International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)
Vol. 6, Issue 1, pp: (18-32), Month: April - September 2018, Available at: www.researchpublish.com

LOW COST ROOFING TILES USING AGRICULTURAL WASTE

[1]Mrs.K.Saranya M.E., [2*]Mythily.K

Abstract: **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 waterproof glaze. 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. In this project wehave 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 M-sand in making roofing tiles with the rice husk powder in appropriate propositions which gave compressive strength as similar as before replacement. By replacing the M-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: **M-sand, Red soil, Clay, Rice husk ash, compressive strength.**

1. INTRODUCTION

1.1 GENERAL:

Roof tiles are designed mainly to keep out rain, and are traditionally made from locally availablematerials 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.

Building materials have undergone a lot of modification from ancient times till this present technology era. With everyone seeking for affordable and comfortable houses to live in, every scientist and engineer is working hard to develop and optimize new building materials that would be durable and cost effective. Building materials range from roofing sheet, block, concrete, gravel, sand, clay, stone, cement, roofing tiles, steel, fine aggregate, coarse aggregate, laterite among others. Materials used for roof cladding in building have evolved over time. A number of them have been deployed for specific reasons such as: building type, weather condition, availability, cost, durability, and weight, among others. Common ones in use are: metal, asphalt, wood, ceramic, polymers and quite recently concrete has been explored as a suitable material and found to be useful.

1.2 PROFILES OF ROOF TILES:

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

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.

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

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

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

Mission or Barrel Tiles: It is semi-cylindrical tiles laid 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.

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

1.3 SIGNIFICANCE OF STUDY:

The use of M- sand, red soil and clay combined with RHA to produce roof tiles will impact significantly in the reduction of roofing tile construction costs, while still converting the country's deposits of agricultural waste which is obviously an environmental health hazard to economic purposes for national development.

1.4 AIM OF THE PROJECT:

The aim of this research was to explore the possibility of using of rice husk ash (RHA) and red soil with clay to reduce the cost of production of low cost roof tiles by partially replacing Ordinary M-sand with RHA and red soil with clay content

The objectives are:

1. To determine the physical properties of rice husk ash. These include specific gravity and particle size distribution of the RHA , M-sand , red soil and clay.

2. To produce concrete roof tile using Rice Husk Ash with replacement of M-sandat (7%, 14%, 21%, 28%, 35%, and 42 %) and red soil at (23%) with replacement of clay at (27%)

3. Testing the produced sample for physical variations from the control sample produced. (compressive strength)

4. To compare the obtained result with standards for low cost roof tiles.

1.5 SCOPE AND OBJECTIVES:

This study focuses on use of rice husk ash as partial replacement for M-sand in the production of low cost roofing tiles. It makes use of the growing rice husk waste produced by varying its proportions (7%, 14%, 21%, 28%, 35% & 42%) in partial replacement of M-sand and 23% of red soil with 27% of clay used for low cost roof tiles.

2. LITERATURE REVIEW

- Disposal of rice husk ash is an important issue in the countries that cultivate large quantities of rice. Rice husk has a very low nutritional value and as they take very long to decompose are not appropriate for composting or manure. Therefore the 100 million tons of rice husk produced globally begins to impact the environment if not disposed of properly. One effective method used today to rid the planet of rice husk is to use it to fuel kilns. These kilns help to produce bricks and other clay products that are used in daily life and are also useful in parboiling units that use RH as their fuel **(Nnamdi, 2011).** Burning the rice husk is an efficient way to dispose of the rice cultivation byproduct while producing other useful goods. After the kilns have been fired using rice husk, the ash still remains. This ash still has very significant application in the construction industry, As the production rate of rice husk ash is about 20 % of the dried rice husk, the amount of RHA generated yearly is about 20 million tons worldwide **(Hwang, 1985).**

- The rice husk ash is a highly siliceous material that can be used as an admixture in concrete if the rice husk is burnt in a specific manner. The characteristics of the ash are dependent on the components, temperature and time of burning **(Hwang, et.al 1985).** During the burning process, the carbon content is burnt off and all that remains is the silica content. The silica must be kept at a non-crystalline state in order to produce an ash with high pozzalonic activity. The high pozzalonic behavior is a necessity if you intend to use it as a substitute or admixture in concrete. It has been tested and found that the ideal temperature for producing such results is between 600 °C and 700 °C. If the rice husk is burnt at too high a temperature or for too long the silica content will become a crystalline structure. If the rice husk is burnt at too low a temperature or for too short a period of time the rice husk ash will contain too large an amount of un-burnt carbon **(Zemke and Woods 2009).**

- The use of pozzolanas as alternatives for the commonly used Portland cement have been used in the past few decades either for cost reduction, performance & durability enhancement or environmental reasons **(Nair, 2007). Malhorta and Mehta (1999)**state thatpozzolanas are defined as siliceous or siliceous and aluminous materials which in themselves possess little or no cementing property, but will in a finely dispersed form in the presence of water chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. When water is added to a mixture with pozzolanic material it acts as cement, in some instances providing a stronger bond than cement alone.

