Low Cost Roofing Tiles using Agricultural Wastes

Saravanan J[#1], ImthiyasAhamed S[*2],Muniyasamy X[*2], Muthu Ganesh P[*2], Rawther Ibrahim Ali Sait[*2]
[#1]*Assistant Professor, Civil Engineering, Renganayagi Varatharaj College of Engineering, Sivakasi, India*
[*2] *UG Students, Civil Engineering, Renganayagi Varatharaj College of Engineering, Sivakasi, India*

Abstract:

The scenario of living in huts in slum areas is becoming very difficult day by day due to vast change in climate. Replacing the ordinary huts and conventional poor class roofs with much efficient alternate roof cover is being the most required. On the other side, proper and efficient disposal of agricultural wastes is being the key factor in solid waste management in most of the Indian States.Having both the problems in a single line, in this project we have prepared and evaluated the performance of low cost roofing tiles using agricultural wastes as raw material. Based on the results, it is suggested that we can efficiently replace significant quantity of river sand in making roofing tiles with the corn cob powder and rice husk powder in appropriate propositions which gave compressive strength as similar as before replacement. By replacing the river sand in making roofing tiles would reduce its manufacturing cost as well as selling price and makes it more affordable. Thus preparation of such sand replaced roof tiles will significantly reflect healthy environmental and economic benefits.

Keywords — *Roofing tiles, Corn cob, Rice husk, Partial sand replacement, Compressive strength.*

I. INTRODUCTION

Roof tiles are designed mainly to keep out rain, and are traditionally made from locally available materials such as terracotta or slate. Modern materials such as concrete and plastic are also used and some clay tiles have a water proof glaze. Roof tiles are ‘hung’ from the framework of a roof by fixing them with nails. The tiles are usually hung in parallel rows, with each row overlapping the row below it to exclude rain water and to cover the nails that hold the row below. There are also roof tiles for special positions, particularly where the planes of the several pitches meet. They include ridge, hip and valley tiles. Slate roof tiles were traditional in some areas near sources of supply, and give thin and light tiles when the slate was split in to its natural layers. It is no longer a cheap material, however and is now less common.

II. PROFILES OF ROOF TILES

A large number of profiles of roof tiles have evolved. These include :

A. ***Flat Tiles:*** It is the simplest type, which are laid in regular overlapping rows. Flat roof tiles are usually made of clay but also be made of stone, wood , plastic, concrete or solar cells.

B. ***Imbrex and Tegula:*** It is an ancient Roman pattern of curved and flat tiles that makes rain channels on a roof.

C. ***Roman Tiles:*** It is flat in the middle, with a concave curve at one end and convex curve at the other, to allow interlocking.

D. ***Pantiles:*** It is with an S-shaped profile, allowing adjacent tile to interlock. These result in a ridged pattern resembling a ploughed field.

E. ***Mission or Barrel Tiles:*** It is semi-cylindrical tileslaid in alternating columns of convex and concave tiles. Originally they were made, by forming clay around a curved surface. Today barrel tiles are mass produced from clay, metal, concrete or plastic.

F. ***Interlocking Roof Tiles :*** It is similar to pantiles with side and top locking to improve protection from water and wind.

III. METHODOLOGY

A. Materials

The following materials were used in our research:

- Fine Aggregate
- Corn cob
- Red Soil
- Clay
- Rice Husk
- Water

1) Fine Aggregate

In the present work, the mixes were prepared using locally available river sand free from silt, organic matter and passing through 4.75mm sieve. The sand used was confining to Zone 2 of IS 383-1970. The composition of sand is highly variable, depending on the local rock sources and conditions.

2) Clay

Clay has the smallest particle size of any soil type, with individual particles being so small that they can only be viewed by an electron microscope.This feature plays a large part in clay's smooth texture, because the individual particles are too small to create a rough surface in the clay.Because of the small particle size of clay soils, the structure of clay-heavy soil tends to be very dense.Clay contains very little organic material; you often need to add amendments if you wish to grow plants in clay-heavy soil.

*3) **Red Soil***

Red soils are highly leached soils of the humid tropics having a high content of sesquioxides.Low natural fertility is the main limiting factor for good crop production on these soils and they are frequently acidic and deficient in all essential nutrients, especially N, P, K, Ca, Mg, S, Zn, B, and Cu. Adequate applications of lime and fertilizers are important strategies for replenishing soil fertility and improving crop yields on these soils. Adequate applications of lime and fertilizers are important strategies for replenishing soil fertility and improving crop yields on these soils.

*4) **Corncob***

Corn cobs, the core of corn ears, are very absorbent. They have been used to make inexpensive smoking pipes, and to transport various materials. Ground corn cobs makes an effective blasting media, are friendly to the environment, and delicate while maintaining abrasive capacity.Corncobs are increasingly being used as a low-cost environmentally friendly insulation material for houses.In this study, corncob powder has been used as a filler material replaced partially with fine aggregate.

