International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 02 | Feb 2019 www.irjet.net p-ISSN: 2395-0072

Design of Low Cost Roofing Tiles using Agricultural Waste

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Abstract - *This research deals with the effects of using rice husk ash (RHA) as a partial weight of cement replacement in concrete roof tile production. 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.

Key Words: **Rice Husk Ash, Roofing Tiles, Environment Friendly, Low Cost, Design**

1. INTRODUCTION

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.

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.

1.1 Types of Roofing Tiles

A large number of types 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.

1.2 Objectives

- To determine the properties of rice husk ash (RHA). This include specific gravity and particle size distribution of RHA, M-sand, red soil and clay.
- To produce concrete roof tiles using Rice Husk Ash with replacement of M-sand and red soil with replacement of clay.
- To compare the obtained result with standards for low cost roof tiles.

2. LITERATURE REVIEW

2.1 Author Name: Song (1779)

This paper states that 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.

2.2 Author Name: Hwang (1985)

This paper shows the ash 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 millions tons worldwide. 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 rice husk ash are dependent on the components, temperature and time of burning.

2.3 Author: Malhotra and Mehta **(**Year: 1999)

Malhotra and Mehta state that pozzolans are defined as siliceous and aluminium materials which in themselves possess little or no cementing property, but will in a finely dispersed form in the presence of water chemically 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.

2.4 Author: Zemke and Woods (2009)

They concluded that during the burning process, the carbon content is burnt off and all that remains is the silica content. Pozzalonic behaviour is a necessity if you intend to use it as a substitute or admixture in concrete. If the rice husk is burnt at too low temperature or for too short, a period of time the rice husk ash will contain too large an amount of un-burnt carbon.

2.5 Author: Omatola (2009)

According to Omatola, Rice is the major staple that is consumed worldwide and is grown on every continent except Antarctica. 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 the 17th largest rice producing country in the world. Rice husk is the waste we can get from these areas.

2.6 Author: Opara (2011)

In the research work he concluded that 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.

2.7 Author: Otuoze et.al **(**2012)

He researched that 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. Therefore the need to connect the gap between demand and high price has warranted the need to investigate the use of cheaper alternative sources.

2.8 Author: Agbede Olufemi, Tersoo Akuto **(**2016)

They concluded that addition of RHA in a mortar mix increases workability in so far as the w/c ratio is balanced to meet the standars consistency of cement paste. RHA blended concrete can improve the compressive strength of concrete. RHA helps in enhancing the early age mechanical properties as well long term strength properties of concrete tiles.

2.9 Author: Saravanan J. **(**2017)

From their experimental study, they conclude that replacement of river sand in making roof tiles will effective if the replacement ratio lies below 5%. Thus, both economic and environmental benefits occurs in this manner if the manufacturing of roof tiles is made in large scale.

2.10 Author: Mrs. K. Saranya, Mythily K. **(2018)**

From their experimental study, they conclude that replacement of Rice husk ash in making roof tiles will be light effective if the replacement ratio lies below 7%.

3. METHODOLOGY

3.1 Materials Used:

This chapter deals with the materials used in this research and the various test that were carried out in preparation of the production of concrete roof tiles and also the test that were carried out on the tiles to check durability and compliance according to IS 3978:1967

3.1.1 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.

3.1.2 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.

3.1.3 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.

3.1.4 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,

3.1.5 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.

3.2 Tests on Low Cost Roofing Tles

3.2.1 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.

Fig -1 Water Absorption Test

3.2.2 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:

$$\sigma c = \frac{Pc}{Ac}$$

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.

3.2.3 Bulk Density Determination

After the test specimens completely cure, the dry mass Md was determined by using a loading pan balance of sensitivity of 0.001 gm. The bulk density was calculated using:

$$P = Md/V$$

Where, V is the volume of the tile, which was determined from the length, breadth and thickness of the tile and Md is the dry mass of the tile. The recorded bulk density is based on the average value of five specimens.

3.2.4 Abrasion Test on Tiles

For roofing tiles, the determination of the abrasion resistance of the glaze is made by rotation of an abrasive load on the surface and assessment of the wear by means of visual comparison of abraded test specimens and and non-abraded tiles.

3. CONCLUSION

From our theoretical study, we conclude that replacement of Rice husk ash in making roof tiles will be light effective if the replacement ratio lies between 5% - 10%. This study prove that 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 5 – 10, Rice husk ash and it can be followed for an making of low cost roofing tiles.

ACKNOWLEDGEMENT

It gives us great pleasure in presenting the preliminary project report on **"Low Cost Roofing tiles using Agricultural Waste"**.

We would like to take this opportunity to thank our guide **Prof. P. S. Patil** and Co-guide **Prof. Abhishek Nimbekar** for giving us all the help and guidance needed, especially for the useful suggestion given during the course of project.

We would also like to thank our project co-ordinator **Prof. Punith Upadhye** for his assistance and support. We would also like to thank our Head of Department, **Prof. P. S. Patil** for his unwavering support for this project work.

We are grateful to our Principal **Dr. V. N. Nitnaware** for providing us with an environment to complete our project successfully. We also thank all the staff members, technicians of our college for their help.

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