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Design of low cost roofing tile using agricultural and plastic waste

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Abstract – *This is an experimental research in which ecological impact and economic impact of roofing tile production are analyzed. To achieve this, certain proportion of cement and river sand is replaced by plastic and agricultural wastes. Residential culture of living in huts and slums has become more and more tougher by the cause of time due to unprecedented changes in climate and population. While on other hand scientific and systematic discarding of agricultural residues and plastic is a matter of concern in most of the states in India. By considering both these problems to realization we were able to resolve these issues ideally by extensive production of agro-plastic roofing tile.*

Based on our cognitive study we have found that agricultural and plastic wastes can replace river sand and cement in significant proportion without compromising the flexural strength, water absorption and breaking load of roofing tile. By this sort of replacement roofing tiles can be provided at significantly affordable rates as manufacturing cost and selling price decreases drastically. Thus by utilization of agro-plastic roofing tile improves economical and environmental well-being.

***Key Words*: Agro-Plastic**

1. INTRODUCTION

Large scale industrialization due to urbanization has caused a greater impact of the construction materials. This resulted the over consumption of natural resources which in turn depleted it as well. So the replacement of conventional materials using alternative waste materials that achieve sustainability in the environment should be promoted. Local materials like soil, stone, grass and palm leaves etc. are often used which require a lot of maintenance and are not always resistant to climatic condition like heavy rain or snow fall. The roof is the covering provided on top most part of the building that protects from various climatic variations. The right material must be used in order to obtain the proper covering using a roof. Thus the demand and high cost relation must be considered and the researches to use cheaper alternative sources should be aimed. The alternate materials should be carefully studied as cheaper houses become economically feasible and it can be environmentally friendly as low-value wastes can be recycled or exploited. Plastics are widely used materials for many purposes and in turn a huge amount of waste is obtained as a residue. Their waste can be used in the construction industry in many ways. This research aims to investigate the efficiency of using plastic wastes for the partial replacement of cement and agricultural wastes as partial replacement of river sand. The key aims of this research are to determine the durability of recycling plastic wastes and agricultural wastes for the manufacture of roof tiles, as well as to investigate the physical properties and strength of the roof tile. This will reduce the building costs.

1.1 Objectives

1. To produce a low cost roofing tile using rice husk, corn cob, and plastic waste by replacing river sand.
2. To promote the economic wellbeing to the present and future population.
3. Effective waste management to achieve a healthy environment.
4. Testing the roof tiles made for the substantial changes from the control samples available.
5. To compare the obtained results with standards for low cost roofing tiles.

2. MATERIALS

The materials used in this project are; Cement, plastic powder, rice hush ash, corn cob powder, river sand, water.

2.1 Cement

Cement is most important ingredient in concrete it forms the binding medium for the ingredient made up of naturally occurring raw materials. Cement is a binder, a substance that sets and hardens independently, and can bind other materials together.

2.2 Plastic powder

There are several types of plastic. Powdered the plastic granules using mixer grinder and used it for the replacement of cement.

2.3 Rice Husk Ash

Rice husk ash during milling of paddy which comes from the fields. It used as a fuel in the boilers for processing of paddy.

2.4 Corn Cob Powder

The corn cobs are powdered into fine particles. It used for partial replacement for cements used to stabilize earth for roofing sheets.

2.5 River Sand

River sand without any organic impurities is used that conforming to IS: 383 – 1970.

2.6 Water

Potable water is used to mixing, curing of specimens.

