COMPRESSIVE STRENGTH DEVELOPMENT OF BRICKS MADE FROM MUDDY CLAY AND PORTLAND CEMENT MIXTURE AS A BUILDING COMPONENTS/MATERIALS IN SOKOTO STATE-NIGERIA

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ABSTRACT

This project is experimental on the use of muddy clay and Portland cement as building components/materials in the production of bricks. The muddy clay samples were obtained from 30m depth below the ground level. A total number of six (6) cubes were cast; three (3) cubes each were cast for muddy clay and Portland cement, and ordinary muddy clay respectively using molds sizes of 150mm x 150mm x 150mm. The batching used was by volume using mix ratio 1:4, and 500ml of water was added to the mortar to form workability. The cubes were cured for 7 days; 14 days and 21 days, and the compressive strength tests were carried out after every curing age. The average compressive strength for muddy clay and muddy clay mixed with Portland cement of the same mix ratio of 1:4 was 20.40N/mm^2 and 42.50N/mm^2 respectively. Therefore, it was recommended that 100% muddy clay should not be used for bricks production due to low compressive strength observed during crushing. However, 90% muddy clay with 10% cement replacement is recommended in the production of bricks as this may reduce the cost of building.

Keywords: Compressive, Strength, Bricks, Muddy-clay, Portland-Cement, Building, Components

INTRODUCTION

In many countries, the need for locally manufactured building materials can hardly be overemphasized because there is a balance between the demands for housing and expensive conventional building materials coupled with the depreciation of traditional building material to address this situation, attention has been focused on low – cost alternative building materials. (Balkema, 2015). In Sokoto metropolis and its surrounding towns, the most common walling materials are the conventional sandcrete blocks and fire clay bricks. The cost of sandcrete blocks coupled with the low strength properties of commercially available block necessitated the search for an alternative that was fire clay bricks. The production of fireclay bricks is labor-intensive, and the process of firing is usually carried out using given species of trees. This could lead to their extinction and deforestation. the firing of bricks requires great quantities of firewood and energy loss in the form of heat is about 40 – 50%. In addition to the environmental problem, clay bricks can only be produced in a location where suitable clay soil deposits exist. This potential is not being maximized compared to sandcrete blocks. It is economical to use muddy clay bricks production because very little cement is required and the cost of transportation is limited compare to fire clay

bricks. The production of muddy clay bricks does not involve the firing process to cure the clay bricks (Milland, 2014).

Consequently, the mortal required per joining per square meter of the wall is reduced significantly. Good muddy clay bricks were produced from different sites in Ogun state when muddy clay mold was stabilized with 3 to 7% cement, (Osula, 2014). Muddy clay stabilized with cement was used successfully to produce brick in Sudan. Hence, this research aimed to investigate the compressive strength development of bricks made from muddy clay and Portland cement mixture as building components / materials in Sokoto State-Nigeria. To achieve this aim, the following objectives were drawn.

1. To determine the effect of water content on the compressive strength development of bricks made from "the mixture of" muddy clay and Portland cement.

2. To determine the effect muddy clay "content" and Portland cement on compressive strength development of bricks made from the mixture of muddy clay and Portland cement.

3. To determine the effect of curing age on the compressive strength development of bricks made from the mixture of muddy clay and Portland cement.

JUSTIFICATION OF THE STUDY

The shortage of building materials and the escalating prices of those available are responsible for the shortfall in the provision of adequate housing in Nigeria and the world at large both in an urban and rural area. In order to find an alternative to conventional building materials and reduce the cost of housing provision, muddy clay and Portland cement have been considered to make bricks a viable alternative to fire clay bricks. Hence this research work is focused on the compressive strength development of bricks made from the mixture of muddy clay and Portland cement. Muddy clay and Portland cement are usually and readily available and also cheaper, the use of muddy clay will also support the sustainability principle in the construction industry. Due to this, it becomes worthwhile to investigate its performance in an environment to provide more information for its usage. The use of muddy clay will ensure the use of locally available materials and reduce the cost of construction, and it will also protect the environment from pollution caused as a result of firing or other pollutant materials used. This research covers the investigation of the compressive strength development of bricks made from muddy clay and Portland cement mixture and the levels of Portland cement by muddy clay in making bricks at various curing ages.

