composition of cellulose, hemi cellulose & lignin. Coconut fibers are reported best for retaining its original tensile strength when subjected to alternate wetting and drying by continuous immersion for 60 days in three medium. (water, saturated lime, sodium hydroxide) when coir fibers are used along with cement paste in some fraction amount the strength and modulus of rupture of the paste increases up to certain amount of fraction volume but, beyond that if the proportion of fiber increases, the tensile strength, modulus of rupture start decreasing.Hence,it is observed that coconut fiber with length of 38mm and volume fraction of 4% give maximum strength of cement paste composite as shown in table 1. It is also seen that workability of concrete decreases with increase in the addition of coconut fiber so Super plasticizer are added to the mix with higher fiber content to obtained slump value 125±25 mm.

Table: 1 Detail of modulus of rupture and tensile strength.

Fibre volume fraction (%)	Tensile Strength (MPa)	Modulus of Rupture (MPa)
2	1.9	3.6
3	2.5	4.9
4	2.8	5.45
5	2.2	5.4
6	1.5	4.6

When coconut fibers are added to the plain concrete the torsional strength increases between 26 to 77 N.M which is an increase between 10 to 20%. The twist capacity and elastic deformation capability of the concrete matrix just before failure increases considerably with the inclusion of coconut fibers. As shown in figure:2 the graph of stress v/s strain, strain carrying capacity of coconut fiber reinforced concrete is more than plain concrete.

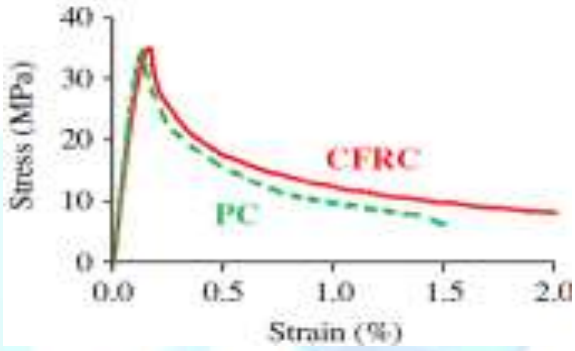

Fig: 2 Stress v/s strain graph for CFRC & PC. (Source: Google)

PROCESS OF MAKING COIR FIBRE REINFORCED CONCRETE

Materials used:
Ordinary Portland cement, fine aggregate, coarse aggregate. Coconut fibers diameter ranging from 0.29 to 0.83 and approximate mean aspect ratio of 150.The above material are used in preparation and testing of specimen as given in the table 2.

Table: 2 Proportion of materials used in coir fibre reinforced concrete

MATERIALS			
CEMENT(kg)	2		
FINE AGGREGATE(kg)	3.5		
COARSE AGGREGATE(kg)	5.5		
WATER (kg)	1		
FIBER(gm)	10	20	30

Mixing of the concrete with coconut fiber is another

important aspect so that the fibers are well distributed and randomly oriented; to prevent the balling and interlocking, usually the mixing is done with hand rather than using the mixture. All the cement, aggregate are taken in the pan 80% of the water is added to it and mixing is done for few minutes and fibers are added continuously during the mixing process of 2-3 minutes. And finally rest 20% of water is added along with the super plasticizers and still the mixing is continued for additional 2minutes to ensure the even distribution of fibers. From this mix total 6 cylinders and 3 cubes are casted for these moulds are further compacted for 60 seconds on a vibration table to align the fibers normal to the direction of vibration for proper strength. Then the cubes are cured for 28 days by submerging in the water and tests are performed on 28 Th day.

ADVANTAGES AND DIS-ADVANTAGES OF COCONUT FIBER.

ADVANTAGES:-

1) Coconut fibers are moth proof.
2) There are resistant to fungi and rooting.
3) There are not easily combustible.
4) They are flame retardant.
5) They provide excellent insulation against temperature and sound.
6) They are not affected by dampness and moisture.
7) Coirs are usually tough and durable.
8) They have more elasticity so they regain their original shape even on applying constant load.
9) They have resistance to the cracking and spalling effect
10) They have very high tensile strength.
11)The use of coconut fiber in the construction is economical as it has very low cost and is easily available, it is a renewable source of energy and eco-friendly.
12) Coconut fiber enhances toughness and torsional resistance properties of concrete.