According to **Hegazy, et al (2012),** materials such as lime, pozzolana, fly ash, limestone dust, blast furnace slag, rice husk ash, corn cob ash, incinerator ash, billet scales, siliceous and ionic materials have generally being adapted for use in construction works because of their known cementing properties.

- The addition of rice husk ash to a concrete mixture has been proven to increase corrosion resistance. It has a higher early strength than concrete without rice husk ash. The rice husk ash forms a calcium silicate hydrate gel around the cement particles which is highly dense and less porous **(Song, 1779).** This will prevent the cracking of the concrete and protect it from corrosion by not allowing any leeching agents to break down the material. The study done by Song and Saraswathy found that the incorporation of RHA up to 30 % replacement level reduces the chloride penetration, decreases permeability, and improves strength and corrosion resistance properties.

- The effects of humidity can result in a drastic change in the final behavior of the concrete. The comparative tests performed and documented by **(Jauberthie, 2002)** between specimens stored in dry and wet conditions have shown that at high humidity conservation the mortar gains strength by virtue of the well developed pozzolanic reaction. This added strength is only under compression forces, specimens are more brittle under a smaller flexural load than specimens stored at 50 % relative humidity **(Hofstrand, et. al 1984).** For climates with high humidity levels, they indicate that there will be a higher compressive strength, but more brittleness in the concrete produced. For the use of concrete with rice husk ash mixtures, it would be recommended to use it concrete element supporting compressive forces **(Zemke, and Woods 2009).**

- **In 1962**, a "state-of-the-art" high pressure extrusion machine made in England was installed in Fremont, **Calif. In 1966,** faster equipment produced in Australia was place in the factory located in Corona, Calif. The economic production of much higher quality concrete tiles at three to four times the speed formerly obtainable met the rapidly growing demand. Laws requiring fire-retardant roofs created a growing market for concrete tiles. Homeowners and developers found concrete tile roofs aesthetically pleasing, permanent and fire-safe.

- Cement as the major classical binder in construction industry is very expensive. This is because of phenomenal population growth and urbanization which have triggered high demand of cement for several construction purposes to meet up with the need to expand infrastructures**(Otuoze, et.al 2012).** Therefore the need to connect the gap between demand and high price has warranted the need to investigate the use of cheaper alternative sources.

- In a study **(Dabai, et.al 2009)** disclosed that rice husk ash is one of the promising pozzolanic materials that can be blended with Portland cement for the production of durable concrete and at the same time it is a value added product. Addition of rice husk ash to Portland cement does not only improve the early strength of concrete, but also forms a calcium silicate hydrate (CSH) gel around the cement particles which is highly dense and less porous, and may increase the strength of concrete against cracking **(Saraswathy and Ha- Won, 2007).**

- Rice is the major staple that is consumed worldwide and is grown on every continent except Antarctica **(Kartini, 2011).** It is a primary source of food for billions of people, and ranks second to wheat in terms of area and production. Nigeria which ranks as the 17th largest rice producing country in the world **(Omatola, 2009),** cultivates rice in virtually all the agro-ecological zones in Nigeria and the most important region for rice production being River Niger basin **(Nnamdi, 2011).**

- Benue, Abakaliki, Afikpo, Ogoja, Ikepe, Lafiagi, Badeji, Pategi, Sokoto, BirninKebi, Abeokuta, Benin and Delta region **(Opara, 2011).** Rice husk is the waste product generated from the accumulation of the outer covering of rice grains during the milling process. Each country is faced with the challenging problem of the disposal of this low valued by product within the framework of her economy.

- In Makurdi and other towns in Benue state rice husk dumps are increasing in large proportions, and as stated in **(Omoniyi, 2013)** use or. RHA could be obtained as a waste product from the furnaces of rice parboiling units that utilize RH as their fuel **(Ramezanianpour, 2009).**

3. MATERIALS

3.1 GENERAL:

This chapter deals with the materials used in this research and the various test that were carried out in preparation of the production of Low cost roof tiles and also the test that were carried out on the tiles to check durability and compliance according to ASTM C1492.