LITERATURE REVIEW

A brick is a building material used to make walls, pavements, and other elements in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote any rectangular units lay in mortar. A brick can be composed of clay-bearing soil, sand, and lime or concert materials. Bricks are produced in numerous classes, types, materials, and sizes which carry with region and time period and are produced in bulk quantities. Two basic categories of bricks are fired and unfired bricks. The earliest brick was dried brick, meaning that they were formed from clay-bearing earth or mud dried (usually in the sun) until they were strong enough for use, the oldest

discovered bricks, originally made from shaped mud and dating before 7500BC, were found at Tell Aswad, in the upper Tigris region and in southeast Anatolia close to Diyarbakir. Type of bricks bond may include English, Flemish, stretching, heading,etc. (Solanke et al., 2015). The first evidence of human using a form of mortar was at Ziggurat of salt in Iran, built of sun-dried bricks Type M mortar mix has the highest amount of Portland cement and this composed of 3 parts of Portland, parts of lime and 12 part of sand. It is recommended primarily for masonry for walls bearing heavy loads. Type M mortar mix can be used primarily for masonry below-grade foundation, retaining walls, and driveways. These types will provide with at least 2,500 pounds per square inch compressive strength. (Okupe, 2016).

RESEARCH METHODOLOGY

The methods employed in carrying out this research work are described as in 3.1- 3.4 below:

SAMPLE COLLECTION

The sample of muddy clay used in this research work was collected from Arkilla federal low-cost housing estate in Wamakko local government of Sokoto State. The samples were obtained at a depth of 30m below the ground level, and it was clearly muddy clay. The tests conducted on this research work include particle size analysis, moisture content, specific gravity, and the determination of compressive strength development of brick made from muddy clay and Portland cement mixture.

MOULDS PREPARATION AND LABORATORY ANALYSIS

The molds used for the casting of cubes were 150mm x 150mm x 15mm in size. The cubes were tested to determine the compressive strength attained after 7, 14, and 21 days of production respectively. The inner surface of the molds was coated with engine oil to facilitate easy removal of the cubes from the mold. The bricks made with muddy clay and Portland cement was labeled mcp1, mpc2, mcp3, and mcp4, while brick with ordinary muddy clay label omc1, omc2, omc3, omc4 respectively. Apparatuses and materials used during the practical works are a Hand towel, Sampling tray, Scoop, Hand shovel, Water bottle, Weighing balance, Tamping rod for compacting, Muddy clay, Portland cement.

Procedural Operations Involved

The platform on which bricks are to be manufactured was prepared and clean, and the required weight of muddy clay to be used was calculated, measured, and spread on the clean surface accordingly. The required weight of cement was also calculated and poured into the spread of muddy clay and was then mixed thoroughly by the use of hand shovel until a homogenous mixture was attained. The required weight of water 500ml was added instantly as mixing commences using a hand shovel. The mixing continued until a homogenous fresh brick mix was attained. The mix was collected in a head pan and transported immediately to the point of placement. The fresh mortar was then placed into the molds in three layers as a standard particle prescribed mold was first filled with the fresh muddy clay mixed with cement, and the compaction was done using tamping rod for about

twenty – five (25) blows then the mortar (muddy clay and cement) was added up to two-thirds ($^2/_3$) of the mold after which compaction was filled allowing for only 1% or air content. The surface of the cube formed was then finished using hand trowel to acquire smooth surface. A sharp object, e.g. a knife was then used to inscribe on the surface of the cubes in order to differentiate them in terms of aggregate sample used. The molds were dismantled, and cubes were removed, and then after 24hours of removal, cubes were immersed in water for curing.

NATURAL MOISTURE CONTENT

Some portion of the soil sample was taken into the container and then weighted and recorded. The weighted sample was placed and left inside the oven for about 24hours at a temperature of about 11^{o}c the sample was weighed after being oven-dried the mass of the present sample was determined by finding the difference between the weight of the sample before and after drying.

The moisture content (MC)

$$MC = \frac{W_2 - W_3 \quad X \quad 100\ \%}{W_3 - W1}$$

Where W_1 = Weight of empty Can

W_2 = Weight of Can + Weight of wet soil

W_3 = Weight of Can + Weight of dry soil sample

The strength of the paste depends on the ratio of water-cement. The water-cement ratio is the weight of the mixing water divided by the weight of the cement. (Madedor, 2015).

