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Experimental Determination of Physical Properties of a Sun Dried Clay Bricks with Cement and Ashes

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ABSTRACT

The rising cost of cement and the problem of waste disposal with regard to coconut and rice husks lead to research on a clay brick with good physical properties that can replace cement brick and at the same time keep our environment clean. In line with this, bricks were moulded with clay, cement, rice husk ash, and coconut husk ash. The bricks were analyzed to determine their physical properties. In this study, a set of tables for mixing the proportion of raw material in grams with 33.3 cm3 of water, the table involved the addition of a certain additive to clay to improve the physical properties of adobe bricks developed. Five bricks were constructed for seventeen samples that give a total of 85 bricks which were tested in the laboratory for physical properties. The results shows that the bricks constructed with clay mixed with cement and coconut husk ash has the highest compressive strength of 4270.0 x 10-3 Nmm-2 and a modulus of rupture of 1750.0 x 10-2 Nmm2. The bricks constructed with clay, cement and rice husk ash and bricks of clay mixed with cement and rice husk ash and coconut husk ash both are having the highest water absorption of 1000 cm3. This result indicated that the brick moulded with clay, cement and coconut husk ash is stronger for building that can stay for many years without collapsing. Also, it indicated that the bricks moulded with clay, and coconut husk ash were good for the low heat conduction in the houses. And also bricks constructed with clay, cement, rice husk ash and coconut husk ash has low weight and can be used for the construction of lightweight houses.

Keywords: Compressive strength, Physical properties, Modulus of rapture, Water absorption.

1.0 INTRODUCTION

Clay is a finely grained natural rock or soil material that combines one or more clay mineral with possible trace of quarts ($Si0_2$) metal oxides (Al_20_3Mg0) and organic matter. Geological clay deposits are mostly composed of phyllosilicate minerals containing variable amount of water trapped in the mineral structure. Clays are plastic due to the particle size and geometry as well as water content and become hard, brittle and non-plastic upon drying or firing.

Depending on the soil content in which it is found, clay can appear in various colors from white to dull grey or brown to deep orange red. Although many naturally occurring deposits include both silt and clay, clays are distinguished from other fine grained soil by differences in size and mineralogy. Silt, which are fine grained soils that do not include clay mineral, tend to have larger particle size than clays. There is however, some overlap in particle properties. The distinction between silt and clay varies by discipline. Geologist and soil scientists usually consider the separation to occur at particle size of 2μm (clay being finer than silt). Sedimentology's often uses 4-5um and colloid chemists use 1μm Geotechnical engineers distinguished between silts and clay based on the plasticity properties of soil as measured by the soils Waterberg limits. The 14014688 grades clay particles as being smaller than 2 μm and slit particle is being larger [1].

Mixture of sand, silt and less than 40% clay are called loam. Loam make good soil and is used over long periods of time as a result of the gradual chemical weathering of rocks, usually silicate bearing, by low concentration of carbonic acid and other dilute solvent. These solvents, usually acidic migrate through the weathering rock after leaching through upper weathered layers. In addition to Clay brick also known as adobe, the word has existed for around 4000 years with the relative little change in either pronunciation or meaning. The word can be traced from the middle Egyptian 200 BC meaning Mud (sun dried) brick. As middle Egyptian evolution in to late Egyptian, Demotic, and finally Coptic 600 BC adobe called tube. This was borrowed into Arabic

language as at-tub (mud) brick which was assimilated into the old Spanish language as adobe still with the meaning mud brick. English borrowed the word from Spanish in early 18th century [2].

Various walling materials have been used at different time in architectural history. In many parts of Africa the traditional wall consist a kneaded mud sometimes interspersed with stick and these can still be seen in many Nigeria towns and villages. Muds have advantage of being heat resistance but are easily weakened by rain. Wall must be resistant damp penetration resistance. Most porous building swells on getting wet and shrink on drying. [3]. Due to the weathering process, some clay minerals are formed through hydrothermal activity [4].

The Physical properties of adobe bricks refer to the properties of the bricks determine from adobe brick formed with cement and ashes. These properties include: Compressive strength, Module of rapture (flexural strength) and Water Absorption.