DISADVANTAGES:-

1) As the percentage of coconut fiber increases compressive strength of concrete decreases.
2) Coconut fibers like many natural fibers is originally flexible and become stiff when in contact with the hydration product of concrete, therefore workability decreases.
3) As the fibers are long and unevenly distributed in length and diameter their mixing with concrete cannot be done properly using mechanical mixer and hence the use of hand is to be made for proper mixing.
4) The properties of coconut fiber vary depending upon their origin and species hence compilation of these fibers in construction leads to variation in the properties of resultant product so it's use is difficult.
5) In case of improper alignment of coconut fibers or increase of fiber length beyond the critical length, the fiber - fiber interaction get worse and thus, reduces the toughness , strength and modulus.
6) By addition of coconut fiber to the concrete it becomes difficult to compact it due to which there is increase in pores which leads to formation of cracks.
7) High water absorption of coconut fibers causes unstable volume and low cohesion with the fiber and matrix.
8) Coconut fiber decomposed rapidly in the all align environment of cement and concrete.
9) Coconut fibers contained cellulose, hemicellulose and lignin as major composition, these composition affect the different property of coconut fibers. The pretreatment of fiber changes the composition and ultimately changes not only its properties but also properties of composite. Sometimes it improves the behavior of fibers but sometime its effect is not favorable.

APPLICATION:-

Generally the concrete material is used for construction. But, it is strong in compression and weak in tension so, steel reinforcement is used as tension carrying material. Now a days coconut fiber is also used in construction industry due to its high tensile strength.

1) USED AS A PLASTER MATERIAL: when the fibers are used in the mortar for plastering walls etc. it is observed that they have higher durability. Even after years when the plaster is removed there is no significant difference in the lignin content of fibers.
2) USED AS ROOFING MATERIAL: As the coconut fibers have high insulation properties, they are cheaper and readily available. It makes them an ideal material to be used as roofing material.
3) USED IN SLAB: The slab specimens (300×300×20) were reinforced with natural fibers (coconut jute and sisal)having different content (0.5,1,1.5,2.5% by weight of content) with fiber lengths. (20, 30,40mm)were tested and it was found that and fiber content of 2% and fiber length of 40 mm of coconut fibers showed best performance among all the natural fibers by showing fiber pull out failure rather than fracture failure. Hence the coconut fiber can be used as reinforcing material in corrugated slabs for low cost housing. Where high flexural strength is required.
4) USED IN WALL PANELS: The wall panels made of gypsum and cement as binder and coconut fibers as reinforcement was tested. It was observed that the bending strength of wall panel was not affected by coconut fibers. But compressive strength increased with increased in coconut fibers. But due to increase in water content , compressive strength further decreased and density increased.
5) AS HOUSE CONSTRUCTING MATERIAL: The coconut fiber board (CFB) can replace construction material like tiles, bricks, plywood, and asbestos and cement hollow blocks. It can be used for interior and exterior walls ,partition and ceiling. It can also be used as a fabricating material for furniture, boxes and vases. The CFB has following properties:
1) Density: 550-650 kg/cu.m
2) Water absorption: 32%
3) Thickness swelling: 4-2%
4) Bending strength: 8.30 kg/cm^2
5) Thermal conductivity: 0.090wt/mt.
6) SLOPE STABILIZATION: Coir fibers can be used in making geo-text tiles which serves an important material for stabilization of slopes in railway cutting and embankments, also used for protection of water courses, reinforcement of temporary walls and rural unpaved roads and filtration in road drains. Containment of soil and concrete as temporary

seeding etc. Highway cut and fills slopes, control of gully erosion and shallow mass waste. Used as sub base layer in construction of road pavements. Used as bio-degradable filtration material for recycling of waste sludge in filtration plants. Used in manufacturing of bullet proof vest, car parts like trunk, liners, floor boards and interior door covers. Used in yarns , ropes, mats mattresses , brushes sacking rugs ,insulation panels and packaging.

CONCLUSION

It has been observed from the experimental studies that addition of coconut fibers significantly improved many of engineering properties like torsion, toughness and tensile strength. But, it decreased the compressive strength. So, it is unlikely to replace steel for vast majority of structures. However as they are easily available and cheaper it proves to be a good alternative to conventional building material and can be used in non- structural application or in ones where the consequence of failure are not too severe. So there is a need of investigating the behavior of coconut fiber reinforced concrete to be used in main structural components like beams asnd columns. Economic methods of natural fiber extraction, handling, and economical and automated method of dispersing fibers at batching plant if needed in large quantities are to be used in construction is to be found out. Moreover, the use of fiber enhanced concrete or mortar is going to increase in near future due to its thermal and sound insulation properties. Since, the use of coconut fibers have given some marvelous product there is still possibility of invention of new products containing coconut fibers with improved results in near future.

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