*5) **Water***

Potable tap water was used for mixing and curing of specimens. The water reacts with the clay and sand, which bonds the other components together, creating a solid like material.

B. Methods

Roof tiles are made as per the recommendations provided in IS 3978-1967. The mixing ratios were adopted from the local roof tile manufacturing plant located nearby Subraminiyapuram, Sivakasi.

*1) **Mixing Procedure***

The default mixing ratios followed in the plant was:

River sand	**Red soil**	**Clay**
55%	35%	10%

In the above normal mixing ratio, we have altered the River sand ingredient initially with Corncob powder to find out the optimum replacement ratio and then with Rice Husk as partial replacements. All the mixing was done in weight basis, as follows:

Table 1: Control Tile - Mixing Ratio

Control Tiles / Normal Tiles 8 x 8 (Inches)		
River sand	55%	1.375 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

Table 2: 5% Corn Tile - Mixing Ratio

5% Corn Tile 8 x 8 (Inches)		
River sand	50%	1.25 Kg
	5% Corn powder	0.125 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

Table 3: 10% Corn Tile - Mixing Ratio

10% Corn Tile 8 x 8 (Inches)		
River sand	45%	1.125 Kg
	10% Corn powder	0.250 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

Table 4: 20% Corn Tile - Mixing Ratio

20% Corn Tile 8 x 8 (Inches)		
River sand	35%	0.875 Kg
	20% Corn powder	0.5 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

Table 5: 30% Corn Tile - Mixing Ratio

30% Corn Tile 8 x 8 (Inches)		
River sand	25%	0.625 Kg
	30% Corn powder	0.75 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

Table 6: 40% Corn Tile - Mixing Ratio

40% Corn Tile 8 x 8 (Inches)		
River sand	15%	0.375 Kg
	40% Corn powder	1 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

By visually inspecting the tiles (after ‘brick kiln’ burning) with the above said mixing ratios, we could easily understand that more the replacement of corn cob powder more the brittleness of tiles occurs. So, before testing for the compression strength, we prepared other set of tiles with Rice Husk + Corn cob as replacement for river sand. The mix ratios for the later are as follows:

Table 7: 5% Corn + 5% Rice Husk Tiles- Mixing Ratio

5% Corn + 5% RH7 x 7 (Inches)		
River sand	45%	1.125 Kg
	5% Corn powder	0.125 Kg

	5% RH	0.125 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

RH = Rice Husk

Table 8: 5% Corn + 10% Rice Husk Tiles- Mixing Ratio

5% Corn + 10% RH 7 x 7 (Inches)		
River sand	40%	1 Kg
	5% Corn powder	0.125 Kg
	10% RH	0.25 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

RH = Rice Husk

Table 9: 5% Corn + 15% Rice Husk Tiles- Mixing Ratio

5% Corn + 15% RH 7 x 7 (Inches)		
River sand	35%	0.875 Kg
	5% Corn powder	0.125 Kg
	15% RH	0.375 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

RH = Rice Husk

Table 10: 5% Corn + 20% Rice Husk Tiles- Mixing Ratio

5% Corn + 20% RH 7 x 7 (Inches)		
River sand	30%	0.750 Kg
	5% Corn powder	0.125 Kg
	20% RH	0.5 Kg
Red Soil	35%	0.875 Kg
Clay	10%	0.25 Kg

RH = Rice Husk

2) Testing of Specimen for Failure Load

Since the compressive strength of typical roof tiles lies between 200 to 700 N/mm^2, we need to have the least count of CTM (Compression testing Machine) as 10N which is unavailable in our college strength of materials laboratory. So, we have adopted manual loading method like as pile load test in the field. We used cast prism, cube and bricks of concrete and weighed them in machine. We have taken the weights of Concrete Prism as 11.7 Kg, Concrete Cube as 8.5 Kg, Brick as 2.5 Kg and concrete cylinder as 13.7 Kg. The loading test has been carried out as follows:

- Setting up of rigid base by using 4 concrete cubes.
- Placing the tile on the concrete cubes such a way that all the 4 corners of the tile are equally rest on the concrete cubes.
- Placing the brick (2.5Kg) transversely on the tile and wait for 1 minute. (;Loading/min)
- After a minute, placing another brick / concrete cube/ concrete prism over the brick in one minute interval until the tile breaks.
- Noting the load applied (in Kgs) when the tie breaks as failure load of the tile.

Fig 1: Casting of Tiles

Fig 2: Placing of Tile on Concrete Cube Base

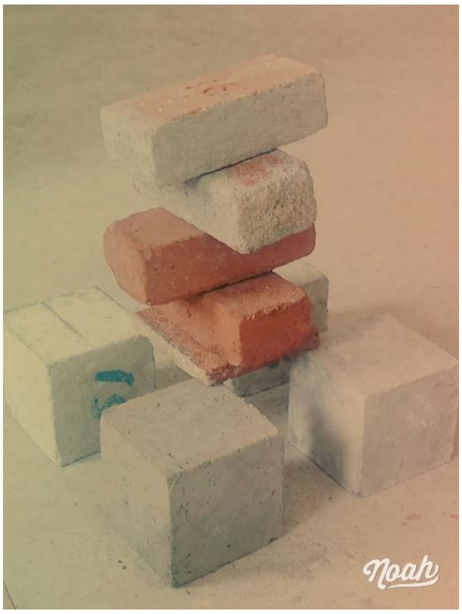

Fig 3: Brick loading on tile

Fig 4: Prism and Cube loading on tile

Fig 5: Cracks on tile after failure load

3) Water Absorption test

The tiles were dipped in a tray of water for 24 hours for determining the water absorption capacity.