3.2 M-SAND:

Manufactured sand is crushed fine aggregate produced from a source material and designed for use in concrete or for other specific products. Only source materials with suitable strength, durability and shape characteristics should be used. Production generally involves crushing, screening and possibly washing. Separation into discrete fractions, recombining and blending may be necessary.

3.3 CLAY:

Clay has the smallest particle size of any soiltype, with individual particles being so small that they can only be viewed by an electron microscope.Thisfeature 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-heavysoil tends to be very dense.Clay contains very littleorganic material; you often need to add amendments if you wish to grow plants in clay-heavy soil.

3.4 REDSOIL:

Red soils are highly leached soils of thehumid 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 importantstrategies for replenishing soil fertility and improving crop yields on these soils.

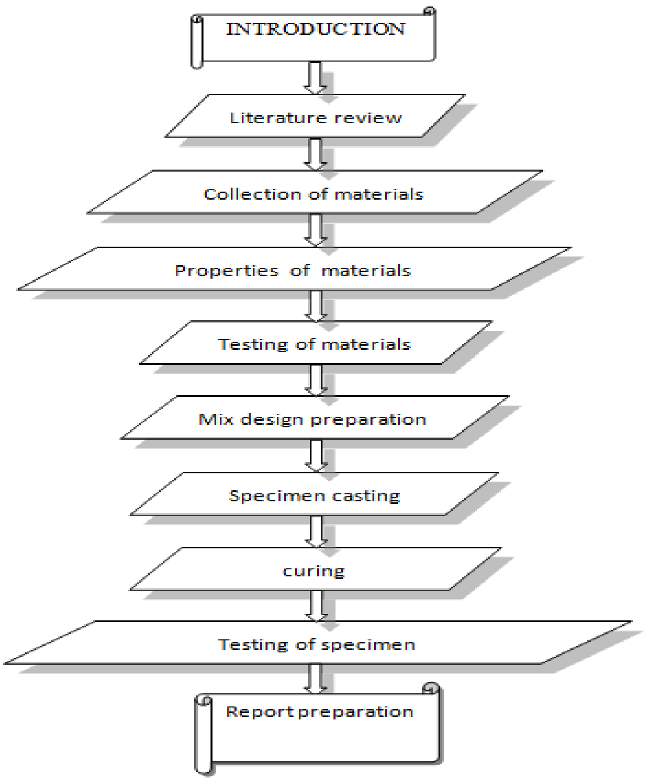
3.5 RICE HUSK ASH:

Rice Husk Ash is an Rice milling industry generates a lot of rice husk during milling of paddy which comes from the fields. This rice husk is mostly used as a fuel in the boilers for processing of paddy. Rice husk is also used as a fuel for power generation. Rice husk ash (RHA) is about 25% by weight of rice husk when burnt in.

3.6 WATER:

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

4. METHODOLOGY



5. EXPERIMENTAL STUDY

5.1 PRILIMINARY TEST FOR MATERIALS:

Specific gravity and Sieve Analysis was made for an each materials of Rice husk ash, Clay, Red soil and M-sand.

5.1.1 Specific Gravity of Rice Husk Ash:

Aim: To determine the specific gravity of Rice Husk ash.

Apparatus:

1. A Pycnometer
2. A balance of 3kg capacity
3. ½ Litres of capacity glass jar and ground glass dish.
4. A drying duster.

Theory:

The specific gravity of a material is the ratio of its unit weight to that of water. For the purpose of mix design, the specific gravity of saturated and surface-dry basis is used. Thespecific gravity of Rice husk ashfalls with the range of 2.00 — 3.00. The specific gravity of anRice husk ash is an important factor affecting the density of the resulting roof tiles. The specific gravity of a Rice husk ash can be determined from the expression below.

$$Specific\ gravity(Gs) = \frac{B}{P + B - Ps}$$

Where B = Weight of Rice husk ash.

P= Weight of Pycnometer

Ps=W eight of Pycnometer + water + Rice husk ash.

Procedure:

Step 1: The Pycnometer was filled with distilled water to full capacity with the screw in position and the outside dried and the weight was recorded (P).

Step2: The cap was unscrewed and a sample of surface dry (oven dry) sand of know weight (600g) or (mg of Rice husk ash) (B) was introduced.

Step 3: The cap was replaced and the Pycnometer refilled to full the Capacity with distilled water. All trapped was eliminated by rotating the Pycnometer on its side whilst covering the hole with finger.

Step 4: The outside of the Pycnometer was dried and reweighed (Ps). The Pycnometer now contained less water than before and the weight of water occupying the same volume as the sample is (P + B + PS).

5.1.2 Specific Gravity Of Clay:

Aim: To determine the specific gravity of Clay.