A form of natural architecture build with environmentally friendly materials earth construction provides indoor protection from outside temperature condition. In Thailand, adobe bricks that contain rice husk are the most widely used material in building construction [5].

There is need to search for local material as alternatives for the construction of functional but low cost building in both rural and urban areas. Red clay is experiencing a renewed interest due to its environment-friendly properties as well as its Physical properties; the use of clay in building has also many economic benefits. The alternative method to manage and utilize these waste have to be found. The utilization of these waste reduce the negative effects of their disposal. Many attempts have been made with limestone dust, wood saw dust, processed waste tea, fly ash, polystyrene and sludge into building material **[**6**]**.

The utilization of clay bricks usually has positive effect on the properties, the positive effect such as improved shrinkage, porosity, thermal properties and strength can be obtained by the recycled wastes. Some waste materials which has potential as adobe brick additives are rice husk, cow dung, neem leave and saw dust ash and coconut husk ash and they are bio degradable but also create a problem for waste disposal. Their disposal into the environment also does not provide an environmental friendly solution. Hence, the use of the organic additive in construction materials can be a worthy solution to the environment pollution caused by these solid waste [7,8].

A research conducted by [9] on the effect of rice husk and rice husk ash to properties of bricks. Their research aimed to study effect between rice husk and rice husk ash to properties of bricks, comparative adding between rice husk and rice husk ash varied by 0 - 10% by weight. The result showed that the more rice husk is added the less the compressive strength and density of specimens. Otherwise the porosity increases when adding rice husk. By adding 2% of rice husk ash by weight is the best of bricks properties which 6.20 MPa of compressive strength, 1.68g/cm^3 of density and 1.520% of water absorption.

Investigation carried out by [10] using clay soil mixed with cow dung to produce sustainable brick, the study intended to explore how cow dung can be used to enhance the quality of clay bricks that can be used for low cost building construction in various communities around Namibia. The result shows a solution to deal with expensive building materials towards construction through the use of naturally occurring clay containing soil which is then stabilized to produce bricks.

A research by [11] on the effect of wood ash and sawdust admixtures on the engineering properties of a burnt literate clay brick, and the admixture were added in various combinations of proportion by volume (from 0 to 10%). It was also discovered that the major contributions of sawdust admixture are the reduction in the dry density of the finished burnt brick product (from 1755kgm^{-3} for the control mix with 10% sawdust content). The wood ash mixture in line with its pozzolanic nature was able to contribute in attaining denser product with higher compressive strengths, higher softening coefficients and lower water absorption rates, lower saturation coefficients and lower abrasion indexes. Increasing sawdust in the mixes produced the opposite results in the finished products, mainly due to its effect of producing a less compact structure in the finished product.

Work by [12] on thermo physical properties of clay bricks with cement and neem leave ash where the mixture of clay, cement and neem leaves ash was loaded into a wood mould compartment , manually levelled and cured 5,13, 19, 26 and 33 days. The result showed that when neem leaves ash content is 0% (20% cement), the highest average compressive strength of 1.50 Nmm^{-2} at 33 curing days was obtained, when neem leave ash content is also 10% (20% cement) the highest module of rapture of 0.71 Nmm^{-2} at 12 curing days was obtained when neem leaves ash content is 20% (10% cement), the highest water absorption of 16.1% at 5 days of curing was obtained, when neem leaves ash content is 5% (25% cement), the highest initial rate of absorption of 1.43 kgm^{-2} min^{-1} at 5 curing days was obtained, when 0% neem leaves ash (30% cement), the highest density of 2.8 kgmm^{-3} was obtained, also when neem leaves content is 10% (20% cement) of 2 cm thickness the highest thermal conductivity of 164.45 Wm^{-1} at 6

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minute of 26 days was obtained. However, neem leaves ash a partial replacement of cement in clay bricks possess better reliability and workability in both the physical and thermal properties of clay bricks.

