VIVA-TECH IJRI
ANNUAL RESEARCH JOURNAL

VIVA-TECH INTERNATIONAL JOURNAL FOR RESEARCH AND INNOVATION

ANNUAL RESEARCH JOURNAL
ISSN(ONLINE): 2581-7280

LOW-COST ROOFING TILES FROM AGRICULTURAL WASTE

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Abstract : *The living conditions in slum areas, where people rely on huts, are becoming increasingly challenging due to significant climate changes. There is an urgent need to replace traditional hut roofs with more efficient and sustainable alternatives. At the same time, proper disposal of agricultural waste has become a crucial issue in solid waste management in many Indian states. Addressing both concerns, this project focuses on the development and assessment of low-cost roofing tiles made from agricultural waste. Our findings suggest that by replacing a substantial amount of river sand with corn cob powder and rice husk powder in the production of roofing tiles, we can maintain similar compressive strength as before. This substitution not only reduces the manufacturing cost and selling price of the tiles but also makes them more affordable. Consequently, producing roof tiles with reduced sand content offers both environmental and economic benefits.*

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

I. INTRODUCTION

Roof tiles are primarily designed to protect against rain, and traditionally, they are made from locally sourced materials like terracotta or slate. In modern construction, materials such as concrete and plastic are also used, and some clay tiles even feature a waterproof glaze. These tiles are typically secured to the roof framework with nails and arranged in overlapping rows, with each row covering the nails of the row below it to prevent rainwater from entering. There are specialized tiles, such as ridge, hip, and valley tiles, for areas where multiple roof pitches meet. Slate tiles, once a traditional choice in areas near slate deposits, produce thin, lightweight tiles when split along their natural layers. However, slate is now less affordable and less common. Building materials have evolved significantly from ancient times to today's technological era. With increasing demand for affordable and comfortable housing, scientists and engineers are continuously working to develop and optimize new, durable, and cost-effective materials. Building materials encompass a wide variety of products, including roofing sheets, blocks, concrete, gravel, sand, clay, stone, cement, roofing tiles, steel, aggregates (both fine and coarse), and others. Over time, the materials used for roof cladding have adapted to specific needs, such as the type of building, weather conditions, cost, durability, and weight. Some commonly used materials today include metal, asphalt, wood, ceramics, and polymers, while concrete has recently been explored as a sustainable option and has proven to be a valuable roofing material.

II. LITERATURE REVIEW

1. Mr. Oma tola had investigated on “Experimental study on the compressive strength and water absorption of roofing tile by partial replacement of river sand with RHA and corncob”. it can conclude that RHA is a good pozzolana and Corn cob makes the bond of particles stronger and develop other properties. It was concluded that 7% of RHA is used for better performance and 5 % of corncob powder.
2. Mr. Malhorta and mehta(1999) had studied on “Feasibility of using Rice husk ash”. The Feasibility of using Rice husk ash, a finely grounded waste product from the Rice mill industry, as partial replacement for river sand in production of roofing tiles. Usage of 7%, 14%, 21%,27% of RHA as partial replacement of river sand can give different values. The test results show us more than 14% of RHA usage will highly effective and it will affect the strength of the low-cost roof tiles.
3. Miss Aishwarya Rajendra Jamdar, VM SanadeManaging waste is a global challenge that challenges the protection of our ecosystem due to its high rate of generation and its non-biodegradability.
4. 4Humayun Nadeem, Noor Zainab Habib, Choon Aun Ng, Salah Elias Zoorob, Zahiraniza Mustaffa, Swee Yong Chee, Muhammad Younas Utilization of catalyzed waste vegetable oil as a binder for the production of environmentally friendly roofing tiles. Conclusively, environmentally friendly and economic production of tiles, conservation of existing resources and overcoming the issue of waste management are the remarkable outcomes of this research.
5. Mangesh V Madurwar, Rahul V Ralegaonkar, Sachin A Mandavgane, Application of agro-waste for sustainable construction material. The application of agro-waste for sustainable construction materials provides a solution which offers reduction in natural resource use as well as energy.
6. GHMJ Subashi De Silva, THF Aagani, Kidane F Gebremariam, SM Samindi MK Samarakoon, Engineering properties and microstructure of a sustainable roof tile manufactured with waste rice husk ash and ceramic sludge addition. Tiles were cast by clay replacement with waste RHA and CS in four mixtures: 10 %RHA and 0 % CS, 10 % RHA and 10 % CS, 10 % RHA and 15 % CS, and 10 % RHA and 20 % CS (by weight).