3. METHODOLOGY

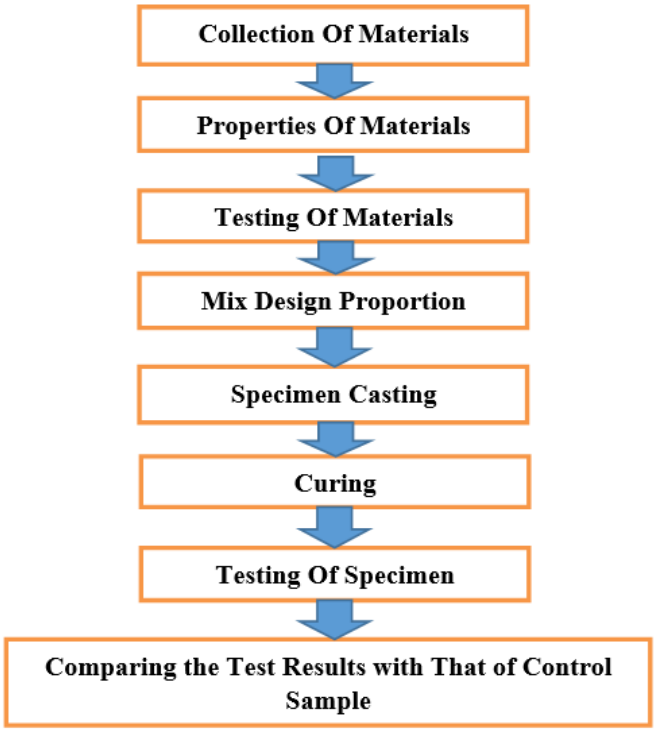

Fig-1 Methodology

Low cost roofing tiles with partial replacement of cement with plastic and fine aggregate with rice husk ash and corn cob powder. Roofing tiles is made by mixing of cement, fine aggregates, plastic powder, rice husk ash, corn cob powder and water. Adding plastic granules, rice husk ash and corn cob powder into the mixture reduces the weight and cost of the roofing tiles. The procedure adopted in the study in brief is illustrated in above figure.

3.1 Collection of Materials

The materials used for this project are cement, river sand, plastic granules, rice husk ash and corn cob powder. Each used materials was collected from a different location.

3.2 Properties of Materials

The method we used to check the properties of the materials in this project is sieve analysis. Sieve analysis is a method that is used to determine the grain size distribution of soils that are greater than 0.075 mm in diameter. It is usually performed for sand and gravel but cannot be used as the sole method for determining the grain size distribution of finer soil. The sieves used in this method are made of woven wires with square openings.

3.3 Mix Design Proportion

Made 6 samples each for different mix proportion. Have given 4 different mix proportions in this project namely mix proportion 1, mix ratio 2, mix ratio 3, mix ratio 4.

3.3.1 Mix Ratio 1

The first ratio had a no replacement of cement and sand. The ratio of cement to sand is 1:2. In this Mix ratio we have used 1500g cement and 3000g sand for the casting of roofing tile. This is the standard ratio of cement-sand roofing tile.

3.3.2 Mix Ratio 2

The second ratio, 30% cement is replaced by plastic powder and 10% sand is replaced by Rice Husk Ash and Corn Cob Powder. Rice husk ash and corn cob powder are added at the rate of 5% each. A total of 1050 g cement, 2700 g sand, 150 g rice husk ash and 150 g corn cob powder and 450 g plastic powder is used in this mix ratio.

3.3.3 Mix Ratio 3

The third ratio, 20% cement is replaced by plastic granules and 11% sand is replaced by Rice Husk Ash and Corn Cob Powder. Rice husk ash and corn cob powder are added at the rate of 6% and 5%. A total of 1200 g cement, 2670 g sand, 180 g rice husk ash and 150 g corn cob powder and 300 g plastic powder is used in this mix ratio.

3.3.4 Mix Ratio 4

The fourth ratio, cement had no replacement and 8% sand is replaced by Rice Husk Ash and Corn Cob Powder. Rice husk ash and corn cob powder are added at the rate of 4% each. A total of 1500 g cement, 2670 g sand, 120 g rice husk ash and 120 g corn cob powder is used in this mix ratio.

3.4 Specimen Casting and Curing

The moulds used for casting of specimen was bought from *MAURYA MOULDS, PUNJAB*. The mould was made of PVC of size 120 x 90 mm.

3.4.1 Casting

Casting of roof tiles was done in mould of size 120x90x10 mm and for different mix ratios 1, 2, 3 and 4.

Fig-2 Casting

3.4.2 Curing

Curing is defined as the process of maintaining the moisture and temperature conditions for hydration reaction to occur normally so that concrete develops hardened properties overtime. Immersion curing was used here. The specimens were immersed in curing tank for 7 days. After 7 day curing, the set tiles were taken out from the curing tank and prepared for testing.