The aim of this work is to examine the effect of changing the percentage of cement from 5%, 10%, 15%, 20%, 25% up to 30% while red clay with percentage of 100% and 70%, while rice husk ash of percentage 5%, 10%, 15%, 20%, 25% and 30% so also coconut husk ash of percentage 5%, 10%, 15%, 20%, 25% and 30% on the thermophysical properties of adobe bricks.
The objectives of the research work include the following:

i. To construct adobe bricks with ashes of different materials mixed with some percentage of cement.
ii. To test the compressive strength, module of rapture and water absorption for the molded adobe brick.
iii. To test for the density and thermal conductivity of the molded adobe brick.
iv. To determine the combination of additive (clay, cement, rice husk ash and coconut husk ash) for more suitable of production of bricks in diverse climates conditions.

This work focuses on the feasibility of Physical properties of adobe bricks form with ashes of different materials like, rice husk ash and coconut ash mixed with some percentage of cement and red clay in order to construct powerful bricks. However the research study investigates how additives that includes, cement, rice husk ash, coconut husk ash and red clay can be used to improve the quality of adobe bricks for low cost building.

2.0 MATERIALS AND METHOD

2.1 Materials

The materials that were used for this research were clay soil, ordinary Portland cement, rice husk ash and coconut husk ash. The clay used for the research is red clay which is available in Sokoto city and the cement used as ordinary Portland cement is the type that has the chemical constituents of lime (CaO) 60 to 67%, silica (SiO_2) 17 to 25%, alumina (Al_2O_3) 3 to 8%, iron oxide (Fe_2O_3) 0.5 to 6%, magnesia (MgO) 0.1 to 4%, Sulphur trioxide (SO_3) 1 to 3%, and soda or potash ($Na_2O + K_2O$) 0.5 to1.3%.and has the properties of 3.12 specific gravity, normal consistency of 29%, initial setting time of 65min, final setting time of 275min fineness of 330 kg/m^2, soundness 25mm and bulk density of 830 to 1650 kg/m^3. The rice husk used was obtained from "*kalambaina*" and the coconut husk was obtained from "*Kasuwar Daji Market*".

2.2 Method

The field experimentation was carried out at the Sokoto Energy Research Centre Sokoto Nigeria and Sokoto is at extreme Northern Nigeria with latitude of 13^o 01" N, longitude of 5^o 15'' E and elevation of 350m above see level. The climatic conditions are sahelian with abundant clay materials [6].

2.2.1 Preparation of Raw material

The rice husk ash was obtained by burning the husk in a galvanized metal sheet, thereafter the rice husk was stream on the metal sheet and kerosene was applied and put fire on it and allow fire for some minutes and then turning husk up and down until it turn into ashes. The ashes are kept it for two hours to cool in order to be ready for use. The same method was applied to obtained coconut husk ashes, but it was kept for four hours to cool before it is used, because it absorbed heat more than the rice husk ash that's why it has to be kept for more than two hours. .

2.2.2 Testing the Sample

For testing the specimen 5 bricks were produced for each sample and test. Two specimens of bricks was used for the test of compressive strength and modulus of rapture and two for water absorption and density, then one was left for thermal conductivity test, which gives the total of 85 bricks.

2.2.3 Determination of Compressive Strength of the Bricks

The compressive strength was measured for brick sample according to [13]. This strength is the best and most common test for checking the quality of the cement for the test to be taken, cement sample, clay (standardized) and water (distilled water) are needed. The ratio of sand to cement is 3:1 where the sand = 1350g, cement sample =450 g. Water = 225 g the standard (already prepared) of 1350g was weighed the cement sample was weighted as 450g followed by the distilled water was also weighed out as 225 g. The cement sample was then put into the mixing bowl containing weighed water; the sand was also added and allows undergoing mixing process in the mixing machine. The content was transferred into prism mold (160 mm long) mounted on the jolted machine and jolted for 120 second (2minutes), the prism mold was removed from the machine and was cured for 24hours in the curing chamber, the cured content was remolded and the cubes removed, the cubes were cured in the curing chamber 19^{0}c to 20^{0}c as its temperature and humidity above 90%. The prism cube was removed from the curing chamber daily to be crushed by

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the compressive strength testing machine. The machine was operated at low speed in other to enable easy recording of the readings. The compressive strength reading is in Nmm^2 which is the same as measuring the pressure of an object.
Compressive strength = force /Area.

