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# Analysis of Reinforced Natural Fibre Cement Composite Roofing Tiles

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**Abstract:**
In present roofing tiles, they have heavy weight and limited life time with poor indoor climate. Engineers have always been on the lookout for efficient and light roofing tiles which requires minimum maintenance and labour to install. Natural fibre 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 objective of this project work is to produce cost effective roofing tiles without compromising their quality by replacing cement up to 15%.In this work there are three different types of natural fibres are used as a reinforcing agent to the exits cemented roofing tiles. The natural fibre reinforced roofing tiles with different reinforcing agents are prepared and the climatic comfortness & mechanical properties are tested.

**Keywords:** Natural fibers, Cement

## I.INTRODUCTION

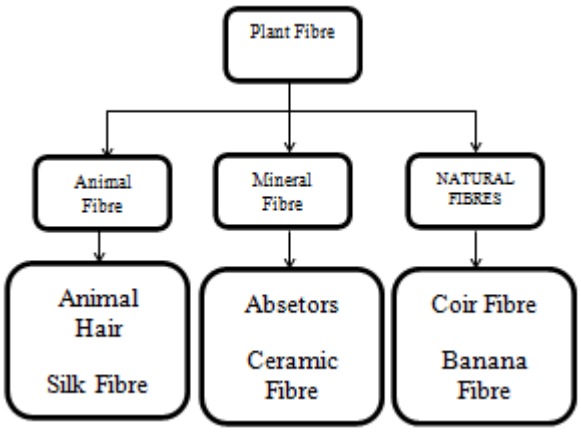
In almost all developing countries, there is a great shortage of roofing material. Local materials are often used, like soil, stone, grass and palm leaves. These roofs require a lot of maintenance and are not always resistant to heavy rain. Materials like Corrugated Iron Sheets (CIS) and asbestos cement sheets have replaced traditional materials. Roofing materials tend to be the biggest expense for individual home builders. The disadvantages of CIS roofs in tropical areas are that they give a poor indoor climate and make a lot of noise when it rains. They also require a lot of energy to produce. Asbestos cement sheets should not even be considered, because of the health hazard associated with making them. Ceramic tile roofs are good. However, if the kiln does not allow adequate temperature control during firing, the quality of the finished tiles can be very much uneven. Concrete tiles have partially replaced ceramic tiles for purely economic reasons but what limits the use of concrete tiles is their weight on the roof, which requires a strong load bearing structure. Therefore, changing an existing system of roof also requires strengthening of the roof framework. They can be made lightweight by incorporating natural fibres into its composite matrix. Fibre composites offer many benefits such as high strength, light weight, water resistance, chemical resistance, high durability, electrical resistance, fire resistance and corrosion resistance. Moreover, the properties and performance of fibre composites can be engineered according to the requirements and thus prove cost effective in most usage. Owing to these general advantages and the rich availability of the material in the South Indian tropics, Natual fibres has found desirable applications in the field of construction with the advent of light-weight concrete technology. The cheap availability of the raw material can also reduce the production costs and hence the housing expenditure on roofing, which is otherwise the most expensive part in building construction, can be considerably truncated. The main objectives of this project work is to develop natural fibre reinforced cement concrete roof tiles and to seek its pros and cons as a roofing material based on standard specifications. The structural behaviour and strength characteristic of natural fibres reinforced tile were compared with Cement Concrete roofing tiles. Main objectives of the present work are

- To develop lightweight concrete roofing tiles with coir reinforced cement concrete composite.
- To study the strength and behaviour of these tiles relative to the Cement Concrete roofing tiles.

## II.NATURAL FIBRES

Natural fibers include those made from plant, animal and mineral sources. Natural fibers can be classified according to their origin.

1. Animal fibre
2. Minareal fibre
3. Plant fibre




### A.Animal Fibre

Animal fibres are natural fibres that consist largely of particular proteins. Instances are silk, hair/fur (including wool) and feathers. The animal fibres used most commonly both in the manufacturing world as well as by the hand spinners are wool from domestic sheep and silk. Also very popular are alpaca fibre and mohair from Angora goats. Unusual fibres such as Angora wool from rabbits and Chiengora from dogs

also exist, but are rarely used for mass production. Not all animal fibres have the same properties, and even within a species the fibre is not consistent. Merino is very soft, fine wool, while Cotswold is coarser, and yet both merino and Cotswold are types of sheep. This comparison can be continued on the microscopic level, comparing the diameter and structure of the fibre. With animal fibres, and natural fibres in general, the individual fibres look different, whereas all synthetic fibres look the same. This provides an easy way to differentiate between natural and synthetic fibres under a microscope.

