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Effect of Charcoal and Paddy Husk on Engineering Properties of Bricks

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Abstract: **The construction practices of today demands production of alternative building materials which consume less energy and can be used for construction. In this work, the insulating fire bricks were prepared using the locally available soil in the nearby region of Mysuru. The main objective of this research was to check the properties of insulating bricks prepared by mixing some additives in the local river sand (red soil & black soil).The additives, which were previously mixed into raw or compounded clay, start to ignite during the firing process, providing extra thermal energy inside the product and decreasing the external thermal energy needed. Beside this effect, the combustion of additives increases the porosity of the product resulting in enhanced thermal insulation properties. Different samples of bricks were made by replacing 10%, 15%& 20% of additive proportion with charcoal and paddy husk to make the bricks light and more insulating than normal brick .The bricks were compacted to high pressure before being fired to temperature of 650^{0}C.The properties of brick samples were tested for water absorption, porosity, modulus of rupture, and compressive strength. Other important test performed was thermal conductivity. With the addition of charcoal and paddy husk the thermal conductivity decreased from 1.2W/mK to 0.053W/mK and 0.03W/mK respectively.**

I. INTRODUCTION

Insulation brick is characterized by the presence of large amount of porosity in it. The pores are mostly closed pores. The presence of porosity decreases the thermal conductivity of the brick drastically. The bulk densities of these bricks are usually low due to the presence of the porosity in these bricks. The use of agricultural by products in the fire clay bricks. Energy is very important in today's world. Energy growth is directly linked to well being and prosperity across the globe. Meeting the growing demand for energy in a safe and environmentally responsible manner is a key challenge. Hence energy needs to be conserved. Also there is a huge demand for the development of the bricks with better insulation capability. The use of insulation fire bricks decreases the total energy need of the industrial furnace as the pore forming additives present along with the clay burns during the firing process and provides extra thermal energy. Thus this would even result in lowering the thermal conductivity of the bricks thus improving the atmosphere within the building.

The thermal conductivity also depends on the pore size and shape. The production of light weight clay bricks with higher insulation properties is possible by using organic residues in appropriate amounts and particle sizes. Some of the additives used for this are saw dust, paddy husk, glass wool, sunflower seed shell, etc. Each particle which is dissipated during firing process and leaves behind it a cavity can improve the thermal insulation property of the brick. Thus these additives are used as a pore forming materials in the brick body to reduce the thermal conductivity and reduce the density of the brick which leads to the reduction of the mass of the brick and improvement of its resistance. If some of the organic residues are added to the raw material it is possible to increase volume of voids with controlled operating modes. By increasing the volume of the empty spaces, the weight of the brick is reduced. This leads to specific properties like increased thermal resistance in the finished product.

II. METHODOLOGY

The raw material used in this research was locally available river soil obtained from the regions in and around Mysuru. The soil obtained for the preparation of bricks was analyzed for few desired properties. The additives used were charcoal and paddy husk in proportions of 10%, 15% and 20% along with the raw material.

2.1 Preparation of Sample

The base material soil was extracted from rivers and other places in and around Mysuru. The soil was then blended with the pulverized charcoal and paddy husk separately along with water and the whole mass was kneaded under the feet of a man and stored in damp condition. Thus, a homogeneous mass with plasticity was obtained capable of holding the shape and weight which was easy to press into a mould. A rectangular mould with a volume of $(222 * 112 * 72)$ mm^3 was used for the purpose of moulding. The brick samples containing various proportions of the additives charcoal and paddy husk were prepared and analyzed.

III. EXPERIMENTAL PROCEDURE

The prepared brick samples were analyzed for few mechanical properties, brick characteristics and thermal conductivity.

3.1 Mechanical properties

Mechanical properties play a dominating role in analyzing the strength of the brick.

3.1.1 Compressive strength

The compressive strength of each specimen was determined using the compression testing machine. Blocks were air dried for 1 day and the blocks are tested for dry compressive strength where the specimen was compressed between the upper and lower platens of the machine until fracture of the specimen had occurred.