Where ρ = F = ma (2.1)

$A = 4\pi r^2$ (2.2)

2.2.4 Modulus of rapture

The modulus of rapture was measured according to [13], this was adopted for adobe, and the test set up for flexural strength test consisted of a system that applied a single point load at the mid span of the prismatic specimen. The two end supports where placed about 50mm inside the edge of the beam resulting in an effect span of 400mm. The test set up was mounted on the universal testing machine detection sensor were used to measure the beam deflection in order to plat the load deflection curve.

2.2.5 Determination of Water Absorption

The water absorption was measured according to ASTM C373-88, [7]. The bricks were immersed in water for 24 hours and dry the specimen in ventilated areas at a temperature of 105^0c to 115^0C till it achieves considerable constant mass, and cooled the specimen to room temperature and take it weight (M_1). When the specimen was completely dry, then immersed it in clean water at

the room temperature (27^0) for 24 hours and then remove it from the water after 24 hours and wipe out water with a damp cloth and weight the specimen (M_2) after 3 minutes of removing from the water.

$$W = \frac{M_2 - M_1}{M_1} X\ 100 \quad (2.3)$$

2.2.6 Weight of the Clay Brick Sample

Weighting of the sample was done by the used of digital weighing balance, and the prism mold was measured before mixing of the additive, then after mixing the additive the weight was also done as M_1, and after molding the bricks and dry it in a ventilated area at temperature of 105^0 to 115^0 and then griped it in water at temperature of 27^0 for 24 hours, after removing it then to the scale for the weighing of the sample as M_2.

3.0 RESULTS

3.1 Results of laboratory test

The results of laboratory test conducted here depicted in Figure 3.1 to Figure 3.2 the physical determined include; compressive strength, modulus of rapture, water absorption, and weight of brick sample. The result of the compressive strength that are represented in figure 3.1, indicated that the brick sample that was molded with clay, cement, and coconut husk ash has the highest compressive strength with the value of 4270.0 x 10^{-3} nmm^2 while the brick sample that molded with clay, rice husk and coconut husk ash has the lowest compressive strength the value of 80.0 x $^{10\text{-}3}Nmm^2$, in this research it indicated that the bricks that constructed with clay mixed with cement and coconut husk ash was the best for construction of buildings.

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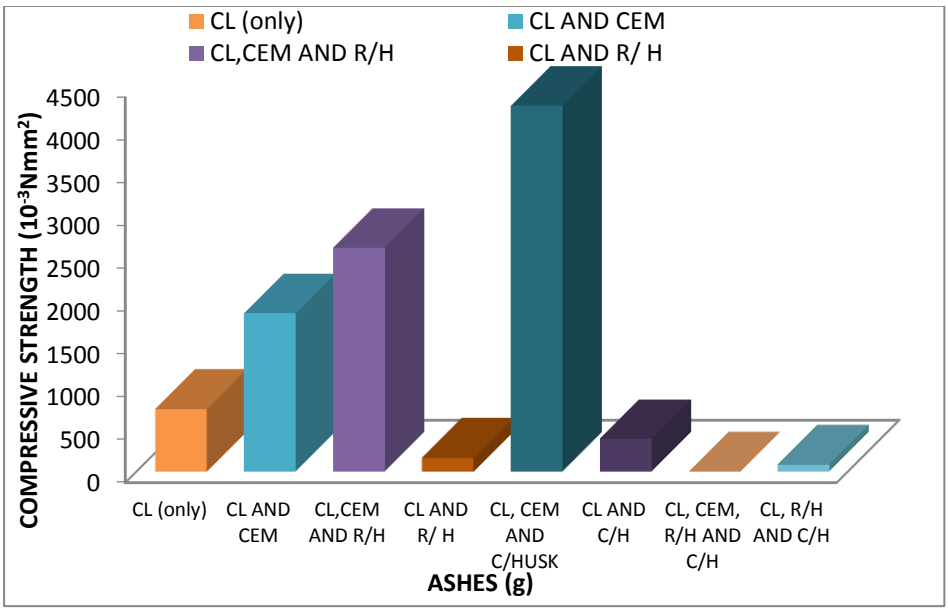