Table 11: Water Absorption of Tiles

Particulars	Dry Weight	Wet Weight	Water Absorption
Control Tiles	800 g	1000 g	25%
5% Corn Tiles	800 g	1000 g	25%
5% Corn + 5% Rice Husk Tiles	600 g	800 g	25%
5% Corn + 10% Rice Husk Tiles	600 g	800 g	25%
5% Corn + 20% Rice Husk Tiles	600 g	800 g	25%

Fig 6: Water Absorption test on tiles

IV. RESULTS AND DISCUSSIONS

The failure loads of the tiles of various mixing ratios were determined as given in Table 11. The water absorption of control tiles was determined as 25% and for Corn-rice husk tiles as 25% which showed that there is no difference in water absorption characteristics of control and other tiles.

Table 12: Compressive Strength of Tiles

Tile 7 x 7 Inches		Failure Load		Average Compressive Strength
Control	S1	46.8 Kg	459.101 N	3.41 N/cm^2
	S2	63.1 Kg	619.01 N	
5% Corn	S1	49.3 Kg	483.633 N	1.560 N/cm^2
	S2	51.3 Kg	503.253 N	
5% Corn + 5% RH	S1	24.5 Kg	240.345 N	0.721 N/cm^2
	S2	22 Kg	215.82 N	
5% Corn + 10% RH	S1	21 Kg	206.01 N	0.628 N/cm^2
	S2	19.5 Kg	191.25 N	
5% Corn + 15% RH	S1	11 Kg	107.91 N	0.301 N/cm^2
	S2	8.8 Kg	82.4 N	
5% Corn + 20% RH	S1	8.8 Kg	82.4 N	0.217 N/cm^2
	S2	5.6 Kg	54.93 N	

S = Sample; RH = Rice Husk

From the above table, we can estimate the effectiveness of replacement of river sand in making roof tiles with alternate materials (Agricultural wastes).

V. CONCLUSIONS

From our experimental study, we conclude that replacement of river sand in making roof tiles will be effective if the replacement ratio lies below 5%. For example, if future study prove that 2% replacement of river sand in roof tiles with similar compressive strength, it would be a great benefit in both economic and environmental concern. If we replace 1% river sand with agricultural wastes (Corn cob, Rice husk, etc.) effectively, it will indirectly reduce the demand for river sand and reduce the manufacturing cost of clay roof tiles, which induce the conversion of huts in slum areas into tiled houses. Thus, both economic and environmental benefits occurs in this manner if the manufacturing of roof tiles is made in large scale.

REFERENCES

[1] [1] IS 3978-1967 Indian Standard Code of Practice for Manufacture of Burnt Clay Mangalore Pattern Roofing Tiles

[2] [2] YaningZung, A.E.Ghaly, Bingxi Li, "Physical Proiperties of Corn Residues", American Journal of Biochemistry and Biotechnology, Aug, 2012. ISSN 1553-3468.

[3] [3] Saravanan J, Sridhar M, "Construction Technology, Challenges and Possibilities of Low Carbon Buildings in India", International Journal of Civil Engineering (SSRJ-IJCE), Vol 2 Issue 11, November 2015. ISSN 2348-8352.

[4] [4] Saravanan J, Sridhar M, Vinitha Judith J, "Effective Utilization of Vinyl Flex Banners – A Solid Waste Management Perspective", International Journal of Applied Engineering Research, Vol 10, No 38 (2015). ISSN 0973-4562.

[5] [5] Saravanan J, Sridhar M, "Flex Crete: Low Cost Concrete Using Old Vinyl Banners as Partial Replacement of Coarse Aggregate – Solid Waste Management Perspective", International Journal of Engineering Trends and Technology(SSRJ-IJETT), Volume 30 Number 4, December 2015. ISSN 2231-5381.

[6] Gunasekaran. K et al, "Mechanical and bond properties of coconut shell concrete" (2011), construction and building materials 25 92-98. 9.

[7] K.Gunasekaran, P.S.Kumar, - "Lightweight concrete mix design using coconut shell aggregate" Proceedings of International Conference on Advances in Concrete and Construction, ICACC- 2008 ,7-9 February, 2008, Hyderabad, India pp. 450-459.

[8] Nnamdi O.P, "Low cost materiasl for Buildings and Construction: A Case study of Rice Husk", Journal of Sustainable Development and Environmental Pollution, 2011.