III. METHODOLOGY

1. Collection Of Material

Materials used :- I. Clay, II. Red Soil, III. Rice Husk, IV. Corn Cob, V. M Sand, VI. Water

2. Testing Of Materials

- Specific Gravity

Sr No.	Materials	Specific gravity
1.	Clay	2.12
2.	Red soil	1.53
3.	Rice husk	1.23
4.	Corn cob	1.25
5.	M sand	2.13

- Particle Size Distribution

Sieve analysis :- M Sand

S.NO	IS SIEVE	WeightRetained (grams)	Cum weight retained	Cum (%) retained		
Empty weight sieve		Retained Weight of sieve		Retained weight of soil		
1	4.75	0.402	0.419	0.017	0.017	0.00017
2	2.36	0.353	0.585	0.232	0.249	0.0024
3	0.6	0.315	0.883	0.568	0.817	0.00817
4	0.3	0.0324	0.506	0.182	0.999	0.099
5	0.15	0.307	0.308	0.001	1	0.01
6	0.075	0.307	0.307	0	1	0.01
7	pan	0.280	0.330	0.005	1.05	0.0105

Sieve analysis :- Red Soil

Table 5.2.2: sieve analysis – Red soil S.NO	IS SIEVE		Weight Retained (grams)	Cum weight retained Empty weight sieve		Cum (%) retained Retained Weight of sieve
Empty weight sieve		Retained Weight of sieve		Retained weight of soil		
1	4.75	0.402	0.210	0.282	0.282	0.0028
2	2.36	0.353	0.072	0.281	0.563	0.0556
3	0.6	0.315	0.430	0.115	0.678	0.0067
4	0.3	0.0324	0.357	0.033	0.711	0.007
5	0.15	0.307	0.143	0.164	0.875	0.0087
6	0.075	0.307	0.046	0.261	1.136	0.01136
7	pan	0.280	0.053	0	1.136	0.01136

Sieve analysis :- clay

Table 5.2.3: sieve analysis – Clay S.NO	IS SIEVE		Weight Retained (grams)	Cum weight retained Empty weight		Cum (%) retained Retained Weight of
Empty weight sieve		Retained Weight of sieve		Retained weight of soil		
1	4.75	0.402	0.899	0.497	0.497	0.0049
2	2.36	0.353	0.354	0.001	0.498	0.0049
3	0.6	0.315	0.931	0.616	1.114	0.0114
4	0.3	.0324	0.601	0.277	1.391	0.0139
5	0.15	0.307	0.450	0.143	1.534	0.0153
6	0.075	0.307	0.341	0.034	1.568	0.0156
7	pan	0.280	0.340	0.06	1.628	0.0162

3. MIX DESIGN PROPORTION

SR.NO	MATERIALS	PERCENTAGE	WEIGHT IN KG
1	M-SAND	55%	1.375
2	RED SOIL	35%	0.875
3	CLAY	10%	0.25
		TOTAL	2.5

2ND MIX: 5% CORN + 5% RICE HUSK

SR.NO	MATERIALS	PERCENTAGE	WEIGHT IN KG
1	M-SAND	45%	1.125
2	CORN-COB	5%	0.125
3	RICE HUSK	5%	0.125

4	RED SOIL	35%	0.875
5	CLAY	10%	0.25
		TOTAL	2.5

3RD MIX: 5% CORN + 10% RICE HUSK

SR.NO	MATERIALS	PERCENTAGE	WEIGHT IN KG
1	M-SAND	40%	1
2	CORN-COB	5%	0.125
3	RICE HUSK	10%	0.25
4	RED SOIL	35%	0.875
5	CLAY	10%	0.25
		TOTAL	2.5