Figure 3.1. Compressive strength for various brick samples

Key: CL = Clay, CEM = Cement, R/H =Rice husk, C/H =Coconut husk

The result for compressive strength that are represented in figure 3.1, indicated that the brick samples that was molded with clay, cement and coconut husk ash has the highest compressive strength with the value of 270 x 10^{-3} Nmm^2, and the brick sample that constructed with the mixture of clay, rice husk ash and coconut husk ash has the lowest compressive strength with the value of 80.0 x 10^{-3} Nmm^2, this show that the bricks that has highest compressive strength was the best for building houses in rural areas and can stayed for long without collapsing.

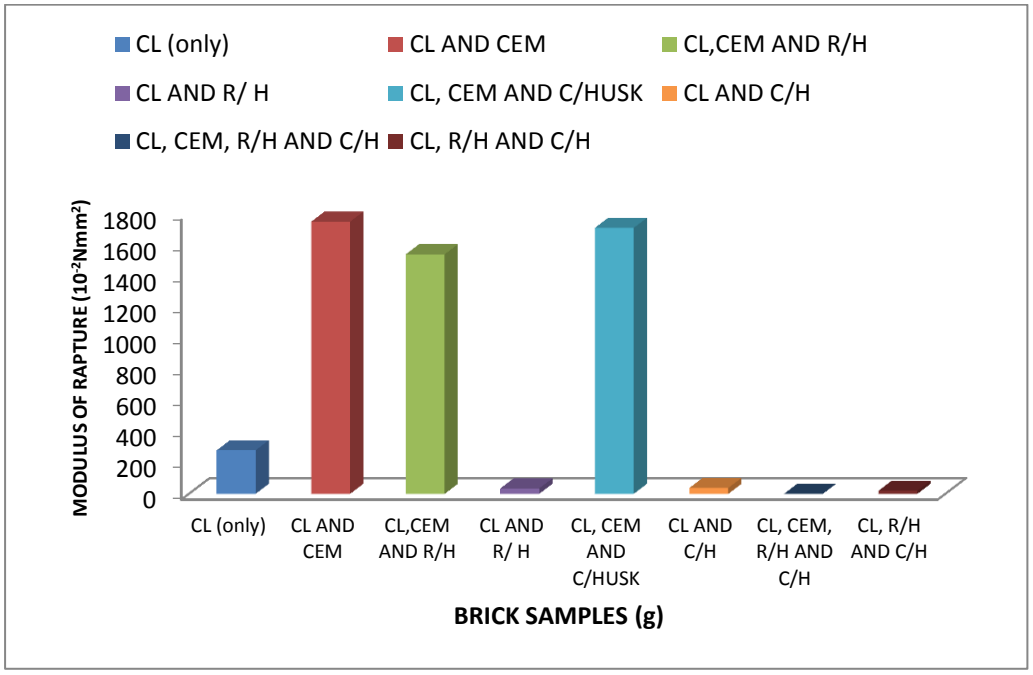

Figure 3.2: Modulus of Rapture for bricks sample

The result for modulus of rapture that are represented in the figure 3.2, indicated that the brick sample that was molded with clay and cement has the highest modulus of rapture with the value of 1750.0 x 10^{-2} Nmm^2 and brick sample that constructed with the mixture of clay, rice husk ash and coconut husk ash has the lowest modulus of rapture with the value of 20.0 x 10^{-2} Nmm^2, this indicated that the bricks constructed with clay mixed with cement has high flexibility and low weight and its good for building construction in some local areas.