3.1.2 Modulus of rupture

Modulus of rupture is a commonly used method that measures transverse breaking strength to construction materials. The test was made on test bars the ends of which rest on knife edges while force is applied through a knife edge that is lowered midway between the ends. Loads were then applied uniformly at the middle of the specimen, uniformly. The transverse breaking strength or modulus of rupture was calculated by the formula.

$$MOR = \frac{3PL}{2bd^2} N/mm^2$$

Where,
L- the distance between two knife edges(mm)
b- breadth of the specimen(mm)
d- depth of the specimen(mm)
P- breaking load in kg

3.2 Brick Characteristics

3.2.1 Water absorption test

This test was performed using tap water. The specimen was placed in a container of water at room temperature. At the end of 24 hours the sample was removed from water and the process was repeated until it reached the saturation (equilibrium) condition. During this period, the specimens' weight difference was recorded at different times. The percentage of water retention was calculated using the following formula

$$\boldsymbol{WR\%} = \frac{\boldsymbol{W_2 - W_1}}{\boldsymbol{W_1}}$$

Where, W_1=Weight of wet sample
W_2=Weight of dry sample

3.2.2 Porosity Test

The density or porosity mainly affects the strength of the brick. An insulating fire brick with the highest porosity has the greatest strength. The samples were heated continuously in boiling water for about six hours and left to cool overnight which enables the pores to get filled up with water to saturation. The saturated specimens were then weighed by immersing in water as (W_1) and in air as (W_2). The samples were then placed in hot air oven at 200 ˚C and dried for about six hours to remove the water contents completely and then weighed as (W_3). To standardize the values of the results the percentage of porosity was calculated using the relation.

$$Percentage\ of\ porosity = \frac{W_2 - W_3}{W_2 - W_1} * 100$$

Where
W_1 = Weight of specimen after immersing in water
W_2 = Weight of specimen in dry air
W_3 = Weight of oven dried specimen

3.3 Thermal conductivity

The thermal conductivity of the brick sample was determined using Lee disc apparatus. For this the brick samples were prepared in the form of a circular disc of thickness 5mm. The thermal conductivity of the brick sample was calculated by using the formula

$$k = \frac{mc(\frac{dT}{dt})x}{\pi r^2 (T_2 - T_1)} * \left[\frac{r + 2h}{2(r + h)}\right] \quad W/mK$$

Where,
m= Mass of the brass disc (Kg)
r = $\frac{c}{2\pi}$ = Radius of the brass disc (m)
c = Circumference of the disc (m)
h = Thickness of the brass disc (m)
S = Specific heat of brass disc (J/Kg/K)
x = Thickness of the bad conductor (m)

IV. RESULTS AND DISCUSSION

This chapter comprises the results regarding the soil analysis, determination of mechanical properties, brick characteristics and thermal conductivity of the brick samples. Based on the results obtained, this chapter even includes comparison of the various brick samples.

4.1 Soil Properties

Uniformity Coefficient	3.8
Liquid Limit	30.5%
Plastic Limit	18.29%
Shrinkage Limit	12.61%

The grain size or the sieve analysis was carried out to access the particle size distribution of the soil sample. From the grain size distribution curve shown in Fig 1 the uniformity coefficient C_u was estimated to be 3.8 According to standards if the uniformity coefficient is less than 4, the sample is considered to be uniformly graded containing the particles of the same size.

Liquid limit is the minimum water content at which the soil is still in the liquid state, but has a small shearing strength against flow. From the flow curve shown in Fig 2 the liquid limit of the soil sample was obtained to be 30.5%. Plastic limit is a percentage moisture content at which a soil changes with decreasing wetness from plastic to semi-solid consistency or with increasing wetness from the semi-solid to the plastic consistency. A small increase in moisture above the plastic limit destroys cohesion of the soil. The plastic limit was estimated to be 18.29%.

Shrinkage limit is a water content where further loss of moisture will not result in any more volume reduction. The shrinkage limit of the soil sample was found to be 12.61%.