4TH MIX: 5% CORN + 15% RICE HUSK

SR.NO	MATERIALS	PERCENTAGE	WEIGHT IN KG
1	M-SAND	35%	0.875
2	CORN-COB	5%	0.125
3	RICE HUSK	2%	0.375
4	RED SOIL	35%	0.875
5	CLAY	10%	0.25
		TOTAL	2.5

5TH MIX: 5% CORN + 20% RICE HUSK

SR.NO	MATERIALS	PERCENTAGE	WEIGHT IN KG
1	M-SAND	30%	0.750
2	CORN-COB	5%	0.125
3	RICE HUSK	20%	0.5
4	RED SOIL	35%	0.875
5	CLAY	10%	0.25
		TOTAL	2.5

4. EQUIPMENT USED FOR CASTING OF SPECIMEN:

Moulds (Wooden/metal):

Because clay mortar sets slowly and the tiles need to be left on the moulds at least overnight before they can be removed. Because it is important that roof tiles cure in a damp environment, the enveloping type of mould was used. These moulds were stacked one on top of the other and hence cover the curing tiles and prevent them from drying out too quickly.

SPECIMEN SIZE:

Length = 7”

Width = 7”

Thickness = 1”

Fig 1 . mould

5. Tests on Low Cost Roofing Tles

- **Water Absorption Test**

To determine how much water in percentage absorbed by each tile sample when exposed to water for 24 hours.

Procedure

The mass of each tile specimen was weighed and re-weighed after it was submerged into, water for about 24 hours. The specimen was then taken out of water and their surface carefully wiped to remove excess water.

Evaluation and Report of Test Result

The percentage water absorption, ‘A’ according to IS 3978: 1967 is calculated using the relationship,

$$A = \frac{Ms - Md}{Md}$$

Where Ms is the mass of the saturated tile and Md is the mass of the dried tile.

Table 11: Water Absorption of Tiles

Particulars	**Dry Weight**	**Wet Weight**	**Water Absorption**
Standard Tile	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 + 15% Rice Husk Tiles	600 g	800 g	25%
5% Corn + 20% Rice Husk Tiles	600 g	800 g	25%

Fig 2 . Water absorption test on tile

- **Compressive (Crushing)**

Test Load was applied manually to a hydraulic press machine through a cylindrical steel indenter of 19.5 mm in diameter and length of about 30mm on the tiles under test. The load was centrally applied on the tile specimen until the first sign of crack was observed then the load at cracking was recorded to be the crushing load. The compressive strength of each tile specimen is calculated by:

$$\sigma C = \frac{p_c}{Ac}$$

Where Pc is the total load on the specimen at failure, Ac is the calculated cross-sectional area of the cylindrical steel indenter and σc is the compressive strength of the test.

Tile Sample	**Compressive Strength**
Standard	619.01 N
5% Corn + 5% Rice Husk Tiles	215.82 N
5% Corn + 10% Rice Husk Tiles	191.25 N
5% Corn + 15% Rice Husk Tiles	82.4 N
5% Corn + 20% Rice Husk Tiles	54.93 N

Fig 3 : Brick loading on tile

Fig 4 : Crack on tile after failure load

IV. CONCLUSION

Based on our experimental findings, we conclude that replacing river sand in the production of roof tiles is effective when the replacement ratio does not exceed 5%. For instance, if future research shows that a 2% replacement of river sand with agricultural wastes results in similar compressive strength, it would bring significant economic and environmental benefits. Replacing even 1% of river sand with materials like corn cob or rice husk could help reduce the demand for river sand, lower the manufacturing cost of clay roof tiles, and promote the transition from huts to tiled houses in slum areas. Therefore, large-scale production of roof tiles using this approach would result in both economic and environmental advantages.

Acknowledgements

We are using this opportunity to express our gratitude to everyone who has supported us throughout the completion of this project. We are thankful for their guidance, constructive entices and friendly advice, during the project work. We express our gratitude to **Prof. Ramya Raju** for giving us an opportunity to carry out project on – Low Cost Roofing Tiles From Agricultural Waste. We would also like to thank Prof. Akshay Mistry, Head of Civil Department and Dr. Arun Kumar, the Principal for their whole hearted support. Lastly, we express our gratitude towards all those who directly or indirectly helped us in the completion of our project.

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