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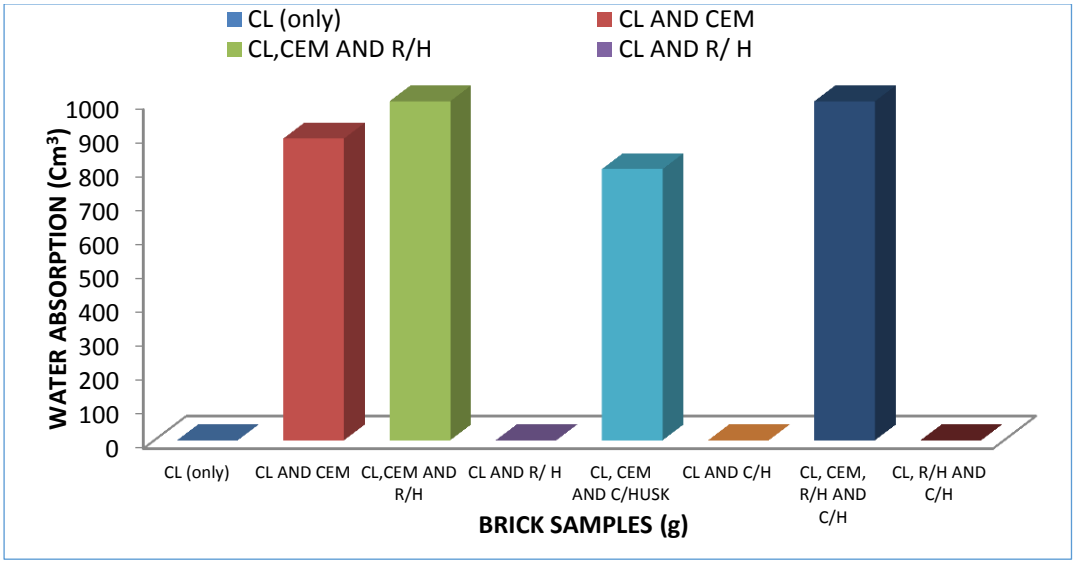

Figure 3.3: Result for water absorption of brick samples.

Figure 3.3 shows brick samples molded different materials. Brick molded with clay, cement, rice husk and coconut husk ash has the highest water absorption with the value of 1000.0 cm^3 and brick samples molded with clay, cement and coconut husk ash has the lowest water absorption with value of 800.0 cm^3, this indicated that the bricks molded with the mixture of cement and some additive has the highest water absorption and it also indicated that bricks with no mixture with cement completely dissolved in water.

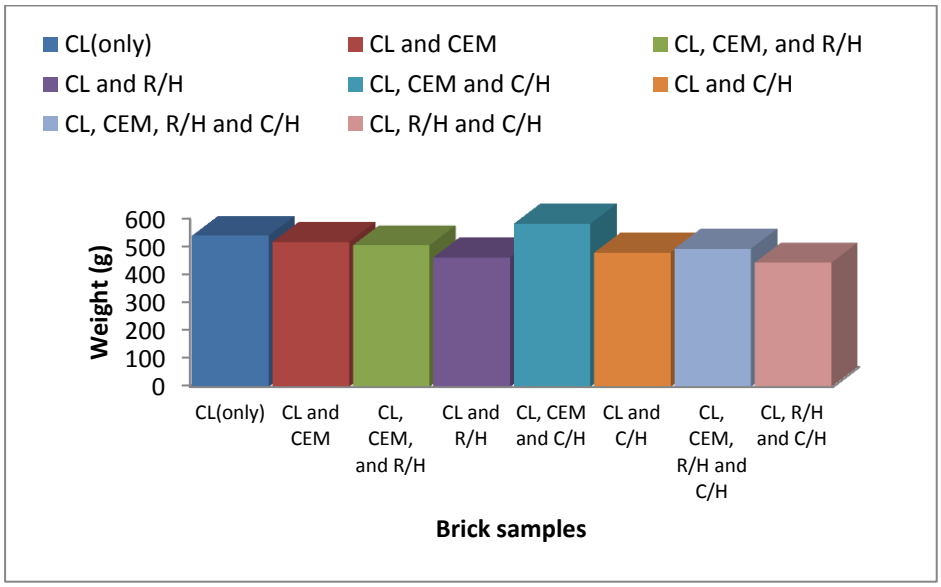

Figure 3.4: Weight of brick samples before moulding

The result for the weight of brick samples represented on the above figure 3.4, shows that the bricks moulded with clay, cement and coconut husk ash has the highest weight measurement of 582 g before moulding the brick samples and the mixture of clay, rice husk ash and coconut husk ash has the lowest weight measurement of 443 g, this indicated that after mixing the additive of brick sample and constructed bricks, the weight of bricks can change with small values.