Apparatus:

1. A Pycnometer
2. A balance of 3kg capacity
3. ½ Litres of capacity glass jar and ground glass dish.
4. A drying duster.

Theory:

The specific gravity of a material is the ratio of its unit weight to that of water. For the purpose of mix design, the specific gravity of saturated and surface-dry basis is used. The specific gravity of Clay falls with the range of 1.80 — 2.50. The specific gravity of an Clay is an important factor affecting the density of the resulting roof tiles. The specific gravity of a clay can be determined from the expression below.

$$Specific\ gravity(Gs) = \frac{B}{P + B - Ps}$$

Where B = Weight of Clay.

P= Weight of Pycnometer

Ps=W eight of Pycnometer + water + Clay.

Procedure:

Step 1: The Pycnometer was filled with distilled water to full capacity with the screw in position and the outside dried and the weight was recorded (P).

Step2: The cap was unscrewed and a sample of surface dry (oven dry) sand of know weight (600g) of Clay (B) was introduced.

Step 3: The cap was replaced and the Pycnometer refilled to full the Capacity with distilled water. All trapped was eliminated by rotating the Pycnometer on its side whilst covering the hole with finger.

Step 4: The outside of the Pycnometer was dried and reweighed (Ps). The Pycnometer now contained less water than before and the weight of water occupying the same volume as the sample is (P + B + PS).

5.1.3 Specific Gravity of Red Soil:

Aim: To determine the specific gravity of Red soil.

Apparatus:

1. A Pycnometer

2. A balance of 3kg capacity

3. ½ Litres of capacity glass jar and ground glass dish.

4. A drying duster.

Theory:

The specific gravity of a material is the ratio of its unit weight to that of water. For the purpose of mix design, the specific gravity of saturated and surface-dry basis is used. The specific gravity of Red soil falls with the range of 1.20 — 1.50. The specific gravity of an Red soil is an important factor affecting the density of the resulting roof tiles. The specific gravity of a Red soil can be determined from the expression below.

$$Specific\ gravity(Gs) = \frac{B}{P + B - Ps}$$

Where B = Weight of Red soil.

P= Weight of Pycnometer

Ps=W eight of Pycnometer + water + Red soil.

Procedure:

Step 1: The Pycnometer was filled with distilled water to full capacity with the screw in position and the outside dried and the weight was recorded (P).

Step2: The cap was unscrewed and a sample of surface dry (oven dry) sand of know weight (600g) of Clay (B) was introduced.

Step 3: The cap was replaced and the Pycnometer refilled to full the Capacity with distilled water. All trapped was eliminated by rotating the Pycnometer on its side whilst covering the hole with finger.

Step 4: The outside of the Pycnometer was dried and reweighed (Ps). The Pycnometer now contained less water than before and the weight of water occupying the same volume as the sample is (P + B + PS).

5.1.4 Specific Gravity of M-sand:

Aim: To determine the specific gravity of M-sand.

Apparatus:

1. A Pycnometer

2. A balance of 3kg capacity

3. ½ Litres of capacity glass jar and ground glass dish.

4. A drying duster.

Theory:

The specific gravity of a material is the ratio of its unit weight to that of water. For the purpose of mix design, the specific gravity of saturated and surface-dry basis is used. The specific gravity of M-sand falls with the range of 2.00 — 2.80. The specific gravity of an M-sandis an important factor affecting the density of the resulting roof tiles. The specific gravity of aM-sandcan be determined from the expression below.

$$Specific\ gravity(Gs) = \frac{B}{P + B - Ps}$$

Where B = Weight of M-sand.

P= Weight of Pycnometer

Ps=W eight of Pycnometer + water + M-sand.

Procedure:

Step 1: The Pycnometer was filled with distilled water to full capacity with the screw in position and the outside dried and the weight was recorded (P).

Step2: The cap was unscrewed and a sample of surface dry (oven dry) sand of know weight (600g) of Clay (B) was introduced.

Step 3: The cap was replaced and the Pycnometer refilled to full the Capacity with distilled water. All trapped was eliminated by rotating the Pycnometer on its side whilst covering the hole with finger.

Step 4: The outside of the Pycnometer was dried and reweighed (Ps). The Pycnometer now contained less water than before and the weight of water occupying the same volume as the sample is (P + B + PS).

Table 5.1: Specific Gravity for Rice husk ash, Clay, Red soil and M-sand

S.NO	MATERIALS	SPECIFIC GRAVITY
1	RICE HUSK ASH	2.3
2	CLAY	2.12
3	RED SOIL	1.53
4	M-SAND	2.13

5.2 Particle size Distribution:

Aim:

Determination of particle size distribution in a sample of M-sand, Red soil and Clay.