4.2 Mechanical Properties

4.2.1 Compressive Strength

The compressive strength of the normal clay brick was estimated to be 66.55 kg/cm^2. According to IS10719557 code specifications the brick sample used belongs to Class II or Grade B. These bricks are commonly used at places where brick is to be provided with a coat of plaster. Hence among the insulation fire bricks, the maximum compressive strength was obtained to be 47.49kg/cm^2 for brick containing 10% saw dust with clay. As the porosity increases the compressive strength of the bricks decreases and the bricks having a value below 35kg/cm^2 are not advisable to the construction industry.

4.2. Modulus of Rupture

The modulus of rupture of the normal clay brick was estimated to 36.32kg/cm^2. Among the insulation bricks the maximum transverse breaking strength was obtained as 25.49kg/cm^2 for saw dust of 10% as an additive when mixed with the clay material. Modulus of rupture is inversely proportional to the percentage of the additives being added to the raw clay material. This is because as the percentage of the additive increases less matter or less raw material or clay will be available to bear the load. A brick with high porosity will have lower load bearing capacity.

4.3 Brick Characteristics

4.3.1 Water Absorption

The percentage of water absorption in the normal brick was estimated to be 10.77%. As the percentage of additive added to the raw clay material increases the water absorption also increases. For a good brick the amount of water absorbed should not exceed 20% of the weight of the dry brick sample. Hence only 10% of the additives namely charcoal, paddy husk, and 15% charcoal can be used along with the base clay material to prepare the bricks since their percentage of the water absorbed was well within the prescribed limits.

4.3.2 Porosity

The porosity of the samples increase with the increase in the addition of the additives. Porosity is related to the internal structure of the brick. Porosity is inversely proportional to thermal conductivity. The empty spaces or voids insulate the thermal air flow thus lowering the thermal conductivity of the brick. The porosity of the normal brick was obtained to be 34.37% thus having a higher thermal conductivity of 1.2W/mK. On the other hand the brick samples corresponding to paddy husk of 20% when mixed with base clay material had the highest porosity of 54.54% thus having a very low thermal conductivity of 0.014W/mK.

4.4 Thermal Conductivity

Air is a much better insulator than any solid material, the larger proportion of air present, the greater will be the thermal insulation power of the brick. As the porosity increases the thermal conductivity of the brick samples decreases. The thermal conductivity also depends on the texture and the particle size of the additive used during the preparation of the brick samples. Also a fine grained material will have a greater thermal conductivity than one with the coarser open texture. The least thermal conductivity was obtained as 0.014 W/mK for paddy husk of 20% when mixed as an additive with the base clay material while the thermal conductivity of the normal clay brick was obtained to be 1.2W/mK.