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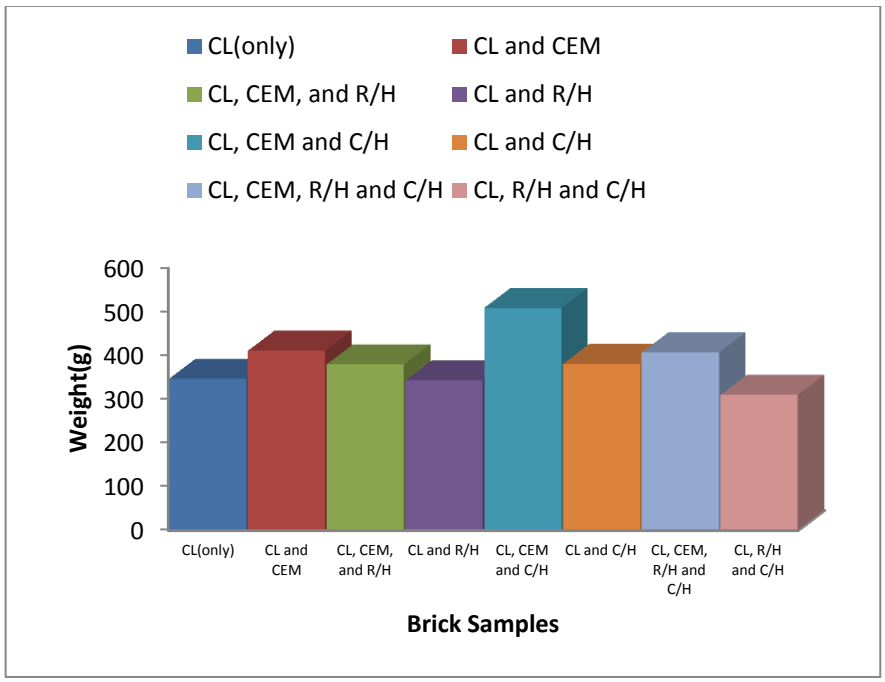

Figure 3.5: Result for weight of bricks after de moulding

Figure 3.5, show that the brick samples that melded with clay, cement and coconut husk ash has the highest weight of 509 g and the brick sample moulded with clay, rice husk ash and coconut husk ash has the lowest weight of 310 g. This indicated that the weight decreases after de moulding the brick sample from the moulder with the value of 73.0 g.

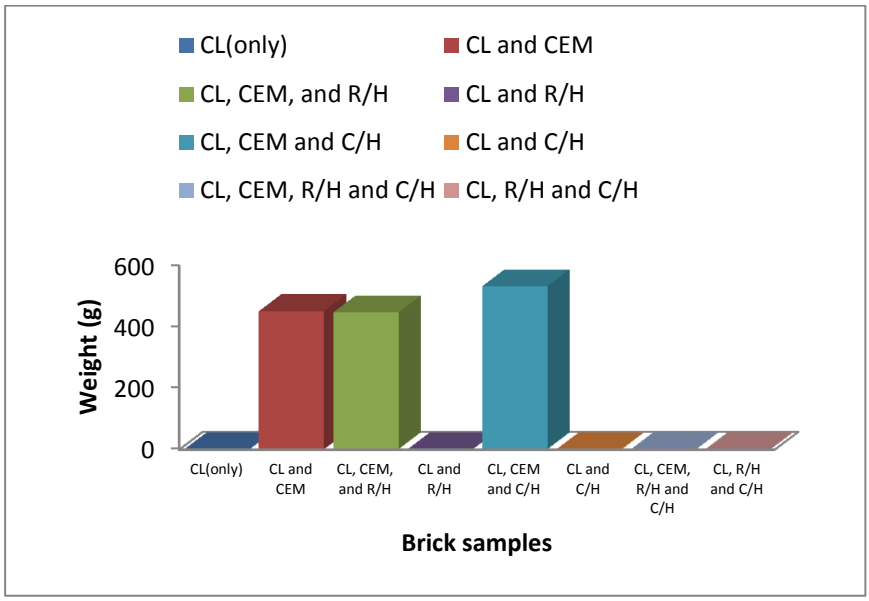

Figure 3.6: Result of weight of brick sample after water absorption.