**B. Mineral Fibre**

A general term for any non metallic, inorganic fibres. Examples of mineral fibers are asbestos, graphite, and glass. Asbestos occurs naturally as fibres. Synthetic mineral fibres, called slag wool or rock wool, are produced by blowing air or steam through molten rock or slag. Mineral fibres are used as fillers in thermal insulation and fireproofing materials.

**C. Plant Fibre**

Plant fibres are generally composed of cellulose, often in combination with other components such as lignin. Examples include cotton, hemp, jute, flax, ramie, sisal, and bagasse. Plant fibres are classified according to their source in plants.

- Bast or stem fibres, derived from the fibrous bundles in the inner bark of plant stems.
- Leaf fibres, which run lengthwise through the leaves of monocotyledonous plants.
- Seed-hair fibres, such as cotton.

## III.MATERIALS AND METHODS

### A. Materials

**Coir Fibre**

Coir is the natural fibre extracted from the husk of coconut. It is mostly used in product such as floor mates, door mates, brushes. The coir fibre is relatively waterproof and it is one of the few natural fibres resistant to damage by saltwater.

**Banana Fibre**

Banana fibre are extracted from stems of banana plant. It is mostly used as textile fibre. Since the fibre is less weight it is used in making dresses.

**Sugarcane**

Sugarcane is a natural fibre extracted from sugarcane plants. After the juice is extracted the remaining sugarcane fibre pulp is called bagasse. It is mostly used for textile production because of its high fibre content.

**Cement**

The cement used should confirm to IS specifications. There are several types of cements are available commercially in the market of which Portland cement Specific Gravity is 3.15 the most known and available everywhere. OPC 53 grade confirms to IS 8112:1989 is used for this work.

**Water**

Water is an important ingredient of concrete as it chemically participates in the reactions with cement to form the hydration product C-S-H gel. The strength of cement concrete depends mainly from the binding action of the hydrated cement paste gel. A higher water-binder ratio will degrease the strength, durability, water-tightness and other related properties of concrete. As per Neville, the quantity of water added should be the minimum required for chemical reaction of hydrated cement, as any excess of water would lead end up only in the formation of undesirable voids (capillary pores) in the hardened cement concrete paste. Hence, it is essential to use a little paste as possible consistent with the requirements of workability and chemical combination with cement.

### B. Methodology

After selecting suitable materials like cement, sand and Natural fibres (Coir, Banana, sugarcane),material properties were determined. In order to replace cement with Natural fibres (Coir, Banana, sugarcane), initial studies were conducted to finalise the 15 % replacement of cement with three different fibres. After finalising the same, tile specimens were prepared using specially prepared mould. Accelerated curing was given to the specimens using oven. Tests were conducted as per Indian Standard specification for tiles.

## IV. EXPERIMENTAL INVESTIGATION

### A. Sample Preparation

Blended cement were prepared by mixing the Portland cement with different natural fibres like coir fibre, banana fibre, sugarcane fibre and water. The mixing process carried out by using the wink worth mixer machine. The water was added gradually to the fibre cement mixture for 5 minutes. The fibre which is used in blended cement process was 7 cm in size at the composition of 15 %. The homogenous mixture was then hand pressed into a mould of 300mm X 300mm and 15mm thickness. The sample were finally cooled at room temperature and kept for mechanical testing.

### B.Testing

After completion of three different fibre composition tile specimen the mechanical tests of the composition samples was carried out in respective machines.

**Breaking Load test:**

For breaking load test on concrete, three different fibre composite cubes of 300mm were employed. All the cubes were tested in saturated condition after wiping out surface moisture from the specimen. For each trial mix combination, two cubes were tested at the age of 7 and 28 days. The load was applied in a direction perpendicular to the cube, at a uniform rate of 450 to 550 N/min. The individual breaking load of the three tiles was recorded in wet condition separately and the average was takenas the load carrying capacity. Test results are shown in Table 4.1.

**Table.4.1. Result of Breaking Load Test**

| Tiles specimen | % of Fibre | Breaking load in N/mm$^2$ | |
|---|---|---|---|
| | | 7 days | 28 days |
| Standard Cement Tiles | 0 | 19.12 | 25.23 |
| Coir Rein forced tiles | 15 | 25.45 | 30.21 |
| Banana Reinforced Tiles | 15 | 23.78 | 28.34 |
| Sugarcane Reinforced Tiles | 15 | 21.32 | 26.65 |

Tests are also conducted to find the strength of the specimen. As per literature, the required bending strength is an average

load of at least 60kg for the five tiles, and a minimum load of 50kg for any single tile. During testing it was observed that tiles with natural fibres exhibit better ductility comparing with those of ordinary concrete tile.