Apparatus:

1. Set of B.S Sieves of sizes (5.0, 3.35, 2.36, 1.70, 1.80, 0.85, 0.60, 0.425, 0.30, 0. 5, 0.075, pan) mm for all sample.

2. Balance readable and accurate to 0.1% of the weight is test samples.

Theory:

Sieve analysis involves determination of the size ranges of particle present in all sample expressed as a percentage of the total dry weight. The sieve analysis method is used to determine the particle sizes of aggregate larger than 0.075mm e.g. Sand, gravels, cobbles, pebbles, boulders etc. while the hydrometer analysis are use to determine the particle size soil aggregate less than or smaller than 0.075mm in diameter.

In sieve analysis, the soil sample is passed through a series of standard test sieves having progressively smaller openings (smaller mesh sizes). The weight of the soil retained in each of the sieves is determined and the cumulative percentage by weight passing each sieve is calculated mathematically.

The sieve analysis procedure were repeated same for all the particles to find the particle size distribution.

5.2.1 Procedure for M-sand:

Step 1: AM-sand sample was sun dried to remove all the moisture in the sand.

Step 2: The sample was the weighed 1000g and poured into the mounted set of sieves.

Step 3: The sieves were manually vibrated for 30 seconds.

Step 4: Then each sieve was carefully removed and the retained sample was weighed and recorded.

Step 5: The process in step 4 was continued until all the retained mass on the sieve was recorded.

5.2.2 Procedure for Red soil:

Step 1: A Red soil sample was sun dried to remove all the moisture in the sand.

Step 2: The sample was the weighed 1000g and poured into the mounted set of sieves.

Step 3: The sieves were manually vibrated for 30 seconds.

Step 4: Then each sieve was carefully removed and the retained sample was weighed and recorded.

Step 5: The process in step 4 was continued until all the retained mass on the sieve was recorded.

5.2.3 Procedure for Clay:

Step 1: A Clay sample was sun dried to remove all the moisture in the sand.

Step 2: The sample was the weighed 1000g and poured into the mounted set of sieves.

Step 3: The sieves were manually vibrated for 30 seconds.

Step 4: Then each sieve was carefully removed and the retained sample was weighed and recorded.

Step 5: The process in step 4 was continued until all the retained mass on the sieve was recorded.

Table 5.2.1: 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

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

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

5.3 MIX DESIGN:

5.3.1 SPECIMEN SIZE:

Length = 8”

Width = 8”

Thickness = 1”

- **MASS = VOULME (X) DENSITY**

= 203.2 * 203.2 * 0.0254 * 2400

= 2.5 KG

TOTAL WEIGHT = 2.5 kg (8” * 8” * 1”)

- The water quantity will be maintain same for all mix ratio : 0.5 kg

5.3.2 MIX RATIO:

1st **MIX:** STANDARD ROOF TILES

S.NO	MATERIALS	PERCENTAGE	WEIGHT(kg)
1	M-SAND	50%	1.25
2	RED SOIL	23%	0.575
3	CLAY	27%	0.675
		TOTAL	2.5

2nd **MIX:** 7% OF RHA AND 43% OF M-SAND

S.NO	MATERIALS	PERCENTAGE	WEIGHT(kg)
1	M-SAND	43%	1.075
2	RICE HUSK ASH	7%	0.175
3	RED SOIL	23%	0.575
4	CLAY	27%	0.675
		TOTAL	2.5

3rd **MIX:** 14% OF RHA AND 36% OF M-SAND

S.NO	MATERIALS	PERCENTAGE	WEIGHT(kg)
1	M-SAND	36%	0.9
2	RICE HUSK ASH	14%	0.35
3	RED SOIL	23%	0.575
4	CLAY	27%	0.675
		TOTAL	2.5

4th **MIX:** 21% OF RHA AND 29% OF M-SAND

S.NO	MATERIALS	PERCENTAGE	WEIGHT(kg)
1	M-SAND	29%	0.725
2	RICE HUSK ASH	21%	0.525
3	RED SOIL	23%	0.575
4	CLAY	27%	0.675
		TOTAL	2.5

5th **MIX:** 28% OF RHA AND 22% OF M-SAND

S.NO	MATERIALS	PERCENTAGE	WEIGHT(kg)
1	M-SAND	22%	0.55
2	RICE HUSK ASH	28%	0.7
3	RED SOIL	23%	0.575

4	**CLAY**	**27%**	**0.675**
		TOTAL	**2.5**

6th MIX: 35% OF RHA AND 15% OF M-SAND

S.NO	**MATERIALS**	**PERCENTAGE**	**WEIGHT(kg)**
1	**M-SAND**	**15%**	**0.375**
2	**RICE HUSK ASH**	**35%**	**0.875**
3	**RED SOIL**	**23%**	**0.575**
4	**CLAY**	**27%**	**0.675**
		TOTAL	**2.5**