PARTICLE OF SIZE ANALYSIS (SIEVE ANALYSIS)

The method employed for determination of the grading of the size of the aggregate making the composition of the samples/materials in accordance with the BS812. The particle of aggregate is allowed to pass through various stages of the sieve (depending on the size range required) from the top of the sieving apparatus where the largest size was present and arranged in descending order to the least of the sieve. The arranged sieves was than subjected to shaking vibration through the use of mechanically driven sieve shaker, where the separation of various size of aggregate were collected at various categories size sieve capacity [BS812; 55103 : 1990 Version] The percentage passing (timer) and that of the cumulative percentage of soil retained was calculated by the following

$$\%\ \text{soil retained} = \frac{\text{Weight of soil retained } (W_2 - M) \text{ X } 100\%}{\text{Total soil weight (w)}}$$

Where W = Total weight of soil

W_1 = Weight of sieve only

W_2 = Weight of sieve of soil

The percentage passing = CP: Cumulative Percentage of soil retained.

The result of this research was representing a plotted form in a tabular form. The shape of the particle size distribution curve for an aggregate sample can be expressed approximately by a coefficient of informally (Cu).

$$Cu = \frac{D60}{D10}$$

Where D60 = Soil diameter of which 60% of the soil weight is finer
D10 = Soil diameter of which 10% of the soil weight is finer

SPECIFIC GRAVITY

The specific gravity of any materials is the ratio of the weight of a given volume of that material to the weight of a volume of water. The purpose of this test is to determine the relative weight of the material so as to know the batching to be employed. The specific gravity of the soil particles was calculated using the expression below.

$$GS = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

Where W_1 = weight of muddy clay
W_2 = weight of muddy clay + Sample
W_3 = weight of muddy clay + Water to fill
W_4 = weight of bottle + Water to fill

BRICKS CURING

Cast cubes were cured in order to obtained good bricks and also to ensure its maturity under a controlled temperature. The placing of an appropriate mix must be cured in a suitable environment during the early stages of hardening. Curing is the name given to procedure used to promote the hydration of cement and consists of control of the temperature and of the moisture movement from and into the mortar. Curing affects both durability and strength of the brick. The object of curing at normal temperature was to keep the brick saturated or as nearly saturated as possible until the originally water-filled space in the fresh mortar paste has been occupied to the desired extent by the products of hydration of cement (Neville et al., 2015). The necessity of curing arises from the fact that hydration of cement takes place only in water-filled capillaries. This is why the loss of water by evaporation from the capillaries has to be prevented or replaced respectively, i.e. increases of water into the cube must take place. The cast cubes were carefully removed from the molds on the next day after casting and placed into a curing tank filled with water of portable quality. This was because the quality of water used for curing should be the same as mixing water and free from substances that attack hardened of the bricks. (Neville et al., 2015). It was ensured that the cubes were totally immersed in water so that the evaporation was minimized if not completely prevented and this was done at room temperature.

COMPRESSIVE STRENGTH DETERMINATION

The methodology adopted for the determination of the compressive strength of the bricks and cured cubes was the crushing test. The cubes were taken 7days from curing tank transported directly to the lab for crushing tests. The specimens were crushed with ELE 200KN Capacity mechanically drive hydraulic compressive testing machine. It was done for the sample at various mix proportion, the crushing strength of a brick is found out by placing in a compressive testing machine, it will be pressed on the brick until its breaks as per BS1510 77 – 1957. The compressive strength of cube is determined by using.

$$\text{Compressive strength} = \frac{\text{Crushing load (N)} \times 100}{\text{Area of a cube (mm)}}$$

Cement stabilized soils are usually evaluated by unconfined compressive strength (UCS) test with a minimum 7 – day UCS value of 1720 KN/m^2 as the criterion for effective stabilization, the maximum permissible cement of 5% was specified by Nigerian Building and Road Research Institute (NBRRI) (Olabiran, 2013).