**Fig.4.1. Universal Testing Machine**

**Water absorption**

The test specimen were dried in an oven at a temperature of about 105-110 C prior to the test. Dry weights were measured after atmospheric cooling and were immersed in clean water at room temperature (24-30ºC) for about 24hrs.The specimen was then removed from water and surface dried and weighed. The increase in weight with respect to the original dry weight was taken as the water absorption for that sample. Mean water absorption of the three different composite samples was taken as the water absorption of the prepared mix. A test conducted for different compositions and the results are tabulated in the table 4.2

**Table.4.2 Result of Water Absorption**

| Nartual Fibre | Dry Weight In kg | Wet Weight In kg | % of absorption |
|---|---|---|---|
| Coir Reinforced tiles | 2.847 | 3.022 | 6.14 |
| Banana Reinforced Tiles | 2.811 | 3.003 | 6.37 |
| Sugarcane Reinforced Tiles | 2.925 | 3.034 | 6.38 |

**Permeability Test**

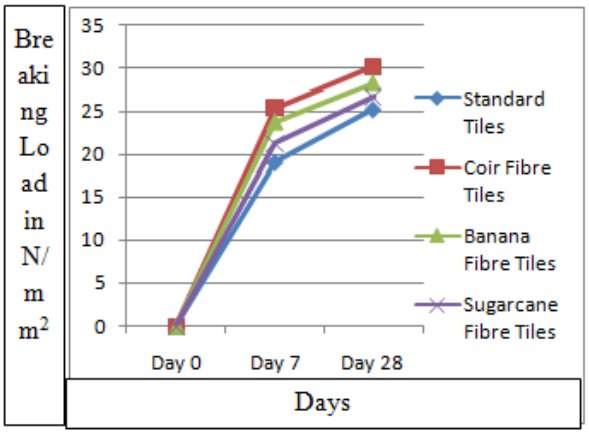
The test was conducted in a rectangular trough, open at the bottom, the dimensions being equal to the size of tile under test. The tile was fitted at the bottom of the trough and the space between the tile and the sides of the trough were plugged water-tight with a suitable material like wax, bitumen, etc. Water was poured into the mould so that it stands over the lowest tile surface to a height of 5cm. The water in the trough was allowed to stand for a period of 24 hours. The bottom of the tile was carefully examined to see whether the water has seeped through the tile.

## V.RESULT AND DISCUSSION

This section focuses on presenting the observations and findings gathered during the course of experiments .The data analysis provides the basis and justification for the conclusion drawn in this work .Three types experiment were carried out which are breaking load test ,water absorption test and permeability test for determining mechanical properties.

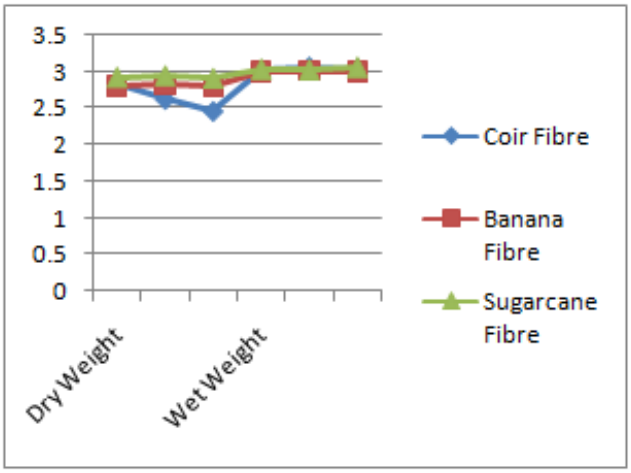
**A. Breaking Load Test Results:**

From the above test it is clear that when15% of coir fibre is reinforced with concrete it shows the best BREAKING LOAD(i.e 30.21 N/mm$^2$) as compared to reinforced banana and sugarcane fibre concrete tiles.




**B.Water Absorption Test Results:**

From the above test it is clear shows that the quantity of absorption of water is very much less in coir fibre tiles when compare to other two fibre tiles.




## VI.CONCLUSION

An eco-friendly product was developed using locally available material. When comparing to banana and sugarcane fibre coir fibre tiles results in reduction of self-weight and cost. Mechanical properties like breaking load and ductility were improved. From the difference in cracking pattern of tiles which used coir fibre and those without coir fibre it was observed that the cracks are more sharp in the latter. This can be justified because of the presence coir fibres in the roofing tile it has shown a cracking pattern with less sharpness and this physical observation lead to this conclusion

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