Figure 3.6 shows that the brick samples moulded with clay, cement and coconut husk ash has the highest weight of 531 g and the one of clay cement and rice husk ash has the lowest weight of 446 g. The other brick samples were dissolved in water during curing of brick samples in water, this show that the same brick sample of mixture of clay, cement and coconut husk ash has the highest weight.

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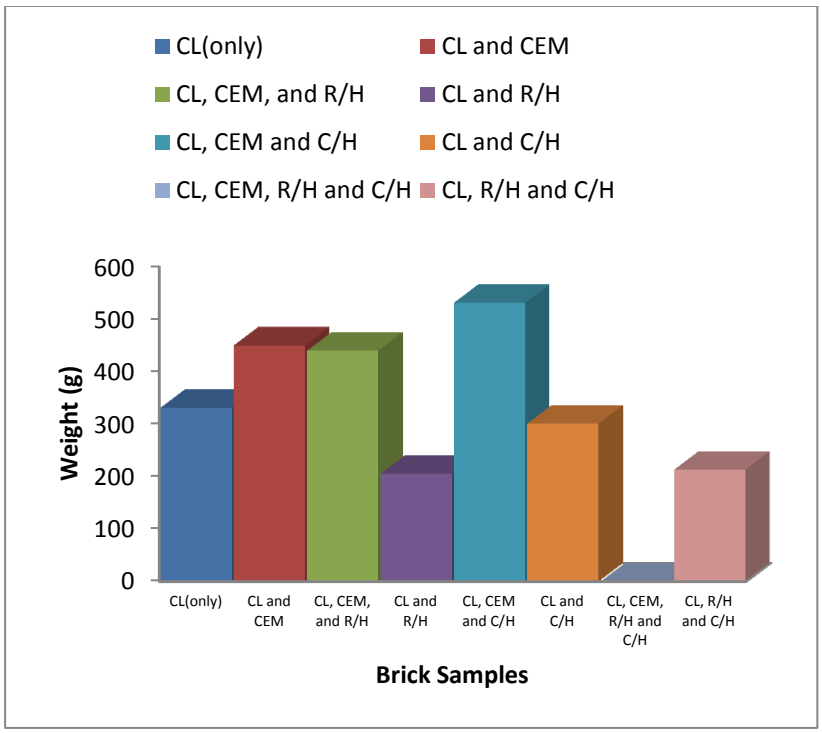

Figure 3.7: Weight of brick samples after drying

The result for the weight of brick sample after drying represented in figure 3.7 above, indicated that the brick samples molded with clay cement and coconut husk ash has the highest weight of 531 g, and the brick sample molded with clay and rice husk ash has the lowest weight with value of 205 g. This show that the bricks constructed with clay, cement, and coconut husk ash are the one that has the highest weight among all the bricks constructed in this research.

4.0 SUMMARY

This paper is on the determination of physical properties of adobe bricks formed with cement and ashes of different materials as additive were evaluated for each sample. The physical properties involves compressive strength, modulus of rapture and water absorption.

A total of 85 bricks were produced based on the percentage of mixture proportion of raw materials. In each sample five bricks were produced in seventeen sample which gives total of 85 bricks. This give us an opportunity to measure the compressive strength, modulus of rapture, water absorption. This was carriedout in order to get a better adobe bricks for good measurement of physical properties and it was found that the bricks that was formed with clay and cement has the highest compressive strength and bricks that was moulded with clay and coconut husk ash has the highest modulus of rapture and bricks with clay, cement, rise husk ash, and coconut husk ash has the highest water absorption and for thermal properties the bricks constructed with clay but the bricks constructed with clay, cement and rice husk ash, after absorbing water has the highest weight than any other bricks.

5.0 CONCLUSION

This research indicated that the physical properties were observed from the constructed bricks and it was shown the bricks with high compressive strength, low modulus of rapture and low water absorption are the best for building construction of different houses which remain for many years without collapsing. And it also indicated that the bricks constructed with mixture of clay, cement and coconut husk ash has the highest compressive strength than bricks with ordinary clay and straw.

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