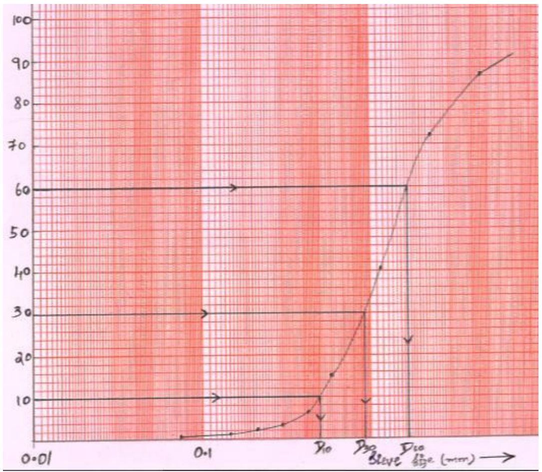

Fig 1 Grain Size Distribution Curve

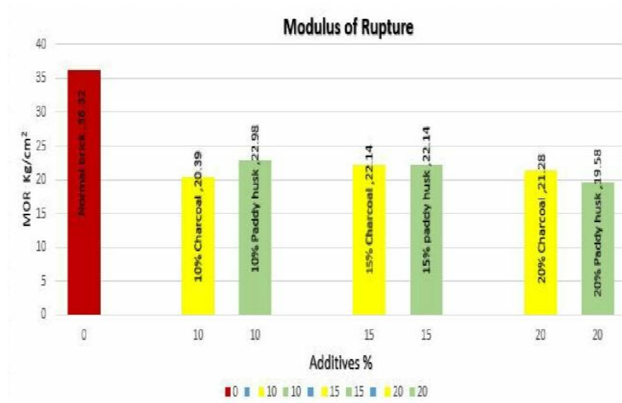

Fig 4 Additive % vs Modulus of Rupture

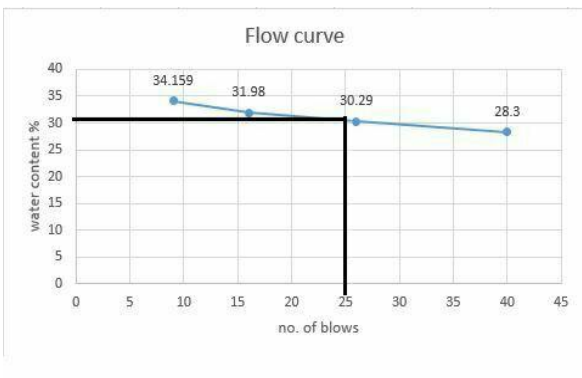

Fig 2 Flow Curve

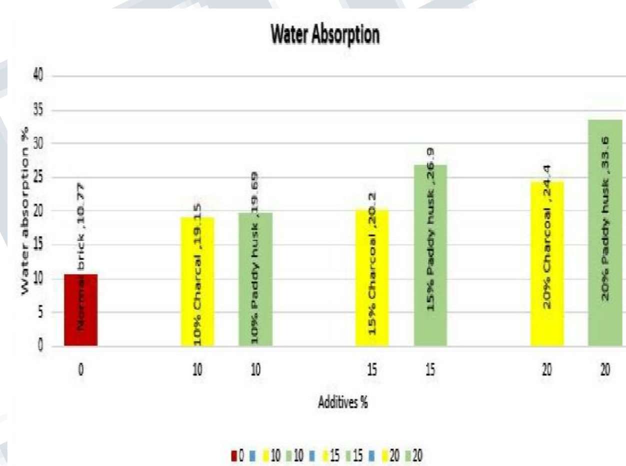

Fig 5 Additive % vs Water Absorptions

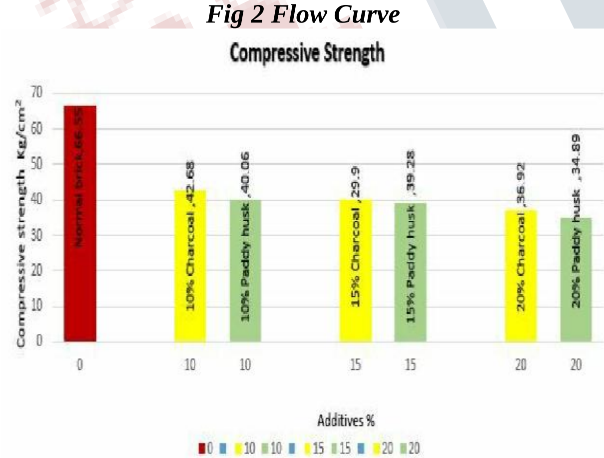

Fig 3 Additive % vs Compressive Strength

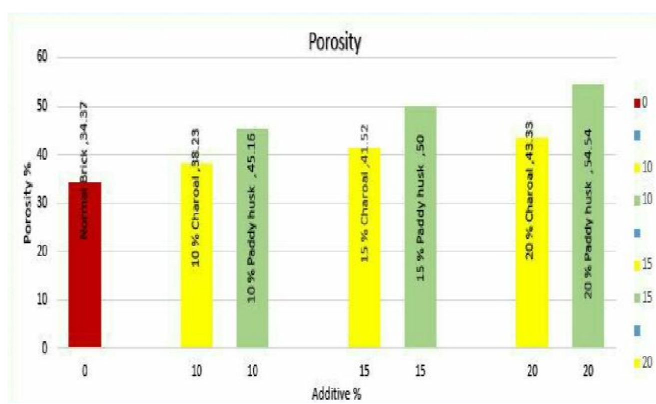

Fig 6 Additive % vs Porosity

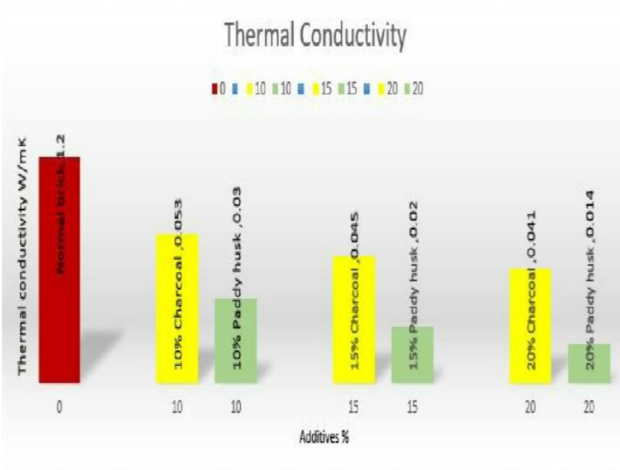

Fig 7 Additive % vs Thermal Conductivity

V. CONCLUSION

From the discussions on soil properties we can conclude that the soil selected for the preparation of the bricks posses good properties and results in the preparation of good quality bricks. Hence from the discussion so far it can be concluded that these pore forming additives can be suitably used along with the base clay material to produce insulating fire bricks. It was found that the highest decrease in thermal conductivity was obtained with the addition of the paddy husk. Thus, the addition of 20% paddy husk to the basic clay mixture decreased the thermal conductivity of the brick sample product from 1.2 W/mK to 0.014 W/mK with a porosity of 54.54%. Since it's compressive strength was below the minimum strength required for the construction of buildings, this class of brick is not recommendable. Considering all the parameters namely compressive strength, modulus of rupture, water absorption, porosity and thermal conductivity we recommend the insulation bricks manufactured by the addition of 10% of charcoal with the clay material which has a low thermal conductivity equal to 0.053 W/mK and high compressive strength of 42.68kg/cm^2 when compared to the other insulation fire bricks.

REFERENCES