7th MIX: 42% OF RHA AND 8% OF M-SAND

S.NO	MATERIALS	PERCENTAGE	WEIGHT(kg)
1	M-SAND	8%	0.2
2	RICE HUSK ASH	42%	1.05
3	RED SOIL	23%	0.575
4	CLAY	27%	0.675
		TOTAL	2.5

5.4 EQUIPMENT USED FOR CASTING OF SPECIMEN:

Thespecimens were casted according to the mix procedure by the following equipments and curing were made at the outside of the lab.

5.4.1 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.

Fig: 5.4.1 wooden mould

5.5 PRODUCTION OF ROOFING TILES:

1. The materials were collected according to the batch. Where weights are taken for each materials according to the mixes.
2. All the materials were poured into a pan mixer for each batch and allowed to mix by using trowel thoroughly before finally adding water gradually while monitoring workability. In this experiment various mix ratios for cement replacement with RHA will be done at 7, 14, 21, 28, 35 and 42% with M-sand.
3. The mortar mix was now transferred onto wheelbarrow and driven to the casting table, then spreading of the mortar in the mould.
4. The damping rod were used to dump the clay mortar in the mould for an well settlement of roof tiles.
5. The tile was now removed and the green tile carefully slid to set.
6. The moulds were then stacked and allowed to cure slowly for 24 hours.
7. After 24 hours the tiles were removed from the moulds and placed at the outside of the lab , leaning the tiles against each other.

5.6 EXPERIMENTAL TEST PROCEDURES ON ROOF TILES:

- Due to the preciseness required in the production of roofing tiles and the time available for this research, the replacement levels were limited to a maximum of 42 %.
- The development of the sample size is 8 inch length × 8 inch width ×1 inch thickness.
- The shape of the tile is flat and unbevelled, and has no provision for installation since this research has limited funding, manufacture of formwork to otherwise provide for this elaborate design would seem unreasonable thus the viability of the tile and not its usability is tested.
- Only the compressive strength and water absorption are determined; thus no simulation of installed tile to examine performance in rainfall and wind condition has been carried out. This research has produced 7 samples each of the replaced ratios including the control samples.
- One sample per test for each tile batch mix, testing of the tile was done for durations after casting; of 7 days curing. A total of 7 samples were produced and test made for each sample to monitor strength gain.

5.7 TESTING OF LOW COST ROOF TILES:

Two test have been made for low cost roof tiles. This test are made to find out the water absorption capacity of low cost roof tiles and ultimate strength of the low cost roofing tiles. The tests are:

i **Water Absorption Test.**

ii **Compressive Strength Test.**

5.7.1 WATER ABSORPTION TEST:

AIM:

- To determine the percentage of water absorption of roofing tiles.

APPARATUS REQUIRED:

- A sensitive balance.

PROCEDURE:

- Dry the tiles selected in an oven at a temperature of 105 ° TO 110 °C till they attain constant weight and then cool and weigh (M_1).

- When cool, immerse the dry specimen completely in clean water at 27±2°C for 24 hours.
- Remove each specimen, wipe off the surface water carefully with a damp cloth and weigh the specimen nearest to a gram (M_2) within 3 minutes after removing the specimen from the tank.

CALCULATION:

- Percentage of water absorption
- Where M_2 =wt. of the specimen after 24 hours immersion in clean water
- M_1 = wt. of the dry specimen.

$$W = \frac{M_2 - M_1}{M_1} X\ 100$$

Table: 5.7.1 water absorption test

MIXES	PARTICULARS	DRY WEIGHT (M_1)	WET WEIGHT (M_2)	WATER ABSORPTION PERCENTAGE (%)
MIX 1	Standard tiles	800	1200	50
MIX 2	7% of RHA	780	1100	41
MIX 3	14% OF RHA	770	1100	42.85
MIX 4	21% OF RHA	750	1055	40.66
MIX 5	28% OF RHA	728	1070	46.97
MIX 6	35% OF RHA	710	1100	54.92
MIX 7	42% OF RHA	705	1120	58.86

5.7.2 COMPRESSIVE STRENGTH TEST:

- Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In this study and shear strength of roof tiles can be analyzed independently.
- The compressive strength test were made and values were finded by using the compressive strength testing machine at capable of 10N.
- 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:

$\sigma_c = \frac{Pc}{Ac}$.........Equation 4

- Where "Pc" is the total load on the specimen at failure,
- "Ac" is the calculated cross-sectional area and
- "σ_c" isthe compressive strength of the test

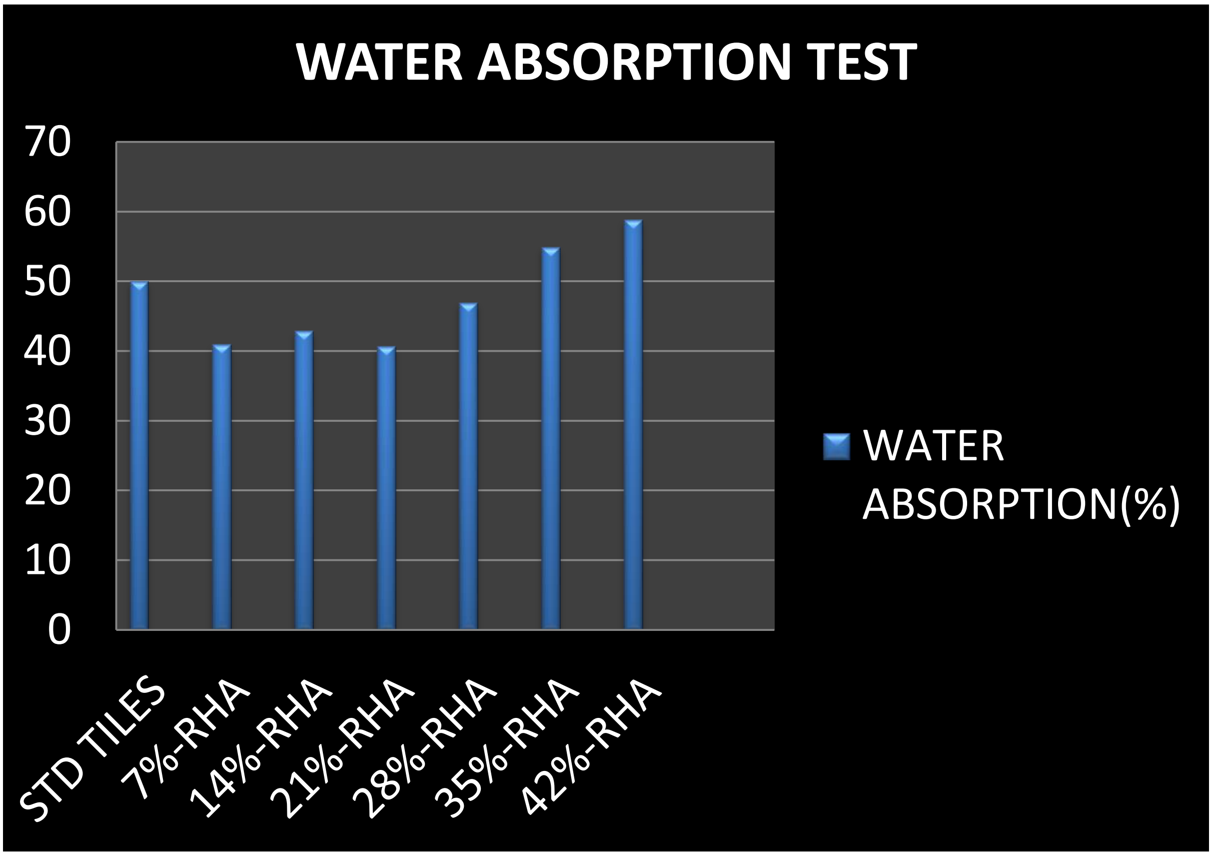
Table: 5.7.2 Compressive strength test

MIXES	PARTICULARS	LOAD	COMPRESSIVE STRENGTH TEST (N/mm^2)
MIX 1	STANDARD TILES	8.67	0.21
MIX 2	7% OF RHA	9.49	0.23
MIX 3	14% OF RHA	7.84	0.19
MIX 4	21% OF RHA	5.78	0.14
MIX 5	28% OF RHA	4.54	0.11
MIX 6	35% OF RHA	3.30	0.08
MIX 7	42% OF RHA	2.06	0.05