Fig-3 Curing

4. TESTING SPECIMEN

4.1 Water Absorption Test

Water absorption test is the measurement of moisture quantity that roofing tile may absorb. If water absorption is too high, the tile may suffer from cracking which is not desirable. Percentage of water absorption can be computed using the following equation:

W= ((M2-M1)/M1)*100 , where

W: water absorption of the specimen which is expressed in percentage

M1: weight of dry specimen

M2: weight of the specimen after 24 hours immersion in clean water.

4.2 Flexural Strength Test

The Tile Flexure Testing Machine is used to determine the flexural strength of clay roofing tiles and cement concrete flooring tiles. The Tile Flexure Testing Machine is a double lever loading machine where load is placed by a flow of lead metal that automatically stops as the sample breaks. Flexural modulus is used an indicator of the materials stiffness when flexed. Flexural strength is calculated from formula:

$\sum = 3\,PL/2\,bt^2$ where

P - Load applied

L – Length of specimen

b – Width of specimen

t- Thickness of specimen

5. EXPERIMENTAL RESULTS

5.1 Testing of Specimens and Control Samples

Table -1: Comparison of Specimen and Control Sample

Specimen	Flexural Strength (N/mm²)	Water Absorption (%)	Breaking Load (Gm)
Mix ratio 1	1.79	7.567	6599
Mix ratio 2	0.76	18.241	2170
Mix ratio 3	0.87	13.667	2669
Mix ratio 4	1.06	8.445	3457
Clay roof tile	1.033	14.285	3428
Cement roof tile	-	1.304	-

5.2 Result Analysis

The specimen with 8% replacement of river sand with corn cob powder (4%) and rice husk ash (4%) has higher flexural strength and less water absorption and higher breaking load. The mix ratio 3 has water absorption slightly less than clay roofing tile. The mix ratio 2 has high water absorption and low flexural strength.

6. ESTIMATION

The cost estimation of the tile is given in Table 2. The price of one clay roofing tile is Rs.38 and that of cement tile ranges within Rs.60-90 for various sizes. By this sort of replacement roofing tiles can be provided at significantly affordable rates as manufacturing cost and selling price decreases drastically.

Table -2: Estimation

SL NO	MATERIALS	QUANTITY (FOR 100 TILES)	RATE (Rs)	AMOUNT (Rs)
1	CEMENT	40 Kg	460/Bag	368
2	SAND	89 Kg	2/Kg	178
3	RICE HUSK ASH	6 Kg	-	
4	PLASTIC	10 Kg	-	
5	CORN COB POWDER	4 Kg	-	
6	LABOUR	QUANTITY (FOR 100 TILES)		2000
		For 100 Tiles		2546
		For 1 Tile		25.46

7. CONCLUSION

The study investigates the effect of partial replacement of cement and river sand using agricultural and plastic waste in making of roofing tiles. From our experimental study, we conclude that partial replacement of river sand and cement in the percentages of 11% and 20% respectively using rice husk (6%) and corn cob (5%) and plastic powder 20%. This proportion is the Mix Ratio 3 which got the water absorption rate (13.6%) less than that of the conventional clay roofing tile (14.28%). The flexural strength of the mix ratio 3 and the clay roof tile has a difference of only 0.163. The breaking load of clay roof tile is 3.43 kg and of mix ratio 3 is 2.7 kg. Hence, we can see a little lesser but still comparative value for both by considering the materials used for production of roof tile. The mix ratio 4 has no cement replacement and 8% sand is replaced by equal amount of rice husk ash and corn cob powder. The mix ratio 4 has a water absorption rate (8.45%) which is lesser than that of the clay roof tile (14.28%). The flexural strength of the mix ratio 4 has a greater value than that of clay roof tile. The breaking load of clay roof tile is 3.43 kg and of mix ratio 4 is 3.45 kg. Hence, we can see that the mix ratio 4 has a slightly higher breaking load as compared to clay roof tile. By comparing the experimental values, making roof tiles will be effective if the mix ratio 3 & 4 is adopted. It would benefit in both economically and environmentally. It lowers the manufacturing cost of roof tiles, which helps in converting huts into tiled houses. Thus, becoming beneficial both ecologically and economically, if agro-plastic roofing tiles are manufactured in large scale.

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