[1] G.Viruthagiri, Sri Nithya Nareshananda, N. Shanmugam," Analysis of Insulating Fire Bricks from Mixtures of Clays With Sawdust Addition", IJAR,2013

[2] Viktor Bánhidi, "Enhancement of insulating properties of brick clay by renewable agricultural wastes" , Processing and Application of Ceramics, Page 75–79,2008

[3] EdwardBwayo, S.K.Obwoya, "Thermal Conductivity of Insulation Brick Developed from Sawdust and Selected Uganda clays" Volume: 03 Issue: 09 Sep-2014

[4] Okeugo Christian, Nwabineli Emmanuel, "Production of Insulating Bricks Using Unwana Clay, Edda Clay, Kaolin and Wood Soft Dust", The International Journal of Engineering and Science, Volume:01, Issue:02, Page 184-187, 2012

[5] Bachir Chemani, Halima Chemani, "Effect of Coal on Engineering Properties in Building Materials: Opportunity to Manufacturing Insulating Bricks". ISSRI,2014

[6] Ali M. Othman, "Experimental Investigations of the Effect of Some Insulating Materials on the Compressive Strength, Water Absorption and Thermal Conductivity of Building Bricks" JJMIE,2010

[7] Chaouki Sadik, Abderrahman Albizane, Iz-Eddine Amrani, "Production of Porous Firebrick from Mixtures of Clay and Recycled Refractory Waste with Expanded Perlite Addition", July 2013

[8] Bharath B, Maheshwar Reddy L, Juberahmed Pathan, Rahul R Patel, "Studies on Stabilised Adobe Blocks", IJRET

[9] Fatai Olufemi Aramide ,"Production and Characterization of Porous Insulating Fired Bricks from Ifon Clay with Varied Sawdust Admixture", September 2012

[10] Nonthaphong Phonphuak, Sakdipown Thiansem, "Effects of characoal on Physical and mechanical properties of fired test briquettes", May 2011

[11] Golden Makaka," Influence of Fly Ash on Brick Properties and the Impact of Fly Ash Brick Walls on the Indoor Thermal Comfort for Passive Solar Energy Efficient House" 2014

[12] Building Materials and Construction, Page 16-42, 2006