5.8 COMPARISON OF RESULTS:

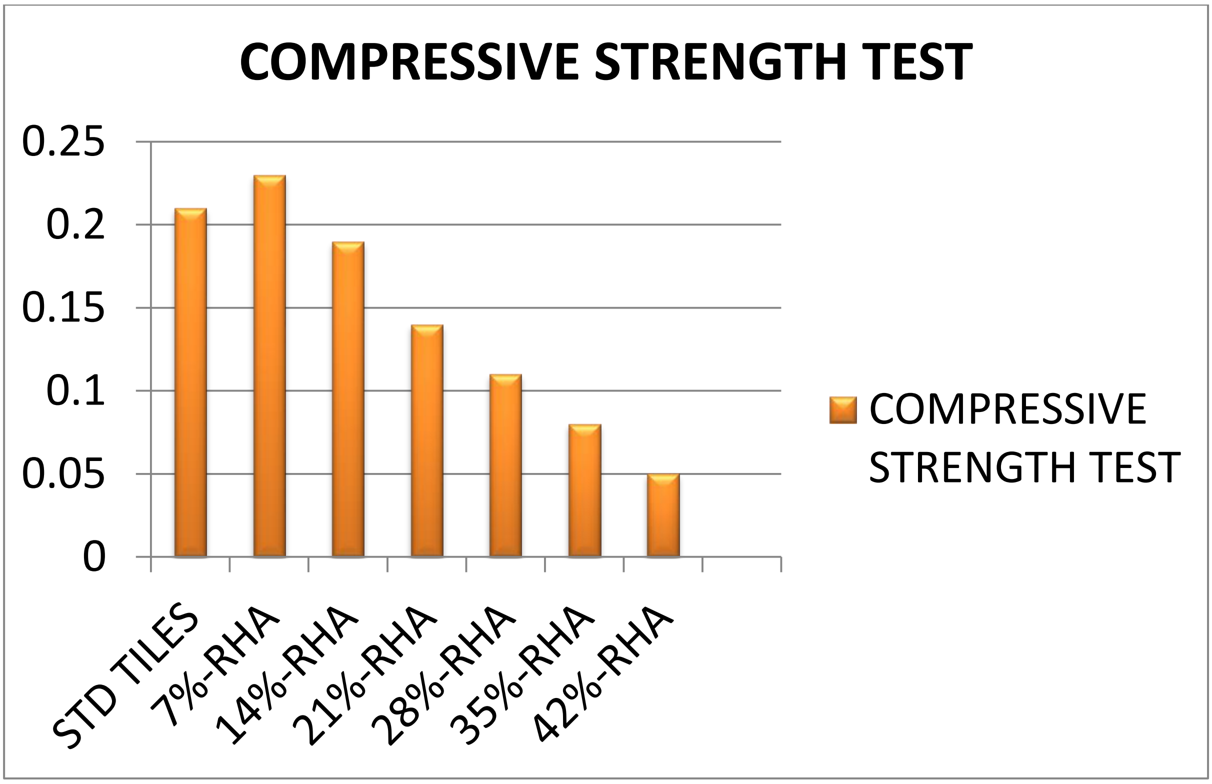
5.8.1 WATER ABSORPTION:

Table 5.7.1 shows water absorption of specimen at various replacement levels. Comparison graph indicates highest levels of water absorption for 35 and 42 % replacement Rice husk ash with M-Sand for 24 hrs. This complies with water content increasing linearly with % increment of RHA. The graph shows the best trend for water absorption at 42 % replacement.



5.8.2 COMPRESSIVE STRENGTH:

Table 5.7.2 displays the average compressive strength in N/mm^2 of the tile specimen at different levels of replacement. At 0 % replacement compressive strength gain after 7 days records 0.21 N/mm^2 moving through to 0.05 N/mm^2 at final replacement of Rice husk ash with M-sand. The best curve is at 7 % replacement where strength gain starts form 0.21 N/mm^2 at standard roof tiles and progresses steadily to 0.23 N/mm^2 at 7% replacement of Rice husk ash with M-sand. The graph shows the difference of strength attain by roof tiles at different mix proportions.



6. CONCLUSION

• From our experimental study, we conclude that replacement of Rice husk ash in making roof tiles will be light effective if the replacement ratio lies below 7%. This study prove that 7% replacement of Rice husk ash in roof tiles with similar compressive strength, it would be a great benefit in both economic and environmental concern. And further replacement of Rice husk ash at the percentage of (14%, 21%, 28%, 35% and 42%) effectively, it will indirectly reduce the strength of the low cost roof tiles. Thus, both economic and environmental benefits occurs at the percentage of 7%Rice husk ash and it can be followed for an making of low cost roofing tiles.

REFERENCES

[1] IS 3978-1967 Indian Standard Code of Practice for Manufacture of Burnt Clay Mangalore Pattern Roofing Tiles. Yaning Zung, A.E. Ghaly, Bingxi Li, "Physical Proiperties of Corn Residues", American Journal of Biochemistry and Biotechnology, Aug, 2012. ISSN 1553-3468.

[2] 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.

[3] 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.

[4] 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.

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