ANALYSIS AND DISCUSSION OF RESULTS

This section presents the results and the experiments carried out as was in-lined with the objectives of this research work. The compressive strength of Portland cement and muddy clay brick cured in water at different ages are presented in Table 4.1

Table 4.1: Results of Compressive strength of 100% Muddy clay, 90% Muddy clay + 10%Portland cement and 95%Muddy clay bricks

x Constitution	mpressive strength (N/mm^2)		
0% Muddy clay	ays .40	days .40	days .40
% Muddy clay + 10% Portland cement	.25	.50	.80
% Muddy clay + 5% Portland cement	. 20	.40	.80

Table 4.1 shows that compressive strength increases with increasing curing age for all the mix combination. The compressive strength attained at 100% muddy clay was 19.40n/mm^2, 20.40N/mm^2 at 7days, 14days and 21days respectively. The compressive strength attained at 90% muddy clay was 40N/mm^2, 42.50N/mm^2, and 47.80N/mm^2 at 7days, 14days, and 21days respectively. The compressive strength attained at 95% of muddy clay was 38.20N/mm^2, 39.40N/mm^2, 39.80N/mm^2 at 7days, 14days, 21day respectively.

uddy clay ntent %	ring age	ushing load forecuring (KN)	ushing load after ring (KN)	ean load N)	mpressive strength /mm^2)
				.50	.40
				.00	.85
				.00	.30
0				*.50*	*.40*
				.00	.40
				.00	.40

Table 4.2: Results of Characteristic Strength of Brick Cubes in Water With Mix Ratio 1:4

However, Table 4.2 shows the variation of compressive strength development of brick made from muddy clay and Portland cement. It shows that the compressive strength of sample it slightly decreases with increases in the percentage replacement of muddy clay at 0 to 5% and increase on average with an increase in the replacement of Portland cement at 5% to 10%. So, therefore, 90% of muddy clay and 10% of Portland cement with ratio 1:4 developed the compressive strength of bricks made from muddy clay and Portland cement.

CONCLUSION

The following conclusion was drawn from the work done after the laboratory experiments and the analysis of the results of the study.The compressive strength of Portland cement brick decrease with increasing content of muddy clay The compressive strength of the Portland cement and muddy clay increased with increasing curing age in water.The observations during the experimentation stage also show that 100% of muddy clay replacements produce weak samples which are unsuitable for crushing. Hence, it is advised to make use of 5-10% of Portland cement mix with muddy clay in the production of bricks.

RECOMMENDATIONS

Based on the tests carried out and the conclusions drawn, the following recommendations were made.

1. 100% of muddy clay should not be used for bricks due to low compressive strength observed during crushing.
2. 90% of muddy clay mix with 10% cement contents is recommended in the production of brick
3. The uses of muddy clay and Portland cement mixture is recommended as this may reduce the cost of the building

REFERENCES

Balkema (2015). *Building construction handbook four edition* MPG Books Ltd BodmerCornwall Britain

Madedor A.O., (2011), the impact of building material research on low-cost housing development in *Nigeria, Engineering focus April-June, the publication of the Nigerian Society ,of Engineers,* Vol 4, no 2, p.37-41

Milland, R.S. (2014). Cement and lime-stabilization, *Road building in the tropics*, Trans Res lab, State of the art Review no 9, P.183-185

Neville and Brook, (2015), *Environmental impact of cement production,* Retrieve August 13, 2015, from Ecos, mart concrete, WWW. Ecos mart concrete.com

Okupe, T.A., (2013), Sourcing and utilization of local building materials to provide avoidable houses for Nigerians: in sourcing and utilization of local materials for housing development in Nigeria, *ATTCON* proceedings, National workshop held ata central hotel, Kano, October 16-20, (2013)

Olabiran, O.E., (2013), Innovative local materials for use in housing: in sourcing and utilization of local raw material for housing development in Nigeria, *ATTCON proceedings,* National workshop held at a central hotel, Kano, October 16-20,2013, p. 149-165.

Osula, D.O.A (2014). A comparative evaluation of cement and lime, modification of muddy clay soil*Engineering Geology* vol.42., P.71-81

Solanke, O. Sa'ad, T.H., Arayela, T.O (2015). Brick industry and its impact on the housing sector Nigeria (2012-2015): Insourcing and utilization of local raw materials for housing development in Nigeria, *ATTCON proceedings,* National Workshop Held at a central hotel, October, 16-20, (2015), P.104-110. www.housing corpsahcn.org